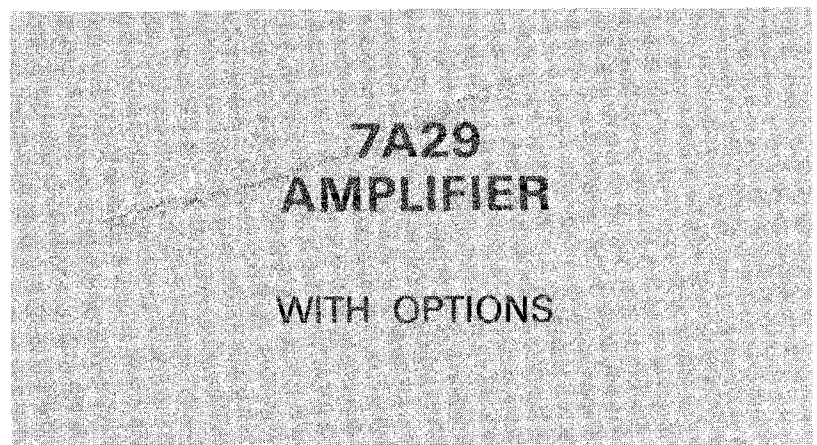


**Tektronix**<sup>®</sup>  
COMMITTED TO EXCELLENCE




INSTRUCTION MANUAL

Tektronix, Inc.  
P.O. Box 500  
Beaverton, Oregon 97077

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

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# TABLE OF CONTENTS

	PAGE		PAGE
LIST OF ILLUSTRATIONS .....	iii	<b>SECTION 3 THEORY OF OPERATION</b>	
LIST OF TABLES .....	iii	BLOCK DIAGRAM .....	3-1
OPERATORS SAFETY SUMMARY .....	iv	DETAILED CIRCUIT OPERATION .....	3-1
SERVICE SAFETY SUMMARY .....	v	INPUT SWITCHING AND READOUT .....	3-3
<b>SECTION 1 GENERAL INFORMATION</b>		DELAY LINE .....	3-3
INTRODUCTION .....	1-1	AC-OFF-DC .....	3-3
INSTALLATION .....	1-1	INPUT ATTENUATORS .....	3-3
INITIAL INSPECTION .....	1-1	INPUT PROTECTION .....	3-3
OPERATING INFORMATION .....	1-1	POWER SUPPLIES .....	3-3
OPERATING TEMPERATURE .....	1-2	READOUT SWITCHING .....	3-3
PACKAGING FOR SHIPMENT .....	1-2	INPUT AMPLIFIER .....	3-4
SPECIFICATIONS .....	1-2	FAST OVERLOAD PROTECTION .....	3-4
STANDARD ACCESSORIES .....	1-6	FEEDBESIDE .....	3-4
RECOMMENDED ACCESSORIES .....	1-6	INPUT AMPLIFIER .....	3-4
PROBES .....	1-6	POSITION .....	3-5
<b>SECTION 2 OPERATING INSTRUCTIONS</b>		TRIGGER AND OUTPUT AMPLIFIER .....	3-6
CONTROLS AND CONNECTORS .....	2-1	OUTPUT AMPLIFIER .....	3-6
CHECKOUT PROCEDURE .....	2-1	TRIGGER AMPLIFIER .....	3-6
BEFORE YOU BEGIN .....	2-1	<b>SECTION 4 MAINTENANCE</b>	
TEST EQUIPMENT REQUIRED .....	2-1	PREVENTIVE MAINTENANCE .....	4-1
SETUP PROCEDURE .....	2-1	CLEANING .....	4-1
AMPLIFIER FUNCTIONS .....	2-3	EXTERIOR .....	4-1
DETAILED OPERATING INFORMATION .....	2-4	INTERIOR .....	4-1
PROBES .....	2-4	VISUAL INSPECTION .....	4-1
VERTICAL GAIN CHECK AND		PERIODIC ELECTRICAL ADJUSTMENT .....	4-2
ADJUSTMENT .....	2-4	SEMICONDUCTOR CHECKS .....	4-2
INPUT COUPLING .....	2-4	TROUBLESHOOTING .....	4-2
VOLTS/DIV SWITCH .....	2-5	TROUBLESHOOTING AIDS .....	4-2
POLARITY SWITCH .....	2-5	DIAGRAMS .....	4-2
TRACE IDENTIFICATION AND		CIRCUIT BOARD ILLUSTRATIONS .....	4-2
READOUT FUNCTIONS .....	2-5	TROUBLESHOOTING CHART .....	4-2
VARIABLE DELAY (OPTION 4) .....	2-5	TEST POINT AND ADJUSTMENT	
MATCHING DELAY TIMES USING TWO		LOCATIONS .....	4-2
7A29 UNITS, ONE HAVING VARIABLE		COMPONENT COLOR CODING .....	4-2
DELAY (OPTION 4) .....	2-5	SEMICONDUCTOR LEAD CONFIGURATIONS .....	4-5
		WIRING COLOR CODE .....	4-5
		INTER-BOARD PIN CONNECTOR	
		IDENTIFICATION .....	4-5
		MULTI-PIN CONNECTOR IDENTIFICATION .....	4-5
		INTERFACE CONNECTOR PIN LOCATIONS .....	4-5
		TROUBLESHOOTING EQUIPMENT .....	4-6
		TROUBLESHOOTING TECHNIQUES .....	4-6
		1. CHECK CONTROL SETTINGS .....	4-6
		2. CHECK ASSOCIATED EQUIPMENT .....	4-6
		3. VISUAL CHECK .....	4-6
		4. CHECK INSTRUMENT ADJUSTMENT .....	4-6
		5. ISOLATE TROUBLE TO A CIRCUIT .....	4-6
		6. CHECK VOLTAGES AND WAVEFORMS .....	4-7
		7. CHECK INDIVIDUAL COMPONENTS .....	4-7
		8. REPAIR AND ADJUST THE CIRCUIT .....	4-7

**WARNING**

THE REMAINING PORTION OF THIS TABLE OF CONTENTS LISTS THE SERVICING INSTRUCTIONS. THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CALLED OUT IN THE OPERATING INSTRUCTIONS UNLESS QUALIFIED TO DO SO.

# TABLE OF CONTENTS (CONT.)

	PAGE		PAGE
CORRECTIVE MAINTENANCE .....	4-8	PART I--PERFORMANCE CHECK .....	5-8
OBTAINING REPLACEMENT PARTS .....	4-8	INDEX TO PART I--PERFORMANCE CHECK .....	5-8
SOLDERING TECHNIQUES .....	4-8	PERFORMANCE CHECK POWER-UP SEQUENCE ...	5-8
COMPONENT REMOVAL AND REPLACEMENT .....	4-9	A. LOW FREQUENCY .....	5-9
OPTION 4 VARIABLE DELAY LINE .....	4-9	B. HIGH FREQUENCY .....	5-14
CIRCUIT BOARDS .....	4-9	C. INPUT PROTECTION .....	5-18
AC-OFF-DC SWITCH .....	4-10	PART II--ADJUSTMENT AND PERFORMANCE	
INPUT ATTENUATORS .....	4-11	CHECK .....	5-21
SEMICONDUCTORS .....	4-14	INDEX TO PART II--ADJUSTMENT	
INTEGRATED CIRCUITS .....	4-14	AND PERFORMANCE CHECK .....	5-21
INTERCONNECTING METHODS .....	4-15	ADJUSTMENT AND PERFORMANCE CHECK	
COAXIAL END-LEAD CONNECTOR		POWER-UP SEQUENCE .....	5-21
(PELTOLA CONNECTOR) .....	4-16	A. LOW FREQUENCY .....	5-22
END-LEAD PIN CONNECTOR (P220) .....	4-16	B. HIGH FREQUENCY .....	5-29
MULTIPLE END-LEAD PIN CONNECTOR		C. INPUT PROTECTION .....	5-36
(HARMONICA CONNECTOR) .....	4-16		
INTERBOARD MULTI-PIN CONNECTOR			
(COMB CONNECTOR, J70) .....	4-16		
CIRCUIT-BOARD PINS .....	4-16	<b>SECTION 6 INSTRUMENT OPTIONS</b>	
FRONT-PANEL RESET LIGHT .....	4-17		
ADJUSTMENT AFTER REPAIR .....	4-17	<b>SECTION 7 REPLACEABLE ELECTRICAL PARTS</b>	
<b>SECTION 5 CALIBRATION</b>		<b>SECTION 8 DIAGRAMS AND CIRCUIT BOARD</b>	
USING THESE PROCEDURES .....	5-2	<b>ILLUSTRATIONS</b>	
PERFORMANCE CHECK SUMMARY .....	5-2		
ADJUSTMENT INTERVAL .....	5-5	<b>SECTION 9 REPLACEABLE MECHANICAL PARTS</b>	
TEKTRONIX FIELD SERVICE .....	5-5		
TEST EQUIPMENT REQUIRED .....	5-5	<b>CHANGE INFORMATION</b>	
SPECIAL FIXTURES .....	5-5		
TEST EQUIPMENT ALTERNATIVES .....	5-5		





# OPERATORS SAFETY INFORMATION

The following general safety information applies to all operators and service personnel. Specific warnings and cautions will be found throughout the manual where they apply and should be followed in each instance.

**WARNING** statements identify conditions or practices which could result in personal injury or loss of life.

**CAUTION** statements identify conditions or practices which could result in damage to the equipment or other property.



## GROUND THE INSTRUMENT

*To reduce electrical-shock hazard, the mainframe (oscilloscope) chassis must be properly grounded. Refer to the mainframe manual for grounding information.*

## DO NOT REMOVE INSTRUMENT COVERS

*To avoid electric-shock hazard, operating personnel must not remove the protective instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.*

## DO NOT OPERATE IN EXPLOSIVE ATMOSPHERE

*To avoid explosion, do not operate this instrument in an explosive atmosphere unless it has been certified for such operation.*



## PREVENT INSTRUMENT DAMAGE

*To prevent instrument damage, plug-in units should not be installed or removed without first turning off the mainframe power.*

# SERVICE SAFETY INFORMATION

## FOR QUALIFIED SERVICE PERSONNEL ONLY

The following are safety precautions which appear in the service information sections of this manual. This Service Safety Information is in addition to the Operators Safety Information given previously.

### WARNING

#### DO NOT SERVICE ALONE

*Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.*

#### DISCONNECT INSTRUMENT POWER

*To avoid electrical-shock hazard, disconnect the instrument from the power source before removing protective panels, soldering, or replacing components.*

### CAUTION

#### AVOID EXCESSIVE MOISTURE

*Circuit boards and components must be dry before applying power to prevent damage from electrical arcing. Pins 2 and 3 of U246 and U266 are especially sensitive to moisture. Excessive moisture in this area of the circuit board will cause the trace to wander irregularly and possibly leave the screen area.*

#### EXERCISE CARE WHEN SOLDERING

*The Main Amplifier circuit board is a multilayer type with two identical conductive paths laminated between the top and bottom board layers. All soldering on this board should be done with care to prevent breaking the connections to the center conductors. Only experienced maintenance personnel should attempt repair of any circuit board.*

#### USE PROPER CLEANING AGENTS

*Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Use a nonresidue type of cleaner, preferably isopropyl alcohol, totally denatured ethyl alcohol, or a fluorinated solvent (i.e. trifluorotrchloroethane), such as Freon TF cleaner or Spray-On #2002. Before using any other type of cleaner, consult your Tektronix Service Center or representative.*

#### DO NOT USE PIN SOCKETS FOR CONNECTION POINTS

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



OPTION 4 INSTRUMENT

STANDARD INSTRUMENT

2320-2

### 7A29 FEATURES

The 7A29 is a wide-bandwidth Amplifier Plug-In Unit designed primarily for use in vertical compartments of the 7000-Series Oscilloscopes. The input is 50-ohm impedance with selectable DC or AC coupling and automatic overload disconnect. Seven calibrated deflection factors, VARIABLE deflection factor and polarity INVERT selections are provided. Readout encoding provides for deflection factor readout including coded probes, uncalibrated indication, polarity INVERT and IDENTIFY functions. A Variable Signal Delay of +0.5 ns is available with the Option 4 instrument.

# GENERAL INFORMATION

## INTRODUCTION

The Instruction Manual is divided into the following main sections:

Section 1—General Information contains instrument description, electrical specifications, environmental characteristics, standard and recommended accessories, installation, and packaging for shipment instructions.

Section 2—Operating Instructions contains information relative to operating and checking the instrument operation.

### WARNING

*THE REMAINING PORTIONS OF THIS INSTRUCTION MANUAL CONTAIN SERVICING INSTRUCTIONS. THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK OR OTHER PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT DESCRIBED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.*

Section 3—Theory of Operation contains basic and general circuit analysis that may be useful for servicing or operating the instrument.

Section 4—Maintenance describes routine and corrective maintenance procedures with detailed instructions for replacing assemblies, subassemblies, and individual components.

Section 5—Calibration contains procedures to check the operational performance and electrical characteristics of the instrument. Procedures also include methods for adjustment of the instrument to meet specifications.

Section 6—Instrument Options contains a description of available options and locations of incorporated information for those options.

Section 7—Replaceable Electrical Parts contains information necessary to order replaceable parts and assemblies related to the electrical functions of the instrument.

Section 8—Diagrams and Circuit Board Illustrations includes detailed circuit schematics, locations of assembled boards within the instrument, voltage and waveform information, circuit board component locators, and locations of adjustments to aid in performing the Adjustment and Performance Check portions of the Calibration procedure.

Section 9—Replaceable Mechanical Parts includes information necessary to order replaceable mechanical parts and shows exploded drawings which identify assemblies.

## INSTALLATION

### INITIAL INSPECTION

#### WARNING

*Dangerous voltages exist inside the instrument. To avoid electrical-shock hazards, operating personnel must not remove protective instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.*

This instrument was inspected both mechanically and electrically before shipment from the factory and it should be free of marks or scratches and should meet or exceed all electrical specifications. To confirm this, inspect the instrument for physical damage incurred in transit. Test the electrical performance by following the Operators Checkout Procedure in section 2 and then refer qualified service personnel to the Performance Check Procedure in this Instruction Manual. If there is damage or deficiency, contact your local Tektronix Field Office or representative.

### OPERATING INFORMATION

#### CAUTION

*To prevent instrument damage, plug-in units should not be installed or removed without first turning off the mainframe power.*

The 7A29 is calibrated and ready for use as received. It can be installed in any compartment of Tektronix 7000-series oscilloscopes, but is intended principally for use in vertical plug-in compartments. To install, align the upper and lower rails of the 7A29 with the oscilloscope tracks and insert. The 7A29 front panel will be flush with the

## General Information—7A29

front of the oscilloscope and the latch at the bottom left corner of the 7A29 will be in place against the front panel when the 7A29 is fully installed.

To remove the 7A29, pull on the release latch (inscribed with the unit identification "7A29") and the 7A29 will unlatch. Continue pulling to slide the 7A29 out of the oscilloscope.

### OPERATING TEMPERATURE

The 7A29 can be operated where the ambient air temperature is between 0° and +50° C and can be stored in ambient temperatures from -55° to +75° C. After storage at temperatures outside the operating limits, allow the chassis temperature to reach a safe operating temperature before applying power.

### PACKAGING FOR SHIPMENT

If this instrument is to be shipped for long distances by commercial transportation, we recommend that the instrument be packaged in the original manner. The carton and packaging material in which your instrument was shipped should be saved for this purpose.

If this instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the following: Owner of the instrument (with address), the name of the person at your firm who can be contacted, complete instrument type and serial number, and a description of the service required.

If the original packaging is unfit for use or not available, package the instrument as follows:

1. Obtain a corrugated cardboard carton with at least a 200-pound test strength and dimensions at least six inches larger than the instrument's dimensions.
2. Surround the instrument with polyethylene sheeting, or equivalent, to protect the instrument.
3. Allow a 3-inch cushion on all sides by tightly packing dunnage or urethane foam between the carton and the instrument.
4. Seal the carton with shipping tape or with an industrial stapler.
5. Mark the address of the Tektronix Service Center and your return address in one or more prominent locations on the exterior of the shipping carton.

## SPECIFICATIONS

The electrical characteristics listed in Table 1-1 apply when the following conditions are met: (1) Adjustment of the instrument must have taken place at an ambient temperature between +20° C and +30° C, (2) the instrument must be allowed a 30-minute warm-up period, and (3) all specifications are valid at an ambient temperature of 0° to +50° C, unless otherwise stated.

**TABLE 1-1**  
**Electrical Characteristics**

Characteristics	Performance Requirement
Deflection Factor	
Calibrated Range	From 10 mV/div to 1 V/div in 7 switch positions using a 1-2-5 switching sequence.
Attenuator Accuracy	All deflection factors within 2% with gain adjusted at 0.1 VOLTS/DIV when driven from a 50 Ω source.
VARIABLE (VOLTS/DIV) Range	At least 2.5:1. See Figure 1-1 for effect on bandwidth.
GAIN Range	Adjustable to at least 3% from nominal at 0.1 V/div.

**TABLE 1-1 (CONT.)**  
**Electrical Characteristics**

Characteristic	Performance Requirement
Frequency Response (10 mV/DIV to 1 V/DIV) High Frequency, AC or DC Coupled	When operated in the vertical compartment of the following oscilloscope series: 7100, 1 GHz (0° to 35° C); 7900, 500 MHz (0° to 30° C); 7800, 400 MHz (0° to 35° C); 7700, 175 MHz; 7600, 100 MHz; 7300, 25 MHz.  <b>NOTE</b>  <i>Use of the VARIABLE (Volts/Div) control affects frequency response. See Figure 1-1.</i>
Low Frequency, AC Coupled	1 kHz or less from a 50 Ω source; 200 Hz or less with a 10X 50 Ω probe.
Maximum Input DC Coupled	10 V rms or 1-watt-second pulses not exceeding 50 V peak. See Figure 1-2, and Detailed Operating Information, section 2.
AC Coupled	100 V additional dc component. Derate linearly to 0 V additional at 60 Hz.  <b>CAUTION</b>  <i>Signals of more than 50 V peak amplitude must be connected with input switch in OFF position so that input coupling capacitor is precharged.</i>
Input Protection Disconnect Threshold	+10 V dc within 2 V dc, -10 V dc within 2 V dc, or approximately 10 V rms up to 100 MHz.
Input Protection Disconnect Time	Less than 30 ms for 50 V dc of either polarity; 40 ms to 150 ms for 25 V dc of either polarity.
Input Impedance Resistance	Dc coupled: 50 Ω within 1 Ω. Ac coupled: 50 Ω within 1 Ω in series with at least 1.6 μF.
Reflection Coefficient	0.05 or less in a 1 GHz ±20% time domain reflectometer system.
VSWR (Except Option 4) DC Coupled	1.4:1 at 10 mVOLTS/DIV. 1.20:1 from 20 mVOLTS/DIV to 1 VOLTS/DIV; dc to 1 GHz.
AC Coupled	1.4:1 at 10 mVOLTS/DIV. 1.20:1 from 20 mVOLTS/DIV to 1 VOLTS/DIV; 1 MHz to 1 GHz.
VSWR (Option 4) DC Coupled	1.5:1 dc to 800 MHz.
AC Coupled	1.5:1, 1 MHz to 800 MHz.
Input Offset Current	50 μA or less.
VARIABLE (VOLTS/DIV) Balance	0.2 div maximum trace shift.

**TABLE 1-1 (CONT.)**  
**Electrical Characteristics**

Characteristic	Performance Requirement
POLARITY Balance	0.5 div maximum trace shift.
IDENTIFY	Deflects trace upward 0.2 to 0.4 div.
POSITION Range	9 div each direction from graticule center within 1.0 div.
DC Drift	
Drift With Ambient Temperature (Line Voltage Constant)	0.04 div/°C or less.
Delay Range (Option 4 only)	At least 1 ns.

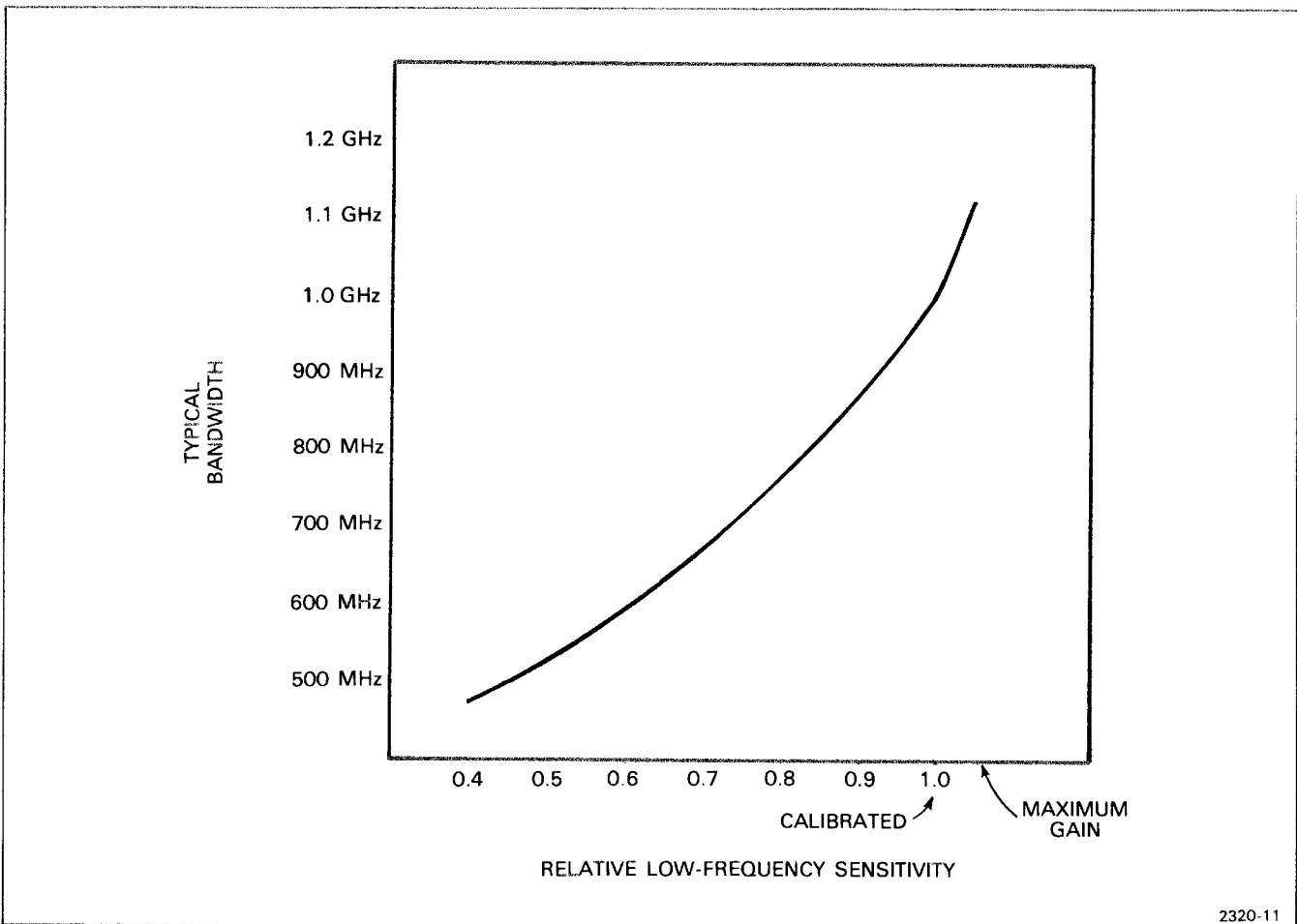


Figure 1-1. VARIABLE (Volts/Div) control effect on bandwidth.



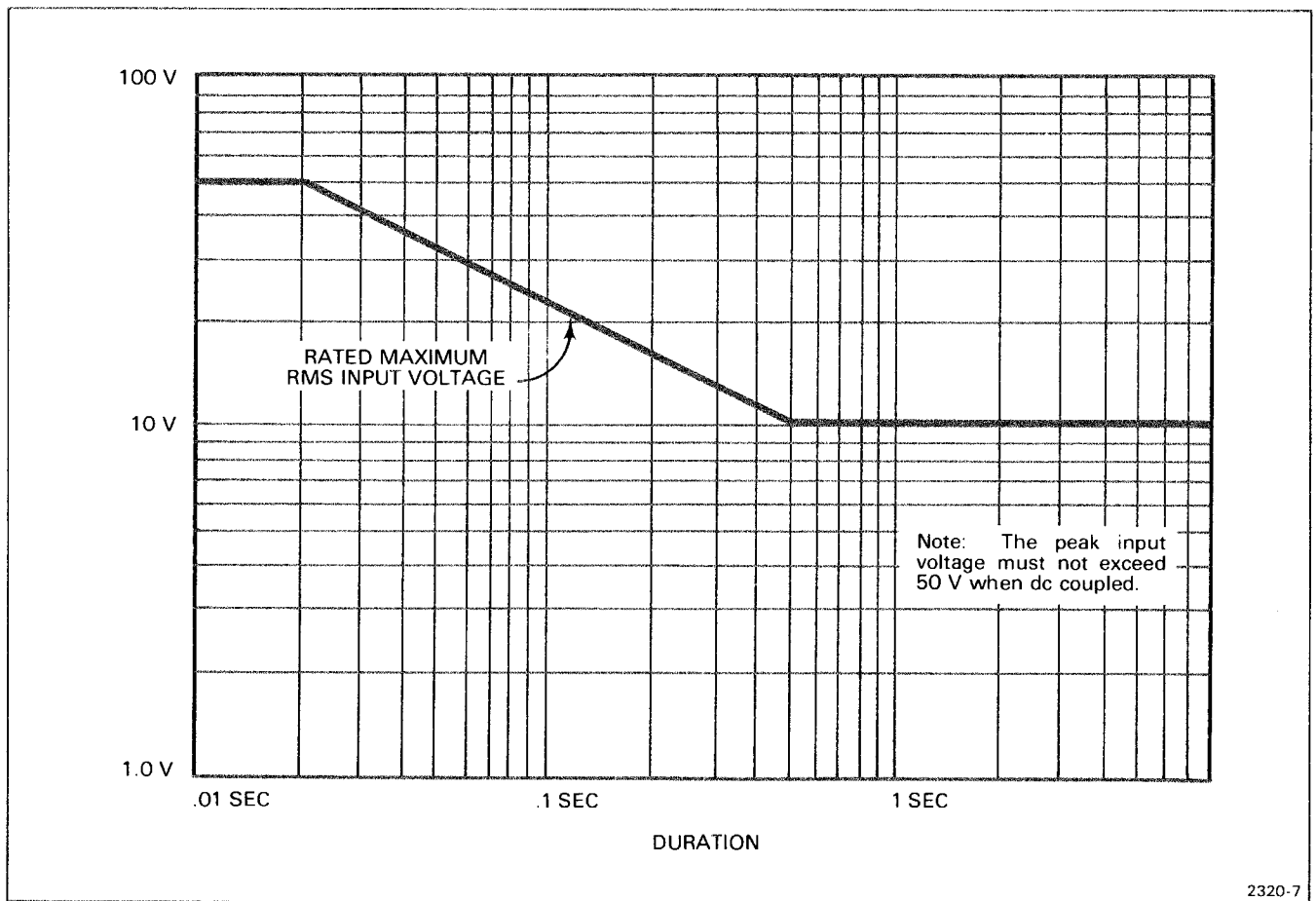


Figure 1-2. Maximum rms input voltage.

TABLE 1-2  
Environmental Characteristics

Characteristic	Performance Requirement
Temperature	
Calibration	+20° to +30°C (+68° to +86° F).
Operating	0° to 50° C (+32° to +122° F).
Storage	-55° to +75° C (-67° to +167° F).
Altitude	
Operating	To 15,000 feet.
Storage	To 50,000 feet.
Transportation	Qualified under National Safe Transit Committee Test Procedure 1A, Category II.

**TABLE 1-3  
Physical Characteristics**

Characteristic	Performance Requirement
Overall Dimensions	Compatible with all 7000-series plug-in compartments; see Figure 1-3, for dimensional drawing.
Net Weight Standard Instrument	Approximately 2 lbs. 8 oz. (1.14 kg).
Option 4 Instrument	Approximately 3 lbs. 4 oz. (1.48 kg).

## STANDARD ACCESSORIES

1 ea ..... Instruction Manual

### RECOMMENDED ACCESSORIES

The following accessories have been selected from our catalog specifically for your instrument. They are listed as a convenience to help you meet your measurement needs. For detailed information and prices, refer to a Tektronix Products Catalog or contact your local Tektronix Field Representative.

#### P6057

The P6057 is a passive 100X attenuating probe with a bandwidth of dc to 1.4 gigahertz and a 5 kilohm input resistance for use with 50 ohm inputs.

### PROBES

#### P6201

#### P6056

The P6056 is a passive 10X attenuating probe with a bandwidth of dc to 3.5 gigahertz, and a 500 ohm input resistance for use with 50 ohm inputs.

The P6201 is an active (FET) nonattenuating probe with a bandwidth from dc to 900 megahertz, an input impedance of 100 kilohms and 3 picofarads (1 megohm and 1.5 picofarads with 10X and 100X attenuating heads).

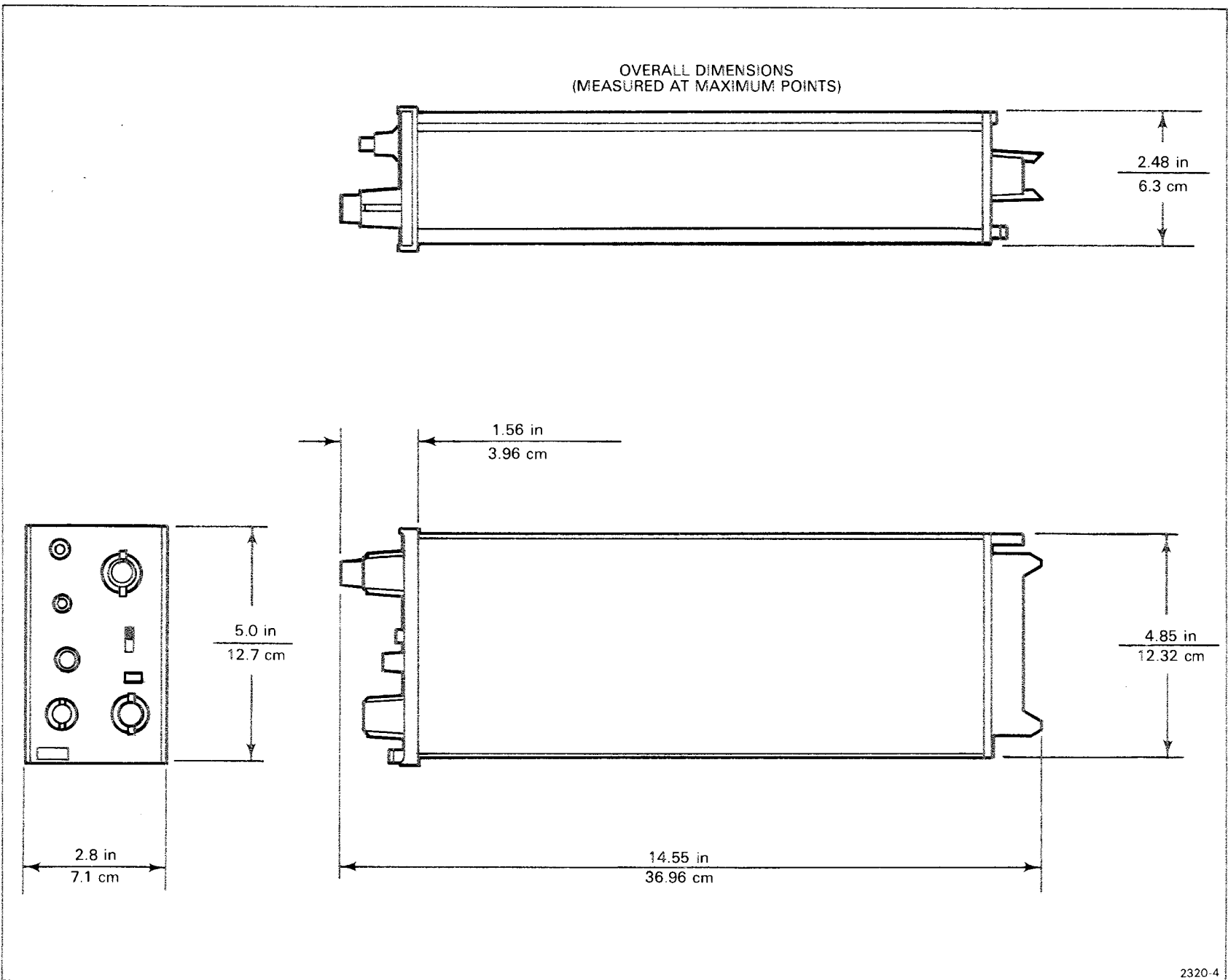


Figure 1-3. 7A29 dimensional drawing.

# OPERATING INSTRUCTIONS

To use the 7A29 effectively, 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.

## CONTROLS AND CONNECTORS



*Before applying any signal in excess of 10 volts to the 7A29, refer to Detailed Operating Information given later in this section of the manual.*

The 7A29 front panel is shown in Figure 2-1. A brief, functional description of each control and connector is included in the illustration. Refer to Detailed Operating Information for additional information.

## CHECKOUT PROCEDURE

The following procedure can be used for incoming inspection to verify proper operation, and may also be used by the operator for instrument familiarization. Only instrument functions (not measurement quantities or specifications) are checked in the procedure; therefore, a minimum amount of test equipment is required. If performing the Checkout Procedure reveals improper performance or instrument malfunction, first check the operation of associated equipment; then refer to qualified service personnel for repair or adjustment of the instrument.

### NOTE

*Refer qualified service personnel to the Calibration section of this manual for the procedure to check the Option 4 VARIABLE DELAY control.*

## BEFORE YOU BEGIN:

Refer to the Change Information at the rear of this manual for any modifications which may affect this procedure.

## TEST EQUIPMENT REQUIRED

The following test equipment was used in preparing the Operators Checkout Procedure. Other test equipment which meets these requirements may be substituted. When other equipment is substituted, the control settings or setup may need to be altered.

1. 7000-series oscilloscope mainframe (e.g. 7104, 7904, or 7704A).
2. 7B-series time-base unit (e.g. 7B10, 7B15, 7B80, or 7B85).
3. One bnc cable: 50-ohm coaxial, Tektronix Part 012-0057-01.

## SETUP PROCEDURE

1. With the 7000-series oscilloscope power switch in the off position, connect the oscilloscope to a suitable power source.
2. Install the 7A29 in the left vertical compartment.
3. Install the 7B-series time-base unit in the B horizontal compartment.
4. Set the front-panel controls as follows:

### 7A29 AMPLIFIER:

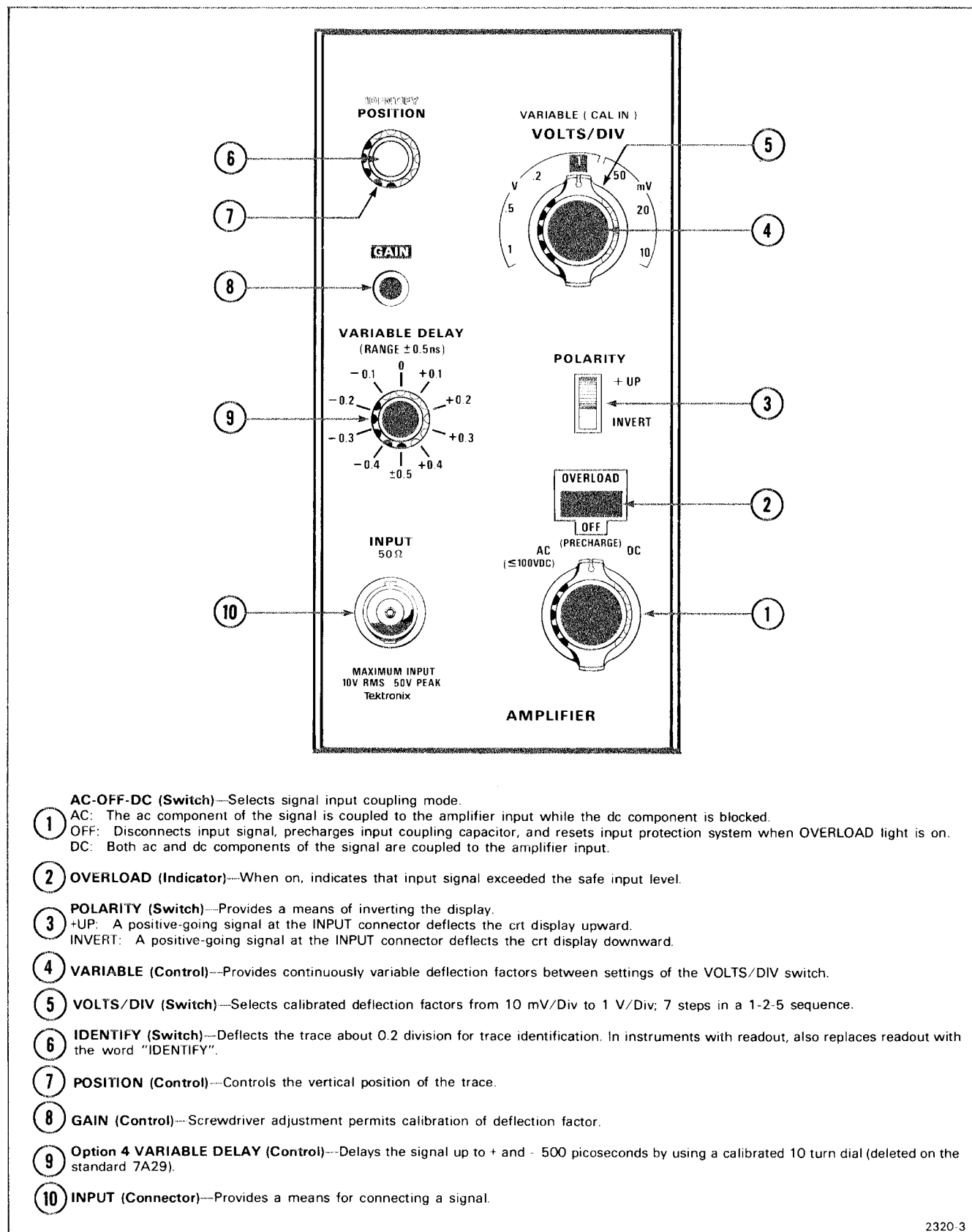
VOLTS/DIV .....	0.1 V
VARIABLE (Volts/Div) .....	CAL IN
POSITION .....	Midrange
POLARITY .....	+UP
AC-OFF-DC .....	OFF

### Time-Base Unit:

Time/Div .....	1 ms
Position .....	Midrange
Magnifier .....	X1
Triggering	
Mode .....	Auto
External Trigger In .....	In
Coupling .....	AC
Source .....	Internal

### Oscilloscope:

Vertical Mode .....	Left
Horizontal Mode .....	B
B Trigger Source .....	Vert Mode
Calibrator .....	4 V
A and B Intensity .....	Counterclockwise



**AC-OFF-DC (Switch)**—Selects signal input coupling mode.

- ① AC: The ac component of the signal is coupled to the amplifier input while the dc component is blocked.
- OFF: Disconnects input signal, precharges input coupling capacitor, and resets input protection system when OVERLOAD light is on.
- DC: Both ac and dc components of the signal are coupled to the amplifier input.

② **OVERLOAD (Indicator)**—When on, indicates that input signal exceeded the safe input level.

- ③ **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.

④ **VARIABLE (Control)**—Provides continuously variable deflection factors between settings of the VOLTS/DIV switch.

⑤ **VOLTS/DIV (Switch)**—Selects calibrated deflection factors from 10 mV/Div to 1 V/Div; 7 steps in a 1-2-5 sequence.

⑥ **IDENTIFY (Switch)**—Deflects the trace about 0.2 division for trace identification. In instruments with readout, also replaces readout with the word "IDENTIFY".

⑦ **POSITION (Control)**—Controls the vertical position of the trace.

⑧ **GAIN (Control)**—Screwdriver adjustment permits calibration of deflection factor.

⑨ **Option 4 VARIABLE DELAY (Control)**—Delays the signal up to + and - 500 picoseconds by using a calibrated 10 turn dial (deleted on the standard 7A29).

⑩ **INPUT (Connector)**—Provides a means for connecting a signal.

2320-3

Figure 2-1. Front-panel controls, connectors and indicators.

5. Set the oscilloscope's power switch on and allow at least 20 minutes warmup.

**AMPLIFIER FUNCTIONS**

1. Connect a bnc cable from the oscilloscope's calibrator output connector to the 7A29 INPUT connector.

2. Rotate the B intensity control clockwise until the trace is just visible.

3. Set the 7A29 AC-OFF-DC switch to DC.

4. With the POSITION control, align the display with the center 4 divisions of the graticule area. Adjust the GAIN (screwdriver adjustment) for 4 divisions of display.

5. With the POSITION control, align the bottom of the displayed signal with the center horizontal graticule line.

6. Set the AC-OFF-DC switch to AC. Notice that the displayed signal shifts downward approximately 2 divisions, and that the tops of the waveforms are tilted.

7. Set the AC-OFF-DC switch to DC. With the POSITION control, align the trace with the center and top-most graticule lines.

8. Set the POLARITY switch to the INVERT position. Notice that the displayed signal is now inverted, being roughly aligned with the center and bottom graticule lines.

9. Set the POLARITY switch to the +UP position.

10. Rotate the POSITION control fully counterclockwise and notice that the displayed signal can be positioned off the graticule area at the bottom of the crt.

11. Set the POLARITY switch to INVERT.

12. Rotate the POSITION control fully clockwise, and notice that the displayed signal can be positioned off the graticule area at the top of the crt.

13. Return the POLARITY switch to the +UP position. Position the display to the center 4 divisions of the graticule area.

14. Press to release the VARIABLE (Volts/Div) control. Rotate the VARIABLE (Volts/Div) control fully counterclockwise and notice approximately 1.6 divisions of displayed signal. Rotate the VARIABLE (Volts/Div) control fully clockwise and notice at least 4 divisions of displayed signal.

15. Press the VARIABLE (Volts/Div) control in.

16. Set the AC-OFF-DC switch to the OFF position and notice that no signal is displayed on the crt.

17. Press the IDENTIFY button. Notice that the displayed trace is deflected upward approximately 0.25 division and, in oscilloscope mainframes equipped with readout, notice that the 7A29 readout display is replaced with the word "IDENTIFY".

18. Rotate the VOLTS/DIV control through each position and note that the 7A29 readout display corresponds with the front-panel nomenclature. Change the POLARITY switch to INVERT. Rotate the VOLTS/DIV control through each position. Again note that the 7A29 readout display corresponds with the front-panel nomenclature. Note additionally that a downward-pointing arrow appears within the readout display.

19. Press and release the VARIABLE (Volts/Div) control. Note that a ">" symbol appears in the readout display between the downward pointing arrow and the deflection factor information.

20. Change the POLARITY switch to +UP. Note the disappearance of the "I" symbol. Press and latch the VARIABLE (Volts/Div) control. Note the disappearance of the ">" symbol.

21. Disconnect the bnc cable from the INPUT connector of the 7A29.

22. Connect a 10X readout-encoded probe to the INPUT connector and note the corresponding change in the deflection factor of the displayed readout. Repeat with 100X probe.

**NOTE**

*Readout encoding is accomplished by connecting a resistance from the outer ring of the 7A29 INPUT connector to ground. The following gives the resistance value necessary to simulate a probe, and may be used in place of an actual probe.*

<u>Function</u>	<u>Resistance</u>
X1 .....	Open circuit
X10 .....	11 KΩ, within 5%
X100 .....	6.2 kΩ, within 5%
IDENTIFY .....	∅ ohms

23. This completes the Operators Checkout Procedure.

## DETAILED OPERATING INFORMATION

### PROBES

Probes recommended for use with the 7A29 are the P6056 (10X) or P6057 (100X). Both probes are compatible with 50-ohm systems, and will allow good frequency response. These probes also contain trace IDENTIFY and readout encoding functions.

If the P6201 Probe is used, a one-megohm input impedance may be achieved (with some loss in bandwidth). Consult your local Tektronix Field Engineer or Representative for further information.

### VERTICAL GAIN CHECK AND ADJUSTMENT

To check the gain of the 7A29, set the VOLTS/DIV switch to 0.1 V and connect a 0.4 V, 1 kHz signal from the oscilloscope mainframe calibrator to the 7A29 INPUT connector.

#### NOTE

*Oscilloscope calibrators typically have an output impedance of either 50  $\Omega$  or 450  $\Omega$ . The 50-ohm input impedance of the 7A29 forms a voltage divider with the calibrator output impedance, reducing the voltage to the 7A29 by a precise factor of 2 (for 50-ohm calibrators) or 10 (for 450-ohm Calibrators). Thus the 4 V calibrator output of the 7104 and 7904 must be selected for an output voltage of 0.4 volts.*

The vertical deflection should be exactly four divisions. If not, adjust the front-panel GAIN adjustment for exactly four vertical divisions.

### INPUT COUPLING

The AC-OFF-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 signals with frequencies below about 1 kHz the DC coupling position is necessary to avoid signal attenuation.

In the AC coupling position the dc component of the signal is blocked by a 2 microfarad 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.

In the OFF position of the input coupling switch, the signal path of the amplifier is interrupted so that there is no displayed signal. However, a signal connected to the INPUT connector will be loaded by approximately 390 kilohms dc, or by 195 kilohms ac. At extremely high frequencies a small portion of the input signal will still be displayed. For example, the signal attenuation in the OFF position is about 32 dB at 1 gigahertz.

The OVERLOAD protection feature of the 7A29 activates when a signal capable of causing damage (to 7A29 internal circuitry) is applied to the INPUT connector. To reset the 7A29, turn the AC-OFF-DC switch to the OFF position and remove the cause of overloading. The 7A29 is then ready for normal operation.

The 7A29 is capable of withstanding short term overloads in excess of its continuous rating of 10 V rms. Thus, it is possible to apply 50 V peak (the same as 50 V rms for a single pulse) for 20 ms, or a 20 V rms signal for 125 ms. The 7A29 integrates the rms input power and disconnects the signal before damage can occur.

Generally speaking, the 7A29 will protect itself from excessive (damaging) signals; however, there are exceptions. Continuous wave or pulsed radio frequency signals above 100 MHz are not sensed by the input protection circuitry and may cause damage to the input attenuator if in excess of the 10 V rms, 50 V peak, rating.

The relay contacts which disconnect the 7A29 from excessive voltages may themselves be damaged by arcing. If the contacts open with a signal greater than 50 V applied to the INPUT, the contacts may be permanently damaged.

The ac coupling capacitor used in the AC position of the AC-OFF-DC switch is rated at 100 V dc. Since the input protection circuitry is located after the ac coupling capacitor, application of up to 100 V dc to the INPUT is possible in the AC coupled mode. However, in order to avoid a fast-rise pulse being sent to the 7A29 from a signal in excess of 50 V dc, turn the AC-OFF-DC switch to OFF before connecting such a signal to the 7A29 INPUT. In the OFF position, the ac coupling capacitor is safely precharged to the average dc voltage.

Figure 1-2 in section 1 shows the maximum rms amplitude which may safely be applied to the 7A29 INPUT. Figure 1-2 also corresponds approximately to the rms voltage the 7A29 will accept without automatically disconnecting itself. A complex pulse, whose rms value is equal to the amount shown in Figure 1-2, is safe if it is also less than 50 V peak.

For example, a 30 V rms sinusoid may be applied for up to 55 ms, but a 36 V rms sinusoid may not be applied because the peak voltage exceeds 50 V. The 7A29 INPUT may be connected to a 50 V power supply for up to 20 ms because the rms and peak values of the resulting pulse are both 50 V.

### VOLTS/DIV SWITCH

The amount of deflection produced by a signal is determined by the signal amplitude, the attenuation factor of the probe, and the setting of the VOLTS/DIV switch. Calibrated deflection factors represented by the VOLTS/DIV switch apply only: (1) When the probe attenuation is X1 or when the input signal is appreciably above 1 kHz with AC coupling (the dc blocking capacitor attenuates signals below 1 kHz), and (2) when the VARIABLE (Volts/Div) control is in the CAL IN position.

### POLARITY SWITCH

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

### TRACE IDENTIFICATION AND READOUT FUNCTIONS

When the IDENTIFY button is pressed, the trace is deflected upward about 0.25 division to identify the 7A29 trace. This feature is particularly useful when multiple traces are displayed on the crt. In oscilloscope mainframes with readout, the IDENTIFY button also replaces the 7A29's deflection factor readout display with the word "IDENTIFY". The 7A29 is equipped with probe encoding circuitry that, when used with a coded probe, corrects the deflection factor readout.

### VARIABLE DELAY (OPTION 4)

The option VARIABLE DELAY line provides a means for delaying the signal applied to the INPUT connector up to  $\pm 500$  picoseconds relative to another 7A29, a 7A19, or 7A19 Option 4. When the Option 4 instrument is used with a standard 7A29 (which has a fixed delay) the

VARIABLE DELAY control can be used to match the signal delay time of both units.

### MATCHING DELAY TIMES USING TWO 7A29 UNITS, ONE HAVING VARIABLE DELAY (OPTION 4)

In some applications it is necessary to view the time relationship of two signals, one with respect to the other. With high speed signals, the delay times of the probes and amplifiers can distort the true time relationship of the two signals. By using the VARIABLE DELAY (Option 4), the delay times between the two units can be matched to within a few picoseconds, thus giving a true time relationship of the signals being viewed.

For matching delay times of two 7A29 units with probes, proceed as follows:

1. Install the standard 7A29 in the left vertical plug-in compartment of the oscilloscope.
2. Install the 7A29 Option 4 in the right vertical plug-in compartment.
3. Connect both 7A29 INPUT connectors to one of the signal sources and adjust the time-base unit for the fastest convenient sweep available.
4. Set the oscilloscope's trigger source switch to Left Vert, and vertical mode switch to Alternate.
5. Set both 7A29 units to the same deflection factor settings.
6. Center both displays vertically.
7. Adjust the front-panel VARIABLE DELAY knob so that the two displays are superimposed. The delay times of both units and the associated cables (or probes) are now matched.



Table 2-1 (cont)

Characteristics	Performance Requirement	Supplemental Information
External Trigger Input Input R and C		Approximately 1 MΩ paralleled by 20 pF.
Maximum Safe Input Voltage		500 V (dc + Peak ac). 500 V peak-to-peak ac at 1 kHz or less.
Level Range EXT	At least + and - 1.5 V.	
EXT ÷ 10	At least + and - 15 V.	
Internal Trigger Jitter	1 ns or less at 75 MHz.	

DELAYED TRIGGERING

Trigger Sensitivity	Triggering Frequency Range	Minimum Trigger Signal Required	
		INT <sup>a</sup> (div)	EXT (mV)
COUPLING			
AC	30 Hz to 10 MHz	0.3	100
	10 MHz to 100 MHz	1.5	500
DC	dc to 10 MHz	0.3	100
	10 MHz to 100 MHz	1.5	500
External Trigger Input Maximum Safe Input Voltage	(DLY'D TRIG source set to EXT)	500 V (dc + peak ac). 500 V peak-to-peak ac at 1 kHz or less.	
Input R and C		1 MΩ paralleled by 20 pF.	
Level Range	At least + and - 1.5 V.		
Internal Trigger Jitter	1 ns or less at 75 MHz.		

## **WARNING**

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

# THEORY OF OPERATION

This section of the manual describes the circuitry used in the 7A29 Amplifier. The description begins with a discussion of the instrument using the block diagram shown in Figure 3-1, and then continues in detail, showing the relationships between the stages in each major circuit. Schematics of all major circuits are given in Section 8, Diagrams and Circuit Board Illustrations. Refer to these schematics throughout the following discussions for specific electrical values and relationships.

## BLOCK DIAGRAM

The following discussion is provided to aid in understanding the overall concept of the 7A29 before the individual circuits are discussed in detail. A basic block diagram is shown in Figure 3-1. Each block represents a major circuit in the instrument. Only the basic interconnections between the blocks are shown on the block diagram.

Signals to be displayed on the crt are applied to the 7A29 input connector and pass through the Delay Line to the AC-OFF-DC Switch. (The fixed delay line standardizes the signal transit time of the 7A29). The 7A29 can be ordered with variable delay line (Option 4), which allows up to 1 nanosecond variation in the signal transit time (360° phase shift at 1 GHz).

When the front-panel AC-OFF-DC switch is set to the AC or DC position, the signal is coupled to the Input Attenuator. When the front-panel AC-OFF-DC switch is set to the OFF position the signal path is opened by a relay. If the input signal is sufficient to overload the instrument, the Input Protection circuitry will open the same relay to prevent damage to the Input Attenuator.

The front-panel VOLTS/DIV switch selects the appropriate attenuator to display the signal on the crt. The 2X, 5X, and 10X divider networks are selected in the appropriate sequence to provide 2X, 5X, 10X, 20X, 50X, and 100X signal attenuation.

The Fast Overload Protection circuit protects the Input Amplifier from large signals until the relay associated with the AC-OFF-DC switch can disconnect the input signal.

The front-panel GAIN, POLARITY, and VARIABLE (Volts/Div) controls determine the signal amplification within the Input Amplifier. The Input Amplifier converts the single-ended input signal to a push-pull signal. The Output Amplifier further amplifies the signal and provides a portion of the signal to the Trigger Amplifier. The Trigger Amplifier supplies the oscilloscope mainframe with trigger information of the correct amplitude.

## DETAILED CIRCUIT OPERATION

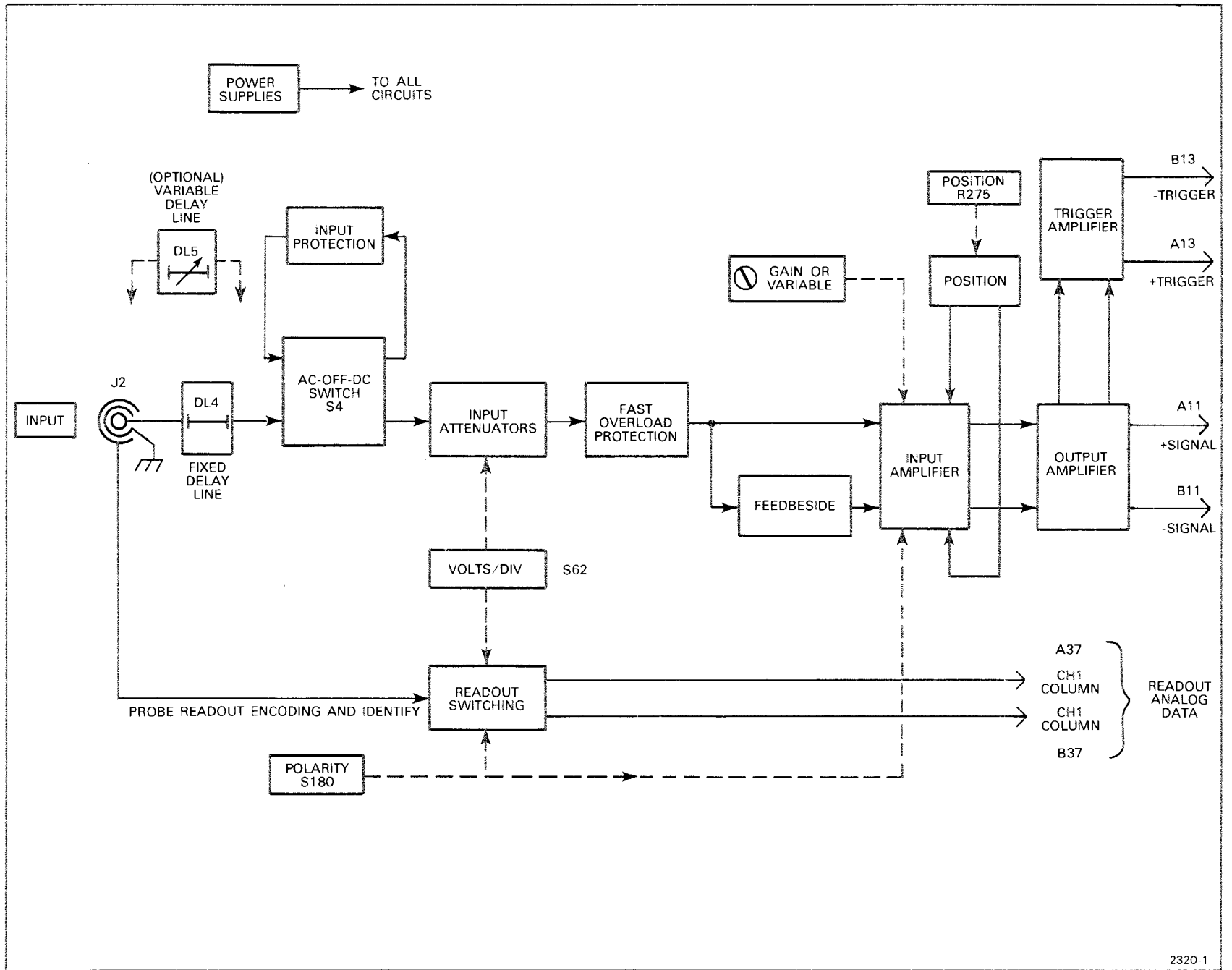
This portion of the Theory of Operation section provides a detailed description of the electrical operation and relationship of circuits unique to this instrument. Circuits commonly used in the electronics industry are not described in detail. If more information is desired on these commonly-used circuits, refer to the following textbooks:

Deboo, Gordon V., *Integrated Circuits and Semiconductor Devices*, McGraw-Hill, New York, 1971.

Malvino, Albert Paul, *Transistor Circuit Approximations*, McGraw-Hill, New York, 1973.

Milman, Jacob and Herbert Taub, *Pulse, Digital and Switching Waveforms*, McGraw-Hill, New York, 1965.

Figure 3-1. Basic block diagram of the 7A29 Amplifier.







## INPUT SWITCHING AND READOUT

A schematic diagram of the Input Switching and Readout circuitry is given on diagram 1 in Section 8, Diagrams and Circuit Board Illustrations. The schematic is divided by gray shaded lines separating the circuitry into major stages. These stages aid in locating components mentioned here. Sub-headings in the following discussion use the stage names to further identify portions of the circuitry on diagram 1.

### DELAY LINE

Unless variable delay (Option 4) is requested, all 7A29 instruments are equipped with a fixed Delay Line which consists of a precision length of 50  $\Omega$  semi-rigid coaxial cable. The fixed Delay Line DL4 is in series with the signal path so that the 7A29 delay time matches the nominal delay of the 7A29 Option 4, the 7A19, and the 7A19 Option 4. (The optional variable Delay Line DL5, when requested at the time of ordering, replaces the fixed Delay Line.)

### AC-OFF-DC

Each position of the AC-OFF-DC switch affects the manner in which applied signals are coupled from J4 to J14. In the DC position, the signal is coupled without attenuation. However, in the AC position, dc and low frequency signals are attenuated by coupling capacitor C5, while high frequencies are passed without attenuation. In the OFF position, KS14 opens the signal path so that none of the input signal reaches J14. Resistors R5 and R6 charge or discharge coupling capacitor C5. Without this precharge feature, the 7A29 and the circuit under test might both be subjected to a large voltage transient upon switching from OFF to AC.

### INPUT ATTENUATORS

Three matched attenuators are selected in an appropriate sequence by the VOLTS/DIV switch, S62, to set the 7A29 deflection factor. Use of matched attenuator sections maintains the input resistance at 50  $\Omega$ , independent of the deflection factor selected. The attenuator is protected against input signals that exceed 2 watts dissipation by relay K14 (see the discussion under Input Protection in this section of the manual).

### NOTE

*Between switch positions the 7A29 input resistance is very high. If the circuit under test has a very high source impedance, voltage at the 7A29 input may become very large between switch positions. This may be interpreted by the 7A29 as an overload condition and cause the Input Protection circuit to disconnect the 7A29 from the load.*

### INPUT PROTECTION

The 7A29 utilizes two input protection circuits to prevent damage to the instrument from most common overloads. First, U100 protects the Input Amplifier (diagram 2) from high-frequency transients (see Fast Overload Protection under Input Amplifier in this section). Second, relay K14, a latching relay whose contacts are designated KS14, is activated by U26, Q24, and Q34. Relay K14 has two purposes: (1) to disconnect the Input Attenuator and subsequent circuitry when the front-panel AC-OFF-DC switch is in the OFF position and, (2) to disconnect the Input Attenuator and subsequent circuitry when a signal capable of damaging the Input Attenuator or U100 is applied to the front-panel INPUT connector, J2.

The input signal is sampled and attenuated by R12 and R22. Integrated circuit U26 performs an approximate rms conversion on the input signal for frequencies up to about 100 megahertz. Capacitor C28 at pin 1 of U26 is used to integrate the rms signal. When the voltage across C28 exceeds 2 volts, pin 12 of U26 latches high causing Q34 to conduct and K14 to open contacts KS14. At this time the red RESET lamp, DS18, lights. Integrated circuit U26 remains in this state until reset, which is accomplished by connecting pin 13 to ground with the AC-OFF-DC switch. This occurs in the OFF mode.

An attenuator or resistor network will safely dissipate more than its continuous rating for a short period of time due to its thermal mass. By integrating the rms input voltage, U26 and C28 allow short term input of up to 50 watts (50 volts), an amount safely handled by the 7A29. Above 50 volts the risk of permanent damage to relay contacts KS14 becomes significant.

Radio frequencies (cw) above 100 megahertz and greater than 2 watts (10 V rms) can cause damage since the sensitivity of U26 is reduced above 100 megahertz. (For overload parameters, refer to the Specifications, section 1, in this manual under Input Protection.)

### POWER SUPPLIES

Components U36 and Q32 are connected as a -5 volt regulating supply. The resistive divider network, consisting of R37 and R36, applies a negative 5 volts to pin 3 of U36. The supply output voltage on the emitter of Q32 is fed back to pin 2 of U36 where it is compared with, and adjusted to, the voltage on pin 3. The remaining supplies (+15, -15, +50, -50, and +5 volts) are applied to the 7A29 through the rear-edge connector from the oscilloscope mainframe in which the 7A29 is installed.

### READOUT SWITCHING

The 7A29 Readout Switching network is an integral part of the 7000-series oscilloscope readout system. The readout system in 7000-series oscilloscope mainframes provides an alphanumeric display of information encoded by all plug-in units. This display is presented on the crt and is written by the crt beam on a time-shared basis with the analog waveform display.

## Theory of Operation—7A29

The readout system located in the oscilloscope mainframe produces a pulse train consisting of ten negative-going pulses called time-slots. Each pulse represents a possible character in a readout word, and is assigned a time-slot number corresponding to its position in the word. Each time-slot pulse is directed to one of ten output lines, labeled TS 1 through TS 10 (time slots one through ten), which are connected to the vertical and horizontal plug-in compartments. Two output lines, row and column, are connected from each channel (two channels per plug-in compartment) back to the readout system.

Data is encoded on these output lines either by connecting resistors between them and the time-slot input lines or by generating equivalent currents. The resulting output is a sequence of analog current levels on the row and column output lines. The row and column current levels are decoded by the oscilloscope mainframe readout system to address a character matrix during each time slot, thus selecting a character to be displayed or a special instruction to be followed.

The front-panel VOLTS/DIV switch (S62) selects the appropriate resistors to provide row and column current to the 7A29 rear-edge connector, on pins A37 and B37. An "IDENTIFY" function is provided as an aid to the instrument operator when multiple traces are being displayed on the crt. When pressed, the front-panel IDENTIFY switch (S50) connects the junction of R50, R52, and R53 to ground. This causes the readout system to display the word "IDENTIFY" on the crt. The 15 volt change at the junction of R50, R52, and R53 is attenuated by R50, R51, and R273 (on diagram 2) and applied to the Position control circuit causing the 7A29 trace position to move upward approximately 0.25 divisions.



### INPUT AMPLIFIER

A schematic diagram of the Input Amplifier circuitry is given on diagram 2 in Section 8, Diagrams and Circuit Board Illustrations. The schematic is superimposed with gray shaded lines separating major circuits. Sub-headings in the following discussion refer to each of the major circuits on diagram 2.

#### FAST OVERLOAD PROTECTION

This stage provides protection for the Input Amplifier. Without fast overload protection, fast-rise signals of high amplitude could damage U255 before the Input Protection circuitry, diagram 1, could respond and interrupt the input signal.

Under normal operating conditions, four diodes internal to U100 are forward biased. Signals applied to pin 8 pass through U100 to pin 18 with 15% attenuation. Bias resistors in U100 and the four diodes constitute a matched 50  $\Omega$  attenuator. The voltage supplied at pin 3 of U100 is closely regulated by U111 and Q114. The

current in Q124 is adjusted by R124 (Input I) to equal the current supplied to pin 3 of U100 by Q114. This maintains 0 volts at pins 8 and 18 of U100 in the absence of an input signal.

Variable resistor R107 (Z In) adjusts the voltage at pins 3 and 13 of U100 to set the current in U100. Because changing this current affects the dynamic impedance of the four diodes in U100 and because these diodes are in series with the signal, the impedance seen at pin 8 of U100, and hence at the 7A29 input may be varied over a limited range by R107. The sum of all the currents flowing into pin 8 of U100 is set to equal zero by R124.

Because the dynamic resistance of these diodes is a function of both temperature and current, it is possible to vary the current in pin 3 and pin 13 as a function of temperature to hold the diode dynamic resistance constant at all temperatures. Component RT108 senses the ambient temperature and adjusts the voltage at pin 3 of U100 to force the operation of U100 to be independent of temperature.

Signals in excess of about 1.0 volt cause one of the two left-hand diodes within U100 to cut off. The upper left diode goes into cutoff for positive signals, and the lower left diode goes into cutoff for negative signals. At most, current from one of the two 13.5 volt power supplies will flow to U255 through one of the two resistors in U100. This results in only about 0.9 volt being applied to the U255 input, which it can safely handle.

#### FEEDBESIDE

The function of feedbeside is to compensate for low-frequency imperfections in the frequency response of U255 and U322. Self-heating of the transistor base-emitter junction of some transistors within U255 and U322 causes the low frequency gain to appear slightly larger than the midband gain. To correct this, a portion of the input signal is picked off by R130, inverted and amplified by U132 which is connected as an operational amplifier, and distributed to four RC (resistive capacitive) networks. Each network has a different time constant. Components R152, R150, R148, R146, R144, R140, and C162 are adjusted to provide a correction signal. This signal is inverted again, amplified by U162, then injected into U255 through pin 12. This signal is subtracted from the signal entering U255 at pin 7. Proper adjustment results in flat frequency response and optimum transient response at the output (pins A11 and B11 on diagram 3). Diode network CR133, CR135, CR134, and CR136 limit the amplitude of the Feedbeside signal to improve overload recovery.

#### INPUT AMPLIFIER

The Input Amplifier stage provides gain and polarity control as well as amplification of the vertical signal. The single-ended input signal from the Fast Overload Protection stage is applied to pin 7 of U255, and the correction signal from the Feedbeside network is applied to pin 12.

The current flow through R238 and R239 dictates the proportion of signal current which flows in each pair of common base transistors within U255. The polarity of the input signal can be inverted within U255 by exchanging the current that flows through R238 with the current that flows through R239. This is done by analog switch U228A, B, C, and D, according to the front-panel POLARITY switch (S180) setting. In the +UP position of the POLARITY switch, a HI logic level is applied to pins 5 and 6 of U228. This connects pin 4 to pin 3 of U228B, and pin 9 to pin 8 of U228C. In this condition, Q226A supplies current to pin 13 of U255 through R239, and Q226B supplies current to pin 14 through R238. This same HI level is also applied to pin 6 of U178C connecting pin 8 to pin 9 and enabling the +UP Var Bal adjustment (R170). In this position of the POLARITY switch, transistor Q184 supplies a LO level to the remaining analog switches within U228 and U178. If the POLARITY switch is now changed to the INVERT position, a LO level is applied to pins 5 and 6 of U228 and pin 6 of U178 causing the switches of U228B-C and U178C to open. A HI level is also supplied by Q184 to close the switches of U228A-D and U178D. This results in the exchange of current through R238 and R239, reversing the polarity of the output signals from U255 and enabling the Inverted Var Bal adjustment (R175).

The gain of the Input Amplifier stage is controlled by either the front-panel GAIN control (R220) or the VARIABLE VOLTS/DIV control (R222). With the VARIABLE VOLTS/DIV control in the CAL IN position, the GAIN control determines the biasing current of U255.

The circuitry within U255 is basically a cascode amplifier utilizing a Gilbert multiplier. For ease of discussion, assume that the currents flowing through R238 and R239 are equal, forward-biasing Q3, Q4, Q5, and Q6 of U255 to equal conduction. Also assume the analog switches of U228 and U178 are in the positions shown on the schematic, and that the base of Q2 in U255 is held at a constant level (although in reality the feedbeside signal is injected here). Transistors Q1 and Q2 act as a phase splitter with the signal at the collector of Q2 in phase with the signal applied to the base of Q1, and the signal at the collector of Q1 out of phase with the signal applied to the base of Q1. Assuming that a positive-going signal is applied to pin 7 of U255, the emitters of Q3 and Q4 are pulled to a more negative voltage level, increasing their conduction. At the same time, the emitters of Q5 and Q6 rise to a more positive level through Q2, decreasing their conduction by an amount equal to the increase in Q3 and Q4. Since the transistor pairs Q4-Q5 and Q3-Q6 are cross-coupled to pins 17 and 19 respectively, and one transistor in each pair increases its conduction by an amount equal to the decrease in conduction of the other, there is no change in current at pins 17 and 19 of U255. This is the zero gain condition for this circuit. (In actual circuit operation this zero gain condition does not occur since the circuit is designed to operate between full gain and 36% of full gain.)

When the voltage at the base of Q266B goes more negative, due to an increase in the setting of either the GAIN or VARIABLE (Volts/Div) control, Q266A, Q266B,

and U234A increase the current flow through R238 and decrease that through R239. Integrated circuit U234A ensures that the total current through R238 and R239 does not vary.

The increased current in R238 causes Q3 and Q6 to conduct more, while Q4 and Q5 reduce conduction due to the decrease in current flowing through R239. The summation of currents at the collectors of transistors Q3 and Q5 results in a current at pin 19 of U255 that is out of phase with the input at pin 7. This is due to Q3 conducting more of the out-of-phase signal at its emitter than Q5 is conducting of the in-phase signal at its emitter. Similarly, Q6 conducts more of the in-phase signal at its emitter than Q4 conducts more of the out-of-phase signal at its emitter. The increased conduction of Q3 and Q6, together with the decreased conduction of Q4 and Q5, results in a finite gain for U255.

Zener diodes VR254 and VR256 shift the output level of U255 from +6 volts to the -6 volts needed by U322 on diagram 3. Optimum high-frequency response of the output signals is determined by LR240, LR241, LR261, and LR260. Trace drift due to temperature changes in VR254 and VR256 are eliminated by supplying operating current for them and U255 from current sources.

For further information on Gilbert multipliers refer to the following articles:

Addis, John. "Three Technologies on One Chip Make a Broadband Amplifier." *Electronics*, 5 June 1972, p. 103.

Gilbert, Barrie. "A New Wide-Band Amplifier Technique." *IEEE Journal of Solid State Circuits*, Vol. SC-3, No. 4, Dec. 1968, p. 353.

## POSITION

A constant current flow is maintained through Q248 by U246 and through Q268 by U266. Current in Q248 and Q268 is sensed by current-sampling resistors R248 and R268, respectively. The front-panel POSITION control, R275, injects position-signal current into U246 at pin 3 through R276. This alters the current flowing through Q248 and Q268 and positions the trace displayed on the crt. A small correction signal applied to U255 through R277 and U174 forces the VARIABLE (Volts/Div) to control the gain of U255 without affecting its dc balance. Without this correction, thermal effects in the four output transistors of U255 would cause a varying trace shift at different POSITION control settings when the VARIABLE (Volts/Div) control is rotated.



## TRIGGER AND OUTPUT AMPLIFIER

A schematic diagram of the Trigger and Output Amplifier circuitry is given on diagram 3, in Section 8, Diagrams and Circuit Board Illustrations.

The circuitry on this schematic is divided into two major circuits, Trigger Amplifier and Output Amplifier. The Output Amplifier stage provides final amplification of the vertical signal. The Trigger Amplifier stage provides final amplification of the + and - Trigger signals.

### OUTPUT AMPLIFIER

The differential signal from the Input Amplifier on diagram 2 is applied to the Output Amplifier. This signal is amplified by U322 and applied to the rear-panel edge connector pins A11 and B11 for use by the oscilloscope mainframe. Biasing for U322 is provided by U314. The average dc level at the input of U322 (pins 7 and 9) is available at pin 12 of U322 and is compared by U314 with the dc voltage level at the junction of R312 and R313 (-6.0 volts). Pin 8 of U322 is held at the voltage required to set the input of U322 at -6.0 volts.

In order to maintain the overall amplification of U255 and U322 at all temperatures, the dc standing current in U322 is varied from 32 milliamperes to 40 milliamperes over a temperature range of 0° to +50° C by RT317.

The voltage on pin 18 of U322 must vary from 0.775 volts at 0° C to 1.0 volt at 50° C to maintain the average voltage at pins A11 and B11 within 0.15 volt of ground. Thermistor RT345 senses the ambient temperature and, with the voltage regulator (consisting of U334B and Q342), sets the correct voltage at pin 18 of U322.

The dc voltage level at pin 14 of U322 and pin 13 of U352 is provided by the dc voltage regulator U334A. Integrated circuit U334A maintains a voltage on pin 14 of U322 equal to that developed by the resistor divider network of R333 and R334. Resistors R335 and R336 bias off transistors not used in U322 and U352.

### TRIGGER AMPLIFIER

A portion of the differential signal applied to U322 is routed to the Trigger Amplifier stage (from pins 2 and 4 of U322 to pins 7 and 9 of U352). This differential signal is amplified by U352 to become the + and - Trigger signals, and is applied to the rear-panel edge connector on pins A13 and B13. The TRIG BAL adjustment is set to balance the quiescent dc level between A13 and B13 in the absence of an output signal.



# MAINTENANCE

This section of the manual contains information for performing preventive maintenance, troubleshooting, and corrective maintenance for the 7A29 Amplifier.

## PREVENTIVE MAINTENANCE

Preventive maintenance, when performed on a regular basis, can prevent instrument breakdown and may improve the reliability of the instrument. The severity of the environment to which the instrument is subjected will determine the frequency of maintenance. A convenient time to perform preventive maintenance is just preceding electrical adjustment of the instrument.

### CLEANING

The 7A29 Amplifier should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket which prevents efficient heat dissipation, and also provides an electrical conduction path which may result in instrument failure.

#### CAUTION

*Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Use a non-residue type of cleaner, preferably isopropyl alcohol, totally denatured ethyl alcohol, or a fluorinated solvent (i.e. trifluorotrchloroethane) such as Freon TF or Spray-On #2002. Before using any other type of cleaner, consult your Tektronix Service Center.*

### INTERIOR

Cleaning the interior of the instrument should only be necessary occasionally. The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air (approximately 5 lb/in<sup>2</sup>). Remove any dirt which remains with a soft brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces, or for cleaning more delicate circuit components.

#### CAUTION

*The cleaning process, either hand cleaning with a solvent or machine cleaning in an automatic detergent wash, is not recommended for boards fitted with HYPCON connectors. Contaminants will degrade the conductivity of the contacts. See the information given for HYPCON connectors under Component Removal in Section 4, Maintenance.*

### EXTERIOR

#### WARNING

*To prevent damage from electrical arcing, circuit boards and components must be dry before applying power to the instrument.*

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

### VISUAL INSPECTION

The 7A29 Amplifier should be inspected occasionally for such defects as broken connections, improperly seated semiconductors, damaged or improperly installed circuit boards, and heat-damaged parts. The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged parts are found. Overheating usually indicates other trouble in the instrument; therefore, the cause of overheating must be corrected to prevent recurrence of the damage.

## PERIODIC ELECTRICAL ADJUSTMENT

To ensure accurate measurements, check the electrical adjustment of this instrument after each 1000 hours of operation, or every six months if used infrequently. In addition, replacement of components may necessitate adjustment of the affected circuits. Complete adjustment instructions are given in Section 5, Calibration. This procedure can be helpful in localizing certain troubles in the instrument, and in some cases, may correct them.

## SEMICONDUCTOR CHECKS

Periodic checks of semiconductors are not recommended. The best check of semiconductor performance is actual operation in the instrument. More details on semiconductors are given under Troubleshooting later in this section.

# TROUBLESHOOTING

The following information is provided to facilitate troubleshooting the 7A29 Amplifier. Information contained in other sections of this manual should be used in conjunction with the following data to aid in locating a defective component. An understanding of the circuit operation is helpful in locating troubles. See Section 3, Theory of Operation, for this information.

## TROUBLESHOOTING AIDS

### DIAGRAMS

Complete schematic diagrams are given on the foldout pages in Section 8, Diagrams and Circuit Board Illustrations. The component number and electrical value of each component in this instrument are shown on these diagrams. (See the first page of the Diagrams and Circuit Board Illustrations section for definitions of the reference designators and symbols used to identify components in this instrument.) Important voltages and numbered waveform test points are also shown on the diagrams. Important waveforms and the numbered test points where they were obtained are located adjacent to each diagram. Circuitry mounted on circuit boards is enclosed with heavy solid black lines. Each schematic diagram is divided into functional stage blocks, as indicated by the wide shaded lines. These functional blocks are described in detail in Section 3, Theory of Operation.

### CIRCUIT BOARD ILLUSTRATIONS

To aid in locating circuit boards, a circuit board location illustration appears on the back of the foldout page facing each schematic diagram. In addition, an illustration of the circuit board is included here, with the physical location of the components and waveform test points that appear on the schematic diagram identified. Each circuit board illustration is arranged in a grid locator with an index to facilitate rapid location of components contained in the schematic diagrams.

### TROUBLESHOOTING CHART

A troubleshooting chart is given in Section 8, Diagrams and Circuit Board Illustrations, to aid in locating a defective circuit. The shaded blocks of the Troubleshooting Chart indicate stages which may cause the specified malfunction. The stage names given in

shaded blocks correspond directly to the names given in the functional stage blocks of the schematic diagrams. The circuits are discussed in detail in Section 3, Theory of Operation.

### TEST POINT AND ADJUSTMENT LOCATIONS

To aid in locating test points and adjustable components called out in the Performance Check and Adjustment procedure, a "Test Point and Adjustment Locations" foldout page is provided in Section 8, Diagrams and Circuit Board Illustrations.

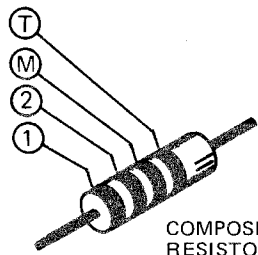
### COMPONENT COLOR CODING

This instrument contains composition resistors, metal-film resistors, and one wire-wound resistor. The resistance of wire-wound resistors is usually printed on the component body. The resistance of composition resistors and metal-film resistors is color coded on the components using the EIA color code (some metal-film resistors may have the resistance printed on the body). The color code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes, which consist of two significant figures, a multiplier, and a tolerance value (see Fig. 4-1). Metal film resistors have five stripes consisting of three significant figures, a multiplier, and a tolerance value.

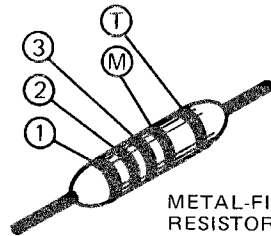
The values of common disc capacitors, silver mica capacitors, and small electrolytics are marked on the side of the component body.

The cathode end of glass-encased diodes is indicated by a stripe, a series of stripes, or a dot. The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

COLOR CODE



COMPOSITION RESISTORS



METAL-FILM RESISTORS

① ② and ③ - 1ST, 2ND, AND 3RD SIGNIFICANT FIGS.

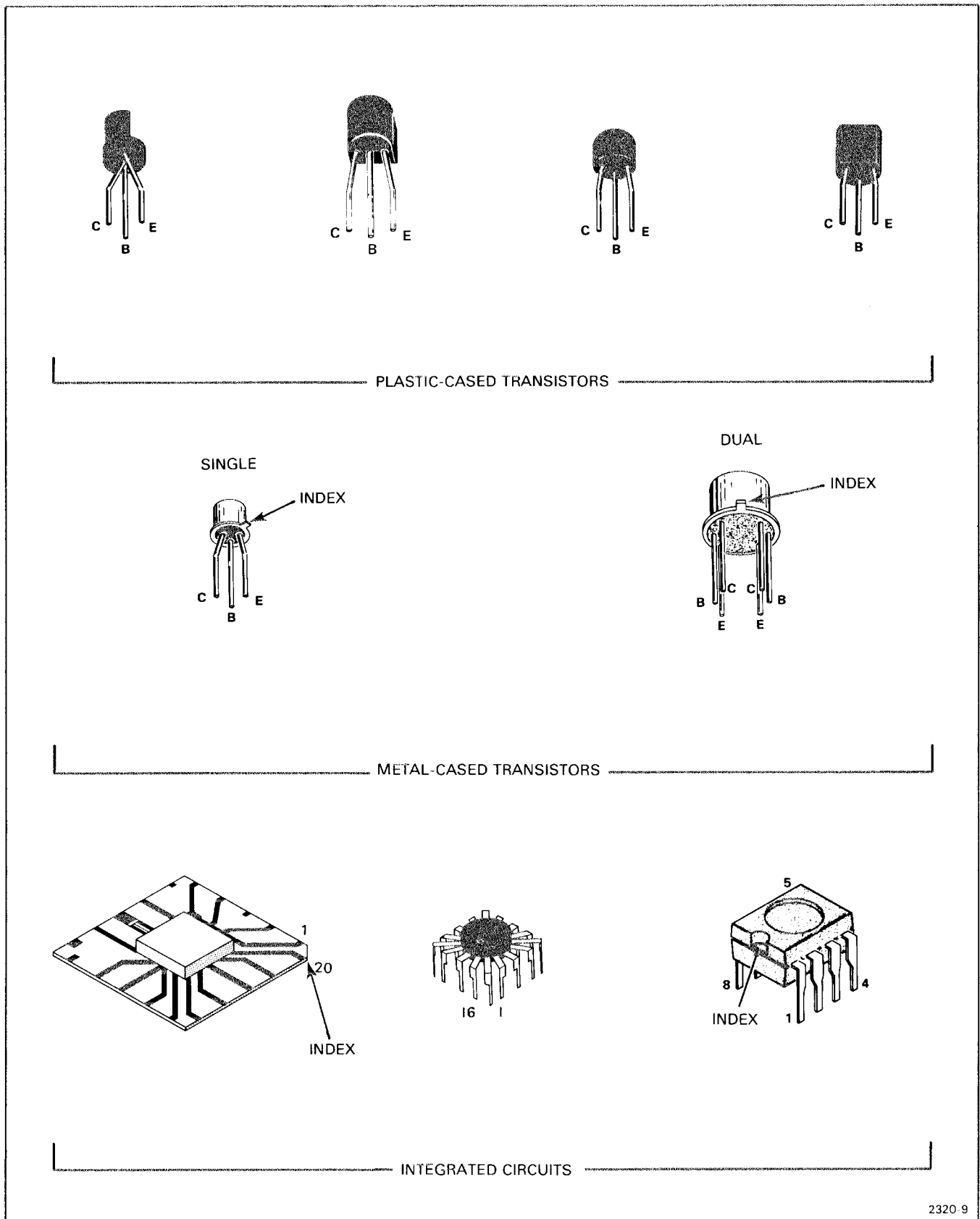
Ⓜ - MULTIPLIER Ⓣ - TOLERANCE;

Ⓣc - TEMPERATURE COEFFICIENT.

COLOR	SIGNIFICANT FIGURES	RESISTORS	
		MULTIPLIER (OHMS)	TOLERANCE
BLACK	0	1	---
BROWN	1	10	±1%
RED	2	10 <sup>2</sup> or 100	±2%
ORANGE	3	10 <sup>3</sup> or 1 K	±3%
YELLOW	4	10 <sup>4</sup> or 10K	±4%
GREEN	5	10 <sup>5</sup> or 100 K	±1/2%
BLUE	6	10 <sup>6</sup> or 1 M	±1/4%
VIOLET	7	---	±1/10%
GRAY	8	---	---
WHITE	9	---	---
GOLD	---	10 <sup>-1</sup> or 0.1	±5%
SILVER	---	10 <sup>-2</sup> or 0.01	±10%
NONE	---	---	±20%

(1862-74) 2320-6

Figure 4-1. Color code for resistors.



2320 9

Figure 4-2. Semiconductor lead configurations.

### SEMICONDUCTOR LEAD CONFIGURATIONS

Figure 4-2 illustrates the basing configurations for all semiconductors used in this instrument. Some plastic-case transistors have lead configurations that do not agree with those shown here. If a replacement transistor is made by a different manufacturer than the original, check the manufacturer's basing diagram. All transistor sockets in this instrument are wired for the standard basing used for metal-case transistors.

### WIRING COLOR CODE

Insulated wire and cable used in this instrument is color coded to facilitate circuit tracing.

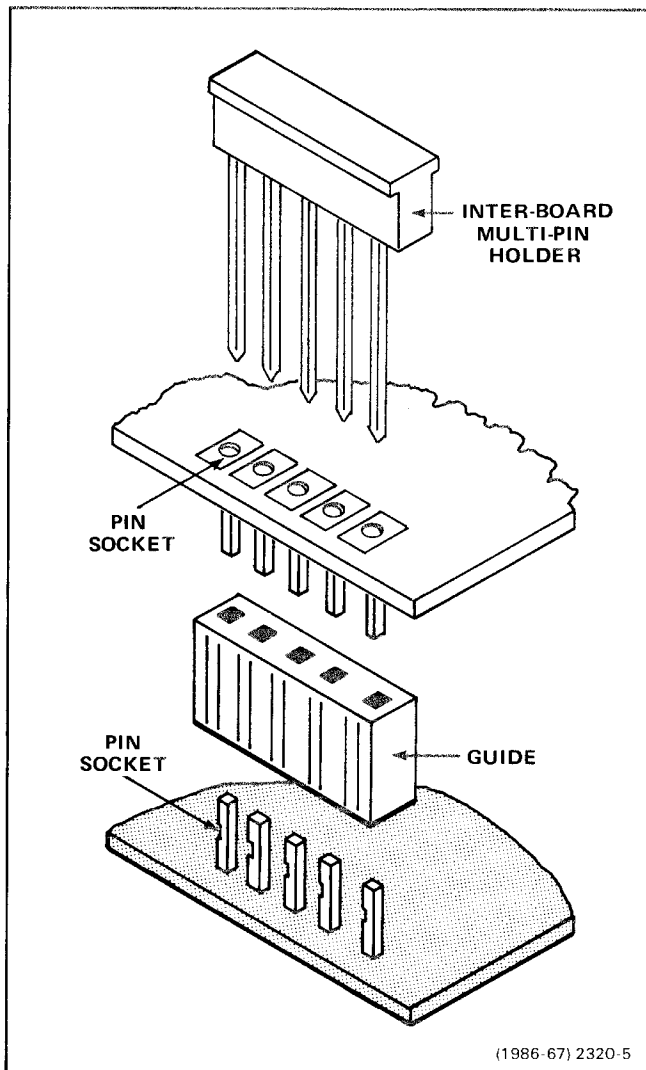


Figure 4-3. Inter-board multi-pin connector assembly.

### INTER-BOARD PIN CONNECTOR IDENTIFICATION

The inter-board pin connector sockets are installed on circuit boards, in groups of 5 sockets (as shown in Fig. 4-3). Inter-board pin connector J70 consists of two groups of 5 sockets. Each socket is numbered on both the Readout and Main Amplifier boards. The J number corresponds to the J (jack) and P (plug) circuit numbers on the schematic diagrams.

### MULTI-PIN CONNECTOR IDENTIFICATION

Multi-pin connectors mate with groups of pins soldered to circuit boards. Pin number 1 is indexed with a triangular mark on the circuit board and molded on the holder of the multi-pin connector, as shown in Figure 4-4. Each group of pins is identified by its corresponding P number etched on the circuit board. The J and P numbers on the circuit boards correlate to the J and P component numbers on the schematic diagrams.

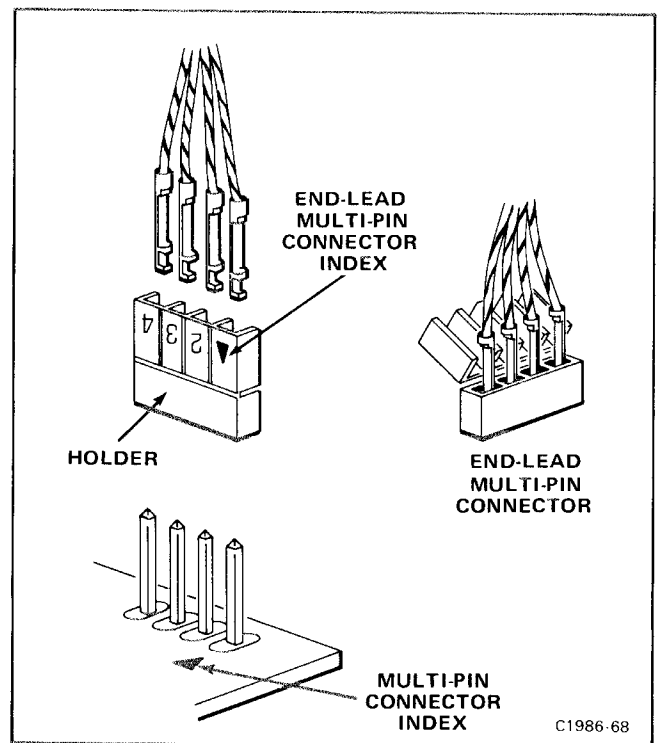


Figure 4-4. Orientation of multi-connector holders.

### INTERFACE CONNECTOR PIN LOCATIONS

The Main Amplifier circuit board couples the plug-in unit to the associated mainframe (oscilloscope). Figure 4-5 identifies the pins on the interface connector as shown in Section 8, Diagrams and Circuit Board Illustrations.

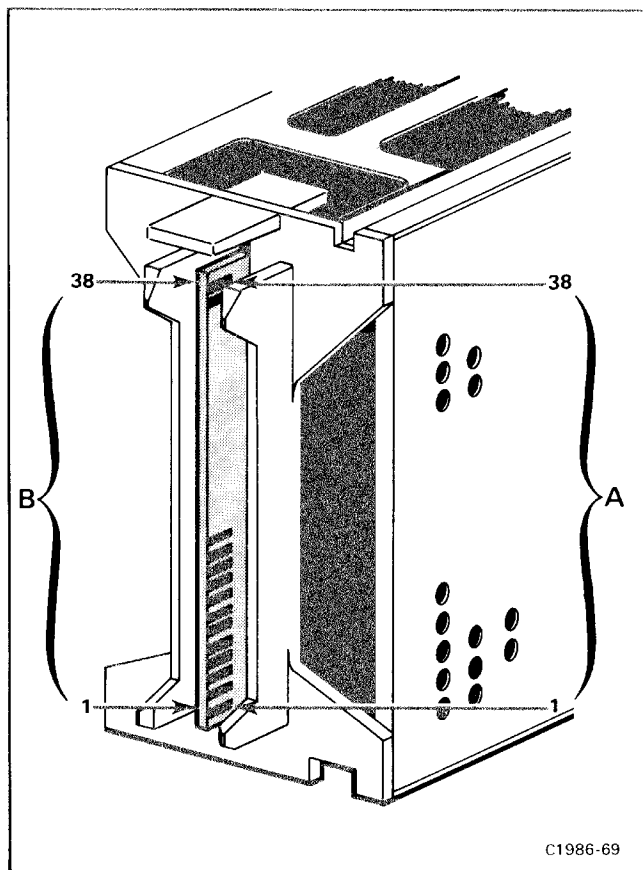


Figure 4-5. Location of pin numbers on interface connector.

## TROUBLESHOOTING EQUIPMENT

The following equipment, in addition to that listed in the Calibration section, is useful for troubleshooting the 7A29 Amplifier:

### Semiconductor Tester

**Description:** Dynamic-type tester.

**Purpose:** To test the semiconductors used in this instrument.

**Recommended type:** TEKTRONIX Type 576 CURVE TRACER or equivalent.

### Test Oscilloscope

**Description:** Frequency response, dc to ten megahertz minimum; deflection factor, five millivolt/division to five volts/division.

**Purpose:** To check operating waveforms.

**Recommended type:** Refer to the Tektronix Products catalog for applicable oscilloscope system.

## TROUBLESHOOTING TECHNIQUES

This troubleshooting procedure is arranged in an order that checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection, operation, and adjustment. If the trouble is located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, replace it using the replacement procedure given under Component Replacement in this section.

### 1. CHECK CONTROL SETTINGS

Incorrect control settings can simulate a trouble that does not exist. If there is any question about the correct function or operation of any control on the 7A29, refer to Section 2, Operating Instructions.

### 2. CHECK ASSOCIATED EQUIPMENT

Before proceeding with troubleshooting, check that the equipment used with this instrument is operating correctly. Also, check that the input signals are properly connected and that the interconnecting cables are not defective. Check the line-voltage source.

### 3. VISUAL CHECK

Visually check that portion of the instrument in which the trouble is located. Many troubles can be found by visible indications, such as unsoldered connections, broken wires, damaged circuit boards and damaged components.

### 4. CHECK INSTRUMENT ADJUSTMENT

Check the electrical adjustment of this instrument, or of the affected circuit if the trouble appears in one circuit. The apparent trouble may only be a result of misadjustment. Complete adjustment instructions are given in Section 5, Calibration.

### 5. ISOLATE TROUBLE TO A CIRCUIT

To isolate trouble to a particular circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. When trouble symptoms appear in more than one circuit, check the affected circuits by taking voltage and waveform readings.

The Troubleshooting Chart in Section 8, Diagrams and Circuit Board Illustrations, provides a guide for locating a defective circuit. Start at the top left of the Troubleshooting Chart and perform the checks given across the top of the chart until the indicated results are not found. Then proceed to further checks, or the circuit in which trouble is suspected, as listed beneath the step. The shaded blocks of the Troubleshooting Chart indicate circuits which may cause the malfunction, and correspond directly to the functional blocks on the schematic diagrams. The circuits listed are discussed in detail in Section 3, Theory of Operation. After the defective circuit has been located, proceed with steps 6 and 7 of Troubleshooting Techniques to isolate the defective component.

## 6. CHECK VOLTAGES AND WAVEFORMS

Often the defective component can be located by checking for the correct voltages or waveforms in the circuit. Typical voltages and waveforms are given in Section 8, Diagrams and Circuit Board Illustrations.

### NOTE

*Voltages and waveforms given in Section 8, Diagrams and Circuit Board Illustrations, are not absolute and may vary slightly between 7A29 Amplifier units. To obtain operating conditions similar to those used to make these readings, see the appropriate schematic.*

## 7. CHECK INDIVIDUAL COMPONENTS

The following procedures describe methods of checking individual components in the 7A29 Amplifier. Components which are soldered in place are best checked by first disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

### Transistors

A good check of transistor operation is actual performance under operating conditions. A transistor can most effectively be checked by substituting a new component for it (or one which has been checked previously). However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester. Static-type testers are not recommended, since they do not check operation under simulated operating conditions.

### Integrated Circuits

Integrated circuits can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of the circuit operation is essential when troubleshooting circuits using integrated circuits. In addition, operating waveforms, logic levels, and other operating information for the integrated circuits are given in Section 3, Theory of Operation, and Section 8,

Diagrams and Circuit Board Illustrations. Use care when checking voltages and waveforms around the integrated circuits so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the in-line multi-pin integrated circuits is with an integrated-circuit test clip. This device also doubles as an integrated-circuit extraction tool.

### Diodes

A diode can be checked for an open or shorted condition by measuring the resistance between terminals with an ohmmeter. The resistance should be very high in one direction and very low when the meter leads are reversed.

### Resistors

Check the resistors with an ohmmeter. Resistor tolerance is given in Section 7, Replaceable Electrical Parts. Normally, resistors do not need to be replaced unless the measured value varies widely from the specified value.

### Capacitors

A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. 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 if the capacitor passes ac signals.

Intermittent components can sometimes be located by freezing one small area at a time with refrigerant spray. However, moisture condensing on U246 and U266 will normally cause the trace position to deviate significantly from its normal position.

## 8. REPAIR AND ADJUST THE CIRCUIT

If any defective parts are located, follow the replacement procedures given under Component Replacement in this section. Check the performance of any circuit that has been repaired or that has had any electrical components replaced. Adjustment of the circuit may be necessary.

# CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in the 7A29 Amplifier are given here.

## OBTAINING REPLACEMENT PARTS

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

### NOTE

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

Some components of the 7A29 are manufactured or selected by Tektronix, Inc. to meet specific performance requirements. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. To determine the manufacturer of parts, refer to parts list, Cross Index Mfg. Code Number to Manufacturer. Order all special parts directly from your local Tektronix Field Office or representative.

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 the circuit number).
4. Tektronix part number.

## SOLDERING TECHNIQUES

### WARNING

*To avoid electric shock and possible damage to the instrument, remove the 7A29 Amplifier from the oscilloscope before soldering.*

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 resin-core, electrical-grade solder. The choice of soldering iron is determined by the repair to be made. When soldering on circuit boards or small wiring, use only a 15 - 20 watt, pencil-type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering-iron tip properly tinned to ensure the best heat transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat-sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint. Use a solder-removing wick to remove excess solder from connections or to clean circuit board pads.

The following technique should be used to replace a component soldered to a circuit board in this instrument. Most components can be replaced without removing the board(s) from the instrument.

### CAUTION

*To prevent damage to the HYPCON connectors, follow the procedure given under Component Removal—HYPCON Connectors, later in this section when removing or installing components near the Hypcon board.*

1. Touch the soldering iron to the lead at the solder connection. Never place the iron directly on the board, as this may damage the board.
2. Melt a small amount of solder onto the component lead connection. This replaces the flux, which may have been removed during instrument cleaning, and facilitates removal of the component.
3. Grip the component lead with a pair of long-nose pliers. When the solder begins to flow, gently pull the component lead from the board. If unable to separate the lead from the board, try removing the other end of the component.



**NOTE**

*Some components are difficult to remove from the circuit board due to a bend placed in each lead during machine insertion of the component. The purpose of the bent leads is to hold the component in position during a flow-solder manufacturing process which solders all components at once. To make removal of machine inserted components easier, straighten the leads of the component on the back of the circuit board using a small screwdriver or pliers, while heating the soldered connection. If the component is known to be defective or if a replacement is readily available, the component may be cut from the circuit board. The leads remaining in the board can then be removed with a suction-type desoldering tool or long-nose pliers.*

4. Bend the leads of the replacement component to fit the holes in the circuit board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes in the board so that the component is firmly seated against the board, or as originally positioned.
5. Touch the iron to the connection and apply enough solder to make a firm solder joint.
6. Cut off any excess lead protruding through the board (if not clipped in step 4).
7. Clean the area around the solder connection with a flux-removing solvent. Be careful not to remove information printed on the circuit board.

## COMPONENT REMOVAL AND REPLACEMENT

**WARNING**

*To avoid electric shock and possible damage to the instrument, always remove the 7A29 Amplifier from the oscilloscope mainframe before replacing components.*

The exploded-view drawings associated with the Replaceable Mechanical Parts list (located at the rear of this manual) may be helpful in the removal or disassembly of individual components or sub-assemblies. Circuit board locations are shown in the diagrams section.

## OPTION 4 VARIABLE DELAY LINE

**NOTE**

*The 7A29 Option 4 instrument requires removal of the variable Delay Line before the Main Amplifier circuit board can be removed.*

Remove and replace the variable delay line as follows:

1. Set VARIABLE DELAY control to "0".
2. Use 1/16" allen wrench to loosen two set screws on coupler which connects to variable delay line shaft. Slide coupler toward front of instrument, and retighten shaft.
3. Remove both SMA connections at rear of delay line.
4. Remove four screws that hold variable delay line to circuit board standoffs.
5. Remove variable delay line.
6. To install variable delay line, reverse order of removal.

**NOTE**

*In order to remove the AC-OFF-DC switch and/or attenuator, the variable delay line must be removed first.*

## CIRCUIT BOARDS

If a circuit board is damaged beyond repair, the entire assembly, including all soldered-on components, can be replaced. Part numbers for the completely wired boards are given in Section 7, Replaceable Electrical Parts.

### Main Amplifier Circuit Board

Remove and replace the Main Amplifier circuit board as follows:

1. Set the VOLTS/DIV switch to 10 mV, the VARIABLE (Volts/Div) control to the uncalibrated position, and the AC-OFF-DC switch to DC.
2. With a (5/64") allen wrench, loosen set screw holding the VARIABLE (Volts/Div) shaft to the push-push mechanism. Remove the VARIABLE (Volts/Div) shaft. Loosen set screws on the VOLTS/DIV and AC-OFF-DC knobs. Remove knobs from shafts.
3. Note color of multi-pin connectors and P (pin) numbers to which each connects. Disconnect all multi-pin connectors from board. Disconnect single harmonia plug (P220) by pulling on the body of the plug (not the wire).
4. Remove the four screws that secure the gray plastic rear panel to the instrument frame.

## Maintenance--7A29

5. Remove the six screws that secure the perimeter of the board to the instrument frame.
6. Disconnect the semi-rigid coaxial cable from the INPUT connector, Main Amplifier board, and AC-OFF-DC switch.
7. Remove the attenuator and AC-OFF-DC switch which are each attached to the Main Amplifier board with two screws visible from the left side of the 7A29.
8. Remove the Main Amplifier circuit board through the rear of the instrument. The middle section of the flexible shaft coupling will now be loose and should be removed to prevent loss.

To install Main Amplifier circuit board, reverse order of removal.

### Readout Circuit Board

Remove and replace the Readout circuit board as follows:

1. Push and unlatch the VARIABLE (Volts/Div) control. Loosen the set screw which attaches the VARIABLE VOLTS/DIV shaft to the push-push mechanism. The screw is located in the middle of the Readout circuit board. Remove the VARIABLE (VOLTS/DIV) shaft from 7A29.
2. Remove the two male-comb connectors (P70) extending through to the Main Amplifier circuit board.
3. Remove the single harmonica plug (P220) by pulling on the body of the plug (not the wire).
4. Remove the four screws in the corners of the Readout board. Remove the 3mm SMA connector (P20) from the attenuator rear if clearance is needed.
5. Locate the bottom set screw (closest to the switch shaft). Remove the Readout board by sliding the entire assembly toward the rear of the instrument. The middle section of the flexible shaft coupling will now be loose and should be removed to prevent loss.
6. To install the Readout circuit board, reverse the order of removal.

### AC-OFF-DC SWITCH

#### NOTE

*An intermittent AC-DC-OFF Switch (119-0913-00) should be replaced as a unit. An exchange unit may be obtained at a considerable cost savings. Contact your Tektronix Field Office or representative.*

In the event that this is not convenient, an adjustment procedure follows. It may be possible to locate and correct one set screw adjustment by observing the conditions under which the fault occurs and performing a partial adjustment procedure. However, overtightening a set screw may lead to internal damage. More than 1/4 turn clockwise from the original position should be considered excessive.

### AC-OFF-DC Switch Adjustment Procedure

#### A. Test Equipment Required:

1. Digital Voltmeter.
2. Two "SMA" to pig tail adapters. (Any cable with male SMA connectors on each end may be cut in half and striped to provide access to the center conductor.)
3. Two DVM leads with alligator clips.
4. 'L' shaped Allen wrench for #4-40 set screw.

#### B. Bottom Side Adjustment:

1. Remove the AC-OFF-DC switch from the 7A29. Connect the DVM from the SMA center conductor at the switch front to the SMA center conductor at the switch rear (nearest solenoid) using the two SMA to pig tail adaptors.



*Do not attempt to connect the DVM directly to the connector's center conductor. The center conductor is fragile and will break without proper handling.*

2. Place the DVM in the ohms mode.
3. Rotate the switch fully clockwise to DC position and place the solenoid in up position (toward side opposite the switch shaft).
4. Using an 'L' shaped Allen wrench, rotate the set screw nearest the switch shaft counterclockwise until the DVM indicates the contact is open (if not already so).
5. Rotate the set screw clockwise until the DVM indicates contact closure.
6. Release hands from wrench to make certain the contact closure is being made without added stress.
7. Rotate the set screw clockwise 1/2 turn to its final adjusted position.

C. Top Side Adjustment:

1. Move the solenoid to the down position (toward the switch shaft). Move the DVM lead from the input to a ground (screw head, etc.).
2. Locate the top set screw (farthest from switch shaft). Using an 'L' shaped Allen wrench, rotate the set screw clockwise just until a resistance of 42.5 to 57.5 ohms is indicated on DVM.
3. Release hands from wrench to make certain the contact closure is being made without added stress.
4. Rotate the set screw clockwise 1/2 turn to its final adjusted position.

**INPUT ATTENUATORS**

An intermittent input attenuator (119-0914-00) should be replaced as a unit. An exchange attenuator may be obtained at a considerable cost savings. Contact your Tektronix Field Office or representative.

In the event that this is not convenient, an adjustment procedure follows. It may be possible to locate and correct one pair of set screw adjustments by observing the conditions under which the fault occurs according to Table 4-1.

**TABLE 4-1**  
**Attenuator Fault Location**

Position at Fault	Attenuator Section	Set Screw Adjustment Location
10 mV	All	Top (nearest switch shaft)
20 mV	Front	Bottom (away from switch shaft)
50 mV	Rear	Bottom (away from switch shaft)
.2V, .5V, 1V	Center	Bottom (away from switch shaft)

Do not tighten a set screw by more than 1/4 turn from its original factory position as permanent damage may result.

**Input Attenuator Adjustment Procedure**

A. Test Equipment Required:

1. Digital Voltmeter.
2. Two 'SMA' to pig tail adapters. (Any cable with male SMA connectors on each end may be cut in half and striped to provide access to the center conductor.)

3. Two DVM leads with alligator clips.
4. 'L' shaped Allen wrench for #4-40 set screw.

**NOTE**

*If the 10 mV/DIV position (fully clockwise) has not been intermittent, skip to step C1.*

B. Top Adjustments:

1. Remove the attenuator from the 7A29. Pry off the switch shaft cover. Connect the DVM from the SMA center conductor at the attenuator front to the SMA center conductor at the attenuator rear, using the two SMA to pig tail adapters.



*Do not attempt to connect the DVM leads directly to the connector's center conductor. The center conductor is fragile and will break without proper handling.*

2. Place the DVM in the ohms mode.
3. Rotate cam shaft fully clockwise to the stop.
4. Back off the six allen set screws along the attenuator top until they are flush with the inside surfaces of the actuator yokes. Using the 'L' shaped Allen wrench, rotate each set screw one full turn clockwise. If the DVM indicates a completed switch connection has been made, go to step #5. If not, adjust each of the six set screws an additional 1/4 turn clockwise and recheck the DVM for completed switch connection. Repeat as required until the DVM indicates the switch connection has been completed from input to output. Care must be exercised not to overstress the switch contacts due to excessive adjustment of the set screws.
5. Starting from the front end of the attenuator, adjust the set screws one at a time as follows:
  - a. Rotate the set screw counterclockwise until the DVM indicates an open switch contact.
  - b. Rotate the set screw clockwise just until the DVM indicates contact closure.
  - c. Release hands from wrench to make certain the contact closure is being made without added stress.
  - d. Rotate the set screw clockwise 1/2 turn to its final adjusted position.
6. Repeat step #5 for the other five set screws.



### DISASSEMBLY AND REMOVAL

- ① Note index on circuit board (arrow) and Hypcon plastic frame (pointed mounting ear).
- ② Unscrew and remove the 4 screw/washer assemblies.
- ③ Lift Hypcon connector from board.
- ④ Note index location of hybrid and remove from board with tweezers.
- ⑤ Note index location of elastomer contact holder and remove by grasping a corner of the contact holder with tweezers and lifting up. Do not touch the gold-plated contacts with your fingers.

### REASSEMBLY AND REPLACEMENT

Grasp corner of elastomer contact holder with tweezers and place in plastic frame slot being careful to match the flat contact holder with the flat frame corner. Place a clean plastic envelope over finger and press with finger to seat contact holder into the frame. The contact holder must be evenly seated on all four sides.

Match hybrid flat corner with board receptacle flat corner and place hybrid in receptacle. Match pointed mounting ear of Hypcon connector with flat corner of receptacle and guide registration pins into the board holes.

Insert mounting hardware and apply 2 inch-pounds of torque to secure the connector assembly.

(2316-23B) 2320-14

Figure 4-6. HYPCON connector assembly (continued).

C. Bottom Adjustments:

1. Use the two SMA to pig-tail adapters to connect the DVM to the SMA connectors at the front and rear of the attenuator.

2. Rotate the switch shaft one position counterclockwise to make the set screw adjustments on the 2X attenuation section (20 mV/div). This corresponds to the actuator yoke closest to the attenuator front.

3. Back off the two Allen set screws on the bottom side of the front actuator yoke of the attenuator until they are flush with the inside surface of the actuator yoke. Using an 'L' shaped Allen wrench, rotate each of the two set screws alternately, using approximately 1/4 turn per adjustment, until a resistance (from attenuator input to output) of 33.3 ohms<sup>1</sup> is indicated on the DVM.

4. Starting again on the same two set screws, adjust one at a time as follows:

a. Rotate the set screw counterclockwise until the DVM indicates an open switch contact.

b. Rotate the set screw clockwise just until DVM indicates contact closure.

c. Release hands from wrench to make certain the contact closure is being made without added stress.

d. Rotate the set screw clockwise 1/2 turn to its final adjusted position.

5. Rotate the cam shaft counterclockwise one more position to the 5X attenuation section (50 mV/div). This engages the rear actuator yoke.

6. Repeat steps #3 and #4 to make the set screw adjustments on the rear attenuator. The input to output DVM reading should be 66.7<sup>1</sup> ohms.

7. Rotate the cam shaft two more positions counterclockwise (0.2V/div).

8. Repeat steps #3 and #4 to make the set screw adjustment on the center attenuation section. The input to output DVM reading should be 90.5<sup>1</sup> ohms.

<sup>1</sup> The lead resistance from the DVM to the attenuator may result in a slightly higher reading.

## SEMICONDUCTORS

Semiconductors should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of semiconductors may affect the adjustment of the instrument. When semiconductors are replaced, check the operation of circuits which may be affected.

### WARNING

*To avoid electric-shock, always remove the 7A29 Amplifier from the oscilloscope before replacing components.*

Replacement semiconductors should be of the original type or a direct replacement. Lead configurations of the semiconductors used in this instrument are shown in Figure 4-2. Some plastic-cased transistors have lead configurations which do not agree with those shown. If a replacement transistor is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in the 7A29 are wired for the standard basing as used for metal-cased transistors.

## INTEGRATED CIRCUITS

An extracting tool should be used to remove the in-line integrated circuit to prevent damaging the pins. This tool is available from Tektronix, Inc., order Tektronix Part 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the integrated circuit. Try to avoid disengaging one end from the socket before the other end.

## HYPCON Connectors

The HYPCON connector is a precision-made connector designed to provide low-loss electrical connection between the printed circuit board and hybrid integrated circuit. An exploded view of the HYPCON connector is shown in Figure 4-6. Care must be taken when replacing the hybrid IC's not to touch the elastomer gold-plated contacts with the fingers or to use a cleaner which will degrade contact reliability. The HYPCON connector and hybrid IC should be removed if it becomes necessary to use a cleaning solvent near the connector when replacing adjacent (within 1/2") circuit board components. **IMPORTANT:** Remove all traces of solder flux or foreign material contamination from the circuit board contact area before replacing the connector. Contamination usually takes place during the soldering and cleaning processes. Even when the soldering is done carefully, flux, oil, or other contaminants can be carried under the connector during the cleaning operation. When the solvent evaporates, nonconductive contaminants may remain on or near the contact interfaces.

The cleaning process, either hand cleaning with a solvent or machine cleaning in an automatic detergent wash, is not recommended for boards fitted with HYPCON connectors.

If a component adjacent to a HYPCON connector must be replaced, the following steps are recommended:

1. Remove the hybrid IC and HYPCON connector (see Disassembly and Removal instructions) before any soldering or cleaning, and store in a dirt-free covered container.
2. Hand soldering
  - a. Use small-diameter solder (0.030"-0.040").
  - b. Use low-wattage soldering iron (15 to 20 watts).
  - c. Use care with solder amount and placement.
3. Remove solder flux and contact contamination with isopropyl alcohol.
4. Flush the hybrid and HYPCON connector mounting area with isopropyl alcohol. Do not scrub with a cotton-tipped applicator, as cotton fibers will adhere to edges and surfaces of contact areas and cause open or intermittent connections. The elastomer should be examined under light for dust, hair, etc. before it is re-installed. If the etched circuit board surfaces require more cleaning, scrub with a soft rubber eraser and blow or vacuum clean while dusting surface with a small clean brush.
5. If the hybrid IC and elastomer contact holder are contaminated, clean the contact holder and hybrid by flushing or spraying with alcohol and oven dry at 50° C. Do not scrub with a cotton-tipped applicator or similar device. If the contact holder is excessively contaminated, replace it with a new one.

Two inch-pounds of torque should be applied to the mounting screws to secure the HYPCON to the circuit board.

Make sure that the elastomer is properly seated in the contact holder before remounting the assembly to the circuit board. The elastomer is keyed to fit snugly in the plastic holder in only one orientation. Exercise care when mounting the frame-elastomer connector holder-hybrid IC assembly to the circuit board to prevent misalignment between the connector and board.

#### CAUTION

*Because of close tolerances involved, special care must be taken to ensure correct index alignment of each HYPCON part during reassembly. Failure to do so can result in a cracked hybrid substrate. See Figure 4-6 for index locations.*

When replacing the hybrid, insert it into the board opening and then position the HYPCON connector in the board registration holes for perfect alignment. The outer portion of the HYPCON frame should be flush with the

circuit board before the four mounting screws are tightened. Avoid touching the hybrid and elastomer contact holder with your fingers; finger oils can degrade reliability.

A procedure for removal and replacement is included in Figure 4-6.

Hybrid substrate contact numbers 1 and 20 are printed on the substrate at the index corner. See Figure 4-2, Semiconductor Lead Configurations.

## INTERCONNECTING METHODS

Three methods of interconnection are used to connect the circuit boards with other boards and components. When the interconnection is made with a coaxial cable, a special end-lead connector plugs into a socket on the board (Fig. 4-7). When the interconnection is made with a wire lead, an end-lead connector is used which mates with the interconnecting pin soldered into the board (Fig. 4-4). When the interconnection is made between adjacent boards, an interboard multi-pin connector is used (Fig. 4-3). The following information provides the removal and replacement procedure for the various types of interconnection methods.

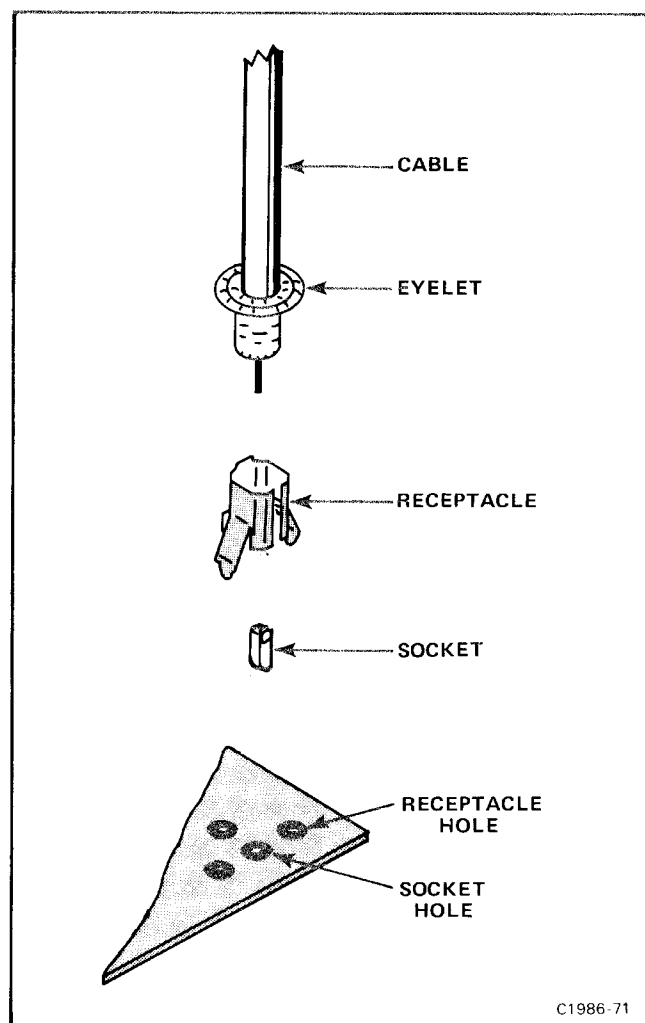


Figure 4-7. Coaxial end-lead connector assembly.

### COAXIAL END-LEAD CONNECTOR (PELTOLA CONNECTOR)

Replacement of coaxial type end-lead connectors requires special tools and techniques. We recommend that the cable be replaced as a unit. For cable part numbers, see the Replaceable Mechanical Parts list. An alternative solution is to refer the replacement of the defective connector to your local Tektronix Field Office or representative.

### END-LEAD PIN CONNECTOR (P220)

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

### MULTIPLE END-LEAD PIN CONNECTOR (HARMONICA CONNECTOR)

Some of the pin connectors are grouped together and mounted in a plastic holder; the overall result is that these connectors are removed and installed as a multi-pin connector (see Fig. 4-4). To provide correct orientation of this multi-pin connector when it is replaced, an arrow is marked on the circuit board and a matching arrow is molded into the plastic holder of the multi-pin connector. Be sure these arrows are aligned as the multi-pin connector is replaced. If the individual end-lead pin connectors are removed from the plastic holder, note the color of the individual wires for replacement.

### INTERBOARD MULTI-PIN CONNECTOR (COMB CONNECTOR, J70)

The interboard multi-pin connector pin-holder (J70) is not repairable and should be replaced as a unit (see Fig. 4-3). Refer to the Replaceable Mechanical Parts list for the part number. Interboard multi-pin connector pin-sockets are soldered to circuit boards (see Fig. 4-3). To replace a socket, first remove the guide. Then, remove the old socket using soldering techniques previously described. Solder the new socket in place, making sure it will align properly with the interboard connector pins.

### CIRCUIT-BOARD PINS

#### CAUTION

*The Main Amplifier circuit board in this instrument is a multilayer type board with two identical conductive paths laminated between the top and bottom board layers. All soldering on this board should be done with care to prevent breaking the connection to the center conductors. Only experienced maintenance personnel should attempt repair of the board.*

A circuit board pin-replacement kit including the necessary tools, instructions and replacement pins is available from Tektronix, Inc. Order Tektronix Part 040-0542-00. Replacement of circuit-board pins on multi-layer boards is not recommended; refer such repairs to your local Tektronix Field Office or representative.

To replace a damaged pin which is mounted on a single-layer circuit board, first disconnect any pin connectors. Then (using Soldering Techniques given earlier in this section), unsolder the damaged pin and pull it from the board with a pair of pliers, leaving the ferrule (see Fig. 4-8) in the hole, if possible. If the ferrule remains in the circuit board, remove the spare ferrule from the replacement pin and press the new pin into the hole in the circuit board. If the ferrule is removed with the damaged pin, clean out the hole using a solder-removing wick and a scribe. Then, press the replacement pin with attached spare ferrule into the hole. Position the replacement pin in the same manner as the damaged pin. Solder the pin to the circuit board on each side of the board. If the old pin was bent at an angle to mate with a connector, carefully bend the new pin to the same angle. Replace the pin connector.

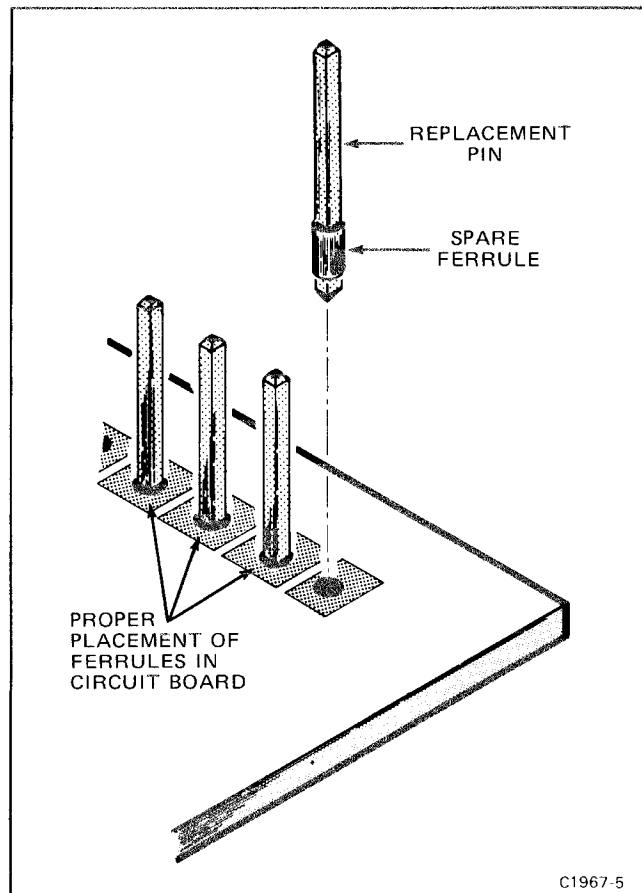


Figure 4-8. Exploded view of circuit-board pin and ferrule.



### FRONT-PANEL RESET LIGHT

This instrument uses a 5-volt incandescent lamp for the front-panel RESET light. To replace the lamp, remove the cap from the sleeve as in Figure 4-9. Note lead wire color coding and lamp lead configuration. Unsolder wire leads and remove lamp from the cap. Solder the replacement lamp and lead wires to the socket cap as noted previously. Install the cap in the sleeve.

### ADJUSTMENT AFTER REPAIR

After any electrical component has been replaced, the adjustment of that particular circuit should be checked, as well as the adjustment of any closely related circuits. See Section 5, Calibration, in this manual for a complete adjustment procedure.

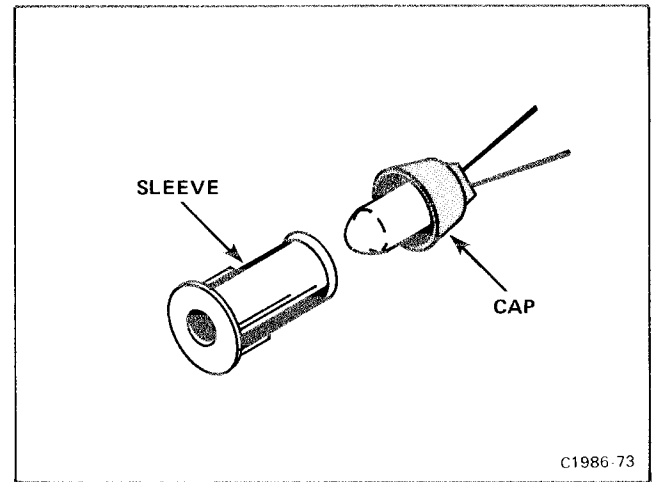


Figure 4-9. Front-panel light socket assembly.

# CALIBRATION

This section provides procedures for calibrating this instrument. These procedures are designed to compare the performance of this instrument with measurement instruments of known accuracy to detect, correlate, or eliminate by adjustment, any variation from the electrical specifications. These procedures also verify that the controls function properly.

This section is divided into two parts: Part I—Performance Check is provided for those who wish to verify that this instrument meets the applicable electrical specifications in section 1 without making internal adjustments. Part II—Adjustment and Performance Check provides a complete calibration procedure that includes adjustments and performance checks in addition to verifying that the controls function properly. The procedures in Part I and Part II are written so that the entire instrument, or any major circuit or part of a circuit, can be checked or adjusted.

Table 5-1, Calibration Procedure Electives, lists the choices available and instructions for performing complete or partial calibration procedures. Also refer to page 5-2, Using These Procedures, for more detailed information.

**TABLE 5-1**  
**Calibration Procedure Electives**

Electives	Procedures
Functional Check	1. A functional check only is provided in the Checkout Procedure in section 2.  2. A functional check is also accomplished by performing Part II—Adjustment and Performance Check.
Performance Check Only	Perform Part I—Performance Check.
Complete Calibration	Perform Part II—Adjustment and Performance Check.
Partial Procedures	Proceed to the desired step(s) (e.g., A2, A3, B2, B3, etc.; as listed in the Index to Part I—Performance Check or Index to Part II—Adjustment and Performance Check).  <p style="text-align: center;"><b>NOTE</b></p> <p style="text-align: center;"><i>When adjustments are made we recommend that the entire major functional circuit procedure be performed.</i></p>

**USING THESE PROCEDURES**

**NOTE**

*In these procedures, capital letters are used within the body of the text to identify front-panel controls, indicators, and connectors on the 7A29 (e.g., VOLTS/DIV). Initial capitalization is used to identify all the associated test equipment and their controls, indicators, and connectors (e.g., Amplitude) used in the procedures. Initial capitalization is also used to identify internal adjustments of the 7A29 (e.g., Trig Bal).*

These procedures are divided into subsections by major functional circuits (e.g. A. Low Frequency, B. High Frequency, etc.). The order in which the subsections and procedures appear is the recommended sequence for a complete performance check or calibration of the instrument.

The first step in each subsection (A1, B1, C1, etc.) contains reference information and control settings that must be performed before proceeding.

The Setup Conditions provide equipment connection information and control settings for both this instrument and any associated test equipment. Also, the Setup Conditions are written so that if desired, each subsection (A, B, C, etc.) or step (A2, A3, B2, B3, etc.) can be performed independently.

The terms CHECK, EXAMINE, ADJUST, or INTERACTION when used as the first word of an instruction are defined as follows:

1. **CHECK**—indicates the instruction accomplishes an electrical specification check. Each electrical specification checked is listed in Table 5-2, Performance Check Summary (see the Performance Check Summary discussion for more information).

2. **EXAMINE**—usually precedes an ADJUST instruction and indicates that the instruction determines whether adjustment is necessary. If no ADJUST instruction appears in the same step, the EXAMINE instruction concerns measurement limits that do not have a related adjustment. Measurement limits following the word EXAMINE are not to be interpreted as electrical specifications. They are provided as indicators of a properly functioning instrument and to aid in the adjustment process.

3. **ADJUST**—describes which adjustment to make and the desired result. We recommend that adjustments not be made if a previous CHECK or EXAMINE instruction indicates that no adjustment is necessary.

4. **INTERACTION**—indicates that the adjustment described in the preceding instruction interacts with other circuits. The nature of the interaction is described and reference is made to the step(s) affected.

**PERFORMANCE CHECK SUMMARY**

Table 5-2, Performance Check Summary, lists the electrical specifications that are checked in Part I and Part II of this section. Table 5-2 is intended to provide a convenient means for locating the procedures in Part I and Part II that check and/or adjust the instrument to meet the applicable electrical specifications. For example: if the Trigger Amplifier had been repaired, use Table 5-2 to locate the electrical specifications affected by the repair. Then, note the title of the procedure in Part I or Part II in which those specifications are checked and/or adjusted. Use the index provided at the front of Part I and Part II to determine the page number of the desired procedures.

**TABLE 5-2  
Performance Check Summary**

Characteristic	Performance Requirement	Part I Performance Check Procedure Title	Part II Adjustment and Performance Check Procedure Title
Deflection Factor  Calibrated Range	From 10 mV/DIV to 1 V/DIV in 7 switch positions using a 1-2-5 switching sequence.	A5. Check Gain.	A8. Check/Adjust Gain.
Attenuator Accuracy	All deflection factors within 2% with GAIN adjusted at 0.1 V/div when driven from 50 Ω source.		

**TABLE 5-2 (CONT.)  
Performance Check Summary**

<b>Characteristic</b>	<b>Performance Requirement</b>	<b>Part I Performance Check Procedure Title</b>	<b>Part II Adjustment and Performance Check Procedure Title</b>
Deflection Factor (cont.)		A5. Check Gain.	A8. Check/Adjust Gain.
Variable Range	At least 2.5:1.		
GAIN Range	Adjustable at least $\pm 3\%$ from nominal at 0.1 V/div.		
Frequency Response			
High Frequency AC or DC Coupled 10 mV/ DIV to 1 V/DIV	When operated in the 7104, 1 GHz ( $0^\circ$ to $+35^\circ$ C).	B2. Check 1 GHz Gain.	B4. Check 1 GHz Gain.
Low Frequency AC Coupled	1 kHz or less from a 50 $\Omega$ source; 200 Hz or less with 10X, 50 $\Omega$ probe.	A8. Check AC Low Frequency Response.	A10. Check AC Low Frequency Response.
Maximum Input			
DC Coupled	10 V rms or 1-watt-second pulses not exceeding 50 V peak. See Figure 1-2 and Detailed Operating Information, section 2.	Does not normally require customer verification. Satisfactory operation substantiated at the factory.	
AC Coupled	100 V additional component. Derate linearly to 0 V additionally at 60 Hz.	Does not normally require customer verification. Satisfactory operation substantiated at the factory.	
Input Protection Disconnect Threshold	+10 V dc within 2 V, -10 V dc within 2 V, or approximately 10 V rms up to 100 MHz.	C2. Check 10 V Input Protection.	C2. Check 10 V Input Protection.
Input Protection Disconnect Time	Less than 30 ms for 50 V dc of either polarity. 40 ms to 150 ms for 25 V dc of either polarity.	C3. Check +25 and +50 V Input Protection.  C4. Check -25 V and -50 V Input Protection.	C3. Check +25 V and +50 V Input Protection.  C4. Check -25 V and -50 V Input Protection.
Input Impedance			
Resistance	DC Coupled, 50 $\Omega$ within 1 $\Omega$ .  AC Coupled, 50 $\Omega$ within 1 $\Omega$ in series with at least 1.6 $\mu$ F.	A7. Check Input Resistance.  A8. Check Input Resistance.	A3. Check/Adjust Input Resistance.  A10. Check AC Low Frequency Response.

**TABLE 5-2 (CONT.)  
Performance Check Summary**

<b>Characteristic</b>	<b>Performance Requirement</b>	<b>Part I Performance Check Procedure Title</b>	<b>Part II Adjustment and Performance Check Procedure Title</b>
Input Impedance (cont.)  Reflection Coefficient	5% or less in a 1 GHz $\pm 20\%$ time domain reflectometer system.	B3. Check Input Reflection Coefficient.	B5. Check Input Reflection Coefficient.
VSWR (Except Option 4)  DC Coupled  AC Coupled	1.4:1 at 10 mV/DIV. 1.2:1 at 20 mV/DIV to 1 V/DIV; dc to 1 GHz.  1.4:1 at 10 mV/DIV. 1.2:1 from 20 mV/DIV to 1 V/DIV; 1 MHz to 1 GHz.	B5. Check VSWR.	B7. Check VSWR.
VSWR (Option 4)  DC Coupled  AC Coupled	1.5:1, dc to 800 MHz.  1.5:1, 1 MHz to 800 MHz.	B5. Check VSWR.	B7. Check VSWR.
Input Offset Current	50 $\mu$ A or less.	A2. Check Input Current.	A2. Check/Adjust Input Current.
VARIABLE Balance	0.2 div or less maximum trace shift.	A3. Check Variable Balance.	A4. Check/Adjust Variable Balance.
POLARITY Balance	0.5 div maximum trace shift.	A4. Check Invert Balance.	A5. Check Invert Balance.
IDENTIFY	Deflects trace upward 0.2 to 0.4 div.	A3. Check Variable Balance.	A2. Check/Adjust Variable Balance.
POSITION Range	9 div each direction from graticule center within 1.0 div.	Does not normally require customer verification.	A6. Adjust Position Centering.
DC Drift  Drift With Ambient Temperature (Line Voltage Constant)	0.04 div/ $^{\circ}$ C or less.	Does not normally require customer verification. Satisfactory operation substantiated at the factory.	
Delay Range (Option 4 only)	At least 1 ns.	B4. Check Option 4 (VARIABLE DELAY).	B6. Check Option 4 (VARIABLE DELAY).

**ADJUSTMENT INTERVAL**

To maintain instrument accuracy, check performance every 1000 hours of operation, or every 6 months if used infrequently. Before complete adjustment, thoroughly clean and inspect this instrument as outlined in the Maintenance section.

**TEKTRONIX FIELD SERVICE**

Tektronix Field Service Centers and the Factory Service Center provide instrument repair and adjustment services. Contact your Tektronix Field Office or representative for further information.

**TEST EQUIPMENT REQUIRED**

The test equipment listed in Table 5-3 is required for a complete Adjustment and Performance Check of the instrument. If only a Performance Check is to be performed, the items required for Adjustment are not required and are indicated by footnote 1. The remaining test equipment is common to both procedures.

The specifications for test equipment, given in Table 5-3, are the minimum required to meet the performance requirements. Detailed operating instructions for test equipment are omitted in these procedures. Refer to the test equipment instruction manual if more information is needed.

**SPECIAL FIXTURES**

Special fixtures are used only where they facilitate instrument adjustment. These fixtures are available from Tektronix, Inc. Order by part number from Tektronix Field Offices or representatives.

**TEST EQUIPMENT ALTERNATIVES**

All of the listed test equipment is required to completely calibrate this instrument. However, complete checking or adjusting may not always be necessary or desirable. You may be satisfied with checking only selected characteristics, thereby reducing the amount of test equipment actually required.

The calibration procedures in Part I and Part II are based on the first item of equipment given as an example. When other equipment is substituted, control settings or setups may need to be altered. If the exact item of equipment given as an example in Table 5-3 is not available, first check the Minimum Specifications column carefully to see if any other equipment might suffice. Then check the Purpose column to see what this item is used for. If used for a performance check or adjustment that is of little or no importance for your measurement requirements, the item and corresponding step(s) can be deleted.

**TABLE 5-3**  
**Test Equipment**

Description	Minimum Specifications	Purpose	Examples of Applicable Test Equipment
1. Oscilloscope Mainframe	Tektronix 7000-series 1 GHz bandwidth required for complete procedure.	Used throughout pro- cedure to provide display.	a. TEKTRONIX 7104 Oscilloscope.
2. Time Base	Tektronix 7B-series time-base plug-in unit.	Used throughout pro- cedure to provide sweep.	a. TEKTRONIX 7B10 or 7B15 Time Base.  b. TEKTRONIX 7B80 or 7B85 Time Base.
3. Differential Amplifier	Tektronix 7A-series differential plug-in unit. Dual trace with 1 mV per division sensitivity required.	Check/adjust input resistance and check VSWR.	a. TEKTRONIX 7A22 Differential Amplifier.
4. Signal Standardizer	Tektronix 7000-series plug-in unit.	Low frequency step response adjustment.	a. Tektronix 067-0587-02 Calibration Fixture Signal Standardizer.

**TABLE 5-3 (CONT.)  
Test Equipment**

Description	Minimum Specifications	Purpose	Examples of Applicable Test Equipment
5. Sampling System a. Sampling Amplifier Plug-in Unit  b. Wide band Sampling Head (2 required)  c. Sampling Pulse Generator  d. Time-Domain Reflectometer  e. 1 GHz Sampling Head	System rise time, 80 ps or less; pulse amplitude, 200 mV; sensitivity, 50 mV/div.	Check risetime, aberrations bandwidth and input reflection coefficient.	a. TEKTRONIX 7S12 TDR/Sampler plug-in unit with TEKTRONIX S-6, S-1 Sampling Heads and a TEKTRONIX S-52 Pulse Generator Head. (This system is to be used in the oscilloscope mainframe with the addition of a TEKTRONIX 7S11 Sampling Unit, S-6 Sampling Head and 067-0655-00 signal pickoff fixture.)
6. Digital Voltmeter (DVM)	0.1 mV sensitivity.	Check/adjust input current.	a. TEKTRONIX DM501 Digital Multimeter with TM 500-series Power Module.  b. TEKTRONIX 7D13 Digital Multimeter.
7. Calibration Generator	Amplitude accuracy within 0.25%; range, 50 mV to 5 V into 50 $\Omega$ ; frequency, 1 kHz square wave.	Check gain and volts/division. Low-frequency step response.	a. TEKTRONIX PG506 Calibration Generator with TM 500-series power module.
8. Leveled Sine-Wave Generator	Reference frequency, 10 MHz or less; amplitude accuracy, within 2% of reference frequency; amplitude, 1 V to at least 4 V into 50 $\Omega$ ; frequency, 1 GHz.	Check 1 GHz Gain and check VSWR.	a. TEKTRONIX SG504 Leveled Sine Wave Generator with TM 500-series Power Module.
9. Low-Frequency Sine-Wave Generator	Output 1 kHz sine wave; amplitude, 0.6 V into 50 $\Omega$ ; output impedance, 50 $\Omega$ .	Check ac low-frequency response.	a. TEKTRONIX FG503 Function Generator.  b. TEKTRONIX FG502 Function Generator.
10. Power Supply	Output voltage $\pm 10$ V, $\pm 25$ V, $\pm 50$ V within 5%; current capability, 1 ampere.	Check input protection.	a. Trygon Electronics, Dual Lab Supply DL40-1.
11. 50-ohm Bridge	1/4 percent 50-ohm bridge.	Check/adjust input resistance.	a. Tektronix 067-0875-00 Calibration Fixture.
12. Signal Pickoff Fixture	For use with 7000-series plug-in units.	Check high frequency pulse aberrations.	a. Tektronix 067-0655-00 Calibration Fixture.
13. Flexible Plug-In Extender	For use with 7000-series plug-in units.	Check risetime and aberrations.	a. Tektronix 067-0616-00 Calibration Fixture.

**TABLE 5-3 (CONT.)  
Test Equipment**

Description	Minimum Specifications	Purpose	Examples of Applicable Test Equipment
14. Sampling Head Extender	For use with Tektronix Sampling Heads; length, 3 ft.	Used to provide power to sampling head.	a. Tektronix 012-0124-00 Sampling Head Extender, 3 ft.
15. BNC Coaxial Cable (3 required)	Impedance, 50 ohms; connectors, BNC; length, 18-inch.	Provides signal connections throughout.	a. Tektronix part 012-0057-01.
16. SMA Coaxial Cable	Semirigid, 2 ns, 3 mm; connectors, SMA.	Provides signal connection throughout.	a. Tektronix part 015-1005-00.
17. Adapter (2 required)	Connectors, Peltola-to-GR.	Used to check aberrations.	a. Tektronix part 017-0093-00.
18. Adapter (2 required)	Connectors, SMA male-to-GR.	Used to check aberrations.	a. Tektronix part 015-1007-00.
19. Adapter	Connectors, SMA male-to-BNC female.	Used to check aberrations.	a. Tektronix part 015-1018-00.
20. Adapter	Connectors, BNC male-to-BNC male.	Used to check aberrations.	a. Tektronix part 103-0029-00.
21. Adapter	Connectors, BNC female-to-clip leads.	Used to check input protection.	a. Tektronix part 013-0076-00.
22. Attenuator	Attenuation, 5X; impedance, 50-ohms; connectors, BNC.	Check 1 GHz gain and VSWR.	a. Tektronix part 011-0060-02.
23. Terminator (2 required)	Impedance, 50-ohms; connectors, SMA.	Signal termination.	a. Tektronix part 015-1020-00.
24. Attenuator	Attenuation, 10 X; impedance, 50-ohms; connectors, BNC.	Check 1 GHz gain.	a. Tektronix part 011-0059-02.
25. Attenuator	Attenuation, 2X; impedance, 50-ohms; connectors, BNC.	Check 1 GHz Gain.	a. Tektronix part 011-0069-02.
26. Power Divider	Connectors, GR.	Check input reflection coefficient.	a. Tektronix part 017-0082-00.
27. VSWR Autotester	Frequency range, 10 MHz to 1 GHz.	Check VSWR.	a. Wiltron Model 67B50.
28. Screwdriver <sup>1</sup>	Three-inch shaft, 3/32-inch bit.	Used throughout adjustment procedure.	a. Xcelite R3323.
29. Insulated screwdriver <sup>1</sup>	Fits 5/64-inch (ID) hex cores.	Mid-frequency pulse adjustment.	a. Handle and insert. Tektronix parts 003-0307-00 and 003-0310-00.

<sup>1</sup>Used for Part II—Adjustment and Performance Check only, NOT used for Part I—Performance Check.



# PART I—PERFORMANCE CHECK

The following procedure (Part I—Performance Check) verifies electrical specifications without making internal adjustments. All tolerances given are as specified in the Specification tables (section 1) in this manual.

Part II—Adjustment and Performance Check provides the information necessary to: (1) verify that the instrument meets the electrical specifications, (2) verify that the controls function properly, and (3) perform all internal adjustments.

A separate Checkout Procedure is provided in section 2 to provide instrument familiarization and to verify that the controls function properly.

See Table 5-1, Calibration Procedure Electives, at the beginning of this section, for information on performing a Partial Part I—Performance Check procedure.

## INDEX TO PART I— PERFORMANCE CHECK

	PAGE
A. LOW FREQUENCY .....	5-9
1. Low Frequency Preliminary Setup .....	5-9
2. Check Input Current .....	5-9
3. Check Variable Balance .....	5-10
4. Check Invert Balance .....	5-10
5. Check Gain .....	5-10
6. Check Low-Frequency Step Response .....	5-11
7. Check Input Resistance .....	5-12
8. Check AC Low-Frequency Response .....	5-12
 B. HIGH FREQUENCY .....	 5-14
1. High Frequency Preliminary Setup .....	5-14
2. Check 1 GHz Gain .....	5-14
3. Check Input Reflection Coefficient .....	5-15
4. Check Option 4 (VARIABLE DELAY) .....	5-16
5. Check VSWR .....	5-16
 C. INPUT PROTECTION .....	 5-18
1. Input Protection Preliminary Setup .....	5-18
2. Check 10 Volt Input Protection .....	5-18
3. Check +25 V and +50 V Input Protection .....	5-19
4. Check -25 V and -50 V Input Protection .....	5-20

## PERFORMANCE CHECK POWER-UP SEQUENCE

### NOTE

*The performance of this instrument can be checked at any ambient temperature from 0° to +50° C unless otherwise stated.*

1. Install the 7A29 Amplifier in the left vertical compartment of the Oscilloscope Mainframe.

### CAUTION

*To avoid instrument damage, it is recommended that the POWER switch be turned off before removing or replacing plug-in units.*

2. Install a Time Base unit in the Oscilloscope Mainframe B horizontal compartment.

3. Connect the Oscilloscope Mainframe to a suitable power source and turn on. Allow at least 20 minutes warmup before beginning the procedure.

## A. LOW FREQUENCY

**Equipment Required:** (Numbers correspond to those listed in Table 5-3, Test Equipment.)

- |                            |                                      |
|----------------------------|--------------------------------------|
| 1. Oscilloscope Mainframe  | 9. Low-Frequency Sine-Wave Generator |
| 2. Time Base               | 11. 50-Ohm Bridge                    |
| 3. Differential Amplifier  | 15. BNC Coaxial Cable (3 required)   |
| 4. Signal Standardizer     | 22. Attenuator, (5X)                 |
| 6. Digital Voltmeter (DVM) | 25. Attenuator, (2X)                 |
| 7. Calibrator Generator    |                                      |

### A1. LOW FREQUENCY PRELIMINARY SETUP

a. Perform the Performance Check Power-Up Sequence.

b. Refer to Section 6, Instrument Options, and the Change Information at the rear of this manual for any modifications which may affect this procedure.

c. Set 7A29 Amplifier controls:

VOLTS/DIV ..... 0.1 V  
 VARIABLE (Volts/Div) ..... CAL IN  
 POSITION ..... Midrange  
 POLARITY ..... +UP  
 AC-OFF-DC ..... DC  
 VARIABLE DELAY (Option 4) ..... 0 (centered)

d. Set Oscilloscope Mainframe controls:

Power ..... On  
 Vertical Mode ..... Left  
 Horizontal Mode ..... B  
 Intensity ..... Visible display  
 Focus ..... Well-defined display  
 Trigger Source ..... Vertical mode

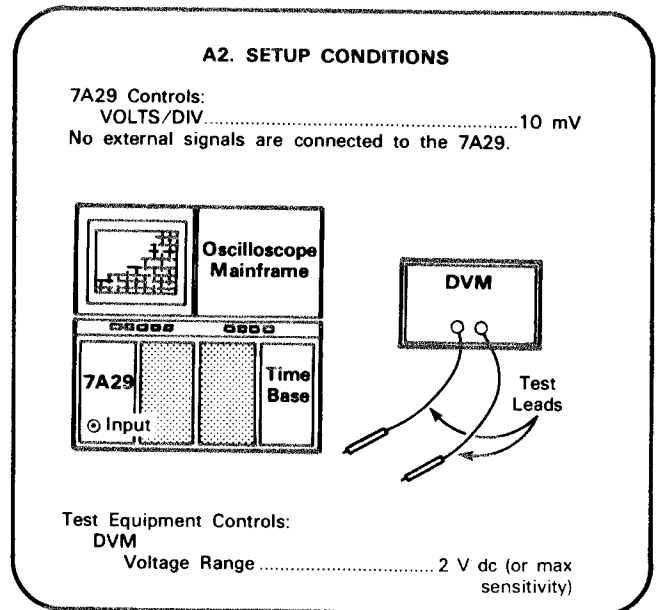
e. Set Time Base controls:

Time/Division ..... 1 ms  
 Triggering ..... Auto, Ac, Internal

### A2. CHECK INPUT CURRENT

#### NOTE

*First perform step A1, then proceed.*



a. Connect the DVM (Digital Voltmeter) between the outer conductor and the inner conductor of the 7A29 INPUT connector.

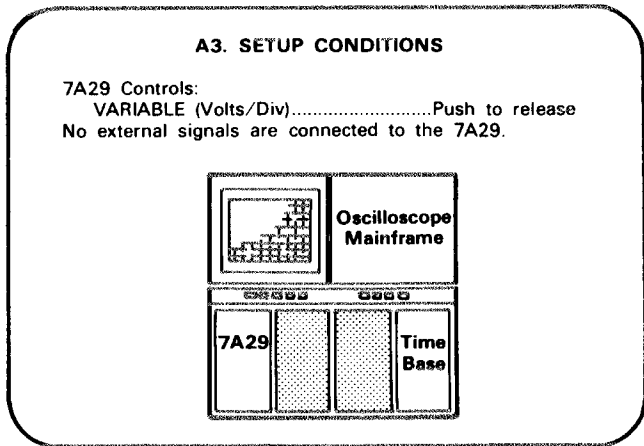
b. **CHECK**—The DVM for a reading of zero volts, within 2.5 mV.

c. Disconnect the DVM from the INPUT connector.

### A3. CHECK VARIABLE BALANCE

#### NOTE

If the preceding step was not performed, first perform step A1, then proceed.



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

b. **CHECK**—The display for less than 0.2 division of vertical trace shift while rotating the VARIABLE (Volts/Div) control throughout its range. Repeat the check with the trace positioned at the top and then at the bottom of the graticule.

c. With the POSITION control, return the trace to the center horizontal graticule line.

d. **CHECK**—Press the 7A29 IDENTIFY pushbutton and observe that the trace is deflected upward between 0.2 and 0.4 division. On Oscilloscope Mainframes equipped with readout, observe that the 7A29 readout display is replaced with the word IDENTIFY.

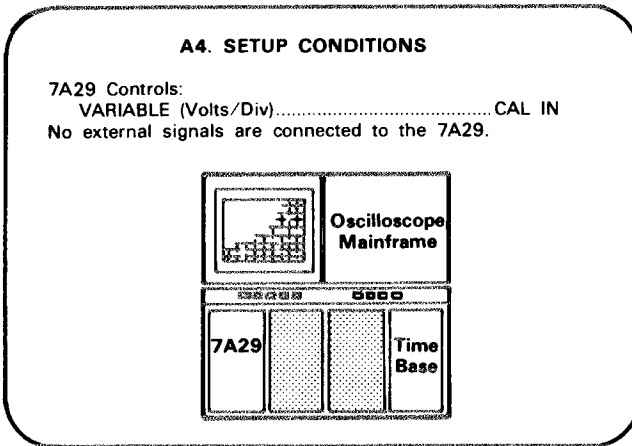
e. Set the POLARITY switch to INVERT and position the trace to the center horizontal graticule line.

f. **CHECK**—The display for less than 0.2 division vertical trace shift while rotating the VARIABLE (Volts/Div) control throughout its range. Repeat the check at the top and then at the bottom of the graticule.

### A4. CHECK INVERT BALANCE

#### NOTE

If the preceding step was not performed, first perform step A1, then proceed.

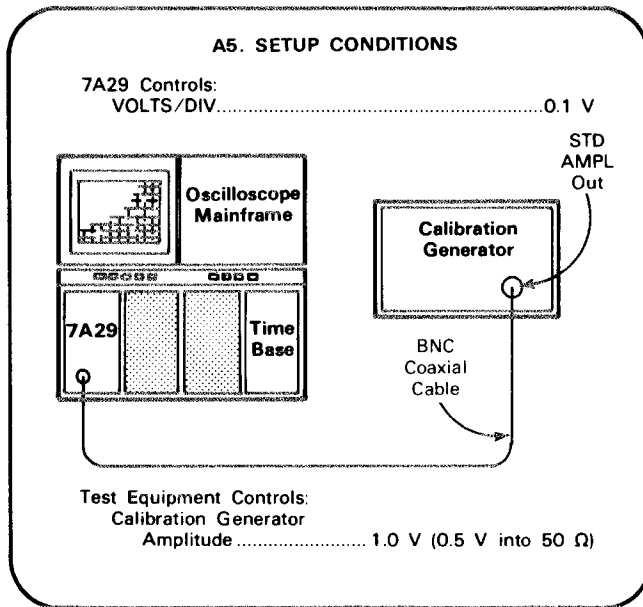


a. **CHECK**—For less than 0.5 division trace shift when the setting of the POLARITY switch is changed.

### A5. CHECK GAIN

#### NOTE

If the preceding step was not performed, first perform A1, then proceed.



a. Set the Calibration Generator for a 0.5-volt square wave into 50 ohms (1.0 volt into an open circuit).

**NOTE**

*It is essential that the Oscilloscope Mainframe sensitivity be properly adjusted prior to performing this step. Check the Oscilloscope Mainframe Instruction Manual for adjustment procedure.*

- b. **CHECK**—Rotate the GAIN control fully clockwise and observe at least 5.15 divisions of displayed square-wave signal.
- c. **CHECK**—Rotate the GAIN control fully counterclockwise and observe 4.85 divisions, or less of displayed square-wave signal.
- d. Set the GAIN control for exactly 5 divisions of square-wave signal.
- e. **CHECK**—Using the VOLTS/DIV and Calibration Generator settings given in Table 5-4, check that the vertical deflection is correct within 2% for each position of the VOLTS/DIV switch.
- f. Push to release the VARIABLE (Volts/Div) control.
- g. Rotate the VARIABLE (Volts/Div) control fully counterclockwise.
- h. **CHECK**—for 1.9 divisions or less of displayed square wave.
- i. Change the POLARITY switch to INVERT.

**TABLE 5-4**  
Vertical Deflection Accuracy

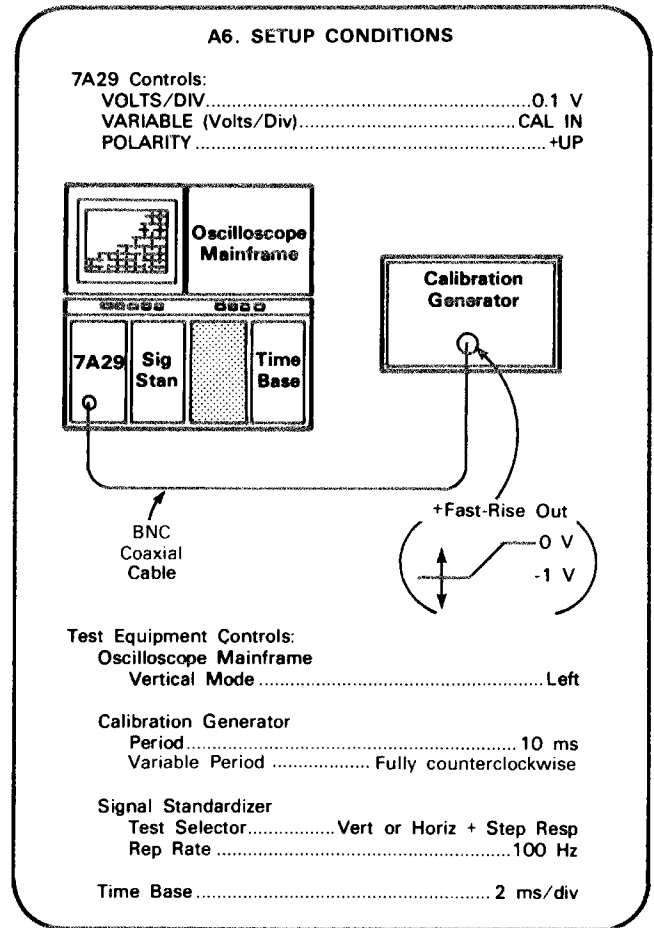
Volts/Div Switch Setting	Calibration Generator Output (open circuit)	Vertical Deflection in Divisions	Maximum Error in Divisions
10 mV	0.1 V	5	±0.1
20 mV	0.2 V	5	±0.1
50 mV	0.5 V	5	±0.1
.2 V	2.0 V	5	±0.1
.5 V	5.0 V	5	±0.1
1 V	10 V	5	±0.1

- j. **CHECK**—For 1.9 divisions or less of displayed square wave.
- k. Disconnect the Calibration Generator from the 7A29.

**A6. CHECK LOW-FREQUENCY STEP RESPONSE**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed.*



2320-36

- a. Set the Calibration Generator Amplitude control to display 8 divisions of signal centered on the crt.
- b. Set the Oscilloscope Mainframe Vertical Mode to Right.
- c. Set the Signal Standardizer Amplitude control to display 8 divisions of signal centered on the crt.

**Calibration Part I—7A29  
Performance Check**

d. Set the Oscilloscope Mainframe Vertical Mode to Alternate.

e. Set the Variable Period control on the Calibration Generator to perfectly align both displayed signals at all frequencies used in the following steps. Make sure the amplitudes of both displayed signals are equal.

f. Position the most positive portions of both waveforms approximately 1.5 divisions below the top graticule line. Overlay the two waveforms at a point 2.5 divisions after a positive transition using the 7A29 POSITION control.

g. **CHECK**—The two waveforms must not separate more than 0.1 division (ignore discrepancies which occur within 10 nanoseconds of the positive transition). Make the same comparison, with the control settings listed in Table 5-5, Control Settings for Low-Frequency Step Response.

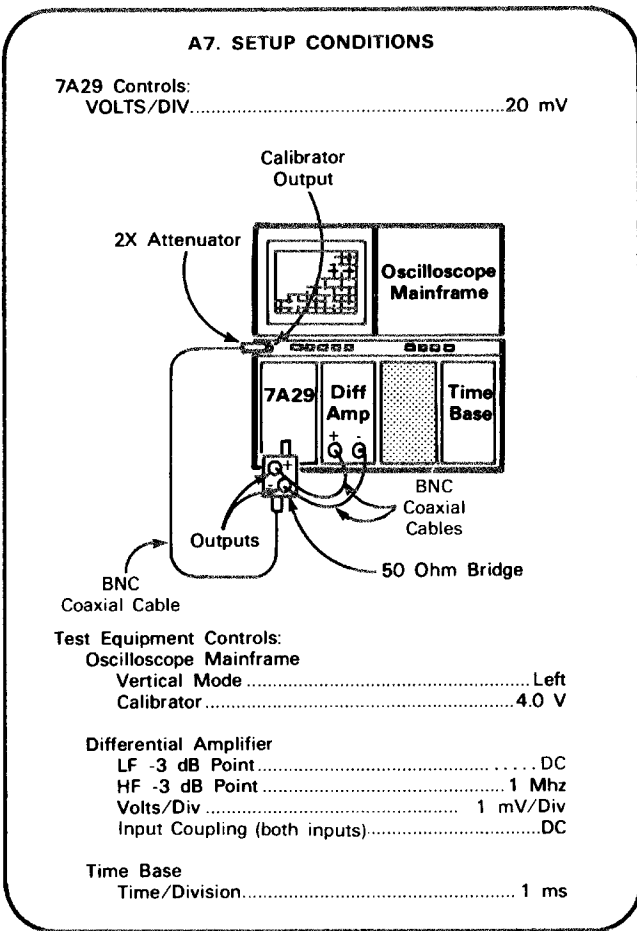
**TABLE 5-5  
Control Settings for Low-Frequency  
Step Response**

Calibration Generator Period	Signal Standardizer Rep Rate	Time Base Time/Div
10 ms	100 Hz	2 ms
1 ms	1 kHz	0.2 ms
.1 ms	10 kHz	20 $\mu$ s
10 $\mu$ s	100 kHz	2 $\mu$ s

**A7. CHECK INPUT RESISTANCE**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed.*



2320-37

a. With the 7A29 VOLTS/DIV switch set to 20 mV, notice approximately 5 divisions displayed on the crt.

b. Set the VOLTS/DIV switch to 10 mV and the Oscilloscope Mainframe Vertical Mode to Right.

c. **CHECK**—That the displayed square-wave amplitude is less than 1 division peak-to-peak (disregard overshoot).

d. **CHECK**—Each position of the 7A29 VOLTS/DIV switch for less than 1 division (peak-to-peak) of displayed square wave.

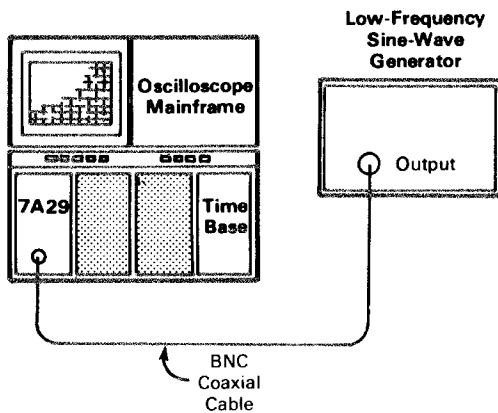
**A8. CHECK AC LOW-FREQUENCY RESPONSE**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed.*

**A8. SETUP CONDITIONS**

7A29 Controls:  
VOLTS/DIV.....0.1 V  
AC-OFF-DC.....DC



Test Equipment Controls:  
Oscilloscope Mainframe  
Vertical Mode..... Left  
Horizontal Mode..... B

Time Base  
Time/Division..... 1 ms  
Triggering..... Auto, AC, Int

Low-Frequency Sine-Wave Generator  
Function..... Sine Wave  
Frequency..... 1 kHz

- a. Set the Low-Frequency Sine-Wave Generator Amplitude control to display a 6-division sine wave.
- b. Set the AC-OFF-DC switch to AC.
- c. **CHECK**—For at least 4.25 divisions of displayed sine-wave signal.

2320-38

## B. HIGH FREQUENCY

**Equipment Required:** (Numbers correspond to those listed in Table 5-3, Test Equipment.)

- |  |                                      |
|--|--------------------------------------|
| 1. Oscilloscope Mainframe                | 19. Adapter (sma male-to-bnc female) |
| 2. Time Base                             | 20. Adapter (bnc male-to-bnc male)   |
| 4. Signal Standardizer                   | 22. Attenuator (5X)                  |
| 5. Sampling System                       | 24. Attenuator (10X)                 |
| 8. Leveled Sine-Wave Generator           | 25. Attenuator (2X)                  |
| 15. BNC Coaxial Cable (2 required)       | 26. Power Divider                    |
| 16. SMA Coaxial Cable                    | 27. VSWR Autotester                  |
| 18. Adapter (sma male-to-GR, 2 required) |                                      |

### B1. HIGH FREQUENCY PRELIMINARY SETUP

a. Perform the Performance Check Power-Up Sequence given at the beginning of Part I—Performance Check.

b. Refer to Section 6, Instrument Options, and the Change Information at the rear of this manual for any modifications which may affect this procedure.

c. Set 7A29 Amplifier controls:

VOLTS/DIV .....	0.1 V
VARIABLE (Volts/Div) .....	CAL IN
POSITION .....	Midrange
POLARITY .....	+UP
AC-OFF-DC .....	DC
VARIABLE DELAY (Option 4) .....	0 (centered)

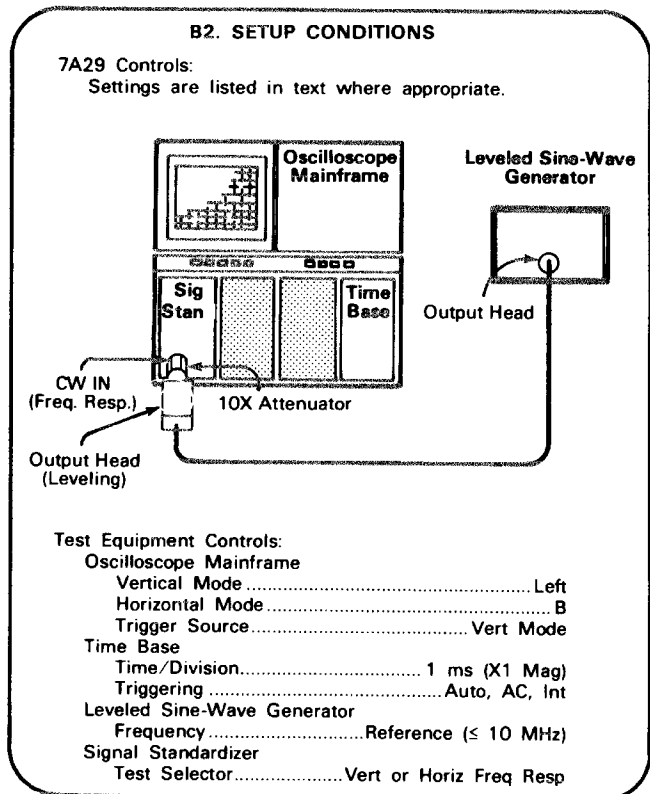
d. Set Oscilloscope Mainframe controls:

Power .....	On
Vertical Mode .....	Left
Horizontal Mode .....	B
Intensity .....	Visible display
Focus .....	Well-defined display
Trigger Source .....	Left Vert

### B2. CHECK 1 GHZ GAIN

#### NOTE

*First perform step B1, then proceed.*



2320-39

**NOTE**

The 7A29 frequency response at 1 GHz is required to be no less than 88.5% of its low-frequency value. The response of any measurement equipment is tested and factored out of the following procedure.

The general test method is to measure the test system response at 1 GHz relative to a low-frequency response (e.g., 10 MHz). The 7A29 is then inserted into the signal path. The combined response (at 1 GHz) of the test system plus the 7A29 must not be less than 88.5% of the test system response at 1 GHz.

- a. Notice that the output of the Leveled Sine-Wave Generator to the CW In connector of the Signal Standardizer is connected through a 10X Attenuator.
- b. Set the Leveled Sine-Wave Generator and Signal Standardizer Amplitude controls to obtain a 6-division display (peak-to-peak) with the Signal Standardizer CW Leveled light on.
- c. Set the Leveled Sine-Wave Generator Frequency control to 1 GHz.
- d. Note the peak-to-peak amplitude of the displayed sine wave.
- e. Remove the Signal Standardizer and insert the 7A29 into the same compartment.
- f. Set the 7A29 VOLTS/DIV switch to 10 mV, and the AC-OFF-DC switch to DC.
- g. Connect the Leveled Sine-Wave Generator to the 7A29 INPUT connector through 10X and 2X Attenuators.
- h. Set the Leveled Sine-Wave Generator to the reference frequency and adjust its Amplitude control to display exactly 6 divisions (peak-to-peak).
- i. **CHECK**—Increase the Leveled Sine-Wave Generator output frequency to 1 GHz and check that the amplitude of the displayed signal is at least 88.5% of the deflection observed in part d.
- j. **CHECK**—Continue checking 1 GHz Gain for each position of the VOLTS/DIV switch, using the generator settings and results given in Table 5-6. In each position of the 7A29 VOLTS/DIV switch, the displayed amplitude must be at least 88.5% of the amplitude observed in part d above. In the last position, 88.5% of 4/6 (or 59%) of the amplitude in part d is required.

**TABLE 5-6**  
**1 GHz Gain**

Volts/Div Switch Setting	Leveled Sinewave Generator Amplitude (Set at Reference Frequency)	Attenuators Needed
10 mV	6 div	2X and 10X
20 mV	6 div	10X
50 mV	6 div	5X
0.1 V	6 div	2X
0.2 V	6 div	2X
0.5 V	6 div	NONE
1 V	4 div	NONE

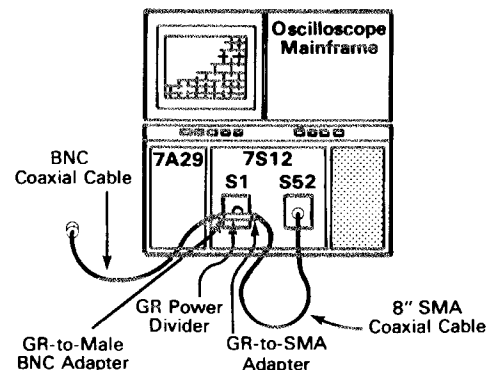
**B3. CHECK INPUT REFLECTION COEFFICIENT**

**NOTE**

If the preceding step was not performed, first perform step A1, then proceed.

**B3. SETUP CONDITIONS**

7A29 Controls:  
VOLTS/DIV.....10 mV  
AC-OFF-DC.....DC



Test Equipment Controls:  
Oscilloscope Mainframe  
Vertical Mode.....Right  
Horizontal Mode.....A  
Trigger Source.....Vertical Mode  
7S12  
Time/Div.....2 ns  
Range.....X 0.1  
mp.....Pushbutton in  
mp Selector Switch.....100  
High Resolution.....Pushbutton out  
Rep.....Pushbutton in  
Locate.....Pushbutton in  
Scan.....Fully clockwise  
Time-Distance.....0

2320-40



**Calibration Part I—7A29  
Performance Check**

**NOTE**

The 7A29 reflection coefficient is specified in a 1 GHz TDR (time domain reflectometry) system since this is its most common usage. There is a wide variety of 1 GHz sampling systems capable of making this measurement, and one such measurement is described. However, an experienced technician can frequently estimate the effects of increased TDR bandwidth on the measurement. Therefore the S-6 Sampling Head and S-52 Pulse Generator may be used to measure input reflection coefficient if the increased bandwidth is taken into consideration. The advantage of using an S-6 Sampling Head lies only in the reduced equipment requirement (no S-1 Sampling Head and Power Divider are needed).

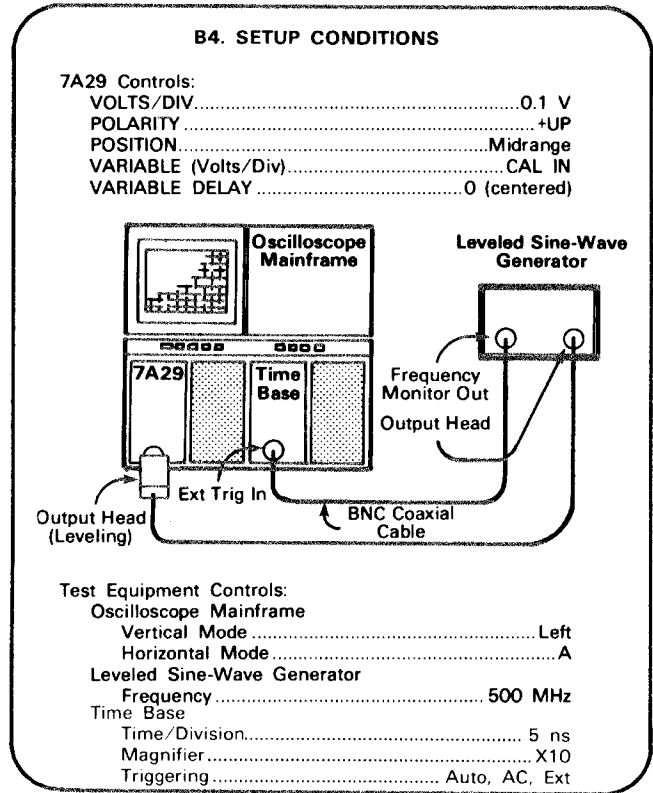
- a. Notice that a 2 ns (8") SMA Coaxial Cable and GR-to-SMA male Adapter is connected from the output of the S-52 pulse generator to one port of the Power Divider; the a second port is connected to the S-1 sampling head.
- b. Set the 7S12 mp Variable control to obtain a four-division reflection from the open cable. This calibrates the deflection factor at  $p = 0.25/\text{division}$ . Use the 7S12 Time-Distance control to set the reflection at the left-most graticule line.
- c. Connect the open cable from the Power Divider to the 7A29 INPUT connector.
- d. Set the 7S12 for 20 mp/division without disturbing the Variable setting. (This is equivalent to a  $p$  of 0.05/division.)
- e. Use the 7S12 DC Offset control to position the right edge of the trace with the center horizontal graticule line.
- f. **CHECK**—At each setting of the 7A29 VOLTS/DIV switch for less than one division deviation of the displayed waveform from the level established at the right-hand edge of the crt screen. This corresponds to a reflection coefficient of 5% or less.

**B4. CHECK OPTION 4 (VARIABLE DELAY)**

**NOTE**

Proceed to the next step if the 7A29 under test is not equipped with Option 4.

If the preceding step was not performed, first perform step B1, then proceed.



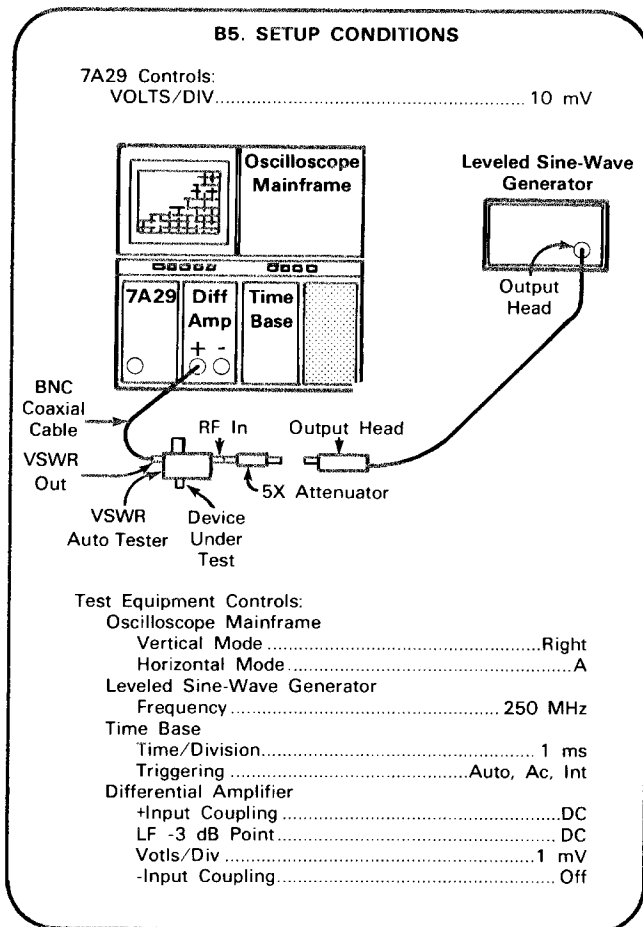
2320-41

- a. Set the Levelled Sine-Wave Generator Amplitude control to obtain a 6-division display.
- b. Move the rising portion of the sine wave to midscreen with the Time-Base Position control.
- c. **CHECK**—That the 7A29 VARIABLE DELAY control will move the rising portion of the sine wave at least 0.8 division on either side of the graticule center line.
- d. **CHECK**—That the total range of the VARIABLE DELAY control is at least 2 divisions.

**B5. CHECK VSWR**

**NOTE**

If the preceding step was not performed, first perform step B1, then proceed.



a. Install the 13 dB Return Loss SWR graticule (supplied with the VSWR Autotester) on the Oscilloscope Mainframe crt.

b. With the Output Head disconnected from the 5X Attenuator, align the Oscilloscope Mainframe trace with the 1.00 line on the 13 dB Return Loss SWR graticule.

c. Connect the Output Head to the 5X Attenuator and set the Leveled Sine-Wave Generator Amplitude control to align the Oscilloscope Mainframe trace with the 1.50 line on the 13 dB Return Loss SWR graticule.

d. Disconnect the 5X Attenuator and connect the output head directly to the VSWR Autotester.

e. Connect the VSWR Autotester Device Under Test connector directly to the 7A29 INPUT connector.

f. **CHECK (Standard 7A29)**—Observe that the oscilloscope trace remains between the 1:00 and 1:40 lines on the 13 dB Return Loss SWR graticule as the Leveled Sine-Wave Generator frequency is changed from 250 MHz to 1 GHz.

g. **CHECK (Standard 7A29)**—Perform step f for all other positions of the 7A29 VOLTS/DIV switch, observing that the oscilloscope trace remains between the 1:00 and 1:20 lines on the 13 dB Return Loss SWR graticule.

h. **CHECK (7A29 Option 4)**—Observe that the oscilloscope trace remains between the 1:00 and 1:50 lines on the 13 dB Return Loss SWR graticule as the Leveled Sine-Wave Generator frequency is changed from 250 MHz to 800 MHz.

i. **CHECK (7A29 Option 4)**—Perform step h for all positions of the 7A29 VOLTS/DIV switch.

## C. INPUT PROTECTION

**Equipment Required:** (Numbers correspond to those listed in Table 5-3, Test Equipment.)

- |                           |  |
|---------------------------|--|
| 1. Oscilloscope Mainframe | 15. BNC Coaxial Cable                            |
| 2. Time Base              | 21. Adapter (bnc female-to-alligator clip leads) |
| 10. Power Supply          |  |

### C1. INPUT PROTECTION PRELIMINARY SETUP

a. Perform the Performance Check Power-Up Sequence given at the beginning of Part I—Performance Check.

b. Refer to Section 6, Instrument Options, and the Change Information at the rear of this manual for any modifications which may affect this procedure.

c. Set 7A29 Amplifier controls:

VOLTS/DIV	..... 0.1 V
VARIABLE (Volts/Div)	..... CAL IN
POSITION	..... Midrange
POLARITY	..... +UP
AC-OFF-DC	..... OFF
VARIABLE DELAY (Option 4)	..... 0 (centered)

d. Set Oscilloscope Mainframe controls:

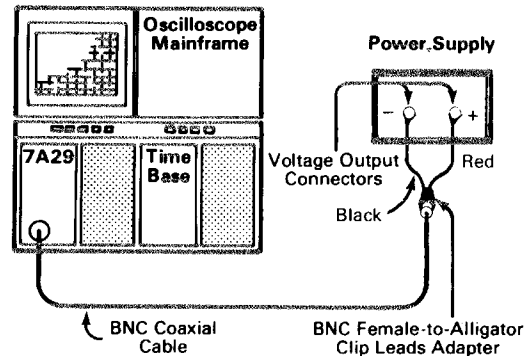
Power	..... On
Vertical Mode	..... Left
Horizontal Mode	..... A
Intensity	..... Visible display
Focus	..... Well-defined display
Trigger Source	..... Vertical mode

### CAUTION

To prevent damage to the 7A29, do not apply more than 12 volts to the INPUT connector unless the OVERLOAD RESET light is on.

### C2. SETUP CONDITIONS

7A29 Controls:  
AC-OFF-DC ..... DC



Oscilloscope Mainframe  
Vertical Mode ..... Left  
Horizontal Mode ..... A  
Power Supply  
Output Voltage ..... +1 V  
Current Limit ..... 1 Ampere  
Time Base  
Time/Division ..... 1 ms  
Magnifier ..... X1  
Triggering ..... Auto, AC, Int

2320-42

### C2. CHECK 10 VOLT INPUT PROTECTION

#### NOTE

First perform step C1, then proceed.

a. Increase the positive voltage applied to the 7A29 INPUT connector until the OVERLOAD RESET light turns on, but do not exceed 12 volts.

b. **CHECK**—The Power Supply output voltage should be between +8 and +12 volts.

c. Set the AC-OFF-DC switch to OFF.

- d. Set the Power Supply output voltage to 1 volt.
- e. Set the AC-OFF-DC switch to DC.
- f. Connect the negative output of the Power Supply to the 7A29 INPUT connector.
- g. Increase the negative voltage applied to the 7A29 INPUT connector until the OVERLOAD RESET light turns on, but do not exceed 12 volts.
- h. **CHECK**—The Power Supply output voltage should be between -8 and -12 volts.
- i. Set the AC-OFF-DC switch to OFF.



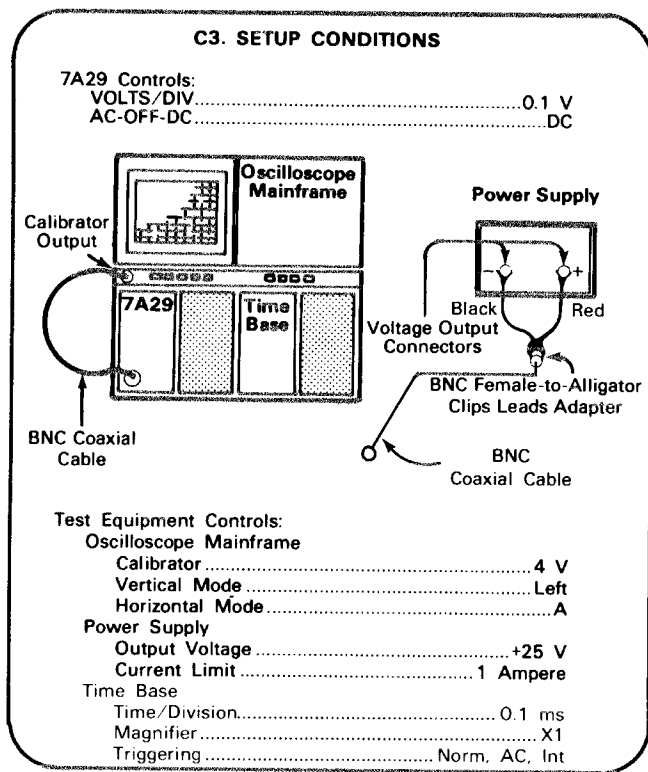
*To avoid damage to the 7A29, do not perform this procedure unless the 7A29 meets the specifications given in step C2.*

- a. Set the Time Base trigger Slope and Level controls to trigger on the positive-going portion of the square-wave signal.
- b. Position the trace to start at the first vertical graticule line and the bottom of the waveform to the center horizontal graticule line.
- c. Disconnect the BNC Coaxial Cable from the 7A29 INPUT connector.
- d. Set the 7A29 VOLTS/DIV switch to 1 V. (The 7A29 input protection works at all sensitivities; however, measurement of the input protection delay time is more convenient at the 1 V setting.)
- e. Set the Time Base Time/Div switch to 20 ms.

**C3. CHECK +25 V AND +50 V INPUT PROTECTION**

**NOTE**

*If the preceding step was not performed, first perform step C1, then proceed.*



2320-43

**NOTE**

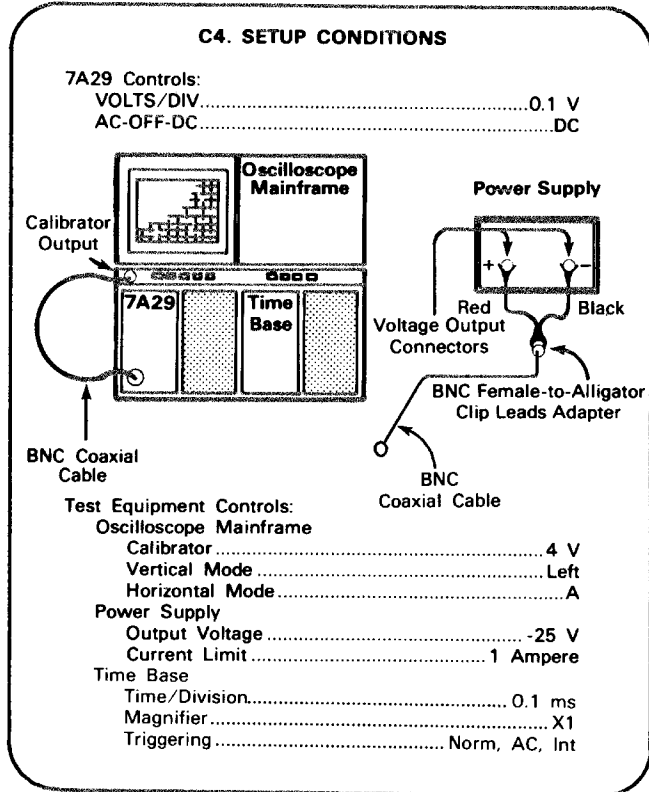
*You may need to repeat this test several times to observe the exact point of trace return. To reset the 7A29, set the AC-OFF-DC switch to OFF. Return the AC-OFF-DC switch to DC before repeating the test.*

- g. Set the Power Supply output to +50 volts.
- h. Set the Time Base Time/Div switch to 10 ms and the 7A29 AC-OFF-DC switch to DC.
- i. **CHECK**—Momentarily connect the BNC Coaxial Cable to 7A29 INPUT connector and observe that the trace returns to the display area in less than 30 milliseconds (3 divisions), and that the 7A29 OVERLOAD RESET light is activated.
- j. Set the AC-OFF-DC switch to OFF.
- k. Disconnect the BNC Coaxial Cable from the bnc female-to-clip leads Adapter.

**C4. CHECK -25 V AND -50 V INPUT PROTECTION**

**NOTE**

*If the preceding step was not performed, first perform steps C1 and C2, then proceed.*



2320-58

**CAUTION**

*To avoid damage to the 7A29, do not perform the following procedure unless the 7A29 meets the specifications given in step C2.*

- a. Set the Time Base trigger Slope control to trigger on the negative-going portion of the square-wave signal.
- b. Position the trace to start at the first vertical graticule line and the bottom of the waveform to the center horizontal graticule line.
- c. Disconnect the BNC Coaxial Cable from the 7A29 INPUT connector.
- d. Set the VOLTS/DIV switch to 1 V. (The 7A29 input protection works at all sensitivities; however, measurement of the input protection delay time is more convenient at the 1 V setting.)
- e. Set the Time Base Time/Div switch to 2 ms.
- f. **CHECK**—Momentarily connect the BNC Coaxial Cable from the Power Supply to the 7A29 INPUT connector and observe that the trace returns to the display area after 40 milliseconds (2 divisions) and before 150 milliseconds (7.5 divisions) of sweep has occurred, and that the OVERLOAD RESET light is activated on the 7A29.

**NOTE**

*You may need to repeat this test several times to observe the exact point of trace return. To reset the 7A29, first remove the -25 volt source, then set the AC-OFF-DC switch to OFF. Return the AC-OFF-DC switch to DC before repeating the test.*

- g. Set the Power Supply output to -50 volts.
- h. Set the Time Base Time/Div switch to 10 ms and the 7A29 AC-OFF-DC switch to DC.
- i. **CHECK**—Momentarily connect the BNC Coaxial Cable from the Power Supply to the 7A29 INPUT connector and observe that the trace returns to the display area in less than 30 milliseconds (3 divisions), and that the OVERLOAD RESET light of the 7A29 is activated.

This completes Part I—Performance Check.

# PART II—ADJUSTMENT AND PERFORMANCE CHECK

The following procedure (Part II—Adjustment and Performance Check) provides the information necessary to: (1) verify that the instrument meets the electrical specifications, (2) verify that the controls function properly, and (3) perform all internal adjustments.

Part I—Performance Check verifies that the instrument meets the electrical specifications without making internal adjustments. All tolerances given are as specified in the Specification tables (section 1) in this manual.

A separate Checkout Procedure is provided in section 2 for instrument familiarization and also to verify that the controls function properly.

See Table 5-1, Calibration Procedure Electives, at the beginning of this section, for information on performing a Partial Part II—Adjustment and Performance Check Procedure.

## INDEX TO PART II—ADJUSTMENT AND PERFORMANCE CHECK

	PAGE
A. LOW FREQUENCY .....	5-22
1. Low Frequency Preliminary Setup .....	5-22
2. Check/Adjust Input Current (R124) .....	5-22
3. Check/Adjust Input Resistance (R107) .....	5-23
4. Check/Adjust Variable Balance (R170 and R175) .....	5-23
5. Check Invert Balance .....	5-24
6. Adjust Position Centering (R270) .....	5-24
7. Adjust Trigger Balance (R365) .....	5-24
8. Check/Adjust Gain .....	5-25
9. Check/Adjust Low-Frequency Step Response (R140, R144, R146, R148, R150, R152, and C162) .....	5-26
10. Check AC Low-Frequency Response .....	5-27
B. HIGH FREQUENCY .....	5-29
1. High Frequency Preliminary Setup .....	5-29
2. Examine Amplifier Rise Time and Aberrations .....	5-29
3. Examine Trigger Rise Time and Aberrations .....	5-31
4. Check 1 GHz Gain .....	5-32
5. Check Input Reflection Coefficient .....	5-33
6. Check Option 4 (VARIABLE DELAY) .....	5-34
7. Check VSWR .....	5-35
C. INPUT PROTECTION .....	5-36
1. Input Protection Preliminary Setup .....	5-36
2. Check 10 Volt Input Protection .....	5-36
3. Check +25 V and +50 V Input Protection .....	5-37
4. Check -25 V and -50 V Input Protection .....	5-37

## ADJUSTMENT AND PERFORMANCE CHECK POWER-UP SEQUENCE

### NOTE

*The performance of this instrument can be checked at any ambient temperature from 0° to +50° C unless otherwise stated. Adjustments must be performed at an ambient temperature between +20° and +30° C for specified accuracies.*

1. Remove the side covers from the 7A29 and install it in the left vertical compartment of the Oscilloscope Mainframe.
2. Remove the left side cover of the Oscilloscope Mainframe to allow access to the 7A29 internal adjustments and test points.

### CAUTION

*To avoid instrument damage, it is recommended that the POWER switch be turned off before removing or replacing plug-in units.*

3. Install a Time Base unit in the Oscilloscope Mainframe B horizontal compartment.
4. Connect the Oscilloscope Mainframe to a suitable power source and turn on. Allow at least 20 minutes warmup before beginning the procedure.

## A. LOW FREQUENCY

**Equipment Required:** (Numbers correspond to those listed in Table 5-3, Test Equipment.)

- |                            |                                      |
|----------------------------|--------------------------------------|
| 1. Oscilloscope Mainframe  | 9. Low-Frequency Sine-Wave Generator |
| 2. Time Base               | 11. 50-Ohm Bridge                    |
| 3. Differential Amplifier  | 15. BNC Coaxial Cable (3 required)   |
| 4. Signal Standardizer     | 25. Attenuator (2X)                  |
| 6. Digital Voltmeter (DVM) | 28. Screwdriver                      |
| 7. Calibration Generator   |                                      |

### A1. LOW FREQUENCY PRELIMINARY SETUP

a. Perform the Adjustment and Performance Check Power-Up Sequence.

b. Refer to Section 6, Instrument Options, and the Change Information at the rear of this manual for any modifications which may affect this procedure.

c. See **TEST POINT AND ADJUSTMENT LOCATIONS** foldout page in Section 8, Diagrams and Circuit Board Illustrations.

d. Set 7A29 Amplifier controls:

VOLTS/DIV .....	0.1 V
VARIABLE (Volts/Div) .....	CAL IN
POSITION .....	Midrange
POLARITY .....	+UP
AC-OFF-DC .....	DC
VARIABLE DELAY (Option 4) .....	0 (centered)

e. Set Oscilloscope Mainframe controls:

Power .....	On
Vertical Mode .....	Left
Horizontal Mode .....	B
Intensity .....	Visible display
Focus .....	Well-defined display
Trigger Source .....	Vertical Mode

f. Set Time Base controls:

Time/Division .....	1 ms
Triggering .....	Auto, AC, Internal

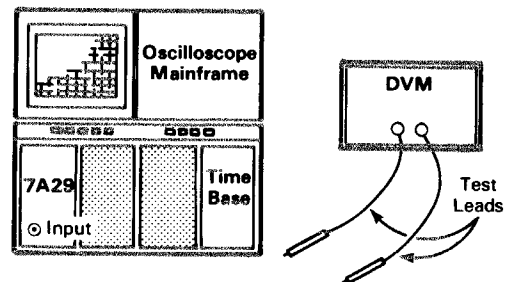
### A2. CHECK/ADJUST INPUT CURRENT (R124)

#### NOTE

*First perform step A1, then proceed.*

#### A2. SETUP CONDITIONS

7A29 Controls:  
VOLTS/DIV ..... 10 mV  
No external signals are connected to the 7A29.



Test Equipment Controls:  
DVM  
Voltage Range ..... 2 V dc (or max sensitivity)

2320-15

a. Connect the DVM (Digital Voltmeter) between the outer conductor and the inner conductor of the 7A29 INPUT connector.

- b. **CHECK**—The DVM for a reading of zero volts, within 2.5 mV.
- c. **ADJUST**—Input I adjustment (R124) for a DVM reading of less than 0.5 mV.
- d. Disconnect the DVM from the INPUT connector.

- c. **CHECK**—That the displayed square-wave amplitude is less than one division peak-to-peak.
- d. **ADJUST**—Z in adjustment (R107) for minimum amplitude of the displayed square wave.

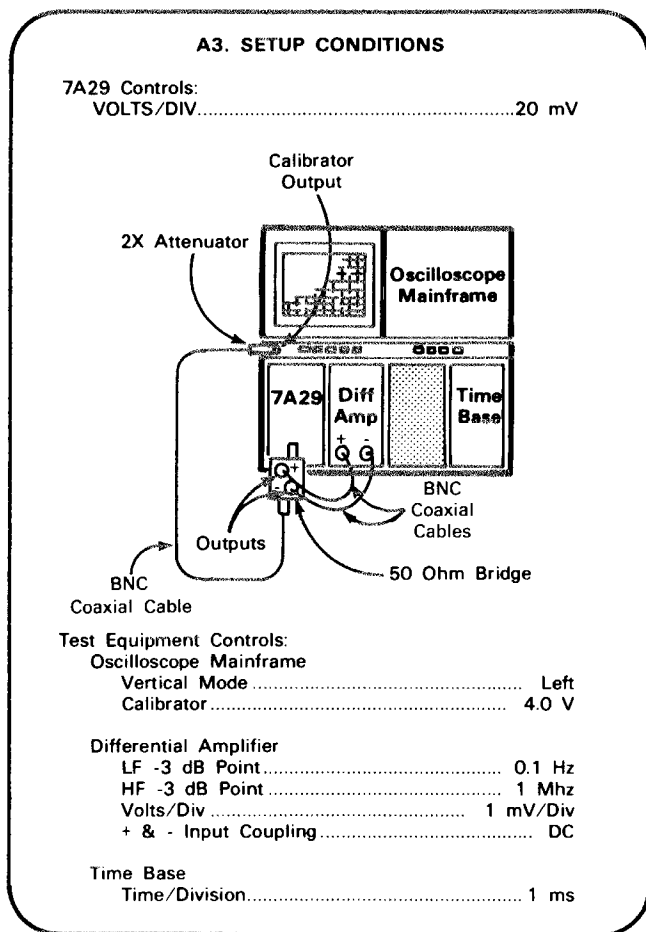
- e. **CHECK**—Each position of the 7A29 VOLTS/DIV switch for less than one division (peak-to-peak) of displayed square wave.

- f. Set the Oscilloscope Mainframe Vertical Mode switch to left. Remove 50 Ohm Bridge and Differential Amplifier.

### A3. CHECK/ADJUST INPUT RESISTANCE (R107)

#### NOTE

If the preceding step was not performed, first perform step A1, then proceed.



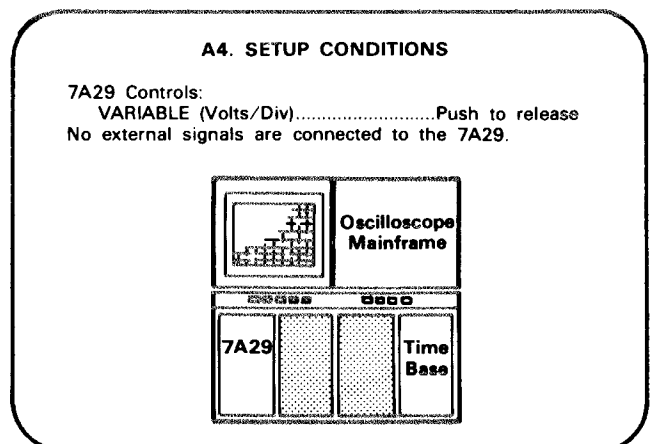
- a. With the 7A29 VOLTS/DIV switch set to 20 mV, notice approximately 5 divisions displayed on the crt.

- b. Set the 7A29 VOLTS/DIV switch to 10 mV and the Oscilloscope Mainframe Vertical Mode to Right.

### A4. CHECK/ADJUST VARIABLE BALANCE (R170 and R175)

#### NOTE

If the preceding step was not performed, first perform step A1, then proceed.



- a. Position the trace to the center horizontal graticule line.

- b. **CHECK**—The display for less than 0.2 division of vertical trace shift while rotating the VARIABLE (Volts/Div) control throughout its range. Repeat the check with the trace positioned at the top and then at the bottom of the graticule.

- c. With the POSITION control, return the trace to the center horizontal graticule line.

- d. **ADJUST**—+Up Var Bal (R170) for minimum vertical trace shift while rotating the VARIABLE (Volts/Div) control throughout its range.



**Calibration Part II—7A29  
Adjustment and Performance Check**

e. **CHECK**—Press the 7A29 IDENTIFY pushbutton and observe that the trace is deflected upward between 0.2 and 0.4 division. On Oscilloscope Mainframes equipped with readout, observe that the 7A29 readout display is replaced with the word IDENTIFY.

f. Set the POLARITY switch to INVERT and position the trace to the center horizontal graticule line.

g. **CHECK**—The display for less than 0.2 division vertical trace shift while rotating the VARIABLE (Volts/Div) control throughout its range. Repeat the check at the top and then at the bottom of the graticule.

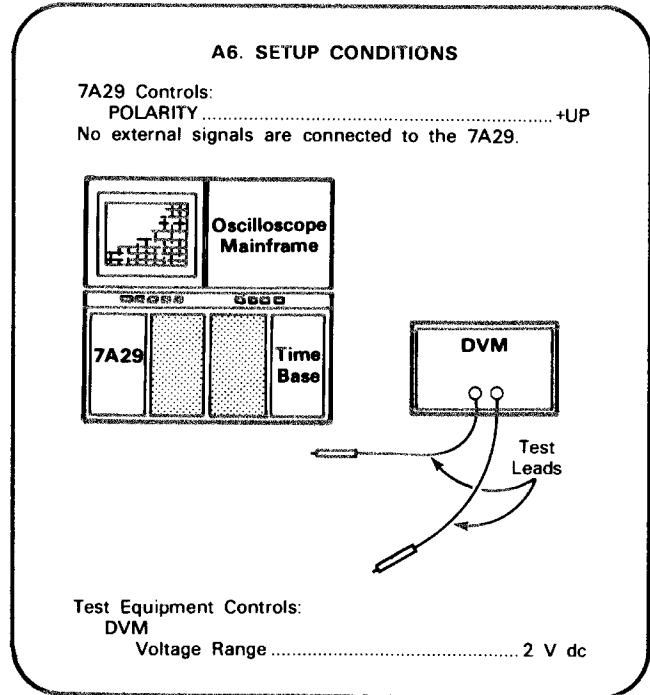
h. Return the trace to the center horizontal graticule line.

i. **ADJUST**—Invert Var Bal (R175) for less than 0.2 division of vertical trace shift while rotating the VARIABLE (Volts/Div) control throughout its range.

**A6. ADJUST POSITION CENTERING (R270)**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed.*

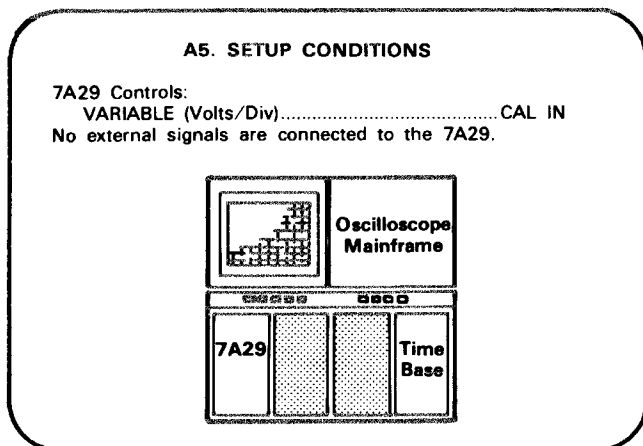


2320-18

**A5. CHECK INVERT BALANCE**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed.*



2320-17

a. **CHECK**—For less than 0.5 division trace shift when changing the POLARITY switch from +UP to INVERT.

a. Connect the DVM between TP249 and ground.

b. Adjust the POSITION control to obtain a reading of less than 0.05 V on the DVM.

c. Connect the DVM between solder points M and K of the Main Amplifier board. (Solder points M and K are located 1.5 inches from the rear edge of the board.)

d. **EXAMINE**—For a DVM reading of less than 20 mV.

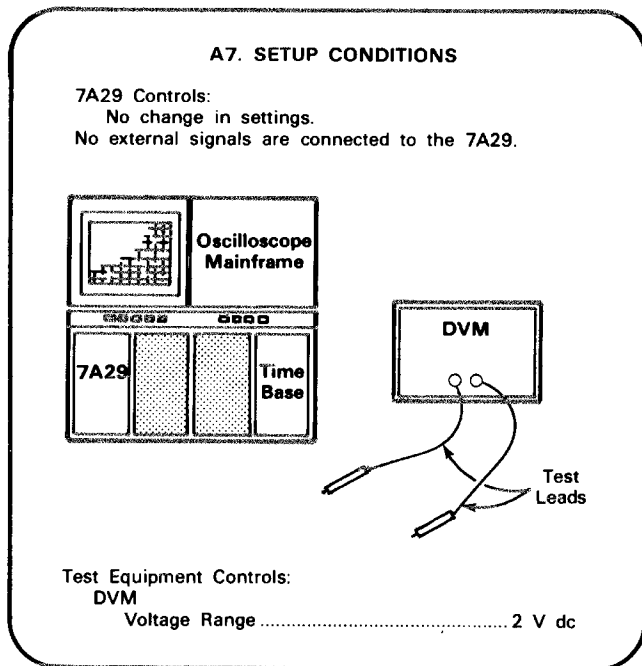
e. **ADJUST**—Pos Center adjustment (R270) for a DVM reading of less than 5 mV.

f. Disconnect the DVM.

**A7. ADJUST TRIGGER BALANCE (R365)**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed.*

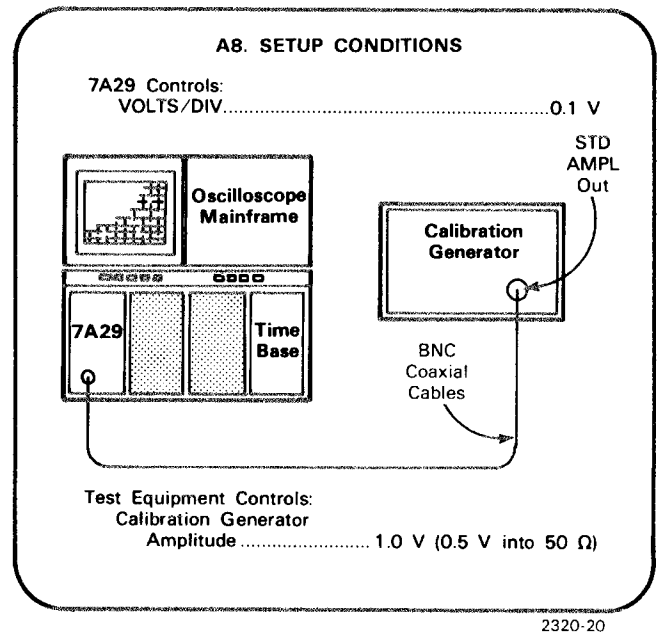


- a. Connect the DVM between solder points M and K of the Main Amplifier board. (Solder points M and K are located 1.5 inches from the rear edge of the board.)
- b. Set the POSITION control to obtain a DVM reading of less than 5 mV.
- c. Disconnect the DVM from solder points M and K and reconnect it between solder points D and E. (Solder points D and E are located directly above points M and K.)
- d. **EXAMINE**—For a DVM reading of less than 20 mV.
- e. **ADJUST**—Trigger Bal adjustment (R365) for a DVM reading of less than 5 mV.
- f. Disconnect the DVM.

## A8. CHECK/ADJUST GAIN

### NOTE

*If the preceding step was not performed, first perform A1, then proceed.*



- a. Set the Calibration Generator for a 0.5-volt square wave into 50 ohms (1.0 volt into an open circuit).

### NOTE

*It is essential that the Oscilloscope Mainframe sensitivity be properly adjusted prior to performing this step. Check the Oscilloscope Mainframe Instruction Manual for adjustment procedure.*

- b. **CHECK**—Rotate the GAIN control fully clockwise and observe at least 5.15 divisions of displayed square-wave signal.
- c. **CHECK**—Rotate the GAIN control fully counterclockwise and observe 4.85 divisions, or less, of displayed square-wave signal.
- d. **ADJUST**—The GAIN control for exactly 5 divisions of square-wave signal.
- e. **CHECK**—Using the VOLTS/DIV and Calibration Generator settings given in Table 5-7, check that the vertical deflection is correct within 2% for each position of the VOLTS/DIV switch.
- f. Push to release the VARIABLE (Volts/Div) control.
- g. Rotate the VARIABLE (Volts/Div) control fully counterclockwise.
- h. **CHECK**—For 1.9 divisions or less of displayed square wave.
- i. Change the POLARITY switch to INVERT.

Calibration Part II—7A29  
Adjustment and Performance Check

TABLE 5-7  
Vertical Deflection Accuracy

Volts/Div Switch Setting	Calibration Generator Output (open circuit)	Vertical Deflection in Divisions	Maximum Error in Divisions
10 mV	0.1 V	5	±0.1
20 mV	0.2 V	5	±0.1
50 mV	0.5 V	5	±0.1
.2 V	2.0 V	5	±0.1
.5 V	5.0 V	5	±0.1
1 V	10 V	5	±0.1

j. **CHECK**—For 1.9 divisions or less of displayed square wave.

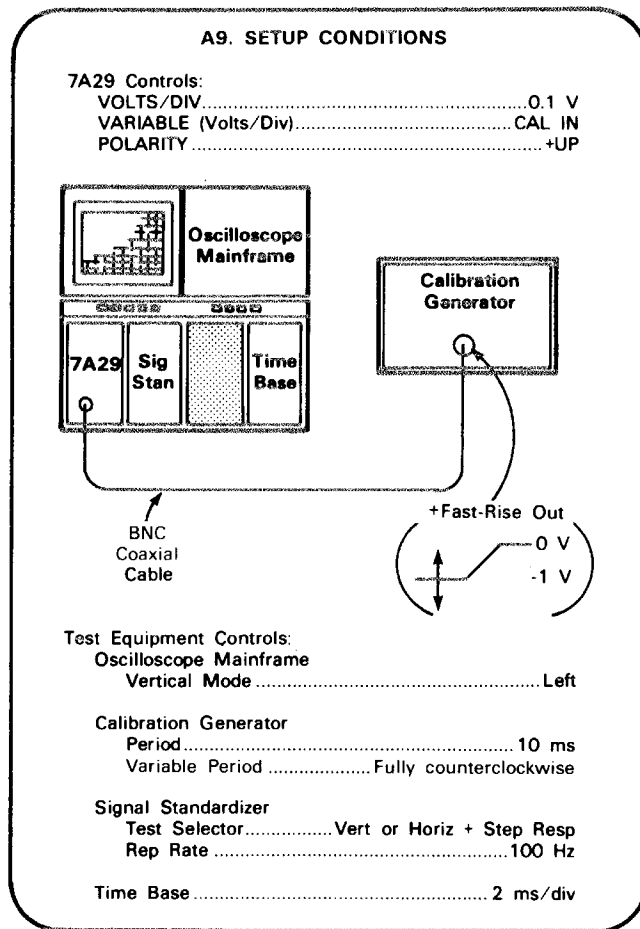
k. **ADJUST**—Min Gain adjustment (R212) for 1.9 divisions of displayed square wave in whichever position of the POLARITY switch yielded the larger amplitude signal.

l. Disconnect the Calibration Generator from the 7A29.

**A9. CHECK/ADJUST LOW-FREQUENCY STEP RESPONSE (R140, R144, R146, R148, R150, R152, and C162)**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed with the following instructions.*



2320-21

a. Set the Calibration Generator Amplitude control to display 8 divisions of signal centered on the Oscilloscope Mainframe crt.

b. Set the Oscilloscope Mainframe Vertical Mode to Right.

c. Set the Signal Standardizer Amplitude control to display 8 divisions of signal centered on the crt.

d. Set the Oscilloscope Mainframe Vertical Mode to Alternate.

e. Set the Variable Period control on the Calibration Generator to perfectly align both displayed signals at all frequencies used in the following steps. Make sure the amplitudes of both displayed signals are equal.

f. Position the most positive portions of both waveforms approximately 1.5 divisions below the top graticule line on the Oscilloscope Mainframe crt. Overlay the two waveforms at a point 2.5 divisions after the positive transition using the 7A29 POSITION control.

g. **CHECK**—The two waveforms must not separate more than 0.1 division (ignore discrepancies which occur within 10 nanoseconds of the positive transition). Make the same comparison, with the control settings listed in Table 5-8, Control Settings for Low-Frequency Step Response. If this performance is adequate, proceed to step A10.

**TABLE 5-8**  
**Control Setting for Low-Frequency Step Response**

Calibration Generator Period	Signal Standardizer Rep Rate	Time Base Time/Div
10 ms	100 Hz	2 ms
1 ms	1 kHz	0.2 ms
.1 ms	10 kHz	20 $\mu$ s
10 $\mu$ s	100 kHz	2 $\mu$ s

h. Set the Signal Standardizer Rep Rate to 100 Hz, the Time Base Time/Div switch to 2 ms and the Calibration Generator Period to 10 ms.

i. **ADJUST**—Comp #1 (R152) and Comp #2 (R150) for minimum separation between the two waveforms. (Performing this adjustment may be aided by superimposing the two waveforms.)

j. Set the Rep Rate of the Signal Standardizer to 1 kHz and the Period of the Calibration Generator to 1 ms.

k. Set the Time Base Time/Div switch to 0.2 ms.

l. **ADJUST**—Comp #3 (R148) and Comp #4 (R146) for minimum separation between the waveforms.

m. Set the Rep Rate of the Signal Standardizer to 10 kHz and the Period of the Calibration Generator to 0.1 ms.

n. Set the Time Base Time/Div switch to 20  $\mu$ s.

o. **ADJUST**—Comp #5 (R144) and Comp #6 (R140) for minimum separation between the waveforms.

p. Set the Rep Rate of the Signal Standardizer to 100 kHz and the Period of the Calibration Generator to 10  $\mu$ s.

q. Set the Time Base Time/Div switch to 2  $\mu$ s.

r. **ADJUST**—Comp #6 (R140) and Comp #7 (C162) for minimum separation between the waveforms.

**NOTE**

*Neither R140 or C162 will affect the first 0.1  $\mu$ s of the 100-kHz square wave.*

s. **INTERACTION**—All adjustments in this step will interact. If any of the ADJUST parts were performed, repeat steps g through r of this step to ensure instrument performance.

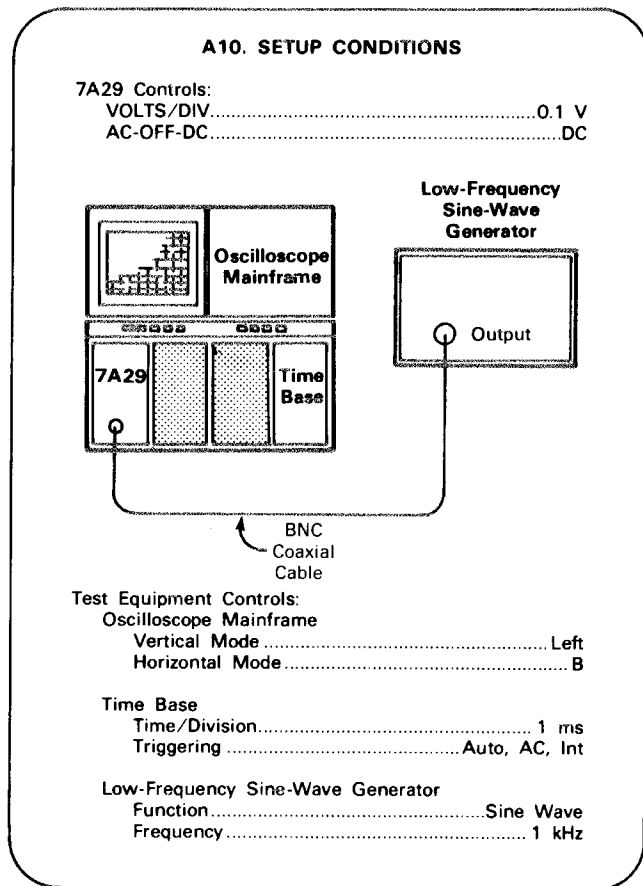
t. Remove the Signal Standardizer from the Oscilloscope Mainframe Right Vertical Compartment and disconnect the Calibration Generator from the 7A29 input.

u. **INTERACTION**—Some adjustments in this step will affect the adjustment of the GAIN control; repeat step A8 to check.

**A10. CHECK AC LOW-FREQUENCY RESPONSE**

**NOTE**

*If the preceding step was not performed, first perform step A1, then proceed.*



2320-23

**Calibration Part II—7A29**  
**Adjustment and Performance Check**

- a. Set the Low Frequency Sine-Wave Generator Amplitude Control to display a 6-division sine wave.
- b. Set the AC-OFF-DC switch to AC.
- c. **CHECK**—For at least 4.25 divisions of displayed sine-wave signal.

## B. HIGH FREQUENCY

**Equipment Required:** (Numbers correspond to those listed in Table 5-3, Test Equipment.)

- |  |                                      |
|--|--------------------------------------|
| 1. Oscilloscope Mainframe                | 19. Adapter (sma male-to-bnc female) |
| 2. Time Base                             | 20. Adapter (bnc male-to-bnc male)   |
| 4. Signal Standardizer                   | 22. Attenuator (5X)                  |
| 5. Sampling System                       | 23. Terminator (sma, 2 required)     |
| 8. Leveled Sine-Wave Generator           | 24. Attenuator (10X)                 |
| 12. Signal Pickoff Fixture               | 25. Attenuator (2X)                  |
| 13. Flexible Plug-In Extender            | 26. Power Divider                    |
| 14. Sampling Head Extender               | 27. VSWR Autotester                  |
| 15. BNC Coaxial Cable (3 required)       | 28. Screwdriver                      |
| 16. SMA Coaxial Cable                    | 29. Insulated Screwdriver            |
| 17. Adapter (Peltola-to-GR, 2 required)  |                                      |
| 18. Adapter (sma male-to-GR, 2 required) |                                      |

### B1. HIGH-FREQUENCY PRELIMINARY SETUP

a. Perform the Adjustment and Performance Check Power-Up Sequence given at the beginning of Part II—Adjustment and Performance Check.

b. Refer to Section 6, Instrument Options, and the Change Information at the rear of this manual for any modifications which may affect this procedure.

c. See **TEST POINT AND ADJUSTMENT LOCATIONS** foldout page in Section 8, Diagrams and Circuit Board Illustrations.

d. Set 7A29 Amplifier controls:  
 VOLTS/DIV ..... 0.1 V  
 VARIABLE (Volts/Div) ..... CAL IN  
 POSITION ..... Midrange  
 POLARITY ..... +UP  
 AC-OFF-DC ..... DC  
 VARIABLE DELAY (Option 4) ..... 0 (centered)

e. Set Oscilloscope Mainframe controls:

Power ..... On  
 Vertical Mode ..... Right  
 Horizontal Mode ..... B  
 Intensity ..... Visible display  
 Focus ..... Well-defined display  
 Trigger Source ..... Vertical Mode

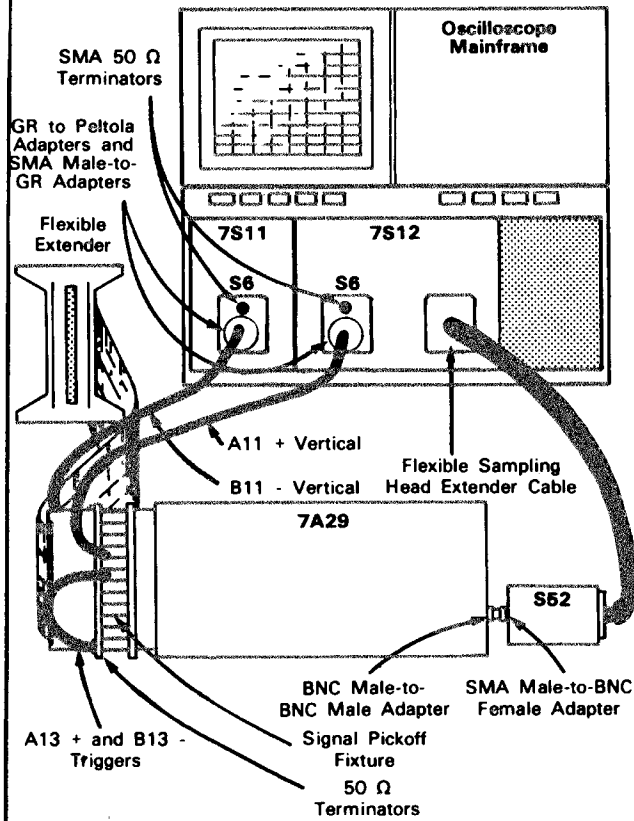
### B2. EXAMINE AMPLIFIER RISE TIME AND ABERRATIONS

#### NOTE

*First perform step B1, then proceed.*

**B2. SETUP CONDITIONS**

7A29 Controls:  
VOLTS/DIV.....50 mV  
POLARITY.....+UP  
AC-OFF-DC.....DC  
VARIABLE C.....CAL IN



**NOTE**

For additional setup information refer to parts a through f of this step.

Test Equipment Controls:  
Oscilloscope Mainframe  
Vertical Mode.....Right  
Horizontal Mode.....A  
7S12  
Variable (Cal In).....50 mV and pushbutton in  
DC Offset.....Midrange  
Locate/Scan.....Pushbutton in  
Rep.....Pushbutton in  
Time/Div  
Range.....X0.1  
Sweep Rate.....1 ns  
High Resolution.....Pushbutton out  
mV.....Pushbutton in  
Scan.....Midrange  
Time Distance.....0  
7S11  
DC Offset.....Midrange  
Invert.....Pushbutton in  
Dot Response.....Midrange (Normal)  
Variable (Cal In).....50 mV and pushbutton in

**NOTE**

The following procedure presumes the availability of a perfect pulse generator/sampler system (without aberrations). Because the 7A29 Amplifier transient response specification requires less than 8% deviation from a perfect step, verifying the particular pulse generator/sampler system used in this procedure is necessary.

To observe the test system transient response, use a Power Divider to connect the Pulse Generator to both sampling heads simultaneously, and set the Oscilloscope Mainframe Vertical Mode to Add.

Even short cables (less than 1 foot in length) contribute observable high-frequency loss. The effects of any cables used to observe the pulse generator/sampler system response must be accounted for.

Aberrations of the pulse generator/sampler system which have components above 1.5 GHz (those which last for less than approximately 250 picoseconds) will be attenuated by the 7A29 and should not be of concern here. However, aberrations of the pulse generator/sampler system below 1.5 GHz should be duplicated when viewed through the 7A29. Only an experienced technician should attempt to delineate various aberration sources.

No substitutions should be made in the Setup Conditions for either the S-52 or S-6 which, in combination, are relatively free from aberrations. The S-52 must not be used to check the 7104/7A29 transient response, instead we recommend the 067-0681-01 for this purpose.

a. Using a Peltola-to-GR adapter and a GR-to-SMA male adapter, connect the positive vertical line (A11, labeled on coaxial cable) from the Signal Pickoff Fixture to the lower input connector on the S-6 head in the 7S12.

b. Connect the negative vertical line (B11, labeled on coaxial cable) of the Signal Pickoff Fixture to the lower input connector on the S-6 head in the 7S11 using a Peltola-to-GR adapter and a GR-to-SMA male adapter. Do not plug the Flexible Plug-In Extender into the Oscilloscope Mainframe yet.

c. Connect the + and - trigger lines (A13 and B13) to the 50-ohm terminations on the Signal Pickoff Fixture.

d. Connect a 50-Ohm SMA Termination to the upper input connector of each S-6 head.

e. Connect the S-52 pulse generator output to the 7A29 INPUT connector using a SMA male-to-bnc female Adapter and a bnc male-to-bnc male Adapter.

f. Connect the Sampling Head Extender to the S-52 sampling pulse generator.

g. Set the 7S12 DC Offset control to center the trace on the crt graticule.

h. Change the Vertical Mode of the Oscilloscope Mainframe to Left.

i. Set the 7S11 DC Offset control to center the trace on the crt graticule.

j. Change the Vertical Mode of the Oscilloscope Mainframe to Chop, and install the Flexible Plug-In Extender in the Oscilloscope Mainframe B Horizontal compartment.

k. With the 7S12 Time/Distance control, position the front-corners of the waveforms to midscreen, then use the 7S11 Delay and DC Offset controls to position the leading edges of the two waveforms so they coincide.

**NOTE**

*For the remainder of procedure B2, use only the 7A29 POSITION control to position the display vertically.*

l. Set the 7S12 and 7S11 Variable mV/Div controls for 2.5 divisions for each displayed pulse.

m. Change the Vertical Mode of the Oscilloscope Mainframe to Add.

**NOTE**

*Slight misadjustment of the 7S11 Delay control will degrade the rise time of the pulse. Adjust the Delay control to obtain an optimum square corner with minimum rise time.*

n. **EXAMINE**—For less than 0.5 division (peak-to-peak) of front-corner aberrations and for less than 0.4 division of overshoot or 0.15 division undershoot.

o. With 5.0 divisions of signal still displayed, adjust the 7A29 POSITION control to position the pulse with the graticule lines marked 0 and 100%.

p. Set the 7S12 for 0.1 nanoseconds/division.

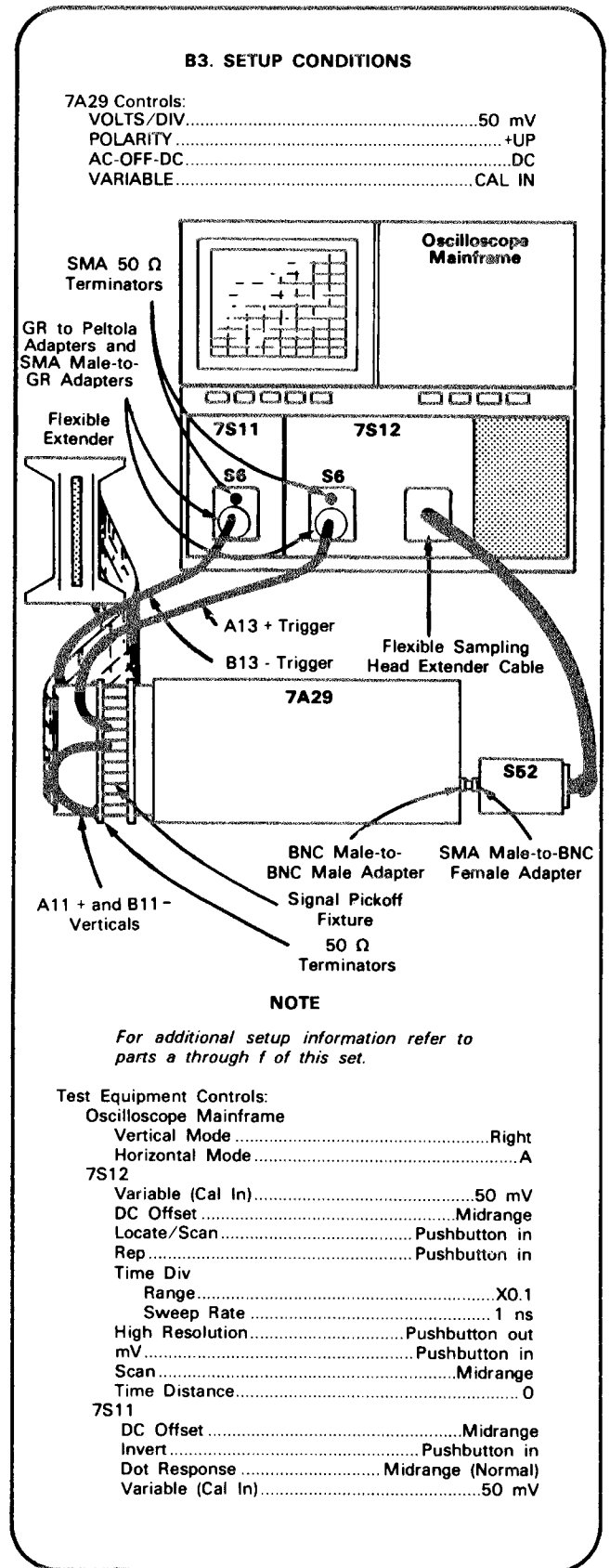
q. Position the leading edge of the displayed pulse to midscreen using the 7S12 Time-Distance control.

r. **EXAMINE**—For less than 290 picoseconds of rise time between the 10% and 90% graticule points.

**B3. EXAMINE TRIGGER RISE TIME AND ABERRATIONS**

**NOTE**

*If the preceding step was not performed, first perform step B1 and B2, then proceed.*



2320-25



**Calibration Part II—7A29  
Adjustment and Performance Check**

**NOTE**

*This procedure is identical to step B2 except that the trigger and vertical lines of the signal pickoff fixture are interchanged and the specifications are relaxed.*

- a. Using a Peltola-to-GR Adapter and a GR-to-SMA male Adapter, connect the positive trigger line (A13, labeled on coaxial cable) from the Signal Pickoff Fixture to the lower input connector on the S-6 head in the 7S12.
- b. Connect the negative trigger line (B13, labeled on coaxial cable) from the Signal Pickoff Fixture to the lower input connector on the S-6 head in the 7S11 using a Peltola-to-GR Adapter and a GR-to-SMA male Adapter. Do not plug the Flexible Plug-In Extender into the Oscilloscope Mainframe yet.
- c. Connect the + and - vertical lines (A11 and B11, labeled on coaxial cable) to the 50-Ohm Terminations on the Signal Pickoff Fixture.
- d. Connect a 50-Ohm SMA termination to the upper input connector of each S-6 head.
- e. Connect the S-52 pulse generator output to the 7A29 INPUT connector using a SMA male-to-bnc female Adapter and a bnc male-to-bnc male Adapter.
- f. Connect the Sampling Head Extender to the S-52 sampling pulse generator.
- g. Set the 7S12 DC Offset control to center the trace on the crt graticule.
- h. Change the Vertical Mode of the Oscilloscope Mainframe to Left.
- i. Set the 7S11 DC Offset control to center the trace on the crt graticule.
- j. Change the Vertical Mode of the Oscilloscope Mainframe to Chop, and install the Flexible Plug-In Extender in the Oscilloscope Mainframe B Horizontal compartment.
- k. Use the 7S11 Delay control to position the leading edge of the two waveforms so they coincide.

**NOTE**

*For the remainder of this step (B3), use only the 7A29 POSITION control to position the display vertically.*

- l. Set the 7S12 and 7S11 Variable mV/Div controls for 2.5 divisions of displayed pulse.
- m. Change the Vertical Mode of the Oscilloscope Mainframe to Add.

**NOTE**

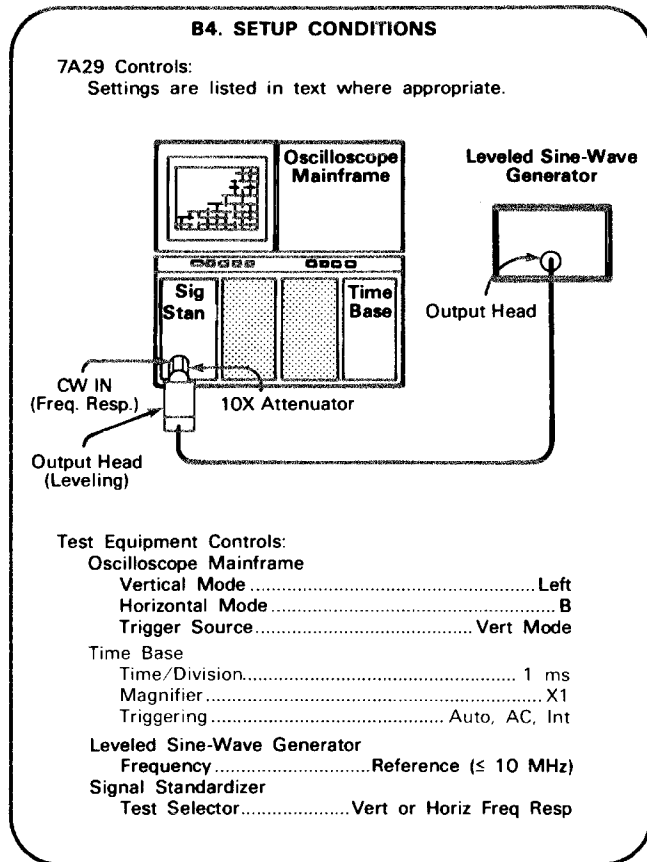
*Slight misadjustment of the 7S11 Delay control will degrade the rise time of the pulse. Adjust the Delay control to obtain an optimum square corner, with minimum rise time.*

- n. Set the 7S12 Time/Div for 1 ns and adjust the Time-Distance control to center the leading edge of the pulse to midscreen.
- o. **EXAMINE**—For less than 0.8 division (peak-to-peak) of front-corner aberrations, and for less than 0.40 division of overshoot or undershoot.
- p. With 5.0 divisions still displayed, adjust the 7A29 POSITION control to position the pulse with the graticule lines marked 0% and 100%.
- q. Set the 7S12 for 0.1 ns/division.
- r. Position the leading edge of the pulse to midscreen with the 7S12 Time-Distance control.
- s. **EXAMINE**—For less than 320 picoseconds of rise time between the 10% and 90% graticule points.

**B4. CHECK 1 GHz GAIN**

**NOTE**

*If the preceding step was not performed, first perform step B1, then proceed.*



**NOTE**

The 7A29 frequency response at 1 GHz is required to be no less than 88.5% of its low frequency value. The response of any measurement equipment is tested and factored out of the following procedure.

The 7104 is used as a detector in the following procedure because it offers better trace definition and superior triggering to the sampling equipment used in steps B2 and B3. The sampling setup of step B2 may be used in place of this procedure if preferred.

- Notice that the output of the Leveled Sine-Wave Generator to the CW In connector of the Signal Standardizer is connected through a 10X Attenuator.
- Set the Leveled Sine-Wave Generator and Signal Standardizer Amplitude controls to obtain a 6-division display (peak-to-peak) with the Signal Standardizer CW Leveled light on.
- Set the Leveled Sine-Wave Generator Frequency to 1 GHz.
- Note the peak-to-peak amplitude of the displayed sine-wave signal.

- Remove the Signal Standardizer and insert the 7A29 into the same compartment.
- Set the 7A29 VOLTS/DIV switch to 10 mV, and the AC-OFF-DC switch to DC.
- Connect the Leveled Sine-Wave Generator to the 7A29 INPUT connector through 10X and 2X attenuators.
- Set the Leveled Sine-Wave Generator to the reference frequency and adjust its Amplitude control to display exactly 6 divisions (peak-to-peak).
- CHECK**—Increase the Leveled Sine-Wave Generator output frequency to 1 GHz and check that the amplitude of the displayed signal is at least 88.5% of the deflection observed in part d. (Amplitude noted in part i divided by amplitude noted in part d should be greater than 0.885%.)
- CHECK**—Continue checking 1 GHz Gain for each position of the VOLTS/DIV switch, using the generator settings and results given in Table 5-9. In each position of the 7A29 VOLTS/DIV switch, the displayed amplitude must be at least 88.5% of the amplitude observed part d above. In the last position (1 V/DIV) two-thirds of 88.5% (or 59%) of the amplitude in part d is required.

**TABLE 5-9**  
Vertical Amplifier Frequency Gain

Volts/Div Switch Setting	Leveled Sinewave Generator Amplitude (Set at Reference Frequency)	Attenuators Needed
10 mV	6 div	2X and 10X
20 mV	6 div	10X
50 mV	6 div	5X
0.1 V	6 div	2X
0.2 V	6 div	2X
0.5 V	6 div	NONE
1 V	4 div	NONE

**B5. CHECK INPUT REFLECTION COEFFICIENT**

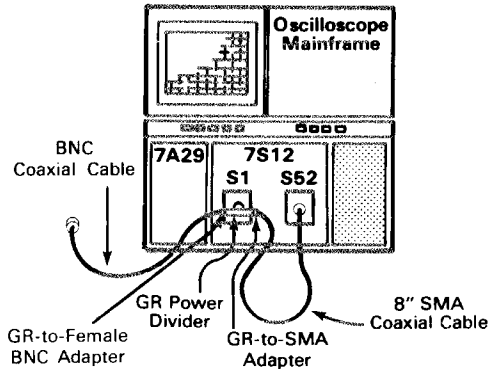
**NOTE**

If the preceding step was not performed, first perform step B1, then proceed.

Calibration Part II—7A29  
Adjustment and Performance Check

**B5. SETUP CONDITIONS**

7A29 Controls:  
VOLTS/DIV ..... 10 mV  
AC-OFF-DC ..... DC



Test Equipment Controls:  
Oscilloscope Mainframe  
Vertical Mode ..... Right  
Horizontal Mode ..... A  
Trigger Source ..... Vertical Mode  
7S12  
Time/Div ..... 2 ns  
Range ..... X 0.1  
mp ..... Pushbutton in  
mp Selector Switch ..... 100  
High Resolution ..... Pushbutton out  
Rep ..... Pushbutton in  
Locate ..... Pushbutton in  
Scan ..... Fully clockwise  
Time-Distance ..... 0

2320-27

**NOTE**

The 7A29 reflection coefficient is specified in a 1 GHz TDR (time domain reflectometry) system since this is its most common usage. There is a wide variety of 1 GHz sampling systems capable of making this measurement, and one such measurement is described. However, an experienced technician can frequently estimate the effects of increased TDR bandwidth on the measurement. Therefore the S-6 Sampling Head and S-52 Pulse Generator may be used to measure the input reflection coefficient if the increased bandwidth is taken into consideration. The advantage of using the S-6 Sampling Head lies only in the reduced equipment requirement (no S-1 Sampling Head and Power Divider are needed).

a. Notice that a 2 ns (8") SMA Coaxial Cable and GR-to-SMA male Adapter is connected from the output of the S-52 pulse generator to one port of the Power Divider; the second port is connected to the S-1 sampling head.

b. Set the 7S12 mp Variable control to obtain a four-division reflection from the open 18" BNC Coaxial Cable. This calibrates the deflection factor at  $p=0.25$ /division. Use the 7S12 Time-Distance control to set the reflection at the left-most graticule line.

c. Connect the open cable from the Power Divider to the 7A29 INPUT connector.

d. Set the 7S12 for 20 mp/division, without disturbing the Variable setting ( $p=0.05$ /division).

e. Use the 7S12 DC Offset control to position the right edge of the trace with the center horizontal graticule line.

f. **CHECK**—At each setting of the 7A29 VOLTS/DIV switch for less than one division deviation of the displayed waveform from the level established at the right-hand edge of the crt screen. This corresponds to a reflection coefficient of 5% or less.

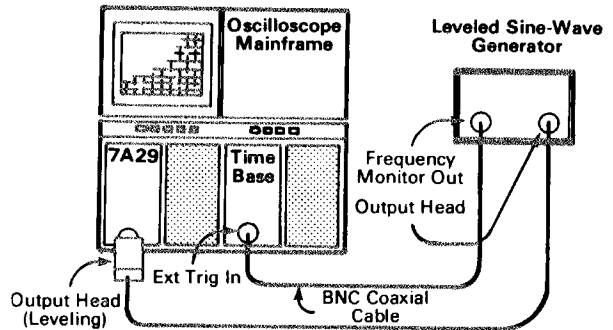
**B6. CHECK OPTION 4 (VARIABLE DELAY)**

**NOTE**

Proceed to the next step if the 7A29 under test is not equipped with Option 4. If the preceding step was not performed, first perform step B1, then proceed.

**B6. SETUP CONDITIONS**

7A29 Controls:  
VOLTS/DIV ..... 0.1 V  
POLARITY ..... +UP  
POSITION ..... Midrange  
VARIABLE (Volts/Div) ..... CAL IN  
VARIABLE DELAY ..... 0 (centered)



Test Equipment Controls:  
Oscilloscope Mainframe  
Vertical Mode ..... Left  
Horizontal Mode ..... A  
Levelled Sine-Wave Generator  
Frequency ..... 500 MHz  
Time Base  
Time/Division ..... 5 ns  
Magnifier ..... X10  
Triggering ..... Auto, AC, Ext

2320-28

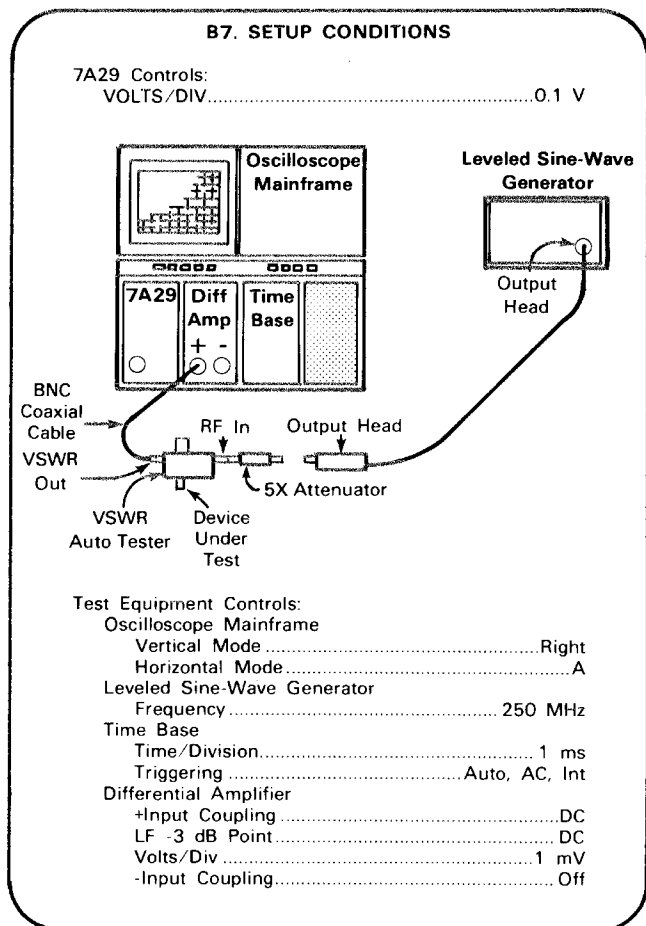
- a. Set the Leveled Sine Wave Generator controls to obtain a 6-division display at 500 megahertz.
- b. Move the rising portion of the sine wave to midscreen with the Time Base Position control.
- c. **CHECK**—That the 7A29 Option 4 VARIABLE DELAY control will move the rising portion of the sine wave at least 0.8 division on either side of the graticule center line.
- d. **CHECK**—That the total range of the Option 4 VARIABLE DELAY control is at least 2 divisions.

- a. Install the 13 dB Return Loss SWR graticule (supplied with the VSWR Autotester) on the Oscilloscope Mainframe crt.
- b. With the Output Head disconnected from the 5X Attenuator, align the Oscilloscope Mainframe trace with the 1.00 line on the 13 dB Return Loss SWR graticule.
- c. Connect the Output Head to the 5X Attenuator and set the Leveled Sine-Wave Generator Amplitude control to align the Oscilloscope Mainframe trace with the 1.50 line on the 13 dB Return Loss SWR graticule.
- d. Disconnect the 5X Attenuator and connect the Output Head directly to the VSWR Autotester.
- e. Connect the VSWR Autotester Device Under Test connector directly to the 7A29 INPUT connector.

**B7. CHECK VSWR**

**NOTE**

*If the preceding step was not performed, first perform step B1, then proceed.*



2320-45

- f. **CHECK (Standard 7A29)**— Observe that the oscilloscope trace remains between the 1:00 and 1:40 lines on the 13 dB Return Loss SWR graticule as the Leveled Sine-Wave Generator frequency is changed from 250 MHz to 1 GHz.
- g. **CHECK (Standard 7A29)**—Perform step f for all other positions of the 7A29 VOLTS/DIV switch, observing that the oscilloscope trace remains between the 1:00 and 1:20 lines on the 13 dB. Return Loss SWR graticule.
- h. **CHECK (7A29 Option 4)**—Observe that the Oscilloscope Mainframe trace remains between the 1:00 and 1:50 lines on the 13 dB Return Loss SWR graticule as the Leveled Sine-Wave Generator frequency is changed from 250 MHz to 800 MHz.
- i. **CHECK (7A29 Option 4)**—Perform step f for all positions of the 7A29 VOLTS/DIV switch.

## C. INPUT PROTECTION

**Equipment Required:** (Numbers correspond to those listed in Table 5-3, Test Equipment.)

- |                           |  |
|---------------------------|--|
| 1. Oscilloscope Mainframe | 15. BNC Coaxial Cable                            |
| 2. Time Base              | 21. Adapter (bnc female-to-alligator clip leads) |
| 10. Power Supply          |  |

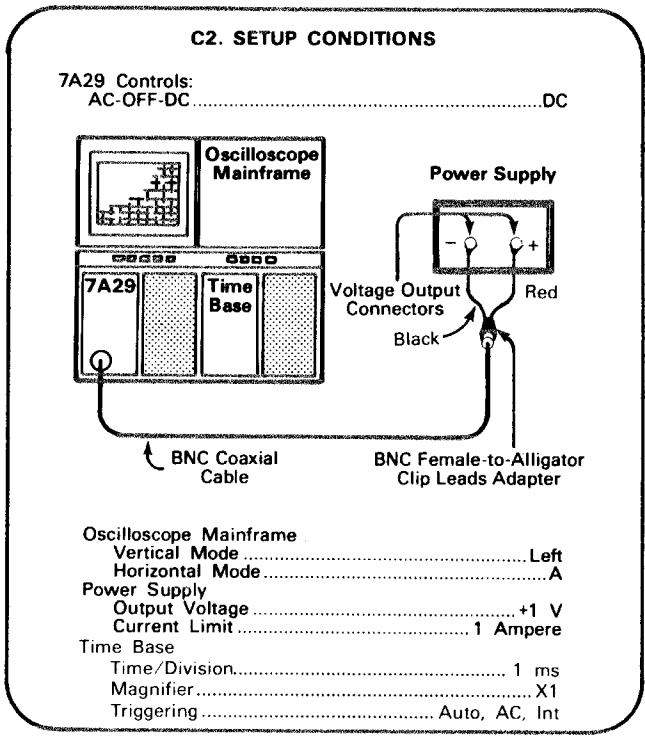
### C1. INPUT PROTECTION PRELIMINARY SETUP

- a. Perform the Performance Check and Adjustment Power-Up Sequence given at the beginning of Part II—Performance Check and Adjustment.
- b. Refer to Section 6, Instrument Options, and the Change Information at the rear of this manual for any modifications which may affect this procedure.

- c. Set 7A29 Amplifier controls:
- |                                 |              |
|---------------------------------|--------------|
| VOLTS/DIV .....                 | 0.1 V        |
| VARIABLE (Volts/Div) .....      | CAL IN       |
| POSITION .....                  | Midrange     |
| POLARITY .....                  | +UP          |
| AC-OFF-DC .....                 | OFF          |
| VARIABLE DELAY (Option 4) ..... | 0 (centered) |
- d. Set Oscilloscope Mainframe controls:
- |                       |                      |
|-----------------------|----------------------|
| Power .....           | On                   |
| Vertical Mode .....   | Left                 |
| Horizontal Mode ..... | A                    |
| Intensity .....       | Visible display      |
| Focus .....           | Well-defined display |
| Trigger Source .....  | Vertical Mode        |

**CAUTION**

*To prevent damage to the 7A29, do not apply more than 12 volts to the INPUT connector unless the OVERLOAD RESET light is on.*



- a. Increase the positive voltage applied to the 7A29 INPUT connector until the OVERLOAD RESET light turns on, however do not exceed 12 volts.
- b. **CHECK**—The Power Supply output voltage should be between +8 and +12 volts with the RESET light on.
- c. Set the AC-OFF-DC switch to OFF.
- d. Set the Power Supply output voltage to 1 volt.

### C2. CHECK 10 VOLT INPUT PROTECTION

**NOTE**

*First perform step C1, then proceed.*

- e. Set the AC-OFF-DC switch to DC.
- f. Connect the negative output of the Power Supply to the 7A29 INPUT connector.
- g. Increase the negative voltage applied to the 7A29 INPUT connector until the OVERLOAD RESET light turns on, but do not exceed 12 volts.
- h. **CHECK**—The Power Supply output voltage should be between -8 and -12 volts.
- i. Set the 7A29 AC-OFF-DC switch to OFF.

- a. Set the Time Base trigger Slope and Level controls to trigger on the positive-going portion of the square-wave signal.
- b. Position the trace to start at the left-most graticule line and the bottom of the waveform to the center horizontal graticule line.
- c. Disconnect the BNC Coaxial Cable from the 7A29 INPUT connector.
- d. Set the 7A29 VOLTS/DIV switch to 1 V. (The 7A29 input protection works at all sensitivities; however, measurement of the input protection delay time is more convenient at the 1 V setting.)
- e. Set the Time Base Time/Div switch to 20 ms.

### C3. CHECK +25 V and +50 V INPUT PROTECTION

#### NOTE

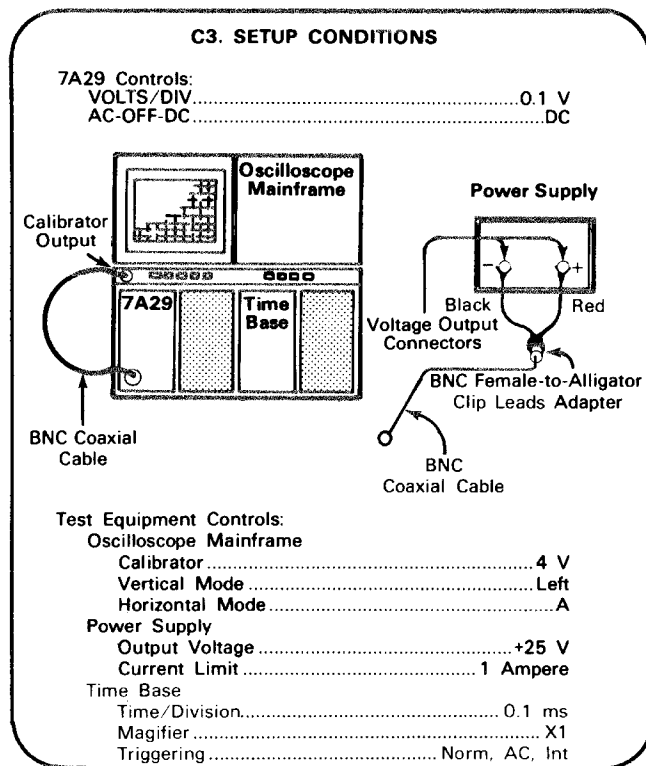
*If the preceding step was not performed, first perform step C1, then proceed.*

#### CAUTION

*To avoid damage to the 7A29, do not perform this procedure unless the 7A29 meets the specifications given in step C2.*

#### NOTE

*You may need to repeat this test several times to observe the exact point of trace return. To reset the 7A29, set the AC-OFF-DC switch to OFF. Return the AC-OFF-DC switch to DC before repeating the test.*



- g. Set the Power Supply output to +50 volts.
- h. Set the Time Base Time/Div switch to 10 ms and the 7A29 AC-OFF-DC switch to DC.
- i. **CHECK**—Momentarily connect the BNC Coaxial Cable to the 7A29 INPUT connector and observe that the trace returns to the display area in less than 30 milliseconds (3 divisions) and that the 7A29 OVERLOAD RESET light is activated.
- j. Set the AC-OFF-DC switch to OFF.

### C4. CHECK -25 V and -50 V INPUT PROTECTION

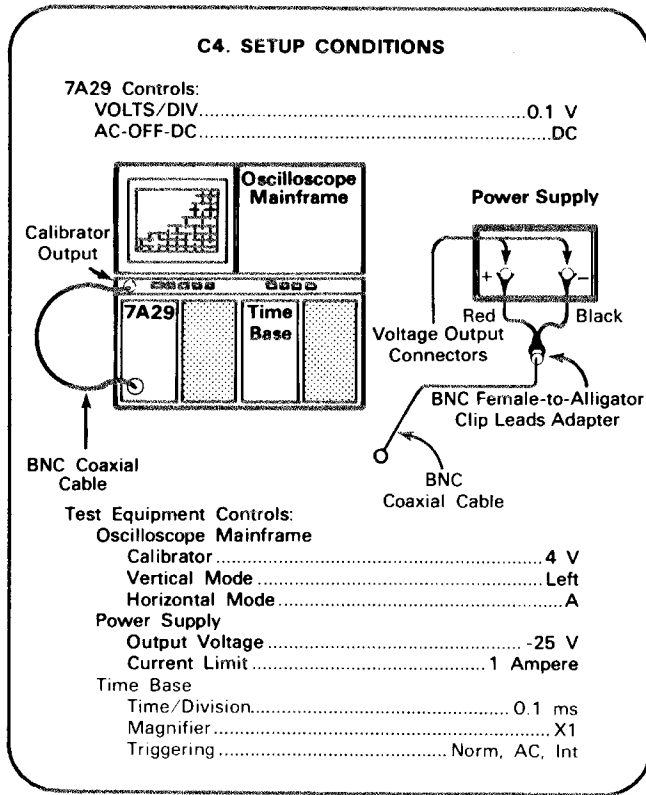
#### NOTE

*If the preceding step was not performed, first perform step C1, then proceed.*

#### CAUTION

*To avoid damage to the 7A29, do not perform the following procedure unless the 7A29 meets the specifications in step C2.*

Calibration Part II—7A29  
Adjustment and Performance Check



- a. Set the Time Base trigger Slope control to trigger on the negative-going portion of the square wave signal.
- b. Position the trace to start at the first vertical graticule line and the bottom of the waveform to the center horizontal graticule line.
- c. Disconnect the BNC Coaxial Cable from the 7A29 INPUT connector.

d. Set the 7A29 VOLTS/DIV switch to 1 V. (The 7A29 input protection works at all sensitivities; however, measurement of the input protection delay time is more convenient at the 1 V setting.)

e. Set the Time Base Time/Div switch to 20 ms.

f. **CHECK**—Momentarily connect the BNC Coaxial Cable, from the Power Supply to the 7A29 INPUT connector and observe that the trace returns to the display area after 40 milliseconds (2 divisions) and before 150 milliseconds (7.5 divisions) of sweep has occurred, and that the OVERLOAD RESET light is activated on the 7A29.

**NOTE**

*You may need to repeat this test several times to observe the exact point of trace return. To reset the 7A29, first remove the -25 V source, then set the AC-OFF-DC switch to OFF. Return the AC-OFF-DC switch to DC before repeating the test.*

g. Set the Power Supply output to -50 volts.

h. Set the Time Base Time/Div switch to 10 ms, and the 7A29 AC-OFF-DC switch to DC.

i. **CHECK**—Momentarily connect the BNC Coaxial Cable from the Power supply to the 7A29 INPUT connector and observe that the trace returns to the display area in less than 30 milliseconds (3 divisions) and that the 7A29 OVERLOAD RESET light is activated.

This completes Part II—Performance Check and Adjustment.

# INSTRUMENT OPTIONS

Your instrument may be equipped with one or more instrument options. A brief description of each available option is given in the following discussion. Option information is incorporated into the appropriate sections of the manual. Refer to Table 6-1 and the Table of Contents for location of option information. For further information on instrument options, see your Tektronix Products catalog or contact your Tektronix Field Office.

## OPTION 4

The 7A29 Option 4 instrument is equipped with a front panel VARIABLE DELAY control which provides a means of delaying the signal applied to the INPUT connector up to  $\pm 500$  picoseconds, relative to another 7A29, 7A19, or 7A19 Option 4.

**TABLE 6-1**  
Option Information Locator

Instrument Option	Manual Section	Location of Information
Option 4	1 General Information	Specification Table 1-1 contains electrical characteristics for Option 4.
	2 Operating Instructions	Detailed Operating Information Provides discussion on Option 4.
	4 Maintenance	Corrective Maintenance Provides Option 4 delay line removal procedure.
	5 Calibration	Adjustment and Performance Check Provides procedure to verify signal delay specification.



# REPLACEABLE ELECTRICAL PARTS

## PARTS ORDERING INFORMATION

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

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number

00X Part removed after this serial number

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

## ABBREVIATIONS

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
00853	SANGAMO ELECTRIC CO., S. CAROLINA DIV.	P O BOX 128	PICKENS, SC 29671
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
01295	TEXAS INSTRUMENTS, INC., SEMICONDUCTOR GROUP	P.O BOX 5012, 13500 N CENTRAL EXPRESSWAY	DALLAS, TX 75222
02111	SPECTROL ELECTRONICS CORPORATION	17070 EAST GALE AVENUE	CITY OF INDUSTRY, CA 91745
03508	GENERAL ELECTRIC COMPANY, SEMI-CONDUCTOR PRODUCTS DEPARTMENT	ELECTRONICS PARK	SYRACUSE, NY 13201
04713	MOTOROLA, INC., SEMICONDUCTOR PROD. DIV.	5005 E MCDOWELL RD, PO BOX 20923	PHOENIX, AZ 85036
07263	FAIRCHILD SEMICONDUCTOR, A DIV. OF FAIRCHILD CAMERA AND INSTRUMENT CORP.	464 ELLIS STREET	MOUNTAIN VIEW, CA 94042
08806	GENERAL ELECTRIC CO., MINIATURE LAMP PRODUCTS DEPARTMENT	NELA PARK	CLEVELAND, OH 44112
12697	CLAROSTAT MFG. CO., INC.	LOWER WASHINGTON STREET	DOVER, NH 03820
14193	CAL-R, INC.	1601 OLYMPIC BLVD.	SANTA MONICA, CA 90404
14433	ITT SEMICONDUCTORS	3301 ELECTRONICS WAY P O BOX 3049	WEST PALM BEACH, FL 33402 ANAHEIM, CA 92806
15454	RODAN INDUSTRIES, INC.	2905 BLUE STAR ST.	ANAHEIM, CA 92806
16546	U.S. CAPACITOR CORP/CENTRALAB ELECTRONICS DIV.	4561 COLORADO	LOS ANGELES, CA 90039
24546	CORNING GLASS WORKS, ELECTRONIC COMPONENTS DIVISION	550 HIGH STREET	BRADFORD, PA 16701
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SEMICONDUCTOR DR.	SANTA CLARA, CA 95051
32997	BOURNS, INC., TRIMPOT PRODUCTS DIV.	1200 COLUMBIA AVE.	RIVERSIDE, CA 92507
55210	GETTIG ENG. AND MFG. COMPANY	PO BOX 85, OFF ROUTE 45	SPRING MILLS, PA 16875
56289	SPRAGUE ELECTRIC CO.		NORTH ADAMS, MA 01247
71590	CENTRALAB ELECTRONICS, DIV. OF GLOBE-UNION, INC.	P O BOX 858	FORT DODGE, IA 50501
72982	ERIE TECHNOLOGICAL PRODUCTS, INC.	644 W. 12TH ST.	ERIE, PA 16512
75042	TRW ELECTRONIC COMPONENTS, IRC FIXED RESISTORS, PHILADELPHIA DIVISION	401 N. BROAD ST.	PHILADELPHIA, PA 19108
76493	BELL INDUSTRIES, INC., MILLER, J. W., DIV.	19070 REYES AVE., P O BOX 5825	COMPTON, CA 90224
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
82389	SWITCHCRAFT, INC.	5555 N. ELSTON AVE.	CHICAGO, IL 60630
91293	JOHANSON MFG. COMPANY	P O BOX 329	BOONTON, NJ 07005
91637	DALE ELECTRONICS, INC.	P. O. BOX 609	COLUMBUS, NE 68601

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A1	670-5053-00	B010100	B029999	CKT BOARD ASSY:MAIN	80009	670-5053-00
A1	670-5053-01	B030000		CKT BOARD ASSY:MAIN	80009	670-5053-01
A2	388-5643-01			CKT BOARD ASSY:HYPCON	80009	388-5643-01
A3	670-5029-00			CKT BOARD ASSY:READOUT	80009	670-5029-00
A4	670-5131-00			CKT BOARD ASSY:SOLENOID	80009	670-5131-00
A64	263-1160-00			SW CAM ACTR AS:READOUT	80009	263-1160-00
C22	283-0005-00			CAP., FXD, CER DI:0.01UF,+100-0%,250V	72982	8131N300Z5U0103P
C24	283-0177-00			CAP., FXD, CER DI:1UF,+80-20%,25V	56289	273C5
C28	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C32	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C34	290-0747-00			CAP., FXD, ELCTLT:100UF,+50-10%,25V	56289	500D148
C35	290-0782-00			CAP., FXD, ELCTLT:4.7UF,+75-10%,35V	56289	503D475G035AS
C42	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C43	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C44	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C46	283-0000-00			CAP., FXD, CER DI:0.001UF,+100-0%,500V	72982	831-516E102P
C108	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C115	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C118	290-0745-00			CAP., FXD, ELCTLT:22UF,+50-10%,25V	56289	502D225
C144	283-0666-00			CAP., FXD, MICA D:890PF,2%,100V	00853	D151F891G0
C148	283-0100-00			CAP., FXD, CER DI:0.0047UF,10%,200V	56289	273C3
C150	283-0239-00	B010100	B020955	CAP., FXD, CER DI:0.022UF,10%,50V	72982	8121N083X7R0223K
C150	283-0268-00	B020956		CAP., FXD, CER DI:0.015UF,10%,50V	72982	8121N083X7R0153K
C152	283-0249-00			CAP., FXD, CER DI:0.068UF,10%,50V	72982	8131N075 C 683K
C162	281-0122-00	B010100	B010249	CAP., VAR, CER DI:2.5-9PF,100V	72982	518-000A2.5-9
C162	281-0123-00	B010250		CAP., VAR, CER DI:5-25PF,100V	72982	518-000A5-25
C240	283-0249-00			CAP., FXD, CER DI:0.068UF,10%,50V	72982	8131N075 C 683K
C254	283-0408-00			CAP., FXD, CER DI:0.68UF,+100-0%,12V	91293	120S41Z684PP2
C256	283-0408-00			CAP., FXD, CER DI:0.68UF,+100-0%,12V	91293	120S41Z684PP2
C260	283-0249-00			CAP., FXD, CER DI:0.068UF,10%,50V	72982	8131N075 C 683K
C356	283-0326-00			CAP., FXD, CER DI:0.082UF,10%,50V	16546	CW20C823K
CR24	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR33	152-0066-00			SEMICONV DEVICE:SILICON,400V,750MA	14433	LG4016
CR34	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR35	152-0066-00			SEMICONV DEVICE:SILICON,400V,750MA	14433	LG4016
CR42	152-0066-00			SEMICONV DEVICE:SILICON,400V,750MA	14433	LG4016
CR43	152-0066-00			SEMICONV DEVICE:SILICON,400V,750MA	14433	LG4016
CR44	152-0066-00			SEMICONV DEVICE:SILICON,400V,750MA	14433	LG4016
CR66	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR114	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR124	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR133	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR134	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR135	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR136	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR229	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR230	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
CR234	152-0141-02			SEMICONV DEVICE:SILICON,30V,150MA	01295	1N4152R
DL4	119-0897-00			DELAY LINE,ELEC:VAR,6.29NS,50 OHM	80009	119-0897-00
DL5	119-0321-01			DELAY LINE,ELEC:VAR,-0.5NS 10 + 0.5NS,50 OHM (OPTION 4 ONLY)	80009	119-0321-01
DS18	150-0048-01			LAMP, INCAND:5V,0.06A,SEL	08806	683AS15
L42	108-0538-00			COIL, RF:2.7UH	76493	70F276A1
L43	108-0538-00			COIL, RF:2.7UH	76493	70F276A1
L44	108-0538-00			COIL, RF:2.7UH	76493	70F276A1

Replaceable Electrical Parts---7A29

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
L166	108-0245-00			COIL, RF: 3.9UH	80009	108-0245-00
L240	108-0924-00			COIL, RF: 1UH	80009	108-0924-00
L241	108-0271-00	B010100	B010229	COIL, RF: 0.025UH	80009	108-0271-00
L241	108-0408-00	B010230		COIL, RF: 100NH	80009	108-0408-00
L245	108-0735-00	B010100	B010229	COIL, RF: FIXED, 560NH	80009	108-0735-00
L245	108-0212-00	B010230		COIL, RF: FIXED, 495NH	80009	108-0212-00
L260	108-0924-00			COIL, RF: 1UH	80009	108-0924-00
L261	108-0271-00	B010100	B0101229	COIL, RF: 0.025UH	80009	108-0271-00
L261	108-0408-00	B010230		COIL, RF: 100NH	80009	108-0408-00
L362	108-0436-00			COIL, RF: FIXED, 240NH	80009	108-0436-00
L363	108-0436-00			COIL, RF: FIXED, 240NH	80009	108-0436-00
Q24	151-0301-00			TRANSISTOR: SILICON, PNP	04713	2N2907A
Q32	151-0301-00			TRANSISTOR: SILICON, PNP	04713	2N2907A
Q34	151-0302-00			TRANSISTOR: SILICON, NPN	07263	S038487
Q54	151-0281-00			TRANSISTOR: SILICON, NPN	03508	X16P4039
Q114	151-0301-00			TRANSISTOR: SILICON, PNP	04713	2N2907A
Q124	151-0302-00			TRANSISTOR: SILICON, NPN	07263	S038487
Q184	151-0302-00			TRANSISTOR: SILICON, NPN	07263	S038487
Q226	151-0261-00			TRANSISTOR: SILICON, PNP, DUAL	80009	151-0261-00
Q248	151-0301-00			TRANSISTOR: SILICON, PNP	04713	2N2907A
Q268	151-0301-00			TRANSISTOR: SILICON, PNP	04713	2N2907A
Q342	151-0302-00			TRANSISTOR: SILICON, NPN	07263	S038487
R18	315-0150-00			RES., FXD, CMPSN: 15 OHM, 5%, 0.25W	01121	CB1505
R22	315-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.25W	01121	CB5105
R24	315-0331-00			RES., FXD, CMPSN: 330 OHM, 5%, 0.25W	01121	CB3315
R25	315-0131-00			RES., FXD, CMPSN: 130 OHM, 5%, 0.25W	01121	CB1315
R26	315-0152-00			RES., FXD, CMPSN: 1.5K OHM, 5%, 0.25W	01121	CB1525
R28	315-0202-00			RES., FXD, CMPSN: 2K OHM, 5%, 0.25W	01121	CB2025
R29	315-0103-00			RES., FXD, CMPSN: 10K OHM, 5%, 0.25W	01121	CB1035
R31	315-0101-00			RES., FXD, CMPSN: 100 OHM, 5%, 0.25W	01121	CB1015
R32	308-0231-00			RES., FXD, WW: 220 OHM, 5%, 3W	91637	RS2B-B220R0J
R33	315-0153-00			RES., FXD, CMPSN: 15K OHM, 5%, 0.25W	01121	CB1535
R35	315-0203-00			RES., FXD, CMPSN: 20K OHM, 5%, 0.25W	01121	CB2035
R36	321-0356-00			RES., FXD, FILM: 49.9K OHM, 1%, 0.125W	91637	MFF1816G49901F
R37	321-0327-00			RES., FXD, FILM: 24.9K OHM, 1%, 0.125W	91637	MFF1816G24901F
R46	315-0470-00			RES., FXD, CMPSN: 47 OHM, 5%, 0.25W	01121	CB4705
R50	315-0105-00			RES., FXD, CMPSN: 1M OHM, 5%, 0.25W	01121	CB1055
R51	315-0105-00			RES., FXD, CMPSN: 1M OHM, 5%, 0.25W	01121	CB1055
R52	321-0222-00			RES., FXD, FILM: 2K OHM, 1%, 0.125W	91637	MFF1816G20000F
R53	315-0471-00			RES., FXD, CMPSN: 470 OHM, 5%, 0.25W	01121	CB4715
R54	321-0299-00			RES., FXD, FILM: 12.7K OHM, 1%, 0.125W	91637	MFF1816G12701F
R55	315-0753-00			RES., FXD, CMPSN: 75K OHM, 5%, 0.25W	01121	CB7535
R61	315-0154-00			RES., FXD, CMPSN: 150K OHM, 5%, 0.25W	01121	CB1545
R62	321-0344-00			RES., FXD, FILM: 37.4K OHM, 1%, 0.125W	91637	MFF1816G37401F
R63	315-0753-00			RES., FXD, CMPSN: 75K OHM, 5%, 0.25W	01121	CB7535
R64	315-0154-00			RES., FXD, CMPSN: 150K OHM, 5%, 0.25W	01121	CB1545
R65	315-0154-00			RES., FXD, CMPSN: 150K OHM, 5%, 0.25W	01121	CB1545
R66	315-0133-00			RES., FXD, CMPSN: 13K OHM, 5%, 0.25W	01121	CB1335
R67	315-0124-00			RES., FXD, CMPSN: 120K OHM, 5%, 0.25W	01121	CB1245
R68	315-0753-00			RES., FXD, CMPSN: 75K OHM, 5%, 0.25W	01121	CB7535
R69	315-0303-00			RES., FXD, CMPSN: 30K OHM, 5%, 0.25W	01121	CB3035
R73	315-0753-00			RES., FXD, CMPSN: 75K OHM, 5%, 0.25W	01121	CB7535
R75	315-0513-00			RES., FXD, CMPSN: 51K OHM, 5%, 0.25W	01121	CB5135
R76	315-0154-00			RES., FXD, CMPSN: 150K OHM, 5%, 0.25W	01121	CB1545
R77	315-0154-00			RES., FXD, CMPSN: 150K OHM, 5%, 0.25W	01121	CB1545
R78	321-0344-00			RES., FXD, FILM: 37.4K OHM, 1%, 0.125W	91637	MFF1816G37401F
R107	311-1227-00			RES., VAR, NONWIR: 5K OHM, 20%, 0.50W	32997	3386F-T04-502

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R109	317-0202-00			RES., FXD, CMPSN: 2K OHM, 5%, 0.125W	01121	BB2025
R110	315-0682-00			RES., FXD, CMPSN: 6.8K OHM, 5%, 0.25W	01121	CB6825
R111	315-0151-00			RES., FXD, CMPSN: 150 OHM, 5%, 0.25W	01121	CB1515
R112	315-0102-00			RES., FXD, CMPSN: 1K OHM, 5%, 0.25W	01121	CB1025
R113	321-0315-00			RES., FXD, FILM: 18.7K OHM, 1%, 0.125W	91637	MFF1816G18701F
R115	315-0200-00			RES., FXD, CMPSN: 20 OHM, 5%, 0.25W	01121	CB2005
R120	315-0512-00			RES., FXD, CMPSN: 5.1K OHM, 5%, 0.25W	01121	CB5125
R121	315-0151-00			RES., FXD, CMPSN: 150 OHM, 5%, 0.25W	01121	CB1515
R122	315-0102-00			RES., FXD, CMPSN: 1K OHM, 5%, 0.25W	01121	CB1025
R123	321-1289-07			RES., FXD, FILM: 10.1K OHM, 0.1%, 0.125W	91637	MFF1816C10101B
R124	311-1223-00			RES., VAR, NONWIR: TRMR, 250 OHM, 0.5W	02111	63M251T602
R125	321-0289-06			RES., FXD, FILM: 10K OHM, 0.25%, 0.125W	91637	MFF1816C10001C
R130	317-0682-00			RES., FXD, CMPSN: 6.8K OHM, 5%, 0.125W	01121	BB6825
R131	317-0821-00			RES., FXD, CMPSN: 820 OHM, 5%, 0.125W	01121	BB8215
R132	315-0303-00			RES., FXD, CMPSN: 30K OHM, 5%, 0.25W	01121	CB3035
R133	321-0260-00			RES., FXD, FILM: 4.99K OHM, 1%, 0.125W	91637	MFF1816G49900F
R134	321-0260-00			RES., FXD, FILM: 4.99K OHM, 1%, 0.125W	91637	MFF1816G49900F
R135	321-0190-00			RES., FXD, FILM: 931 OHM, 1%, 0.125W	91637	MFF1816G931R0F
R140	311-1228-00			RES., VAR, NONWIR: 10K OHM, 20%, 0.50W	32997	3386F-T04-103
R141	315-0473-00			RES., FXD, CMPSN: 47K OHM, 5%, 0.25W	01121	CB4735
R142	315-0392-00			RES., FXD, CMPSN: 3.9K OHM, 5%, 0.25W	01121	CB3925
R143	315-0473-00			RES., FXD, CMPSN: 47K OHM, 5%, 0.25W	01121	CB4735
R144	311-1228-00			RES., VAR, NONWIR: 10K OHM, 20%, 0.50W	32997	3386F-T04-103
R145	321-0222-00			RES., FXD, FILM: 2K OHM, 1%, 0.125W	91637	MFF1816G20000F
R146	311-1226-00			RES., VAR, NONWIR: 2.5K OHM, 20%, 0.50W	32997	3386F-T04-252
R147	321-0289-00			RES., FXD, FILM: 10K OHM, 1%, 0.125W	91637	MFF1816G10001F
R148	311-1230-00			RES., VAR, NONWIR: 20K OHM, 20%, 0.50W	32997	3386F-T04-203
R149	315-0823-00			RES., FXD, CMPSN: 82K OHM, 5%, 0.25W	01121	CB8235
R150	311-1232-00			RES., VAR, NONWIR: 50K OHM, 20%, 0.50W	32997	3386F-T04-503
R151	315-0822-00			RES., FXD, CMPSN: 8.2K OHM, 5%, 0.25W	01121	CB8225
R152	311-1235-00			RES., VAR, NONWIR: 100K OHM, 20%, 0.50W	32997	3386F-T04-104
R153	315-0303-00			RES., FXD, CMPSN: 30K OHM, 5%, 0.25W	01121	CB3035
R154	315-0204-00			RES., FXD, CMPSN: 200K OHM, 5%, 0.25W	01121	CB2045
R155	321-0314-00			RES., FXD, FILM: 18.2K OHM, 1%, 0.125W	91637	MFF1816G18201F
R162	315-0203-00			RES., FXD, CMPSN: 20K OHM, 5%, 0.25W	01121	CB2035
R163	317-0151-00			RES., FXD, CMPSN: 150 OHM, 5%, 0.125W	01121	BB1515
R164	315-0104-00			RES., FXD, CMPSN: 100K OHM, 5%, 0.25W	01121	CB1045
R166	323-0133-00			RES., FXD, FILM: 237 OHM, 1%, 0.50W	75042	CECT0-2370F
R170	311-1235-00			RES., VAR, NONWIR: 100K OHM, 20%, 0.50W	32997	3386F-T04-104
R171	315-0474-00			RES., FXD, CMPSN: 470K OHM, 5%, 0.25W	01121	CB4745
R172	315-0204-00			RES., FXD, CMPSN: 200K OHM, 5%, 0.25W	01121	CB2045
R173	315-0124-00			RES., FXD, CMPSN: 120K OHM, 5%, 0.25W	01121	CB1245
R174	315-0683-00			RES., FXD, CMPSN: 68K OHM, 5%, 0.25W	01121	CB6835
R175	311-1235-00			RES., VAR, NONWIR: 100K OHM, 20%, 0.50W	32997	3386F-T04-104
R176	315-0474-00			RES., FXD, CMPSN: 470K OHM, 5%, 0.25W	01121	CB4745
R177	315-0204-00			RES., FXD, CMPSN: 200K OHM, 5%, 0.25W	01121	CB2045
R178	315-0104-00			RES., FXD, CMPSN: 100K OHM, 5%, 0.25W	01121	CB1045
R179	315-0394-00			RES., FXD, CMPSN: 390K OHM, 5%, 0.25W	01121	CB3945
R182	315-0513-00			RES., FXD, CMPSN: 51K OHM, 5%, 0.25W	01121	CB5135
R183	315-0104-00			RES., FXD, CMPSN: 100K OHM, 5%, 0.25W	01121	CB1045
R184	315-0333-00			RES., FXD, CMPSN: 33K OHM, 5%, 0.25W	01121	CB3335
R185	315-0272-00			RES., FXD, CMPSN: 2.7K OHM, 5%, 0.25W	01121	CB2725
R186	315-0473-00			RES., FXD, CMPSN: 47K OHM, 5%, 0.25W	01121	CB4735
R187	315-0104-00			RES., FXD, CMPSN: 100K OHM, 5%, 0.25W	01121	CB1045
R212	311-1466-00			RES., VAR, NONWIR: 2K OHM, 20%, 0.50W	01121	E2B202
R219	321-0202-00			RES., FXD, FILM: 1.24K OHM, 1%, 0.125W	91637	MFF1816G12400F
R220	311-0566-00			RES., VAR, NONWIR: 5K OHM, 20%, 0.5W	71590	BA147-011

Replaceable Electrical Parts—7A29

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R221	321-0266-00	B010100	B010279	RES.,FXD,FILM:5.76K OHM,1%,0.125W	91637	MFF1816G57600F
R221	321-0257-00	B010280		RES.,FXD,FILM:4.64K OHM,1%,0.125W	91637	MFF1816G46400F
R222	311-0566-00			RES.,VAR, NONWIR:5K OHM,20%,0.5W	71590	BA147-011
R223	321-0286-00			RES.,FXD,FILM:9.31K OHM,1%,0.125W	91637	MFF1816G93100F
R224	321-0400-00			RES.,FXD,FILM:143K OHM,1%,0.125W	91637	MFF1816G14302F
R225	321-0162-00			RES.,FXD,FILM:475 OHM,1%,0.125W	91637	MFF1816G475R0F
R226	321-0223-00			RES.,FXD,FILM:2.05K OHM,1%,0.125W	91637	MFF1816G20500F
R227	321-0223-00			RES.,FXD,FILM:2.05K OHM,1%,0.125W	91637	MFF1816G20500F
R228	321-0428-00			RES.,FXD,FILM:280K OHM,1%,0.125W	91637	MFF1816G28002F
R229	323-0310-00			RES.,FXD,FILM:16.5K OHM,1%,0.50W	75042	CECT0-1652F
R230	321-0295-00			RES.,FXD,FILM:11.5K OHM,1%,0.125W	91637	MFF1816G11501F
R231	321-0281-00			RES.,FXD,FILM:8.25K OHM,1%,0.125W	91637	MFF1816G82500F
R232	321-0289-03			RES.,FXD,FILM:10K OHM,0.25%,0.125W	91637	MFF1816D10001C
R233	321-0612-03			RES.,FXD,FILM:500 OHM,0.25%,0.125W	91637	MFF1816D500R0C
R234	321-0289-03			RES.,FXD,FILM:10K OHM,0.25%,0.125W	91637	MFF1816D10001C
R235	321-0363-00			RES.,FXD,FILM:59K OHM,1%,0.125W	91637	MFF1816G59001F
R236	321-0289-00			RES.,FXD,FILM:10K OHM,1%,0.125W	91637	MFF1816G10001F
R237	317-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.125W	01121	BB5105
R238	317-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.125W	01121	BB5105
R239	317-0510-00			RES.,FXD,CMPSN:51 OHM,5%,0.125W	01121	BB5105
R241	321-0318-07			RES.,FXD,FILM:20K OHM,0.1%,0.125W	24546	NE55E2002B
R242	321-0318-07			RES.,FXD,FILM:20K OHM,0.1%,0.125W	24546	NE55E2002B
R243	317-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.125W	01121	BB3915
R244	321-1313-07			RES.,FXD,FILM:18.0K OHM,0.1%,0.125W	91637	CMF110X216C180
R245	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R246	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R247	317-0391-00			RES.,FXD,CMPSN:390 OHM,5%,0.125W	01121	BB3915
R248	321-0059-00			RES.,FXD,FILM:40.2 OHM,1%,0.125W	91637	MFF1816G40R20F
R249	321-0318-07			RES.,FXD,FILM:20K OHM,0.1%,0.125W	24546	NE55E2002B
R261	321-0289-07			RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R262	321-0289-07			RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R263	321-0314-00			RES.,FXD,FILM:18.2K OHM,1%,0.125W	91637	MFF1816G18201F
R264	321-1313-07			RES.,FXD,FILM:18.0K OHM,0.1%,0.125W	91637	CMF110X216C180
R265	315-0221-00			RES.,FXD,CMPSN:220 OHM,5%,0.25W	01121	CB2215
R266	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	01121	CB1025
R267	321-1313-07			RES.,FXD,FILM:18.0K OHM,0.1%,0.125W	91637	CMF110X216C180
R268	321-0059-00			RES.,FXD,FILM:40.2 OHM,1%,0.125W	91637	MFF1816G40R20F
R269	321-0289-07			RES.,FXD,FILM:10K OHM,0.1%,0.125W	91637	MFF1816C10001B
R270	311-1235-00			RES.,VAR, NONWIR:100K OHM,20%,0.50W	32997	3386F-T04-104
R271	315-0245-00			RES.,FXD,CMPSN:2.4M OHM,5%,0.25W	01121	CB2455
R273	315-0396-00			RES.,FXD,CMPSN:39M OHM,5%,0.25W	01121	CB3965
R274	131-0566-00	B010100	B010254X	LINK,TERM.CONNE:0.086 DIA X 2.375 INCH L	55210	L-2007-1
R275	311-1320-00	B010100	B021049	RES.,VAR, NONWIR:5K OHM,1W,W/SW	12697	381CM-39700
R275	311-1320-01	B021050		RES.,VAR, NONWIR:5K OHM,10%,1W,SPST SW (FURNISHED AS A UNIT WITH S50)	12697	OBD
R276	315-0245-00			RES.,FXD,CMPSN:2.4M OHM,5%,0.25W	01121	CB2455
R277	315-0105-00			RES.,FXD,CMPSN:1M OHM,5%,0.25W	01121	CB1055
R306	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R307	317-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.125W	01121	BB1015
R312	321-0280-00			RES.,FXD,FILM:8.06K OHM,1%,0.125W	91637	MFF1816G80600F
R313	321-1296-03			RES.,FXD,FILM:12K OHM,0.25%,0.125W	91637	MFF1816D12001C
R314	301-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.50W	01121	EB2015
R315	323-0116-00			RES.,FXD,FILM:158 OHM,1%,0.50W	75042	CECT0-1580F
R316	315-0131-00			RES.,FXD,CMPSN:130 OHM,5%,0.25W	01121	CB1315
R318	323-0120-00			RES.,FXD,FILM:174 OHM,1%,0.50W	91637	MFF1226G174R0F
R333	321-0231-00			RES.,FXD,FILM:2.49K OHM,1%,0.125W	91637	MFF1816G24900F
R334	321-0298-09			RES.,FXD,FILM:12.4K OHM,1%,0.125W	24546	NE55E1242F

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
R335	315-0102-00			RES., FXD, CMPSN: 1K OHM, 5%, 0.25W	01121	CB1025
R336	315-0103-00			RES., FXD, CMPSN: 10K OHM, 5%, 0.25W	01121	CB1035
R337	317-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.125W	01121	BB5105
R338	317-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.125W	01121	BB5105
R342	315-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.25W	01121	CB5105
R343	321-0286-00			RES., FXD, FILM: 9.31K OHM, 1%, 0.125W	91637	MFF1816G93100F
R344	321-0126-00			RES., FXD, FILM: 200 OHM, 1%, 0.125W	91637	MFF1816G200ROF
R352	317-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.125W	01121	BB5105
R353	317-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.125W	01121	BB5105
R354	317-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.125W	01121	BB5105
R355	317-0510-00			RES., FXD, CMPSN: 51 OHM, 5%, 0.125W	01121	BB5105
R356	317-0121-00			RES., FXD, CMPSN: 120 OHM, 5%, 0.125W	01121	BB1215
R357	317-0121-00			RES., FXD, CMPSN: 120 OHM, 5%, 0.125W	01121	BB1215
R362	323-0184-00			RES., FXD, FILM: 806 OHM, 1%, 0.50W	91637	MFF1226G806ROF
R363	323-0184-00			RES., FXD, FILM: 806 OHM, 1%, 0.50W	91637	MFF1226G806ROF
R365	311-1221-00			RES., VAR, NONWIR: 50 OHM, 20%, 0.50W	32997	3386F-T04-500
RT108	307-0642-00			RES., THERMAL: 10K OHM, 5%, 25DEG C	15454	DG125103J
RT129	307-0477-00			RES., THERMAL: 1K OHM, 10%, 6MW/DEG C	14193	1013-10000K
RT317	307-0126-00			RES., THERMAL: 100 OHM, 10%	14193	2D21-101-D
RT345	307-0250-00			RES., THERMAL: 390 OHM, 10%	15454	DG125390K
S4	119-0914-00			SWITCH ASSY: AC/DC, W/INPUT PROTECTION	80009	119-0914-00
S50	311-1320-00	B010100	B021049	RES., VAR, NONWIR: 5K OHM, 1W, W/SW	12697	381CM-39700
S50	311-1320-01	B021050		RES., VAR, NONWIR: 5K OHM, 10%, 1W, SPST SW (FURNISHED AS A UNIT WITH R275)	12697	OBD
S62	119-0913-00			ATTEN VARIABLE: 10MV TO 1V, 7 POSITION	80009	119-0913-00
S180	260-1833-00			SWITCH, SLIDE: DPDT	82389	11P-1092
S222	263-1160-00			SW CAM ACTR AS: READOUT	80009	263-1160-00
U26	155-0076-00			MICROCIRCUIT, LI: INPUT PROTECTION	80009	155-0076-00
U36	156-0067-00			MICROCIRCUIT, LI: OPERATIONAL AMPLIFIER	80009	156-0067-00
U100	155-0180-00			MICROCIRCUIT, LI: FAST INPUT PROTECTION	80009	155-0180-00
U111	156-0067-00			MICROCIRCUIT, LI: OPERATIONAL AMPLIFIER	80009	156-0067-00
U121	156-0067-00			MICROCIRCUIT, LI: OPERATIONAL AMPLIFIER	80009	156-0067-00
U132	156-0770-00			MICROCIRCUIT, DI: OPERATIONAL AMPLIFIER	27014	LF356H
U162	156-0770-00			MICROCIRCUIT, DI: OPERATIONAL AMPLIFIER	27014	LF356H
U174	156-0067-00			MICROCIRCUIT, LI: OPERATIONAL AMPLIFIER	80009	156-0067-00
U178	156-0644-00			MICROCIRCUIT, DI: QUAD BILATERAL SWITCH	80009	156-0644-00
U228	156-0644-00			MICROCIRCUIT, DI: QUAD BILATERAL SWITCH	80009	156-0644-00
U234	156-0158-04			MICROCIRCUIT, LI: DUAL OPERATIONAL AMPLIFIER	04713	MC1458U
U246	156-0067-00			MICROCIRCUIT, LI: OPERATIONAL AMPLIFIER	80009	156-0067-00
U255	155-0181-00			MICROCIRCUIT, LI: INPUT AMPLIFIER	80009	155-0181-00
U266	156-0067-00			MICROCIRCUIT, LI: OPERATIONAL AMPLIFIER	80009	156-0067-00
U314	156-0067-00			MICROCIRCUIT, LI: OPERATIONAL AMPLIFIER	80009	156-0067-00
U322	155-0175-00			MICROCIRCUIT, LI: TRIGGER AMPLIFIER	80009	155-0175-00
U334	156-0158-04			MICROCIRCUIT, LI: DUAL OPERATIONAL AMPLIFIER	04713	MC1458U
U352	155-0175-00			MICROCIRCUIT, LI: TRIGGER AMPLIFIER	80009	155-0175-00
VR35	152-0265-00			SEMICONV DEVICE: ZENER, 0.4W, 24V, 5%	04713	SZG35009K8
VR254	153-0069-00			SEMICONV DVC, SE: MATCHED PAIR	80009	153-0069-00
VR256	153-0069-00			SEMICONV DVC, SE: MATCHED PAIR	80009	153-0069-00

# 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 ( $\Omega$ ).

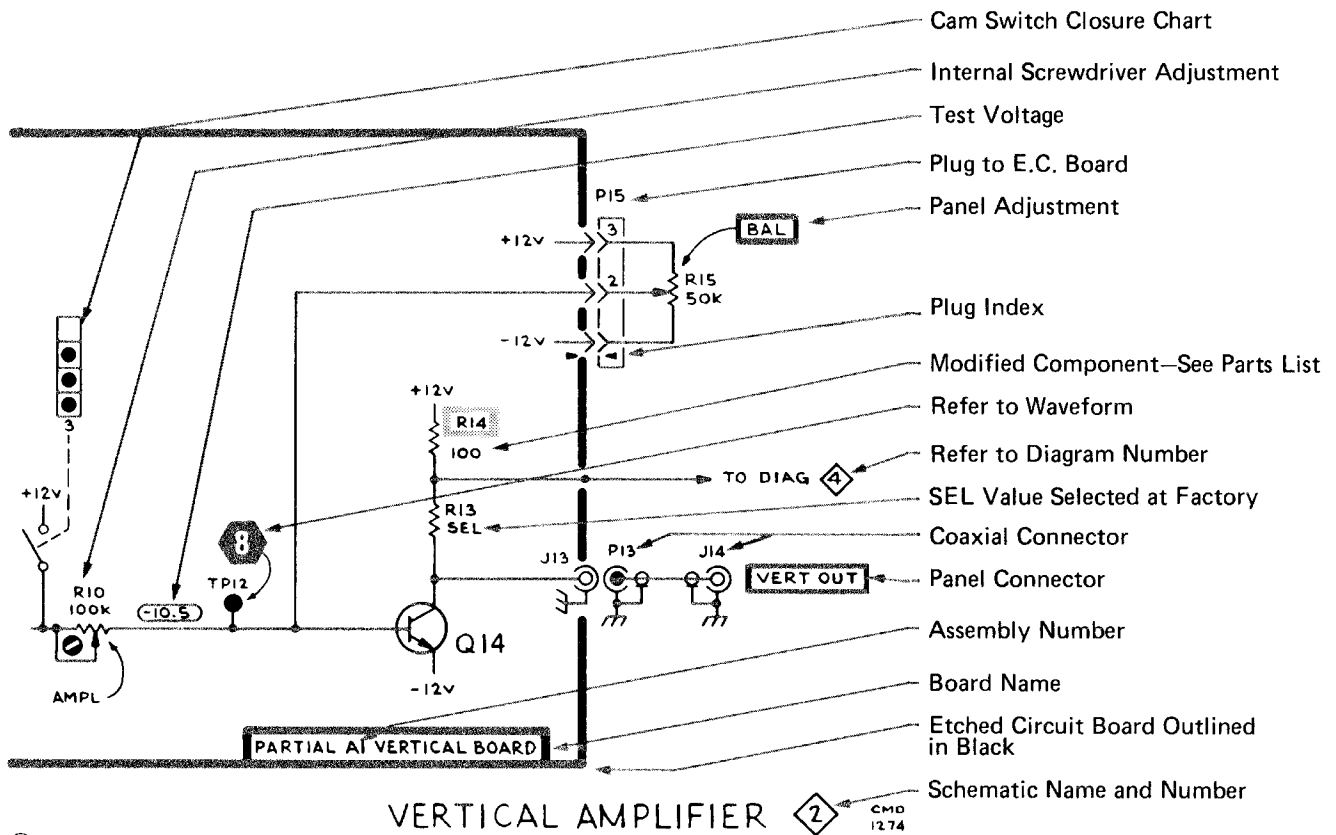
Symbols used on the diagrams are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

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

The following special symbols are used on the diagrams:





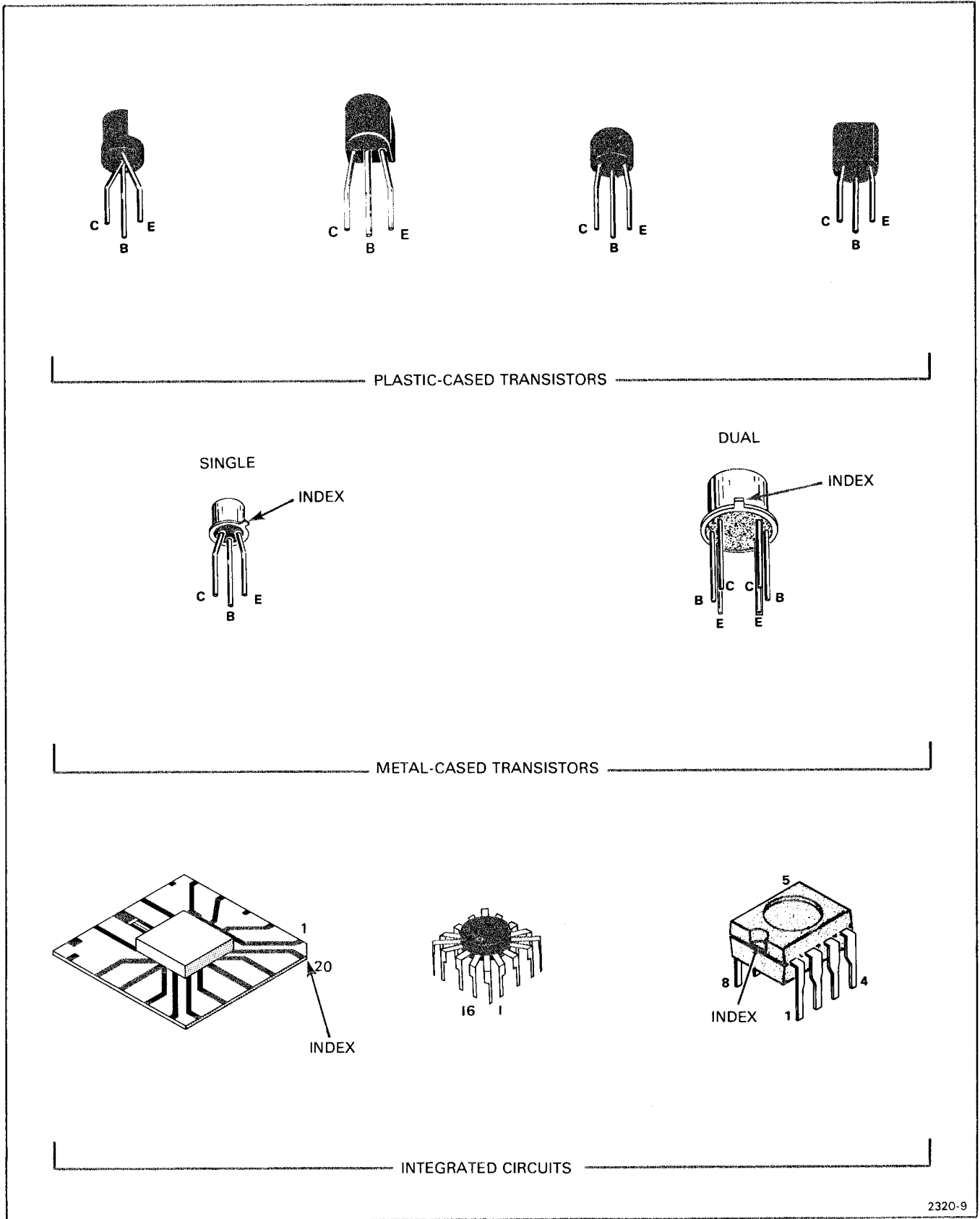


Figure 8-1. Semiconductor Lead Configurations.

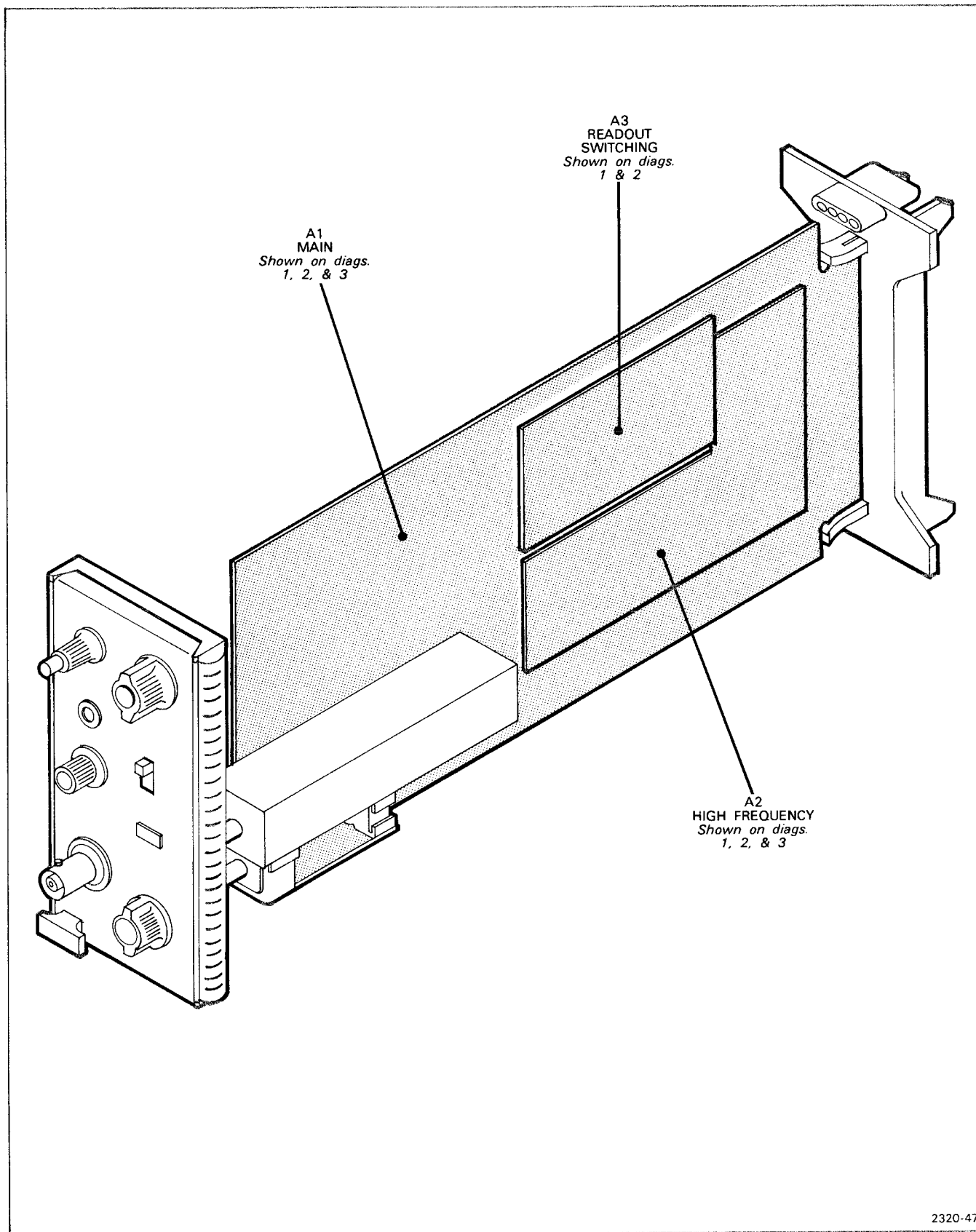


Figure 8-2. Circuit Board Locations.

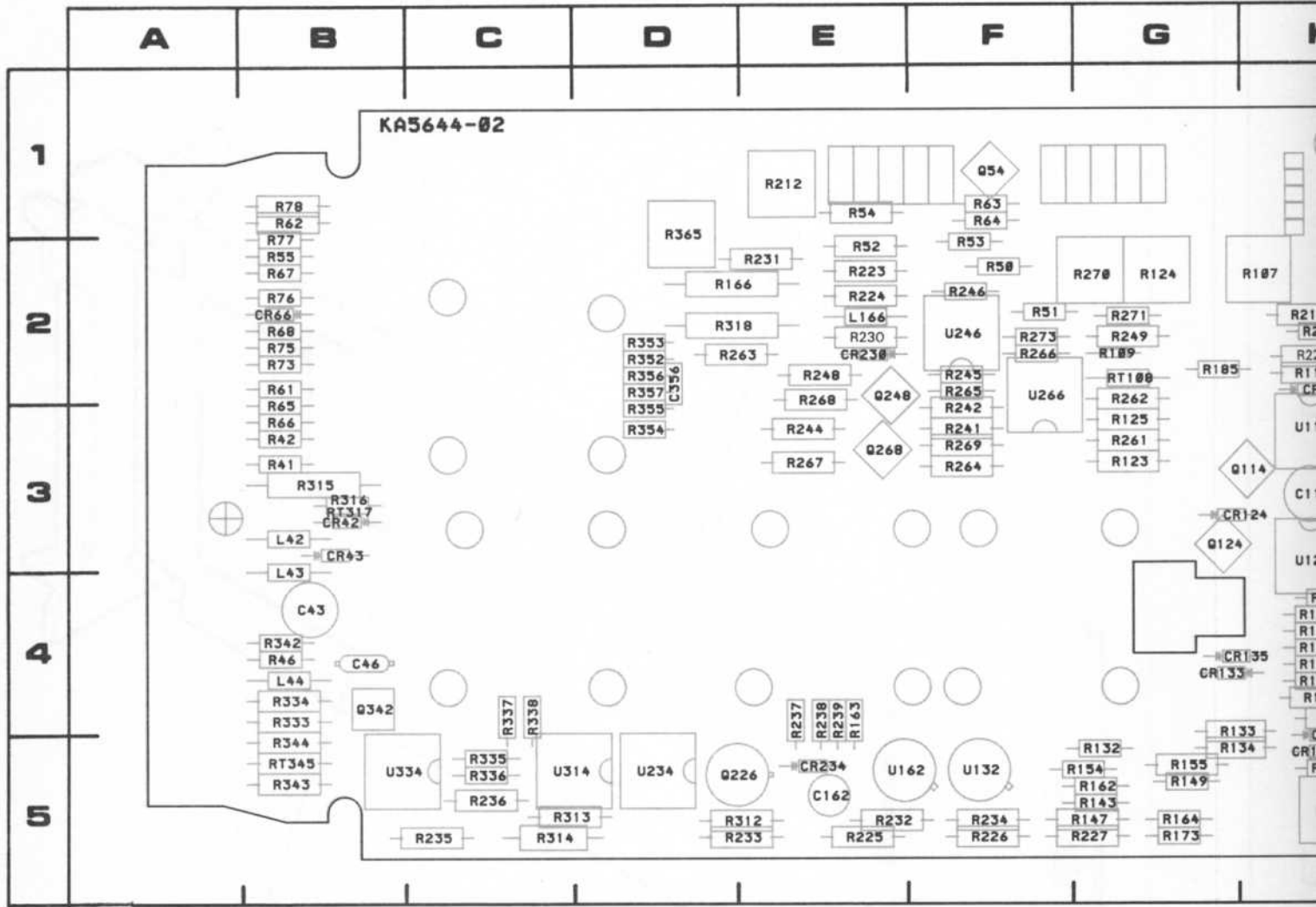


Figure 8-3. A1—Main circuit board assembly.

CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD
C22	1I	CR43	3B	Q54	1F	R42	3B	R109	2G	R147	5G	R182	
C24	3I	CR44	3J	Q114	3G	R46	4B	R110	3I	R148	5I	R183	
C28	2J	CR66	2B	Q124	3G	R50	2F	R111	3I	R149	5G	R184	
C32	1J	CR114	2H	Q184	1L	R51	2F	R112	3I	R150	5J	R185	
C34	2I	CR124	3G	Q226	5D	R52	2E	R113	2H	R151	4H	R186	
C35	1K	CR133	4G	Q248	3E	R53	2F	R115	3I	R152	5J	R187	
C42	1H	CR134	5H	Q268	3E	R54	1E	R120	4H	R153	4H	R212	
C43	4B	CR135	4G	Q342	4B	R55	2B	R121	4H	R154	5G	R219	
C44	1K	CR136	5H			R61	2B	R122	4H	R155	5G	R221	
C46	4B	CR229	3J	R18	2I	R62	1B	R123	3G	R162	5G	R223	
C115	3H	CR230	2E	R22	1J	R63	1F	R124	2G	R163	4E	R224	
C144	5I	CR234	5E	R24	3I	R64	1F	R125	2G	R164	5G	R225	
C148	5I			R25	2I	R65	3B	R132	5G	R166	2D	R226	
C150	5B	J22	1J	R26	2I	R66	3B	R133	5G	R170	5K	R227	
C152	5I			R28	2I	R67	2B	R134	5G	R171	5K	R228	
C162	5E	L42	3B	R29	2I	R68	2B	R135	4H	R172	4K	R229	
C356	2D	L43	4B	R31	2J	R69	2J	R140	5H	R173	5G	R230	
		L44	4B	R32	1K	R73	2B	R141	5H	R174	4K	R231	
CR24	1I	L166	2E	R33	2J	R75	2B	R142	4H	R175	5K	R232	
CR33	2I			R35	2I	R76	2B	R143	5G	R176	5K	R233	
CR34	2I	Q24	1I	R36	2K	R77	2B	R144	5H	R177	4K	R234	
CR35	2I	Q32	1J	R37	2K	R78	1B	R145	4H	R178	4K	R235	
CR42	3B	Q34	1H	R41	3B	R107	2H	R146	5I	R179	4K	R236	



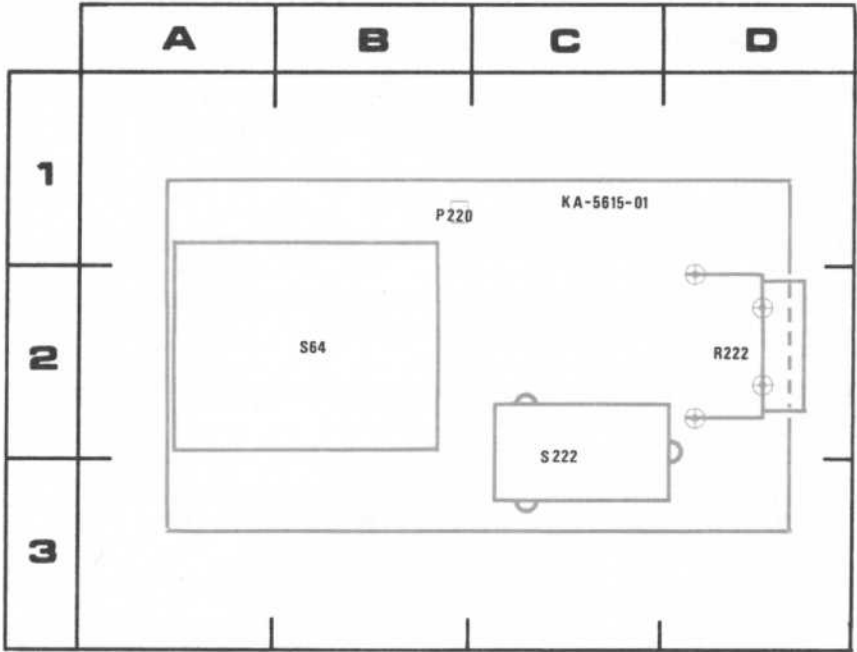
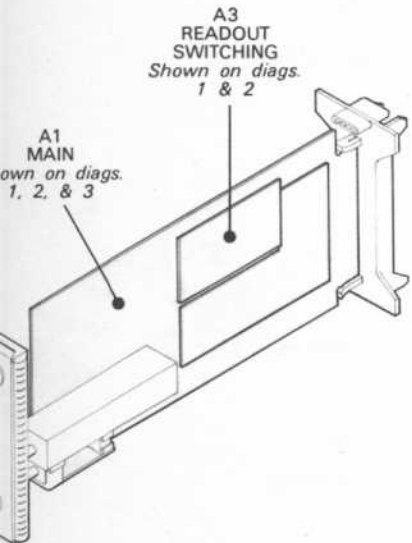


Figure 8-4. A3—Readout Switching circuit board assembly.

CKT NO	GRID COORD	CKT NO	GRID COORD
P220	1B	S64	2B
R222	2D	S222	2C



## VOLTAGE CONDITIONS

The voltages shown were obtained with the 7A29 controls set as follows: VOLTS/DIV switch set to 0.1; VARIABLE (Volts/Div) set to CAL IN; AC-OFF-DC set to DC; POLARITY set to +UP; and POSITION set to center the display.

**Voltage Conditions.** The voltages shown on the diagram were obtained using a digital multimeter with a 1 M $\Omega$  input impedance (TEKTRONIX DM 501 Digital Multimeter or TEKTRONIX 7D13 Digital Multimeter used with readout equipped, 7000-series oscilloscope).











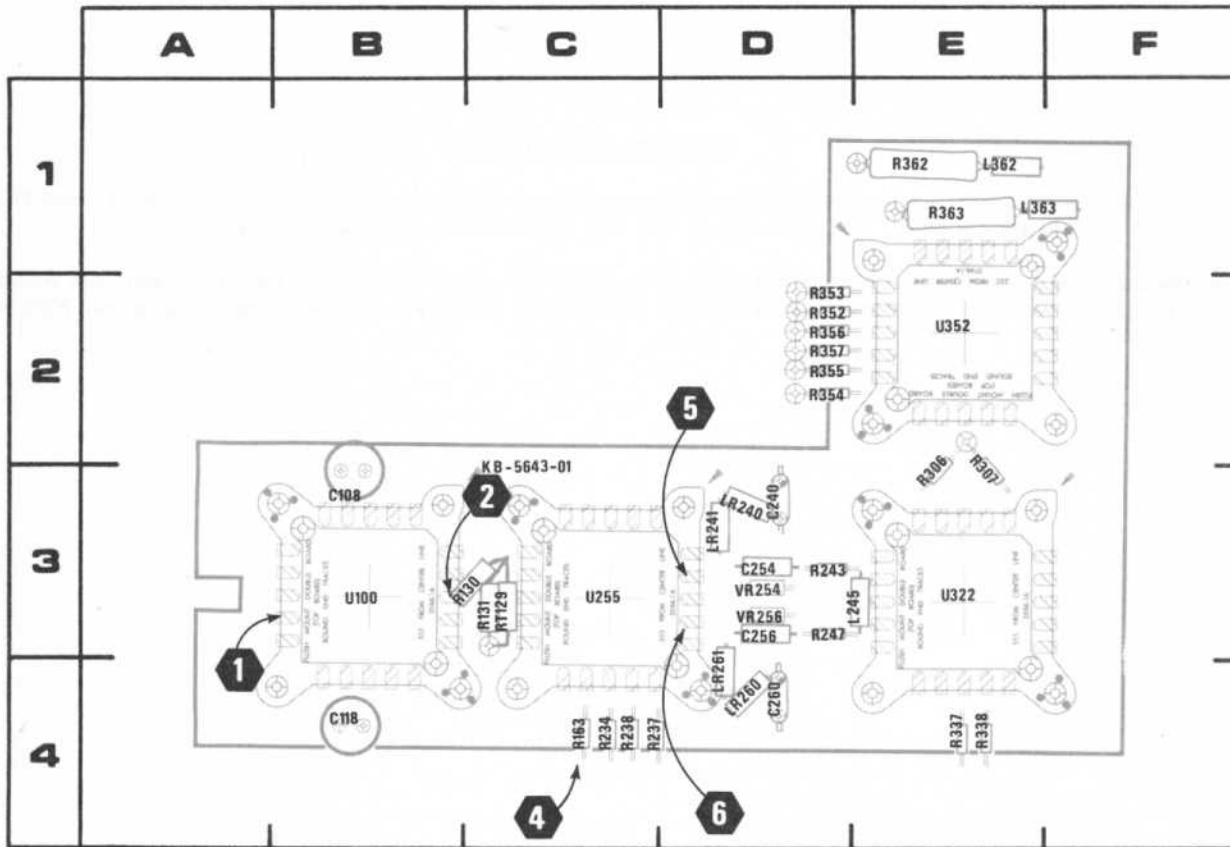


Figure 8-6. A2—High Frequency circuit board assembly.

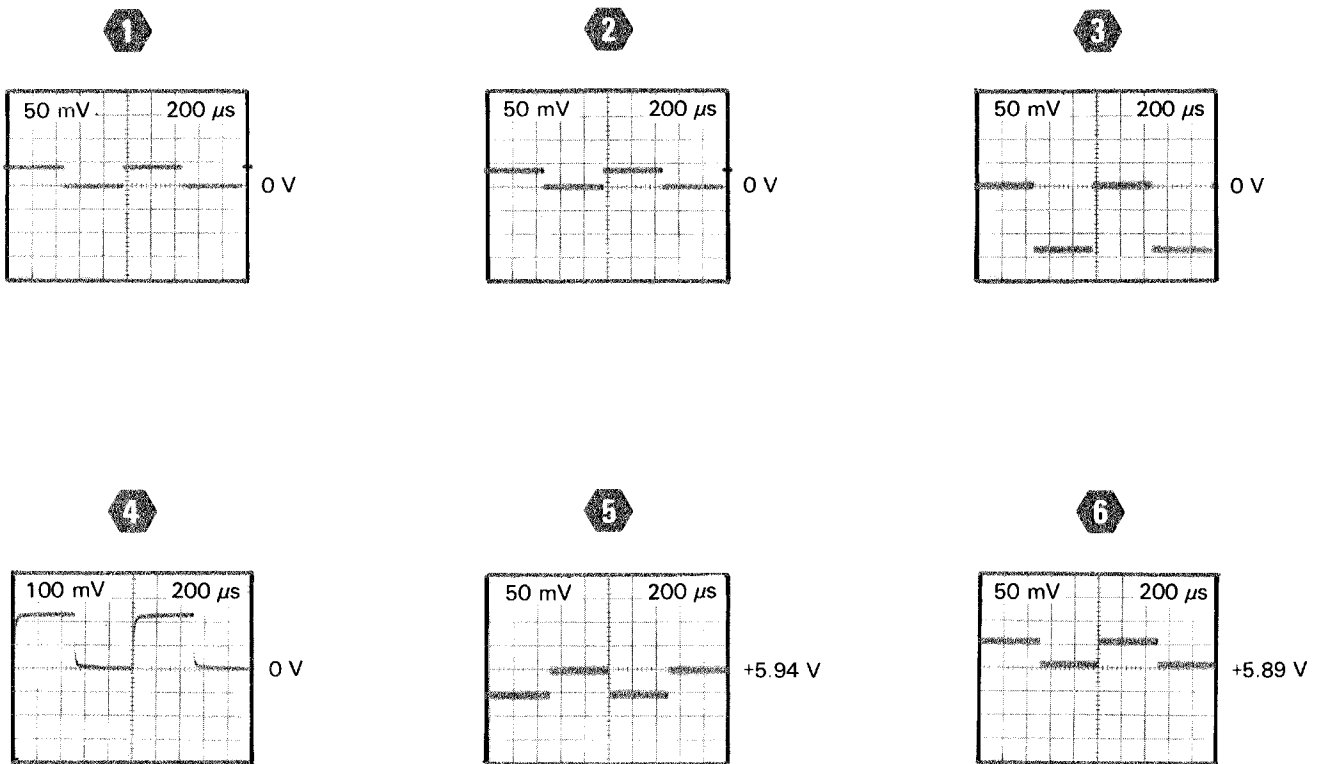
CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD
C108	3B	R130	3C	R356	2D
C118	4B	R131	3C	R357	2D
C240	3D	R163	4C	R362	1E
C254	3D	R234	4C	R363	1E
C256	3D	R237	4C	RT129	3C
C260	4D	R238	4C	U100	3B
L245	3D	R243	3D	U255	3C
L362	1E	R247	3D	U322	3E
L363	1E	R306	2E	U352	2E
LR240	3D	R307	2E	VR254	3D
LR241	3D	R337	4E	VR256	3D
LR260	4D	R338	4E		
LR261	3D	R352	2D		
		R353	2D		
		R354	2D		
		R355	2D		

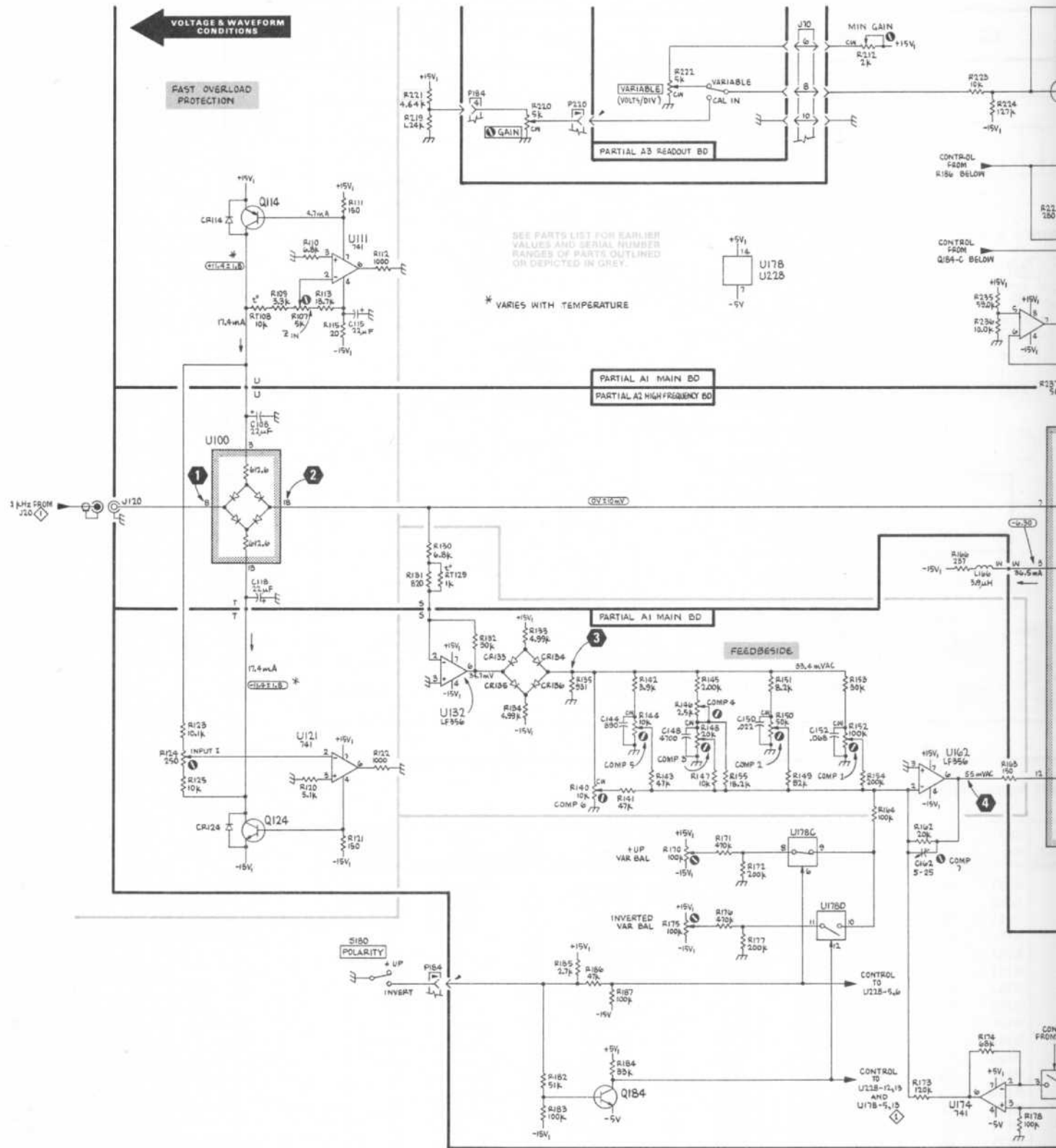
## VOLTAGE AND WAVEFORM CONDITIONS

The voltages and waveforms shown were obtained with the 7A29 controls set as follows: VOLTS/DIV switch set to 0.1; VARIABLE (Volts/Div) set to CAL IN; AC-OFF-DC set to DC; POLARITY set to +UP; and POSITION set to center the display.

**Voltage Conditions.** The voltages shown on the diagram were obtained using a digital multimeter with a 1 M $\Omega$  input impedance (TEKTRONIX DM 501 Digital Multimeter or TEKTRONIX 7D13 Digital Multimeter used with readout equipped, 7000-series oscilloscope).

**Waveform Conditions.** The waveforms shown below were obtained using a test oscilloscope system with 1 M $\Omega$  input impedance and at least 75 MHz bandwidth (TEKTRONIX 7904 Oscilloscope, 7B80 Time Base, and 7A13 Differential Comparator with a P6053B 10X probe). A 0.4 V, 1 kHz square wave signal was applied to the 7A29 INPUT. Test oscilloscope deflection factor and sweep rate appear on the waveform illustrations.





VOLTAGE & WAVEFORM CONDITIONS

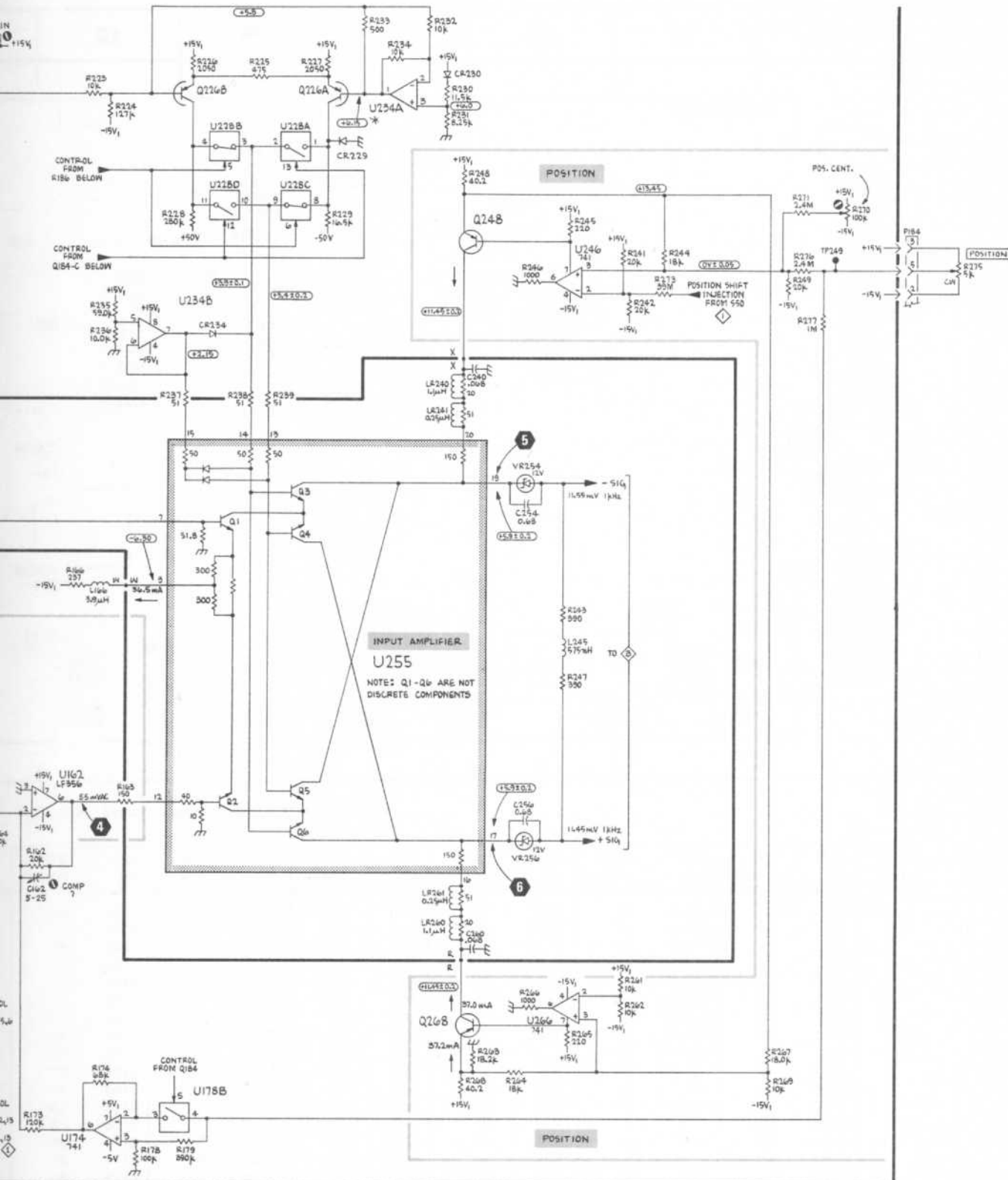
FAST OVERLOAD PROTECTION

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.

\* VARIES WITH TEMPERATURE

PARTIAL A1 MAIN BD  
PARTIAL A2 HIGH FREQUENCY BD

FEEDBACKSIDE

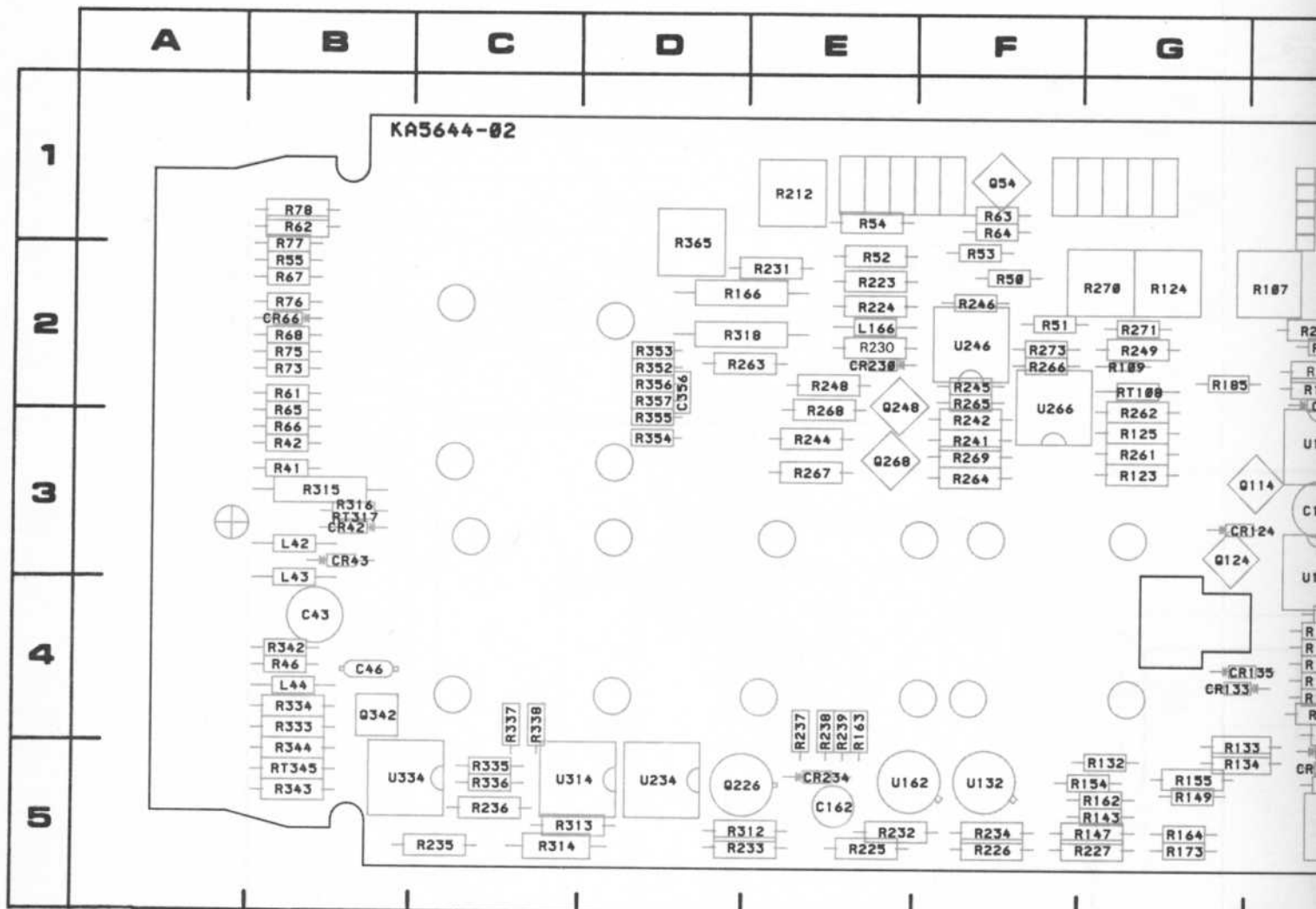


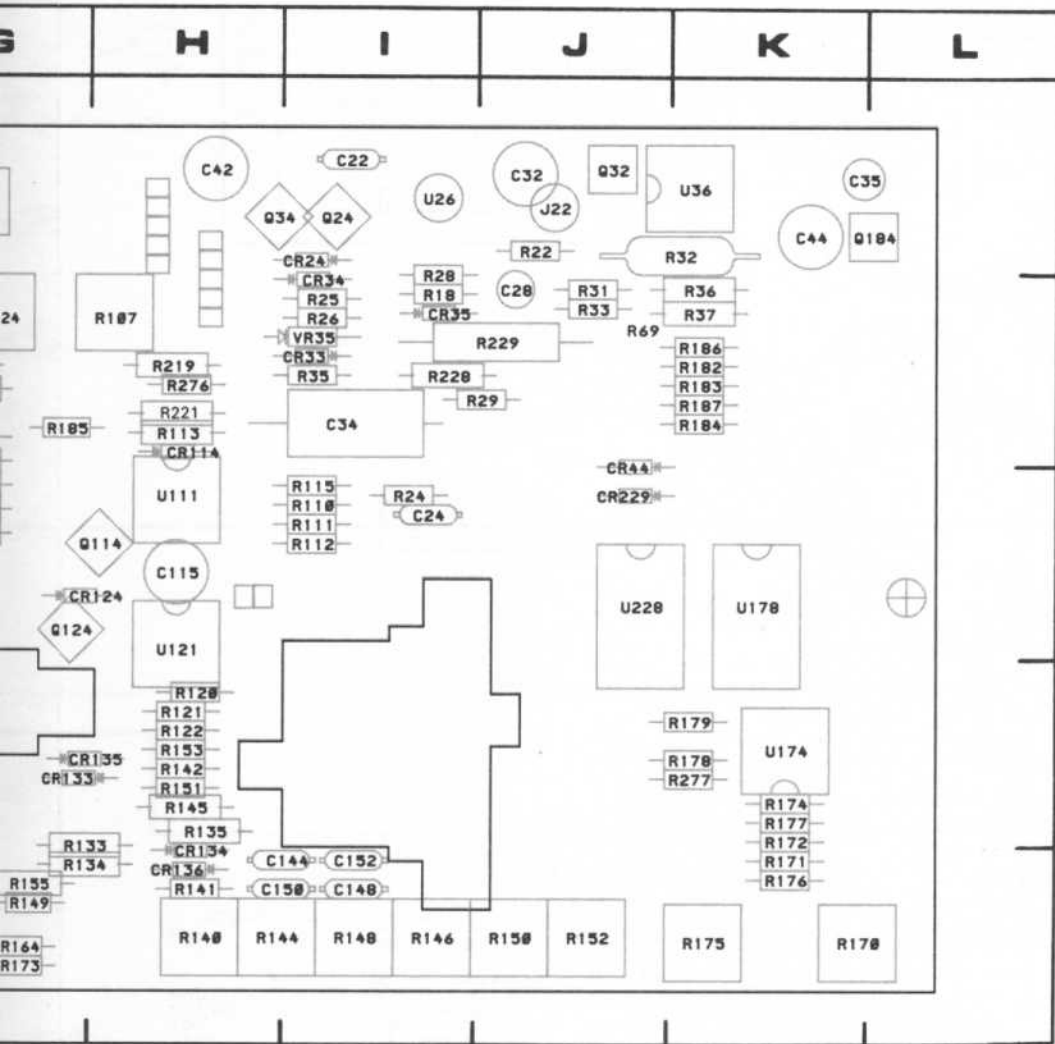
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SEE PARTS LIST FOR SEMICONDUCTOR TYPES.

INPUT AMPLIFIER 2

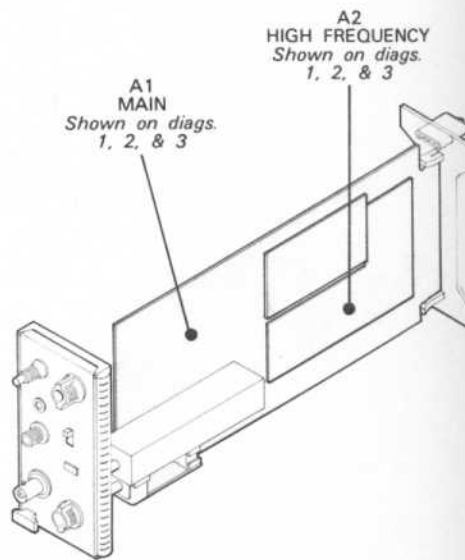
2 Input Amplifier Reverse Side A1 & A2





assembly.

GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO
5G	R182	2K	R237	4E	R277	4K	RT108	2G	
5I	R183	2K	R238	4E	R312	5D	RT317	3B	
5G	R184	2K	R239	4E	R313	5C	RT345	5B	
5J	R185	2G	R241	3F	R314	5C			
4H	R186	2K	R242	3F	R315	3B	U26	1I	
5J	R187	2K	R244	3E	R316	3B	U36	1K	
4H	R212	1E	R245	3F	R318	2D	U111	3H	
5G	R219	2H	R246	2F	R333	4B	U121	3H	
5G	R221	2H	R248	2E	R334	4B	U132	5F	
5G	R223	2E	R249	2G	R335	5C	U162	5E	
4E	R224	2E	R261	3G	R336	5C	U174	4K	
5G	R225	5E	R262	2G	R337	4C	U178	3K	
2D	R226	5F	R263	2D	R338	4C	U228	3J	
5K	R227	5G	R264	3F	R342	4B	U234	5D	
5K	R228	2I	R265	3F	R343	5B	U246	2F	
4K	R229	2J	R266	2F	R344	5B	U266	3F	
5G	R230	2E	R267	3E	R352	2D	U314	5C	
4K	R231	2E	R268	2E	R353	2D	U334	5B	
5K	R232	5E	R269	3F	R354	3D			
5K	R233	5D	R270	2G	R355	3D	VR35	2I	
4K	R234	5F	R271	2G	R356	2D			
4K	R235	5C	R273	2F	R357	3D			
4K	R236	5C	R276	2H	R365	2D			





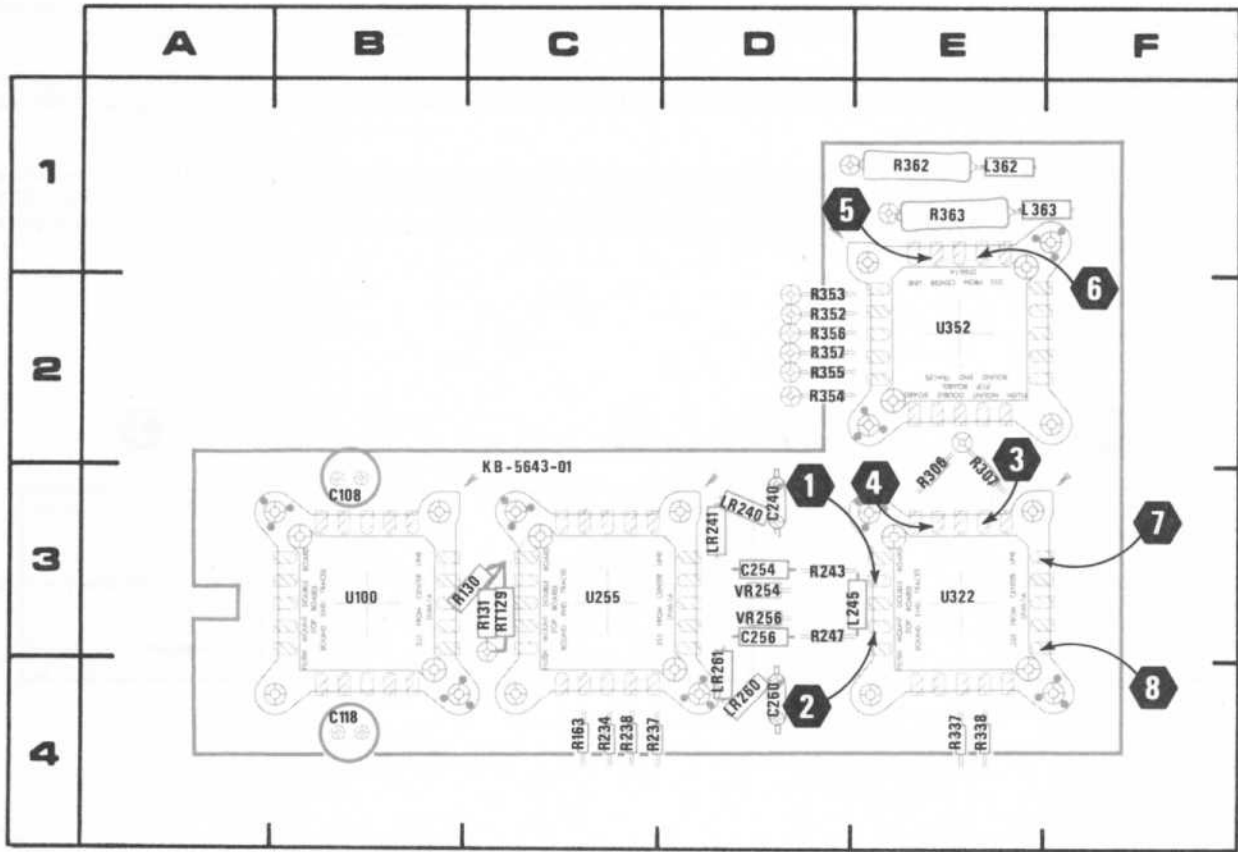


Figure 8-8. A2—High Frequency circuit board assembly.

CKT NO	GRID COORD	CKT NO	GRID COORD	CKT NO	GRID COORD
C108	3B	R130	3C	R356	2D
C118	4B	R131	3C	R357	2D
C240	3D	R163	4C	R362	1E
C254	3D	R234	4C	R363	1E
C256	3D	R237	4C		
C260	4D	R238	4C	RT129	3C
		R243	3D		
L245	3D	R247	3D	U100	3B
L362	1E	R306	2E	U255	3C
L363	1E	R307	2E	U322	3E
		R337	4E	U352	2E
		R338	4E		
LR240	3D	R352	2D	VR254	3D
LR241	3D	R353	2D	VR256	3D
LR260	4D	R354	2D		
LR261	3D	R355	2D		

QUENCY  
diags.  
& 3

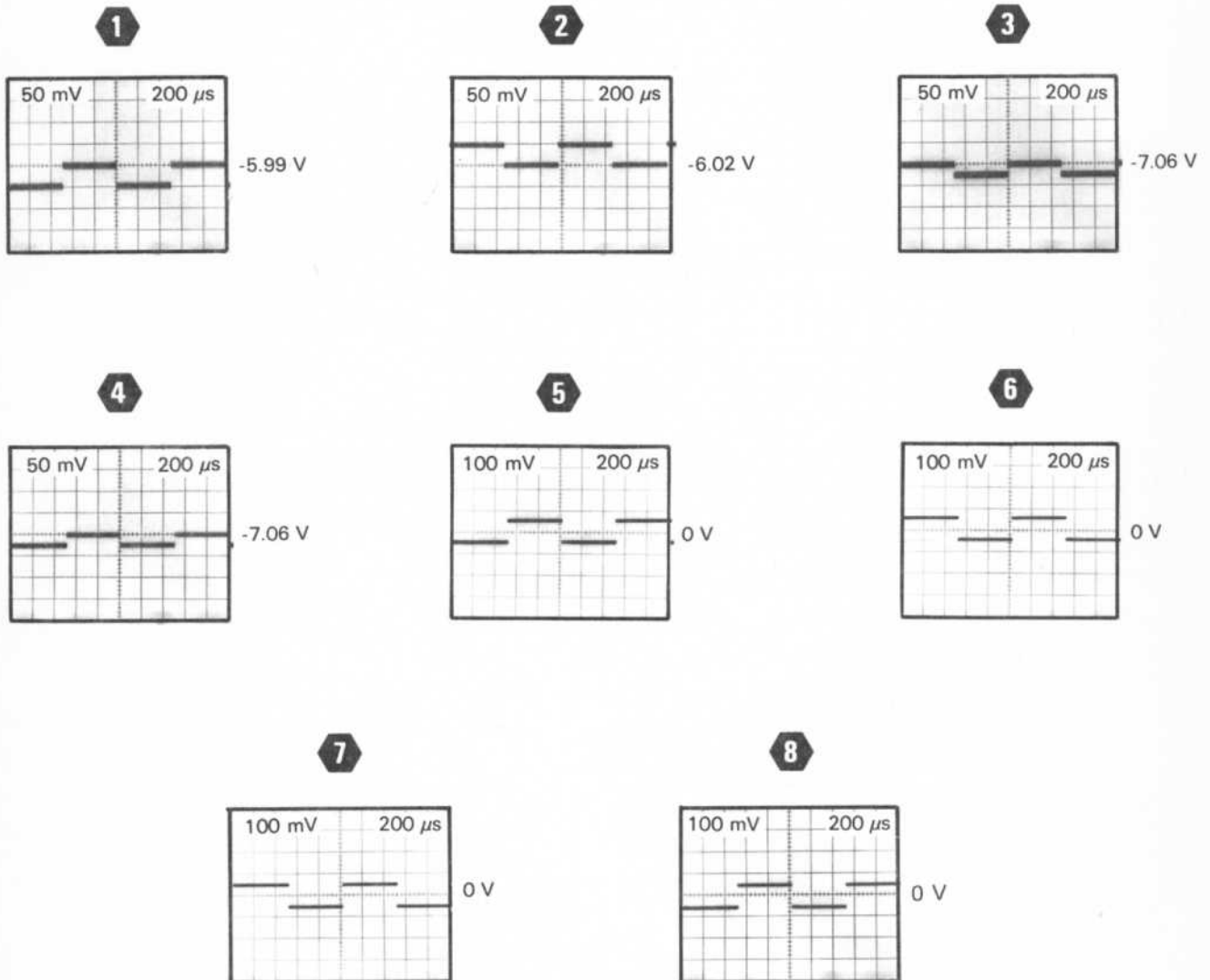


### VOLTAGE AND WAVEFORM CONDITIONS

The voltages and waveforms shown were obtained with the 7A29 controls set as follows: VOLTS/DIV switch set to 0.1; VARIABLE (Volts/Div) set to CAL IN; AC-OFF-DC set to DC; POLARITY set to +UP; and POSITION set to center the display.

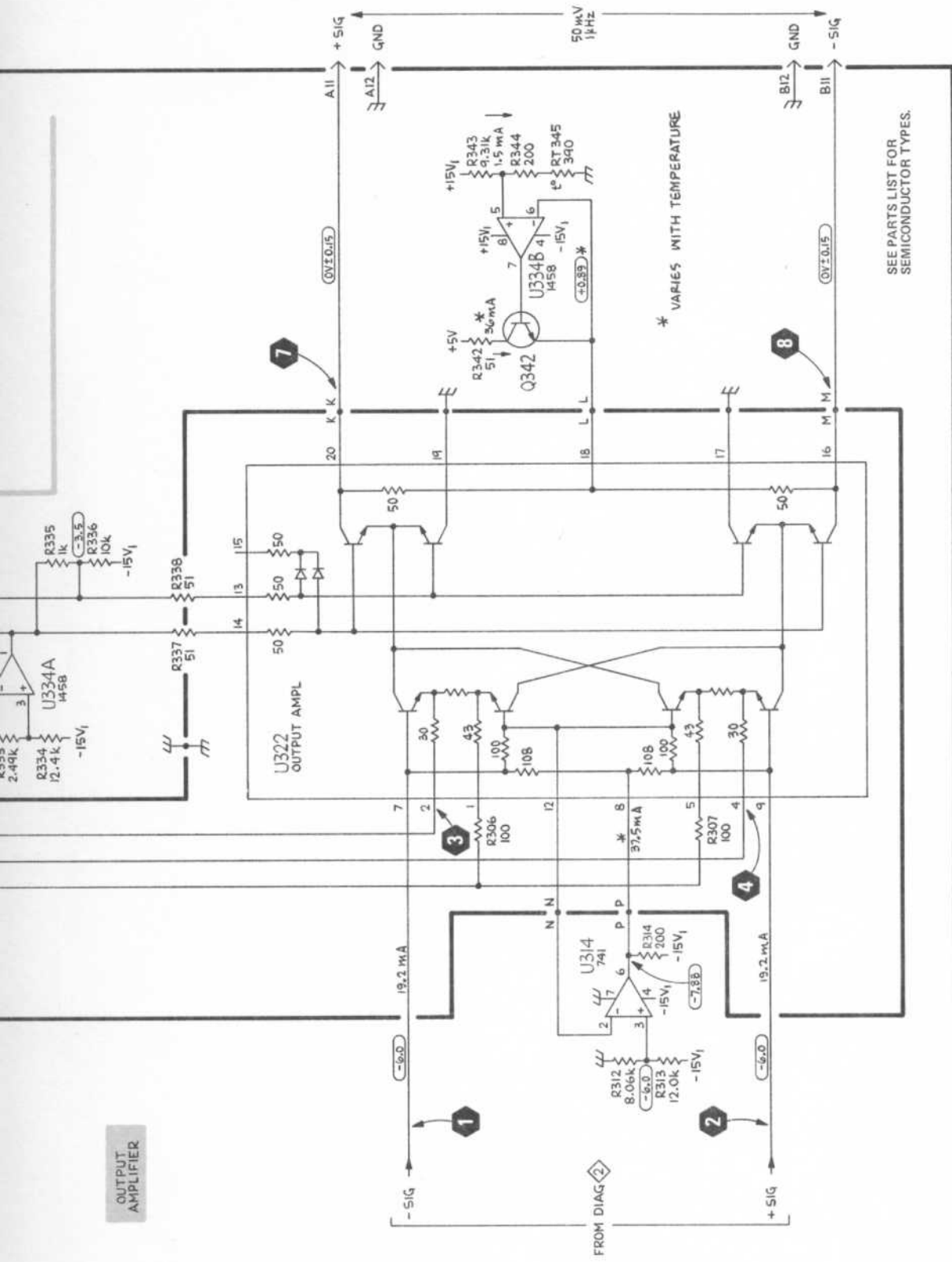
**Voltage Conditions.** The voltages shown on the diagram were obtained using a digital multimeter with a  $1\text{ M}\Omega$  input impedance (TEKTRONIX DM 501 Digital Multimeter or TEKTRONIX 7D13 Digital Multimeter used with readout equipped, 7000-series oscilloscope).

**Waveform Conditions.** The waveforms shown below were obtained using a test oscilloscope system with  $1\text{ M}\Omega$  input impedance and at least 75 MHz bandwidth (TEKTRONIX 7904 Oscilloscope, 7B80 Time Base, and 7A13 Differential Comparator with a P6053B 10X probe). A 0.4 V, 1 kHz square wave signal was applied to the 7A29 INPUT. Test oscilloscope deflection factor and sweep rate appear on the waveform illustrations.





OUTPUT AMPLIFIER



TRIGGER AND OUTPUT AMPLIFIER 3

SEE PARTS LIST FOR SEMICONDUCTOR TYPES.

1. Beginning at the top left block of the chart, proceed with the instructions following the solid arrows, until the instrument does not perform as indicated.

2. Then follow the dashed arrows, as the symptom indicates, until a malfunction is located. Each shaded block indicates a circuit which may be the cause of the malfunction, and corresponds directly to the circuit names given on the schematic diagrams.

3. Refer to the numbered schematic diagrams for the numbered waveform test points, conditions under which the waveforms are to be taken, and the schematic. Located on the schematic diagram of the 7A29 shown in the illustration of the 7A29 shown in the illustration of the circuit board, the circuit components and waveforms are indicated.

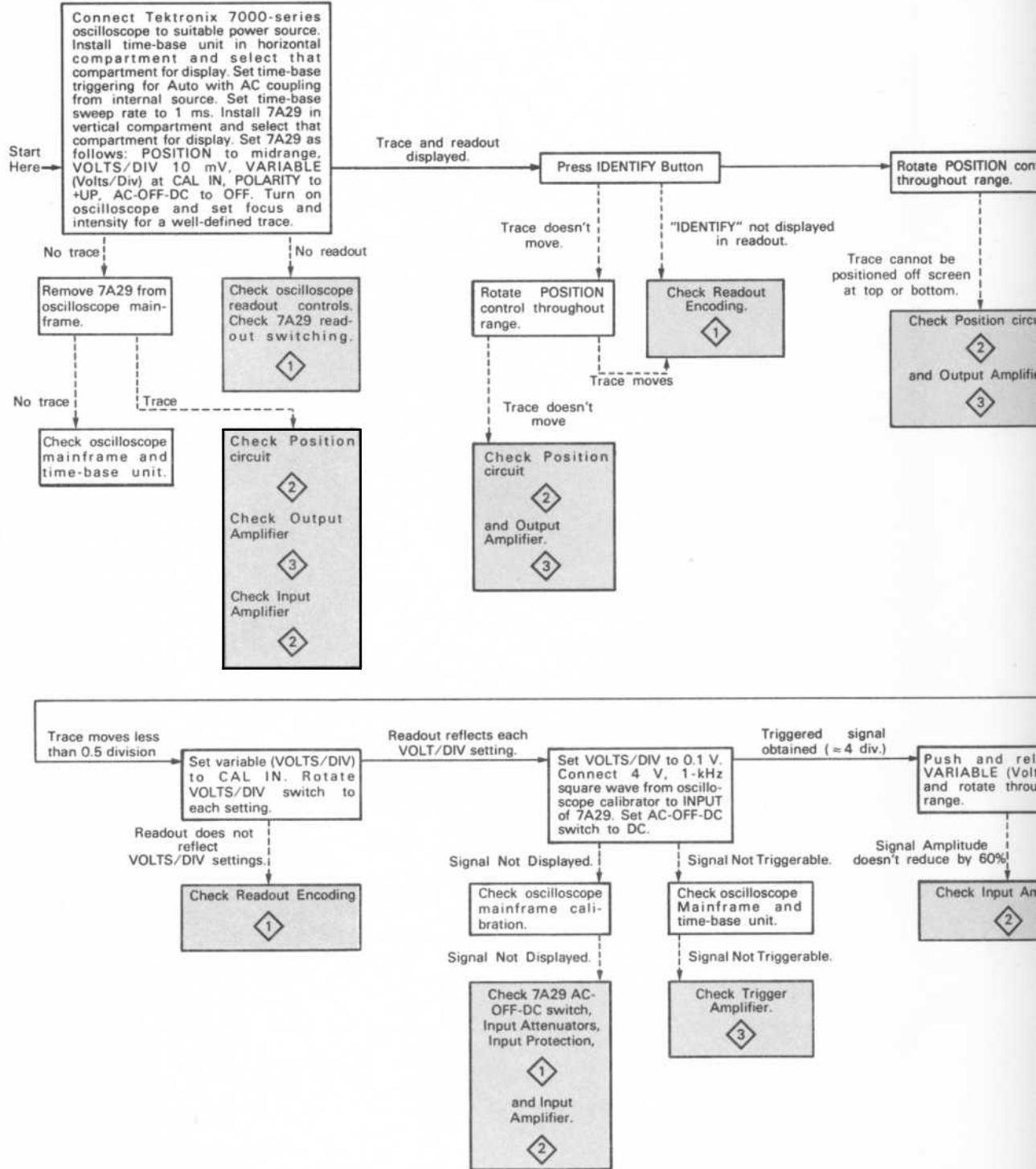
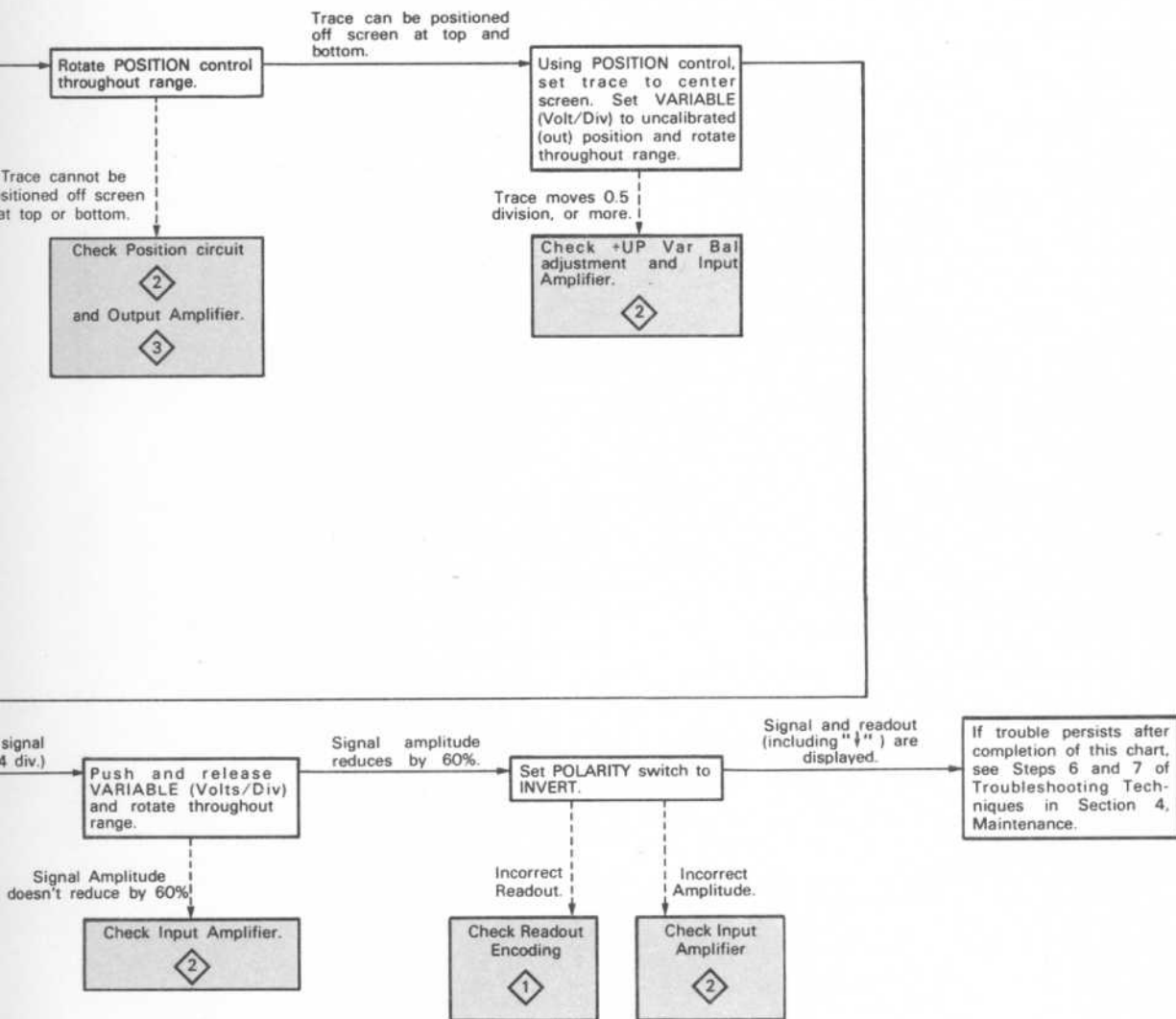


Figure 8-9. 7A29 Troubleshooting

## TROUBLESHOOTING CHART INSTRUCTIONS

Refer to the numbered schematic indicated in the shaded box. Important voltages and numbered waveform test points are given on the schematics. Typical waveforms, and the conditions under which the voltages and waveforms were taken, are located adjacent to the schematic. Located on the back of the foldout page facing the schematic is an illustration of the 7A29 showing the location of the circuit board. In addition, an illustration of the circuit board is included here, identifying the physical location of the circuit components and waveform test points.

- If additional understanding of the circuit is required, refer to the Theory of Operation, section 3. The circuit or stage names given in this chart and on the schematics are repeated as sub-headings in section 3, where they are discussed in detail.



2320-52

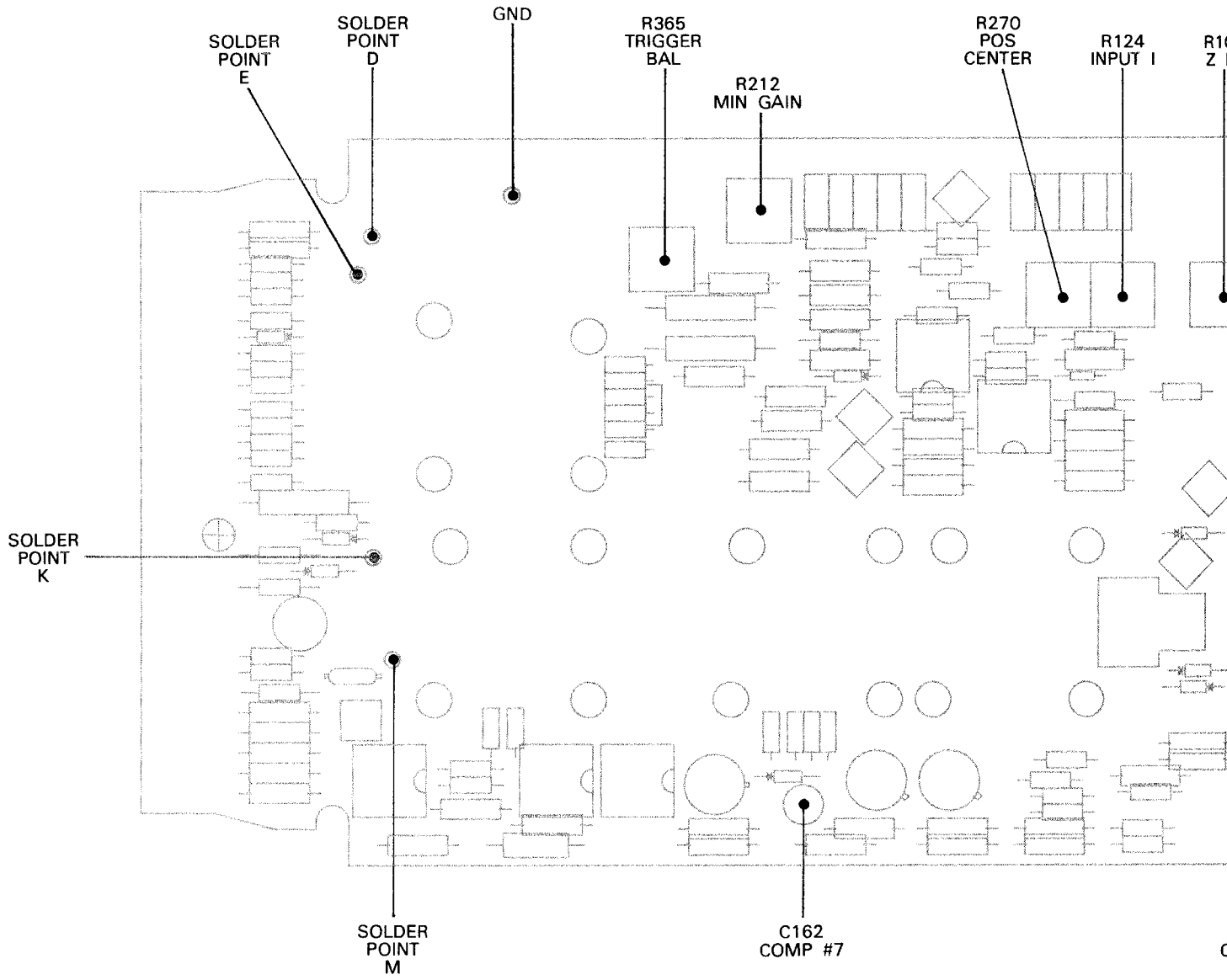
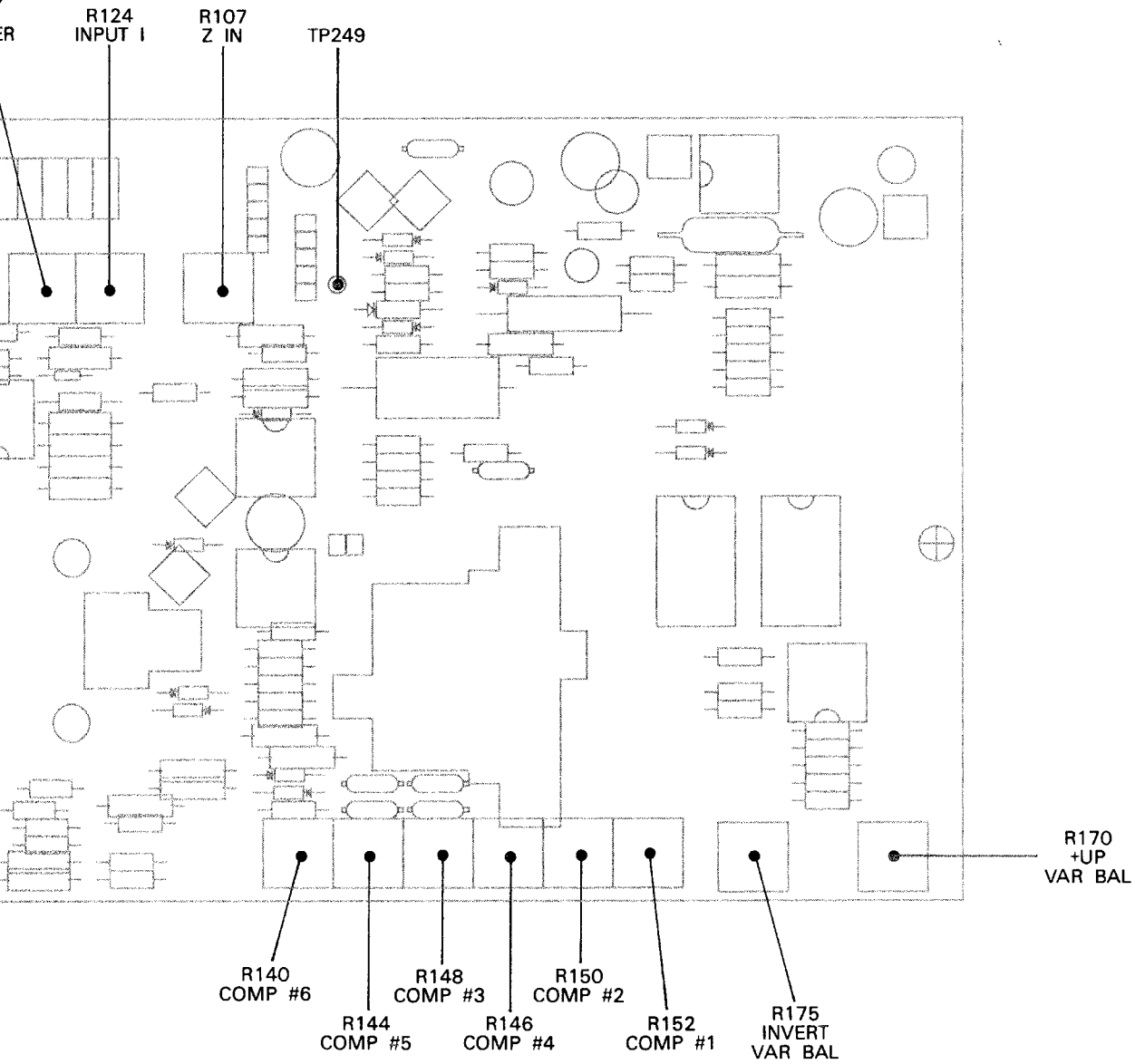


Figure 8-10. Test Point & Adjustment Location



Test Point and  
Adjustment Locations

& Adjustment Locations.



# REPLACEABLE MECHANICAL PARTS

## PARTS ORDERING INFORMATION

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

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

## SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number  
00X Part removed after this serial number

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```

1 2 3 4 5           Name & Description
Assembly and/or Component
Attaching parts for Assembly and/or Component
    --- * ---
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
    --- * ---
Parts of Detail Part
Attaching parts for Parts of Detail Part
    --- * ---
  
```

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol --- \* --- indicates the end of attaching parts.

**Attaching parts must be purchased separately, unless otherwise specified.**

## ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

## ABBREVIATIONS

"	INCH	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
#	NUMBER SIZE	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ACTR	ACTUATOR	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICON	SEMICONDUCTOR
ADPTR	ADAPTER	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
ALIGN	ALIGNMENT	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
AL	ALUMINUM	EOPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSEM	ASSEMBLED	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ASSY	ASSEMBLY	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
ATTEN	ATTENUATOR	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
AWG	AMERICAN WIRE GAGE	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BD	BOARD	FLTR	FILTER	OBD	ORDER BY DESCRIPTION	SQ	SQUARE
BRKT	BRACKET	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRS	BRASS	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BRZ	BRONZE	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
BSHG	BUSHING	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAB	CABINET	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CAP	CAPACITOR	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CER	CERAMIC	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CHAS	CHASSIS	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
CKT	CIRCUIT	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
COMP	COMPOSITION	HLCPS	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
CONN	CONNECTOR	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
COV	COVER	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CPLG	COUPLING	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
CRT	CATHODE RAY TUBE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DEG	DEGREE	IDENT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
DWR	DRAWER	IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
000AH	STANDARD PRESSED STEEL CO., UNBRAKO DIV.	8535 DICE ROAD	SANTA FE SPRINGS, CA 90670
000BK	STAUFFER SUPPLY	105 SE TAYLOR	PORTLAND, OR 97214
000CY	NORTHWEST FASTENER SALES, INC.	7923 SW CIRRUS DRIVE	BEAVERTON, OREGON 97005
000FW	WESTERN SINTERING CO INC.	2620 STEVENS DRIVE	RICHLAND, WA 99352
00779	AMP, INC.	P O BOX 3608	HARRISBURG, PA 17105
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
22599	ESNA, DIV. OF AMERACE CORPORATION	16150 STAGG STREET	VAN NUYS, CA 91409
24931	SPECIALITY CONNECTOR CO., INC.	2620 ENDRESS PLACE	GREENWOOD, IN 46142
46384	PENN ENGINEERING AND MFG. CORP.	P O BOX 311	DOYLESTOWN, PA 18901
73743	FISCHER SPECIAL MFG. CO.	446 MORGAN ST.	CINCINNATI, OH 45206
73803	TEXAS INSTRUMENTS, INC.; METALLURGICAL MATERIALS DIV.	34 FOREST STREET	ATTLEBORO, MA 02703
74445	HOLO-KROME CO.	31 BROOK ST. WEST	HARTFORD, CT 06110
78189	ILLINOIS TOOL WORKS, INC. SHAKEPROOF DIVISION	ST. CHARLES ROAD	ELGIN, IL 60120
79136	WALDES, KOHINOOR, INC.	47-16 AUSTEL PLACE	LONG ISLAND CITY, NY 11101
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
83385	CENTRAL SCREW CO.	2530 CRESCENT DR.	BROADVIEW, IL 60153
86928	SEASTROM MFG. COMPANY, INC.	701 SONORA AVENUE	GLENDALE, CA 91201
87308	N. L. INDUSTRIES, INC., SOUTHERN SCREW DIV.	P. O. BOX 1360	STATESVILLE, NC 28677
99934	RENBRANDT INC.	6 PARMELEE STREET	BOSTON, MA 02118

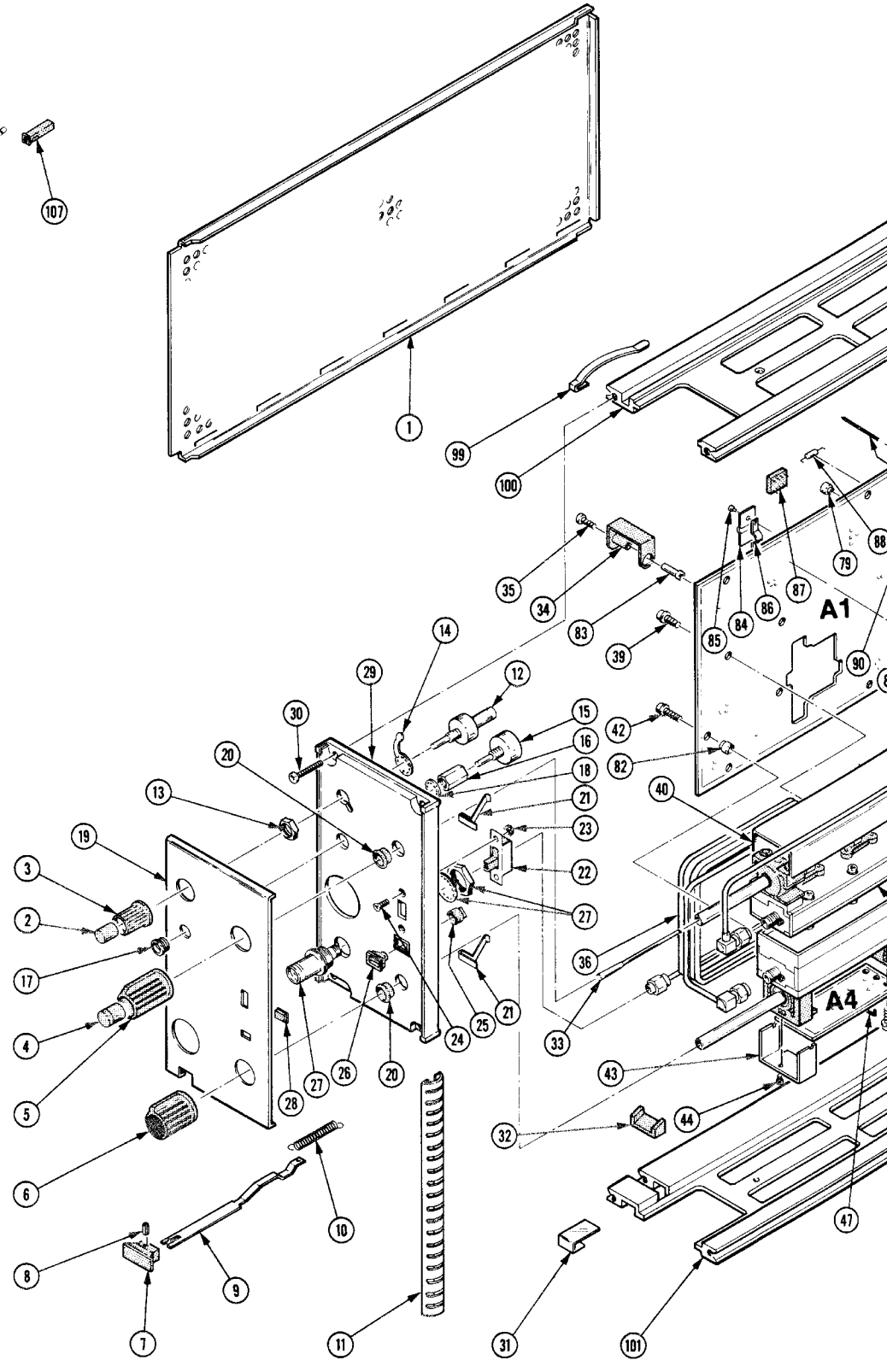
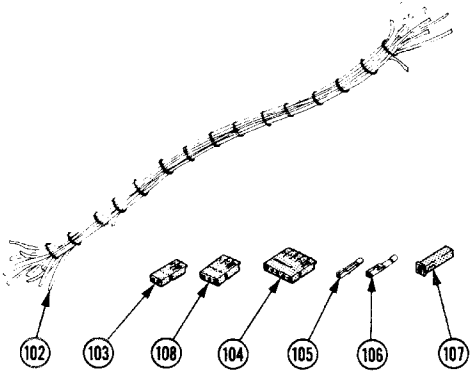
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1	2	3	4	5	Name & Description	Mfr Code	Mfr Part Number
1-1	337-1064-04		2						SHIELD,ELEC:SIDE PLUG-IN UNITS	80009	337-1064-00
-2	366-1059-00		1						PUSH BUTTON:GRAY	80009	366-1059-00
-3	366-1077-00		1						KNOB:GRAY	80009	366-1077-00
	213-0153-00		1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX	000CY	OBD
-4	366-1166-00		1						KNOB:RED,0.127 ID X 0.392 OD	80009	366-1166-00
	213-0153-00		1						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX	000CY	OBD
-5	366-1057-00		1						KNOB:GRAY	80009	366-1057-00
	213-0153-00		2						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX	000CY	OBD
-6	366-1028-00		1						KNOB:GRAY	80009	366-1028-00
	213-0153-00		2						. SETSCREW:5-40 X 0.125,STL BK OXD,HEX	000CY	OBD
-7	366-1058-77		1						KNOB:LATCH,MARKED 7A29	80009	366-1058-77
									(ATTACHING PARTS)		
-8	214-1095-00		1						PIN,SPG,SPLIT:0.094 OD X 0.187 INCH LONG	22599	52-022-094-0187
									- - - * - - -		
-9	105-0076-02		1						REL BAR,LATCH:PLUG-IN UNIT	80009	105-0076-02
-10	214-1280-00		1						SPRING,HLCPS:0.14 OD X 1.126"L,0.16"DIA W	80009	214-1280-00
-11	348-0235-00		2						SHLD GSKT,ELEC:4.734 INCH LONG	80009	348-0235-00
-12	-----		1						RESISTOR,VAR:(SEE R275,S50 EPL)		
									(ATTACHING PARTS)		
-13	210-0583-00		1						NUT,PLAIN,HEX.:0.25-32 X 0.312 INCH,BRS	73743	2X20317-402
									- - - * - - -		
-14	210-0223-01		1						TERMINAL,LUG:0.25 INCH DIA,SE,60 DEG BEND	86928	OBD
-15	-----		1						RESISTOR,VAR:(SEE R220 EPL)		
-16	129-0252-00		1						SPACER,POST:0.45 LONG X 0.312 HEX	80009	129-0252-00
									(ATTACHING PARTS)		
-17	358-0342-00		1						BSHG,MACH.THD:0.25 X 32 X 0.352 INCH LONG	80009	358-0342-00
									- - - * - - -		
-18	210-0046-00		3						WASHER,LOCK:0.261 ID,INTL,0.018 THK,BRS	78189	1214-05-00-0541C
-19	333-1213-14		1						PANEL,FRONT:WO/VAR DELAY LINE	80009	333-1213-14
-20	358-0216-00		2						BUSHING,PLASTIC:0.257 ID X 0.412 INCH OD	80009	358-0216-00
-21	131-1075-00		2						CONTACT,ELEC:GROUNDING,CU BE HEAT TRTD	80009	131-1075-00
-22	-----		1						SWITCH,SLIDE:(SEE S180 EPL)		
									(ATTACHING PARTS)		
-23	210-0406-00		2						NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-24	211-0087-01		2						SCREW,MACHINE:2-56 X 0.188" 82 DEG,FLH,STL	83385	OBD
									- - - * - - -		
-25	200-0935-00		1						BASE,LAMPHOLDER:0.29 OD X 0.19 CASE	80009	200-0935-00
-26	352-0277-00		1						LAMPHOLDER:(1)WIRE LEAD TYPE	80009	352-0277-00
-27	131-2038-00		1						CONN,RCPT,ELEC:BNC,FEM	24931	29JJ125-1
-28	378-0690-04		1						LENS,LIGHT:AMBER--RESET	80009	378-0690-04
-29	386-1447-89		1						SUBPANEL,FRONT:	80009	386-1447-89
									(ATTACHING PARTS)		
-30	213-0192-00		4						SCR,TPG,THD FOR:6-32 X 0.50 INCH,PNH STL	87308	OBD
									- - - * - - -		
-31	214-1054-00		1						SPRING,FLAT:0.825 X 0.322,SST	80009	214-1054-00
-32	105-0075-00		1						BOLT,LATCH:7A & 7B SER PL-IN	80009	105-0075-00
-33	384-0405-00		1						EXTENSION SHAFT:9.276 L X 0.125 OD STEEL	80009	384-0405-00
-34	343-0732-00		2						RTNR,DELAY LINE:POLYPROPYLENE,BLACK	80009	343-0732-00
									(ATTACHING PARTS)		
-35	211-0016-00		2						SCREW,MACHINE:4-40 X 0.625 INCH,PNH STL	83385	OBD
									- - - * - - -		
-36	-----		1						DELAY LINE,ELEC:(SEE DL4 EPL)		
-37	175-2144-00		1						CABLE ASSY,RF:50 OHM COAX,9.49 L	80009	175-2144-00
-38	-----		1						ATTEN,VARIABLE:(SEE S62 EPL)		
									(ATTACHING PARTS)		
-39	211-0116-00		2						SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
									- - - * - - -		
-40	200-2084-00		1						. COVER,CAM SW:4 ELEMENTS	80009	200-2084-00
-41	-----		1						SWITCH ASSY:(SEE S4 EPL)		
									(ATTACHING PARTS)		
-42	211-0116-00		2						SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS	83385	OBD
									- - - * - - -		

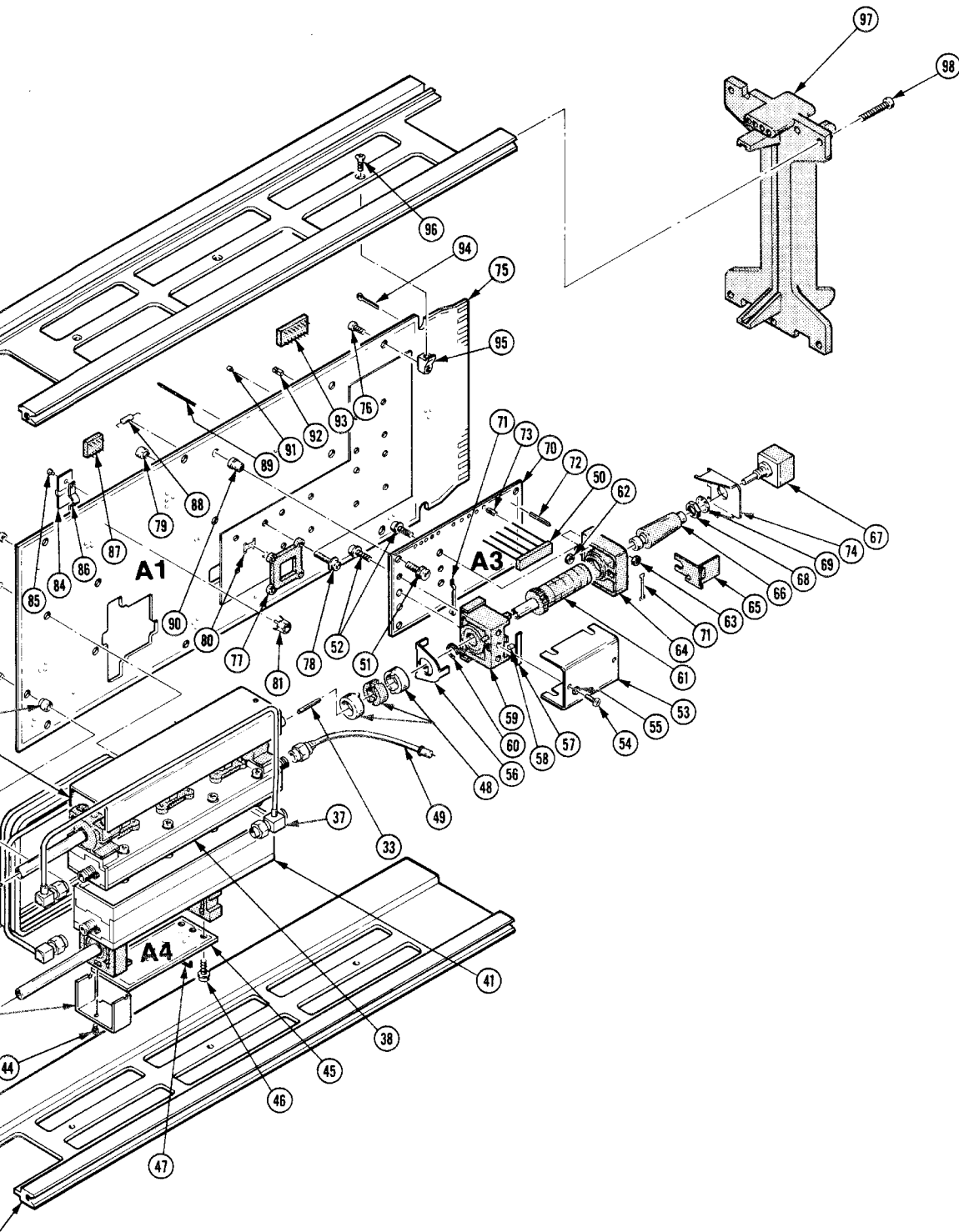
Replaceable Mechanical Parts—7A29

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1	2	3	4	5	Name & Description	Mfr Code	Mfr Part Number
1-43	200-0924-02			1	.	.	.	.	.	COVER,CAM SW: (ATTACHING PARTS)	80009	200-0924-02
-44	211-0162-00			1	.	.	.	.	.	SCREW,MACHINE:2-56 X 0.188 INCH,SCH,SST - - - * - - -	000AH	OBD
-45	-----			1	.	.	.	.	.	CKT BOARD ASSY:SOLENOID(SEE A4 EPL) (ATTACHING PARTS)		
-46	211-0116-00			2	.	.	.	.	.	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -	83385	OBD
-47	131-0589-00			2	.	.	.	.	.	TERM,PIN:0.46 L X 0.025 SQ.PH BRZ GL	22526	47350
-48	376-0091-00			1	.	.	.	.	.	CPLG,SHAFT,FLEX:0.251 ID X 0.672 OD,BRS NP	99934	A-201-165
-49	198-4046-00			1	.	.	.	.	.	WIRE SET,ELEC:	80009	198-4046-00
-50	131-1820-00			2	.	.	.	.	.	CONNECTOR,PLUG,:CKT CD,5 MALE	22526	65306-002
	672-0635-00			1	.	.	.	.	.	CKT BOARD ASSY:READOUT (ATTACHING PARTS)	80009	672-0635-00
-51	211-0116-00			4	.	.	.	.	.	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -	83385	OBD
	-----			1	.	.	.	.	.	SW CAM ACTR AS:READOUT(SEE S222 EPL) (ATTACHING PARTS)		
-52	211-0116-00			4	.	.	.	.	.	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -	83385	OBD
-53	200-1032-00			1	.	.	.	.	.	COVER,CAM SW:5 ELEMENTS (ATTACHING PARTS)	80009	200-1032-00
-54	211-0022-00			2	.	.	.	.	.	SCREW,MACHINE:2-56 X 0.188 INCH,PNH STL	83385	OBD
-55	210-0001-00			2	.	.	.	.	.	WASHER,LOCK:INT'L,0.092 ID X 0.18"OD,STL - - - * - - -	78189	1202-00-00-0541C
-56	407-0714-00			1	.	.	.	.	.	BRACKET,CAM SW:GROUNDING,BRS ALBALOY PL	80009	407-0714-00
-57	214-1126-02			1	.	.	.	.	.	SPRING,FLAT:RED COLORED	80009	214-1126-02
-58	214-1127-00			1	.	.	.	.	.	ROLLER,DETENT:0.125 DIA X 0.125 INCH L	80009	214-1127-00
-59	401-0058-00			1	.	.	.	.	.	BEARING,CAM SW:FRONT (ATTACHING PARTS)	80009	401-0058-00
-60	354-0219-00			1	.	.	.	.	.	RING,RETAINING:FOR 0.25 INCH SHAFT - - - * - - -	79136	5103-25-MD-R
-61	105-0743-00			1	.	.	.	.	.	ACTUATOR,CAM SW:READOUT	80009	105-0743-00
-62	210-0406-00			2	.	.	.	.	.	NUT,PLAIN,HEX.:4-40 X 0.188 INCH,BRS	73743	2X12161-402
-63	210-0405-00			1	.	.	.	.	.	NUT,PLAIN,HEX.:2-56 X 0.188 INCH,BRS	73743	2X12157-402
-64	401-0061-00			1	.	.	.	.	.	BEARING,CAM SW:REAR	80009	401-0061-00
-65	105-0746-00			1	.	.	.	.	.	ACTUATOR,SL SW:OFFSET	80009	105-0746-00
-66	214-1190-02			1	.	.	.	.	.	CPLG,SHAFT,RGD:0.125 OD TO 0.081 OD,AL	80009	214-1190-02
-67	-----			1	.	.	.	.	.	RESISTOR,VAR:(SEE R222 EPL) (ATTACHING PARTS)		
-68	210-0586-00			1	.	.	.	.	.	NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	83385	211-041800-00
-69	210-0046-00			1	.	.	.	.	.	WASHER,LOCK:0.261 ID,INT'L,0.018 THK,BRS - - - * - - -	78189	1214-05-00-0541C
-70	-----			1	.	.	.	.	.	CKT BOARD ASSY:READOUT(SEE A3 EPL)		
-71	131-0604-00			8	.	.	.	.	.	CONTACT,ELEC:CKT BD SW,SPR,CU BE	80009	131-0604-00
-72	131-0589-00			1	.	.	.	.	.	TERM,PIN:0.46 L X 0.025 SQ.PH BRZ GL	22526	47350
-73	136-0263-04			10	.	.	.	.	.	SOCKET,PIN TERM:FOR 0.025 INCH SQUARE PIN	22526	75377-001
-74	407-1963-00			1	.	.	.	.	.	BRACKET,ELEC SW:BRASS	80009	407-1963-00
-75	-----			1	.	.	.	.	.	CKT BOARD ASSY:MAIN(SEE A1 EPL) (ATTACHING PARTS)		
-76	211-0116-00			6	.	.	.	.	.	SCR,ASSEM WSHR:4-40 X 0.312 INCH,PNH BRS - - - * - - -	83385	OBD
-77	426-1351-00			4	.	.	.	.	.	FRAME,MICROCKT:1.75 CM (ATTACHING PARTS)	80009	426-1351-00
-78	211-0259-00			16	.	.	.	.	.	SCR,ASSEM WSHR:2-56 X 0.437,PNH,STL CD PL	78189	OBD
-79	220-0797-00			16	.	.	.	.	.	NUT,CAPTIVE:2-56 X 0.218 DIA,STL CD PL - - - * - - -	46384	KF2-256
-80	131-1967-00			4	.	.	.	.	.	CONT SET,ELEC:MICROCKT,1.75CM,RUBBER	80009	131-1967-00
-81	131-1003-00			1	.	.	.	.	.	CONN,RCPT,ELEC:CKT BD MT,3 PRONG	80009	131-1003-00
-82	361-0834-00			2	.	.	.	.	.	SPACER,SLEEVE:0.125 L X 0.219 OD,STL CD PL	46384	KFE-116-4
-83	129-0561-00			4	.	.	.	.	.	SPACER,POST:0.535 L,W-4-40 INTL ONE END	80009	129-0561-00
-84	131-2033-00			1	.	.	.	.	.	CONTACT,ELEC:SINGLE,BOTTOM,CU BE (ATTACHING PARTS)	80009	131-2033-00
-85	210-0629-00			2	.	.	.	.	.	EYELET,METALLIC:0.059 OD X 0.093 L,BRS - - - * - - -	80009	210-0629-00

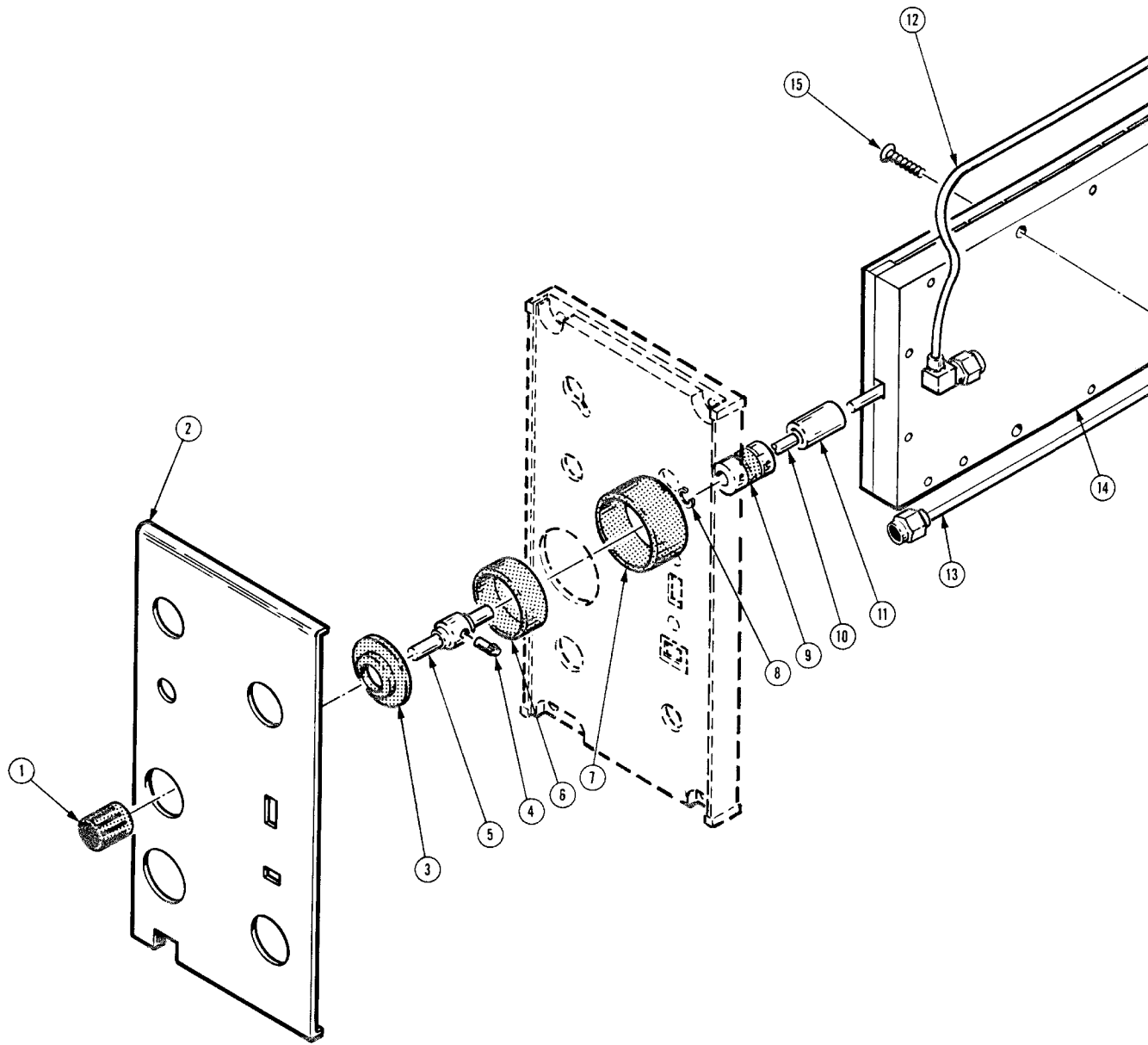
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-86	131-2032-00		1	.	CONTACT, ELEC: SINGLE, TOP, CUBE	80009	131-2032-00
-87	136-0514-00		9	.	SKT, PL-IN ELEC: MICROCIRCUIT, 8 DIP	73803	CS9002-8
-88	-----		1	.	CONN, RCPT, ELEC: (SEE R274 EPL)		
-89	131-0608-00		12	.	TERMINAL, PIN: 0.365 L X 0.025 PH BRZ GOLD	22526	47357
-90	129-0277-00		4	.	SPACER, POST: 0.18 L, W/4-40THD THRU, BRASS	80009	129-0277-00
-91	136-0252-04		53	.	SOCKET, PIN TERM: U/W 0.016-0.018 DIA PINS	22526	75060-007
	136-0252-00		1	.	SOCKET, PIN TERM: 0.145 INCH LONG	00779	2-330808-7
-92	136-0263-04		10	.	SOCKET, PIN TERM: FOR 0.025 INCH SQUARE PIN	22526	75377-001
-93	136-0269-02		2	.	SKT, PL-IN ELEK: MICROCIRCUIT, 14 DIP, LOW CLE	73803	CS9002-14
-94	214-0579-00	B010100 B029999	9	.	TERM, TEST POINT: BRS CD PL	80009	214-0579-00
	214-0579-02	B030000	10	.	TERM, TEST POINT: BRASS	80009	214-0579-02
-95	220-0547-01		6	.	NUT, BLOCK: 0.38 X 0.25 X 0.282"OA (ATTACHING PARTS)	000FW	OBD
-96	211-0105-00		6	.	SCREW, MACHINE: 4-40 X 0.188"100 DEG, FLH STL - - - * - - -	83385	OBD
-97	386-1402-00		1	.	PANEL, REAR: (ATTACHING PARTS)	80009	386-1402-00
-98	213-0192-00		4	.	SCR, TPG, THD FOR: 6-32 X 0.50 INCH, PNH STL - - - * - - -	87308	OBD
-99	214-1061-00		1	.	SPRING, GROUND: FLAT	80009	214-1061-00
-100	426-0499-07		1	.	FR SECT, PLUG-IN: BOTTOM	80009	426-0499-07
-101	426-0505-13		1	.	FR SECT, PLUG-IN: TOP	80009	426-0505-13
-102	179-2561-00		1	.	WIRING HARNESS, :MAIN	80009	179-2561-00
-103	352-0169-08		1	.	CONN BODY, PL, EL: 2 WIRE GRAY	80009	352-0169-08
-104	352-0163-04		1	.	CONN BODY, PL, EL: 5 WIRE YELLOW	80009	352-0163-04
	352-0163-08		1	.	CONN BODY, PL, EL: 5 WIRE GRAY	80009	352-0163-08
-105	131-2084-00		12	.	TERM, QUICK DISC: 26 AWG, COPPER NICKEL	00779	5250-207-2
-106	131-1810-00		1	.	CONTACT, ELEC: FEMALE, FOR 0.025 SQ PIN	00779	87124-1
-107	204-0675-00		1	.	CONN BODY, PLUG: 1 LKG CLIP POZ, 0.025 SQ PIN	00779	87175-2
	198-3818-00		1	.	WIRE SET, ELEC:	80009	198-3818-00
	352-0169-03		1	.	CONN BODY, PL, EL: 2 WIRE ORANGE	80009	352-0169-03
	131-0707-00		4	.	CONNECTOR, TERM.: 22-26 AWG, BRS& CU BE GOLD	22526	47439
-108	352-0161-03		1	.	CONN BODY, PL, EL: 3 WIRE ORANGE	80009	352-0161-03

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty						Name & Description	Mfr Code	Mfr Part Number
		Eff	Dscont		1	2	3	4	5			
2-1	366-1023-01			1						1	1	80009 366-1023-01
	213-0153-00			1						1	1	000CY OBD
-2	333-1213-13			1						1	1	80009 333-1213-13
-3	354-0425-00			1						1	1	80009 354-0425-00
-4	401-0150-00			1						1	1	80009 401-0150-00
-5	384-0827-00			1						1	1	80009 384-0827-00
-6	380-0271-00			1						1	1	80009 380-0271-00
-7	380-0270-00			1						1	1	80009 380-0270-00
-8	354-0163-00			1						1	1	79136 5133-12MD
-9	376-0051-00			1						1	1	80009 376-0051-00
	213-0022-00			4						4	1	74445 OBD
-10	384-0488-00			1						1	1	80009 384-0488-00
-11	376-0029-00			1						1	1	80009 376-0029-00
	213-0075-00			2						2	1	000BK OBD
-12	175-2159-00			1						1	1	80009 175-2159-00
-13	175-2160-00			1						1	1	80009 175-2160-00
-14	119-0321-01			1						1	1	80009 119-0321-01
												(ATTACHING PARTS)
-15	211-0106-00			4						4	1	83385 OBD
												- - - * - - -









7A29 AMPLIFIER

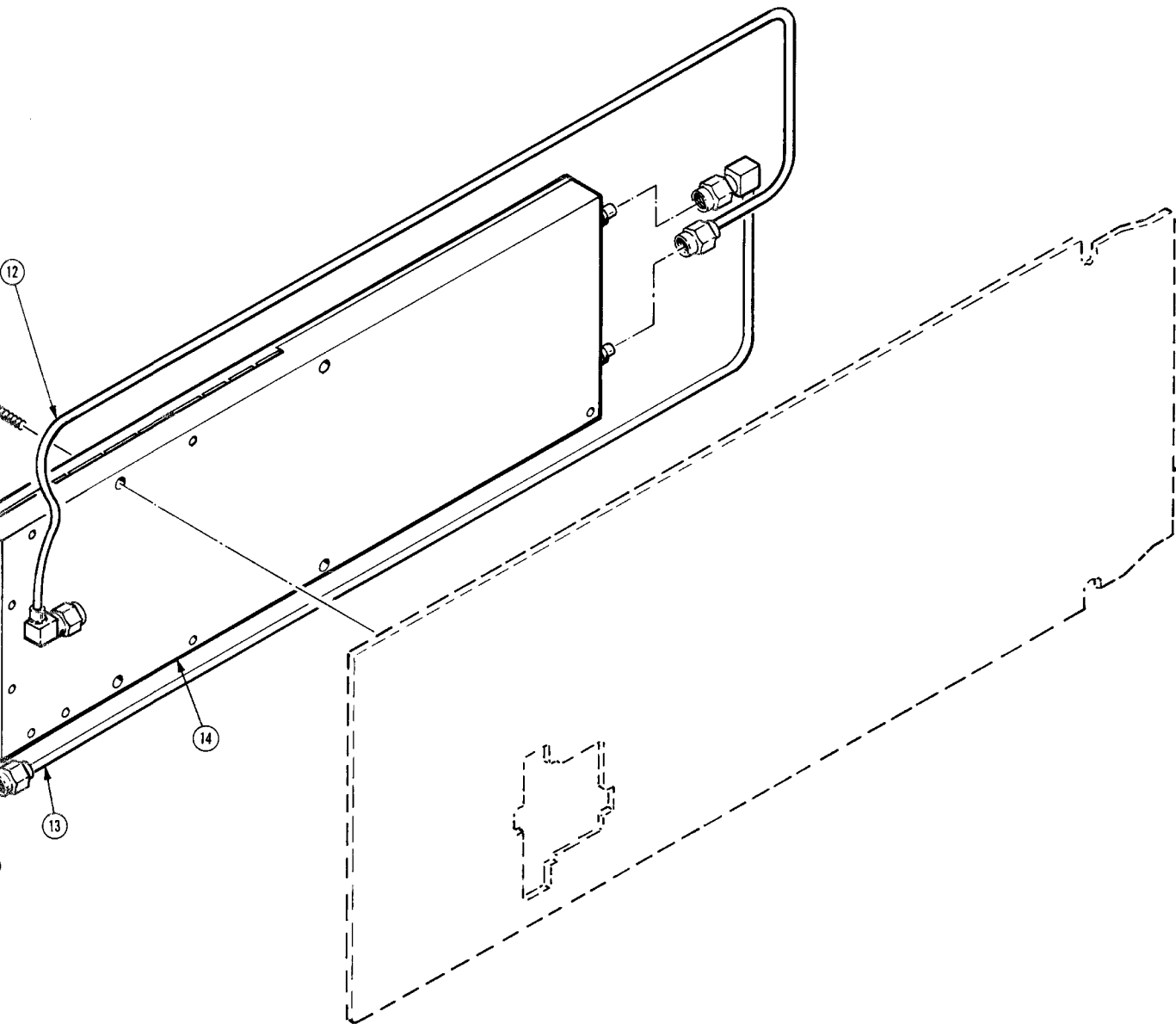


Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty						Name & Description	Mfr Code	Mfr Part Number
		Eff	Dscont		1	2	3	4	5			
	070-2320-00			1						MANUAL, TECH: INSTRUCTION	80009	070-2320-00

ACCESSORIES

## **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. 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 following this page, your manual is correct as printed.

## **SERVICE NOTE**

Because of the universal parts procurement problem, some electrical parts in your instrument may be different from those described in the Replaceable Electrical Parts List. The parts used will in no way alter or compromise the performance or reliability of this instrument. They are installed when necessary to ensure prompt delivery to the customer. Order replacement parts from the Replaceable Electrical Parts List.

# CALIBRATION TEST EQUIPMENT REPLACEMENT

## Calibration Test Equipment Chart

This chart compares TM 500 product performance to that of older Tektronix equipment. Only those characteristics where significant specification differences occur, are listed. In some cases the new instrument may not be a total functional replacement. Additional support instrumentation may be needed or a change in calibration procedure may be necessary.

Comparison of Main Characteristics

DM 501 replaces 7D13		
PG 501 replaces 107 108	PG 501 - Risetime less than 3.5 ns into 50 $\Omega$ . PG 501 - 5 V output pulse; 3.5 ns Risetime	107 - Risetime less than 3.0 ns into 50 $\Omega$ . 108 - 10 V output pulse 1 ns Risetime
PG 502 replaces 107 108 111	PG 502 - 5 V output PG 502 - Risetime less than 1 ns; 10 ns Pretrigger pulse delay	108 - 10 V output 111 - Risetime 0.5 ns; 30 to 250 ns Pretrigger pulse delay
PG 508 replaces 114 115 2101	Performance of replacement equipment is the same or better than equipment being replaced.	
PG 506 replaces 106 067-0502-01	PG 506 - Positive-going trigger output signal at least 1 V; High Amplitude output, 60 V. PG 506 - Does not have chopped feature.	106 - Positive and Negative-going trigger output signal, 50 ns and 1 V; High Amplitude output, 100 V. 0502-01 - Comparator output can be alternately chopped to a reference voltage.
SG 503 replaces 190, 190A, 190B 191 067-0532-01	SG 503 - Amplitude range 5 mV to 5.5 V p-p. SG 503 - Frequency range 250 kHz to 250 MHz.	190B - Amplitude range 40 mV to 10 V p-p. 0532-01 - Frequency range 65 MHz to 500 MHz.
SG 504 replaces 067-0532-01 067-0650-00	SG 504 - Frequency range 245 MHz to 1050 MHz.	0532-01 - Frequency range 65 MHz to 500 MHz.
TG 501 replaces 180, 180A 181 184 2901	TG 501 - Trigger output-slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time. TG 501 - Trigger output-slaved to market output from 5 sec through 100 ns. One time-mark can be generated at a time. TG 501 - Trigger output-slaved to marker output from 5 sec through 100 ns. One time-mark can be generated at a time.	180A - Trigger pulses 1, 10, 100 Hz; 1, 10, and 100 kHz. Multiple time-marks can be generated simultaneously. 181 - Multiple time-marks 184 - Separate trigger pulses of 1 and 0.1 sec; 10, 1, and 0.1 ms; 10 and 1 $\mu$ s. 2901 - Separate trigger pulses, from 5 sec to 0.1 $\mu$ s. Multiple time-marks can be generated simultaneously.

**NOTE: All TM 500 generator outputs are short-proof. All TM 500 plug-in instruments require TM 500-Series Power Module.**

Date: 5-27-81

Change Reference: C2/581

Product: 7A29 AMPLIFIER

Manual Part No.: 070-2320-00

DESCRIPTION

TEXT CORRECTIONS

Page 4-11 INPUT ATTENUATORS

CHANGE TO READ:

An intermittent input attenuator should be replaced as a unit. A replacement attenuator assembly may be obtained...

Page 4-10 AC-OFF-DC SWITCH, NOTE

CHANGE TO READ:

NOTE

An intermittent AC-OFF-DC Switch should be replaced as a unit. A replacement assembly may be ...