

# INSTRUCTION MANUAL

Serial Number 233

TYPE **R293**

**PROGRAMMABLE PULSE  
GENERATOR AND  
POWER SUPPLY**

*Tektronix, Inc.*

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070-0433-00

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## WARRANTY

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

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

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

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A list of abbreviations and symbols used in this manual will be found immediately preceding Section 7. Change information, if any is located at the rear of the manual.





Fig. 1-1. Type R293 Programmable Pulse Generator and Power Supply.



# SECTION 1

## CHARACTERISTICS

The Tektronix Type R293 Programmable Pulse Generator and Power Supply is a combination pulse generator and power supply which may be used for testing time and charge parameters of semiconductor devices. It can also be used to measure switching and propagation time of micro-logic circuits. The unit is useful in a wide variety of applications which require fast-rise and fast-fall pulses. The remote program capabilities make the instrument useful in production line and systems applications.

The Type R293 is programmed by analog resistances connected between appropriate program leads. A single parameter or combination of parameters can be externally pro-

grammed, with the remaining parameters controlled from the front panel. Parameters which may be programmed are:

- Pulse repetition rate
- Pulse amplitude
- Pulse width
- Regulated voltage amplitude
- Regulated current amplitude

The following characteristics apply over an ambient temperature range of 0°C to +50°C. Warm-up time for given accuracy is 10 minutes.

### ELECTRICAL CHARACTERISTICS

#### PULSE GENERATOR

Characteristic	Performance Requirement	Supplemental Information
Pulse Polarity	Positive or negative	
Pulse Amplitude	Variable from 6 volts to 12 volts	
Pulse Amplitude Accuracy	Within $\pm 3\%$ of minimum and maximum values	
Programmed Pulse Amplitude Accuracy	Within $\pm 3\%$ of programmed value	With 1% program resistor
Pulse Amplitude Program Ratio		1 volt/333 microsiemens <sup>1</sup> with 6 volt offset. i.e., 0 $\mu$ S = 6 volts; 2000 $\mu$ S = 12 volts. See Section 2
Pulse Width	Variable from 2 nanoseconds or less to 250 nanoseconds or greater	Measured between 50% amplitude points of leading and trailing edge
Programmed Pulse Width Accuracy	Within $\pm$ (3% of programmed value + 3 nanoseconds)	With 1% program resistor
Pulse Width Program Ratio		2 microsiemens/nanosecond. See Section 2
Pulse Width Jitter		100 picoseconds or less
Pulse Repetition Rate	Variable from 10 kHz or less minimum, to 100 kHz, $-10\%$ $+0\%$ , maximum	
Programmed Pulse Repetition Rate Accuracy	Within $\pm 10\%$ of programmed value	With 1% program resistor
External Program Resistor (ohms)		$\frac{1 \times 10^6}{\text{repetition rate (kHz)}} - 1 \times 10^4$
Risetime	1 nanosecond or less	Checked with maximum pulse amplitude. Performance requirements apply to both positive and negative pulse polarities. See Fig. 1-2 for explanation of terminology. Method of measurement is given in Sections 5 and 6.
Falltime	1 nanosecond or less	
Preshoot	1% or less	
Droop	1% or less	
Flat-top Aberrations	2% or less	
Leading Edge Aberrations (first 10 nanoseconds)		
Overshoot	3% or less	
Rounding	5% or less	
Ringing	3% or less	
Trailing Edge Aberrations (last 15 nanoseconds)		
Storage aberration	5% or less	
Rounding	10% or less	
Ringing	10% or less	
Overshoot	5% or less	

<sup>1</sup> 1 microsiemens ( $\mu$ S) = 1/1 megohm (1  $\mu$ mho).

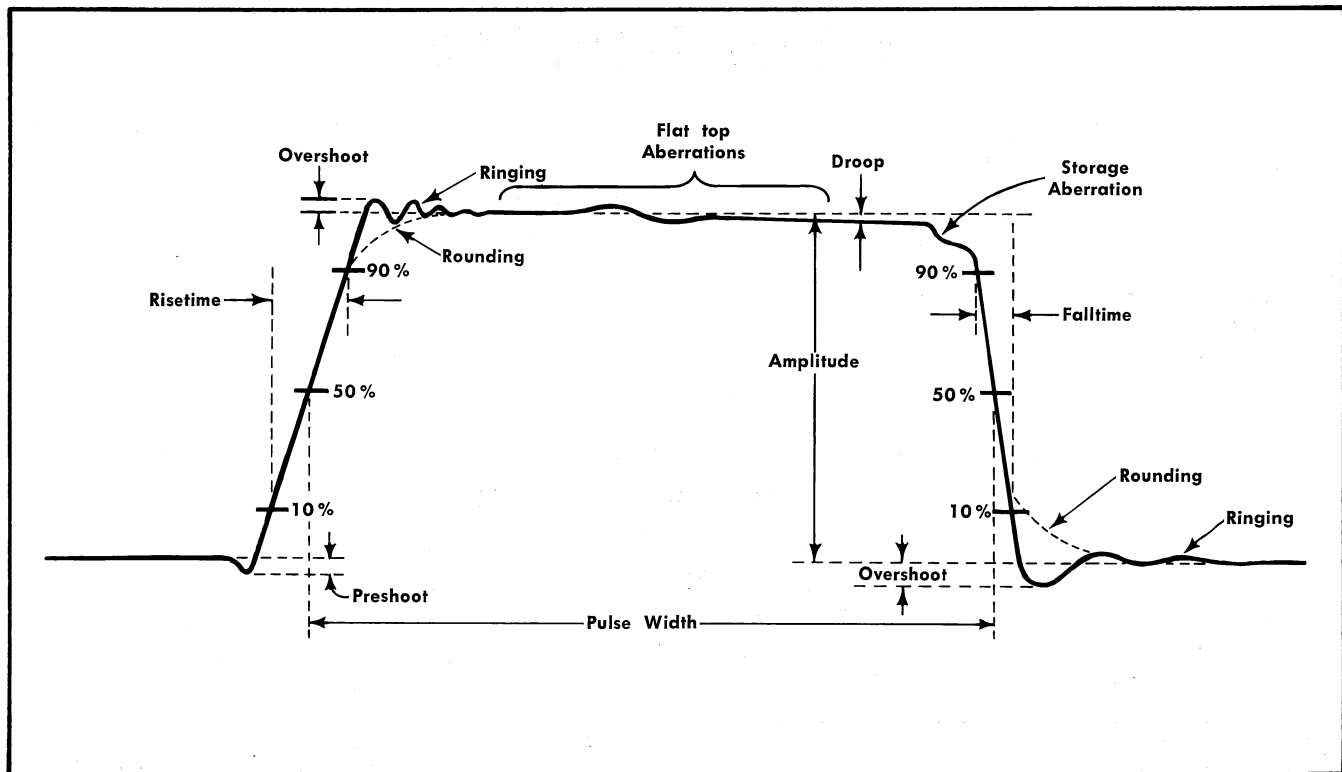


Fig. 1-2. Pulse terminology used in this manual.

#### PULSE GENERATOR (Cont'd)

Characteristic	Performance Requirement	Supplemental Information
Main Pulse Jitter		100 picosecond maximum jitter between pretrigger pulse and main pulse leading edge.
Pretrigger Pulse		
Polarity	Positive	Occurs approximately 200 nanoseconds before leading edge of main pulse
Amplitude	0.5 volt or greater into 50-ohm load, 2 volts or greater into open circuit.	
External Trigger Input		
Sensitivity	2 volts or greater, dc to 100 kHz	Risetime 1 microsecond or less
Maximum input voltage		200 volts, dc

#### PROGRAMMABLE POWER SUPPLY

Regulated Voltage Supply		
Polarity	Positive or negative	
Amplitude	Variable from 0 to 50 volts	
Current		0 to 200 milliamps
Calibration	Within $\pm$ (2% of dial reading + 25 millivolts)	
Programmed accuracy	Within $\pm$ (3% of programmed value + 25 millivolts)	With 1% program resistor
Voltage program ratio		20 microsiemens/volt
Regulation	$\pm$ 1% maximum change with line voltage change between 93.5 and 135 volts	
Ripple	0.05% or less, or 5 millivolts, whichever is greater	
Overshoot		5% or less of change in programmed voltage



### PROGRAMMABLE POWER (Cont'd)

Characteristic	Performance Requirement	Supplemental Information
Regulated Current Supply		
Polarity	Positive or negative	
Amplitude	Variable from 300 microamps to 300 milliamps	
Voltage compliance		0 to 20 volts
Calibration	Within $\pm$ (3% of dial reading + 50 microamps)	
Programmed accuracy	Within $\pm$ (3% of programmed value + 50 microamps)	With 1% program resistor
Current program ratio		202 microsiemens/milliamp
Regulation	$\pm$ 1% maximum change with line voltage change between 93.5 and 135 volts	
Ripple	0.5% or less or 50 microamps, whichever is greater	
Overshoot		0.5% or less of change in programmed current.

### PULSE-GENERATOR POWER SUPPLY

Line Voltage		
115-volts nominal	93.5 to 135 volts, rms, ac line voltage provides regulated dc voltages	Range selected by 115 V-230 V Selector switch on rear panel
230-volts nominal	187 to 270 volts, rms, ac line voltage provides regulated dc voltages	
Line Fuse		
115-volts nominal		0.8 amp, slow-blow
230-volts nominal		0.4 amp, slow-blow
Line Frequency	50 to 400 Hz	
Power Consumption		65 watts maximum

### MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction	
Chassis and cabinet	Aluminum alloy
Panel	Aluminum alloy with anodized finish
Etched-wiring boards	Glass-epoxy laminate
Overall Dimensions (measured at maximum points)	
Height	3.5 inches
Width	19 inches
Depth	18 inches
Net Weight	20.5 pounds
Connectors	
TRIGGER INPUT	BNC
PRETRIGGER OUTPUT	BNC
PULSE GENERATOR OUTPUT	GR874

POWER SUPPLY OUTPUT	4-terminal connector. Mates with Bendix #PC06A-8-4P-SR
Remote Program (rear panel)	24-terminal connector. Mates with Amphenol #57-30240

### ENVIRONMENTAL CHARACTERISTICS

#### NOTE

The Type R293 has been designed to meet the following environmental characteristics. During production, samples of the Type R293 will be checked to assure that the instrument continues to meet the environmental characteristics. When checking the environmental characteristics of the Type R293, be careful not to damage the instrument. Some tests (e.g. vibration or transportation tests) may cause minor physical damage to, or mechanical deformation of the instrument without causing it to malfunction. Complete details on environmental test procedures, including failure criteria, etc., may be obtained from Tektronix, Inc. Contact your local Field Office or representative.

**Characteristics—Type R293**

Characteristic	Requirement
Temperature	
Operating	The Type R293 will perform to the limits given in this section over a temperature range of 0°C to +50°C.
Non-operating	—40°C to +65°C
Altitude	
Operating	The Type R293 will perform to the limits given in this section up to 15,000 feet.
Non-operating	50,000 feet maximum
Vibration	
Operating and non-operating	The Type R293 will perform to limits given in this section following vibration test. Vibrate for 15 minutes along each axis at a total displacement of 0.015 inch (1.9 g at 50 c/s from 10-50-10 c/s in 1 minute cycles. Hold at any resonant point for 3 minutes. If no resonances are present, vibrate at 50 c/s for 3 minutes. Total vibration time, 55 minutes.

Transportation	
Non-Operating	Meets National Safe Transit type of test when factory packaged. Package vibration test — One hour in excess of 1 g. Package drop test — 30-inch drops on one corner, all edges radiating from that corner and all flat surfaces (total of 10 drops).

**STANDARD ACCESSORIES INCLUDED**

Description	Qty.	Tektronix Part No.
50-ohm RG8/AU cable with GR connectors	1	017-0502-00
3-to-2 wire power-cord adapter	1	103-0013-00
4-terminal connector	1	131-0268-00
24-terminal connector	1	131-0325-00
Power cord	1	161-0015-00
#10 finishing washer	2	210-0833-00
Teflon washer	2	210-0917-00
10-32 x 1/2 OHS screw	2	212-0512-00
Slideout track, stationary and intermediate section (pair)	1	351-0084-00
Instruction manual	2	070-0433-00

See Tektronix, Inc. Catalog for optional accessories.



# SECTION 2

## OPERATING INSTRUCTIONS

### General

To effectively use the Type R293, the operation and capabilities of the instrument must be known. This section describes the function of the front- and rear-panel controls and connectors, gives first-time operating information and remote programming information.

### Voltage Considerations

The Type R293 can be operated from either a 115- or a 230-volt nominal line. The 115 V-230 V Selector switch on the rear panel changes the instrument from one operating range to the other. Use a small screwdriver or other pointed tool to slide this switch to the desired position.

#### WARNING

The Type R293 should not be operated when the 115 V - 230 V Selector switch is in the wrong position for the nominal line voltage applied. Operation of the instrument in the wrong voltage range will either provide incorrect operation or damage the instrument.

When changing operating ranges, the line fuse must be changed. Table 2-1 lists the correct fuse for the applicable nominal line voltage.

**TABLE 2-1**  
Line Fuses

Voltage Range	Fuse Rating
115-volts nominal	0.8 amp, slow-blow
230-volts nominal	0.4 amp, slow-blow

### Cooling

The Type R293 requires very little air circulation for proper operation. However, when operating in areas with high ambient temperature or within an enclosure, do not exceed the maximum ambient temperature rating of +50°C.

### Rackmounting

Complete information for mounting the Type R293 in a cabinet rack is given in Section 10.

## CONTROLS AND CONNECTORS

A brief description of the function or operation of the front- and rear-panel controls and connectors follows. Fig. 2-2 shows the front and rear panels.

### Pulse Generator

**PULSE GENERATOR OUTPUT** Output connector for the main pulse.

**TRIGGER INPUT** Input connector for external triggering signal.

**TRIGGER SELECTOR** Switch to select either the internal rate generator (or remote program) or an external trigger signal connected to the TRIGGER INPUT connector.

**RATE** Controls repetition rate of internal rate generator. In the fully clockwise position (detent), an external program resistor determines the rate.

**WIDTH** Controls pulse width. In the fully clockwise position (detent), an external program resistor determines the pulse width.

**PRETRIGGER OUTPUT** Output connector for pretrigger pulse. Pretrigger pulse precedes main pulse approximately 200 nanoseconds.

**AMPLITUDE PROGRAM** Switch to select either the front-panel AMPLITUDE control or an external program resistor to control pulse amplitude.

**AMPLITUDE** Controls main pulse amplitude.

**POLARITY** Selects polarity of main pulse.

### Power Supply

**POWER SUPPLY OUTPUT** Output connector for voltage and current from Programmable Power Supply. See Fig. 2-1 for explanation of terminal nomenclature.

**MODE** Switch to reverse the polarity of the current and voltage at the POWER SUPPLY OUTPUT connector. Center position turns off both supplies.

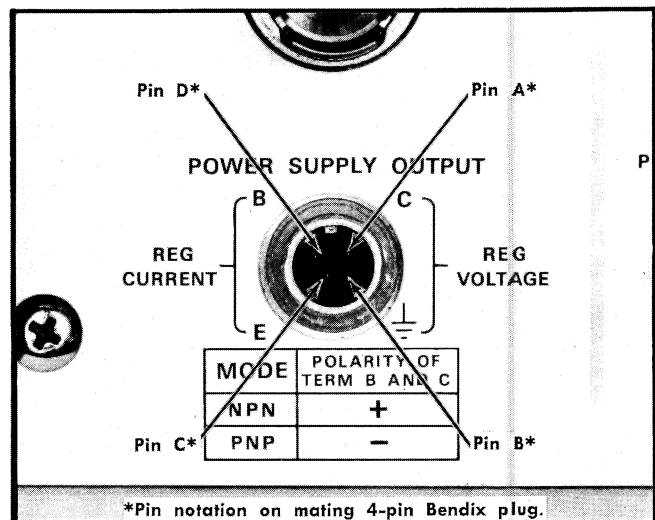


Fig. 2-1. Detailed view of the POWER SUPPLY OUTPUT connector.

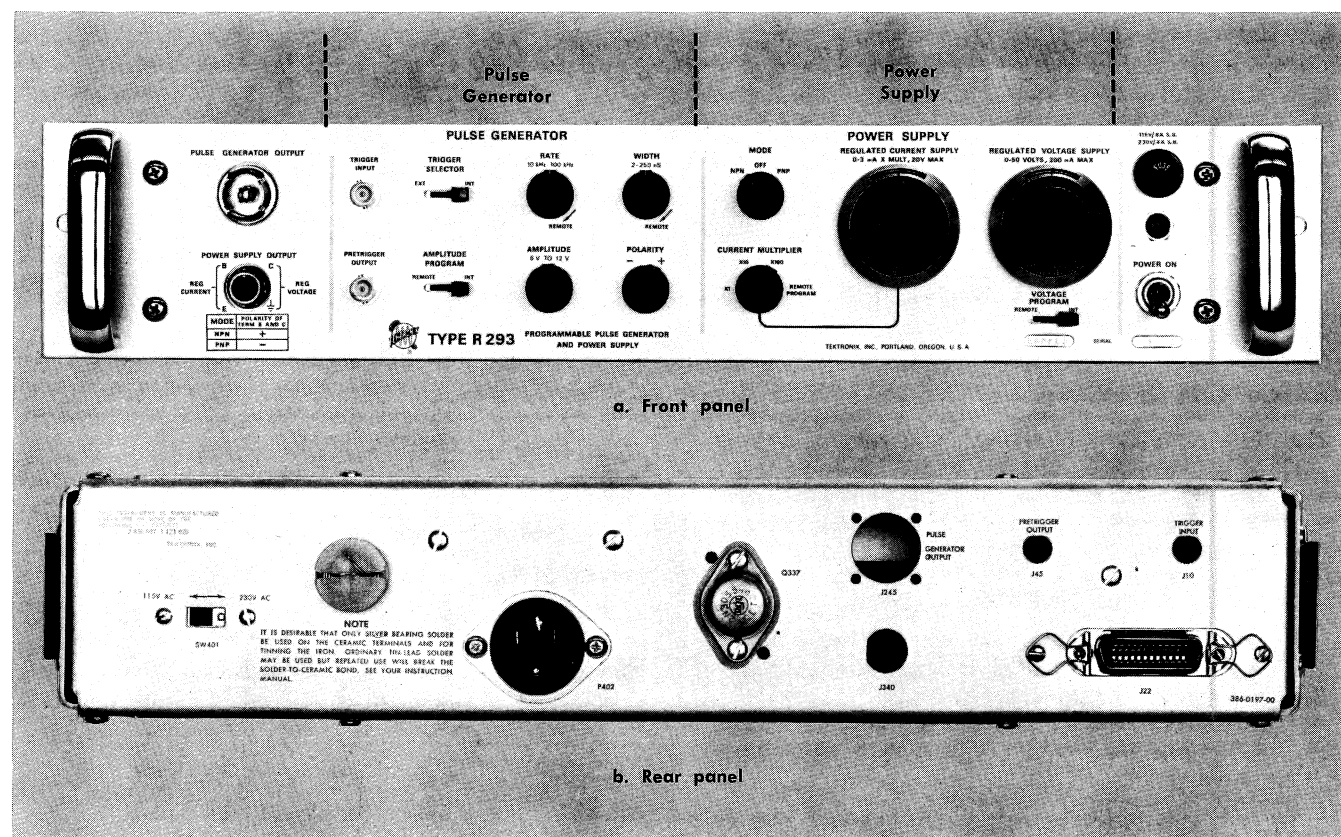


Fig. 2-2. Front- and rear-panel controls and connectors.

**CURRENT MULTIPLIER** Selects the range of the output current. In the REMOTE PROGRAM position, an external program resistor determines output current.

**REGULATED CURRENT SUPPLY** Controls the regulated output of the Programmable Current Supply within the range selected by the CURRENT MULTIPLIER switch.

**REGULATED VOLTAGE SUPPLY** Controls the regulated voltage output of the Programmable Voltage Supply.

**VOLTAGE PROGRAM** Switch to select either the front-panel REGULATED VOLTAGE SUPPLY control or an external program resistor to control output voltage amplitude.

#### Power

**FUSE** Fuse for power input.

**POWER ON** Light: Indicates that POWER switch is on and the instrument is connected to a power source.  
Switch: Applies power to instrument.

#### Rear Panel

**115 V - 230 V Selector** Selects nominal operating range for instrument.

**Power** Input connector for line power.

**Remote Program Connector** to provide remote programming for programmable parameters.

### FIRST-TIME OPERATION

The following steps will demonstrate the basic function of the controls and connectors of the Type R293. It is recommended that this procedure be followed completely for first-time familiarization with the instrument.

1. Set the front-panel controls as follows:

#### Pulse Generator

TRIGGER SELECTOR	INT
RATE	Clockwise (not in REMOTE)
WIDTH	Clockwise (not in REMOTE)
AMPLITUDE PROGRAM	INT
AMPLITUDE	Clockwise
POLARITY	+

#### Power Supply

MODE	NPN
------	-----



CURRENT MULTIPLIER	×1
REGULATED CURRENT SUPPLY	0.00
REGULATED VOLTAGE SUPPLY	0.00
VOLTAGE PROGRAM	INT

2. Connect the Type R293 to a power source that meets the voltage and frequency requirements of the instrument.

3. Set the POWER switch to ON.

4. Connect a cable and 10× attenuator from the PULSE GENERATOR OUTPUT connector to Input A of a sampling system.

5. Connect the PRETRIGGER OUTPUT connector to Input B of a sampling system.

6. Set the sampling-system sweep rate to display both pulses at 1000 dots/division. Note that the spacing between the pulses is about 200 nanoseconds.

7. Set the sampling-system sweep rate to display one complete pulse of the channel A signal.

8. Rotate the RATE control throughout its range. Note the change in pulse repetition rate as shown by a change in display brightness. Return the RATE control to the clockwise position (not in REMOTE detent).

9. If an external signal is available (risetime, 1 microsecond or less; minimum amplitude, 2 volts) the function of the TRIGGER INPUT connector may be demonstrated. Connect the external signal to the TRIGGER INPUT connector and set the TRIGGER SELECTOR switch to EXT. Note that the pulse repetition rate is the same as the repetition rate of the external signal. Return the TRIGGER SELECTOR switch to INT and disconnect the external signal.

10. Rotate the WIDTH control throughout its range. Note the change in pulse width from 2 nanoseconds minimum to 250 nanoseconds maximum. Return the WIDTH control to the clockwise position (not in REMOTE detent).

11. Rotate the AMPLITUDE control throughout its range. Note the change in pulse amplitude between 6 and 12 volts. Return the AMPLITUDE control to the clockwise position.

12. Change the POLARITY switch from + to —. Note that the pulse shape and other characteristics do not change as the polarity is reversed. Return the POLARITY switch to +.

13. Connect a dc voltmeter from terminal C (see Fig. 2-1) of the POWER SUPPLY OUTPUT connector to chassis ground.

14. Rotate the REGULATED VOLTAGE SUPPLY dial throughout its range. Note that the output voltage is variable from 0 to +50 volts.

15. Set the MODE switch to PNP. Note that the output voltage is variable from 0 to —50 volts. Return the MODE switch to NPN.

16. Connect a dc ammeter between terminals B and E of the POWER SUPPLY OUTPUT connector.

17. Rotate the REGULATED CURRENT SUPPLY dial throughout its range. Note that the output current is variable from 0 to 3 milliams.

18. Set the CURRENT MULTIPLIER switch to ×10. Note that the output current is now variable from 0 to 30 milliams.

19. Set the CURRENT MULTIPLIER switch to ×100. Note that the output current is now variable for 0 to 300 milliams.

20. Set the MODE switch to PNP. Note that the polarity of the output current is reversed.

21. To demonstrate the remote programming feature of the Type R293, a 24-terminal connector, Tektronix Part No. 131-0325-00, and the following program resistors are required (1%, fixed).

Resistance	Tektronix Part No.	Power Rating
165 Ω	323-0118-00	½ watt
499 Ω	321-0164-00	⅛ watt
1 kΩ	321-0193-00	⅛ watt
2 kΩ	321-0222-00	⅛ watt
90.9 kΩ	321-0381-00	⅛ watt
249 kΩ	321-0423-00	⅛ watt

22. Insert the 24-terminal connector into the Remote Program jack and connect the 90.9 kΩ resistor between terminals 6 and 15. Set the RATE control to the REMOTE position and the sampling-system sweep rate to display about 10 divisions between pulses. Note that the pulse repetition rate is 10 kHz.

23. Replace the 90.9 kΩ resistor with a shorting strap. Note the pulse repetition rate is 100 kHz. Return the RATE control to the fully clockwise position (not in REMOTE detent).

24. Connect the 249 kΩ resistor between terminals 6 and 18 of the remote-program connector. Set the WIDTH control to the REMOTE position and the sampling-system sweep rate to display a single pulse. Note that the pulse width is 2 nanoseconds.

25. Replace the 249 kΩ resistor with a 2 kΩ resistor. Note that the pulse width is 250 nanoseconds. Return the WIDTH control to the clockwise position (not in REMOTE detent).

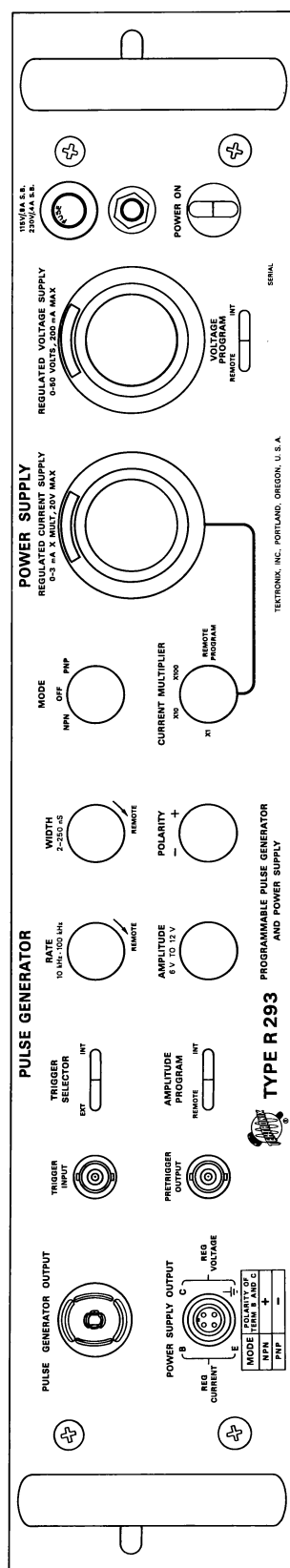
26. Connect the 499 Ω resistor between terminals 3 and 4 of the remote-program connector. Set the AMPLITUDE PROGRAM switch to REMOTE. Note that the pulse amplitude is 12 volts.

27. Remove the 499 Ω resistor and leave the connection between terminals 3 and 4 open (infinite resistance). Note that the pulse amplitude is 6 volts. Return the AMPLITUDE PROGRAM switch to INT and disconnect the sampling system.

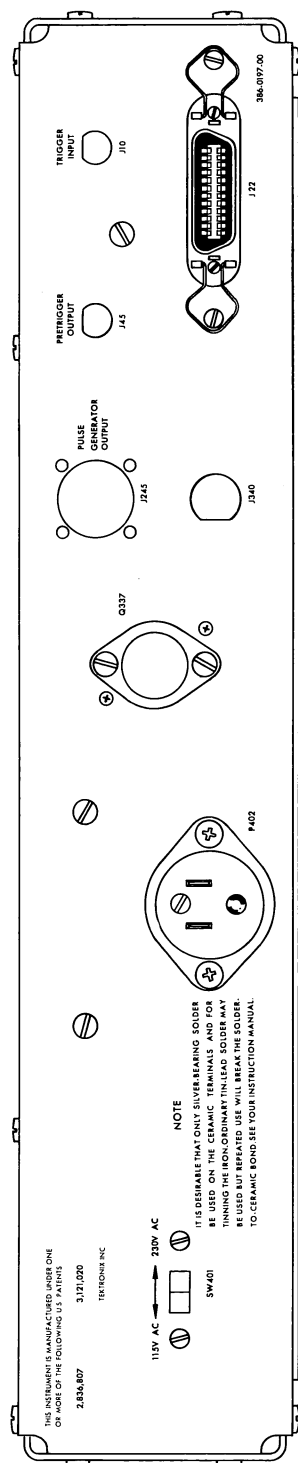
28. Connect the 1 kΩ resistor between terminals 23 and 24 of the remote-program connector. Set the VOLTAGE PROGRAM switch to REMOTE and connect the dc voltmeter from terminal C of the POWER SUPPLY OUTPUT connector to chassis ground. Note that the meter reading is about +50 volts. Disconnect the voltmeter.

29. Connect the 165 Ω resistor between terminals 9 and 21 of the remote-program connector. Set the CURRENT MULTIPLIER switch to REMOTE PROGRAM and connect the dc ammeter between terminals B and E of the POWER

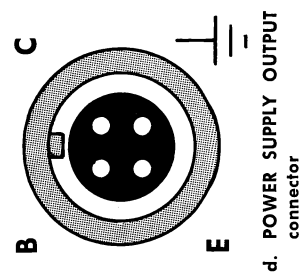
## TYPE R293 CONTROL SETUP CHART



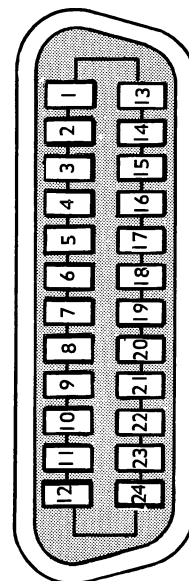
a. Front panel



**b. Rear panel**



**c. J22, Remote Program connector**



**d. POWER SUPPLY OUTPUT**  
connector

**Fig. 2-3. Control Set-up chart.**



SUPPLY OUTPUT connector. Note that the meter reading is about 30 milliamps.

30. This completes the basic operation procedure for the Type R293. More information on the programmable parameters is given under Programming Information.

### CONTROL SETUP CHART

Fig. 2-3 shows the front and rear panels of the Type R293 along with an enlarged view of the Remote Program connector. This chart may be reproduced and used as a test-setup record for special measurements, applications or procedures, or it may be used as a training aid for familiarization with this instrument.

## PROGRAMMING INFORMATION

## General

All functions of the Type R293 except trigger selection, pulse polarity and power-supply mode can be remotely

programmed. Remote programming is accomplished by setting the appropriate control to remote and connecting an external program resistor across the proper terminals of J22. The external program resistor takes the place of the front-panel control of the Type R293.

Parameters which may be programmed are:

Pulse repetition rate

Pulse amplitude

Pulse width

Regulated voltage amplitude

Regulated current amplitude

Specific programming information for these parameters is given on the following pages.

## NOTES

[illegible]

## Pulse Rate

The repetition rate of the Pulse Generator output pulse can be remotely programmed by connecting a program resistor between terminals 6 (—15 volts dc) and 15 of the Remote Program connector J22 when the RATE control is set to REMOTE (fully clockwise). Pulse repetition rate is programmable between 10 and 100 kHz. The value of the external program resistor can be selected by using the graph shown in Fig. 2-4. The relationship between the external program resistor and pulse repetition rate can also be expressed by the formula:

$$R = \frac{1 \times 10^6}{F_p} - 1 \times 10^4$$

Where R = External program resistor (ohms)

$F_p$  = Pulse repetition rate (kHz)

When the RATE control is set to REMOTE, an external program resistor must be connected between terminals 6 and 15 of J22 for the Pulse Generator to be operable. The external program resistor should have a  $\frac{1}{8}$  watt minimum rating. Fig. 2-5 shows a typical remote program resistance network to remotely select pulse repetition rate.

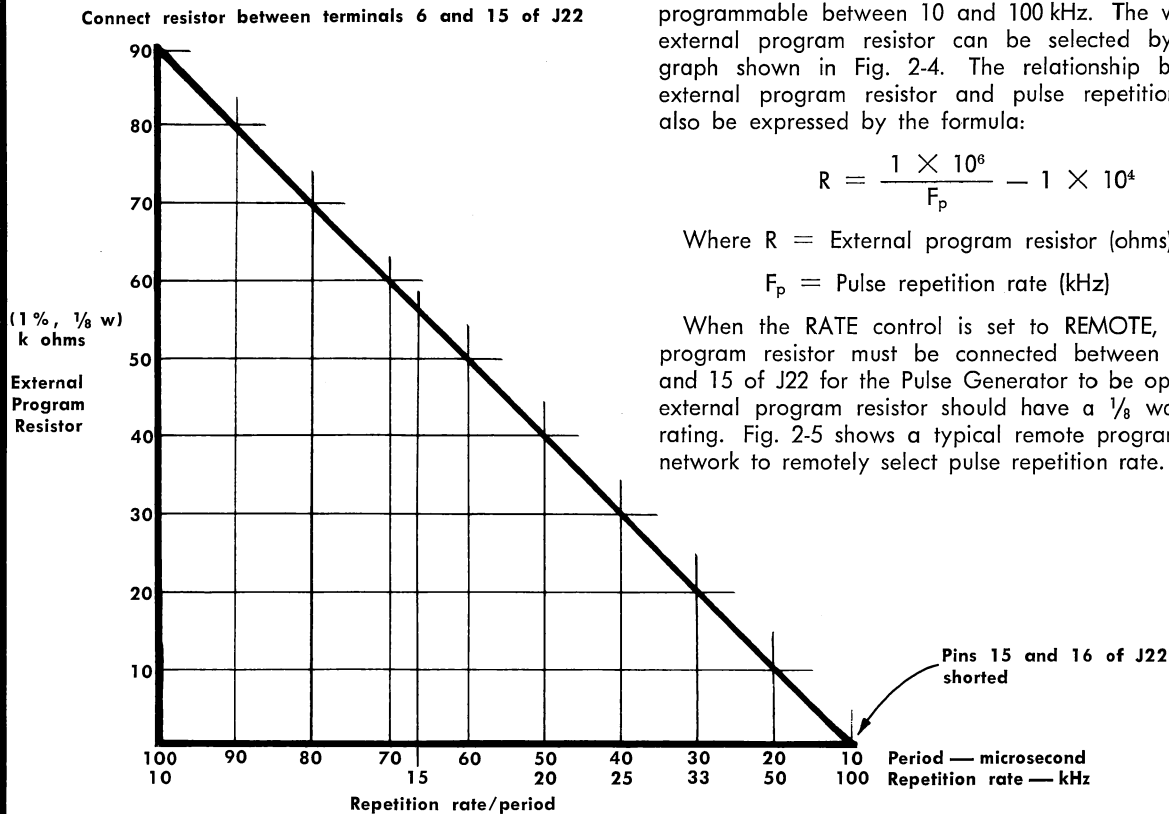


Fig. 2-4. Graphic relationship between external program resistor and pulse repetition rate.

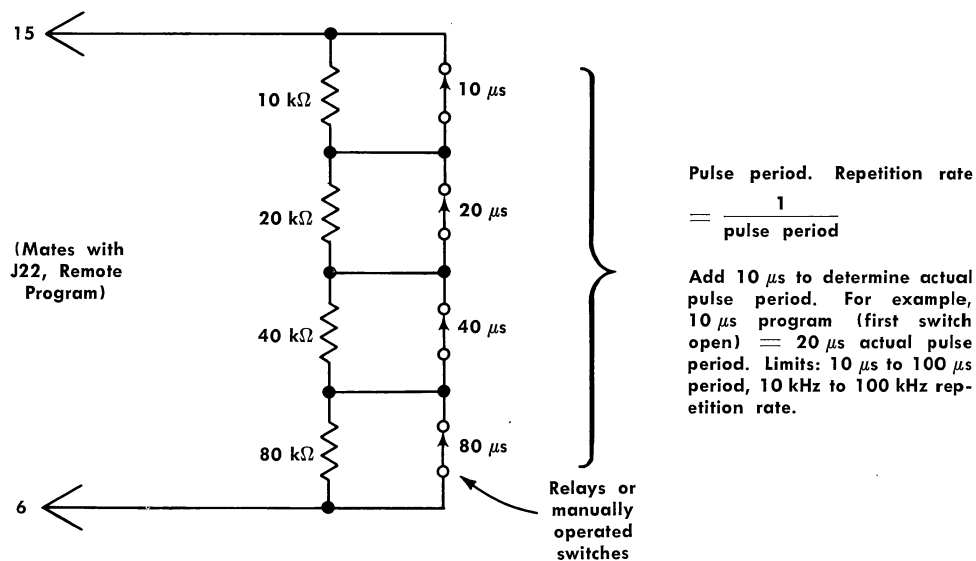


Fig. 2-5. Typical remote program resistance network for pulse repetition rate.

### Pulse Width

The width of the Pulse Generator output pulse can be remotely programmed by connecting a program resistor between terminals 6 (—15 volts dc) and 18 of the Remote Program connector J22 when the WIDTH control is set to REMOTE (fully clockwise). Pulse width is programmable between 2 and 250 nanoseconds. The value of the external program resistor can be selected by using the graph shown in Fig. 2-6. The relationship between the external program resistor and pulse width can also be expressed by the formula:

$$R = \frac{5 \times 10^5}{t_p}$$

Where R = External program resistor (ohms)

$t_p$  = Pulse width (nanoseconds)

When the WIDTH control is set to REMOTE, an external program resistor must be connected between terminals 6 and 18 of J22 for the Pulse Generator to be operable. The program resistor should have a  $\frac{1}{8}$  watt minimum rating. Fig. 2-7 shows a typical remote program resistance network to remotely select pulse width.

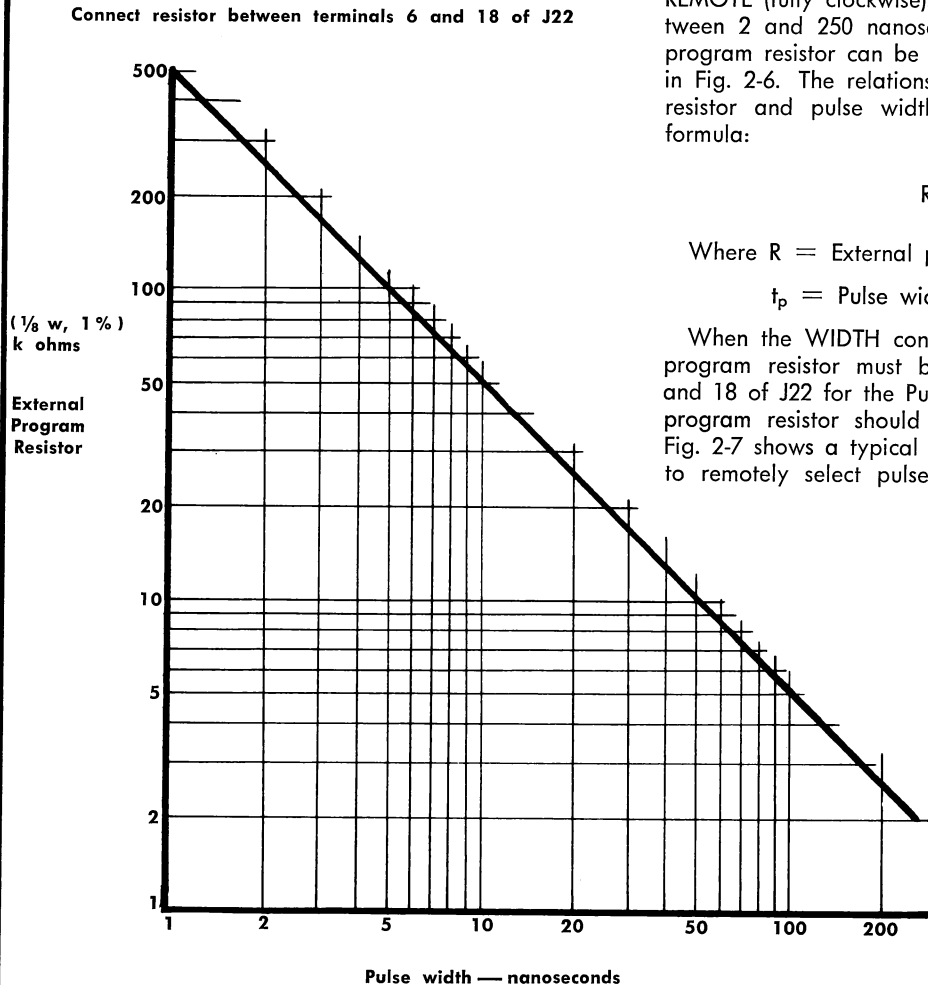
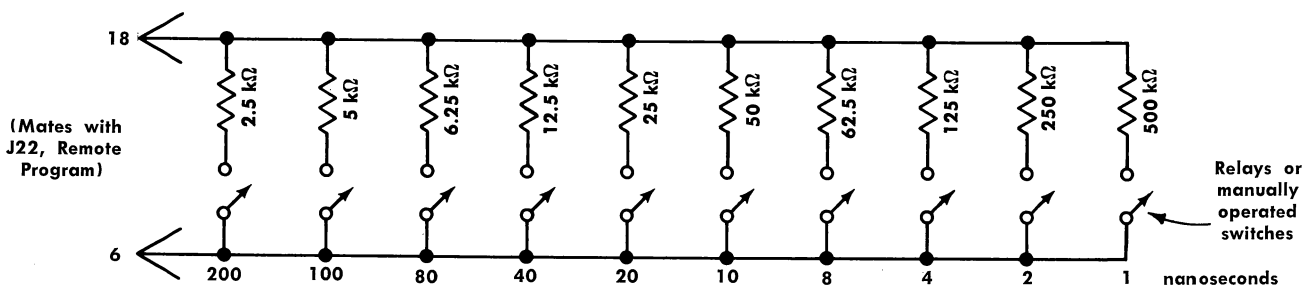


Fig. 2-6. Graphic relationship between external program resistor and pulse width.



Close switches to obtain desired pulse width. For example, to obtain 140 nanosecond pulse width close second and fourth switch. Limit: 250 nanoseconds maximum.

Fig. 2-7. Typical remote program resistance network for pulse width.

## Pulse Amplitude

The amplitude of the Pulse Generator output pulse can be remotely programmed by connecting a program resistor between terminals 3 and 4 of the Remote Program connector J22 when the AMPLITUDE PROGRAM switch is in the REMOTE position. Pulse amplitude is programmable between 6 and 12 volts. The value of the external program resistor can be selected by using the graph shown in Fig. 2-8. The relationship between the external program resistor and pulse amplitude can also be expressed by the formula:

$$R = \frac{3 \times 10^3}{E_p - 6}$$

Where R = External program resistor (ohms)

$E_p$  = Pulse amplitude (volts)

The external program resistor should have a  $\frac{1}{8}$  watt minimum rating. Fig. 2-9 shows a typical remote program resistance network to remotely select pulse amplitude.

Connect resistor between terminals 3 and 4 of J22

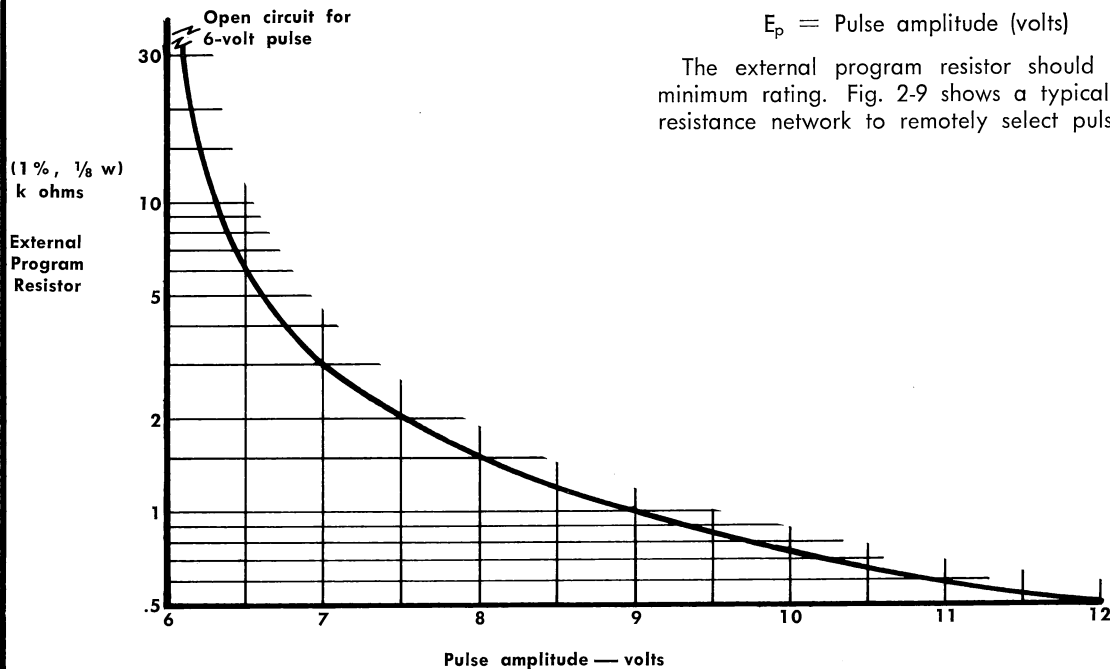
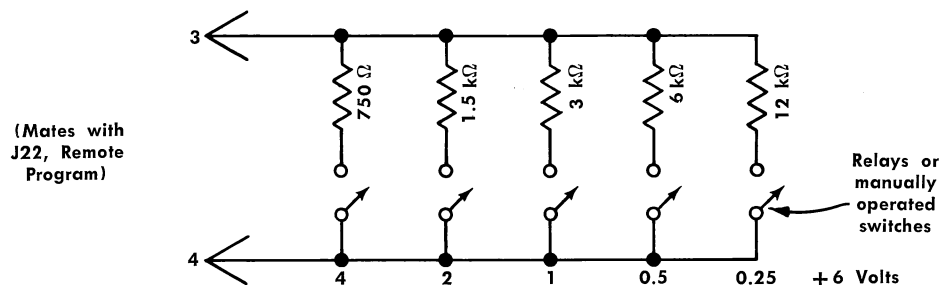


Fig. 2-8. Graphic relationship between external program resistor and pulse amplitude.



Add 6 volts to obtain actual pulse amplitude. For example, 5 volts program (first and third switches closed) = 11 volts actual pulse amplitude. Limits: 6 volts to 12 volts.

Fig. 2-9. Typical remote program resistance network for pulse.



## Voltage Amplitude

The amplitude of the Programmable Power Supply dc voltage can be remotely programmed by connecting a program resistor between terminals 23 and 24 of the Remote Program connector J22 when the VOLTAGE PROGRAM switch is in the REMOTE position. Voltage amplitude is programmable between 0 and 50 volts dc. The value of the external program resistor can be selected by using the graph shown in Fig. 2-10. The relationship between the external program resistor and dc voltage amplitude can also be expressed by the formula:

$$R = \frac{5 \times 10^4}{E_o}$$

Where R = External program resistor (ohms)

$E_o$  = Output voltage (volts)

The program resistor should have a  $\frac{1}{8}$  watt minimum rating. Fig. 2-11 shows a typical remote program resistance network to remotely select dc voltage amplitude.

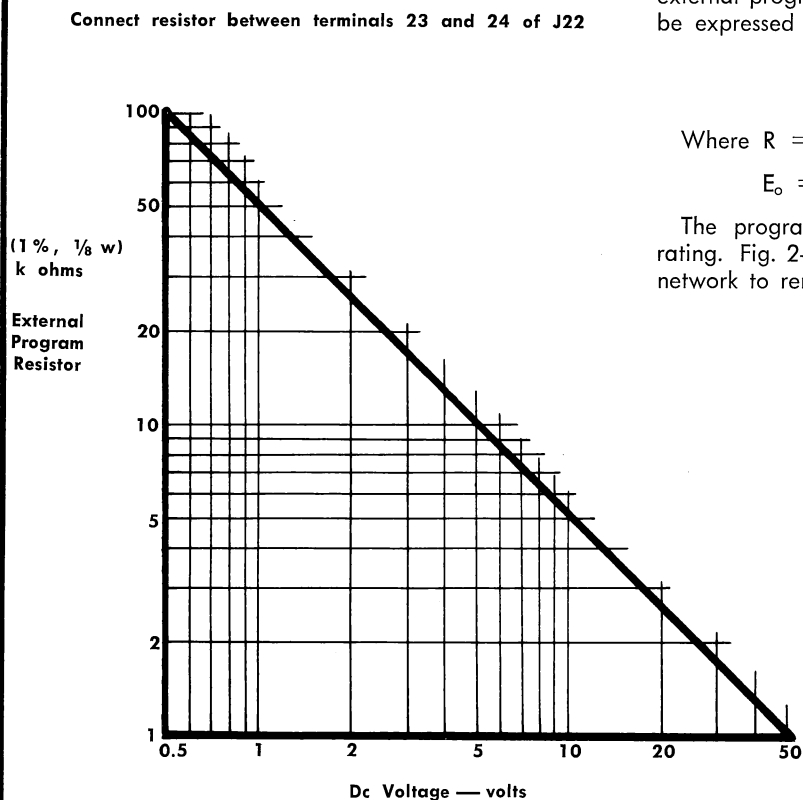


Fig. 2-10. Graphic relationship between external program resistor and dc voltage amplitude.

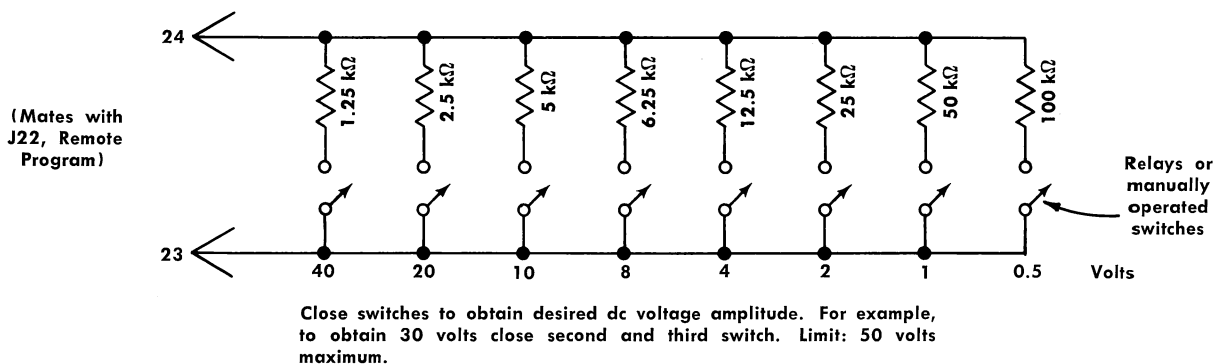


Fig. 2-11. Typical remote program resistance network for dc voltage amplitude.

### Current Amplitude

The amplitude of the Programmable Power Supply dc current can be remotely programmed by connecting a program resistor between terminals 9 and 21 of the Remote Program connector J22. Current amplitude is programmable between 300 microamps and 300 milliamps. The value of the external program resistor can be selected by using the graph in Fig. 2-12. The relationship between the external program resistor and current amplitude can also be expressed by the formula:

$$R = \frac{4.95 \times 10^3}{I_o}$$

Where R = External program resistor (ohms)

$I_o$  = Output current (milliamps)

Note the program resistor wattage rating shown in Fig. 2-12. Fig. 2-13 shows a typical remote program resistance network to remotely select dc current amplitude.

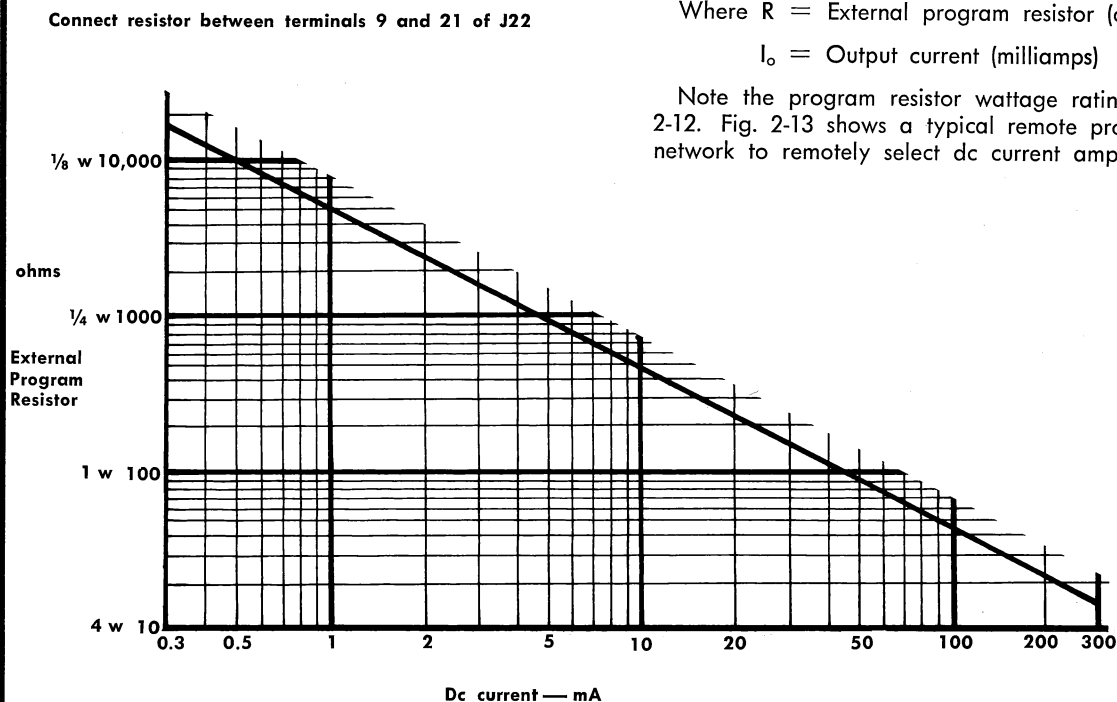


Fig. 2-12. Graphic relationship between external program resistor and dc current amplitude.

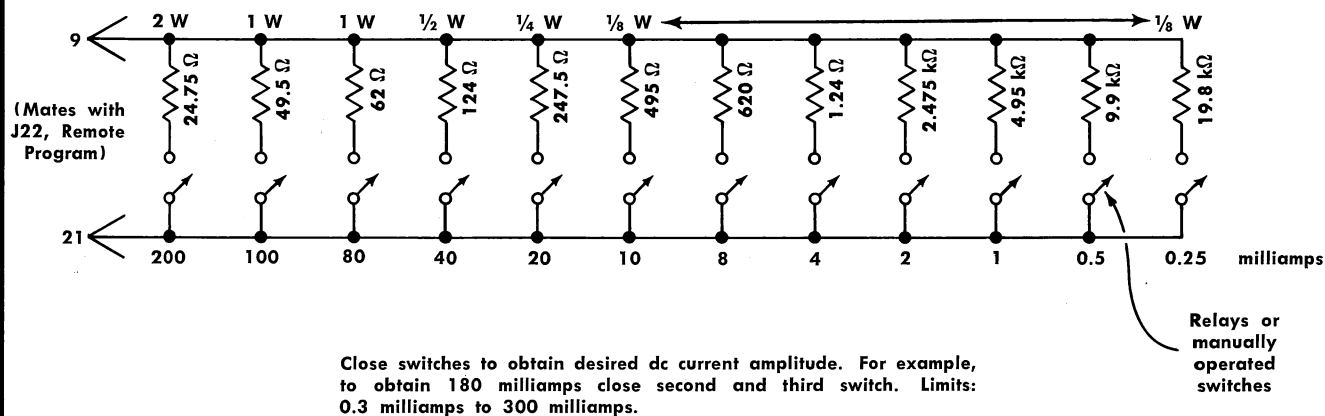


Fig. 2-13. Typical remote-program resistance network for dc current amplitude.

# SECTION 3

## CIRCUIT DESCRIPTION

### Introduction

This section of the manual contains an electrical description of the circuits in the Type R293 Programmable Pulse Generator and Power Supply. A detailed block diagram is given for each main circuit in the following description. A complete block diagram is located in the Diagrams section of this manual. The complete block diagram better illustrates the relationship between the major circuits.

Complete schematic diagrams are also given in the Diagrams section. Refer to these diagrams for electrical values and relationship throughout the following circuit description.

### BLOCK DIAGRAM DISCUSSION

The Rate Generator determines the repetition rate of the output pulse. Repetition rate can be controlled in one of three ways: (1) Front-panel RATE control, (2) Externally programmed through the rear-panel Remote Program connector, (3) External signal connected to front-panel TRIGGER INPUT connector. The output pulse from the Rate Generator circuit is available at the PRETRIGGER OUTPUT connector approximately 200 nanoseconds before the leading edge of the main pulse. This output pulse is also applied to the Fixed Delay, Variable Delay and Charge Line Disconnect circuits.

The Fixed Delay circuit provides approximately 200 nanoseconds delay before it turns on the first Avalanche stage. A variable delay to provide a pulse width between 2 and 250 nanoseconds is provided by the Variable Delay circuit. The output of the Variable Delay circuit turns on the Second Avalanche stage.

The Charge Line Disconnect circuit disconnects the variable power supply stage from the Charge Line during the time that the Avalanche transistors are turned on. The Overload Reset circuit protects the avalanche transistors from damage if they free run.

The leading edge of the output pulse is produced by the First Avalanche stage and the trailing edge is produced by the Second Avalanche stage. These stages are connected across the Charge Line. The width of the output pulse can be changed by varying the amount of delay between the turn on of the First Avalanche and the Second Avalanche stages.

The output pulse from the First Avalanche stage is connected to the Pulse Shaper circuit. This circuit shapes and determines the amplitude of the output pulse.

In addition to the Main Power Supply, the Type R293 contains a Programmable Voltage Supply and a Programmable Current Supply. The output of these programmable supplies may be remotely programmed or set by front-panel controls.

### RATE GENERATOR

#### Internal Operation

When the Type R293 is operated with the TRIGGER SELECTOR switch in the INT position, the Rate Generator operates as follows:

Transistors Q34 and Q44 are connected as a free running oscillator. Repetition rate of the Rate Generator is determined by the capacitor C34 and the amount of charging current applied to it from the Constant Current Source, Q24. The current through Q24 can be varied by the RATE control; as the current is increased, C34 charges faster to produce a higher repetition rate.

To understand the operation of the circuit, assume that C34 is discharged. Charging current is supplied to C34 through Q24 at the charge rate determined by the RATE control. When the charge on C34 becomes high enough, D34 and Q34 are biased on. When Q34 turns on, the negative pulse at its collector turns on Q44 to produce the positive-going pretrigger output pulse. This pulse is also connected back to the base of Q34, increasing its conduction and making the circuit regenerative.

Q34 and Q44 remain in conduction until the charge on C34 is depleted. Q34 and D34 are then reverse-biased and the pulse ends. The cycle begins again as C34 starts to recharge.

The pulse from the collector of Q44 is connected to the PRETRIGGER OUTPUT connector, and the Delay and Avalanche circuits.

#### Programmed Operation

Operation of the Rate Generator in the programmable mode is much the same as described above. When the RATE control is turned fully clockwise to the REMOTE position, SW30 disconnects the emitter of Q24 from the -15-volt supply and connects it to terminal 15 of the Remote Program connector. In this mode the current through Q24, and thus the repetition rate of the Rate Generator, is controlled by a resistor connected between terminals 6 and 15 of the Remote Program connector. This resistor sets the amount of current supplied to the emitter of Q24 to determine the charge rate of C34 in a similar manner to that obtained by varying the RATE control in the normal mode. When SW30 is in the REMOTE position, R30 is in the 100 kHz position of the control. Therefore, zero ohms (shorting strap) will provide a 100-kHz repetition rate. A 90 k $\Omega$  program resistor will provide a 10-kHz repetition rate.

#### External Trigger Operation

When the TRIGGER SELECTOR switch is in the EXT position, the repetition rate of the Rate Generator is determined by an external signal applied to the TRIGGER INPUT connector. Q14 amplifies and shapes the input signal and applies it to D34. In this mode, current is supplied to C34

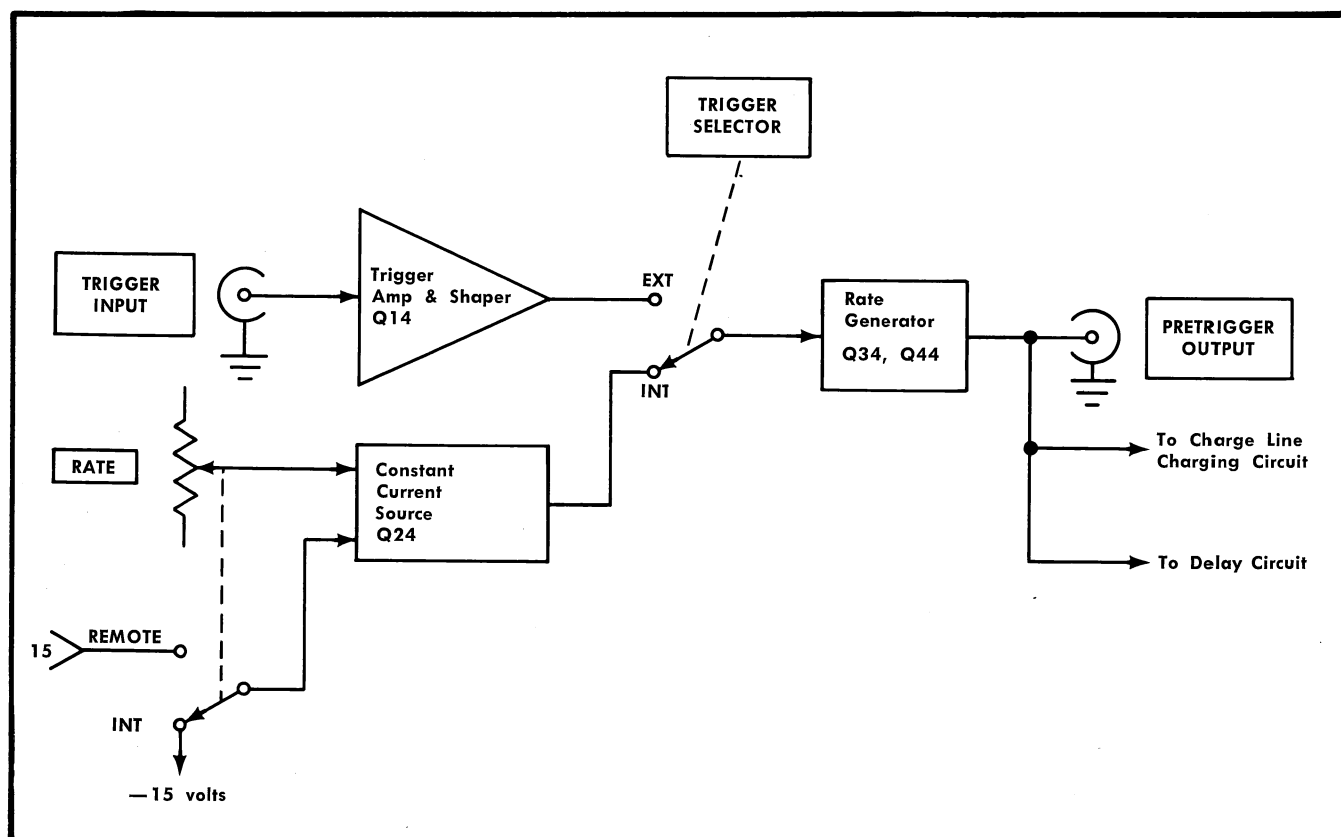


Fig. 3-1. Detailed block diagram of Rate Generator.

from the  $-15$ -volt supply through R16. This current charges C34 until it is clamped by D18. When the amplified external trigger signal is applied to the cathode of D34, it forward biases D34 and Q34. The rate generator pulse is then produced as for internal operation.

## DELAY AND AVALANCHE CIRCUITS

### Fixed Delay

The control pulse from the Rate Generator is connected to the base of Q74. This positive pulse turns Q74 off and its collector goes negative, reverse biasing D76. When D76 is reverse biased, the current which was flowing through it charges C76 toward  $-15$  volts. After charging about 200 nanoseconds, the charge on C76 is negative enough to turn D82 and Q84 on. The exact amount of delay is adjustable by varying the charging rate of C76 with R80. The collector of Q84 goes negative when it turns on, which biases Q94 on also. The positive-going pulse at the collector of Q94 is connected to the First Avalanche stage to form the leading edge of the output pulse.

### Variable Delay

When Q74 is turned off by the control pulse, the negative pulse at its collector turns Q154 off also. C154 begins to charge through the constant-current transistor Q164. When the charge on C154 is negative enough to turn on

D156 and Q124, Q134 is also turned on. The positive-going pulse at the collector of Q134 is connected to the Second Avalanche stage to form the trailing edge of the output pulse.

The amount of delay before Q124 is turned on determines pulse width. This delay can be changed by varying the level at the base of Q124. The width of the output pulse is controlled either by the WIDTH control or an external program resistor connected between terminals 6 and 18 of the Remote Program connector. In the REMOTE position of the WIDTH control (fully clockwise), the external programming resistor determines pulse width; the WIDTH control determines the pulse width in all other positions.

### Charge Line Disconnect

Quiescently, Q54 is off and Q63 is conducting. The charge line is charged to the potential at the cathode of D64. The positive-going pulse produced by the Rate Generator turns Q54 on and Q63 off. When Q63 turns off, D62 and D64 are reverse biased and the Charge Line is disconnected from the + Var Supply.

### Overload Reset

Q55 and Q65 protect the avalanche transistors from damage if they free run. These transistors are connected

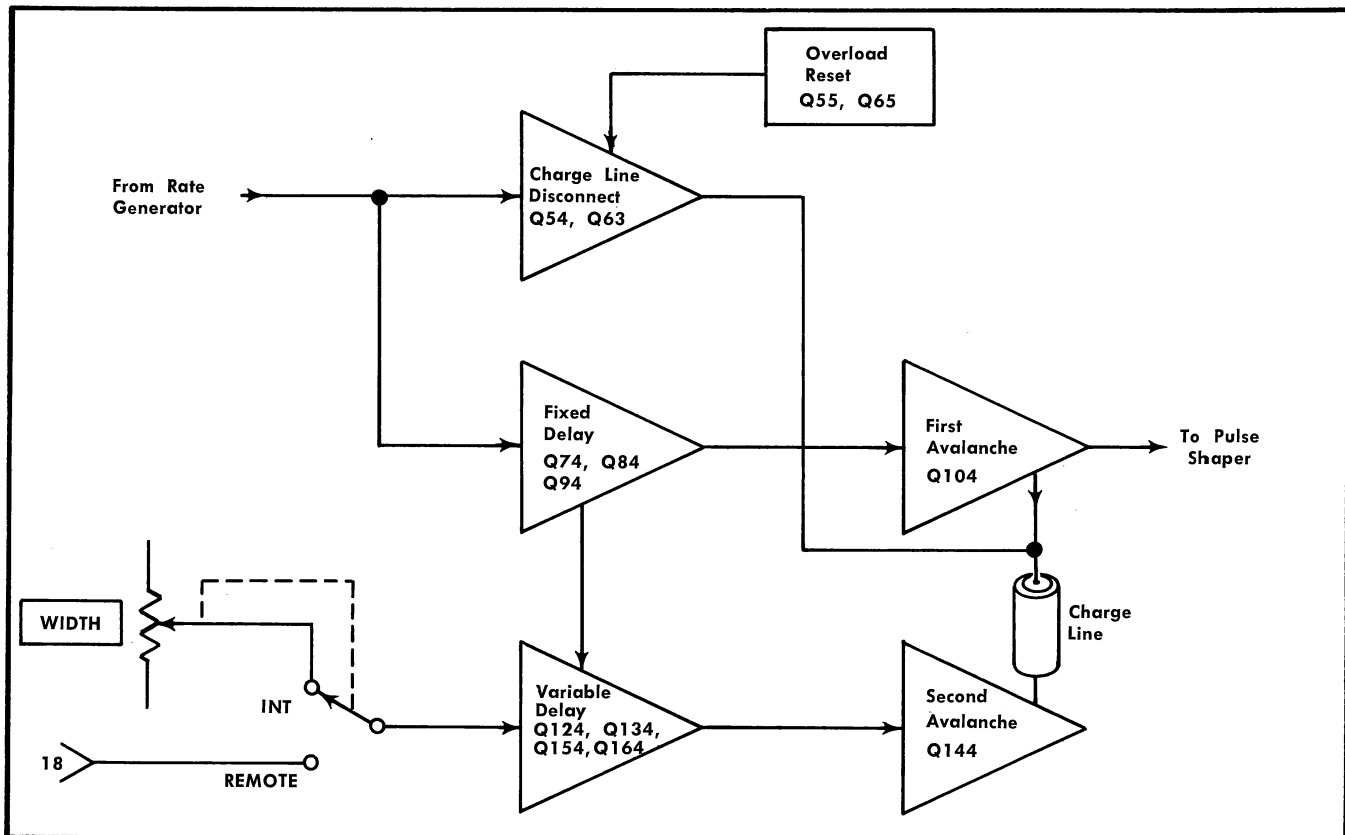


Fig. 3-2. Detailed block diagram of Delay and Avalanche circuits.

as a monostable multivibrator with Q55 quiescently conducting and Q65 turned off. The current applied to the First Avalanche stage from the + Var Supply is sampled by R59. If the current is too high because the avalanche transistors are free running, the voltage across R59 is high enough to reverse bias D58, D59 and Q55 which turns on Q54 and Q65. When Q54 turns on, Q63 is turned off and the avalanche transistors are disconnected from the + Var Supply. The circuit remains in this condition for about 1 millisecond which allows the avalanche transistors to recover. Then, Q55 and Q65 revert to their original state and the + Var Supply voltage is again applied to the avalanche transistors and the Charge Line.

### Avalanche Circuits

The leading edge of the output pulse is produced by the First Avalanche stage, Q104. At the end of the fixed delay time (approximately 200 nanoseconds after the pretrigger pulse is generated), Q104 is driven into avalanche by a pulse from the Fixed Delay stage. Q63 disconnects the Charge Line from the supply voltage upon receipt of the pretrigger pulse, just before Q104 avalanches. The Charge Line is charged to about +70 volts through Q63 before it is disconnected. When Q104 avalanches, the emitter and base rise positive. D94 becomes reverse biased and disconnects the First Avalanche stage from the Fixed Delay circuit. The output pulse is taken from the emitter of Q104.

Meanwhile, the Variable Delay circuit produces a pulse which fires the Second Avalanche stage, Q144. When Q144 avalanches it produces a fast negative-going leading edge at the opposite end of the Charge Line from Q104. This pulse will form the trailing edge of the output pulse.

A variable-width output pulse is produced as follows: Both the First and Second Avalanche stages produce fast rising pulses which are coupled into opposite ends of the Charge Line. The avalanche stages use the stored charge in the Charge Line to keep them in the avalanche region. When this charge is depleted, the pulse will be reflected back along the Charge Line to turn the First Avalanche stage off and end the output pulse. The electrical length of the Charge Line is approximately 130 nanoseconds. Q104 is always turned on about 200 nanoseconds after the pretrigger pulse is generated. However, Q144 may be turned on between 70 and 320 nanoseconds after the pretrigger pulse. The exact time that Q144 is turned on is selected by the WIDTH control or the external program resistor.

When the WIDTH control is set for maximum pulse width, the Second Avalanche stage will be turned on about 12 nanoseconds after the First Avalanche stage has been turned on. The two pulses will meet after the First Avalanche pulse has traveled about 125 nanoseconds down the Charge Line. When the pulses meet, the pulse from the First Avalanche stage will be reflected back to produce a fast trailing edge on the pulse at the emitter of Q104 125 nanoseconds later. Therefore, the total pulse width will be 250 nanoseconds.



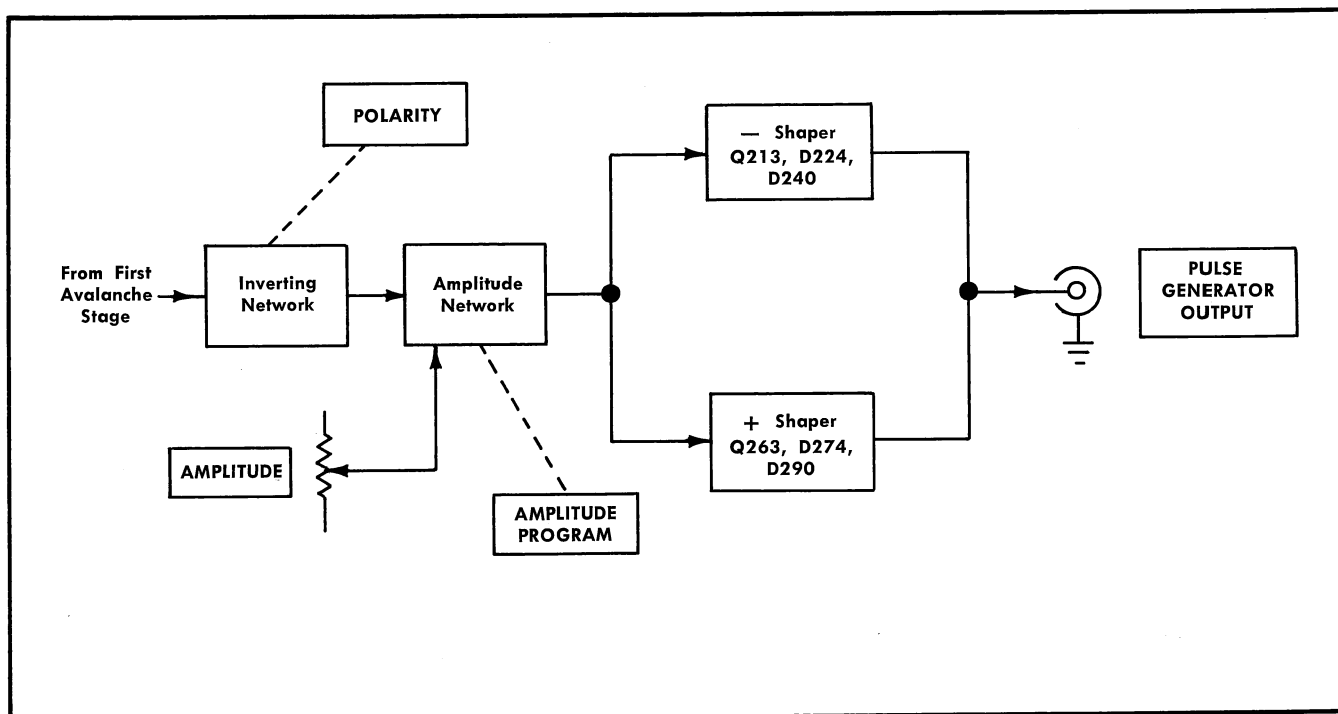


Fig. 3-3. Detailed block diagram of Pulse Shaper.

When the WIDTH control is set for minimum, the Second Avalanche stage will come on about 72 nanoseconds after the pretrigger pulse. Then, when the First Avalanche stage turns on 128 nanoseconds later, Q144 will have depleted all but 2 nanoseconds of the charge on the Charge Line. The two pulses will meet after the First Avalanche pulse has traveled 1 nanosecond down the Charge Line. It will then be reflected back to produce a fast trailing edge at the emitter of Q104 1 nanosecond later. Therefore, the total pulse width will be 2 nanoseconds.

C98 on the collector of Q104 is adjusted to provide optimum pulse risetime and pulse shape. C140 on the collector of Q144 is similarly adjusted for optimum pulse fall-time. The high-frequency peaking network R100-C100-C102 prevents rounding of the output pulse. The network R103-R104-R106-R107-C104-D103 provides correct pulse shaping in conjunction with the pulse shaping controls in the + and - Shaper circuits.

The output from the Avalanche circuits is connected to the Inverting Network.

## PULSE SHAPER

### Inverting Network

The output pulse from the avalanche circuit is connected to the POLARITY switch. In the + position, the signal is coupled directly through the switch. L204 provides a dc current return. In the - position, the signal is inverted by T201.

### Amplitude Network

The pulse is coupled from the POLARITY switch to T205. This transformer couples C201-D207 and C251-D257 together so they move together to reduce aberrations in the output pulse. Diodes D207 and D257 couple the pulse to the Shapers; D207 couples the negative pulses and D257 couples the positive pulses. These diodes are used in conjunction with the AMPLITUDE control to set the amplitude of the output pulse.

The AMPLITUDE control is connected between the + Ref Supply and the - Ref Supply. The output of these supplies is floating and the only ground return is through the center arm of the AMPLITUDE control. Therefore, as the AMPLITUDE control is moved it will vary the level of both the + and - Ref Supplies. However, the total voltage difference between the supplies will remain the same.

To understand the action of the Amplitude Network, assume that the POLARITY switch is set to + and the AMPLITUDE control is set fully clockwise for maximum amplitude. In this condition, the + Ref Supply output will be about +33 volts and the - Ref Supply output will be about -7 volts. D207 will be reverse biased by the positive voltage applied to its cathode through D205. The - Ref Supply voltage applied to D257 will be about -2 volts, reverse biasing D257 only slightly. As the pulse from the avalanche circuits is applied to D257, it will be forward biased and pass most of the signal on to the Shaper circuits.

Operation is much the same in the minimum amplitude condition. However, the - Ref Supply output will be about -19 volts and the + Ref Supply output will be about +21

volts. The voltage at the anode of D257 will be about —12 volts. This means that the pulse applied must overcome this reverse bias on D257 before the pulse can pass to the Shaper circuits. Thus D257 clips the output pulse to provide a lower output amplitude.

### + and — Shaper

The output pulse from the Amplitude network is connected through the Shaper circuits to the PULSE GENERATOR OUTPUT connector. To understand the action of the circuit, once again assume that the POLARITY switch is set to +. In the quiescent condition D244 and D240 (— Shaper) are forward biased slightly through R217 and R234 respectively. When the pulse arrives, these diodes are reverse biased and 'snap off' to provide a fast leading edge. When the pulse amplitude reaches a level selected by R261, D274 will come into conduction and clamp the pulse at this level. The pulse passes on to D290 through R225 where it is clamped at a slightly less positive level determined by R280. This double clamping provides a cleaner output pulse with less storage aberration than if only one clamp diode were used. When the pulse ends, diodes D274 and D290 will be reverse biased and 'snap off' to provide a fast trailing edge.

Emitter followers Q213 and Q263 are used to provide a low-impedance voltage source for the clamping diodes. The voltage level at the base of each emitter follower is varied to set the clamping point of the diodes.

When the POLARITY switch is set to —, conditions are reversed. D274 and D290 'snap off' to provide a fast leading edge and D224 and D240 clamp the negative pulse and 'snap off' to provide a fast trailing edge.

The voltage level at the AMPLITUDE control is connected to the + and — Shaper stages through pin connector F. This voltage level allows the Shaper circuits to follow the AMPLITUDE control so the pulse is correctly shaped at all amplitude levels.

The output pulse is connected to the PULSE GENERATOR OUTPUT connector through C243 and C244. These two capacitors are used in parallel to offset their internal resistance and provide less pulse attenuation.

## PROGRAMMABLE POWER SUPPLY

### Voltage Supply

The main power source for the Programmable Voltage Supply is rectifier D301-D303. The rectifiers D308-D314 and D310-D312 provide operating voltages for circuit operation and allow the Programmable Voltage Supply output to be variable.

The output voltage from the Programmable Voltage Supply is held constant by Regulator Q337. The output voltage level is established by the comparator Q346. This stage also serves as an error amplifier to provide feedback of the output voltage and hold the output voltage constant. Reference voltage for the comparator is applied to the base of Q346B from the variable arm of R368, REGULATED VOLTAGE SUPPLY. This reference voltage is held constant by the reference Zener diode, D352, which is connected across the control. As the voltage at the base of

Q346B is varied by R368, the output of the supply will be varied also.

An error or ripple in the output voltage is corrected by Q346A. A sample of the output voltage is applied to the base of Q346A. If this voltage is different than the level at the base of Q346B because of a change in output level, the conduction of the Regulator transistor, Q337, will be changed so as to correct for the error in the output.

The network D322-D330-D331-C330-C331-R324-R331 limits the conduction of Regulator transistor Q337 to limit the output current to 200 milliamps and thereby protect the power supply from overload.

The MODE switch, SW340, changes the polarity of the output voltage. When in the NPN position, the negative side of the power supply is connected to chassis ground to provide a positive output voltage at terminal C of the POWER SUPPLY OUTPUT connector. The positive side of the power supply is connected to chassis ground in the PNP position to provide a negative output voltage. Terminal C is grounded in the OFF position.

The output voltage of the Programmable Voltage Supply may be remotely programmed when the VOLTAGE PROGRAM switch is in the REMOTE position. An external resistor connected between terminals 23 and 24 of the Remote Program connector, J22, establishes the emitter current of Q363. Q363 in turn sets the voltage level at the base of Q346B which determines the output voltage of the supply as described for INT operation.

### Current Supply

Power for the Programmable Current Supply is provided by rectifier D371-D373. The output of this rectifier is applied across D377 and Q384 to provide a constant current to D380. Zener diode D380 is connected across the REGULATED CURRENT SUPPLY dial, R386.

The output current is provided through Q397 and Q398. The range of the output current is selected by changing the conduction of Q397 and Q398 with the CURRENT MULTIPLIER switch, SW390. The exact output current within the range selected by SW390 is determined by the REGULATED CURRENT SUPPLY dial, R386. This control sets the voltage at the base of Q393 to control the output current. The output current will be that current flowing through the range resistor, R395-R397 or R398. Q397 and Q398 are connected in parallel to supply the output current. Q397 conducts first. When the current flow through R392 reaches about 1.5 milliamps, Q398 will be biased on and supply all additional output current above 1.5 milliamps.

The polarity of the output can be changed with the MODE switch, SW340. When the MODE switch is in the NPN position, terminal B of the POWER SUPPLY OUTPUT connector is positive. When in the PNP position, terminal B is negative. Neither output terminal is grounded in either position, producing a floating supply. The output is disconnected in the OFF position.

The Programmable Current Supply may be remotely programmed when the CURRENT MULTIPLIER switch is in the REMOTE PROGRAM position. An external resistor connected between terminals 9 and 21 of the Remote Program connector, J22, establishes the conduction of Q397 and Q398 to set the output current.

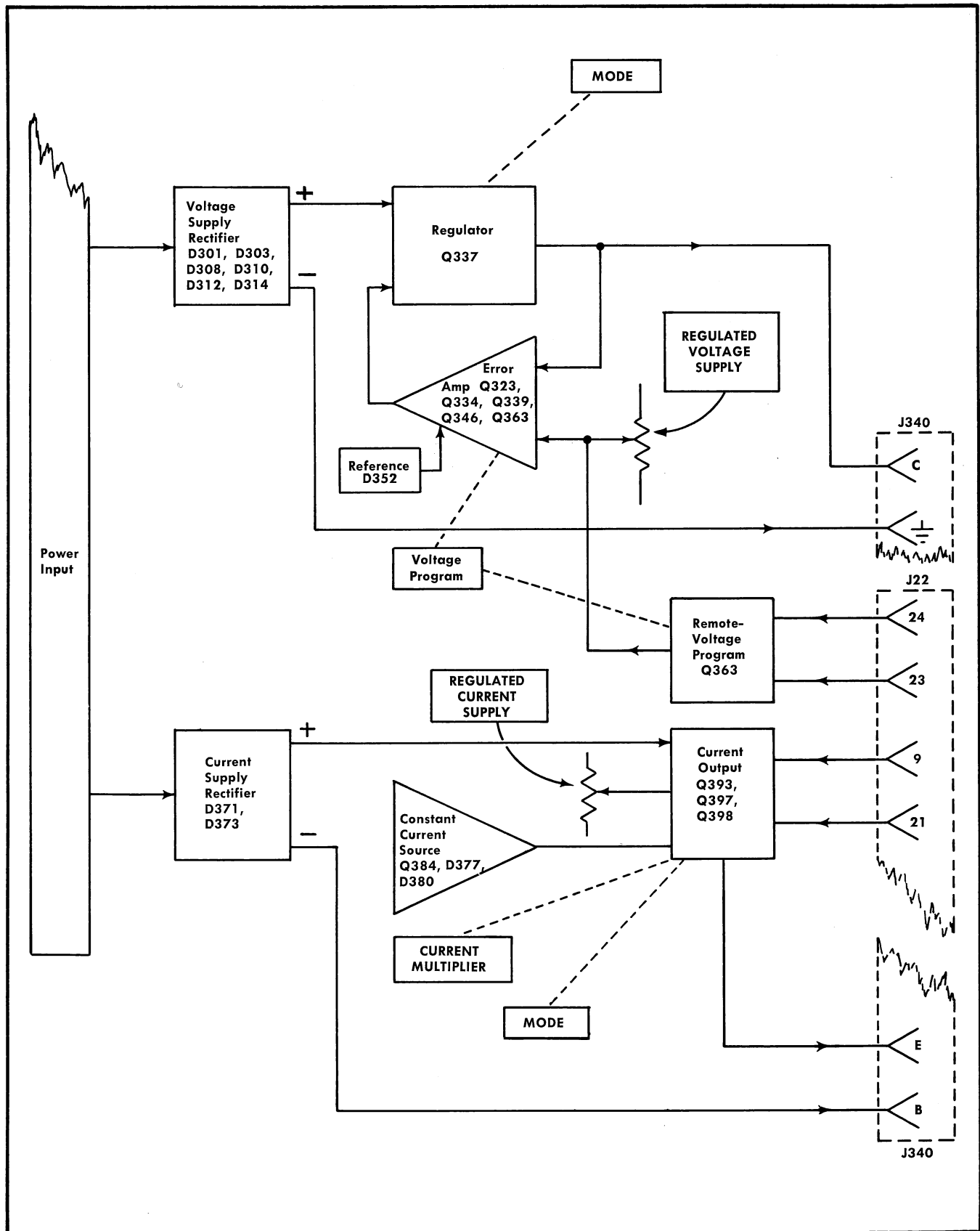


Fig. 3-4. Detailed block diagram of Programmable Power Supply.

## PULSE-GENERATOR POWER SUPPLY

### General

The Pulse-Generator Power Supply provides the operating power for the instrument from four regulated supplies. Electronic regulation is used to provide stable output voltages. A switch on the rear panel switches the instrument from 115-volt nominal line to 230-volt nominal line operation.

### Power Input

Power is applied to the instrument through P402. It is applied to the primary of the transformer through the line filter FL402, line fuse F402, POWER ON switch SW402 and 115 V - 230 V Selector switch SW401. The 115 V - 230 V Selector switch connects the split primaries of T301 in parallel for 115-volt nominal operation or in series for 230-volt nominal operation.

Output from the secondaries of T301 supplies the power for the Pulse-Generator Power Supply as well as the Programmable Voltage and Current supplies.

### —15-Volt Supply

The —15-Volt Supply provides the reference voltage for the +6-Volt and Variable Supplies. Reference for the —15-Volt Supply is provided by Zener diode D446.

Output from the secondary of T301 is rectified by bridge rectifier D432. The output of the rectifier is regulated as follows to provide stable output voltage. Zener diode D446 holds the base of Q446 at about —6 volts. Q446 and Q456 are connected as a comparator. In this configuration, the emitter level will be established by D446 with the emitter current dividing between Q446 and Q456, depending on the setting of R458. Collector current of Q456 controls the conduction of Q443, which in turn controls the conduction of the series regulator Q457 to provide the correct output voltage. The base level of Q456 is set by the —15-Volts adjustment, R458, to provide —15 volts output from the supply.

Ripple in the output voltage is held to a minimum by feeding a sample of the output back to the regulator transistor, Q457. To understand this operation, assume that the ripple is in the negative half of its cycle. This negative voltage change at the output is connected to the base of Q446 through C446 and D446, resulting in reduced current flow through Q446. Reduced current flow through Q446 allows Q456 to conduct more and its collector goes negative. This negative change is connected to the base of Q457 through emitter follower Q443. The result is a reduction in current through Q457 which opposes the original output change due to ripple and provides a stable output voltage. In a similar manner, the regulator circuit compensates for changes in input voltage or changes in load current.

### +6-Volt Supply

Rectified voltage for operation of the +6-Volt Supply is provided by D432 also. The reference voltage for this supply is provided by the voltage divider R438-R439 be-

tween —15 volts and the output of this supply. The output of the —15-Volt Supply is held stable as discussed previously. Therefore, any change at the base of Q434 is from the +6-volt output. If the +6-volt output changes, this change is applied to Q437 as an error signal. Regulation is controlled by the regulator transistor, Q437, in the same manner as described for the —15-Volt Supply.

### + Var Supply

The + Var Supply is used to supply power to the avalanche stages. The output voltage level of this supply is adjusted for correct operation of the avalanche stage.

Reference voltage for the + Var Supply is provided by divider R416-R418-R419 between —15 volts and the output of this supply. Any change in the output voltage is coupled to the base of Q423. This error signal is then connected through Q424 to the base of the regulator transistor, Q427. Regulation is controlled by the regulator transistor as described for the —15-Volt Supply.

### Reference Supply

The Reference Supply is a self-contained supply with a positive and negative output and a zero reference output. The output of this supply is used in the Pulse Shaper circuit in conjunction with the AMPLITUDE control.

Rectified power for operation of the Reference Supply is provided by D472. The reference voltage for this supply is provided by Zener diode D477 connected to the base of Q476. The output level is adjusted by the Ref Volts adjustment, R487 in the base of Q486. Error signals across the + Ref and — Ref output are connected to the comparator Q276-Q486 to control the output voltage. These error signals are connected to the base of Q486 through C490 and are compared to the Zener diode reference voltage. The amplified error signal is applied to the base of Q477 through Q476 to cancel the original error.

Transistors Q487, Q493, Q494 and Q497 form the reference network. This network allows the + Ref and — Ref output voltage to be varied about the 0 Ref level. However, the potential difference between the two outputs does not change.

The AMPLITUDE control in the Pulse Shaper circuit is essentially connected between the + Ref and the — Ref outputs with the variable arm connected to ground. As this control is rotated, the + Ref and — Ref output will change to approximately that voltage appearing across the voltage divider (AMPLITUDE control) between the + and — Ref output and ground.

### Remote Amplitude Network

The Remote Amplitude Network, Q503 and Q513, provides correct pulse amplitude when in the REMOTE position of the AMPLITUDE PROGRAM switch. The Remote Ampl adjustment, R502, adjusts the remote-program pulse amplitude.

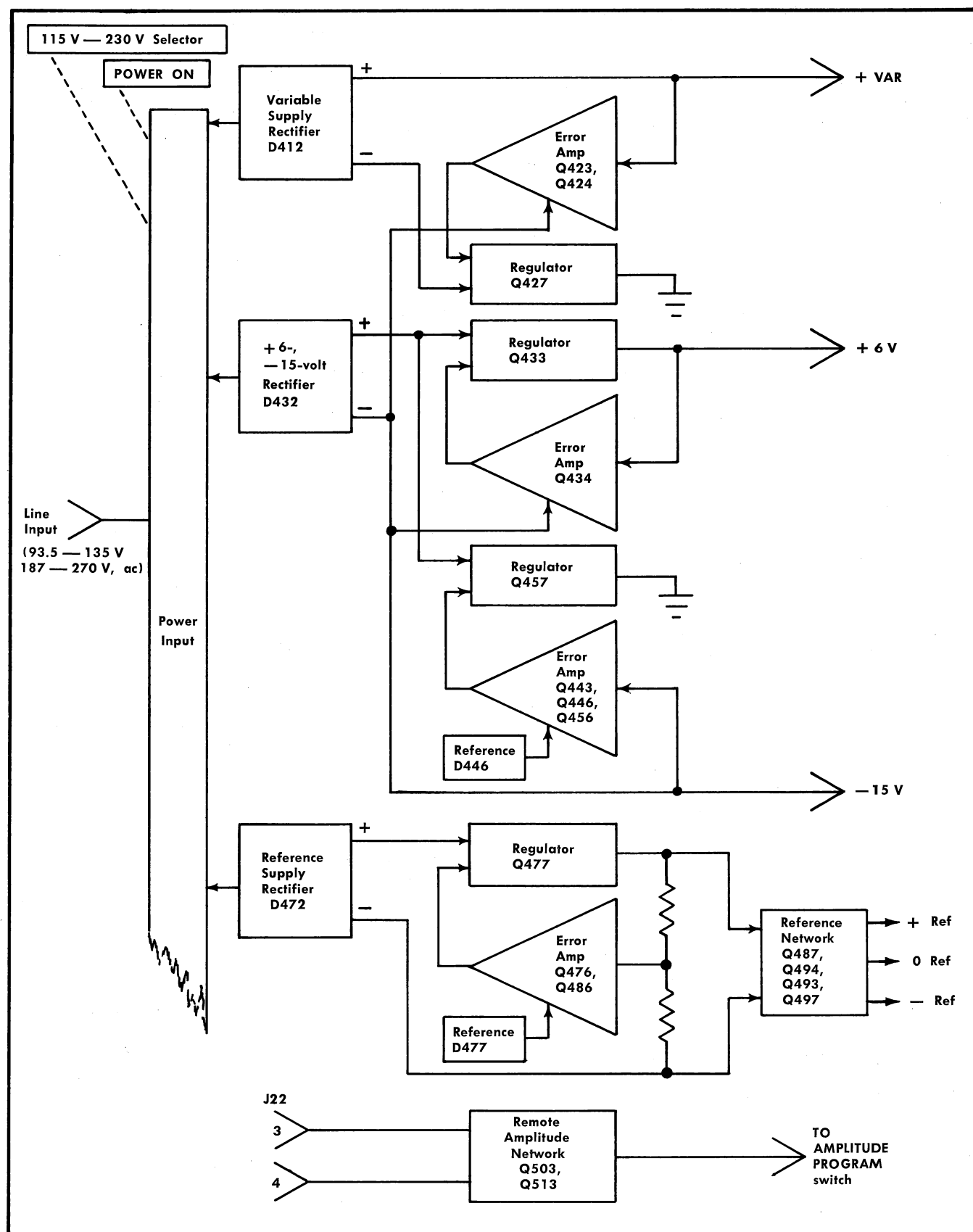


Fig. 3-5. Detailed block diagram of Pulse-Generator Power Supply.



# SECTION 4

## MAINTENANCE

### Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type R293.

### PREVENTIVE MAINTENANCE

#### General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis will help prevent instrument failure and will improve reliability of this instrument. The severity of the environment to which the Type R293 is subjected will determine the frequency of maintenance.

#### Cleaning

The Type R293 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path.

The top and bottom covers provide protection against dust in the interior of the instrument. Operation without the covers in place will necessitate more frequent cleaning.

#### CAUTION

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

**Exterior.** Loose dust accumulated on the outside of the Type R293 can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild solution of water and detergent. Abrasive cleaners should not be used.

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

#### Lubrication

The reliability of potentiometers, rotary switches and other moving parts can be maintained if they are kept

properly lubricated. Use a cleaning-type lubricant (such as Tektronix Part No. 006-0218-00) on shaft bushings and switch contacts. Lubricate switch detents with a heavier grease (such as Tektronix Part No. 006-0219-00). Potentiometers should be lubricated with a lubricant which will not affect electrical characteristics (such as Tektronix Part No. 006-0220-00). Do not use excessive lubrication. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix. Order Tektronix Part No. 003-0342-00.

#### Visual Inspection

The Type R293 should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated transistors, damaged etched-wiring boards or heat-damaged parts.

The remedy for most visible defects is obvious; however, care must be taken if heat-damaged parts are located. Overheating is usually only a symptom of trouble. For this reason, it is essential to determine the actual cause of overheating before the heat-damaged part is replaced; otherwise, the damage may be repeated.

#### Transistor Checks

Periodic checks of the transistors in the Type R293 are not recommended. The best check of transistor performance is its actual operation in the instrument. More details on checking transistor operation is given under Troubleshooting.

#### Recalibration

To assure accurate measurements, check the calibration of this instrument after each 500 hours of operation or every six months if used infrequently. In addition, replacement of components may necessitate recalibration of the affected circuits. Complete instructions are given in the Calibration section.

The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases minor troubles, not apparent during normal use, may be revealed and/or corrected by recalibration.

### CORRECTIVE MAINTENANCE

#### General

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

#### Obtaining Replacement Parts

**Standard Parts.** All electrical and mechanical part replacements for the Type R293 can be obtained through your local Tektronix Field Office or representative. How-

## Maintenance—Type R293

ever, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Parts List for value, tolerance and rating.

### NOTE

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

**Special Parts.** In addition to the standard electronic components, some special parts are used in the Type R293. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the Parts List by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your Tektronix Field Office or representative.

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

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

## Soldering Techniques

### WARNING

Disconnect the instrument from the power source before soldering.

**Etched-Wiring Boards.** Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the etched-wiring boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the etched wiring from the base material.

The following technique should be used to replace a component on an etched-wiring board. Most components can be replaced without removing the boards from the instrument.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board, as it may damage the board.
2. When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick or pointed tool into the hole to clean it out.

3. Bend the leads of the new component to fit the holes in the 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 board until the component is firmly seated against the board. If it does not seat properly, heat the solder and gently press the component into place.

4. Apply the iron and a small amount of solder to the connection to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

5. Clip the excess lead that protrudes through the board.

6. Clean the area around the soldered connection with a flux-remover solvent. Be careful not to remove information printed on the board.

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

A small roll of 3% silver solder is mounted on the rear of the instrument. Additional silver solder should be available locally, or it can be purchased directly from Tektronix; order by Tektronix Part No. 251-0514-00.

Observe the following precautions when soldering ceramic terminal strips.

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

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

Observe the following precautions when soldering metal terminals:

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

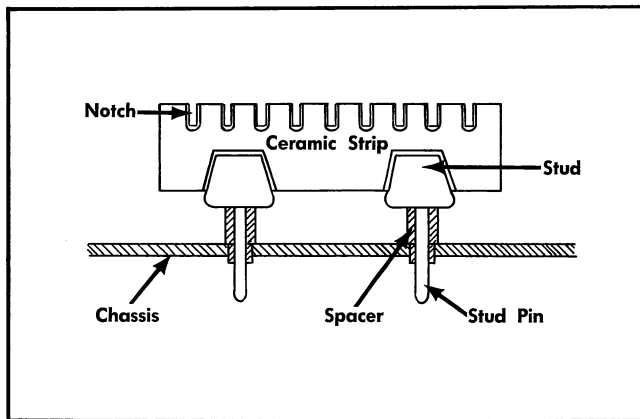


Fig. 4-1. Ceramic terminal strip assembly.

## Component Replacement

### WARNING

Disconnect the instrument from the power source before replacing components.

**Ceramic Terminal Strip Replacement.** A complete ceramic terminal strip assembly is shown in Fig. 4-1. Replacement strips (including studs) and spacers are supplied under separate part numbers. The old spacers may be re-used if they are not damaged.

To replace a ceramic terminal strip, first unsolder all connections. Then, the damaged strip can be pried or pulled loose from the chassis. If the spacers come out with the strip, remove them from the stud pins to be used for installation of the new strip.

After the damaged strip has been removed, place the undamaged spacers in the chassis holes. Then, carefully press the studs into the spacers until completely seated. If necessary, use a soft mallet and tap lightly, directly over the stud area of the strip.

**Etched-Wiring Board Replacement.** If an etched-wiring board is damaged and cannot be repaired, the entire assembly including all soldered-on components, or the board only, can be replaced. Part numbers are given in the Mechanical Parts list for either the completely-wired board or the unwired board.

Procedure for removing etched-wiring boards follows:

**Etched-Wiring Board Removal.** Connections to the etched-wiring boards are made with pin connections. However, several connections are soldered to the Pulse Shaper and Pulse Generator boards. See Pulse Shaper and Pulse Generator Board Removal which follows for removal of these boards.

Most of the components mounted on the etched-wiring boards can be replaced without removing the boards from the instrument. Observe soldering precautions given under Soldering Techniques in this section. However, if the board itself must be replaced, use the following procedure:

1. Disconnect all pin connectors from the board.
2. Remove all screws holding the board to the chassis.

3. Lift the etched-wiring board out of the instrument. Do not force or bend the board.

4. To replace the board, reverse the order of removal. Correct location of the pin connectors is shown in Figs. 4-4 through 4-7. Replace the pin connectors carefully so they mate correctly with the pins. If forced into place incorrectly positioned, the pin connectors may be damaged.

**Pulse Shaper and Pulse Generator Board Removal.** To remove the Pulse Generator board, first unsolder the three cables connected on the bottom side. Observe the soldering precautions given in this section. Then remove the board as described above.

The Pulse Shaper board is removed in a similar manner. First unsolder the cable connected on the bottom side. **Do not unsolder** the large cable leading to the front-panel PULSE GENERATOR OUTPUT connector. Instead, remove the retaining nut at the rear of this connector so the connector, cable and board can be removed as a unit. Now remove the board as described above.

**Transistor Replacement.** Transistors should not be replaced unless actually defective. If removed during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors may affect the calibration of this instrument. When transistors are replaced, check the operation of that part of the circuit which may be affected.

Replacement transistors should be of the original type or a direct replacement. The transistors should be remounted in the same manner as the original. Some of the transistors use silicone grease and special heat sinks to increase heat transfer. Replace the silicone grease and heat sinks when replacing these transistors.

### WARNING

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

**Rotary Switches.** Individual wafers or mechanical parts of rotary switches are normally not replaced. If a switch is defective, replace the entire assembly. Replacement switches can be ordered either wired or unwired; refer to the Parts List for the applicable part numbers.

When replacing a switch, it is recommended that the leads and switch terminals be tagged with corresponding identification tags as the leads are disconnected. Then, use the old switch as a guide for installing the new one. An alternative method is to draw a sketch of the switch layout and record the wire color at each terminal.

## TROUBLESHOOTING

### Introduction

The following information is provided to facilitate troubleshooting of the Type R293, if trouble develops. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component.

## Troubleshooting Aids

**Diagrams.** Circuit diagrams are given on foldout pages in Section 9. The circuit number and electrical value of each component in this instrument are shown on the diagrams. Important voltages and waveforms are also shown on the diagrams.

**Component Numbering.** The circuit number of each electrical part is shown on the circuit diagram. Each main circuit is assigned a series of circuit numbers. Table 4-1 lists the main circuits in the Type R293 and the series of circuit numbers assigned to each. For example, using Table 4-1, a resistor numbered R250 is identified as being located in the Pulse Shaper.

**TABLE 4-1**  
Circuit Numbers

Circuit Numbers on Diagrams	Circuit
1 - 199	Pulse Generator
200 - 299	Pulse Shaper
300 - 399	Programmable Voltage and Current Supplies
400 - 499	Pulse-Generator Power Supply

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

**Etched-Wiring Boards.** Figs. 4-4 through 4-7 show the etched-wiring boards used in the Type R293. Fig. 4-3 shows the location of each board within the instrument. Each electrical component on the boards is identified by its circuit number. The boards are also outlined on the diagrams with a blue line. These pictures used along with the diagrams will aid in locating the components mounted on the etched-wiring boards.

**Wiring Color-Code.** All insulated wire used in the Type R293 is color-coded according to the EIA standard color-code (as used for resistors) to facilitate circuit tracing. The widest color stripe identifies the first color of the code. Power-supply voltages can be identified by three color stripes and the following background color-code: white, positive voltage; tan, negative voltage. Table 4-2 shows the wiring color-code for the power-supply voltages used in the Type R293. The remainder of the wiring in the Type R293 is color-coded with two or less stripes or has a solid background without stripes. The color-coding helps to trace a wire from one point in the instrument to another.

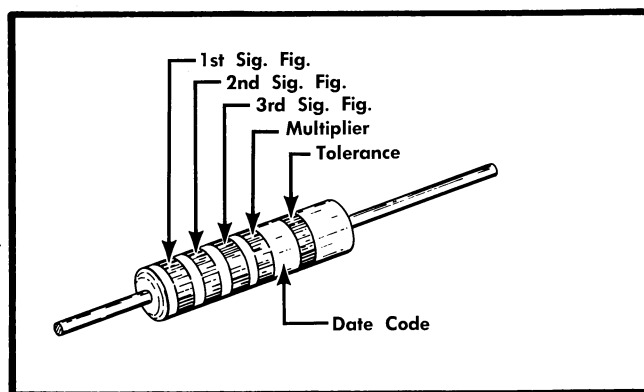
**Resistor Color-Code.** A number of precision metal-film resistors are used in this instrument. These resistors can be identified by their gray body color. If a metal-film resistor has a value indicated by three significant figures and a multiplier, it will be color-coded according to the

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

Supply	Background Color	1st Stripe	2nd Stripe	3rd Stripe
-15 volt	tan	brown	green	black
+6 volt	white	brown	red	black
+ VAR	white	violet	green	black
+ REF	white	brown	—	—
- REF	white	gray	—	—
'0' REF	white	violet	—	—

EIA standard resistor color-code. If it has a value indicated by four significant figures and a multiplier, the value will be printed on the body of the resistor. For example, a 333 k resistor will be color-coded, but a 333.5 k resistor will have its value printed on the resistor body. The color-code sequence is shown in Fig. 4-2.

Composition resistors are color-coded according to the EIA standard resistor color-code.



**Fig. 4-2.** Color-coding of metal-film resistors.

## Troubleshooting Techniques

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

**1. Check Associated Equipment.** Before proceeding with troubleshooting of the Type R293, check that the equipment used with the Type R293 is operating correctly. Check that the signal is properly connected and that the inter-connecting cables are not defective. Also, check the power source.

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

**3. Check Instrument Calibration.** Check the calibration of the instrument, or the affected circuit if the trouble exists in one circuit. The indicated trouble may only be a result of misadjustment or may be corrected by calibration. Complete instructions are given in the Calibration section of this manual. Individual calibration steps can be performed out of sequence. However, if the circuit affects the calibration of other circuits in the instrument, a more complete calibration will be necessary.

**4. Isolate Trouble to a Circuit.** To isolate a trouble to a circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. For example, incorrect pulse width indicates that the Pulse Generator circuit is probably at fault. When trouble symptoms appear in more than one circuit, check all affected circuits. Methods of checking the circuits are given in steps 5 through 8.

The pin connectors used to connect the etched-wiring boards to the instrument provide a unique means of circuit isolation. For example, a short in a power supply can be isolated to the Pulse-Generator Power Supply by disconnecting pin connectors for that voltage at the remaining boards.

Incorrect operation of all circuits often indicates trouble in the Pulse-Generator Power Supply. Check first for correct voltage of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits.

Table 4-3 lists the tolerances of the power supplies in the Type R293. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the supply may be misadjusted or operating incorrectly. Use the procedure given in the Calibration section to adjust the power supplies.

TABLE 4-3

Power Supply Tolerance

Power Supply	Tolerance
-15 volt	$\pm 0.3$ volt
+6 volt	$\pm 0.12$ volt

After the defective circuit has been located, proceed with steps 5 through 8 to locate the defective component(s). If the trouble has not been isolated to a circuit using the procedure described here, check voltages and waveforms as explained in step 7 to locate the defective circuit.

**5. Check Etched-Wiring Board Interconnections.** After the trouble has been isolated to a particular circuit, check the pin connectors on the etched-wiring board for correct connection. Figs. 4-4 through 4-7 show the correct connections for each board.

**6. Visual Check.** Visually check the circuit in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged etched-wiring boards or damaged components.

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

## NOTE

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

**A. VOLTAGES.** Voltage measurements should be taken with a 20,000 ohms/volt dc voltmeter. Accuracy of the voltmeter should be within 3% on all ranges. Be sure that the test prods are well insulated to prevent accidental shorting of components.

**B. WAVEFORMS.** Use a test oscilloscope which has the following minimum specifications:

Bandwidth: dc to 50 MHz

Deflection factor: 0.005 volts/division minimum

Input impedance: 1 Megohm paralleled by about 15 pF.

**8. Check Individual Components.** The following procedures describe methods of checking individual components in the Type R293. Components which are soldered in place can be checked most easily by disconnecting one end. This eliminates incorrect measurements due to the effects of surrounding circuitry.

**A. TRANSISTORS.** The best check of transistor operation is actual performance under operating conditions. If a transistor is suspected of being defective, it can best be checked by substituting a new component 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, a dynamic tester may be used (such as Tektronix Type 575). Static-type testers are not recommended, however, since they do not check operation under simulated operating conditions.

**B. DIODES.** A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of about 1.5 volts, the resistance should be very high in one direction and very low when the leads are reversed.

## CAUTION

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

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

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



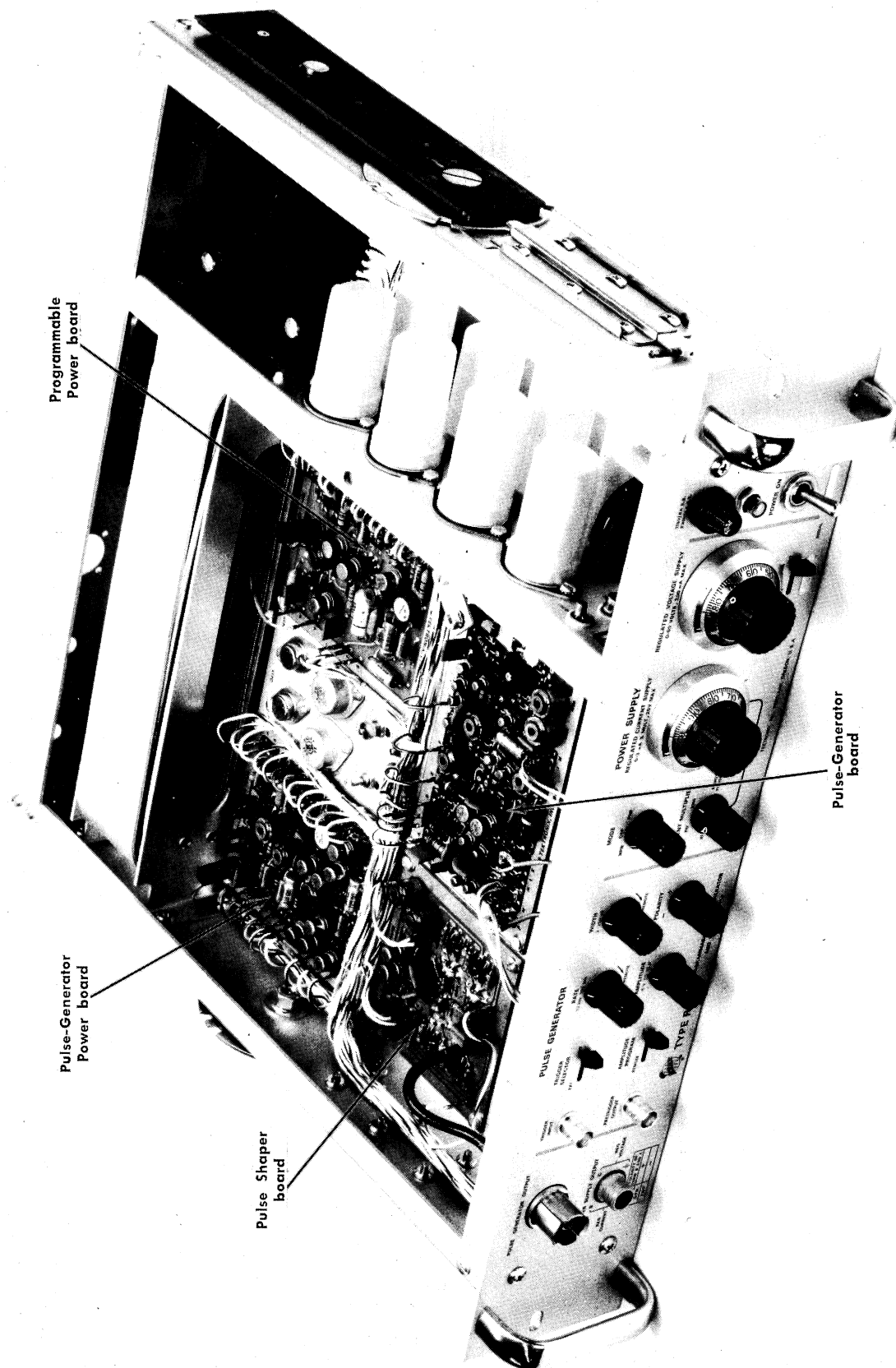
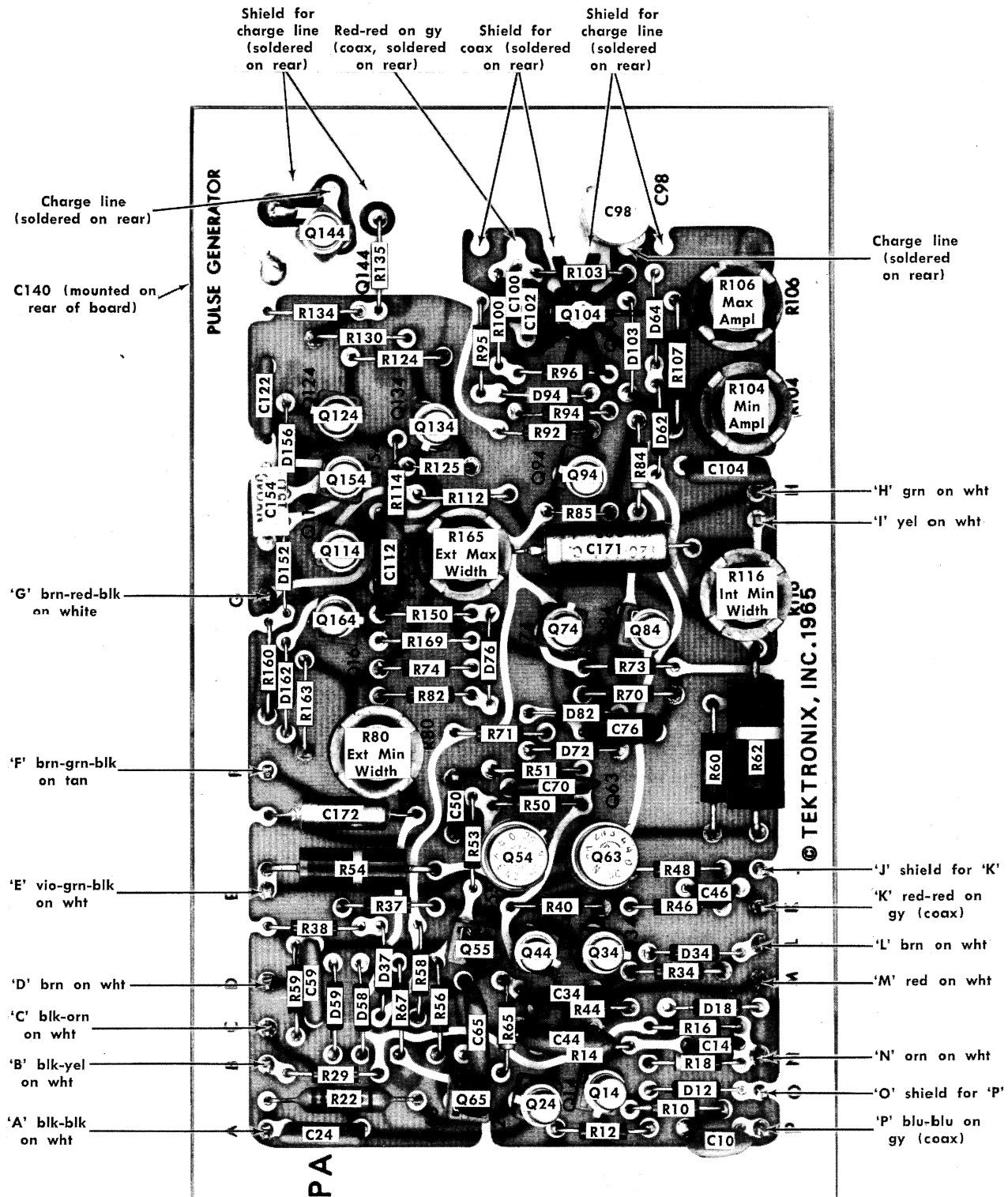


Fig. 4-3. Location of etched-wiring boards in Type R293.



**Fig. 4-4. Pulse Generator etched-wiring board.**

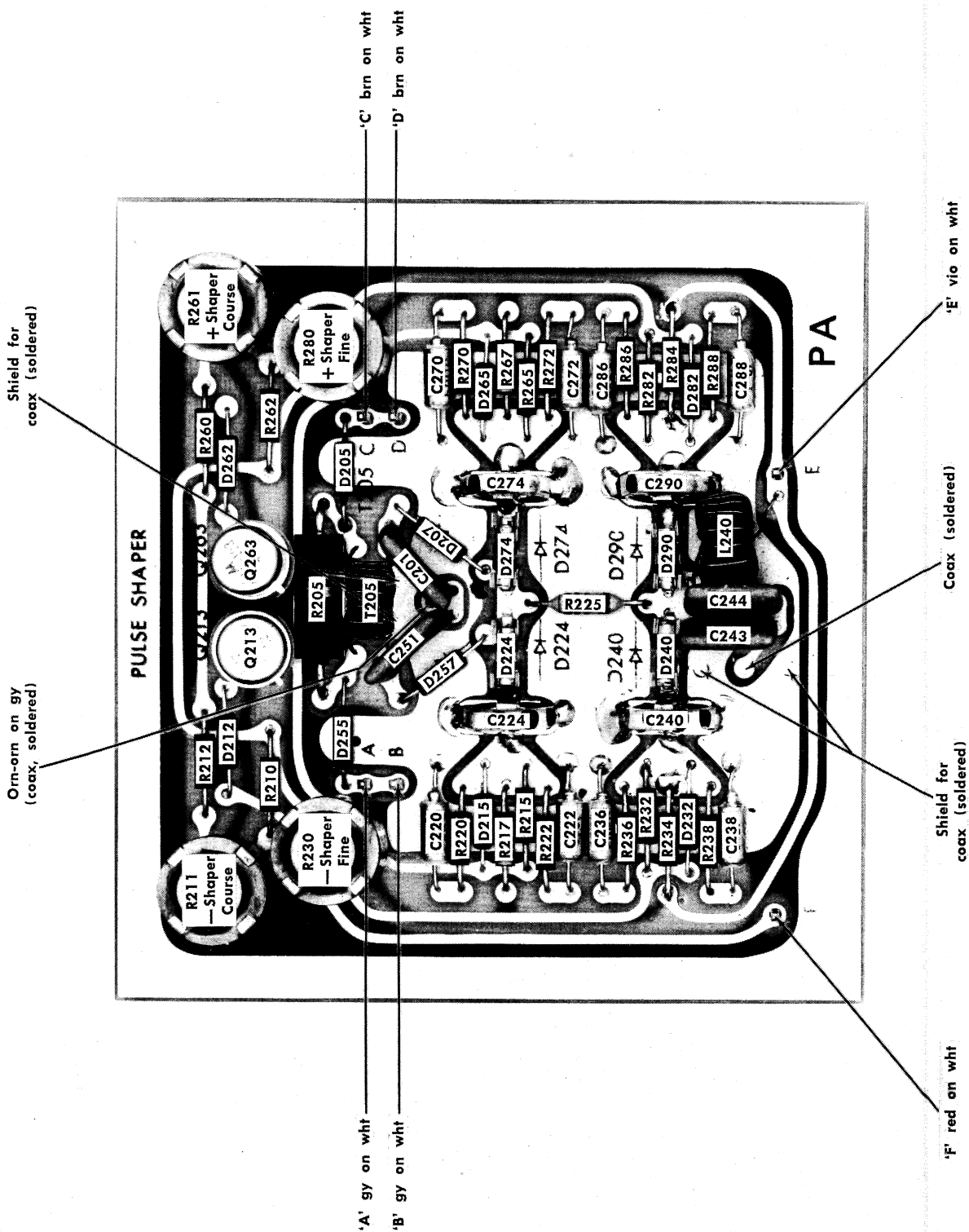


Fig. 4-5. Pulse Shaper etched-wiring board.

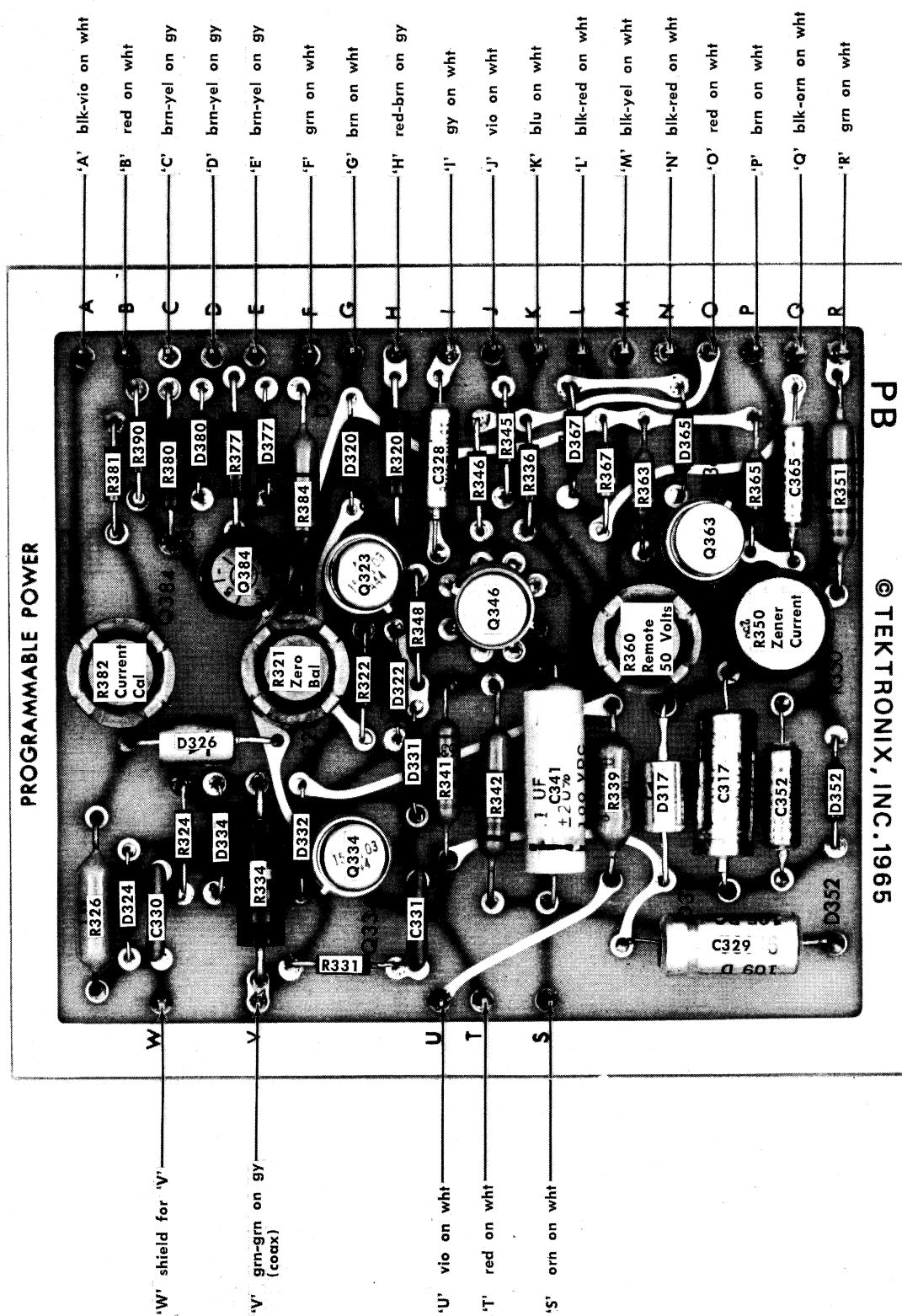
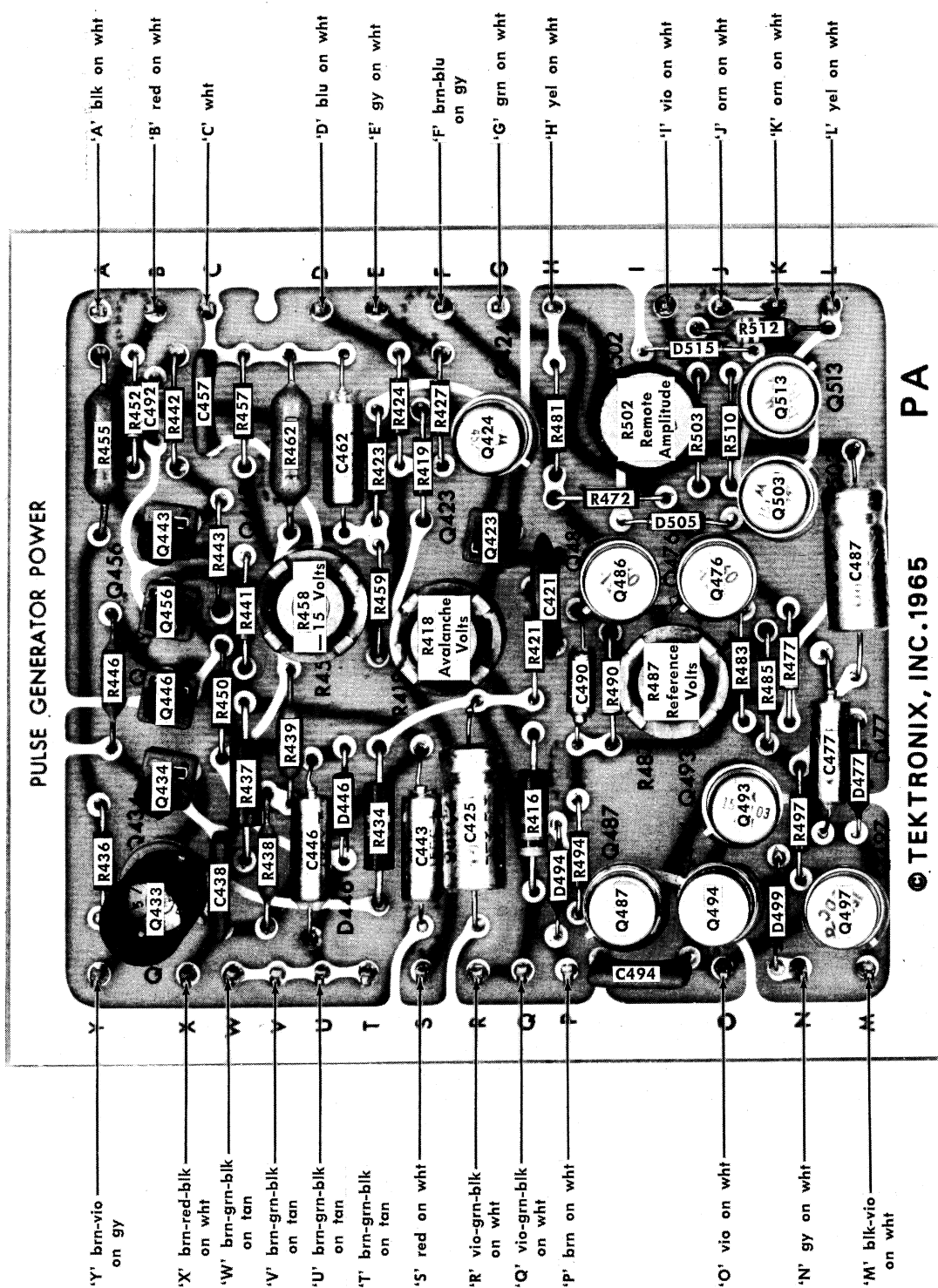


Fig. 4-6. Programmable Power Supply etched-wiring board.



**Fig. 4-7. Pulse-Generator Power Supply etched-wiring board.**

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

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

## This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.



# SECTION 5

## PERFORMANCE CHECK

### Introduction

This performance check procedure is provided to check the operation of the Type R293 without removing the top or bottom covers. This procedure may be used for incoming inspection, instrument familiarization, reliability testing, calibration verification, etc.

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

### Recommended Equipment

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

1. Variable autotransformer. Must be capable of supplying at least 100 volt-amperes over a range of 93.5 to 135 volts (187 to 270 volts for 230-volt nominal line). (If autotransformer does not have an ac voltmeter to indicate output voltage, monitor output with an ac voltmeter with range of at least 135 or 270 volts, rms.) For example, General Radio W10MT3W Metered Variac Autotransformer.

2. Test oscilloscope. Bandpass, dc to 5 MHz; minimum deflection factor, 5 millivolts/division; accuracy, within  $\pm 3\%$ ; must have 2 volt amplitude calibrator (risetime 1 microsecond or less). Tektronix Type 545B Oscilloscope with Type B Plug-In Unit recommended.

3.  $1\times$  probe with BNC connector. Tektronix P6028 Probe recommended.

4. Sampling oscilloscope system. Frequency response, equivalent to dc to 800 MHz minimum; calibrated sensitivity, 200 millivolts/division minimum; calibrated sweep rate, 0.1 microsecond to 1 nanosecond/division. Tektronix Type 661 Oscilloscope with Type 4S1 Dual-Trace Sampling Unit and Type 5T1A or Type 5T3 Timing Unit recommended.

5. Dc voltmeter and ammeter. Voltage: minimum sensitivity, 20,000 ohms/volt; accuracy, checked to within  $\pm 1\%$  at 0, +10 and +50 volts. Current: accuracy, checked to within  $\pm 1\%$  at 50 and 300 milliamps. For example, Simpson Model 262.

6. Cable (two). Impedance, 50 ohm; type, RG-58A/U; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-00.

7. Cable. Impedance, 50 ohms; type, RG-8A/U; length, 5 nanoseconds; connectors, GR874. Tektronix Part No. 017-0502-00.

8. Termination. Impedance, 50 ohms; accuracy,  $\pm 3\%$ ; connectors, BNC. Tektronix Part No. 011-0049-00.

9.  $10\times$  attenuator. Impedance, 50 ohms; accuracy,  $\pm 3\%$ ; connectors, GR. Tektronix Part No. 017-0078-00.

10. Adapter. Connectors, GR874 to BNC jack. Tektronix Part No. 017-0063-00.

11. 24-terminal connector. Mates with J22, Remote Program connector. Tektronix Part No. 131-0325-00. Following resistors required to check remote programming (1%, fixed).

Resistance	Tektronix Part No.	Power Rating
165 $\Omega$	323-0118-00	$\frac{1}{2}$ watt
499 $\Omega$	321-0164-00	$\frac{1}{8}$ watt
1 k $\Omega$	321-0193-00	$\frac{1}{8}$ watt
2 k $\Omega$	321-0222-00	$\frac{1}{8}$ watt
90.9 k $\Omega$	321-0381-00	$\frac{1}{8}$ watt
249 k $\Omega$	321-0423-00	$\frac{1}{8}$ watt

12. 4-pin connector. Mates with J340, POWER SUPPLY OUTPUT connector. Tektronix Part No. 131-0268-00. Following resistors required to provide load for Programmable Power Supply (10 watt, 5%, fixed).

Resistance	Tektronix Part No.
50 $\Omega$	308-0362-00
250 $\Omega$	308-0014-00

### PERFORMANCE CHECK PROCEDURE

#### General

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

The following procedure uses the equipment listed under Recommend Equipment. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

#### Preliminary Procedure

1. If the Type R293 is mounted in a cabinet rack, pull it out to the fully-extended position to gain access to the rear-panel Remote-Program connector.

2. Connect the autotransformer to a suitable power source.

3. Connect the Type R293 to the autotransformer output.

4. Set the autotransformer to 115 (or 230) volts.

5. Set the Type R293 controls as follows:

## Performance Check—Type R293

### Pulse Generator

TRIGGER SELECTOR	INT
RATE	Clockwise (not in REMOTE)
WIDTH	Clockwise (not in REMOTE)
AMPLITUDE PROGRAM	INT
AMPLITUDE	Midrange
POLARITY	+

### Power Supply

MODE	OFF
CURRENT MULTIPLIER	$\times 100$
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

6. Set the POWER switch to ON. Allow at least 10 minutes warm up at  $25^{\circ}\text{C}$ ,  $\pm 5^{\circ}$ , for checking the instrument to the given accuracy.

### 1. Check Internal Repetition Rate

a. REQUIREMENT—100 kHz maximum and 10 kHz minimum pretrigger output pulse repetition rate; 0.5 volts or greater amplitude.

b. Connect the PRETRIGGER OUTPUT connector to the test oscilloscope input through the BNC cable and  $50\ \Omega$  termination.

c. Set the test oscilloscope sweep rate to 2 microseconds/division and the vertical deflection to 0.1 volts/division.

d. CHECK—Test oscilloscope display for 5 to 5.5 division spacing between the leading edges of the pretrigger output pulses (see Fig. 5-1a).

e. Turn the RATE control fully counterclockwise.

f. Set the test oscilloscope sweep rate to 20 microseconds/division.

g. CHECK—Test oscilloscope display for 5-division maximum spacing between the leading edges of the pretrigger output pulses (see Fig. 5-1b).

h. CHECK—Test oscilloscope display for 5 divisions or greater pretrigger output pulse amplitude.

### 2. Check Remote Program Repetition Rate

a. REQUIREMENT—10 kHz,  $\pm 10\%$ , with  $90.9\ \text{k}\Omega$  program resistor. 100 kHz, with shorting strap.

b. Set the RATE control to the REMOTE position.

c. Insert the 24-terminal connector into the rear-panel Remote Program jack.

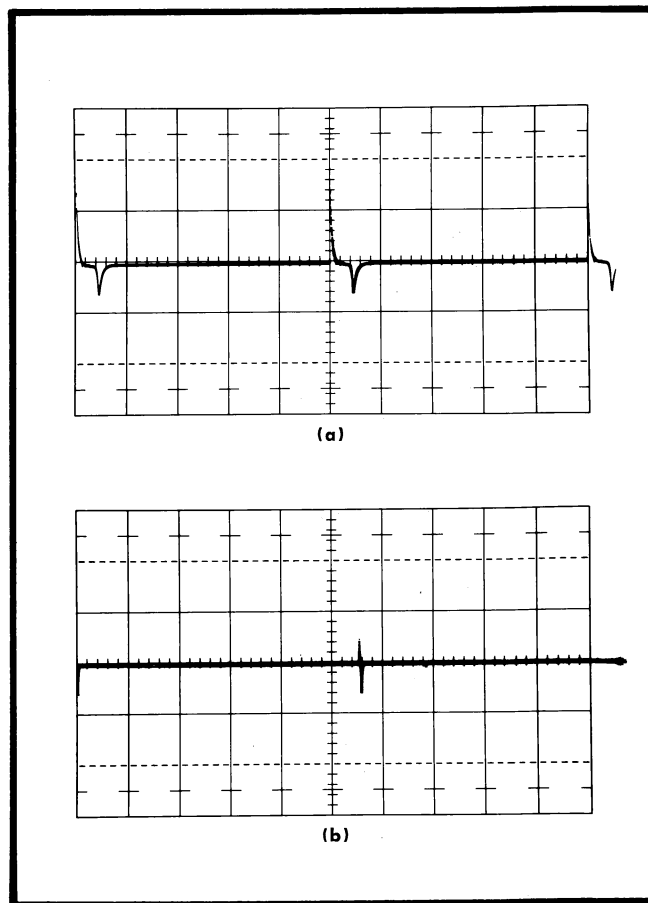


Fig. 5-1. Typical test-oscilloscope display showing correct (a) 100 kHz repetition rate, (b) 10 kHz repetition rate.

d. Connect the  $90.9\ \text{k}\Omega$  resistor between terminals 6 and 15 of the remote-program plug.

e. CHECK—Test oscilloscope display for 4.5 to 5.5-division spacing between the leading edges of the pretrigger output pulses (see Fig. 5-1b).

f. Set the test oscilloscope sweep rate to 2 microseconds/division.

g. Replace the  $90.9\ \text{k}\Omega$  resistor with a shorting strap.

h. CHECK—Test oscilloscope display for five-division spacing between the leading edges of the pretrigger output pulses (see Fig. 5-1a).

### 3. Check External Trigger Operation

a. REQUIREMENT—Pretrigger output pulse with external trigger signal 2 volts or greater in amplitude (risetime 1 microsecond or less).

b. Connect the test oscilloscope cal out connector to the TRIGGER INPUT connector through the BNC cable.

c. Set the test oscilloscope calibrator for 2-volt square-wave output.

d. Set the TRIGGER SELECTOR switch to EXT.

e. CHECK—Test oscilloscope display for pretrigger output pulse.

f. Disconnect all test equipment.

#### 4. Check Pulse Amplitude

a. REQUIREMENT—6 volts to 12 volts,  $\pm 3\%$ .

b. Change the following control settings:

TRIGGER SELECTOR	INT
RATE	Midrange
AMPLITUDE	Clockwise

c. Connect the PULSE GENERATOR OUTPUT connector to Channel A of the sampling system through the GR cable and the 10 $\times$  attenuator.

#### NOTE

To provide correct time-positioning of the pulse, it may be necessary to connect the pretrigger output pulse to channel B and trigger from this channel.

d. Set the vertical deflection to 200 millivolts/division.

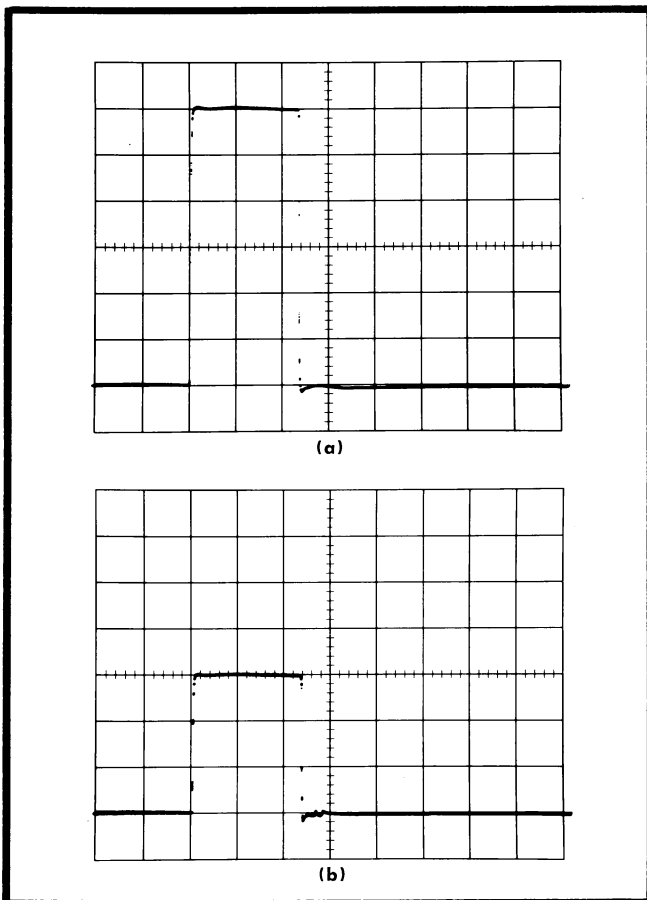


Fig. 5-2. Typical sampling-system display showing correct (a) maximum pulse amplitude, (b) minimum pulse amplitude.

e. CHECK—Sampling-system display for six-division pulse amplitude,  $\pm 0.18$  division (see Fig. 5-2a).

f. Set the AMPLITUDE control fully counterclockwise.

g. CHECK—Sampling-system display for 3-division pulse amplitude,  $\pm 0.09$  division (see Fig. 5-2b).

#### 5. Check Remote-Program Pulse Amplitude

a. REQUIREMENT—Pulse amplitude within  $\pm 3\%$  of programmed value.

b. Set the AMPLITUDE PROGRAM switch to REMOTE.

c. Insert the 24-terminal connector into the rear-panel Remote Program jack.

d. Connect the 500  $\Omega$  resistor between terminals 3 and 4 of the remote-program connector.

e. CHECK—Sampling-system display for 6-division pulse amplitude,  $\pm 0.18$  division (see Fig. 5-2a).

f. Remove the 500  $\Omega$  resistor and leave terminals 3 and 4 open.

g. CHECK—Sampling-system display for 3-division pulse amplitude,  $\pm 0.09$  division (see Fig. 5-2b).

#### 6. Check Pulse Width

a. REQUIREMENT—2 nanoseconds minimum to 250 nanoseconds maximum.

b. Change the following control settings:

AMPLITUDE PROGRAM	INT
AMPLITUDE	12 volts (six divisions)

c. Set the sampling-system sweep rate to 50 nanoseconds/division.

d. CHECK—Sampling-system display for 5-division spacing between 50% amplitude points of leading and trailing edge (see Fig. 5-3a).

e. Set the WIDTH control fully counterclockwise.

f. Set the sampling-system sweep rate to 1 nanosecond/division.

g. CHECK—Sampling-system display for 2-division spacing between 50% amplitude points of leading and trailing edge (see Fig. 5-3b).

#### 7. Check Remote-Program Pulse Width

a. REQUIREMENT—Pulse width within  $\pm (3\% \text{ of programmed value} + 3 \text{ nanoseconds})$ .

b. Set the WIDTH control to REMOTE.

c. Insert the 24-terminal connector into the rear-panel Remote Program jack.

d. Connect the 249 k $\Omega$  resistor between terminals 6 and 18 of the remote-program plug.

e. CHECK—Sampling-system display for zero to five-division spacing between 50% amplitude points of leading and trailing edge (see Fig. 5-3b).

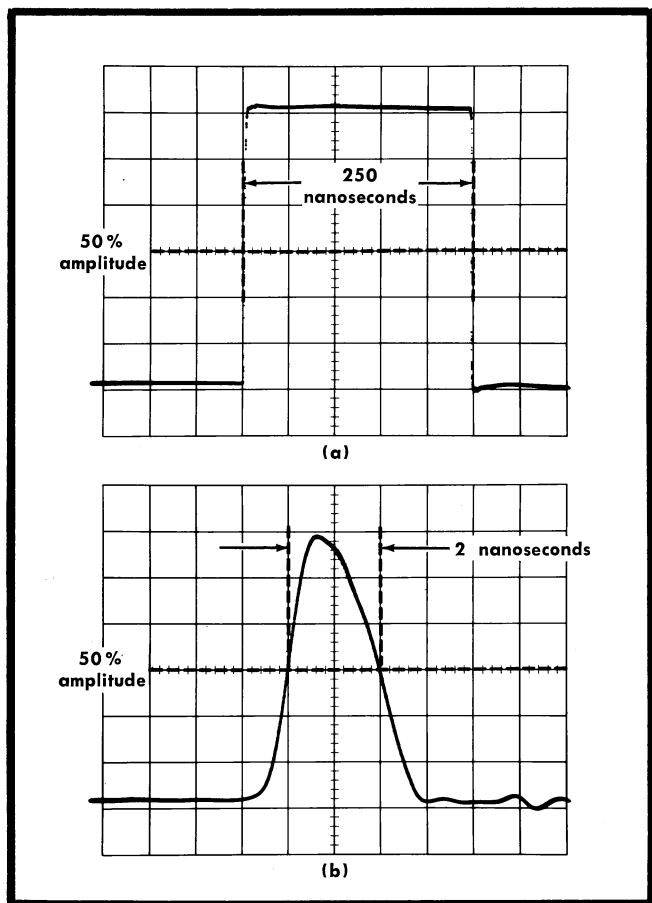


Fig. 5-3. Typical sampling-system display showing correct (a) maximum pulse width, (b) minimum pulse width.

f. Set the sampling-system sweep rate to 50 nanoseconds/division.

g. Replace the 249 k $\Omega$  resistor with a 2 k $\Omega$  resistor.

h. CHECK—Sampling-system display for 5-division,  $\pm 0.15$  division, spacing between 50% amplitude points of leading and trailing edge (see Fig. 5-3a).

## 8. Check Pulse Risettime and Falltime

a. REQUIREMENT—1 nanosecond or less.

b. Turn the WIDTH control fully clockwise (not in REMOTE detent).

c. Set the sampling-system sweep rate to 0.5 nanoseconds/division.

d. Position the display to view the leading edge of the waveform.

e. CHECK—Sampling-system display for 2-division or less spacing between 10% and 90% points of leading edge (see Fig. 5-4a).

f. Position the trailing edge of the waveform on the viewing area.

g. CHECK—Sampling-system display for 2-division or less spacing between 90% and 10% points of trailing edge (see Fig. 5-4b).

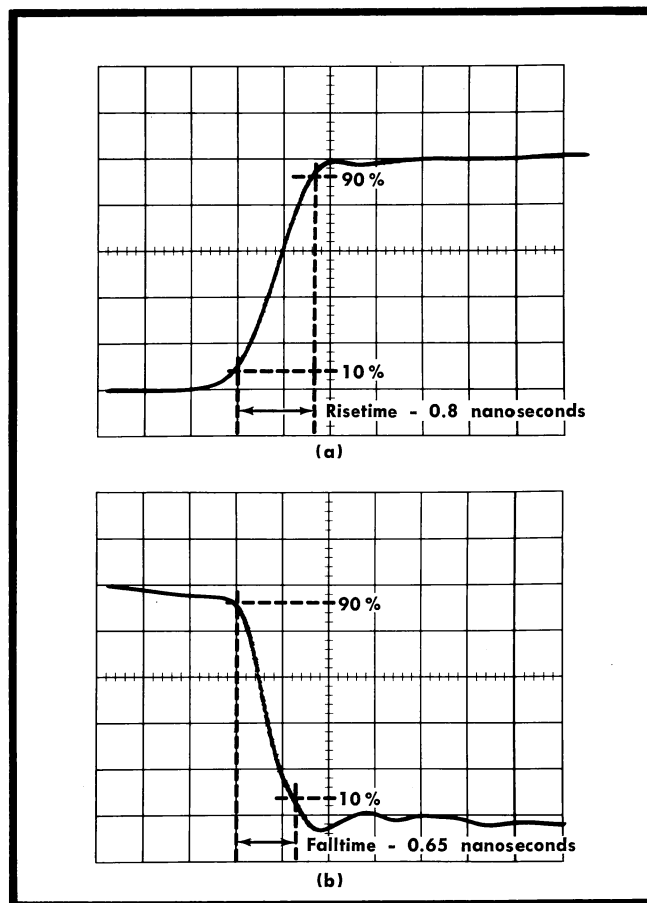


Fig. 5-4. Typical sampling-system display showing correct (a) risetime, (b) falltime.

## 9. Check Aberrations on Pulse Leading Edge

a. REQUIREMENT—Preshoot, 1% or less.

Overshoot, 3% or less.

Rounding, 5% or less.

Ringing, 3% or less.

b. Position the leading edge of the waveform on the viewing area.

c. Set the AMPLITUDE control so the pulse is exactly six divisions in height.

d. Set the sampling-system sweep rate to 1 nanosecond/division.

e. CHECK—Sampling-system display for preshoot 0.06 division or less (see Fig. 5-5).

f. CHECK—Sampling-system display for overshoot 0.24 division or less (see Fig. 5-5).

g. CHECK—Sampling-system display for corner rounding 0.3 division or less (see Fig. 5-5).

h. CHECK—Sampling-system display for ringing 0.24 division or less (see Fig. 5-5).

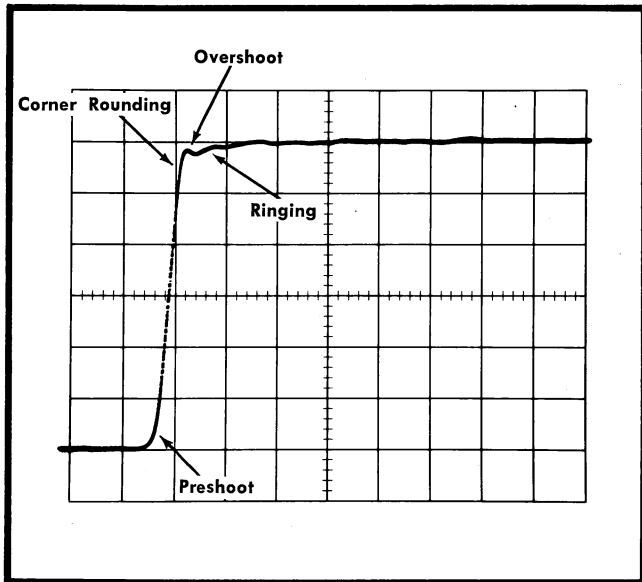


Fig. 5-5. Typical sampling-system display showing leading-edge aberrations.

## 10. Check Aberrations on Pulse Trailing Edge

- a. REQUIREMENT—Storage aberration, 5% or less.  
Rounding, 10% or less.  
Ringing, 10% or less.  
Overshoot, 5% or less.
- b. Position trailing edge of the waveform on the viewing area.
- c. CHECK—Sampling-system display for storage aberration 0.3 division or less (see Fig. 5-6).
- d. CHECK—Sampling-system display for corner rounding 0.6 division or less (see Fig. 5-6).
- e. CHECK—Sampling-system display for ringing 0.6 division or less (see Fig. 5-6).
- f. CHECK—Sampling-system display for overshoot 0.3 division or less (see Fig. 5-6).

## 11. Check Flat-Top Aberrations and Pulse Droop

- a. REQUIREMENT—Flat-top aberration, 2% or less between first 10 nanoseconds and last 15 nanoseconds of pulse; droop, 1% or less.
- b. Position the complete pulse on the viewing area and set the sweep rate to 50 nanoseconds/division.
- c. CHECK—Sampling-system display for aberrations (between the first 10 nanoseconds and last 15 nanoseconds of pulse) 0.12 division or less (see Fig. 5-7).
- d. CHECK—Sampling-system display for droop 0.06 division or less (see Fig. 5-7).
- e. Disconnect all test equipment.

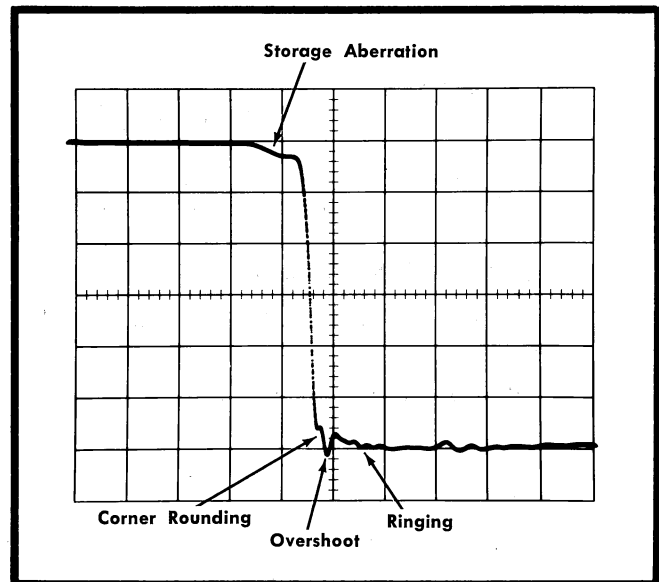


Fig. 5-6. Typical sampling-system display showing trailing-edge aberrations.

## 12. Check Regulated Voltage Supply Output

- a. REQUIREMENT—Within  $\pm$  (2% of dial reading + 25 millivolts).
- b. Set the MODE switch to NPN.
- c. Connect the dc voltmeter from terminal C of the POWER SUPPLY OUTPUT connector to chassis ground.
- d. CHECK—Voltage output within given tolerance at each REGULATED VOLTAGE SUPPLY dial setting listed in Table 5-1.

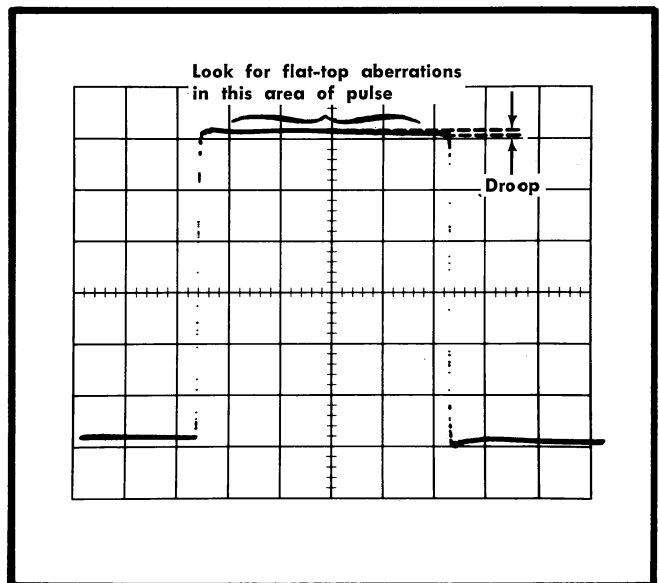


Fig. 5-7. Typical sampling-system display showing flat-top aberrations and droop.

TABLE 5-1

REGULATED VOLTAGE SUPPLY Dial Setting	Tolerance
5.00	$\pm 1.025$ volts
1.00	$\pm 0.225$ volt
0.00	$\pm 0.025$ volt

**13. Check Remote-Program Voltage Amplitude**

- REQUIREMENT—Within  $\pm$  (3% of programmed value + 25 millivolts).
- Insert the 24-terminal connector into the rear-panel Remote Program jack.
- Connect the 49.9 k $\Omega$  resistor between terminals 23 and 24 of the remote-program connector.
- Set the VOLTAGE PROGRAM switch to REMOTE.
- CHECK—Meter reading for 50 volts,  $\pm 1.525$  volts.

**14. Check Programmable Voltage Supply Regulation**

- REQUIREMENT— $\pm 1\%$  maximum change with line voltage change between 93.5 and 135 volts.
- Connect the 250  $\Omega$ , 10 W resistor between pins A and B<sup>1</sup> of the 4-pin connector.
- Insert the 4-pin connector into the front-panel POWER SUPPLY OUTPUT connector.
- Connect the dc voltmeter across the 250  $\Omega$  resistor.
- CHECK—Meter reading for  $\pm 0.5$  volt maximum change while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).
- Disconnect the voltmeter.

**15. Check Programmable Voltage Supply Ripple**

- REQUIREMENT—0.05% or less or 5 millivolts, whichever is greater.
- Connect the 1 $\times$  probe to pin A of the 4-pin connector. Connect the ground lead to chassis ground.
- Set the test oscilloscope for ac input coupling.
- CHECK—Test oscilloscope display for 25 millivolts maximum line-frequency ripple while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).
- Return the autotransformer output voltage to 115 (230) volts.
- Disconnect all test equipment.

<sup>1</sup>Terminals C and ground of POWER SUPPLY OUTPUT connector. See Fig. 2-1.

**16. Check Regulated Current Supply Output**

- REQUIREMENT—Within  $\pm$  (3% of dial reading + 50 microamps).
- Connect the dc ammeter between terminals B and E of the POWER SUPPLY OUTPUT connector.
- CHECK—Current output within given tolerance at each REGULATED CURRENT SUPPLY dial setting listed in Table 5-2.

TABLE 5-2

REGULATED CURRENT SUPPLY Dial Setting	Tolerance
3.00	$\pm 9.05$ milliamps
0.50	$\pm 2.55$ milliamps

**17. Check Current Multiplier Accuracy**

- REQUIREMENT—Within  $\pm$  (3% of dial reading + 50 microamps).
- Set the REGULATED CURRENT SUPPLY dial to 3.00.
- Set the CURRENT MULTIPLIER switch to  $\times 10$ .
- CHECK—Meter reading; 30 milliamps,  $\pm 0.95$  milliamp.
- Set the CURRENT MULTIPLIER switch to  $\times 1$ .
- CHECK—Meter reading; 3 milliamps,  $\pm 0.14$  milliamp.

**18. Check Remote-Program Current Amplitude**

- REQUIREMENT—Within  $\pm$  (3% of dial reading + 50 microamps).
- Insert the 24-terminal connector into the rear-panel Remote Program jack.
- Connect the 165  $\Omega$  resistor between terminals 9 and 21 of the remote-program plug.
- Set the CURRENT MULTIPLIER switch to REMOTE PROGRAM.
- CHECK—Meter reading for 30 milliamps,  $\pm 0.95$  milliamps.

**19. Check Programmable Current Supply Regulation**

- REQUIREMENT— $\pm 1\%$  maximum change with line voltage change between 93.5 and 135 volts.
- Connect the 50  $\Omega$ , 10 W resistor and the dc ammeter in series between pins C and D of the 4-pin connector.
- Insert the 4-pin connector into the front-panel POWER SUPPLY OUTPUT connector.
- Set the CURRENT MULTIPLIER switch to  $\times 100$ .
- CHECK—Meter reading for  $\pm 3$  milliamps maximum change while varying the autotransformer output voltage

between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).

- f. Disconnect the dc ammeter.

## **20. Check Programmable Current Supply Ripple**

- a. REQUIREMENT—0.5% or less, or 50 microamps, whichever is greater.
- b. Connect the 1× probe to pin D of the 4-pin connector. Connect the ground lead to pin C.
- c. Set the test oscilloscope for ac input coupling.
- d. CHECK—Test oscilloscope display for 25 millivolts maximum line-frequency ripple while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).
- e. Return the autotransformer output voltage to 115 (230) volts.
- f. Disconnect all test equipment.

## **21. Check Mode Switch Operation**

- a. REQUIREMENT—Correct polarity at terminals B and C of POWER SUPPLY OUTPUT connector.

- b. Connect the dc voltmeter from terminal C of the POWER SUPPLY OUTPUT connector to chassis ground.

- c. CHECK—Voltage output positive with respect to chassis ground.

- d. Set the MODE switch to OFF.

- e. CHECK—Zero volts output.

- f. Set the MODE switch to PNP.

- g. CHECK—Voltage output negative with respect to chassis ground.

- h. Connect the dc voltmeter between terminals B and E of the POWER SUPPLY OUTPUT connector.

- i. CHECK—Negative meter reading.

- j. Set the MODE switch to OFF.

- k. CHECK—Zero meter reading.

- l. Set the MODE switch to NPN.

- m. CHECK—Positive meter reading.

This completes the performance check procedure for the Type R293. Disconnect all test equipment. If the instrument has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

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# SECTION 6

## CALIBRATION

### Introduction

Complete calibration information for the Type R293 is given in this section. This procedure checks the instrument against the performance requirements listed in the Characteristics section. The Type R293 can be returned to original performance standards by completion of each step in this procedure. If it is desired to merely touch up the calibration, perform only those steps entitled "Adjust . . .". An abridged calibration procedure is also provided in this section for the convenience of the experienced calibrator. It may also be used as a calibration record or as an index to the steps in the complete Calibration Procedure.

The Type R293 should be checked, and recalibrated if necessary, after each 500 hours of operation, or every six months if used infrequently, to assure correct operation and accuracy. The Performance Check section of this manual provides a complete check of the instrument performance without making adjustments. This procedure can be used to verify the calibration of the Type R293 and determine if recalibration is required.

### EQUIPMENT REQUIRED

#### General

The following equipment, or its equivalent, is required for complete calibration of the Type R293 (see Fig. 6-1). Specifications given are the minimum necessary for accurate calibration of this instrument. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

1. Variable autotransformer. Must be capable of supplying at least 100 volt-amperes over a range of 93.5 to 135 volts (187 to 270 volts for 230-volt nominal line). (If autotransformer does not have an ac voltmeter to indicate output voltage, monitor output with an ac voltmeter with range of at least 135 or 270 volts, rms.) For example, General Radio W10MT3W Metered Variac Autotransformer.

2. Dc voltmeter and ammeter. Voltage: minimum sensitivity, 20,000 ohms/volt; accuracy, checked to within  $\pm 1\%$  at  $-15$ ,  $0$ ,  $+6$ ,  $+10$  and  $+50$  volts; range,  $0$ - $100$  volts. Current: accuracy, checked to within  $\pm 1\%$  at  $50$  and  $300$  milliamperes; range,  $0$ - $300$  milliamperes. For example, Simpson Model 262.

3. Test oscilloscope. Bandpass, dc to  $5$  MHz; minimum deflection factor,  $5$  millivolts/division; accuracy, within  $\pm 3\%$ ; must have  $2$  volt amplitude calibrator (risetime  $1$  microsecond or less). Tektronix Type 545B Oscilloscope with Type B Plug-In Unit recommended.

4.  $1\times$  probe with BNC connector. Tektronix P6028 Probe recommended.

5. Sampling oscilloscope system. Frequency response, equivalent to dc to  $800$  MHz minimum; calibrated sensitivity,  $200$  millivolts/division minimum; calibrated sweep

range,  $0.1$  microsecond to  $1$  nanosecond/division; must have dual-trace vertical system. Tektronix Type 661 Oscilloscope with Type 4S1 Dual-Trace Sampling Unit and Type 5T1A or Type 5T3 Timing Unit.

6. Termination. Impedance,  $50$  ohms; accuracy,  $\pm 3\%$ ; connectors, BNC. Tektronix Part No. 011-0049-00.

7.  $10\times$  attenuator. Impedance,  $50$  ohms; accuracy,  $\pm 3\%$ ; connectors, GR. Tektronix Part No. 017-0078-00.

8. Cable. Impedance,  $50$  ohms; type, RG-8A/U; length,  $5$  nanoseconds; connectors, GR874. Tektronix Part No. 017-0502-00.

9. Cable (two). Impedance,  $50$  ohms; type RG-58A/U; length,  $42$  inches, connectors, BNC. Tektronix Part No. 012-0057-00.

10. Adapter. Connectors, GR874 to BNC jack. Tektronix Part No. 017-0063-00.

11. 24-terminal connector. Mates with J22, Remote Program connector. Tektronix Part No. 131-0325-00. Following resistors required to check remote programming ( $1\%$ , fixed).

Resistance	Tektronix Part No.	Power Rating
$165\ \Omega$	323-0118-00	$\frac{1}{2}$ watt
$499\ \Omega$	321-0164-00	$\frac{1}{8}$ watt
$1\text{ k}\Omega$	321-0193-00	$\frac{1}{8}$ watt
$2\text{ k}\Omega$	321-0222-00	$\frac{1}{8}$ watt
$90.9\text{ k}\Omega$	321-0381-00	$\frac{1}{8}$ watt
$249\text{ k}\Omega$	321-0423-00	$\frac{1}{8}$ watt

12. 4-pin connector. Mates with J340, POWER SUPPLY OUTPUT connector. Tektronix Part No. 131-0268-00. Following resistors required to provide load for Programmable Power Supply ( $10$  watt,  $5\%$ , fixed).

Resistance	Tektronix Part No.
$50\ \Omega$	308-0362-00
$250\ \Omega$	308-0014-00

13. Adjustment tools (see Fig. 6-2).

Description	Tektronix Part No.
a. Insulated screwdriver, $1\frac{1}{2}$ inch shaft, non-metallic	003-0000-00
b. Screwdriver, $3$ inch shaft	003-0192-00

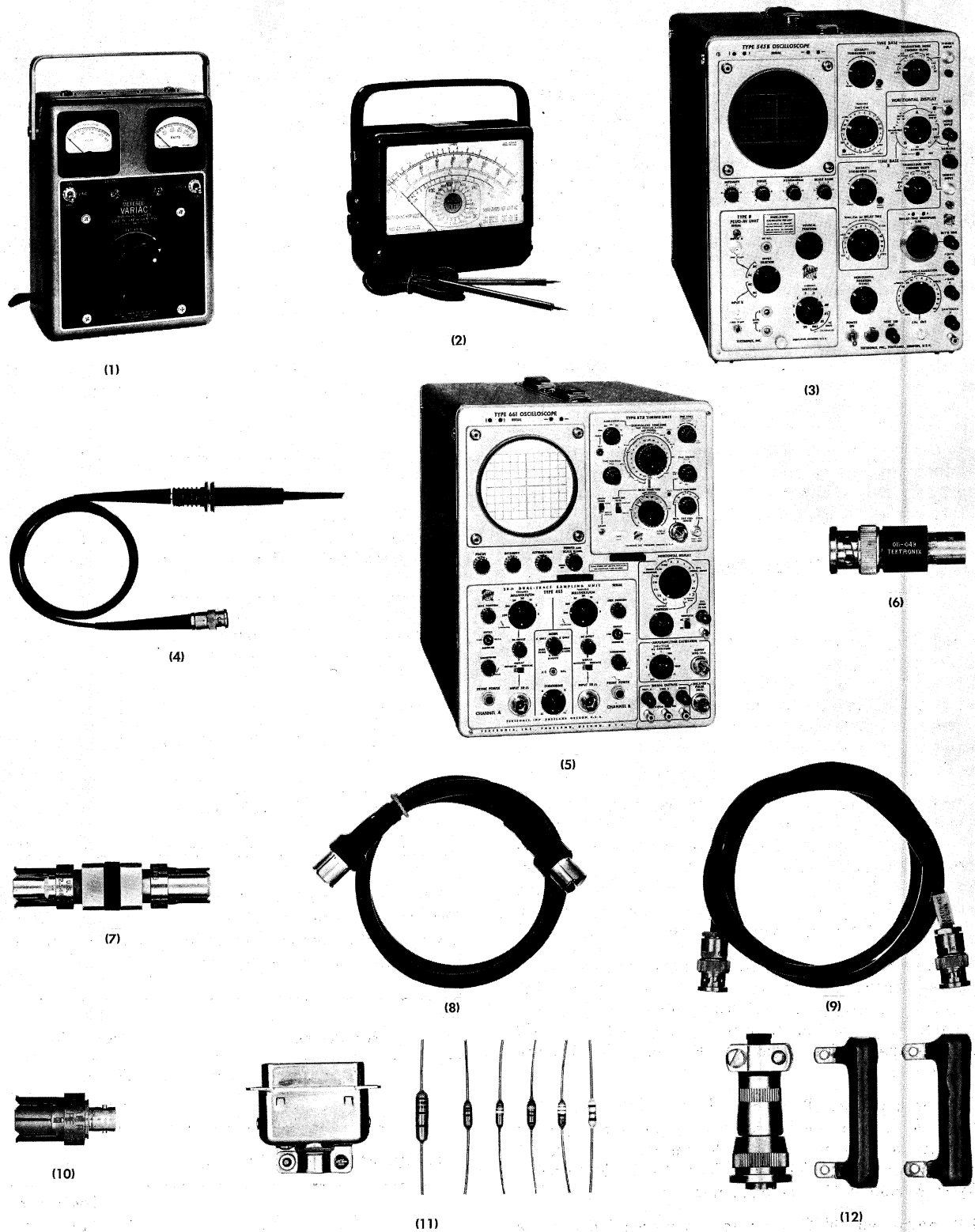


Fig. 6-1. Recommended calibration equipment. Items 1 through 12.

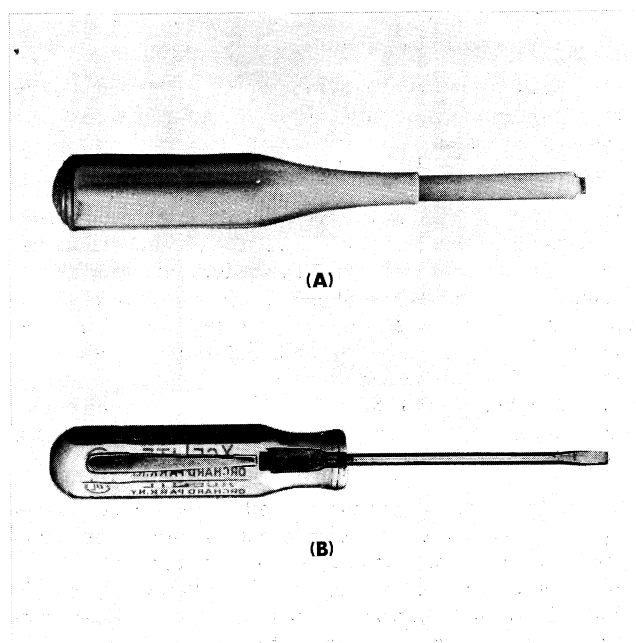


Fig. 6-2. Adjustment tools.

## CALIBRATION RECORD AND INDEX

This abridged calibration procedure is provided to aid in checking the operation of the Type R293. It may be used as a calibration guide by the experienced calibrator, or it may be used as a record of calibration. Since the step numbers and titles used here correspond to those used in the complete Calibration Procedure, this procedure also serves as an index to locate a step in the complete Calibration Procedure. Performance requirements correspond to those given in the Characteristics section.

Type R293, Serial No. \_\_\_\_\_

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

- ☐ 1. Adjust —15-Volt Power Supply (Page 6-5).  
—15 volts,  $\pm 0.3$  volt.
- ☐ 2. Check +6-volt Power Supply (Page 6-6).  
+6 volts,  $\pm 0.12$  volt.
- ☐ 3. Check Main Power-Supply Regulation (Page 6-6).  
—15-Volt supply      Within  $\pm 0.15$  volt  
+6-Volt supply      Within  $\pm 0.06$  volt
- ☐ 4. Check Main Power-Supply Ripple (Page 6-7).  
2 millivolts maximum.
- ☐ 5. Adjust Internal Repetition Rate (Page 6-8).  
Adjust for 100 kHz rate. Check for 10 kHz minimum rate. Pretrigger pulse amplitude, 0.5 volt or greater.
- ☐ 6. Check Remote-Program Repetition Rate (Page 6-8).  
Correct minimum and maximum rate with specified remote-program resistors.
- ☐ 7. Check External Trigger Operation (Page 6-9).  
Pretrigger output pulse with external trigger signal.
- ☐ 8. Adjust Avalanche Voltage (Page 6-10).  
Correct operation of avalanche circuits.
- ☐ 9. Adjust Reference Voltage (Page 6-10).  
Half the avalanche voltage plus 5 volts.
- ☐ 10. Adjust Positive Pulse Shape (Page 6-10).  
Correct pulse shape.
- ☐ 11. Adjust Pulse Amplitude (Page 6-11).  
12-volt maximum amplitude.  
6-volt minimum amplitude.
- ☐ 12. Adjust Remote-Program Pulse Amplitude (Page 6-11).  
12-volt maximum and 6-volt minimum amplitude with specified remote-program resistors.
- ☐ 13. Adjust Negative Pulse Shape (Page 6-13).  
Correct pulse shape.
- ☐ 14. Adjust Pulse Width (Page 6-15).  
250 nanosecond maximum pulse width.  
2 nanosecond minimum pulse width.  
Correct minimum and maximum pulse width with specified remote-program resistors.
- ☐ 15. Check Pulse Risetime and Faltime (Page 6-16).  
Risetime and falltime 1 nanosecond or less.
- ☐ 16. Check Aberrations on Pulse Leading Edge (Page 6-16).  

Preshoot	1% maximum
Overshoot	3% maximum
Rounding	5% maximum
Ringing	3% maximum
- ☐ 17. Check Aberrations on Pulse Trailing Edge (Page 6-17).  

Storage aberration	5% maximum
Rounding	10% maximum
Ringing	10% maximum
Overshoot	5% maximum
- ☐ 18. Check Flat-Top Aberrations and Pulse Droop (Page 6-17).  

Flat-top aberrations	2% maximum
Droop	1% maximum
- ☐ 19. Adjust Zener Current (Page 6-18).  
8.4 volts,  $\pm 0.2$  volt across R351.
- ☐ 20. Adjust Programmable Voltage Supply Maximum Output Voltage (Page 6-18).  
+50 volts,  $\pm 1$  volt.
- ☐ 21. Adjust Zero Balance (Page 6-18).  
Zero volts.
- ☐ 22. Adjust Remote-Program Maximum Output Voltage (Page 6-18).  
+50 volts with specified program resistor.
- ☐ 23. Check Programmable Voltage Supply Regulation (Page 6-19).  
 $\pm 1\%$  maximum change.

## Calibration—Type R293

- ☐ 24. Check Programmable Voltage Supply Ripple (Page 6-19).  
0.05% or less or 5 millivolts, whichever is greater.
- ☐ 25. Check Regulated Voltage Supply Dial Accuracy (Page 6-19).  
Within  $\pm$  (2% of dial reading +25 millivolts).
- ☐ 26. Adjust Programmable Current Supply (Page 6-19).  
300 milliamps,  $\pm$ 9 milliamps.
- ☐ 27. Check Remote-Program Current Amplitude (Page 6-19).  
Correct current amplitude with specified resistor.
- ☐ 28. Check Programmable Current Supply Regulation (Page 6-20).  
 $\pm$ 1% maximum change.
- ☐ 29. Check Programmable Current Supply Ripple (Page 6-20).  
0.5% or less, or 50 microamps, whichever is greater.
- ☐ 30. Check Regulated Current Supply Dial Accuracy (Page 6-20).  
Within  $\pm$  (3% of dial reading +50 microamps).
- ☐ 31. Check Current Multiplier Accuracy (Page 6-20).  
Within  $\pm$ 3%.
- ☐ 32. Check Mode Switch Operation (Page 6-20).  
Correct polarity at terminal B and C of POWER SUPPLY OUTPUT connector.

## CALIBRATION PROCEDURE

### General

The following procedure is arranged in a sequence which allows the Type R293 to be calibrated with the least interaction of adjustments and reconnection of equipment. If desired, the steps may be performed individually or out of sequence. However, some adjustments affect the calibration of other circuits within the instrument. In this case, it will be necessary to check the operation of other parts

of the instrument. When a step interacts with others, the steps which need to be checked will be noted.

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

The Adjust . . . **①** steps in the following procedure provide a check of instrument performance, whenever possible, before the adjustment is made. To prevent recalibration of other circuits when performing a partial calibration, re-adjust only if the listed tolerance is not met. However, when performing a complete calibration, best overall performance will be provided if each adjustment is made to the exact setting, even if the CHECK- . . . is within the allowable tolerance. The symbol **①** is used to identify the steps in which an adjustment is made.

In the following calibration procedure, a test equipment setup is shown for each major group of adjustments and checks. Beneath each setup picture is a complete list of front-panel control settings for the Type R293. To aid in locating individual controls which have been changed during complete calibration, these control names are printed in bold type. If only a partial calibration is performed, start with the nearest setup preceding the desired portion.

The following procedure uses the equipment listed under equipment required. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

### Preliminary Procedure

1. If the Type R293 is mounted in a cabinet rack, pull it out to the fully extended position.
2. Remove the top and bottom covers from the Type R293.
3. Connect the autotransformer to a suitable power source.
4. Connect the Type R293 to the autotransformer output.
5. Set the autotransformer to 115 (or 230) volts.
6. Set the Type R293 POWER switch to ON. Allow at least 10 minutes warm up at 25°C,  $\pm$ 5°, for checking the instrument to the given accuracy.

## NOTES

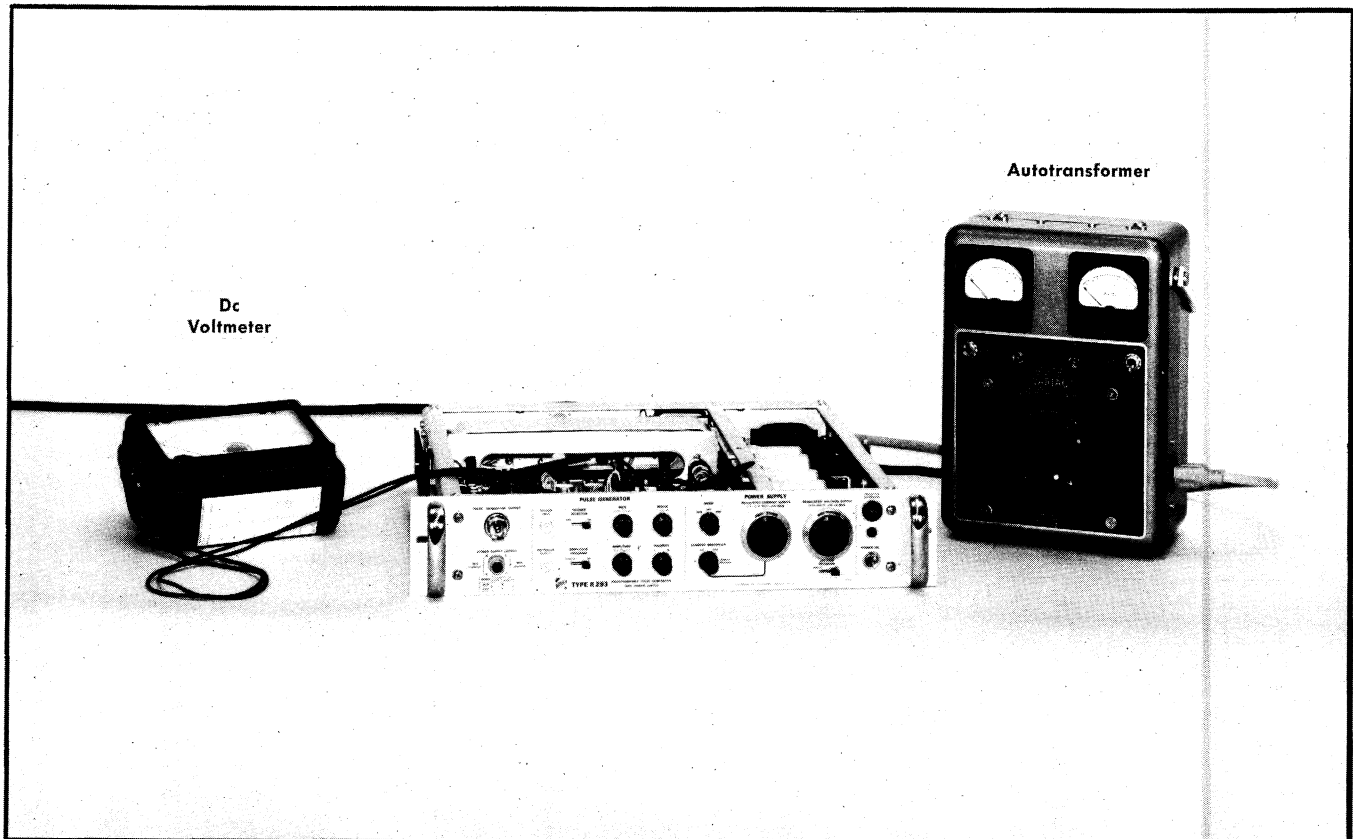


Fig. 6-3. Initial test equipment setup for steps 1 through 3.

### Front-panel control settings

#### Pulse Generator

TRIGGER SELECTOR	INT
RATE	Clockwise
WIDTH	Midrange
AMPLITUDE PROGRAM	INT
AMPLITUDE	Midrange
POLARITY	+

#### Power Supply

MODE	OFF
CURRENT MULTIPLIER	$\times 100$
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

e. Interaction—May affect operation of all circuits within the Type R293.

### 1. Adjust —15-Volt Power Supply

- Test equipment setup is shown in Fig. 6-3.
- Connect the dc voltmeter from the —15-volt test point (pin connector T, Pulse-Generator Power board; see Fig. 6-4) to chassis ground.
- Check—Meter reading; —15 volts,  $\pm 0.3$  volt.
- Adjust— —15 Volts adjustment, R458 (see Fig. 6-4), for —15 volts.

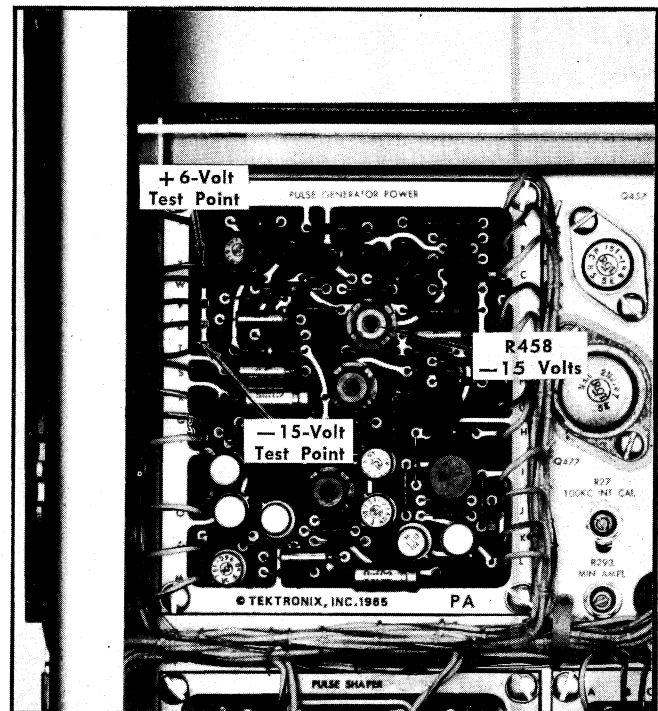


Fig. 6-4. Location of Pulse-Generator Power Supply test points and adjustments (Pulse-Generator Power board).

## 2. Check +6-Volt Power Supply

- Test equipment setup is shown in Fig. 6-3.
- Connect the dc voltmeter from the +6-volt test point (pin connector X, Pulse-Generator Power board; see Fig. 6-4) to chassis ground.
- Check—Meter reading +6 volts,  $\pm 0.12$  volt.

## 3. Check Main Power-Supply Regulation

- Test equipment setup is shown in Fig. 6-3.
- Connect the dc voltmeter from the -15-volt test

point (pin connector T, Pulse-Generator Power board, see Fig. 6-4) to chassis ground.

- Check—Meter reading for  $\pm 0.15$  volt maximum change while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).

- Connect the dc voltmeter to the +6-volt test point (pin connector X, Pulse-Generator Power board; see Fig. 6-4) to chassis ground.

- Check—Meter reading for  $\pm 0.06$  volt maximum change while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270).

- Disconnect the dc voltmeter.

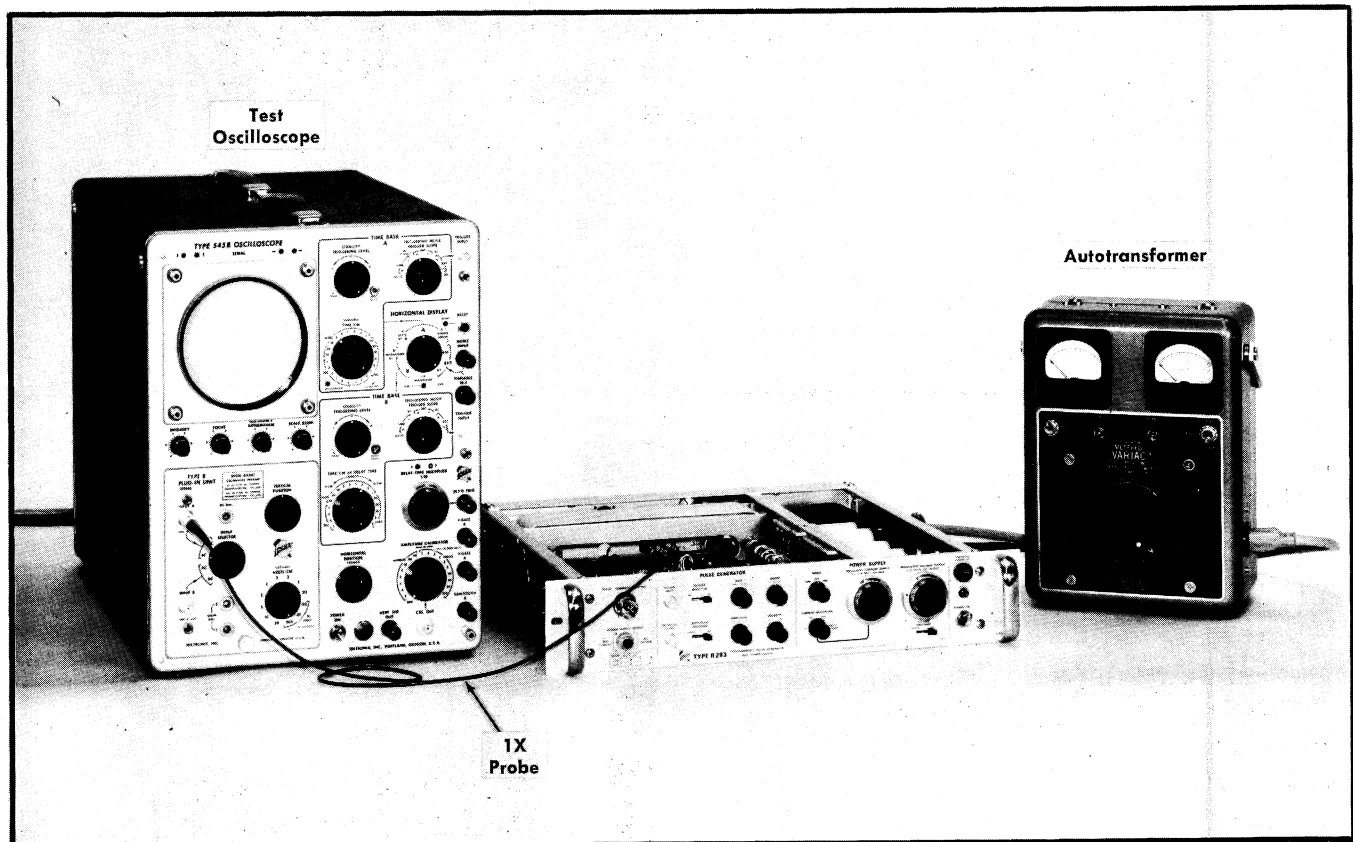


Fig. 6-5. Test equipment setup for step 4.

### Front-panel control settings

#### Pulse Generator

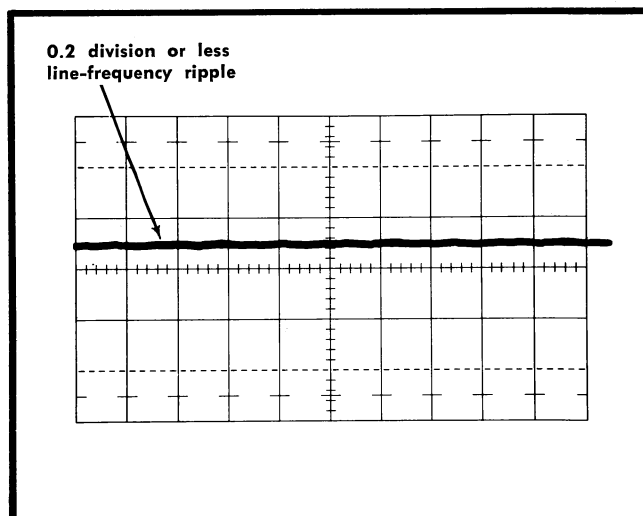
TRIGGER SELECTOR	INT
<b>RATE</b>	<b>REMOTE</b>
WIDTH	Midrange
AMPLITUDE PROGRAM	INT
AMPLITUDE	Midrange
POLARITY	+

### Power Supply

MODE	OFF
CURRENT MULTIPLIER	$\times 100$
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

#### 4. Check Main Power-Supply Ripple

- a. Test equipment setup is shown in Fig. 6-5.
- b. Connect the  $1\times$  probe to the test oscilloscope input connector.
- c. Set the test oscilloscope for a vertical deflection of 0.005 volts/division, ac coupled, at a sweep rate of 5 milliseconds/division.
- d. Connect the  $1\times$  probe tip to the  $-15$ -volt test point (pin connector T, Pulse-Generator Power board; see Fig. 6-4). Connect the probe ground lead to chassis ground.
- e. Check—Test oscilloscope display for 2 millivolts (0.2 division) maximum line-frequency ripple while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal). Fig. 6-6 shows a typical test oscilloscope display of power-supply ripple.
- f. Connect the  $1\times$  probe tip to the  $+6$ -volt test point (pin connector X, Pulse-Generator Power board; see Fig. 6-4). Connect the probe ground lead to chassis ground.
- g. Check—Test oscilloscope display for 2 millivolts (0.2 division) maximum line-frequency ripple while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).



**Fig. 6-6. Typical test-oscilloscope display of power-supply ripple (60-cycle line). Vertical deflection 5 millivolts/division; sweep rate, 5 milliseconds/division.**

- h. Return autotransformer output voltage to 115 (230) volts. Leave the Type R293 connected to the autotransformer for the remainder of this procedure.
- i. Disconnect all test equipment.

## NOTES

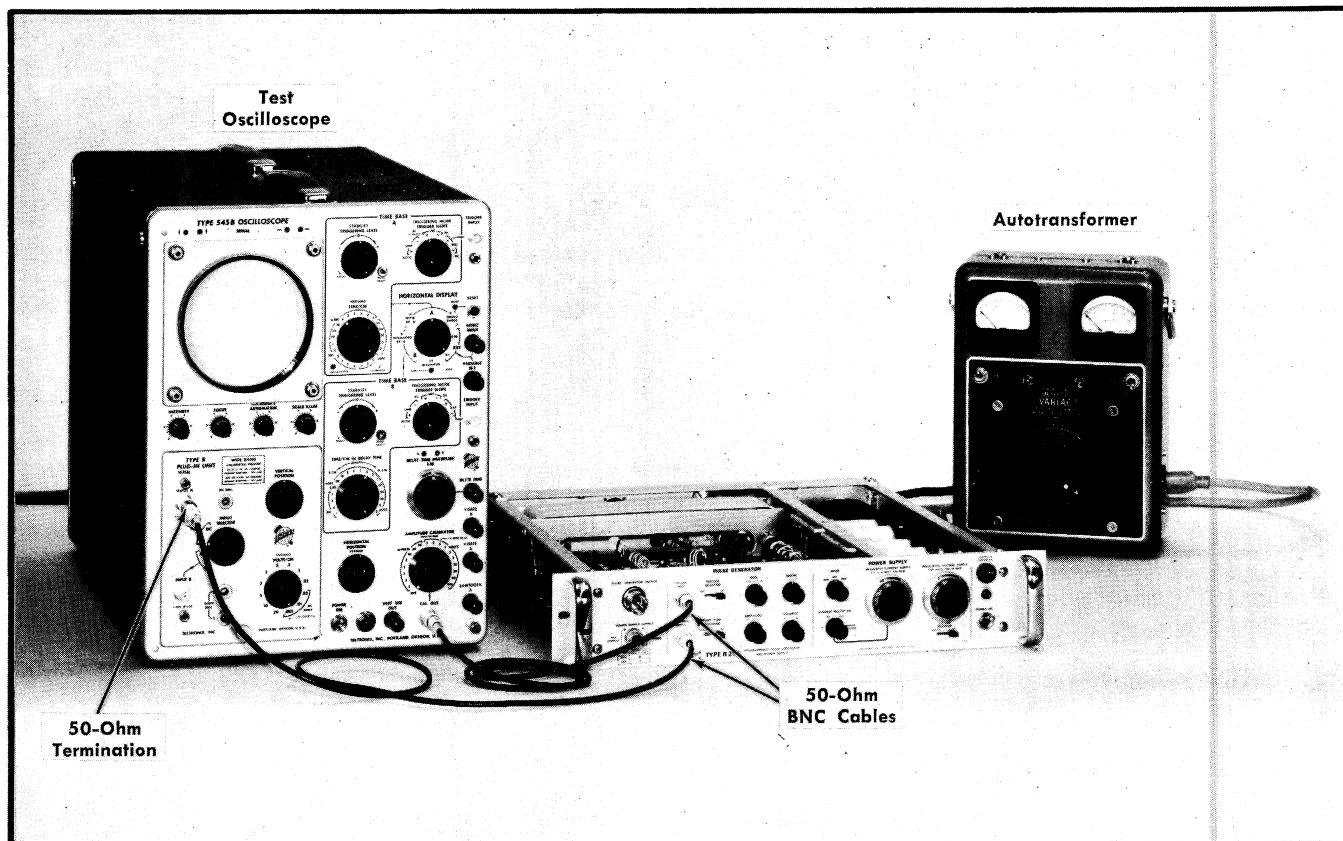


Fig. 6-7. Initial test equipment setup for steps 5 through 7.

## Front-panel control settings

### Pulse Generator

TRIGGER SELECTOR	INT
<b>RATE</b>	<b>Clockwise</b>
WIDTH	Midrange
AMPLITUDE PROGRAM	INT
AMPLITUDE	Midrange
POLARITY	+

### Power Supply

MODE	OFF
CURRENT MULTIPLIER	$\times 100$
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

## 5. Adjust Internal Repetition Rate



- Test equipment setup is shown in Fig. 6-7.
- Connect the PRETRIGGER OUTPUT connector to the test oscilloscope input through the BNC cable and 50-ohm termination.

c. Set the test oscilloscope sweep rate to 2 microseconds/division and the vertical deflection to 0.5 volts/division.

d. Be sure the RATE control is fully clockwise but not in the REMOTE detent.

e. Check—Test oscilloscope display for a 100 kHz,  $-10\%$   $+0\%$  repetition rate as shown by a 5 to 5.5-division spacing between the leading edges of the pretrigger output pulses (see Fig. 6-8a).

f. Adjust—100 kHz Int Cal adjustment, R27 (see Fig. 6-8b), for exactly five-division spacing between the leading edges of the pretrigger output pulses.

g. Turn the RATE control fully counterclockwise.

h. Set the test oscilloscope sweep rate to 20 microseconds/division.

i. Check—Test oscilloscope display for 10 kHz repetition rate as shown by a five-division minimum spacing between the leading edges of the pretrigger output pulses (see Fig. 6-8c).

j. Check—Test oscilloscope display for 5 divisions or greater pretrigger output pulse amplitude.

## 6. Check Remote Program Repetition Rate

- Test setup is given in step 5.



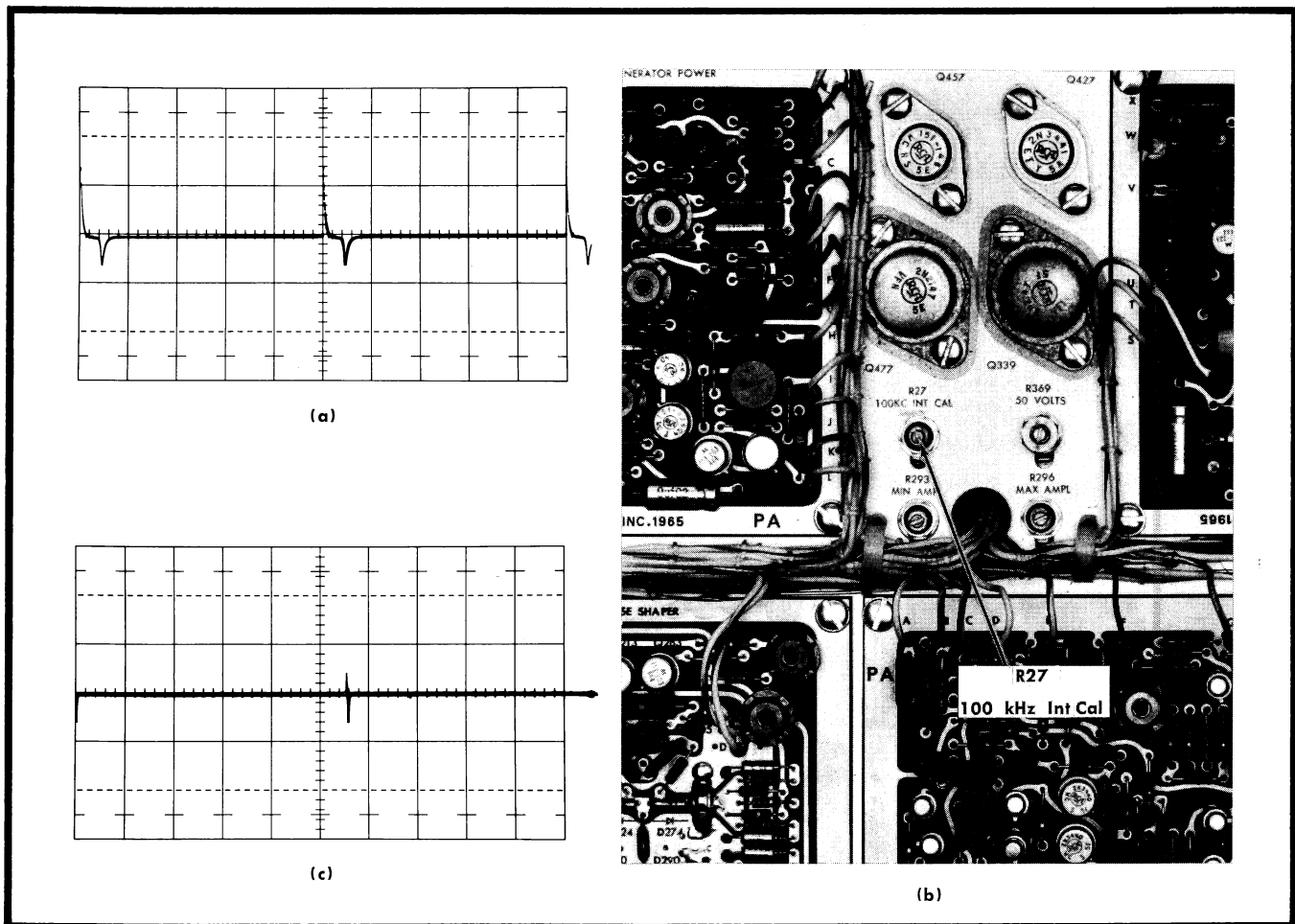


Fig. 6-8. (a) Typical test-oscilloscope display showing correct 100 kHz repetition rate (sweep rate, 2 microseconds/division), (b) Location of 100 kHz Int Cal adjustment (top side), (c) Typical test-oscilloscope display showing correct 10 kHz repetition rate (sweep rate, 20 microseconds/division).

- b. Set the RATE control to the REMOTE position.
- c. Insert the 24-terminal connector in the rear-panel Remote Program jack.
- d. Connect the 90.9 k $\Omega$  resistor between terminals 6 and 15 of the remote-program plug.
- e. Check—Test oscilloscope display for 10 kHz  $\pm 10\%$  minimum repetition rate as shown by a 4.5 to 5.5 division spacing between the leading edges of the pretrigger output pulses (see Fig. 6-8c).
- f. Set the test oscilloscope sweep rate to 2 microseconds/division.
- g. Remove the 90.9 k $\Omega$  resistor and connect a shorting strap between terminals 6 and 15.

- h. Check—Test oscilloscope display for 100 kHz repetition rate as shown by a five-division spacing between the leading edges of the pretrigger output pulses (see Fig. 6-8a).

## 7. Check External Trigger Operation

- a. Test equipment setup is shown in Fig. 6-7.
- b. Connect the test oscilloscope cal out connector to the TRIGGER INPUT connector through the BNC cable.
- c. Set the test oscilloscope Calibrator for 2-volt square-wave output.
- d. Set the TRIGGER SELECTOR switch to EXT.
- e. Check—Test oscilloscope display for pretrigger output pulses.
- f. Disconnect all test equipment.

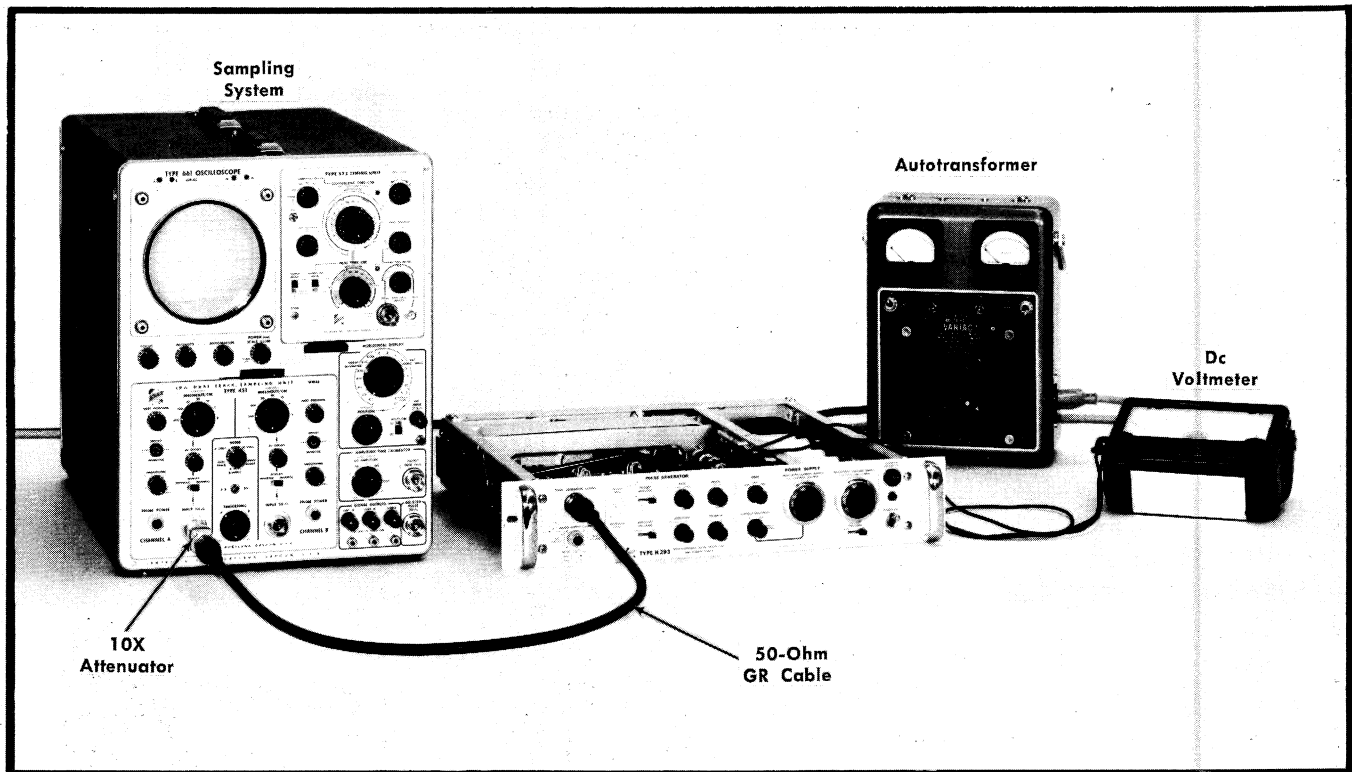


Fig. 6-9. Initial test equipment setup for steps 8 through 13.

## Front-panel control settings

### Pulse Generator

TRIGGER SELECTOR	INT
RATE	Midrange
WIDTH	Midrange
AMPLITUDE PROGRAM	INT
AMPLITUDE	Clockwise
POLARITY	+

### Power Supply

MODE	OFF
CURRENT MULTIPLIER	×100
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

## 8. Adjust Avalanche Voltage

①

- Test equipment setup is shown in Fig. 6-9.
- Connect the PULSE GENERATOR OUTPUT connector to channel A of the sampling system through the GR cable and the 10× attenuator.
- Connect the dc voltmeter from the avalanche voltage test point (pin connector R, Pulse-Generator Power board; see Fig. 6-10a) to chassis ground.
- Set the sampling system controls for a stable display

of the channel A signal at 200 millivolts/division.

### NOTE

To provide correct time-positioning of the pulse, it may be necessary to connect the pretrigger output pulse to channel B and trigger from this channel.

e. Adjust—Avalanche Volts adjustment, R418 (see Fig. 6-10a), until the pulse begins to break up (free run); see Fig. 6-10b. Note the meter reading at this point and then turn R418 counterclockwise to reduce the voltage level five volts. This will provide the correct setting for R418. Note this final meter reading for step 9.

f. Interaction—Check steps 9-12.

## 9. Adjust Reference Voltage

- Test setup is given in step 8.
- Connect the dc voltmeter between the reference voltage test points (pin connectors N and P, Pulse-Generator Power board; see Fig. 6-10a).
- Check—Meter reading exactly half the final setting of the avalanche voltage plus 5 volts.
- Adjust—Reference Volts adjustment, R487 (see Fig. 6-10a), for half the final setting of the avalanche voltage in step 8e plus 5 volts.
- Interaction—Check steps 10-12.

## 10. Adjust Positive Pulse Shape

①

- Test setup is given in step 8.

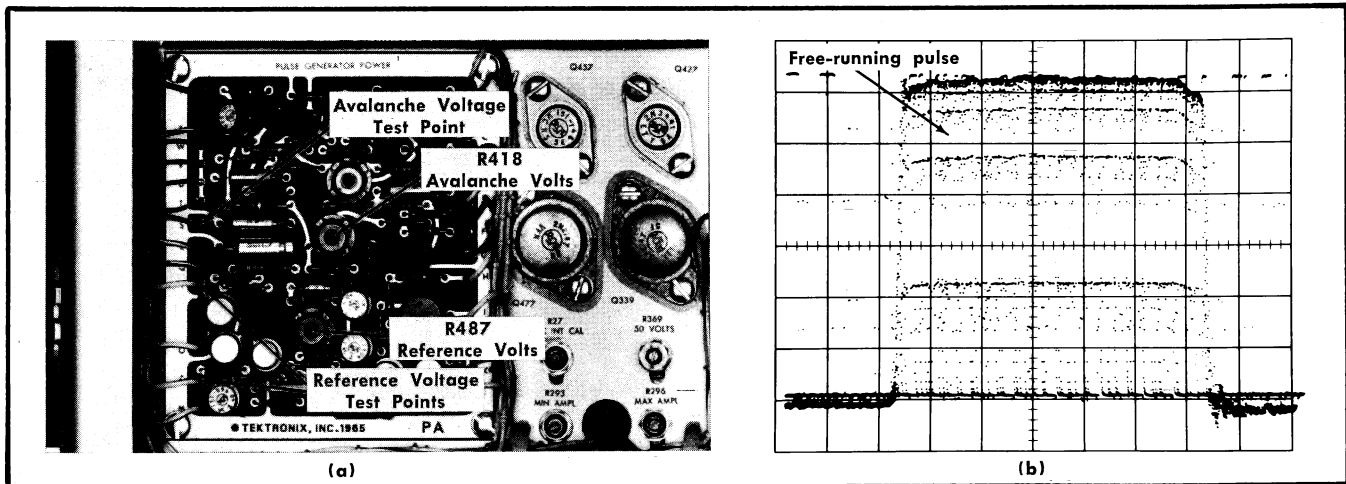


Fig. 6-10. (a) Location of Pulse-Generator Power test points and adjustments (Pulse Generator Power board), (b) Typical test-oscilloscope display when avalanche transistors start to free-run.

b. Set the sampling system to observe the falling edge of the pulse. Waveform should resemble Fig. 6-11a.

#### NOTE

In the following steps, make re-adjustments only if performing a complete recalibration, if components have been replaced or if the pulse does not meet performance requirements. Steps 8 through 11 in the Performance Check procedure (Section 5) provide a convenient means of checking pulse performance.

c. Adjust—+Shaper Coarse adjustment, R261 (see Fig. 6-11d), to shorten negative transition time and produce a waveform similar to Fig. 6-11b.

d. Adjust—+Shaper Fine Adjustment, R280 (see Fig. 6-11d), to fill in the last few nanoseconds before the negative transition. Pulse should now be similar to Fig. 6-11c with about 12-volt (6 divisions) amplitude.

e. Adjust—Max Ampl Pulse Shaper adjustment, R106 (see Fig. 6-11e), until it just starts to affect the trailing edge of the pulse. Recheck step c and readjust if necessary.

f. Set the AMPLITUDE control for six volts output (3 divisions).

g. Adjust—Min Ampl Pulse Shaper adjustment, R104 (see Fig. 6-11e), to smooth out ringing at the trailing edge of the pulse. Recheck step c and readjust if necessary (12-volt pulse amplitude).

h. Set the AMPLITUDE control for 12-volts output (6 divisions).

i. Adjust—C140 (see Fig. 6-11f) for minimum aberrations on the trailing edge.

j. Repeat steps c through i until optimum positive pulse response is obtained.

k. Interaction—Check steps 11 and 12.

### 11. Adjust Pulse Amplitude

a. Test setup is given in step 8.

b. Set the AMPLITUDE control fully clockwise.

c. Check—Sampling-system display for 12-volt maximum pulse amplitude as shown by a six-division display (see Fig. 6-12a).

d. Adjust—Max Ampl adjustment, R296 (see Fig. 6-12b), for 12-volt pulse amplitude.

e. Set the AMPLITUDE control fully counterclockwise.

f. Check—Sampling system display for 6-volt minimum pulse amplitude as shown by a three-division display (see Fig. 6-12c).

g. Adjust—Min Ampl adjustment, R293 (see Fig. 6-12b), for 6-volt pulse amplitude.

h. Recheck steps c through g and readjust if necessary.

### 12. Adjust Remote-Program Pulse-Amplitude

a. Test setup is given in step 8.

b. Set the AMPLITUDE PROGRAM switch to REMOTE.

c. Insert the 24-terminal connector in the rear-panel Remote Program jack.

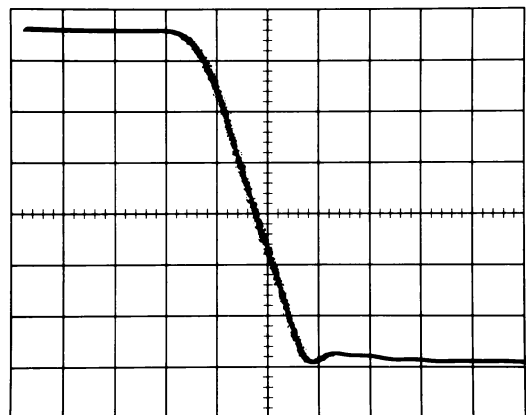
d. Connect the 500  $\Omega$  resistor between terminals 3 and 4 of the remote-program plug.

e. Check—Sampling system display for 12-volt maximum pulse amplitude as shown by a six-division display (see Fig. 6-12a).

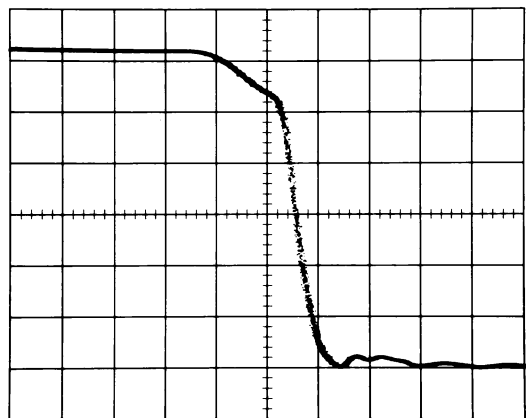
f. Adjust—Remote Amplitude adjustment, R502 (see Fig. 6-13), for a six-division display.

g. Remove the 500  $\Omega$  resistor and leave terminals 3 and 4 open.

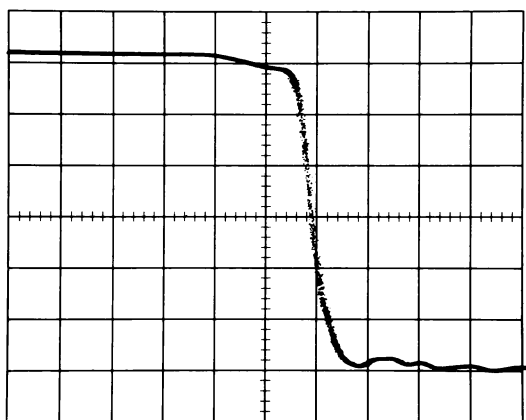
h. Check—Sampling system display for 6-volt minimum pulse amplitude as shown by a three-division display (see Fig. 6-12c).



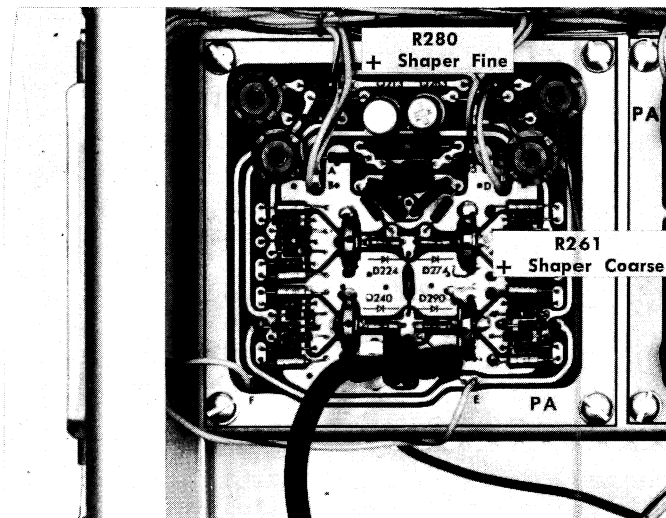
(a)



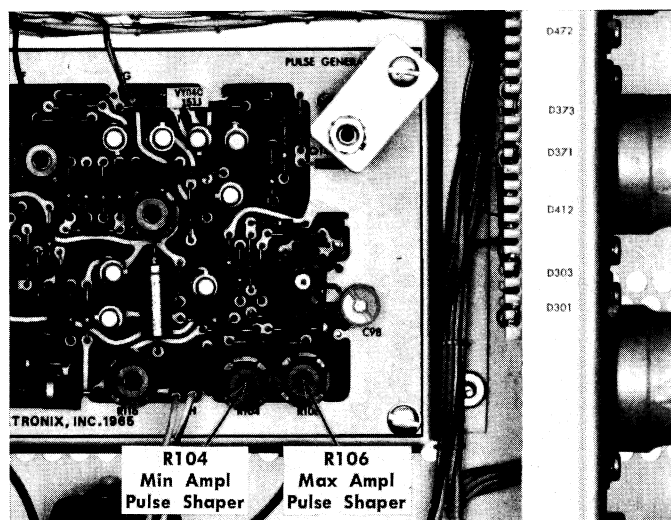
(b)



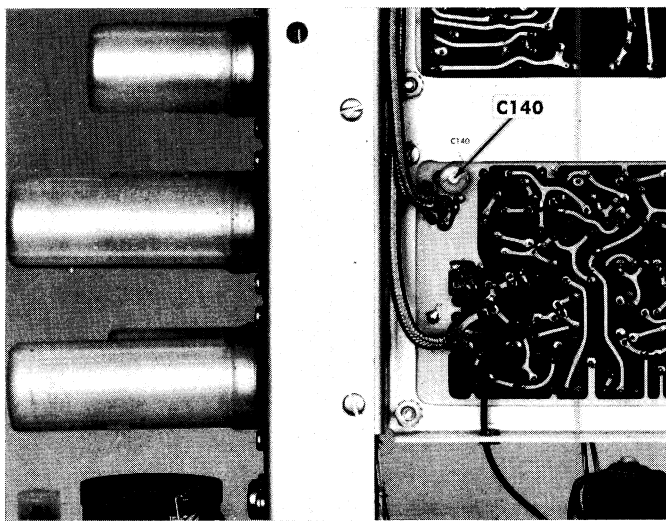
(c)



(d)



(e)



(f)

Fig. 6-11. (a), (b) and (c) Typical sampling-system displays when adjusting positive pulse shape, (d) Location of positive pulse shape adjustments (Pulse Shaper board), (e) Location of pulse shaper amplitude adjustments (Pulse Generator board), (f) Location of C140 (bottom of Pulse Generator board).

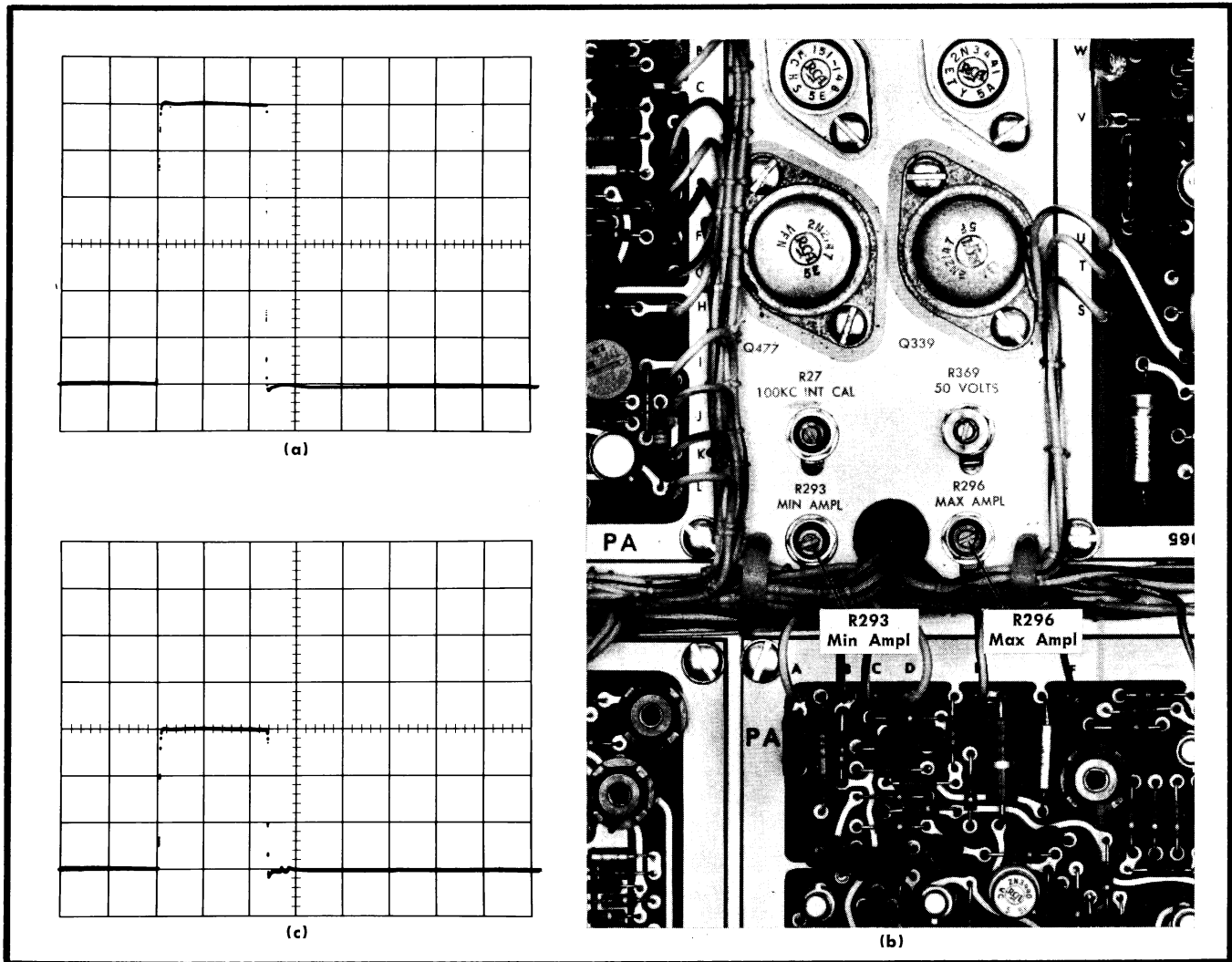


Fig. 6-12. (a) Typical sampling-system display when checking maximum pulse amplitude, (b) Location of maximum and minimum pulse amplitude adjustments (top side), (c) Typical sampling system display when checking minimum pulse amplitude.

### 13. Adjust Negative Pulse Shape

①

- Test setup is given in step 8.
- Set the POLARITY switch to —.
- Set the AMPLITUDE PROGRAM switch to INT and the AMPLITUDE control fully clockwise.
- Position the display to observe the leading edge of the pulse. Waveform should resemble Fig. 6-14a.
- Adjust— —Shaper Coarse adjustment, R211 (see Fig. 6-14d), to decrease risetime and produce a waveform similar to Fig. 6-14b.
- Adjust— —Shaper Fine adjustment, R230 (see Fig. 6-14d), to fill in the last few nanoseconds before the leading edge. Pulse should now be similar to Fig. 6-14c.
- Repeat steps e and f until optimum negative pulse response is obtained.
- Adjust—C98 (see Fig. 6-14e) to just fill in the front corner of the leading edge.

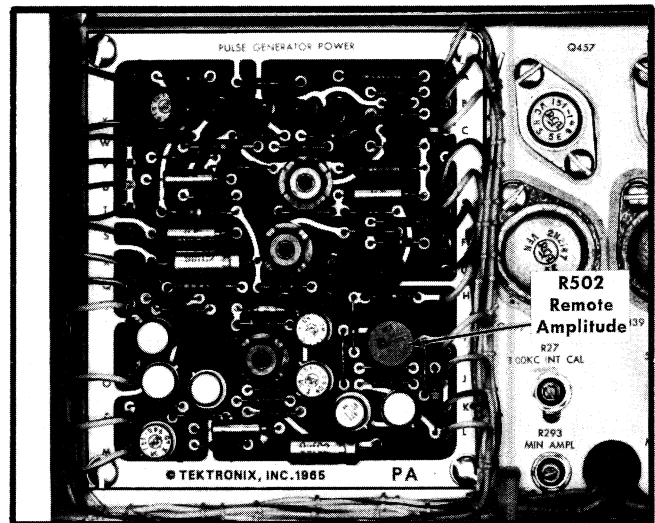


Fig. 6-13. Location of Remote Amplitude adjustment (Pulse-Generator Power board).

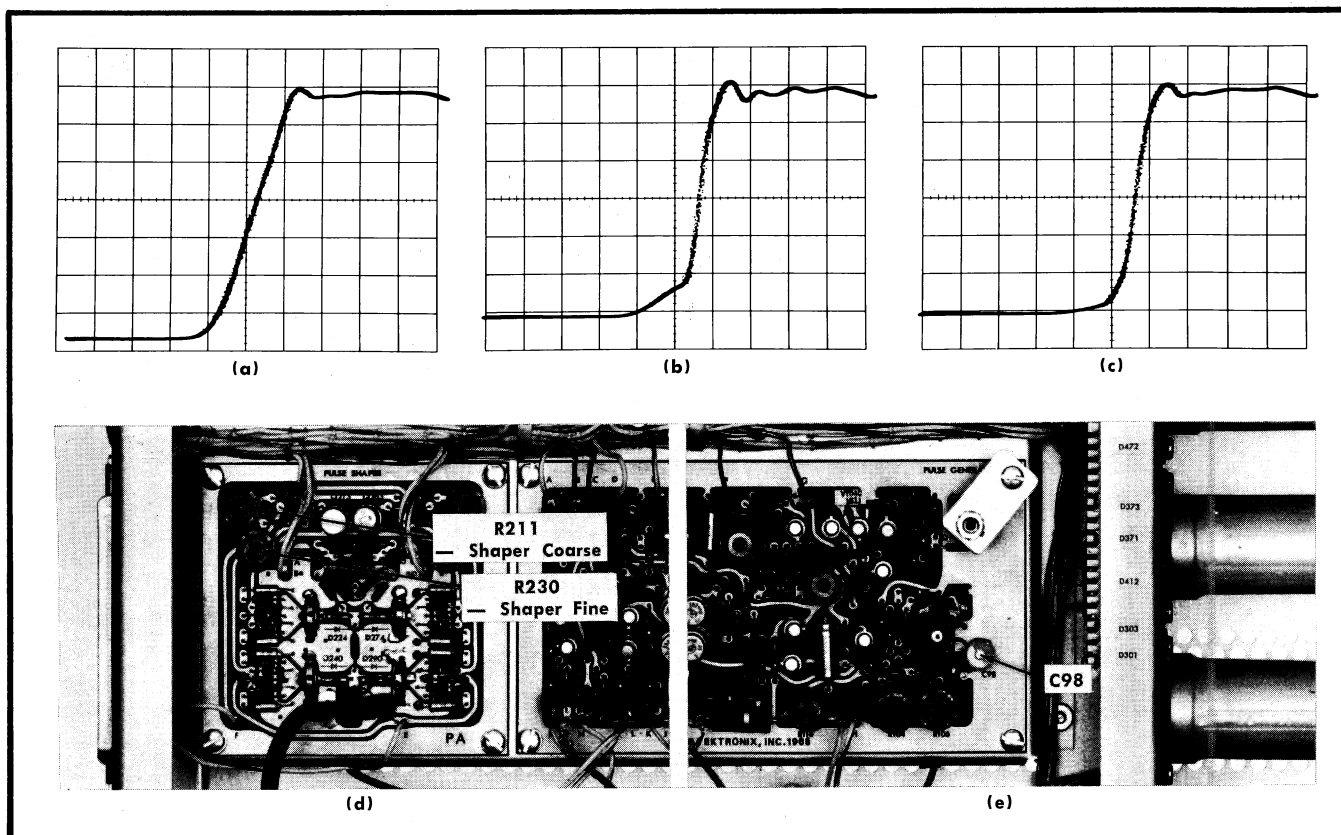


Fig. 6-14. (a), (b) and (c) Typical sampling-system displays when adjusting negative pulse shape, (d) Location of negative pulse shape adjustments (Pulse Shaper board), (e) Location of C98 (Pulse Generator board).

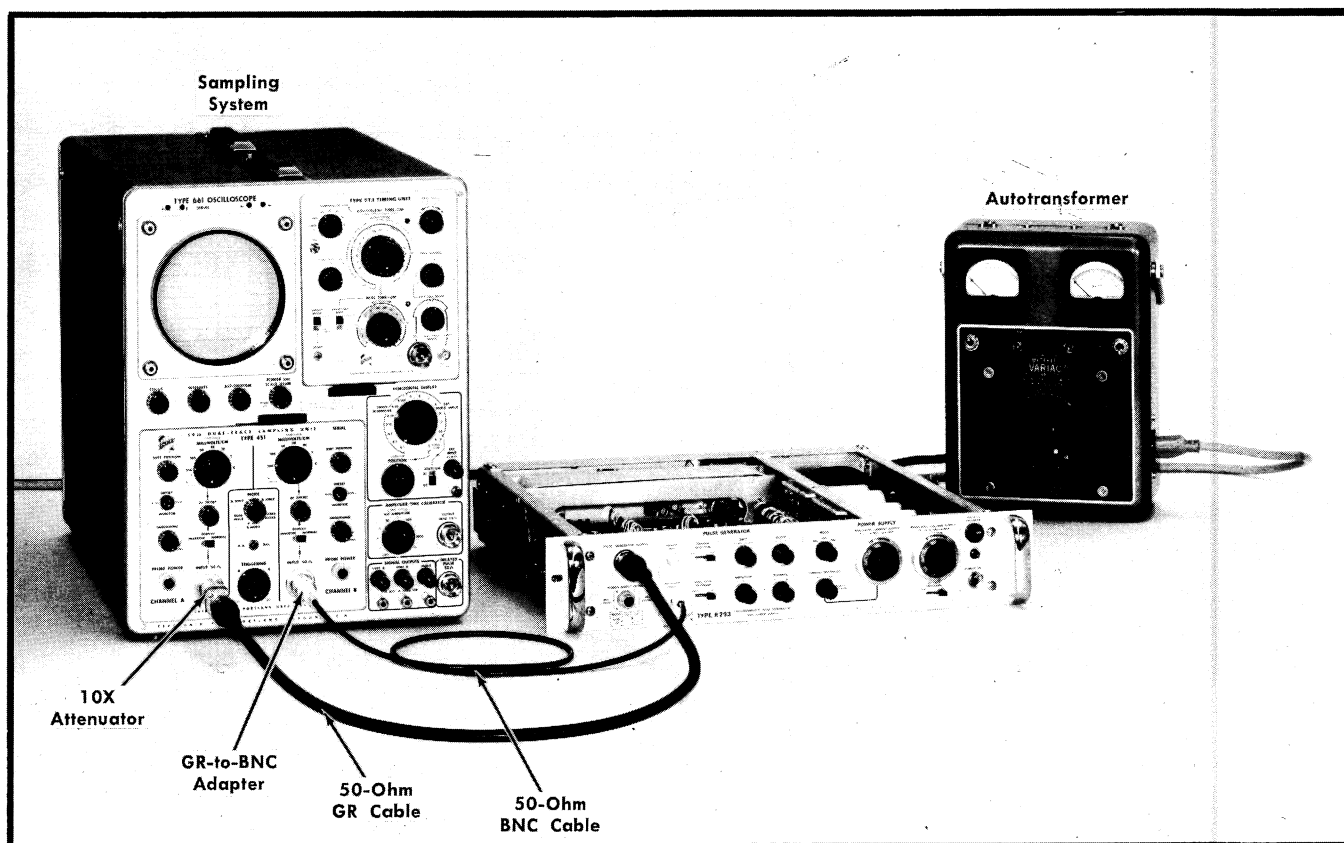


Fig. 6-15. Initial test setup for steps 14 through 18.

## Front-panel control settings

## Pulse Generator

TRIGGER SELECTOR	INT
RATE	Midrange
WIDTH	REMOTE
AMPLITUDE PROGRAM	INT
AMPLITUDE	Midrange
POLARITY	+

## Power Supply

MODE	OFF
CURRENT MULTIPLIER	$\times 100$
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

## 14. Adjust Pulse Width

a. Test equipment setup is shown in Fig. 6-15.

b. Connect the PULSE GENERATOR OUTPUT connector to channel A of the sampling system through the 50-ohm GR cable and the 10 $\times$  attenuator.

c. Connect the PRETRIGGER OUTPUT connector to channel B of the sampling system through the 50-ohm BNC cable and the GR-to-BNC adapter.

d. Set the sampling system to display both the pretrigger pulse and the pulse generator output pulse.

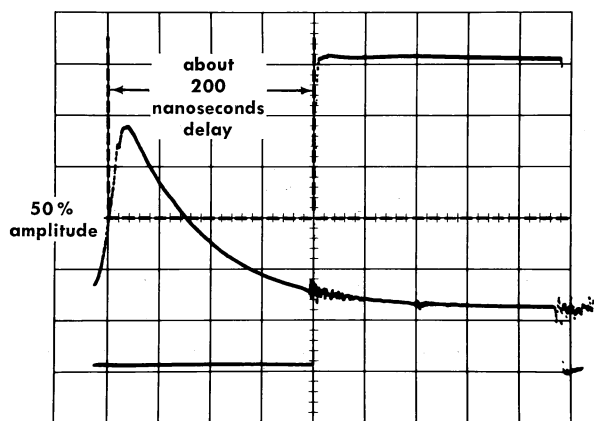
e. Check—Sampling-system display for about 200 nanosecond delay between 50% amplitude point of pretrigger pulse leading edge and 50% amplitude point of pulse generator output pulse leading edge (see Fig. 6-16a).

f. Adjust—Ext Min Width adjustment, R80 (see Fig. 6-16b) for 200 nanosecond delay between the pretrigger pulse and the pulse generator output pulse (preliminary adjustment; adjust only if necessary or for complete recalibration).

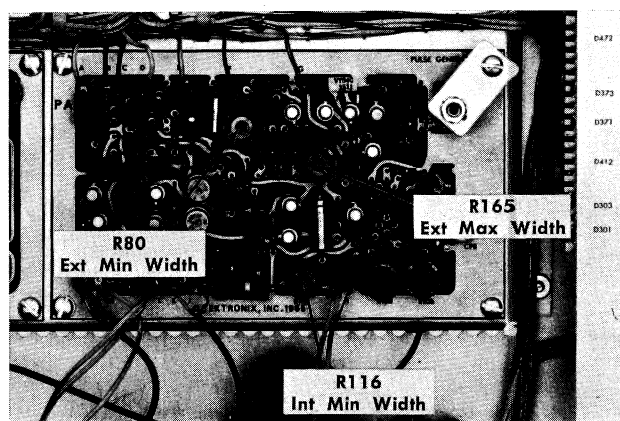
g. Set the sampling system to display channel A at 50 nanoseconds/division sweep rate.

h. Insert the 24-terminal connector in the rear-panel Remote Program jack.

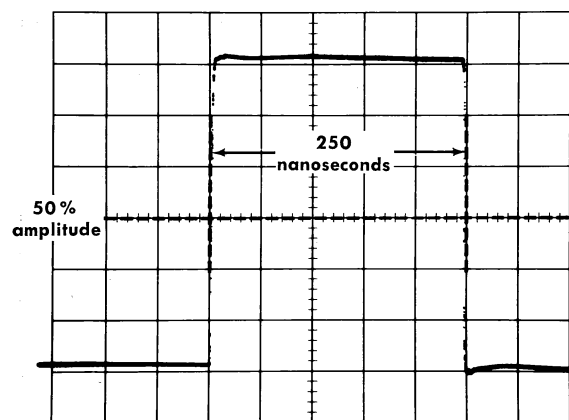
i. Connect the 2 k $\Omega$  resistor between terminals 6 and 18 of the remote-program connector.



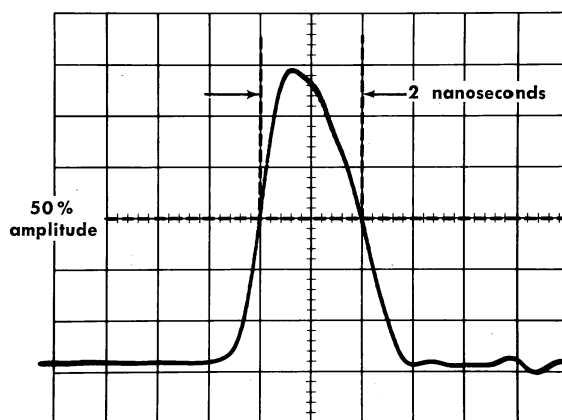
(a)



(b)



(c)



(d)

Fig. 6-16. (a) Typical sampling-system display showing delay between pretrigger pulse and pulse-generator output pulse, (b) Location of pulse width adjustments (Pulse Generator board), (c) Typical sampling-system display showing correct maximum pulse width, (d) Typical sampling-system display showing correct minimum pulse width.

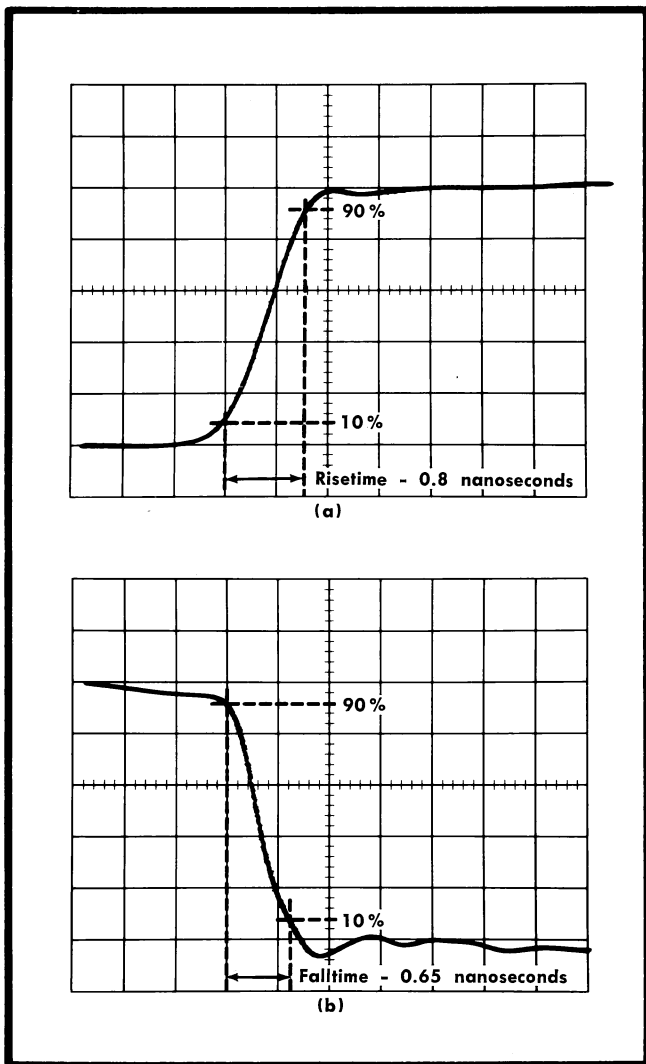


Fig. 6-17. Typical sampling-system display when checking (a) risetime, (b) falltime.

j. Check—Sampling-system display for pulse width of 250 nanoseconds (5 divisions) measured between 50% amplitude points of leading and trailing edge (see Fig. 6-16c).

k. Adjust—Ext Max Width adjustment, R165 (see Fig. 6-16b), for 250 nanosecond pulse width.

l. Replace the 2 k $\Omega$  resistor with a 249 k $\Omega$  resistor.

m. Change the sampling-system sweep rate to 1 nanosecond/division.

n. Check—Sampling-system display for pulse width of 2 nanoseconds (2 divisions) measured between 50% amplitude points of leading and trailing edge (see Fig. 6-16d).

o. Adjust—Ext Min Width adjustment, R80 (see Fig. 6-16b), for 2 nanosecond pulse width (final adjustment).

p. Recheck steps j through o and readjust if necessary.

q. Turn the WIDTH control fully counterclockwise.

r. Check—Sampling-system display for maximum pulse width of 2 nanoseconds (2 divisions) measured between 50% amplitude points of leading and trailing edge (see Fig. 6-16d).

s. Adjust—Int Min Width adjustment, R116 (see Fig. 6-16b), for 2 nanosecond pulse width.

t. Set the sampling-system sweep rate to 50 nanoseconds/division.

u. Turn the WIDTH control fully clockwise (not in REMOTE detent).

v. Check—Sampling-system display for minimum pulse width of 250 nanoseconds (5 divisions) measured between 50% amplitude points of leading and trailing edge; see Fig. 6-16c).

## 15. Check Pulse Risetime and Falltime

a. Test setup is given in step 14.

b. Position the display to observe the leading edge of the waveform at a sweep rate of 0.5 nanoseconds/division.

c. Check—Risetime between 10% and 90% points of leading edge 1 nanosecond or less (see Fig. 6-17a).

d. Position the trailing edge of the waveform on the viewing area.

e. Check—Falltime between 90% and 10% points of trailing edge 1 nanosecond or less (see Fig. 6-17b).

## 16. Check Aberrations on Pulse Leading Edge

a. Test setup is given in step 14.

b. Position the leading edge of the waveform on the viewing area.

c. Set the sampling-system sweep rate to 2 nanoseconds/division.

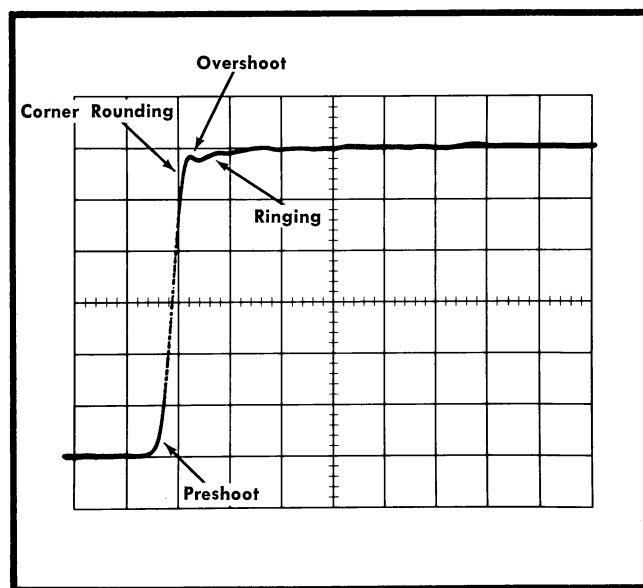


Fig. 6-18. Typical sampling-system display showing leading edge aberrations.



d. Set the AMPLITUDE control so the pulse is exactly six divisions in height.

e. Check—Sampling-system display for preshoot 0.06 division or less (1% maximum; see Fig. 6-18).

f. Check—Sampling-system display for overshoot 0.24 division or less (3% maximum; see Fig. 6-18).

g. Check—Sampling-system display for corner rounding 0.3 division or less (5% maximum; see Fig. 6-18).

h. Check—Sampling-system display for ringing 0.24 division or less (3% maximum; see Fig. 6-18).

## 17. Check Aberrations on Pulse Trailing Edge

a. Test setup is given in step 16.

b. Position the trailing edge of the waveform on the viewing area.

c. Check—Sampling-system display for storage aberration 0.3 division or less (5% maximum; see Fig. 6-19).

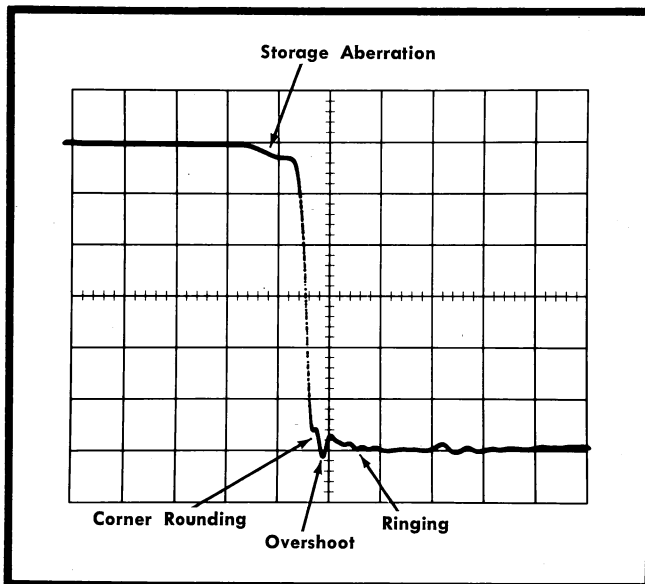


Fig. 6-19. Typical sampling-system display showing trailing-edge aberrations.

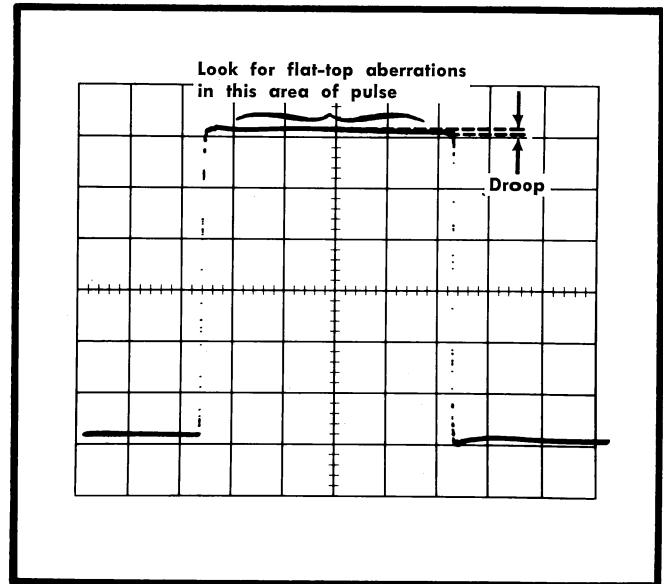


Fig. 6-20. Typical sampling-system display showing flat-top aberrations and droop.

d. Check—Sampling-system display for corner rounding 0.6 division or less (10% maximum see Fig. 6-19).

e. Check—Sampling-system display for ringing 0.6 division or less (10% maximum; see Fig. 6-19).

f. Check—Sampling-system display for overshoot 0.3 division or less (5% maximum; see Fig. 6-19).

## 18. Check Flat-Top Aberrations and Pulse Droop

a. Test setup is given in step 16.

b. Position the complete pulse on the viewing area at a sweep rate of 50 nanoseconds/division.

c. Check—Sampling-system display for aberrations between the first 10 nanoseconds and last 15 nanoseconds of pulse 0.12 division or less (2% maximum; see Fig. 6-20).

d. Check—Sampling-system display for droop 0.06 division or less (1% maximum; see Fig. 6-19).

e. Disconnect all test equipment.

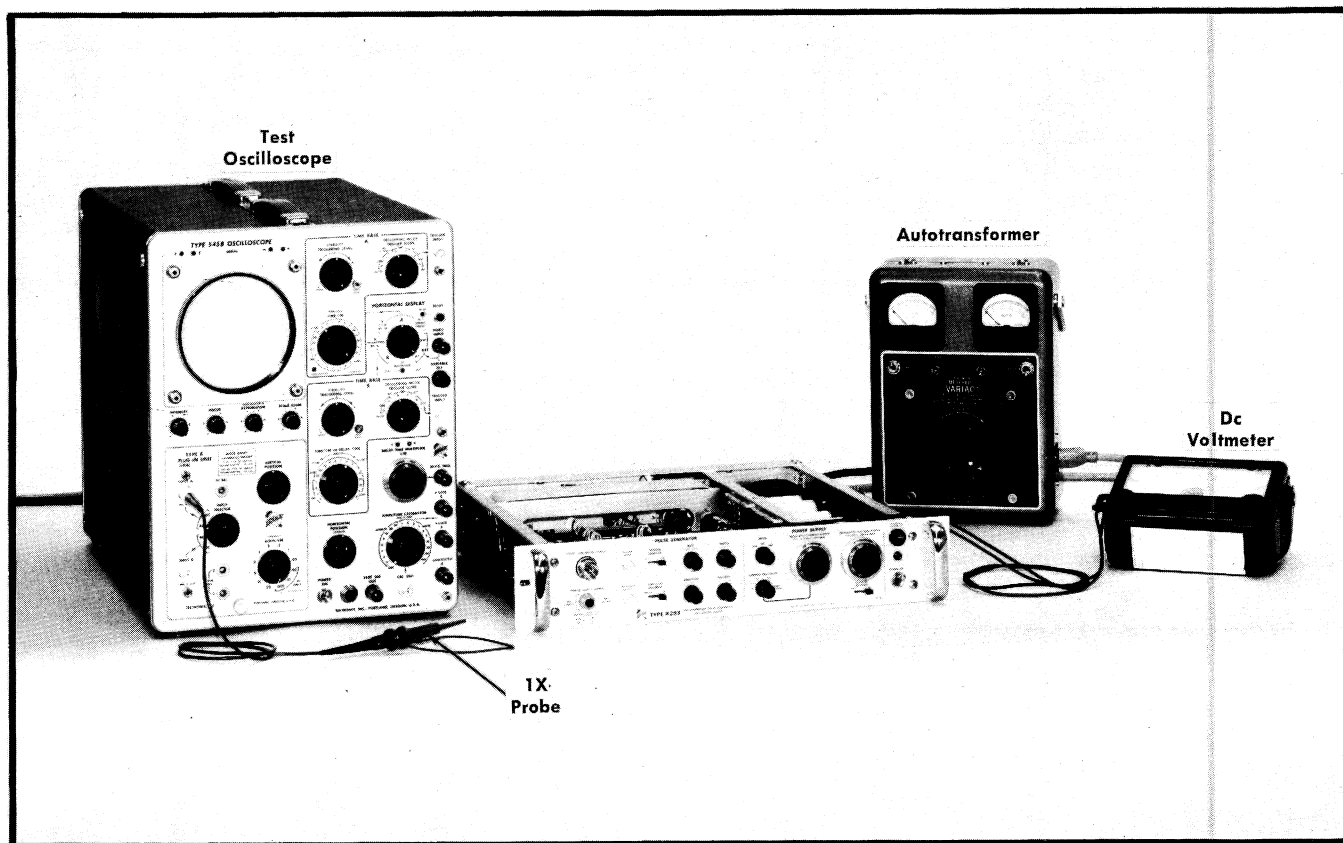


Fig. 6-21. Initial test equipment setup for steps 19 through 32.

## Front-panel control settings

### Pulse Generator

TRIGGER SELECTOR	INT
<b>RATE</b>	<b>REMOTE</b>
WIDTH	Clockwise
AMPLITUDE PROGRAM	INT
AMPLITUDE	Midrange
POLARITY	+

### Power Supply

<b>MODE</b>	<b>NPN</b>
CURRENT MULTIPLIER	$\times 100$
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

## 19. Adjust Zener Current ①

- Test equipment setup is shown in Fig. 6-21.
- Connect the dc voltmeter to the Zener Current test points (see Fig. 6-22).
- Check—Meter reading; 8.4 volts,  $\pm 0.2$  volt.
- Adjust—Zener Current adjustment, R350 (see Fig. 6-22) for exactly 8.4 volts.
- Interaction—Check steps 21 and 22.

## 20. Adjust Programmable Voltage Supply Maximum Output Voltage ①

- Test equipment setup is shown in Fig. 6-21.
- Connect the dc voltmeter from terminal C of the POWER SUPPLY OUTPUT connector to chassis ground.
- Check—Meter reading; +50 volts,  $\pm 1$  volt.
- Adjust—50 Volts adjustment, R369 (see Fig. 6-22), for +50 volts.
- Interaction—Check step 21.

## 21. Adjust Zero Balance ①

- Test setup is given in step 20.
- Set the REGULATED VOLTAGE SUPPLY dial to 0.00.
- Check—Meter reading; zero volts.
- Adjust—Zero Bal adjustment, R321 (see Fig. 6-22), for zero volts.
- Recheck step 20.
- Interaction—Check step 22.

## 22. Adjust Remote-Program Maximum Output Voltage ①

- Test setup is given in step. 20.

- b. Insert the 24-terminal connector in the rear-panel Remote Program jack.
- c. Connect the 49.9 k $\Omega$  resistor between terminals 23 and 24 of the remote-program connector.
- d. Set the VOLTAGE PROGRAM switch to REMOTE.
- e. Check—Meter reading; +50 volts,  $\pm 1$  volt.
- f. Adjust—Remote 50 Volts adjustment, R360 (see Fig. 6-22), for +50 volts.

### 23. Check Programmable Voltage Supply Regulation

- a. Test setup is given in step 20.
- b. Connect the 250  $\Omega$ , 10 W resistor between pins A and B<sup>1</sup> of the 4-pin connector.
- c. Insert the 4-pin connector in the front-panel POWER SUPPLY OUTPUT connector.
- d. Connect the dc voltmeter across the 250  $\Omega$  resistor.
- e. Check—Meter reading for  $\pm 0.5$  volt maximum change while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).
- f. Disconnect the dc voltmeter.

### 24. Check Programmable Voltage Supply Ripple

- a. Test equipment setup is shown in Fig. 6-21.
- b. Connect the 250  $\Omega$  resistor and the 4-pin connector as in step 23.
- c. Connect the 1 $\times$  probe to pin A of the 4-pin connector. Connect the ground lead to chassis ground.
- d. Set the test oscilloscope for ac input coupling.
- e. Check—Test oscilloscope display for 25 millivolts maximum line-frequency ripple while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).
- f. Return the autotransformer output voltage to 115 (230) volts.
- g. Disconnect all test equipment.

### 25. Check Regulated Voltage Supply Dial Accuracy

- a. Test equipment setup is shown in Fig. 6-21.
- b. Connect the dc voltmeter from terminal C of the POWER SUPPLY OUTPUT connector to chassis ground.
- c. Check—Voltage output within given tolerance at each REGULATED VOLTAGE SUPPLY dial setting listed in Table 6-1.

<sup>1</sup>Terminals C and ground of POWER SUPPLY OUTPUT connector. See Fig. 2-1.

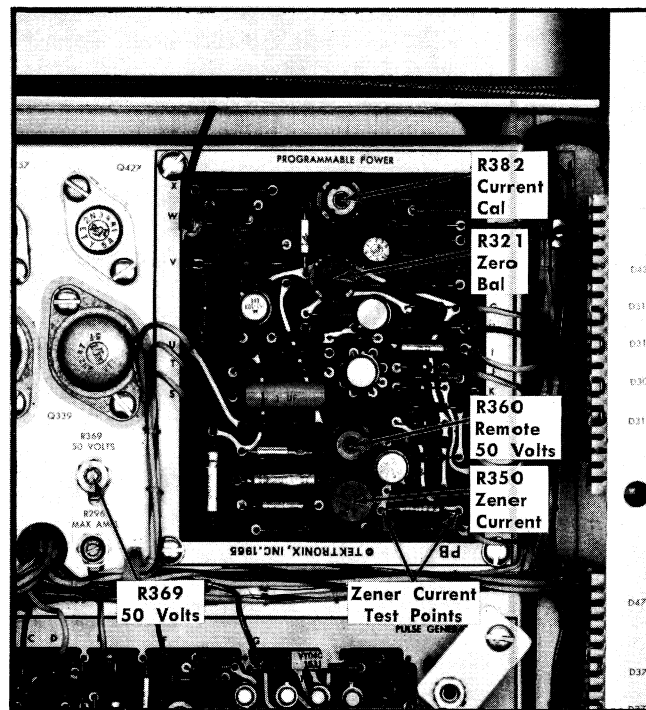


Fig. 6-22. Location of Programmable Power Supply test points and adjustments (Programmable Power board).

TABLE 6-1

REGULATED VOLTAGE SUPPLY Dial Setting	Tolerance
5.00	$\pm 1.025$ volt
1.00	$\pm 0.225$ volt
0.00	$\pm 0.025$ volt

### 26. Adjust Programmable Current Supply ①

- a. Test setup is given in step 21.
- b. Connect the dc ammeter between terminals B and E of the POWER SUPPLY OUTPUT connector.
- c. Check—Meter reading; 300 milliams,  $\pm 6$  milliams.
- d. Adjust—Current Cal adjustment, R382 (see Fig. 6-22), for 300 milliams.

### 27. Check Remote-Program Current Amplitude

- a. Test setup is given in step 26.
- b. Insert the 24-terminal connector in the rear-panel Remote Program jack.
- c. Connect the 165  $\Omega$  resistor between terminals 9 and 21 of the remote-program connector.
- d. Set the CURRENT MULTIPLIER switch to REMOTE PROGRAM.
- e. Check—Meter reading for 30 milliams,  $\pm 0.95$  milliams.

## 28. Check Programmable Current Supply Regulation

- Test setup is given in step 26.
- Connect the 50  $\Omega$ , 10 W resistor and the dc ammeter in series between pins C and D of the 4-pin connector.
- Insert the 4-pin connector in the front-panel POWER SUPPLY OUTPUT connector.
- Set the CURRENT MULTIPLIER switch to  $\times 100$ .
- Check—Meter reading for  $\pm 3$  milliamps maximum change while varying the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).
- Disconnect the dc ammeter.

## 29. Check Programmable Current Supply Ripple

- Test equipment setup is shown in Fig. 6-21.
- Connect the 50  $\Omega$ , 10 W resistor between pins C and D of the 4-pin connector.
- Insert the 4-pin connector in the front-panel POWER-SUPPLY OUTPUT connector.
- Connect the 1 $\times$  probe to pin D of the 4-pin connector. Connect the ground lead to pin C.
- Set the test oscilloscope for ac input coupling.
- Check—Test oscilloscope display for 75 millivolts maximum line-frequency ripple while changing the autotransformer output voltage between 93.5 and 135 volts (187 and 270 volts for 230-volts nominal).
- Return the autotransformer output voltage to 115 (230) volts.
- Disconnect all test equipment.

## 30. Check Regulated Current Supply Dial Accuracy

- Test equipment setup is shown in Fig. 6-21.
- Connect the dc ammeter between terminals B and E of the POWER SUPPLY OUTPUT connector.
- Check—Current output within given tolerance at each REGULATED CURRENT SUPPLY dial setting listed in Table 6-2.

TABLE 6-2

REGULATED CURRENT SUPPLY Dial Setting	Tolerance
3.00	$\pm 9.05$ milliamps
0.50	$\pm 2.55$ milliamps

## 31. Check Current Multiplier Accuracy

- Test setup is given in step 30.
- Set the REGULATED CURRENT SUPPLY dial to 3.00.
- Set the CURRENT MULTIPLIER switch to  $\times 10$ .
- Check—Meter reading; 30 milliamps,  $\pm 0.95$  milliamp.
- Set the CURRENT MULTIPLIER switch to  $\times 1$ .
- Check—Meter reading; 3 milliamps,  $\pm 0.14$  milliamp.

## 32. Check Mode Switch Operation

- Test setup is given in step 30.
- Connect the dc voltmeter from terminal C of the POWER SUPPLY OUTPUT connector to chassis ground.
- Check—Voltage output positive with respect to chassis ground.
- Set the MODE switch to OFF.
- Check—Zero volts output.
- Set the MODE switch to PNP.
- Check—Voltage output negative with respect to chassis ground.
- Connect the dc voltmeter between terminals B and E of the POWER SUPPLY OUTPUT connector.
- Check—Negative meter reading.
- Set the MODE switch to OFF.
- Check—Zero meter reading.
- Set the MODE switch to NPN.
- Check—Positive meter reading.

This completes the calibration procedure for the Type R293. Disconnect all test equipment, replace the top and bottom covers and re-install the instrument in the cabinet rack. If the instrument has been completely calibrated to the tolerances given in this procedure, it will meet the performance requirements given in the Characteristics section of the Instruction Manual.

## PARTS ORDERING INFORMATION

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

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

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

## SPECIAL NOTES AND SYMBOLS

×000 Part first added at this serial number

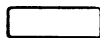
00× Part removed after this serial number

\*000-0000-00 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.

Use 000-0000-00 Part number indicated is direct replacement.



Screwdriver adjustment.



Control, adjustment or connector.



Heat sink.

# ABBREVIATIONS AND SYMBOLS

## NOTE

Greek letters are given with their most common usage.  
Other usages are normally defined in the text.

A or amp	amperes	$\lambda$	lambda—wavelength
ac or AC	alternating current	<	less than
af	audio frequency	LF	low frequency
$\alpha$	alpha—common-base current amplification factor	lg	length or long
AM	amplitude modulation	LV	low voltage
$\approx$	approximately equal to	M or meg	mega or $10^6$
$\beta$	beta—common-emitter current amplification factor	$M\Omega$ or meg	megohm
BHB	binding head brass	$\mu$	micro or $10^{-6}$
BHS	binding head steel	mc	megacycle
BNC	baby series "N" connector	met.	metal
X	by or times	mm	millimeter
		ms	millisecond
C	carbon	—	minus
C	capacitance	mtg hdw	mounting hardware
cap.	capacitor	n	nano or $10^{-9}$
cer	ceramic	no. or #	number
ch	channel	ns	nanosecond
cm	centimeter		
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
$\sim$	cycle	OHS	oval head steel
c/s or cps	cycles per second	$\Omega$	ohm—ohms
crt	cathode-ray tube	$\omega$	omega—angular frequency
CSK	countersunk		
		/	per
dB	decibel	%	percent
dBm	decibel referred to one milliwatt	PHB	pan head brass
dc or DC	direct current	$\phi$	phi—phase angle
DE	double end	$\pi$	pi—3.1416
$^{\circ}$	degrees	PHS	pan head steel
$^{\circ}\text{C}$	degrees Celsius (degrees centigrade)	+	plus
$^{\circ}\text{F}$	degrees Fahrenheit	$\pm$	plus or minus
$^{\circ}\text{K}$	degrees Kelvin	piv	peak inverse voltage
dia	diameter	plstc	plastic
$\div$	divide by	PMC	paper, metal cased
div	division	poly	polystyrene
		prec	precision
EHF	extremely high frequency	PT	paper, tubular
EMC	electrolytic, metal cased	PTM	paper or plastic, tubular, molded
EMT	electrolytic, metal tubular	pwr	power
$\epsilon$	epsilon—2.71828 or % of error		
$\geq$	equal to or greater than	RC	resistance capacitance
$\leq$	equal to or less than	rf	radio frequency
ext	external	RFI	radio frequency interference
		RHB	round head brass
F or f	farad	$\rho$	rho—resistivity
F & I	focus and intensity	RHS	round head steel
FHB	flat head brass	r/min or rpm	revolutions per minute
FHS	flat head steel	rms	root mean square
Fil HB	fillister head brass		
Fil HS	fillister head steel	s or sec.	second
FM	frequency modulation	SE	single end
ft	feet or foot	Si	silicon
		SN or S/N	serial number
G	giga or $10^9$	T	tera or $10^{12}$
g	acceleration due to gravity	TC	temperature compensated
Ge	germanium	TD	tunnel diode
GMV	guaranteed minimum value	THB	truss head brass
GR	General Radio	$\theta$	theta—angular phase displacement
>	greater than	thk	thick
		THS	truss head steel
H or h	henry	—	to
h	height or high	tub.	tubular
hex.	hexagonal		
HF	high frequency	UHF	ultra high frequency
HHB	hex head brass		
HHS	hex head steel	V	volt
HSB	hex socket brass	Vac	volts, alternating current
HSS	hex socket steel	var	variable
HV	high voltage	Vdc	volts, direct current
Hz	hertz (cycles per second)	VHF	very high frequency
		vswr	voltage standing wave ratio
ID	inside diameter		
in.	inch or inches	W	watt
incd	incandescent	w	wide or width
$\infty$	infinity	w/	with
int	internal	w/o	without
$\int$	integral	WW	wire-wound
k	kilohms or kilo ( $10^3$ )	xmfr	transformer
kc	kilocycle		

# SECTION 7

## ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
<b>Bulb</b>			
B401	150-0041-00	Ass'y, Neon NE-2H Amber Lens	
<b>Capacitors</b>			
Tolerance $\pm 20\%$ unless otherwise indicated.			
C10	283-0001-00	0.005 $\mu\text{F}$ Cer	500 V
C14	283-0060-00	100 pF Cer	200 V
C24	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C34	283-0104-00	2000 pF Cer	500 V
C44	283-0010-00	0.05 $\mu\text{F}$ Cer	50 V
C46	283-0047-00	270 pF Cer	500 V
C50	283-0047-00	270 pF Cer	500 V
C59	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C65	283-0010-00	0.05 $\mu\text{F}$ Cer	50 V
C70	283-0079-00	0.01 $\mu\text{F}$ Cer	250 V
C76	283-0598-00	253 pF Mica	300 V
C98	281-0091-00	2-8 pF Cer	Var
C100	283-0094-00	27 pF Cer	200 V
C102	283-0047-00	270 pF Cer	500 V
C104	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C112	283-0027-00	0.02 $\mu\text{F}$ Cer	30 V
C122	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C140	281-0092-00	9-35 pF Cer	Var
C154	281-0594-00	150 pF Cer	100 V
C171	290-0140-00	120 $\mu\text{F}$ EMT	10 V
C172	290-0135-00	15 $\mu\text{F}$ EMT	20 V
C201	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C220	290-0177-00	1 $\mu\text{F}$ EMT	50 V
C222	290-0177-00	1 $\mu\text{F}$ EMT	50 V
C224	283-0563-00	1000 pF Mica	500 V
C236	290-0177-00	1 $\mu\text{F}$ EMT	50 V
C238	290-0177-00	1 $\mu\text{F}$ EMT	50 V
C240	283-0563-00	1000 pF Mica	500 V
C243	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C244	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C251	283-0059-00	1 $\mu\text{F}$ Cer	25 V
C270	290-0177-00	1 $\mu\text{F}$ EMT	50 V
C272	290-0177-00	1 $\mu\text{F}$ EMT	50 V
C274	283-0563-00	1000 pF Mica	500 V
C286	290-0177-00	1 $\mu\text{F}$ EMT	50 V

# Electrical Parts List—Type R293

## Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
C288	290-0177-00	1 $\mu$ F	EMT	50 V	10%
C290	283-0563-00	1000 pF	Mica	500 V	
C292	290-0177-00	1 $\mu$ F	EMT	50 V	
C301	283-0008-00	0.1 $\mu$ F	Cer	500 V	
C305A,B	290-0277-00	2x 140 $\mu$ F	EMC	100 V	
C315	290-0018-00	150 $\mu$ F	EMC	150 V	
C316	290-0018-00	150 $\mu$ F	EMC	150 V	
C317	290-0162-00	22 $\mu$ F	EMT	35 V	
C318	290-0279-00	1000 $\mu$ F	EMC	25 V	
C328	290-0135-00	15 $\mu$ F	EMT	20 V	
C329	290-0271-00	9 $\mu$ F	EMT	125 V	+20%—15%
C330	282-0026-00	0.2 $\mu$ F	Cer	25 V	
C331	283-0026-00	0.2 $\mu$ F	Cer	25 V	
C341	285-0622-00	0.1 $\mu$ F	PTM	100 V	
C352	290-0261-00	6.8 $\mu$ F	EMT	35 V	
C365	290-0261-00	6.8 $\mu$ F	EMT	35 V	10%
C368	283-0067-00	0.001 $\mu$ F	Cer	200 V	
C371	283-0008-00	0.1 $\mu$ F	Cer	500 V	
C375A,B	290-0256-00	2 x 700 $\mu$ F	EMC	50 V	
C392	283-0051-00	0.0033 $\mu$ F	Cer	100 V	
C414	290-0018-00	150 $\mu$ F	EMC	150 V	+20%—15%
C421	283-0079-00	0.01 $\mu$ F	Cer	250 V	
C425	290-0271-00	9 $\mu$ F	EMT	125 V	
C432	290-0278-00	550 $\mu$ F	EMC	50 V	
C438	283-0059-00	1 $\mu$ F	Cer	25 V	
C443	290-0134-00	22 $\mu$ F	EMT	15 V	+80%—20%
C446	290-0134-00	22 $\mu$ F	EMT	15 V	
C457	283-0059-00	1 $\mu$ F	Cer	25 V	
C462	290-0135-00	15 $\mu$ F	EMT	20 V	
C472	290-0018-00	150 $\mu$ F	EMT	150 v	
C477	290-0187-00	4.7 $\mu$ F	EMT	35 V	+20%—15%
C487	290-0271-00	9 $\mu$ F	EMT	125 V	
C490	290-0177-00	1 $\mu$ F	EMT	50 V	
C492	283-0028-00	0.0022 $\mu$ F	Cer	50 V	
C494	283-0059-00	1 $\mu$ F	Cer	25 V	
C495	290-0272-00	47 $\mu$ F	EMT	50 V	+80%—20%

## Diodes

D12	*152-0185-00	Silicon	Replaceable by 1N3605
D18	*152-0185-00	Silicon	Replaceable by 1N3605
D34	*152-0185-00	Silicon	Replaceable by 1N3605
D37	*152-0185-00	Silicon	Replaceable by 1N3605
D58	*152-0185-00	Silicon	Replaceable by 1N3605



## Diodes (Cont'd)

Ckt. No.	Tektronix Part No.		Description	S/N Range
D59	*152-0185-00	Silicon	Replaceable by 1N3605	
D62	*152-0185-00	Silicon	Replaceable by 1N3605	
D64	*152-0185-00	Silicon	Replaceable by 1N3605	
D72	*152-0185-00	Silicon	Replaceable by 1N3605	
D76	*152-0185-00	Silicon	Replaceable by 1N3605	
D82	*152-0185-00	Silicon	Replaceable by 1N3605	
D94	152-0141-00	Silicon	1N3605	
D103	152-0141-00	Silicon	1N3605	
D152	*152-0185-00	Silicon	Replaceable by 1N3605	
D156	*152-0185-00	Silicon	Replaceable by 1N3605	
D162	*152-0185-00	Silicon	Replaceable by 1N3605	
D205	152-0195-00	Zener	1N751A 0.4 W, 5.1 V, 5%	
D207	*152-0185-00	Silicon	Replaceable by 1N3605	
D212	*152-0185-00	Silicon	Replaceable by 1N3605	
D215	*152-0185-00	Silicon	Replaceable by 1N3605	
D224	*152-0022-00	Silicon	Snap off, Checked	
D232	*152-0185-00	Silicon	Replaceable by 1N3605	
D240	*153-0023-00	Silicon	Snap off, Checked	
D255	152-0195-00	Zener	1N751A 0.4 W, 5.1 V, 5%	
D257	*152-0185-00	Silicon	Replaceable by 1N3605	
D262	*152-0185-00	Silicon	Replaceable by 1N3605	
D265	*152-0185-00	Silicon	Replaceable by 1N3605	
D274	*153-0022-00	Silicon	Snap off, Checked	
D282	*152-0185-00	Silicon	Replaceable by 1N3605	
D290	*153-0023-00	Silicon	Snap off, Checked	
D301	152-0066-00	Silicon	1N3194	
D303	152-0066-00	Silicon	1N3194	
D308	152-0066-00	Silicon	1N3194	
D310	152-0066-00	Silicon	1N3194	
D312	152-0066-00	Silicon	1N3194	
D314	152-0066-00	Silicon	1N3194	
D317	152-0060-00	Zener	1N3027A 1 W, 20 V, 10%	
D320	152-0034-00	Zener	1N753 0.4 W, 6.2 V, 10%	
D322	*152-0107-00	Silicon	Replaceable by 1N647	
D324	*152-0107-00	Silicon	Replaceable by 1N647	
D326	152-0066-00	Silicon	1N3194	
D331	*152-0107-00	Silicon	Replaceable by 1N647	
D332	*152-0107-00	Silicon	Replaceable by 1N647	
D334	*152-0107-00	Silicon	Replaceable by 1N647	
D352	152-0212-00	Zener	1N936 9 V, 5% TC	

## Electrical Parts List—Type R293

### Diodes (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
D365	*152-0107-00	Silicon	Replaceable by 1N647
D367	152-0212-00	Zener	1N936 9 V, 5% TC
D371	152-0066-00	Silicon	1N3194
D373	152-0066-00	Silicon	1N3194
D377	152-0034-00	Zener	1N753 0.4 W, 6.2 V, 10%
D380	152-0212-00	Zener	1N936 9 V, 5% TC
D412	152-0200-00	Rectifier bridge MDA 962-5 (Motorola)	
D432	152-0199-00	Rectifier bridge MDA 962-3 (Motorola)	
D446	152-0212-00	Zener	1N936 9 V, 5% TC
D472	152-0199-00	Rectifier bridge MDA 962-3 (Motorola)	
D477	152-0212-00	Zener	1N936 9 V, 5% TC
D494	*152-0107-00	Silicon	Replaceable by 1N647
D499	*152-0107-00	Silicon	Replaceable by 1N647
D505	*152-0075-00	Germanium	Tek Spec
D515	*152-0075-00	Germanium	Tek Spec

### Fuse

F402	159-0018-00	0.8 A, 3AG, Slo-Blo
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### Filter

FL402	119-0028-00	Line Filter
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### Connectors

J22	131-0324-00	24 pin, chassis mtd, female
J340	131-0206-00	4 pin, probe power

### Inductors

L100	*119-0055-00	Delay Line Ass'y
L204	*120-0413-00	Toroid, 15 turns single
L240	*120-0413-00	Toroid, 15 turns single

### Transistors

Q14	*151-0108-00	Replaceable by 2N2501
Q24	*151-0108-00	Replaceable by 2N2501
Q34	*151-0108-00	Replaceable by 2N2501
Q44	*151-0133-00	Selected from 2N3251
Q54	151-0150-00	2N3440
Q55	*151-0155-00	Replaceable by 2N2925
Q63	151-0150-00	2N3440
Q65	*151-0155-00	Replaceable by 2N2925
Q74	151-0131-00	2N964
Q84	*151-0108-00	Replaceable by 2N2501

## Transistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q94	151-0131-00	2N964	
Q104†	*153-0538-00	Avalanche transistor	
Q114	*151-0108-00	Replaceable by 2N2501	
Q124	*151-0108-00	Replaceable by 2N2501	
Q134	151-0131-00	2N964	
Q144†	*153-0538-00	Avalanche transistor	
Q154	151-0131-00	2N964	
Q164	*151-0108-00	Replaceable by 2N2501	
Q213	*151-0134-00	Replaceable by 2N2905	
Q263	*151-0103-00	Replaceable by 2N2219	
Q323	*151-0103-00	Replaceable by 2N2219	
Q334	*151-0103-00	Replaceable by 2N2219	
Q337	*151-0140-00	Selected from 2N3055	
Q339	151-0170-00	2N2147	
Q346	*151-0104-00	Replaceable by 2N2913	
Q363	*151-0103-00	Replaceable by 2N2219	
Q384	*151-0136-00	Replaceable by 2N3053	
Q393	*151-0151-00	Replaceable by 2N930	
Q397	*151-0087-00	Selected from 2N1131	
Q398	*151-0148-00	Selected (RCA 40250)	
Q423	*151-0155-00	Replaceable by 2N925	
Q424	*151-0134-00	Replaceable by 2N2905	
Q427	151-0149-00	2N3441	
Q433	*151-0136-00	Replaceable by 2N3053	
Q434	*151-0155-00	Replaceable by 2N925	
Q443	*151-0155-00	Replaceable by 2N925	
Q446	*151-0155-00	Replaceable by 2N925	
Q456	*151-0155-00	Replaceable by 2N925	
Q457	*151-0148-00	Selected (RCA 40250)	
Q476	*151-0096-00	Selected from 2N1893	
Q477	151-0170-00	2N2147	
Q486	*151-0096-00	Selected from 2N1893	
Q487	*151-0134-00	Replaceable by 2N2905	
Q493	*151-0103-00	Replaceable by 2N2219	
Q494	*151-0087-00	Selected from 2N1131	
Q497	*151-0096-00	Selected from 2N1893	
Q503	*151-0134-00	Replaceable by 2N2219	
Q513	*151-0134-00	Replaceable by 2N2905	

†Q104 and Q144 furnished as a unit (matched pair).

# Electrical Parts List—Type R293

## Resistors

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

Ckt. No.	Tektronix Part No.		Description			S/N Range
R10	316-0102-00	1 k	$\frac{1}{4}$ W			
R12	316-0103-00	10 k	$\frac{1}{4}$ W			
R14	316-0102-00	1 k	$\frac{1}{4}$ W			
R16	316-0273-00	27 k	$\frac{1}{4}$ W			
R18	316-0471-00	470 $\Omega$	$\frac{1}{4}$ W			
R22	322-0289-00	10 k	$\frac{1}{4}$ W		Prec	1%
R26	316-0112-00	1.2 k	$\frac{1}{4}$ W			
R27	311-0443-00	2.5 k		Var		
R29	315-0751-00	750 $\Omega$	$\frac{1}{4}$ W			5%
R30†	311-0417-00	5 k		Var		
R34	316-0820-00	82 $\Omega$	$\frac{1}{4}$ W			
R37	316-0222-00	2.2 k	$\frac{1}{4}$ W			
R38	316-0103-00	10 k	$\frac{1}{4}$ W			
R40	316-0121-00	120 $\Omega$	$\frac{1}{4}$ W			
R44	315-0510-00	51 $\Omega$	$\frac{1}{4}$ W			5%
R46	316-0271-00	270 $\Omega$	$\frac{1}{4}$ W			
R48	315-0111-00	110 $\Omega$	$\frac{1}{4}$ W			5%
R50	316-0472-00	4.7 k	$\frac{1}{4}$ W			
R51	316-0221-00	220 $\Omega$	$\frac{1}{4}$ W			
R53	316-0102-00	1 k	$\frac{1}{4}$ W			
R54	304-0822-00	8.2 k	1 W			
R56	316-0152-00	1.5 k	$\frac{1}{4}$ W			
R58	316-0103-00	10 k	$\frac{1}{4}$ W			
R59	316-0120-00	12 $\Omega$	$\frac{1}{4}$ W			
R60	302-0273-00	27 k	$\frac{1}{2}$ W			
R62	306-0271-00	270 $\Omega$	2 W			
R65	316-0472-00	4.7 k	$\frac{1}{4}$ W			
R67	316-0102-00	1 k	$\frac{1}{4}$ W			
R70	316-0182-00	1.8 k	$\frac{1}{4}$ W			
R71	316-0102-00	1 k	$\frac{1}{4}$ W			
R73	316-0562-00	5.6 k	$\frac{1}{4}$ W			
R74	316-0562-00	5.6 k	$\frac{1}{4}$ W			
R80	311-0462-00	1 k		Var		
R82	316-0152-00	1.5 k	$\frac{1}{4}$ W			
R84	316-0471-00	470 $\Omega$	$\frac{1}{4}$ W			
R85	317-0511-00	510 $\Omega$	$\frac{1}{8}$ W			5%
R92	316-0103-00	10 k	$\frac{1}{4}$ W			
R94	316-0151-00	150 $\Omega$	$\frac{1}{4}$ W			
R95	316-0103-00	10 k	$\frac{1}{4}$ W			
R96	315-0750-00	75 $\Omega$	$\frac{1}{4}$ W			5%

†Furnished as a unit with SW30.

## Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R100	315-0200-00	20 $\Omega$	$\frac{1}{4}$ W		5%
R103	316-0470-00	47 $\Omega$	$\frac{1}{4}$ W		
R104	311-0480-00	500 $\Omega$		Var	
R106	311-0463-00	5 k		Var	
R107	301-0163-00	16 k	$\frac{1}{2}$ W		5%
R110	321-0234-00	2.67 k	$\frac{1}{8}$ W		Prec 1%
R112	315-0200-00	20 $\Omega$	$\frac{1}{4}$ W		5%
R114	321-0227-00	2.26 k	$\frac{1}{8}$ W		Prec 1%
R116	311-0463-00	5 k		Var	
R117	321-0198-00	1.13 k	$\frac{1}{8}$ W		Prec 1%
R118†	311-0417-00	5 k		Var	
R124	316-0471-00	470 $\Omega$	$\frac{1}{4}$ W		
R125	317-0511-00	510 $\Omega$	$\frac{1}{8}$ W		5%
R130	316-0331-00	330 $\Omega$	$\frac{1}{4}$ W		
R134	316-0471-00	470 $\Omega$	$\frac{1}{4}$ W		
R135	316-0100-00	10 $\Omega$	$\frac{1}{4}$ W		
R150	316-0561-00	560 $\Omega$	$\frac{1}{4}$ W		
R160	315-0242-00	2.4 k	$\frac{1}{4}$ W		5%
R163	315-0202-00	2 k	$\frac{1}{4}$ W		5%
R165	311-0480-00	500 $\Omega$		Var	
R169	315-0112-00	1.1 k	$\frac{1}{4}$ W		5%
R205	303-0202-00	2 k	1 W		5%
R210	316-0561-00	560 $\Omega$	$\frac{1}{4}$ W		
R211	311-0496-00	2.5 k		Var	
R212	316-0222-00	2.2 k	$\frac{1}{4}$ W		
R215	316-0822-00	8.2 k	$\frac{1}{4}$ W		
R217	316-0332-00	3.3 k	$\frac{1}{4}$ W		
R220	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W		5%
R222	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W		5%
R225	321-0001-00	10 $\Omega$	$\frac{1}{8}$ W		Prec 1%
R230	311-0510-00	10 k		Var	
R232	316-0822-00	8.2 k	$\frac{1}{4}$ W		
R234	315-0162-00	1.6 k	$\frac{1}{4}$ W		5%
R236	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W		5%
R238	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W		5%
R260	316-0561-00	560 $\Omega$	$\frac{1}{4}$ W		
R261	311-0496-00	2.5 k		Var	
R262	316-0222-00	2.2 k	$\frac{1}{4}$ W		
R265	316-0822-00	8.2 k	$\frac{1}{4}$ W		
R267	316-0332-00	3.3 k	$\frac{1}{4}$ W		
R270	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W		5%
R272	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W		5%
R280	311-0510-00	10 k		Var	
R282	316-0822-00	8.2 k	$\frac{1}{4}$ W		

†Furnished as a unit with SW118.

# Electrical Parts List—Type R293

## Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R284	315-0162-00	1.6 k	1/4 W			5%
R286	307-0103-00	2.7 $\Omega$	1/4 W			5%
R288	307-0103-00	2.7 $\Omega$	1/4 W			5%
R293	311-0487-00	30 k		Var		
R294	311-0315-00	20 k		Var		
R296	311-0448-00	20 k		Var		
R301	307-0024-00	2.7 $\Omega$	1/2 W			
R303	307-0024-00	2.7 $\Omega$	1/2 W			
R305	302-0104-00	100 k	1/2 W			
R306	307-0024-00	2.7 $\Omega$	1/2 W			
R308	307-0103-00	2.7 $\Omega$	1/4 W			5%
R310	307-0103-00	2.7 $\Omega$	1/4 W			5%
R312	307-0103-00	2.7 $\Omega$	1/4 W			5%
R314	307-0103-00	2.7 $\Omega$	1/4 W			5%
R316	308-0067-00	750 $\Omega$	5 W		WW	5%
R317	308-0298-00	560 $\Omega$	3 W		WW	5%
R320	301-0621-00	620 $\Omega$	1/2 W			5%
R321	311-0463-00	5 k		Var		
R322	315-0752-00	7.5 k	1/4 W			5%
R324	316-0222-00	2.2 k	1/4 W			
R326	308-0365-00	1.5	3 W		WW	5%
R331	316-0151-00	150 $\Omega$	1/4 W			
R334	303-0511-00	510 $\Omega$	1 W			5%
R336	316-0103-00	10 k	1/4 W			
R339	308-0077-00	1 k	3 W		WW	
R341	322-0188-00	887 $\Omega$	1/4 W		Prec	1%
R342	323-0265-00	5.62 k	1/2 W		Prec	1%
R345	316-0104-00	100 k	1/4 W			
R346	316-0223-00	22 k	1/4 W			
R348	316-0221-00	220 $\Omega$	1/4 W			
R350	311-0515-00	250 $\Omega$		Var	WW	
R351	323-0153-00	383 $\Omega$	1/2 W		Prec	1%
R360	311-0442-00	250 $\Omega$		Var		
R363	321-0178-00	698 $\Omega$	1/8 W		Prec	1%
R365	321-0206-00	1.37 k	1/8 W		Prec	1%
R367	316-0392-00	3.9 k	1/4 W			
R368	311-0493-00	500 $\Omega$		Var	WW	
R369	311-0378-00	250 $\Omega$		Var	WW	
R371	307-0024-00	2.7 $\Omega$	1/2 W			
R373	307-0024-00	2.7 $\Omega$	1/2 W			
R375	307-0024-00	2.7 $\Omega$	1/2 W			
R377	302-0272-00	2.7 $\Omega$	1/2 W			
R380	301-0621-00	620 $\Omega$	1/2 W			5%
R381	315-0301-00	300 $\Omega$	1/4 W			5%
R382	311-0442-00	250 $\Omega$		Var		

## Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R384	323-0144-00	309 $\Omega$	$\frac{1}{2}$ W	Var	Prec WW	1%
R386	311-0492-00	500 $\Omega$				
R390	315-0753-00	75 k	$\frac{1}{4}$ W			5%
R392	302-0471-00	470 $\Omega$	$\frac{1}{2}$ W		Prec	1%
R395	323-0214-00	1.65 k	$\frac{1}{2}$ W			
R397	323-0118-00	165 $\Omega$	$\frac{1}{2}$ W		Prec	1%
R398	*310-0622-00	16.5 $\Omega$	4 W		Prec	1%
R401	302-0563-00	56 k	$\frac{1}{2}$ W			
R410	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W			5%
R414	302-0104-00	100 k	$\frac{1}{2}$ W			
R416	301-0433-00	43 k	$\frac{1}{2}$ W	Var		5%
R418	311-0463-00	5 k				
R419	315-0752-00	7.5 k	$\frac{1}{4}$ W			5%
R421	316-0102-00	1 k	$\frac{1}{4}$ W			
R423	315-0623-00	62 k	$\frac{1}{4}$ W			5%
R424	315-0621-00	620 $\Omega$	$\frac{1}{4}$ W			5%
R427	316-0120-00	12 $\Omega$	$\frac{1}{4}$ W			
R430	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W			5%
R434	302-0273-00	27 $\Omega$	$\frac{1}{2}$ W			
R436	316-0270-00	27 $\Omega$	$\frac{1}{4}$ W			
R437	302-0152-00	1.5 k	$\frac{1}{2}$ W			
R438	321-0263-00	5.36 k	$\frac{1}{8}$ W		Prec	1%
R439	321-0307-00	15.4 k	$\frac{1}{8}$ W		Prec	1%
R441	315-0302-00	3 k	$\frac{1}{4}$ W			5%
R442	316-0152-00	1.5 k	$\frac{1}{4}$ W			
R443	316-0821-00	820 $\Omega$	$\frac{1}{4}$ W			
R446	321-0183-00	787 $\Omega$	$\frac{1}{8}$ W		Prec	1%
R450	315-0272-00	2.7 k	$\frac{1}{4}$ W			5%
R452	315-0433-00	43 k	$\frac{1}{4}$ W			5%
R455	308-0075-00	100 $\Omega$	3 W		WW	
R457	315-0512-00	5.1 k	$\frac{1}{4}$ W			5%
R458	311-0462-00	1 k		Var		
R459	315-0822-00	8.2 k	$\frac{1}{4}$ W			5%
R462	308-0077-00	1 k	3 W		WW	
R470	307-0103-00	2.7 $\Omega$	$\frac{1}{4}$ W			5%
R472	316-0221-00	220 $\Omega$	$\frac{1}{4}$ W			
R477	315-0432-00	4.3 k	$\frac{1}{4}$ W			5%
R481	316-0103-00	10 k	$\frac{1}{4}$ W			
R483	315-0202-00	2 k	$\frac{1}{4}$ W			5%
R485	315-0242-00	2.4 k	$\frac{1}{4}$ W			5%
R487	311-0463-00	5 k			Var	
R490	315-0912-00	9.1 k	$\frac{1}{4}$ W			5%
R494	315-0111-00	110 $\Omega$	$\frac{1}{4}$ W			5%
R497	315-0111-00	110 $\Omega$	$\frac{1}{4}$ W			5%
R502	311-0540-00	2.5 k			Var	
R503	315-0133-00	13 k	$\frac{1}{4}$ W			5%
R510	315-0160-00	1.6 k	$\frac{1}{4}$ W			5%
R512	321-0164-00	499 $\Omega$	$\frac{1}{8}$ W		Prec	1%

# Electrical Parts List—Type R293

## Switches

Ckt. No.	Tektronix Part No.		Description	S/N Range
	Unwired	Wired		
SW10	260-0473-00		Lever	TRIGGER SELECTOR
SW30†	311-0417-00			
SW118††	311-0417-00			
SW205	260-0640-00		Lever	AMPLITUDE PROGRAM
SW290	260-0702-00		Rotary	POLARITY
SW340	260-0703-00		Rotary	MODE
SW350	260-0640-00		Lever	VOLTAGE PROGRAM
SW390	260-0701-00		Rotary	CURRENT MULTIPLIER
SW401	260-0675-00		Slide	115 V-230 V Selector
SW402	260-0199-00		Toggle	POWER ON

## Transformers

T201	*120-0412-00	Toroid	11 turns
T205	*120-0414-00	Toroid	12 turns, bifilar
T301	*120-0411-00	Power	

†Furnished as a unit with R30.

††Furnished as a unit with R118.

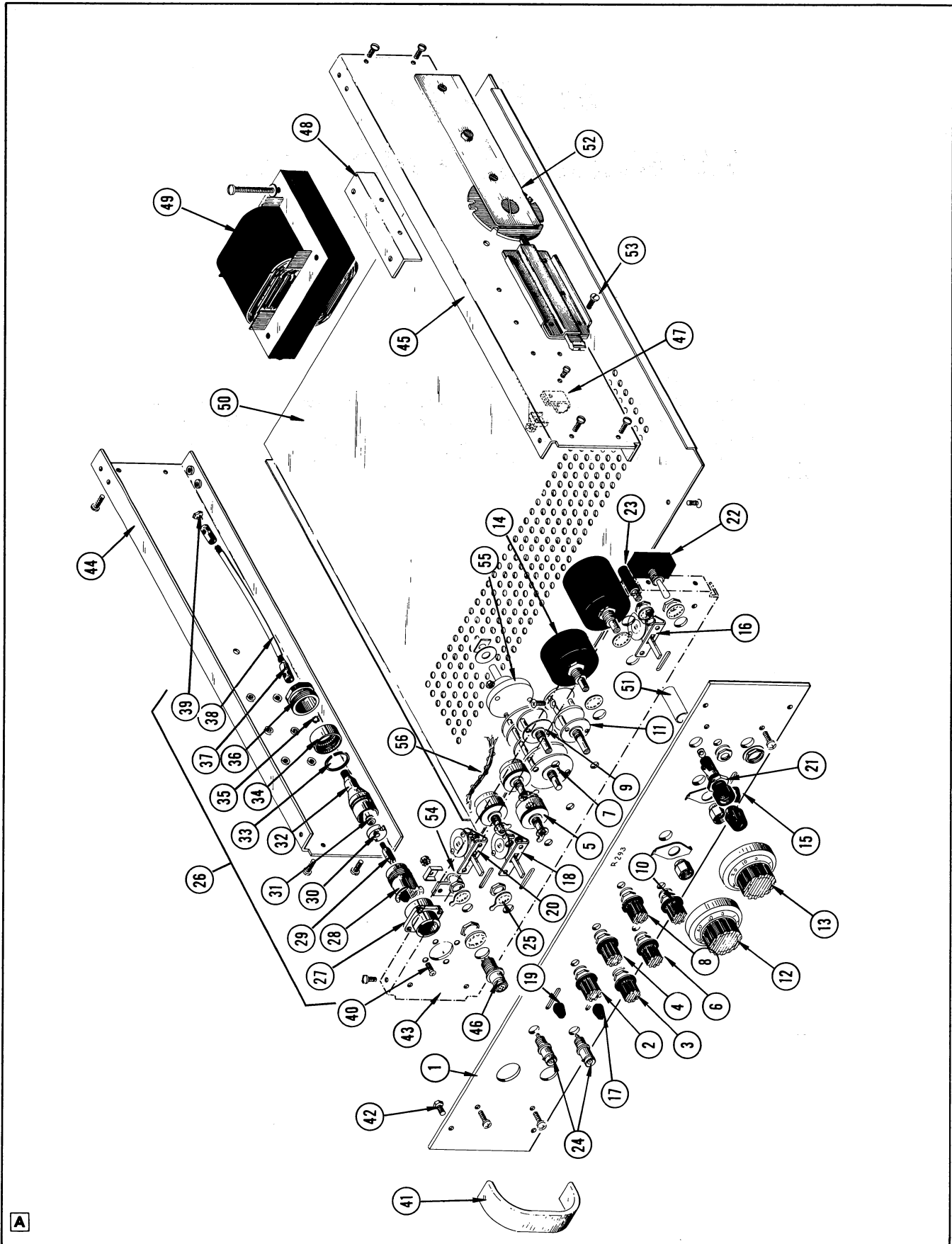


## **SECTION 8**

# **MECHANICAL PARTS LIST**

A list of abbreviations and special symbols in use throughout this manual will be found immediately preceding the Electrical Parts List, Section 7. Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Parts ordering information is also located immediately preceding Section 7.

FRONT & SWITCHES



## FRONT &amp; SWITCHES (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	333-0837-00			1	PANEL, front
	- - - - -			-	mounting hardware: (not included w/panel)
	212-0039-00			4	SCREW, 8-32 x $\frac{3}{8}$ inch, 100° FHS phillips
2	366-0220-00			1	KNOB, charcoal — RATE
	- - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x $\frac{1}{8}$ inch, HSS
3	366-0220-00			1	KNOB, charcoal — AMPLITUDE
	- - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x $\frac{1}{8}$ inch, HSS
4	366-0220-00				KNOB, charcoal — WIDTH
	- - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x $\frac{1}{8}$ inch, HSS
5	- - - - -			3	POT
	- - - - -			-	mounting hardware for each: (not included w/pot)
	210-0207-00			1	LUG, solder, pot, plain, $\frac{3}{8}$ inch
	210-0012-00			1	LOCKWASHER, internal, $\frac{1}{4}$ inch
	210-0978-00			1	WASHER, $\frac{1}{4}$ ID x $\frac{3}{8}$ inch OD
	210-0590-00			1	NUT, hex., $\frac{3}{8}$ -32 x $\frac{7}{16}$ inch
6	366-0220-00			1	KNOB, charcoal — POLARITY
	- - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x $\frac{1}{8}$ inch, HSS
7	260-0702-00			1	SWITCH, unwired — POLARITY
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0978-00			1	WASHER, $\frac{1}{4}$ ID x $\frac{3}{8}$ inch OD
	210-0590-00			1	NUT, hex., $\frac{3}{8}$ -32 x $\frac{7}{16}$ inch
8	366-0220-00			1	KNOB, charcoal — MODE
	- - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x $\frac{1}{8}$ inch, HSS
9	260-0703-00			1	SWITCH, unwired — MODE
	- - - - -			-	mounting hardware (not included w/switch)
	210-0978-00			1	WASHER, $\frac{1}{4}$ ID x $\frac{3}{8}$ inch OD
	210-0590-00			1	NUT, hex., $\frac{3}{8}$ -32 x $\frac{7}{16}$ inch

## FRONT &amp; SWITCHES (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
10	366-0220-00			1	KNOB, charcoal—CURRENT MULTIPLIER
	- - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
11	260-0701-00			1	SWITCH, unwired — CURRENT MULTIPLIER
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0940-00			1	WASHER, 1/4 ID x 3/8 inch OD
	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
12	331-0091-00			1	DIAL ASSEMBLY, w/hardware — REGULATED CURRENT SUPPLY
13	331-0091-00			1	DIAL ASSEMBLY, w/hardware — REGULATED VOLTAGE SUPPLY
14	- - - - -			2	POT w/hardware
15	366-0215-01			1	KNOB, grey, lever — VOLTAGE PROGRAM
16	260-0640-00			1	SWITCH, unwired — VOLTAGE PROGRAM
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
17	366-0215-01			1	KNOB, grey, lever — AMPLITUDE PROGRAM
18	260-0640-00			1	SWITCH, unwired — AMPLITUDE PROGRAM
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
19	366-0215-01			1	KNOB, grey, lever — TRIGGER SELECTOR
20	260-0473-00			1	SWITCH, unwired — TRIGGER SELECTOR
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
21	352-0014-00			1	HOLDER, fuse w/cap
	- - - - -			-	mounting hardware: (not included w/holder)
	- - - - -			1	NUT
	210-0873-00			1	WASHER, rubber, 1/2 ID x 1 1/16 inch OD
22	260-0199-00			1	SWITCH, toggle
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0414-00			1	NUT, hex., 15/32-32 x 9/16 inch
	354-0055-00			1	RING, locking
	210-0902-00			1	WASHER, flat, .470 ID x 2 1/32 inch OD
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided

## FRONT &amp; SWITCHES (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
23	150-0041-00			1	BULB ASSEMBLY, neon, amber lens
	- - - - -			-	mounting hardware: (not included w/assembly)
	210-0012-00			1	LOCKWASHER, pot, internal, $\frac{3}{8} \times \frac{1}{2}$ inch
	210-0413-00			1	NUT, hex., $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
	210-0978-00			1	WASHER, flat, $\frac{3}{8}$ ID x $\frac{1}{2}$ inch OD
	210-0590-00			1	NUT, hex., $\frac{3}{8}$ -32 x $\frac{7}{16}$ inch
24	131-0352-00			2	CONNECTOR, BNC, w/nut
	- - - - -			-	mounting hardware for each: (not included w/connector)
25	210-0255-00			1	LUG, solder, pot, $\frac{3}{8}$ inch
26	175-0357-00			1	CABLE ASSEMBLY, w/connector
	- - - - -			-	assembly includes:
27	132-0040-00			1	ADAPTER
28	132-0002-00			1	SLEEVE, conductor, outer
29	132-0029-00			1	INNER CONDUCTOR
30	132-0116-00			1	INNER TRANSITION
31	132-0028-00			1	INSULATOR
32	132-0115-00			1	OUTER TRANSITION
33	132-0007-00			1	SNAP RING
34	132-0001-00			1	NUT, coupling
35	132-0119-00			1	DISC, teflon
36	132-0121-00			1	NUT, retaining
37	132-0117-00			2	FERRULE
38	175-0007-00			FT	CABLE, 5 inches
39	131-0326-00			1	CONNECTOR, board
	- - - - -			-	mounting hardware: (not included w/assembly)
40	211-0038-00			4	SCREW, 4-40 x $\frac{5}{16}$ inch, phillips
41	367-0044-00			2	HANDLE, oval
	- - - - -			-	mounting hardware for each: (not included w/handle)
42	213-0090-00			2	SCREW, 10-32 x $\frac{1}{2}$ inch, Hex.
43	386-0195-00			1	PLATE, subpanel, front
44	122-0129-00			1	RAIL, left
	- - - - -			-	mounting hardware: (not included w/rail)
	212-0004-00			6	SCREW, 8-32 x $\frac{5}{16}$ inch, PHS phillips
	212-0023-00			4	SCREW, 8-32 x $\frac{3}{8}$ inch, PHS phillips
45	122-0130-00			1	RAIL, right
	- - - - -			-	mounting hardware: (not included w/rail)
	212-0004-00			6	SCREW, 8-32 x $\frac{5}{16}$ inch, PHS phillips
	212-0023-00			4	SCREW, 8-32 x $\frac{3}{8}$ inch, PHS phillips

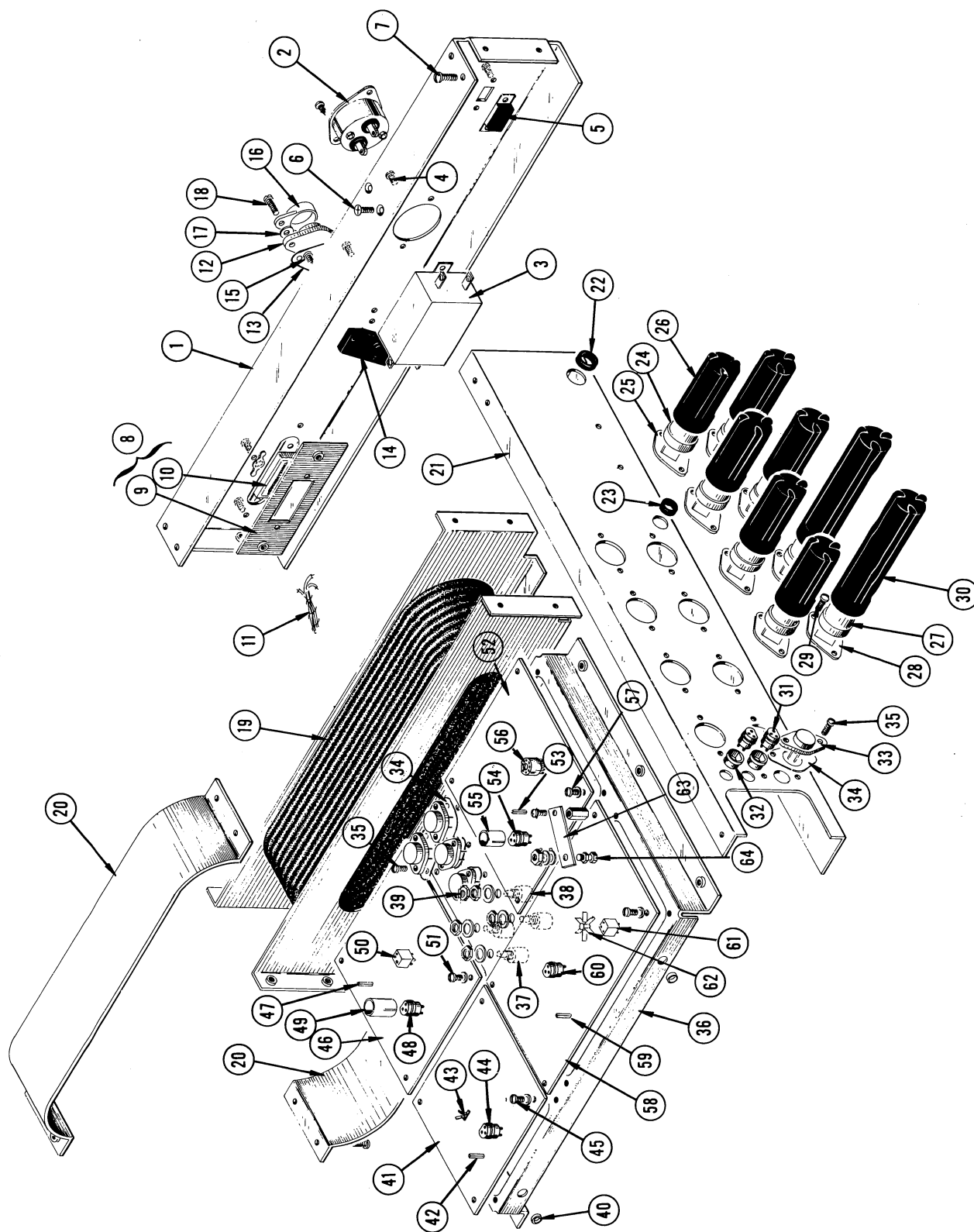
## FRONT &amp; SWITCHES (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
46	131-0206-00			1	CONNECTOR
	- - - - -			-	mounting hardware: (not included w/connector)
	210-0021-00			1	LOCKWASHER
	210-0559-00			1	NUT, hex., $\frac{7}{16}$ -28 x $\frac{9}{16}$ inch
47	343-0002-00			1	CLAMP, cable, $\frac{3}{16}$ inch, plastic
	- - - - -			-	mounting hardware: (not included w/clamp)
	210-0863-00			1	WASHER, "D" type
	210-0457-00			1	NUT, keps, 6-32 x $\frac{5}{16}$ inch
48	407-0141-00			2	BRACKET, transformer
	- - - - -			-	mounting hardware for each: (not included w/bracket)
	212-0004-00			4	SCREW, 8-32 x $\frac{5}{16}$ inch, PHS phillips
49	- - - - -			1	TRANSFORMER
	- - - - -			-	mounting hardware: (not included w/transformer)
	210-0812-00			4	WASHER, fiber, #10
	212-0534-00			4	SCREW, 10-32 x 1 inch, PHS phillips
50	286-0198-00			2	COVER, dust
	- - - - -			-	mounting hardware for each: (not included w/cover)
	211-0504-00			4	SCREW, 6-32 x $\frac{1}{4}$ inch, PHS phillips
51	200-0237-00			1	COVER, insulation, clear polyethylene, $1\frac{5}{8}$ inches long
52	351-0027-00			1	TRACK
	- - - - -			-	mounting hardware: (not included w/track)
53	212-0023-00			12	SCREW, 8-32 x $\frac{3}{8}$ inch, PHS phillips
	210-0008-00			12	LOCKWASHER, internal, #8
54	343-0006-00			1	CLAMP, cable $\frac{1}{2}$ inch, plastic
	- - - - -			-	mounting hardware: (not included w/clamp)
	211-0538-00			1	SCREW, 6-32 x $\frac{5}{16}$ inch, FHS phillips
	210-0863-00			1	WASHER, "D" type
	210-0457-00			1	NUT, keps, 6-32 x $\frac{5}{16}$ inch

## FRONT &amp; SWITCHES (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
55	- - - - -			1	TRANSFORMER
	- - - - -			-	mounting hardware: (not included w/transformer)
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x $\frac{3}{16}$ inch
56	179-1020-00			1	CABLE HARNESS, input

CHASSIS



A



## CHASSIS (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	386-0197-00			1	PLATE, rear
2	131-0150-00			1	CONNECTOR, motor base
	- - - - -			-	connector includes:
	205-0014-00			1	SHELL, motor base mounting
	377-0041-00			1	INSERT
	214-0078-00			2	PIN, connecting
	200-0185-00			1	COVER, motor base
	129-0041-00			1	POST, ground
	211-0015-00			1	SCREW, 4-40 x 1/2 inch, RHS phillips
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
	- - - - -			-	mounting hardware: (not included w/connector)
	213-0104-00			2	SCREW, thread forming, #6 x 3/8 inch, THS phillips
3	- - - - -			1	FILTER, line
	- - - - -			-	mounting hardware: (not included w/filter)
4	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
5	- - - - -			1	SWITCH, slide—115 V - 230 V
	- - - - -			-	mounting hardware: (not included w/switch)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
6	212-0040-00			6	SCREW, 8-32 x 3/8 inch, FHS phillips
7	212-0023-00			20	SCREW, 8-32 x 3/8 inch, PHS phillips
8	643-0203-00			1	CONNECTOR AND CABLE ASSEMBLY
	- - - - -			-	assembly includes:
9	131-0333-00			1	CONNECTOR, plate
10	131-0324-00			1	CONNECTOR, 24 pin
	211-0001-00			2	SCREW, 2-56 x 1/4 inch, RHS
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
11	179-1018-00			1	CABLE HARNESS, chassis
	- - - - -			-	mounting hardware: (not included w/assembly)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS phillips
12	- - - - -			1	TRANSISTOR
13	386-0978-00			3	PLATE, mica washer, large
14	136-0135-00			1	SOCKET, transistor
15	211-0089-00			2	SCREW, 2-56 x 3/8 inch, RHS, black
	210-0001-00			2	LOCKWASHER, internal, #2
	211-0405-00			2	NUT, hex., 2-56 x 3/16 inch
16	200-0196-00			1	COVER, transistor
17	210-0802-00			1	WASHER, #6S x 5/16 inch
18	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS

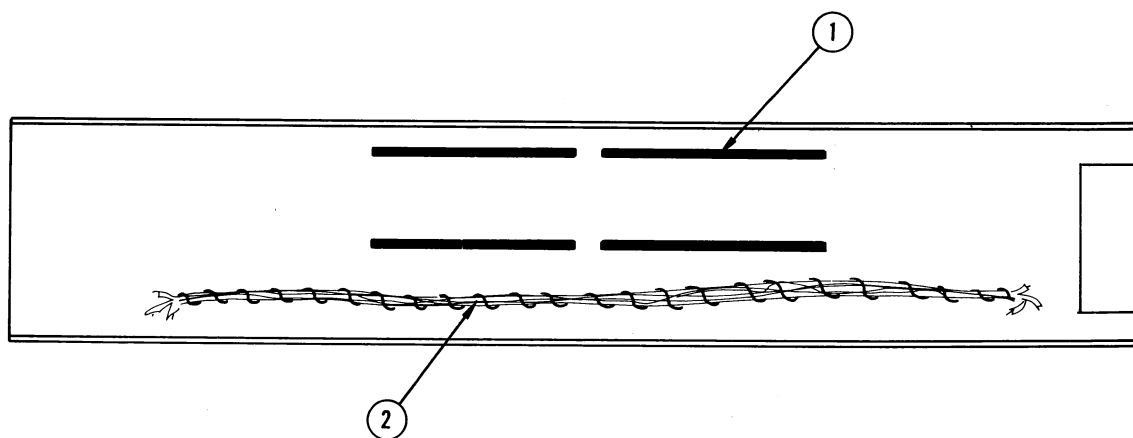
## CHASSIS (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
19	- - - - -			1	DELAY LINE ASSEMBLY
	- - - - -			-	assembly includes:
20	200-0623-00			2	COVER
	211-0510-00			4	SCREW, 6-32 x $\frac{3}{8}$ inch, PHS phillips
	- - - - -			-	mounting hardware: (not included w/delay line)
	212-0004-00			4	SCREW, 8-32 x $\frac{5}{16}$ inch, PHS phillips
	210-0458-00			4	NUT, keps, 8-32 x $\frac{11}{32}$ inch
21	386-0196-00			1	PLATE, bulkhead
22	348-0064-00			1	GROMMET, plastic, $\frac{5}{8}$ inch
23	348-0063-00			2	GROMMET, plastic, $\frac{1}{2}$ inch
24	- - - - -			6	CAPACITOR
	- - - - -			-	mounting hardware for each: (not included w/capacitor)
25	386-0252-00			1	PLATE, fiber
	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips w/lockwasher
	210-0457-00			2	NUT, keps, 6-32 x $\frac{5}{16}$ inch
26	200-0256-00			6	COVER, capacitor
27	- - - - -			2	CAPACITOR
	- - - - -			-	mounting hardware for each: (not included w/capacitor)
28	386-0252-00			1	PLATE, fiber
29	211-0534-00			2	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips w/lockwasher
	210-0457-00			2	NUT, keps, 6-32 x $\frac{5}{16}$ inch
30	200-0255-00			2	COVER, capacitor
31	136-0181-00			2	SOCKET, transistor
32	354-0234-00			2	RING, transistor socket
33	- - - - -			3	TRANSISTOR
	- - - - -			-	mounting hardware for each: (not included w/transistor)
34	386-0143-00			1	PLATE, mica, small
35	211-0510-00			2	SCREW, 6-32 x $\frac{3}{8}$ inch, PHS phillips
	210-0811-00			2	WASHER, fiber, shouldered
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0202-00			1	LUG, solder, SE #6
	210-0407-00			2	NUT, hex., 6-32 x $\frac{1}{4}$ inch
	210-0802-00			1	WASHER, 6S x $\frac{5}{16}$ inch
36	441-0628-00			1	CHASSIS
37	- - - - -			4	POT
	- - - - -			-	mounting hardware for each: (not included w/pot)
38	210-0940-00			1	WASHER, $\frac{1}{4}$ ID x $\frac{3}{8}$ inch OD
	210-0583-00			1	NUT, hex., $\frac{1}{4}$ -32 x $\frac{5}{16}$ x $\frac{1}{16}$ inch thick
39	210-0598-00			1	NUT, hex., $\frac{1}{4}$ -32 x $\frac{5}{16}$ x $\frac{1}{8}$ inch thick, locking
40	348-0055-00			2	GROMMET, plastic, $\frac{1}{4}$ inch

## CHASSIS (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
41	670-0212-00			1	ASSEMBLY, etched wiring board, PULSE SHAPER
	- - - - -			-	assembly includes:
42	214-0506-00			6	PIN
43	344-0108-00			8	CLIP, diode
44	136-0183-00			2	SOCKET, transistor
	388-0658-00			1	BOARD, etched wiring, unwired
	- - - - -			-	mounting hardware: (not included w/assembly)
45	211-0601-00			4	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips w/lockwasher
	210-0457-00			4	NUT, keps, 6-32 x $\frac{5}{16}$ inch
46	670-0209-00			1	ASSEMBLY, etched wiring board, PULSE GENERATOR POWER
	- - - - -			-	assembly includes:
47	214-0506-00			25	PIN
48	136-0183-00			10	SOCKET, transistor
49	214-0269-00			1	HEAT SINK
50	136-0220-00			5	SOCKET, transistor
	388-0647-00			1	BOARD, etched wiring, unwired
	- - - - -			-	mounting hardware: (not included w/assembly)
51	211-0601-00			4	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips w/lockwasher
	210-0457-00			4	NUT, keps, 6-32 x $\frac{5}{16}$ inch
52	670-0210-00			1	ASSEMBLY, etched wiring board, PROGRAMMABLE POWER
	- - - - -			-	assembly includes:
53	214-0506-00			23	PIN
54	136-0183-00			4	SOCKET, transistor
55	214-0269-00			1	HEAT SINK
56	136-0186-00			1	SOCKET, transistor, dual
	388-0648-00			1	BOARD, etched wiring, unwired
	- - - - -			-	mounting hardware: (not included w/assembly)
57	211-0601-00			4	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips w/lockwasher
	210-0457-00			4	NUT, keps, 6-32 x $\frac{5}{16}$ inch
58	670-0212-00			1	ASSEMBLY, etched wiring board, PULSE GENERATOR
	- - - - -			-	assembly includes:
59	214-0506-00			16	PIN
60	136-0183-00			2	SOCKET, transistor
61	136-0220-00			16	SOCKET, transistor
62	214-0498-00			1	HEAT SINK
	388-0649-00			1	BOARD, etched wiring, unwired
	- - - - -			-	mounting hardware: (not included w/assembly)
	211-0601-00			3	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips w/lockwasher
	210-0457-00			3	NUT, keps, 6-32 x $\frac{5}{16}$ inch
63	386-1011-00			1	PLATE, transistor support
	- - - - -			-	mounting hardware: (not included w/plate)
	384-0519-00			1	ROD, hex
	211-0507-00			1	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips
	211-0534-00			1	SCREW, 6-32 x $\frac{5}{16}$ inch, PHS phillips, w/lockwasher
64	214-0653-00			1	HEAT SINK
	- - - - -			-	mounting hardware: (not included w/heat sink)
	210-0983-00			1	WASHER, shouldered, black, anodized
	210-0802-00			1	WASHER, #6S x $\frac{5}{16}$ inch
	210-0457-00			1	NUT, keps, 6-32 x $\frac{5}{16}$ inch

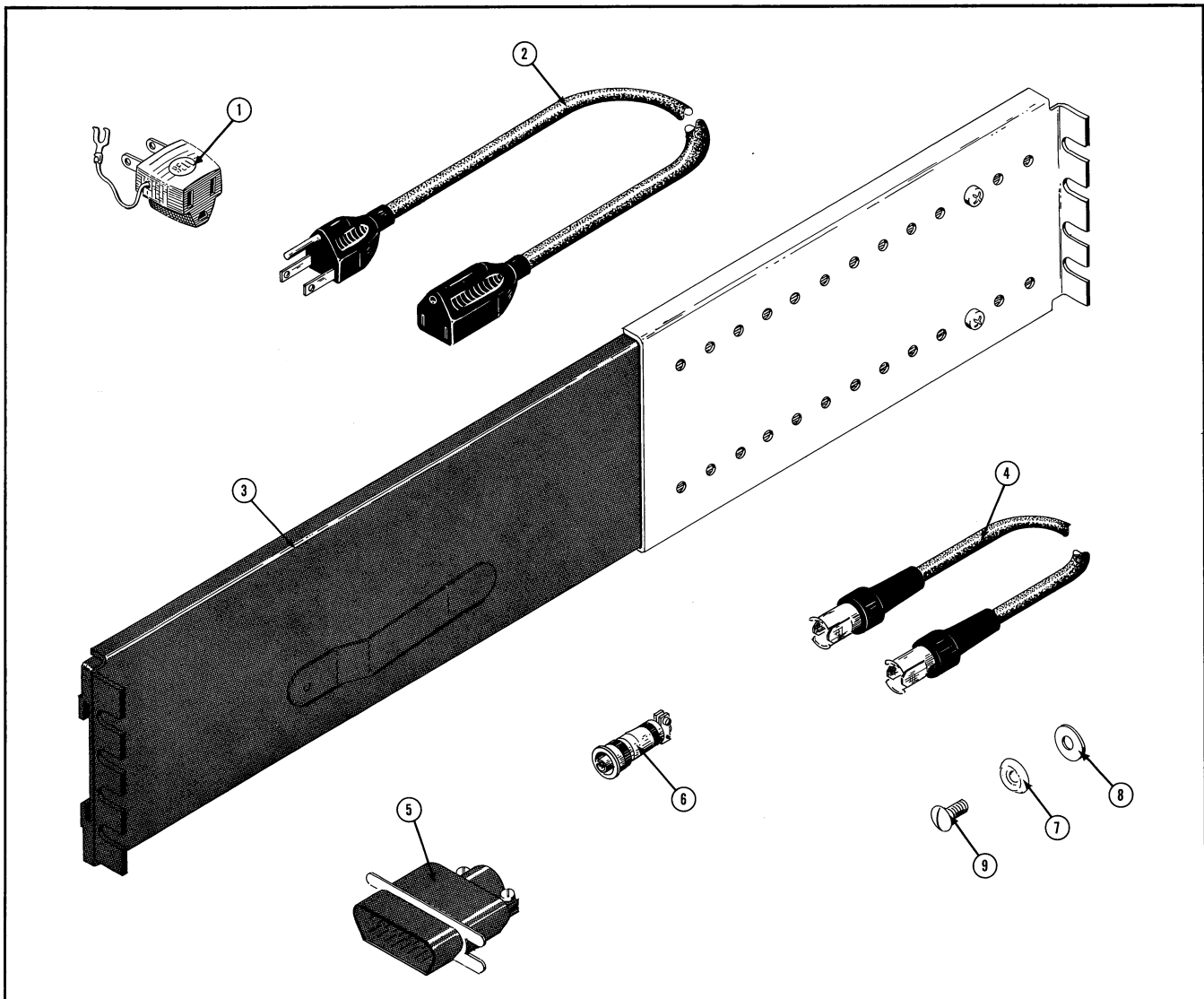
## CERAMIC STRIPS



A

REF. NO.	PART NO.	SERIAL/MODEL NO.		Q T Y.	DESCRIPTION
		EFF.	DISC.		
1	124-0145-00 - - - - - 355-0046-00 - - - - - 361-0009-00			4 - 2 - 2	STRIP, ceramic, $\frac{7}{16}$ inch x 20 notches each strip includes: STUD, nylon mounting hardware for each: (not included w/strip) SPACER, nylon
2	179-1019-00			1	CABLE HARNESS, power

## ACCESSORIES










REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	103-0013-00			1	ADAPTER, power cord, 3 wire to 2 wire
2	161-0015-00			1	CORD, power, 20 gauge, 8 feet, 3 wire
3	351-0084-00			1	TRACK, slide, stationary and inter-sections, pair, left & right
4	017-0502-00			1	CABLE, 50 $\Omega$ , 50 Nsec delay
5	131-0325-00			1	CONNECTOR, 24 pin, cable end, male
6	131-0268-00			1	CONNECTOR, cable plug, 4 male contact w/strain relief
7	210-0833-00			2	WASHER, steel, finishing, #10
8	210-0917-00			2	WASHER, teflon, $\frac{5}{8}$ OD x .191 ID x .125 inch thick
9	212-0512-00			2	SCREW, 10-32 x $\frac{1}{2}$ inch, OHS
--	070-0433-00			2	MANUAL, instruction (not shown)

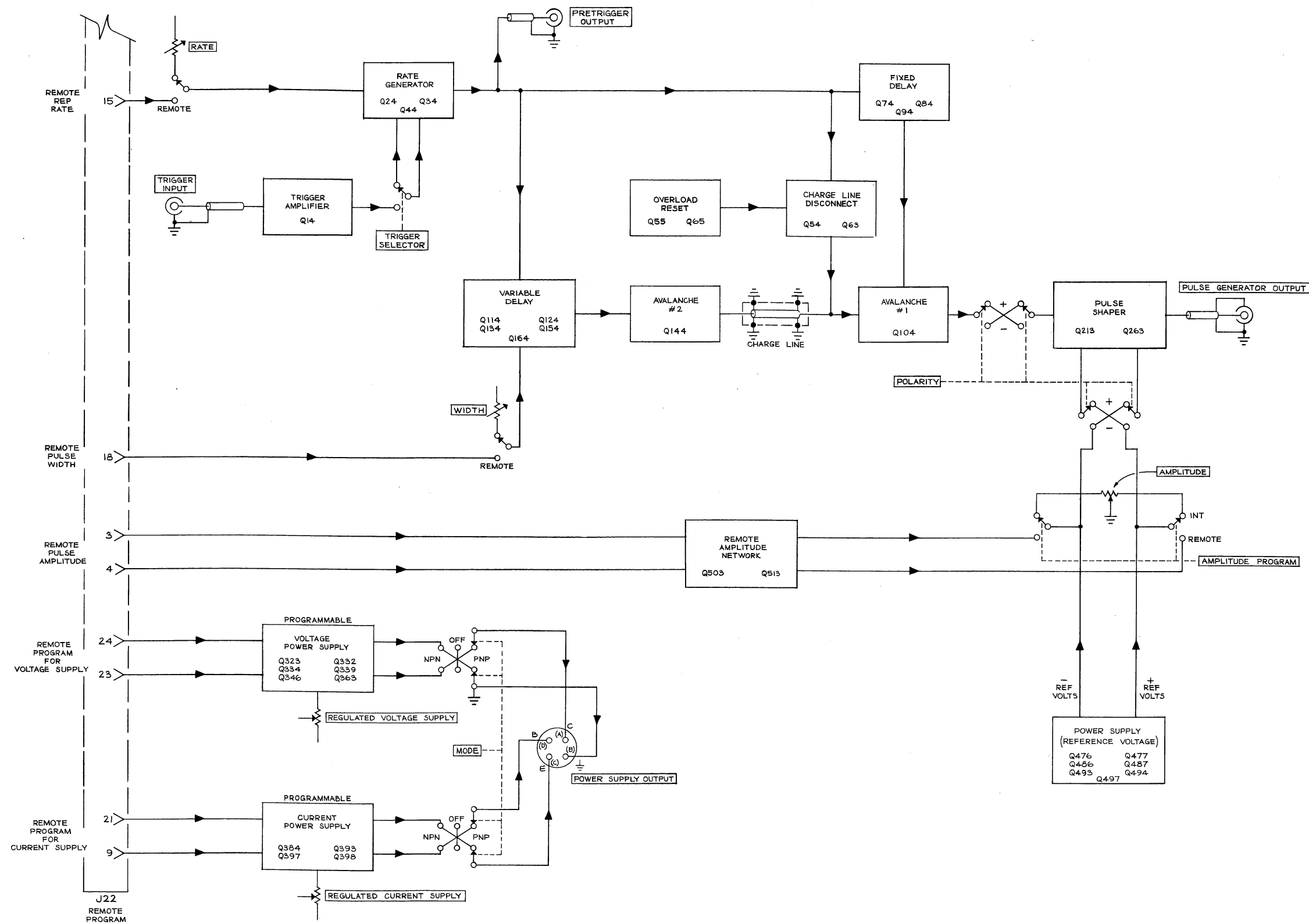
## This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

## SECTION 9

### DIAGRAMS

The following symbols are used on the schematics:

	Screwdriver adjustment
	Front-panel control or connector.
	Clockwise control rotation in direction of arrow.
	Connection made at indicated pin on etched-wiring board.
	Connection soldered to etched-wiring board.
	Blue line encloses components located on etched-wiring board.
	Input from, or output to indicated schematic.



TYPE R293

A

BLOCK DIAGRAM

  
865



## IMPORTANT

### Voltage and Waveform Conditions

Voltages measured with a 20,000 ohms/volt VOM. All readings in volts. Voltages are measured with respect to chassis ground unless otherwise noted.

Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Voltages and waveforms on the schematics (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, calibration or front-panel control settings. Any apparent differences between voltage levels measured with the voltmeter and those shown on the waveforms are due to circuit loading of the voltmeter.

The test oscilloscope used had the following characteristics: Minimum deflection factor, 2 volts/division using a 10X probe; frequency response, dc to 50 MHz. Dc input coupling was used except as noted otherwise. To indicate true time relationship between signals, the test oscilloscope was externally triggered from the PRETRIGGER OUTPUT pulse.

Voltages and waveforms were obtained under the following conditions unless otherwise noted on the individual diagrams:

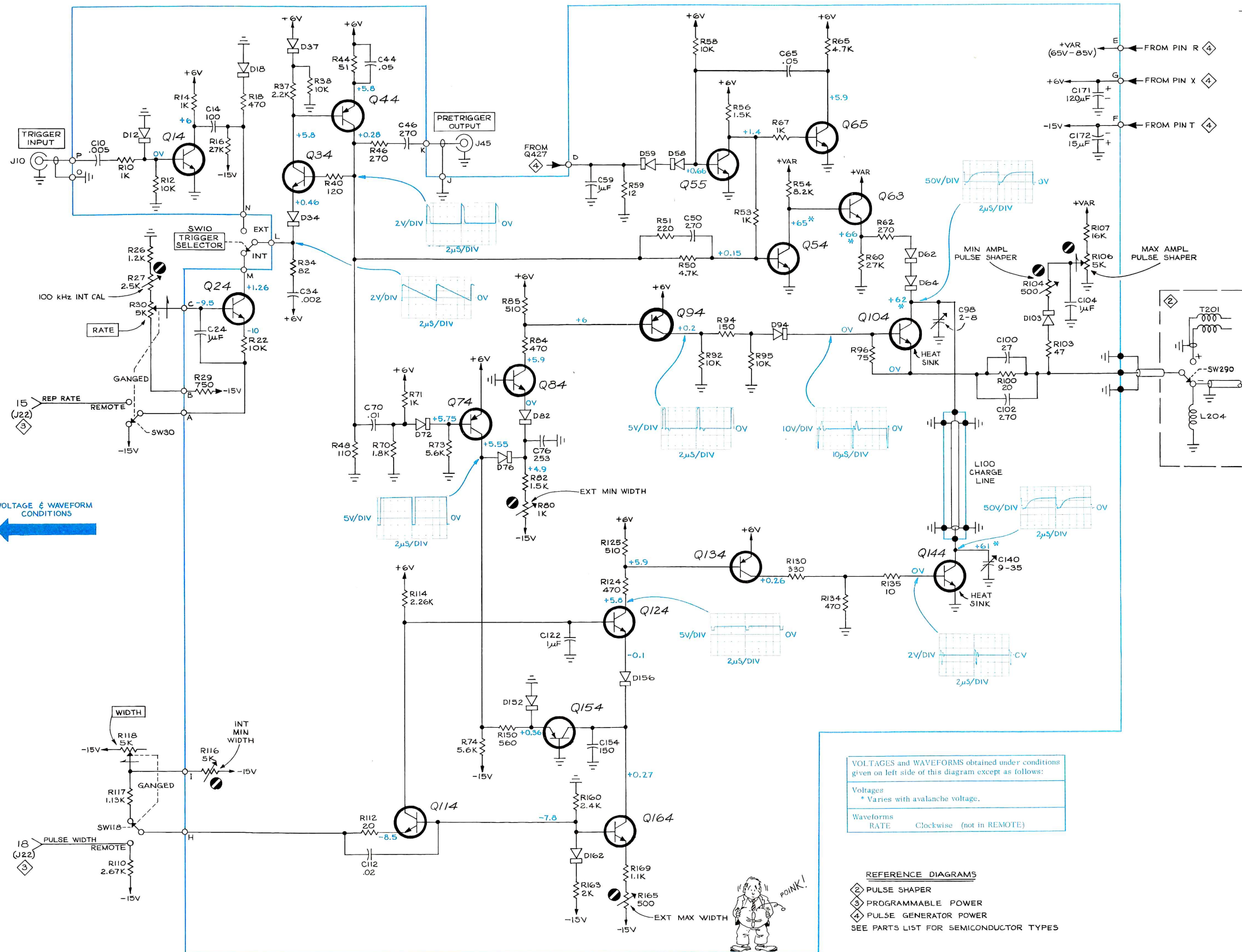
#### Pulse Generator

TRIGGER SELECTOR	INT
RATE	Midrange
WIDTH	Midrange
AMPLITUDE PROGRAM	INT
POLARITY	+
Amplitude	Midrange

#### Power Supply

MODE	NPN
CURRENT MULTIPLIER	X100
REGULATED CURRENT SUPPLY	3.00
REGULATED VOLTAGE SUPPLY	5.00
VOLTAGE PROGRAM	INT

Line Voltage	115 volts
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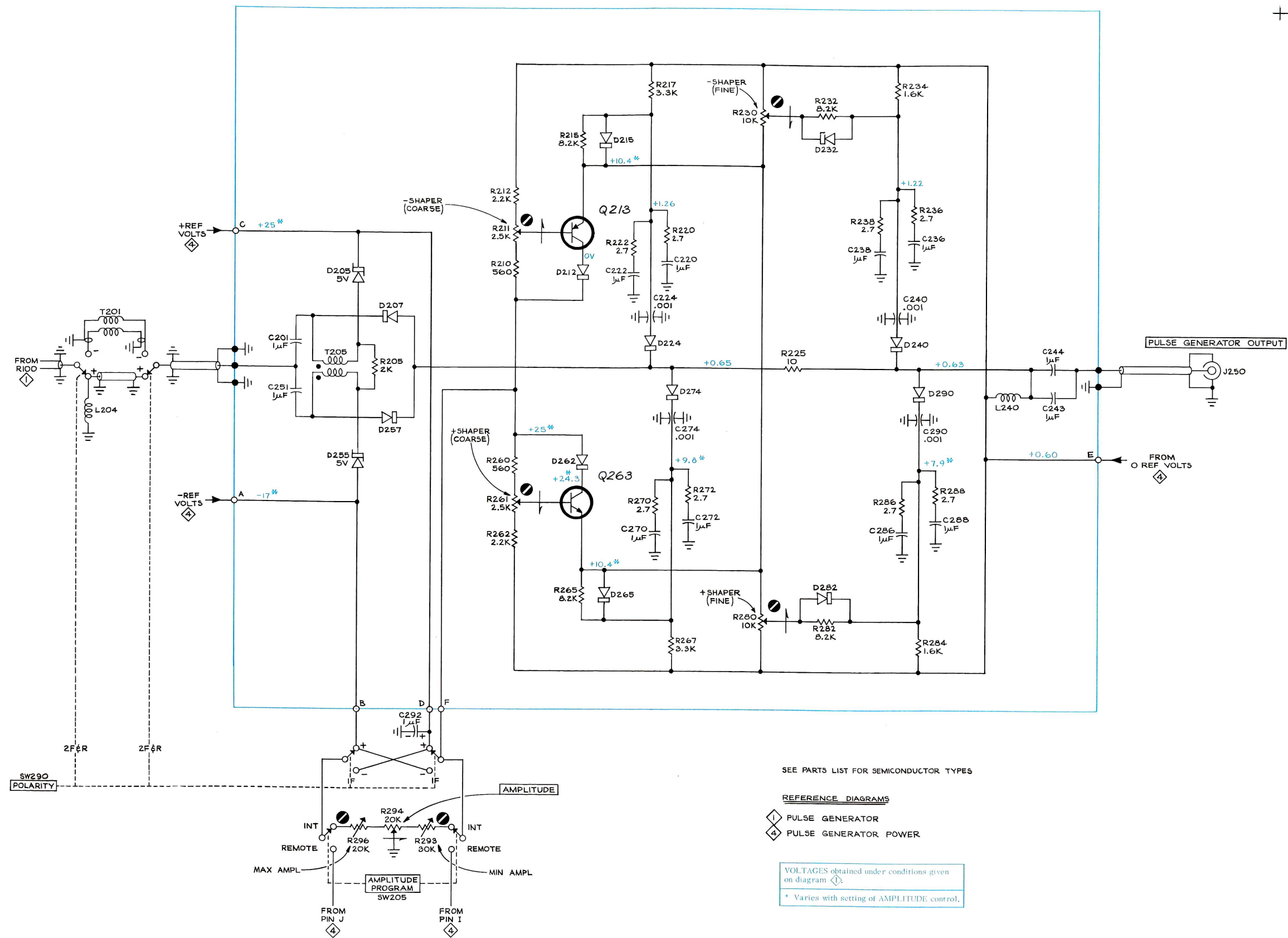


TYPE R293

A

PULSE GENERATOR 1

PULSE GENERATOR 1



TYPE R293

A

PULSE SHAPER 2





### REFERENCE DIAGRAMS

- 2 PULSE SHAPER
- 3 PROGRAMMABLE POWER SUPPLY

### PULSE GENERATOR POWER SUPPLY



# SECTION 10

## RACKMOUNTING

### General Information

The Type R293 is designed to be mounted on slideout tracks in a 19-inch wide rack that has both front and rear rails drilled for universal type mounting (see dimensional drawing). A complete dimensional drawing of the Type R293 is provided on a separate foldout page in this section.

Minimum width of the opening between the left and right front rails (see Fig. 10-1) must be either  $17\frac{5}{8}$  inches or  $17\frac{3}{4}$  inches, depending on the mounting position to be used as described in the Mounting Procedure. At least  $3\frac{1}{2}$  inches of vertical space is required for the front panel of the instrument and a total depth of at least 20 inches is needed—17 inches for the Type R293 and 3 inches or more for power and program cables. Refer to the Operating Instructions section of this manual for cooling requirements.

### Slideout Tracks

Fig. 10-1 shows the Type R293 installed in a cabinet-type rack. The slideout tracks provided with the Type R293 permit it to be extended for maintenance and calibration without removing the instrument from the rack. In the fully extended position, the Type R293 can be tilted and locked in any one of seven positions—horizontal or  $45^\circ$ ,  $90^\circ$  or  $105^\circ$  above or below the horizontal position. To operate the Type R293 in the extended position, be sure the power and program cables are long enough for this purpose. When not extended, the instrument is held into the rack with two securing screws that screw into the front rails of the rack (see Fig. 10-1b).

The slideout tracks consist of two assemblies—one for the left side of the instrument and one for the right side. Fig. 10-2 shows the complete slideout track assembly. The stationary section of each assembly attaches to the front and rear rails of the rack, and the chassis section is attached to the instrument. The intermediate section slides between the stationary and chassis sections and allows the Type R293 to be extended out of the rack. When the instrument is shipped, the stationary and intermediate sections of the tracks are packaged as matched sets, and should not be separated. The left and right assemblies are identical except for the location of the automatic stop. When mounted in the rack, the automatic stop (see Fig. 10-2) should be at the top of both assemblies.

The chassis sections of both assemblies are installed on the instrument and adjusted for correct alignment at the factory prior to shipment.

The small hardware components provided for mounting the stationary section to the rack are shown in Fig. 10-3. Since this hardware is intended to make the tracks compatible with a variety of racks and installation methods, not all of it will be needed for this installation. Use only the hardware that is required for the mounting method used.

### Mounting Procedure

The front flanges of the stationary sections may be mounted in front or behind the front rails of the rack. The mounting position to be used is determined on the basis of the desired effective panel thickness (from the surface of the panel to the front rail), the width of the opening between the rails of the rack and the depth of the rack between rails.

**Minimum Panel Thickness.** By countersinking the mounting screws in the front rails and mounting the front flanges of the tracks **behind** the front rails as shown in Fig. 10-4a, the minimum effective panel thickness of approximately  $\frac{1}{8}$  inch may be obtained (do not countersink the holes if the rails are made of thin metal). In this case, the effective thickness is the actual thickness of the Type R293 front panel. If BHS screws are used instead of countersunk flathead screws, the effective panel thickness will be approximately  $\frac{7}{32}$  inch. In either case with the front flanges mounted behind the front rails and the rear bracket flanges mounted in front of the rear rails, the minimum opening required between the two front rails is  $17\frac{5}{8}$  inches. The minimum distance required from the front rails to the back rails is  $17\frac{3}{4}$  inches and maximum depth between rails is about  $26\frac{1}{2}$  inches. This mounting method is the normal position if the mounting holes are not tapped for #10-32 screws or if the spacing between the front rails is less than  $17\frac{3}{4}$  inches. To use this mounting method if the holes are tapped for #10-32 screws, drill out the threads with a  $\frac{3}{16}$  inch bit.

**Maximum Panel Thickness.** When the flanges of the stationary sections are mounted **in front** of the front rails with BHS screws as shown in Fig. 10-5a, a maximum effective panel thickness of approximately  $\frac{1}{4}$  inch is obtained. If the tracks are to be mounted in this position, the minimum width of the opening between rails must be  $17\frac{3}{4}$  inches. If the width of the opening between the rear rails is also  $17\frac{3}{4}$  inches, this mounting method may be used with rack depths of  $8\frac{1}{2}$  to  $26\frac{1}{2}$  inches between the front and rear rails. This is the normal mounting position if the mounting holes in the front rails are tapped for #10-32 screws.

#### NOTE

The mounting position as shown in Fig. 10-5 for use with tapped mounting holes may also be used with untapped holes by placing bar nuts behind the front rails. Mount in a manner similar to the method shown in Fig. 10-4.

### Instrument Installation

Use the following procedure to install the Type R293 in a rack:

1. Select the proper front-rail mounting holes for the stationary sections using the measurements shown in Fig. 8-6.

2a. If the front flanges of the stationary sections are to be mounted **behind** the front rails, mount each stationary section as shown in Fig. 10-4.

## Rackmounting—Type R293

2b. If the front flanges of the stationary sections are to be mounted **in front** of the front rails, mount each section as shown in Fig. 10-5.

3. Visually check that the left and right stationary sections are parallel with each other.

4. Referring to Fig. 10-9, insert the instrument into the rack, but do not connect the power or program cables and do not install the securing screws until the following adjustments have been made.

## Track Adjustments

To provide easiest operation, adjust the slideout tracks as follows:

1. Position the instrument as shown in Fig. 10-7.
2. Adjust the front of the stationary sections according to the procedure outlined in Fig. 10-7.
3. After adjusting the front of the tracks, slide the instrument all the way into the rack. If the tracks do not slide smoothly, loosen the screws that hold the rear brackets to the rear rails. Allow the rear of both stationary sections to seek their normal position and tighten the screws. If

the instrument still does not slide easily into the rack or if the front panel does not fit correctly, one or both of the chassis sections may require re-adjustment as shown in Fig. 10-8.

4. When the adjustments have been completed and the slideout tracks operate smoothly, connect the power and program cables to the connectors on the rear panel and secure the instrument into the rack with the securing screws and washers as shown in Fig. 10-9.

## Removing or Installing the Type R293

After the slideout tracks have been installed initially and adjusted to the rack, the Type R293 can be removed or reinstalled at any time by following the procedure given in Fig. 10-9. No further adjustments are required.

## Maintenance

The slideout tracks normally require no lubrication. The special finish on the sliding surfaces provides permanent lubrication. However, if the tracks are difficult to operate even after proper adjustment, a thin coating of paraffin may be rubbed onto the sliding surfaces for additional lubrication.

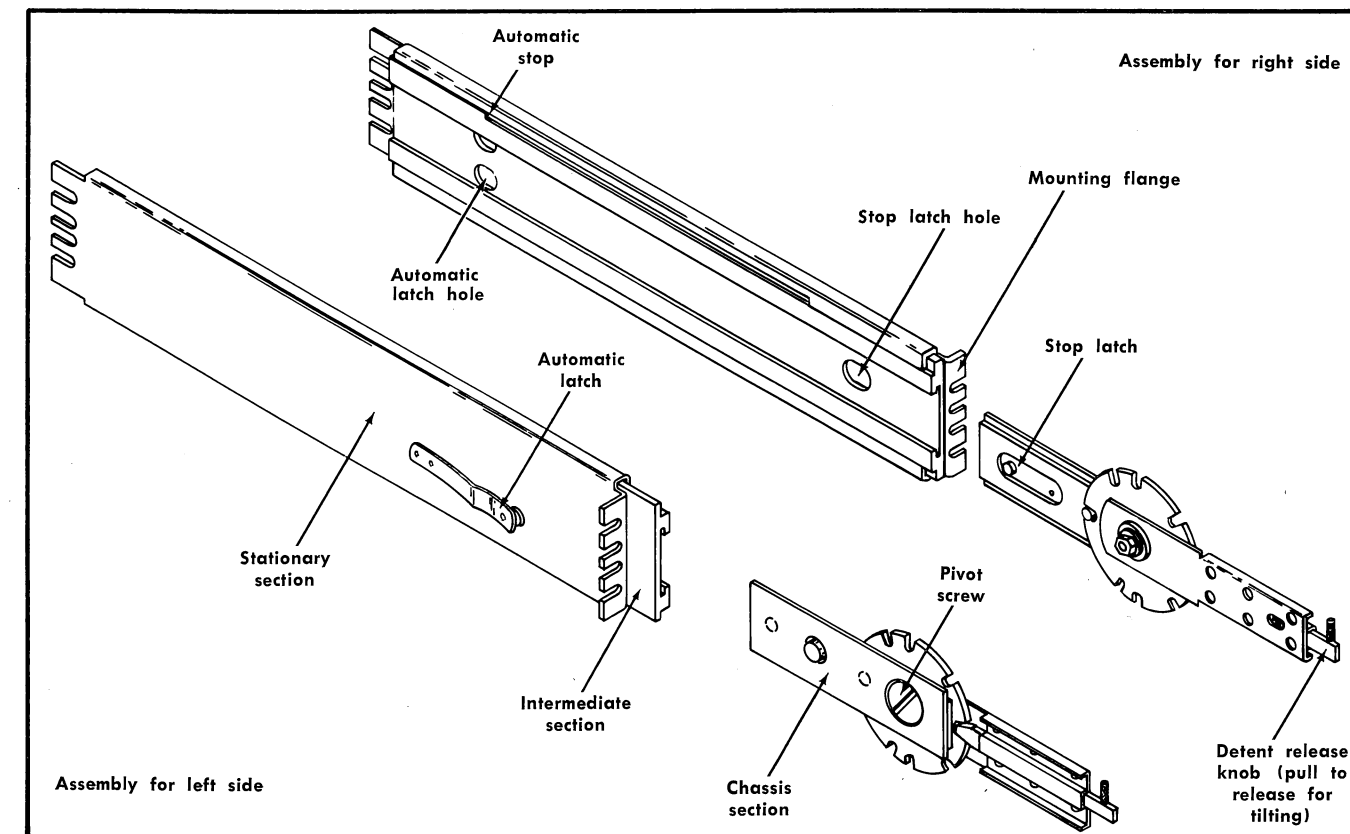


Fig. 10-2. Slideout track assembly.

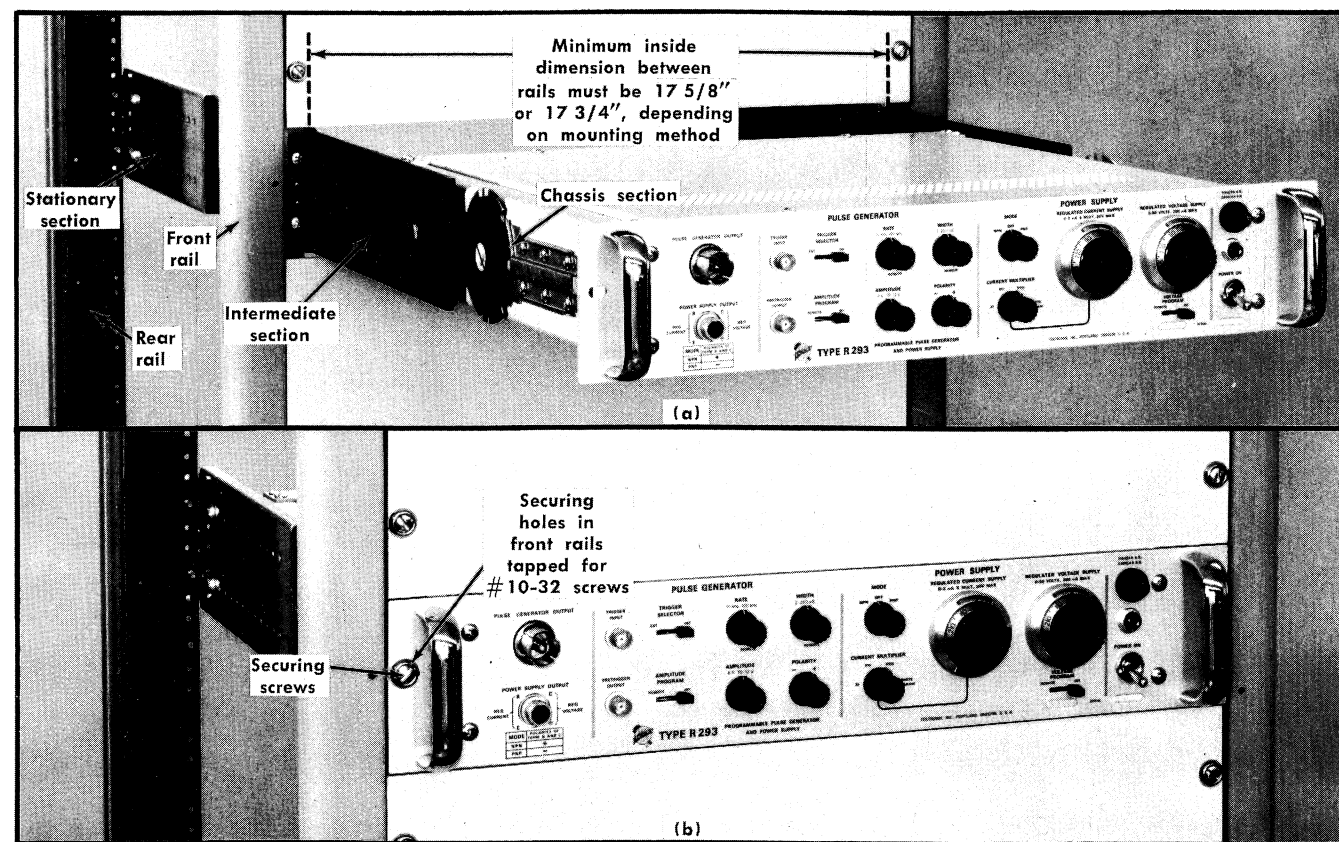


Fig. 10-1. The Type R293 installed in a cabinet-type rack (sides removed). (a) Extended on slideout tracks, (b) Held into rack with securing screws.

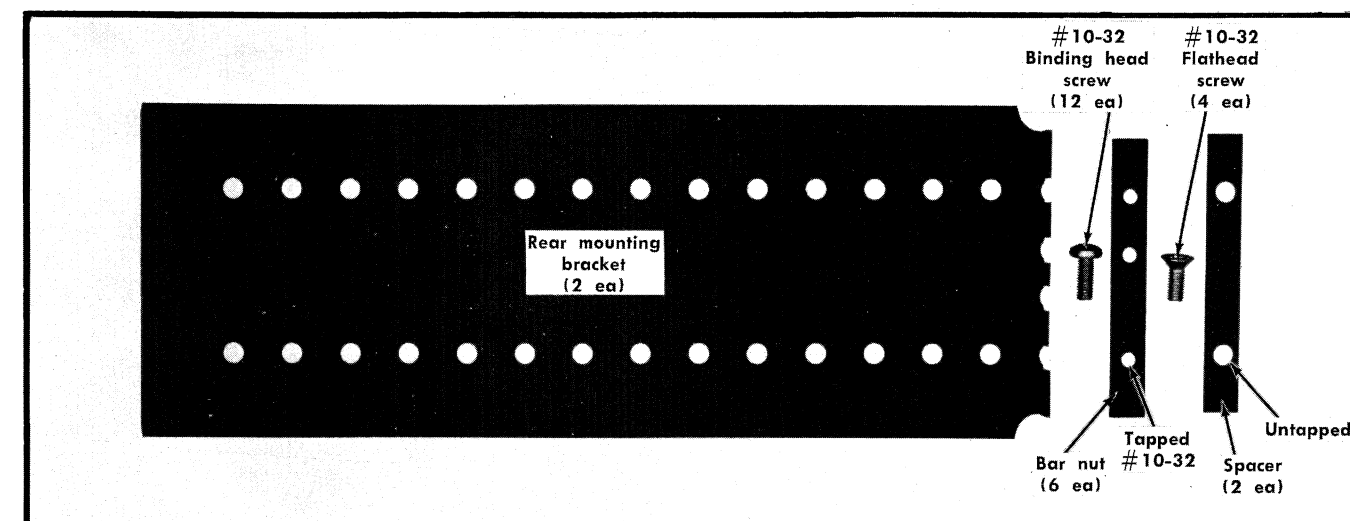
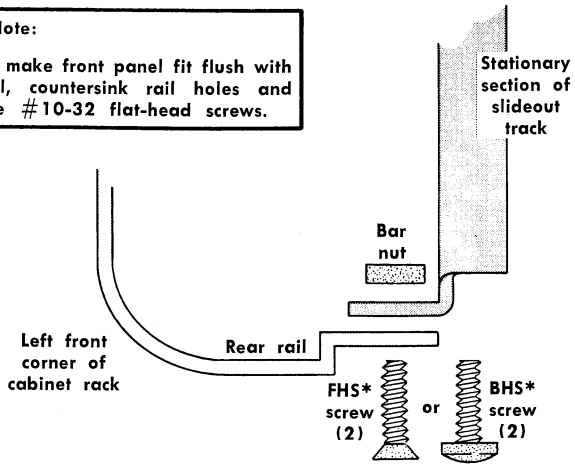


Fig. 10-3. Small hardware components provided for mounting the stationary sections of the slideout tracks to the cabinet-rack rails.

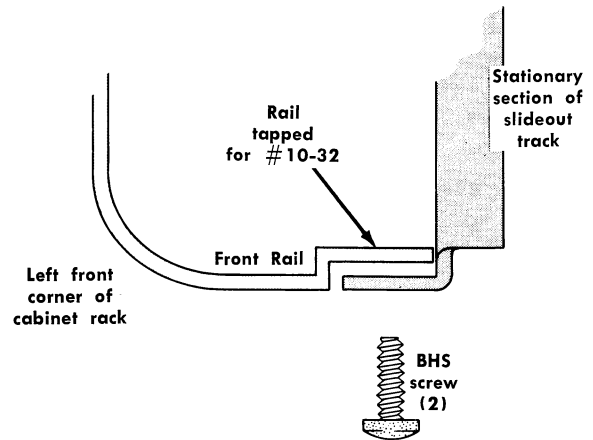
(a) Front

**\*Note:**

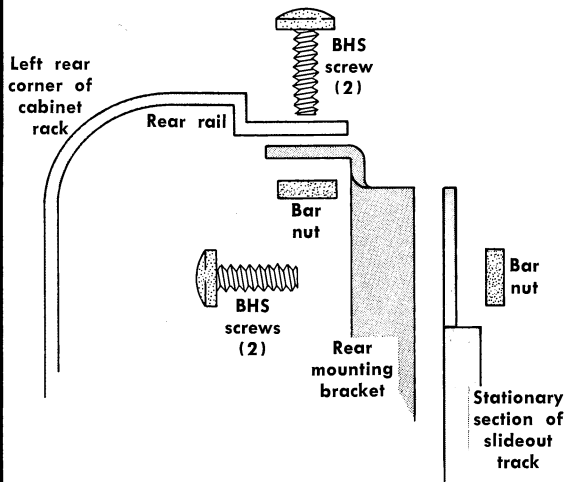
To make front panel fit flush with rail, countersink rail holes and use #10-32 flat-head screws.



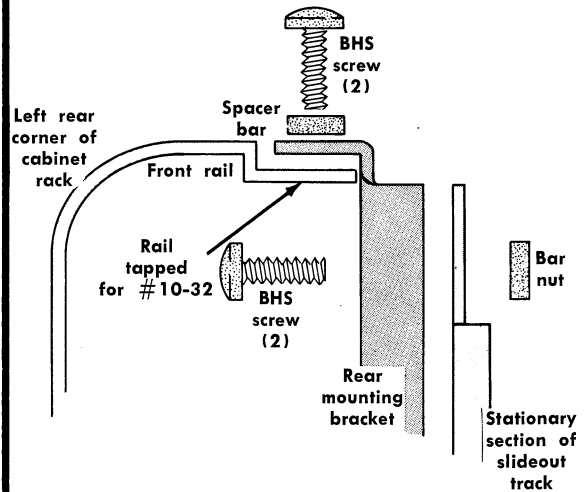
(a) Front



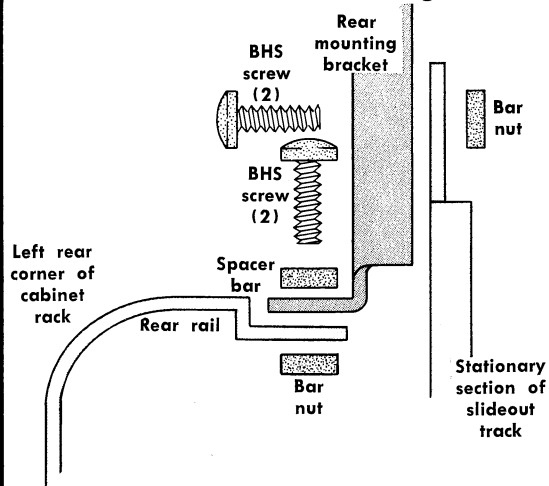
(b) Rear—Deep Rack Configuration:



(b) Rear—Deep Rack Configuration:



(c) Rear—Shallow Rack Configuration:



(c) Rear—Shallow Rack Configuration:

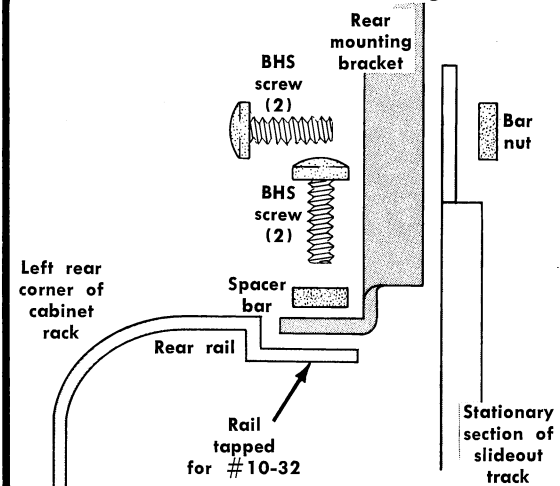


Fig. 10-4. Normal mounting position of the left stationary section for minimum panel thickness.

Fig. 10-5. Normal mounting position of the left stationary section if the mounting holes are tapped for #10-32 screws and the opening between front rails is  $17\frac{3}{4}$ ".



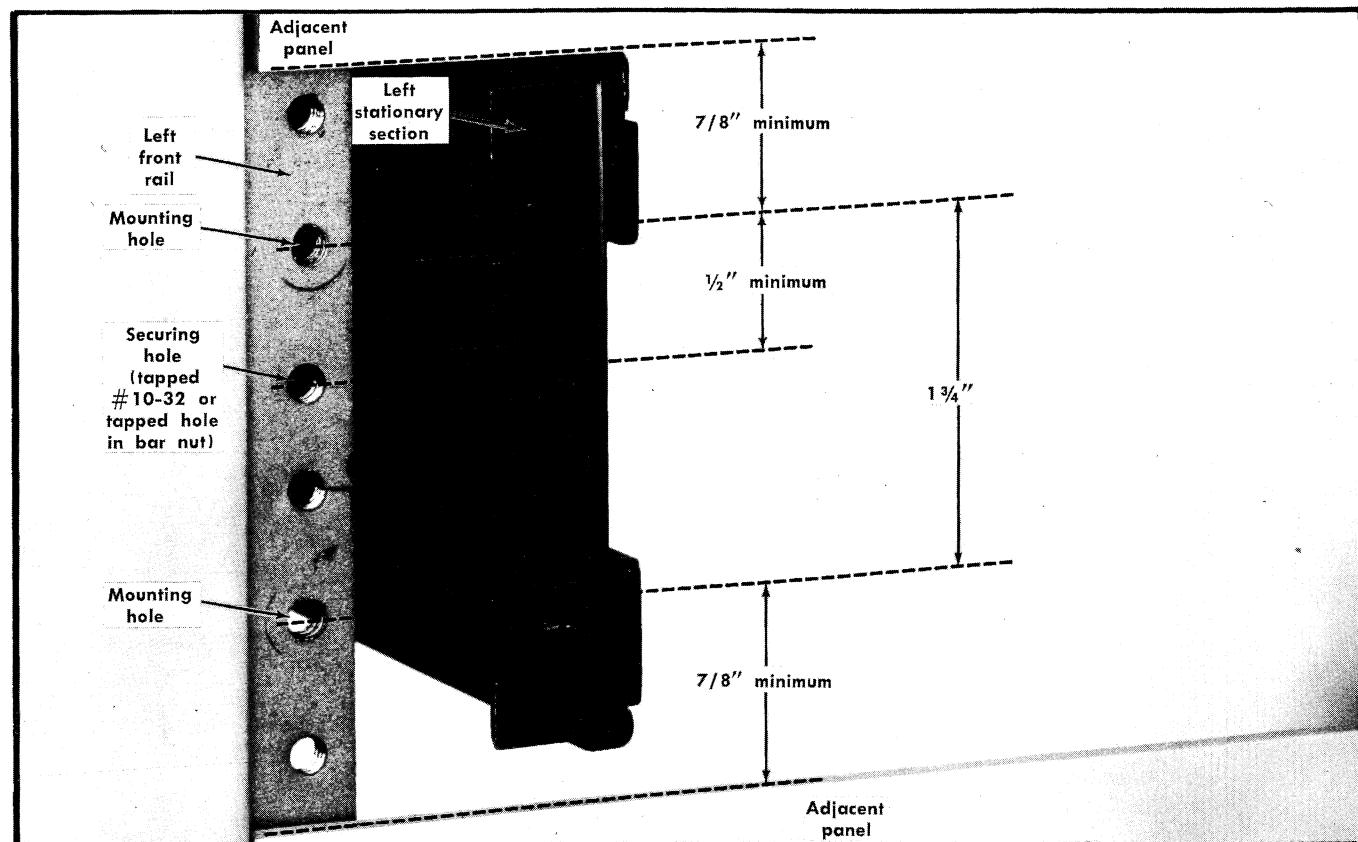


Fig. 10-6. Locating the mounting holes for the left stationary section. Same dimensions apply to the right stationary section.

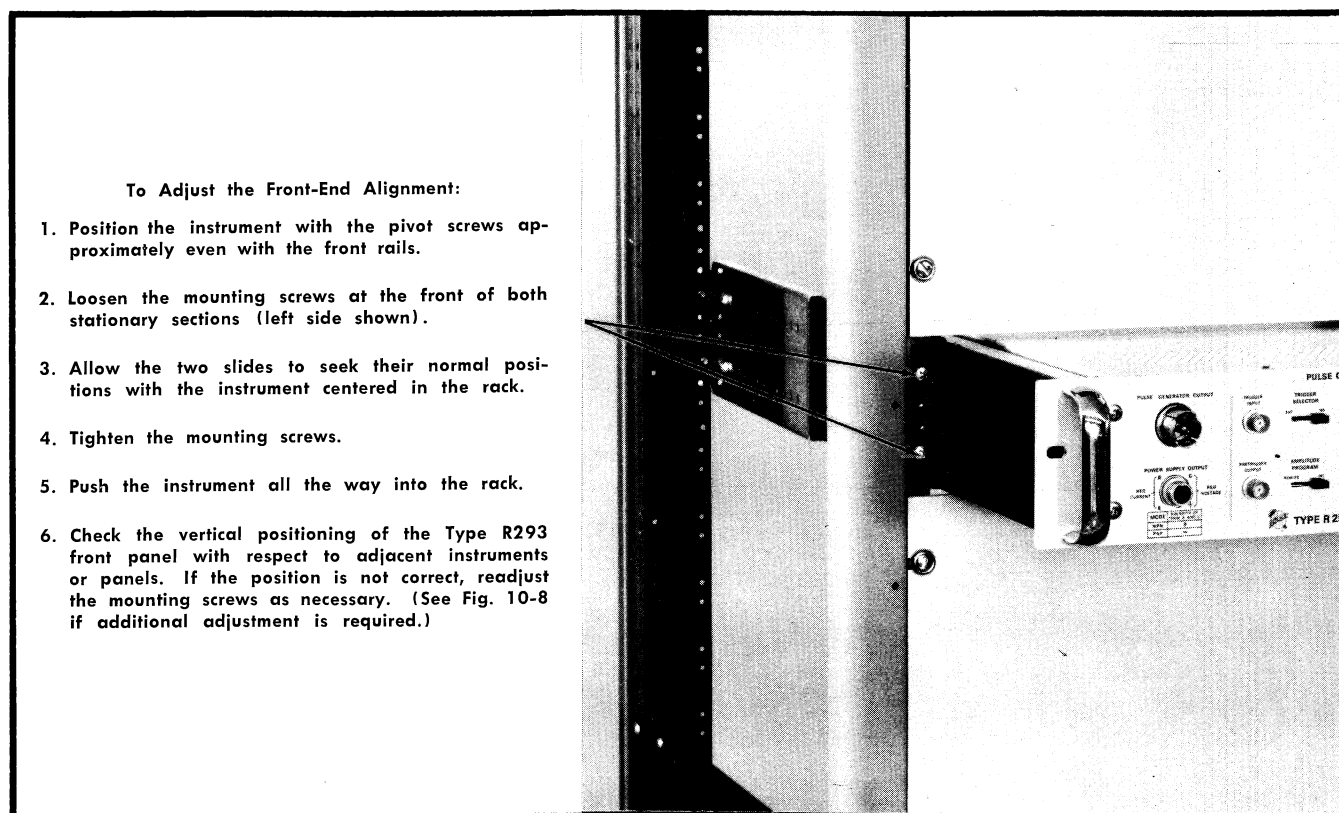


Fig. 10-7. Front-end adjustments for stationary sections.

#### To Adjust Chassis Sections:

1. Remove the top dust cover from instrument.
2. Loosen the nut on the eccentric pivot screw (located inside the instrument) so the pivot screw can be turned.
3. Adjust the pivot screw to align the slide with the bottom of the instrument. (This adjustment may also be made to position the front panel vertically, to align the front panel with the front rails, or to obtain additional adjustment for alignment of the stationary sections.)
4. Hold the pivot screw in position and re-tighten the nut.
5. Repeat steps 2, 3 and 4 for the chassis section on the other side of the instrument if necessary.
6. Reinstall the top dust cover.

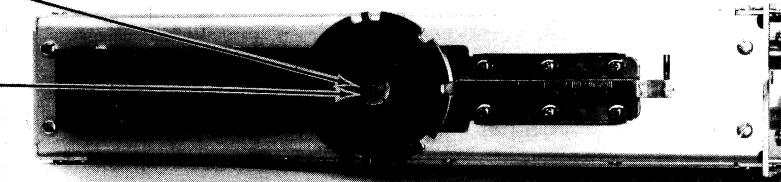
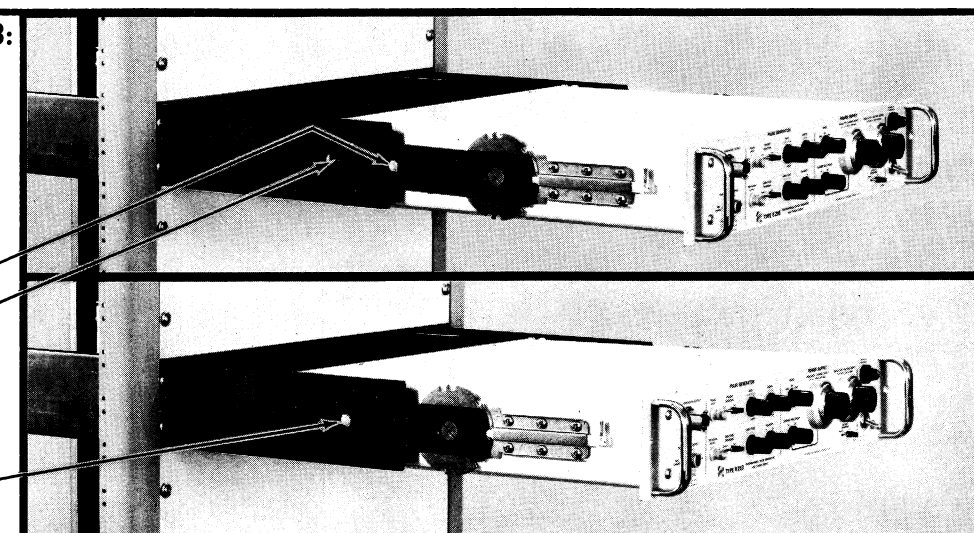


Fig. 10-8. Chassis-section adjustments. Perform only if proper positioning is not obtained with stationary-section adjustments.

#### To insert the Type R293:

1. Pull the intermediate section of each slidout track out to its fully extended position.
2. Insert the chassis sections (on instrument) into the intermediate sections.
3. Press both stop latches and push the instrument into the rack until the latches snap into the stop latch holes.
4. Connect the power cord and program cable to the connectors on the rear panel of the instrument.
5. Again press the stop latches and push the instrument all the way into the rack.
6. To secure the Type R293 into the rack, insert the 2 securing screws (with finishing washers and teflon washers) through the slots in the instrument front panel and screw them into the front rails of the rack.



#### To remove the Type R293:

1. Remove the securing screws and washers.
2. Pull the instrument outward until the stop latches snap into the stop latch holes.
3. Disconnect the power cord and program cable from the instrument.
4. Press both stop latches and pull the instrument out of the rack.

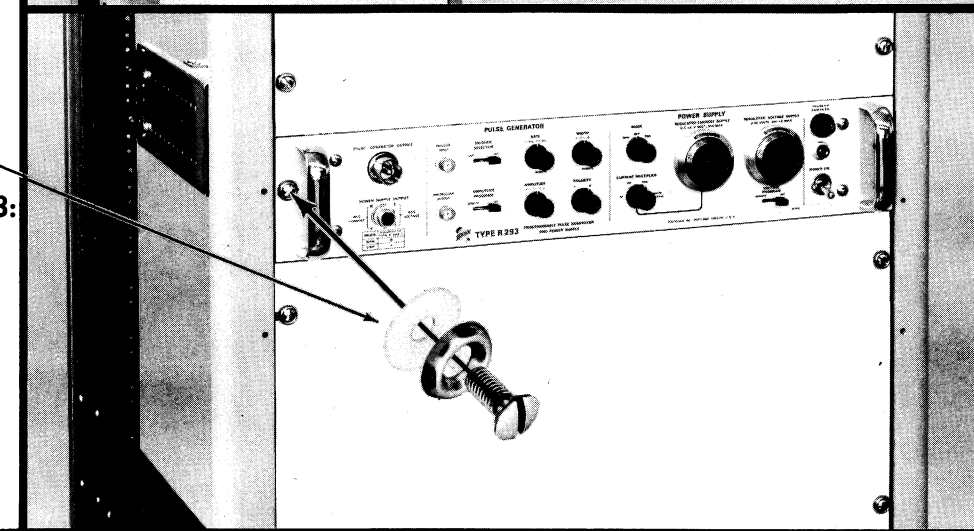


Fig. 10-9. Procedures for inserting and removing the instrument after the slideout tracks have been installed.

## **MANUAL CHANGE INFORMATION**

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

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

## ELECTRICAL PARTS LIST CORRECTION

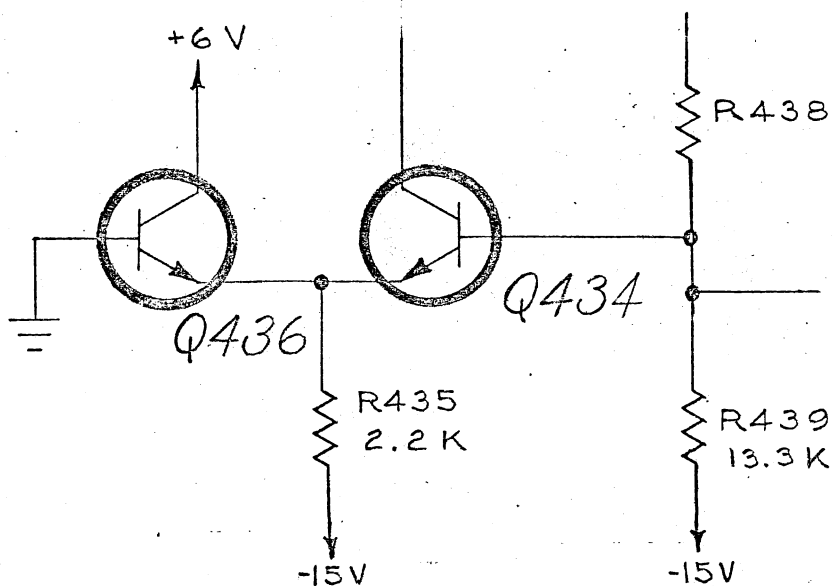
## CHANGE TO:

R439	321-0301-00	13.3 k $\Omega$	1/8 W	Prec	1%
R457	321-0261-00	5.11 k $\Omega$	1/8 W	Prec	1%
R458	311-0532-00	1.5 k $\Omega$	Var	WW	$\pm 5\%$
R459	321-0281-00	8.25 k $\Omega$	1/8 W		1%

## ADD:

Q436	151-0155-00	2N2925			
R435	315-0222-00	2.2 k $\Omega$	1/4 W		5%

## SCHEMATIC CORRECTION



PARTIAL  
PULSE GENERATOR POWER SUPPLY

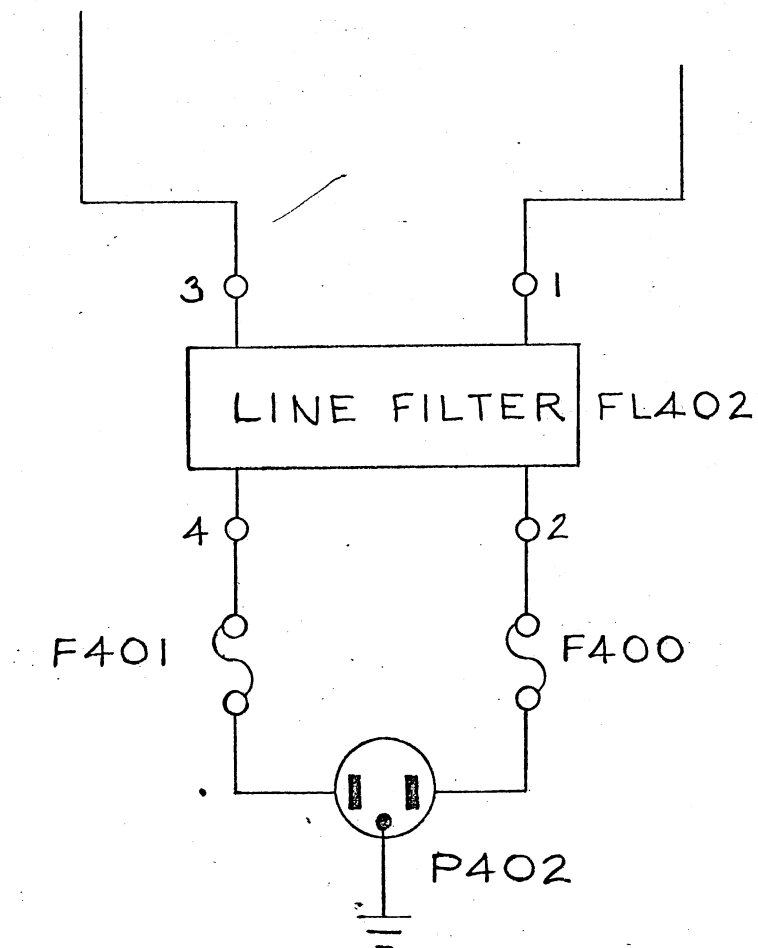
4

TYPE R293


PARTS LIST AND SCHEMATIC CORRECTION

ADD:

F400	159-0053-00	5 A	Fast-Blo
F401	159-0053-00	5 A	Fast-Blo



PARTIAL

PULSE GENERATOR POWER 

M13,077/1067

TEXT CORRECTIONS

Page 1-1

Pulse Amplitude Accuracy--Within  $\pm 5\%$  of minimum and maximum values.

Page 5-3

Step 4a. REQUIREMENT - 6 volts to 12 volts,  $\pm 5\%$ .

TYPE R293

PARTS LIST CORRECTION

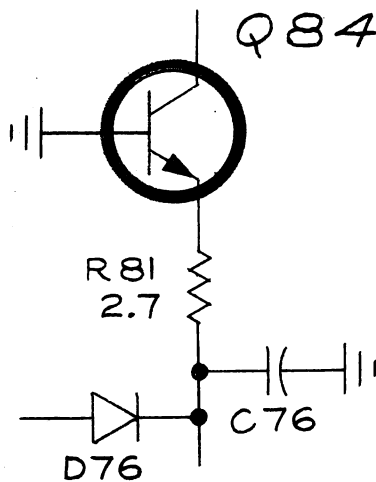
REMOVE:

D82                    152-0185-00                    6185

ADD:

R81                    307-0103-00                    2.7  $\Omega$                     1/4 W                    5%

SCHEMATIC CORRECTION



PARTIAL PULSE GEN

Text Corrections

Text Page 5-6

Step 13c should read:

c. Connect the 1 k $\Omega$  resistor between terminals 23 and 24.....

Text Page 6-19

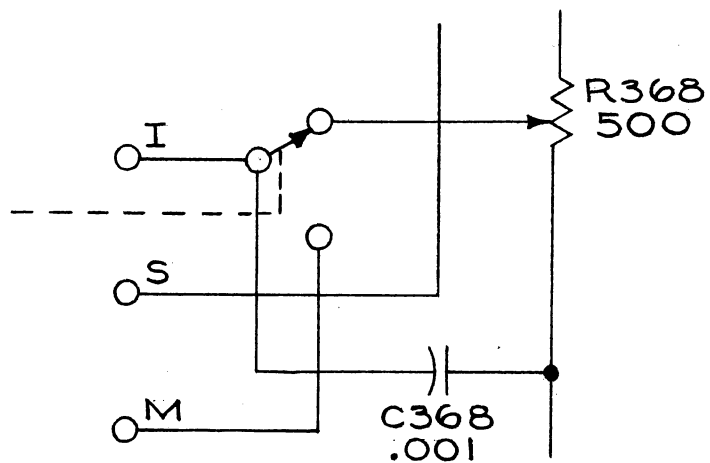
Step 22c should read:

c. Connect the 1 k $\Omega$  resistor between terminals 23 and 24.....

Fig. 6-22 correction:

Zener Current Test Points are at both ends of R351. R351 is located directly below C365, to which the test points presently refer.

SCHEMATIC CORRECTION



PARTIAL—  
PROGRAMMABLE POWER SUPPLY 3