INSTRUCTION MANUAL

Serial Number ____________

NOTE

Beginning with Serial Number 1000, several modifications (not mentioned in the text) have been incorporated in the Type R116 for improved performance. Refer to the insert in the Change Information section at the rear of this manual for the changes resulting from the modifications.

TYPE R116 PROGRAMMABLE PULSE GENERATOR

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

070-0498-00 166

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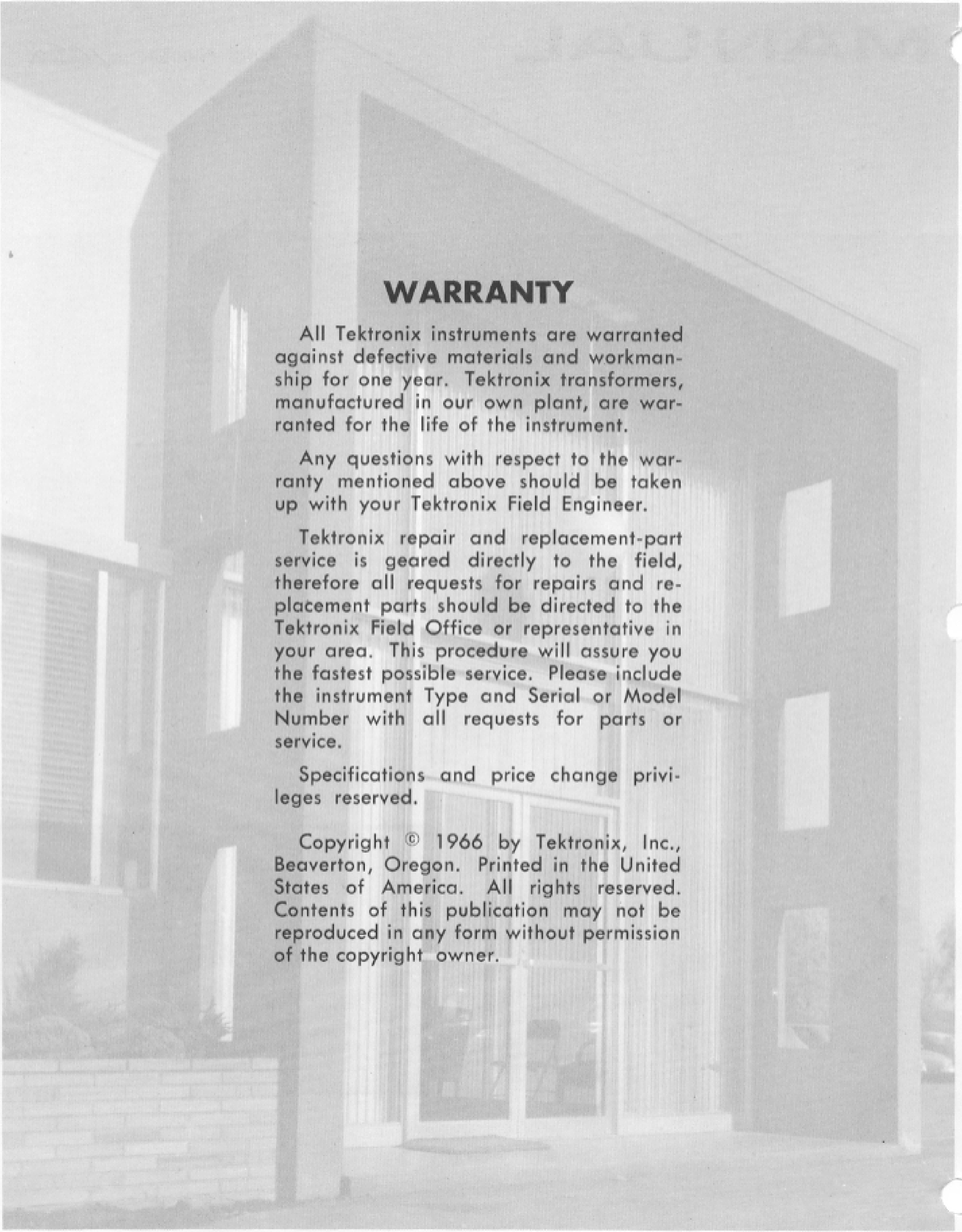


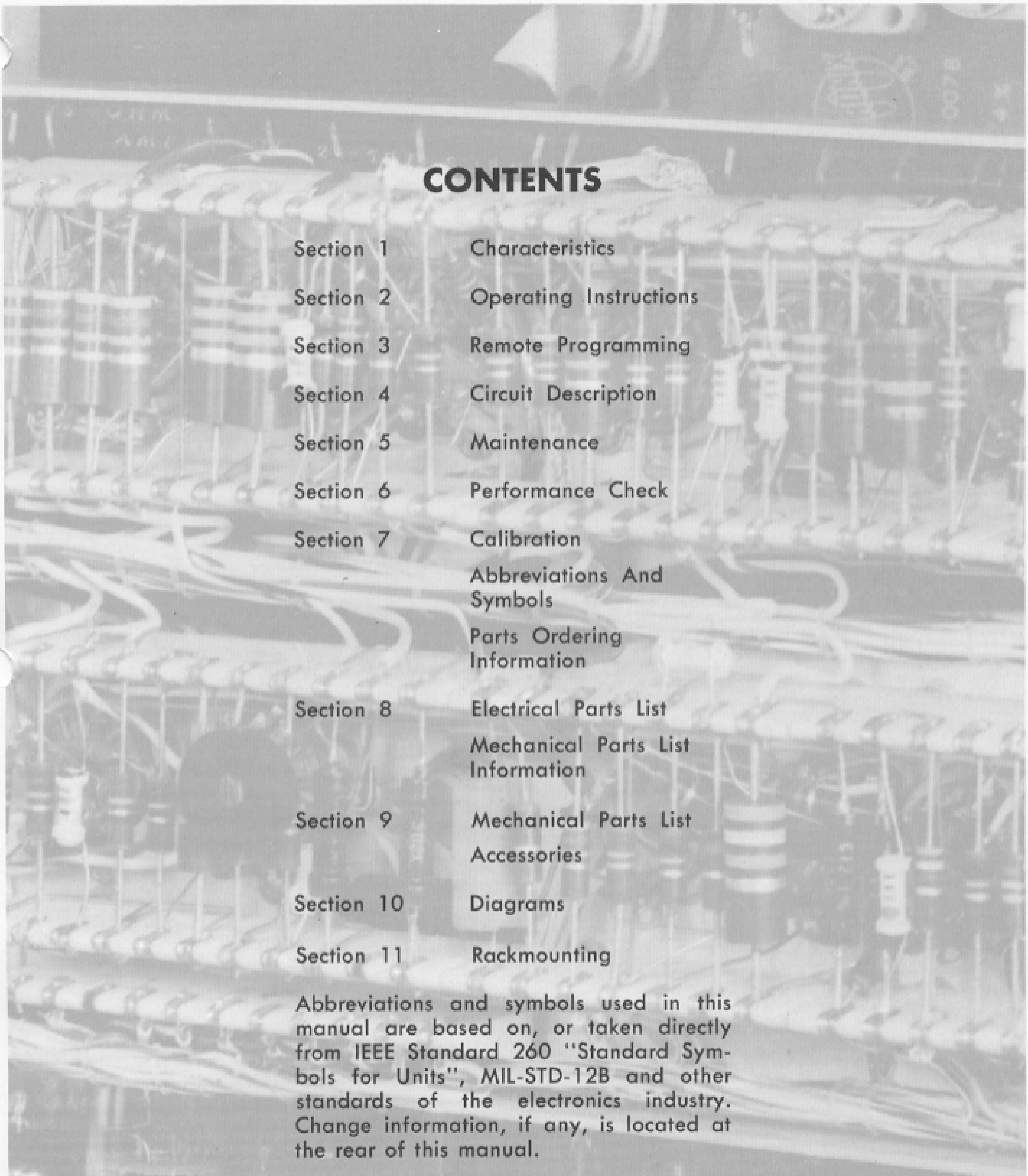
WARRANTY

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 or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.



CONTENTS

Abbreviations and symbols used in this manual are based on, or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

Fig. 1-1. Type R116 Programmable Pulse Generator.

SECTION 1
CHARACTERISTICS

General Information

The Tektronix Type R116 Programmable Pulse Generator is a multi-purpose generator with variable output pulse characteristics. Repetition rates up to 10 MHz are available with amplitudes up to 10 volts and risetimes and falltimes as short as 10 ns. All functions of the Type R116 are programmable, making the instrument appropriate for applications requiring a variety of pulse characteristics that can be changed in rapid sequence. The Type R116 can also be operated entirely from the front panel (using the calibrated front-panel controls) or with a combination of remote programming and front-panel operation.

The variable characteristics of the output pulse include amplitude, width, repetition rate, risetime and falltime. In addition to single equally-spaced pulses (Single mode), the output signal may also be provided as double pulses, bursts or gated series of pulses and the output may be delayed with respect to the triggering signal.

The following electrical characteristics apply at ambient temperature of 25° C (±5° C) after an initial warm-up period of 20 minutes.

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Modes of Operation		
Single	Sequence of Single output pulses; no variable delay with respect to +pretrigger output pulses.	Pulses are equally spaced.
Delayed Single	Sequence of single output pulses with each pulse occurring at end of adjustable delay interval.	Delay interval is time between +pretrigger pulse and start of output pulse rise; pulses are equally spaced.
Double	Sequence of double pulses with delay interval separating leading edges of pulses in each pair.	First pulse of pair starts at same time as pulse in Single mode; second pulse starts at end of delay interval; 50-ns minimum separation required between end of first pulse and start of second pulse (at baseline); characteristics of each pulse same as for Single mode.
Burst	Bursts of output pulse signal for duration set by DELAY OR BURST TIME controls, each burst initiated by external triggering signal or manual trigger button.	Characteristics of pulse signal during burst same as for Single mode (set by PERIOD, WIDTH, etc. controls).
Gated Output	Bursts of output pulse signal for duration of external + gate.	First pulse of burst starts approximately 100 ns after gate exceeds +2 volts; output bursts continue until approximately 100 ns after gate drops below +2 volts; characteristics of output signal during burst same as for Single mode.
Input Signal Requirements		
+Trigger Input		Input impedance is greater than 1 kΩ, dc coupled.
Amplitude	+2 volts to +20 volts for triggering pulses with 100 ns or more between pulses (at baseline).	Maximum amplitude decreases to +4 volts for pulses with 50 ns between pulses; accidental overload ±100 volts maximum.
Frequency		Dc to 10 MHz.
+Gate In		Input impedance is greater than 1 kΩ, dc coupled.
Amplitude	+2 volts to +10 volts.	Accidental overload ±100 volts maximum.
Duration		50 ns or more (up to dc).
Output Signal Characteristics		
+Pretrigger Output		Capacitively - coupled output available in all modes.
Amplitude	+2 volts or more into high impedance load (≥1 kΩ).	
Risetime		Less than 20 ns with no capacitive load; typically 10 ns.
Lead Time		Starts approximately 30 ns or more (up

ELECTRICAL CHARACTERISTICS *(Cont)*

Characteristic	Performance Requirement	Supplemental Information
Output Signal Characteristics *(Cont)*		
		to approximately 50 μs) before start of each undelayed output pulse, depending on risetime selected.
+Delayed Trigger Output		Capacitively - coupled output available in all modes.
Amplitude	+2 volts or more into high-impedance load ($\geq$1 kΩ).	
Risetime		Less than 20 ns with no capacitive load; typically 10 ns.
Lead Time		Starts approximately 30 ns or more (up to approximtely 50 μs) before start of delayed output pulse, depending on risetime selected, or before end of delay interval for modes with no delayed output pulse.
Pulse Output	(See Programming following for performance requirements when remotely programmed).	Dc coupled through 50 Ω coaxial cable.
Polarity	Positive - going (+) or negative - going (—).	Selected by front-panel POLARITY switch.
Period (with TRIGGER SOURCE switch set to INTERNAL	100 ns to 11 ms: Accuracy within 3% of switch and dial readings on 1 mS, 100 μS, 10 μS and 1 μS ranges; accuracy within 5% on 100 nS range.	Continuously variable and calibrated in 5 ranges: 100 ns to 1.1 μs; 1 μs to 11 μs; 10 μs to 110 μs; 100 μs to 1.1 ms; 1 ms to 11 ms. Jitter typically less than (0.05% of period plus 2 ns). Period set by triggering signal with TRIGGER SOURCE switch set to EXTERNAL or MANUAL.
Delay or Burst Time	50 ns to 550 μs: Accuracy within 3% (+ 10 ns) of switch and dial readings.	Continuously variable and calibrated in 4 ranges: 50 ns to 550 ns; 500 ns to 5.5 μs; 5 μs to 55 μs; 50 μs to 550 μs. Jitter typically less than (0.05% of delay time plus 2 ns).

ELECTRICAL CHARACTERISTICS *(Cont)*

Characteristic	Performance Requirement	Supplemental Information
Output Signal Characteristics *(Cont)*		
Width (at 10-ns risetime and falltime and 10-volt amplitude)	50 ns to 550 μs: Accuracy within 3% of switch and dial readings on 10 μS, 1 μS and 100 nS ranges; accuracy within 5% on 10 nS range.	Continuously variable and calibrated in 4 ranges: 50 ns to 550 ns; 500 ns to 5.5 μs; 5 μs to 55 μs; 50 μs to 550 μs. Jitter typically less than (0.05% of width plus 2 ns).
Amplitude	±400 mV to ±10 volts into 50 Ω load: Accuracy within 3% of switch and dial readings.	Continuously variable and calibrated in 3 ranges: 400 mV to 2 volts; 1 volt to 5 volts; 2 volts to 10 volts.
Risetime (10% to 90%) and falltime (90% to 10%) with 10-volt amplitude	10 ns to 110 μs: Accuracy as follows with respect to risetime or falltime reading on switch and dials: Within 5% on 1 μS, 100 nS and 10 nS ranges; within 10% on 1 nS range.	Risetime determined by settings of RISETIME FALLTIME RANGE switch, RISETIME MULT and AMPLITUDE MULTIPLIER controls. Falltime determined by settings of RISETIME FALLTIME RANGE switch, FALLTIME MULT and AMPLITUDE MULTIPLIER controls. Continuously variable and calibrated in 4 risetime-falltime ranges: 1 nS—10 ns to 110 ns; 10 nS—100 ns to 1.1 μs; 100 nS—1 μs to 11 μs; 1 μS—10 μs to 110 μs. Risetime and falltime independently variable within same risetime - falltime range. Accuracy unspecified with AMPLITUDE MULTIPLIER control set below 10.
Rate of rise and rate of fall		Typically linear within 2% of ideal ramp except on 1 nS risetime-falltime range.
Aberrations, overshoot or tilt.	3% or less on 10-volt pulse, either positive - going or negative-going.	Checked with Tektronix 661/4S3 sampling system.

ELECTRICAL CHARACTERISTICS *(Cont)*

Charac-teristic	Performance Requirement	Supplemental Information
Output Signal Characteristics *(Cont)*		
Dc Offset (of pulse baseline) with 50 Ω load.	—5 volts to +5 volts: Accuracy within 150 mV of switch and dial readings; accuracy within 50-mV of zero at 0 setting of DC OFFSET control.	Continuously variable and calibrated in 3 ranges set by AMPLITUDE RANGE switch: —1 volt to +1 volt on .2 V amplitude range; —2.5 volts to +2.5 volts on .5 V amplitude range; —5 volts to +5 volts on 1 V amplitude range. Offset determined by setting of AMPLITUDE RANGE switch and DC OFFSET control; full offset and full amplitude may be used simultaneously.
Programming		
Provides remote control of pulse output signal characteristics with appropriate front-panel switches set to REMOTE or REMOTE PROGRAM. Digital and analog information is applied through rear-panel microribbon connector.		
Switch Operations	Accuracy within 2% of front-panel calibration.	Require digital voltage-level logic inputs to remote program lines as follows: Logical 1 is produced by contact closure to chassis ground (not signal ground), or Logical 0 is produced by open circuit input or by dc voltage of from +12 to +20 volts. Also, require presence of analog information by means of appropriate program resistors (see Variable Operations following).
Trigger Source	Logical 1 enables external or manual trigger; disables Period Generator free-run operation. Logical 0 disables external and manual trigger; enables Period Generator free-run operation.	

ELECTRICAL CHARACTERISTICS *(Cont)*

Charac-teristic	Performance Requirement	Supplemental Information
Programming *(Cont)*		
Mode	Logical 1 on (only) one of 4 input program lines produces corresponding mode (e.g., Double); Logical 0 on all 4 input lines produces Single mode.	(Logical 0 on other 3 input lines.)
Period Range	Logical 1 on (only) one of 4 input program lines produces corresponding period range (e.g., 1 μS); Logical 0 on all 4 inputs produces 100 nS period range.	(Logical 0 on other 3 input lines.)
Delay or Burst Time Range	Logical 1 on (only) one of 3 input program lines produces corresponding delay or burst time range (e.g., 1 μS); Logical 0 on all 3 inputs produces 10 nS delay or burst time range.	(Logical 0 on other 2 input lines.)
Width Range	Logical 1 on (only) one of 3 input program lines produces corresponding width range (e.g., 1 μS); Logical 0 on all 3 inputs produces 10 nS width range.	(Logical 0 on other 2 input lines).
Amplitude Range	Logical 1 on (only) one of 2 input program lines produces corresponding amplitude range (e.g., 1 V); Logical 0 on both inputs produces 0.2 V amplitude range.	(Logical 0 on other input line.)
Risetime-Falltime Range	Logical 1 on (only) one of 3 input program lines produces corresponding risetime-falltime range (e.g., 100 nS); Logical 0 on all 3 inputs produces 1 nS risetime-falltime range.	(Logical 0 on other 2 input lines.)

ELECTRICAL CHARACTERISTICS *(Cont)*

Characteristic	Performance Requirement	Supplemental Information
	Programming *(Cont)*	
Polarity	Logical 1 produces minus (—) polarity of pulse output; Logical 0 produces plus (+) polarity of pulse output.	
Variable Operations	Analog information accuracy within (2% of equivalent front-panel calibration plus error in program resistor).	Require program resistors connected between analog program leads and specific voltage leads.[1] (Program resistors perform same functions as front-panel Multiplier controls.)
Period Analog	1.69 kΩ per unit of multiplication minus 1,[2] connected between period analog lead and —6 volts.[1]	Allowable range of resistance is from 0 Ω (×1) to 16.9 kΩ (×11).
Delay or Burst Time Analog	177.4 Ω per unit of multiplication minus 5, connected between delay or burst time analog lead and —27 volts.[1]	Allowable range of resistance is from 0 Ω (×5) to 8.87 kΩ (×55).
Width Analog	177.4 Ω per unit of multiplication minus 5, connected between width analog lead and —27 volts.[1]	Allowable range of resistance is from 0 Ω (×5) to 8.87 kΩ (×55).
Amplitude Analog	1.109 Ω per unit of multiplication minus 2, connected between amplitude analog lead and signal ground.	Allowable range of resistance is from 0 Ω (×2) to 8.87 kΩ (×10); open program lead (e.g., between programs) produces zero output.
Risetime Analog	343 Ω per unit of multiplication minus 1, connected between risetime analog lead and +25 volts.[1]	Allowable range of resistance is from 0 Ω (×1) to 3.43 kΩ (×11).
Falltime Analog	343 Ω per unit of multiplication minus 1, connected between falltime analog lead and —27 volts.[1]	Allowable range of resistance is from 0 Ω (×1) to 3.43 kΩ (×11).

[1]Voltage with respect to signal ground.

[2]For example: 1.69 kΩ x (3 — 1) = 3.38 kΩ for X3 multiplication.

ELECTRICAL CHARACTERISTICS *(Cont)*

Characteristic	Performance Requirement	Supplemental Information
	Programming *(Cont)*	
Dc Offset Analog	887 Ω per unit of multiplication minus 5[3], connected between dc offset analog lead and signal ground; accuracy within (100 mV of front-panel calibration plus error in program resistor).	Allowable range of resistance is from 0 Ω (×+5) to 8.87 kΩ (× —5); open program lead (e.g., between programs) produces zero dc offset.
	Power Supply	
Voltage Requirements		Range selected by 115 V-230 V selector switch on rear panel.
115 Volts (nominal)	94.5 volts to 137.5 volts ac rms.	
230 Volts (nominal)	189 volts to 275 volts ac rms.	
Line Frequency		50 Hz to 60 Hz.
Power Consumption		Approximately 100 watts.
Line Fuses		Selected by 115 V-230V selector switch:
115-Volt Operation		Two 0.6-A fuses.
230-Volt Operation		One 0.6-A fuse.

ENVIRONMENTAL CHARACTERISTICS

Characteristic	Information
Ambient Temperature	
Operating	0° C to +50° C. Automatic resetting thermal cutout interrupts instrument power if temperature exceeds safe operating level.
Non-operating	—40° C to +65° C.
Ventilation	Forced-air cooling provided by fan mounted in rear panel.
Maximum Altitude	
Operating	15,000 feet.
Non-operating	50,000 feet.
Vibration (operating)	Performs within specifications after being vibrated for 15 minutes along each major axis at frequencies from 10 to 50 c/s and accelerations up to 1.9g.[4]
Transportation (non-operating)	Meets National Safe Transit Test requirements.

[3]Absolute value of the resulting negative number.

[4]1.9 times the acceleration of gravity, corrected to sea level.

MECHANICAL CHARACTERISTICS

Characteristic	Description
Dimensions	
Height	$5^1/_4$ inches.
Width	19 inches.
Depth	$19^1/_8$ inches including handles and connectors.
Construction	
Chassis and cabinet	Aluminum alloy.
Front panel	Aluminum alloy with anodized surface.
Circuit cards	Glass epoxy laminate with photo-etched wiring.
Connectors	
Front panel	BNC type coaxial jacks for signal inputs and outputs.
Remote Program	Microribbon type 36-terminal jack mounted on rear panel.
Power	3-terminal male connector on rear panel.

STANDARD ACCESSORIES

An illustrated list of standard accessories is given in the Mechanical Parts List section of this manual.

OPTIONAL ACCESSORIES AVAILABLE

Item	Description	Tektronix Part Number
Circuit card extender	56-terminal $5^1/_8$-inch extender for trouble-shooting plug-in circuit cards.	012-0078-00

NOTES

SECTION 2

OPERATING INSTRUCTIONS

General Information

This section of the manual provides the basic information required for operating the Type R116. Instructions are included for installing the instrument, using the front-panel controls and connecting the input and output signals. See the Remote Programming section for remote operation information.

INSTALLATION

Rackmounting

Instructions for rackmounting the Type R116 are given in the Rackmounting foldout pages of Section 11. Fig. 2-1 shows the instrument installed in a cabinet-type rack. After the slideout tracks have been installed in the rack, the Type R116 can be removed or re-inserted at any time as described in the Rackmounting section.

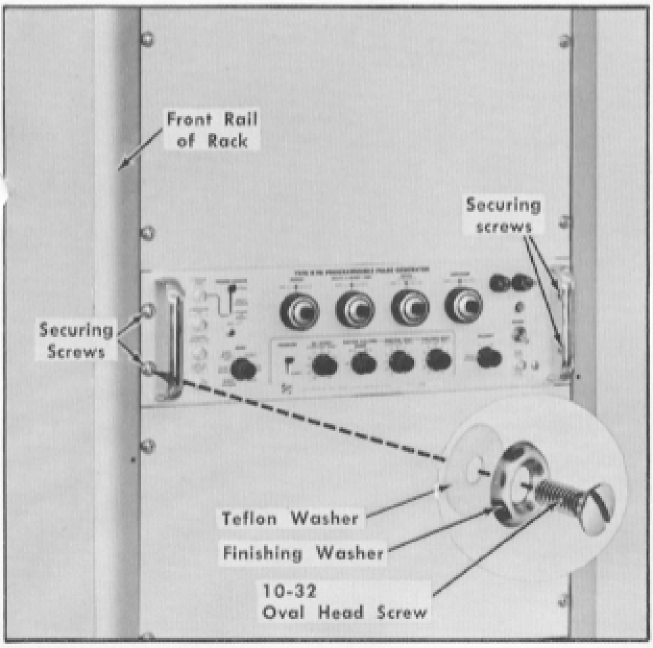


Fig. 2-1. The Type R116 is secured into the rack with 4 screws and washers, assembled as indicated in the inset photo. Remove these screws to extend the Type R116 in its slide-out track. (Refer to the foldout Rackmounting instructions at the rear of this manual for installing the slide-out tracks.)

Bench Mounting

Four mounting feet are provided for operating the Type R116 on a test bench or table. Remove the bottom dust cover from the instrument and install the feet on the dust cover as shown in Fig. 2-2, then replace the cover on the bottom of the instrument. The feet must be removed before inserting the Type R116 into a rack if there is another instrument or panel immediately below the Type R116.

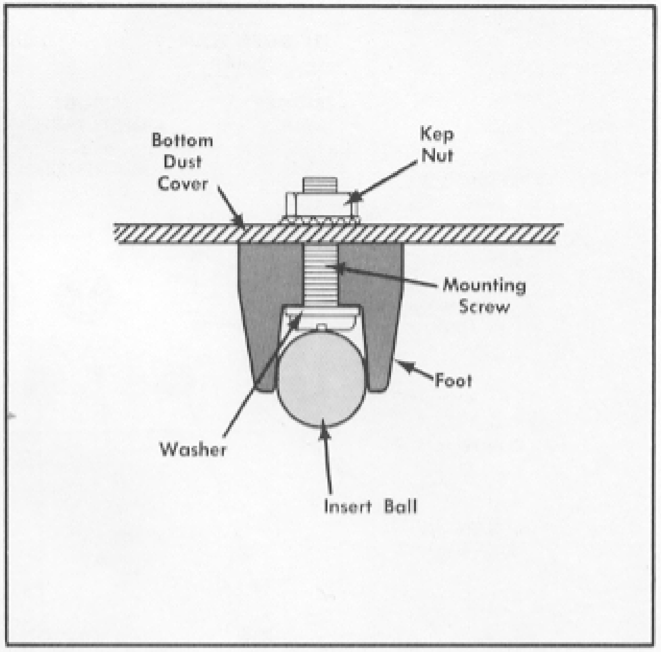


Fig. 2-2. Mounting each of the four feet for operating the Type R116 on a test bench or table.

Cooling

The fan at the rear of the instrument provides forced-air cooling. A free flow of air in the temperature range from 0°C (32°F) to 50°C (122°F) should be provided for adequate cooling of the Type R116.

Normally the fan is operated as an intake fan to provide filtering of the air; however, it can be operated as an exhaust fan if necessary by reversing the entire fan assembly. The direction of air flow should be selected to provide the best cooling, depending on the temperature of the surrounding air and on the direction of air flow through adjacent instruments. In general, all instruments in one rack should have the same direction of air flow to prevent recirculation of over-heated air. Some method of rack ventilation must be provided for removal or cooling of the heated air.

Selecting Line Voltage

This instrument is designed to operate on either 115 volts (nominal) or 230 volts (nominal) ac rms, depending on the position of the 115 V-230 V selector switch on the rear panel. A small screwdriver may be used to operate the switch. For nominal 115-volt operation (94.5 volts to 137.5 volts), set the switch to the upper (115 V) position (see Fig. 2-3). For nominal 230-volt operation (189 volts to 275 volts), set the switch to the lower (230 V) position.

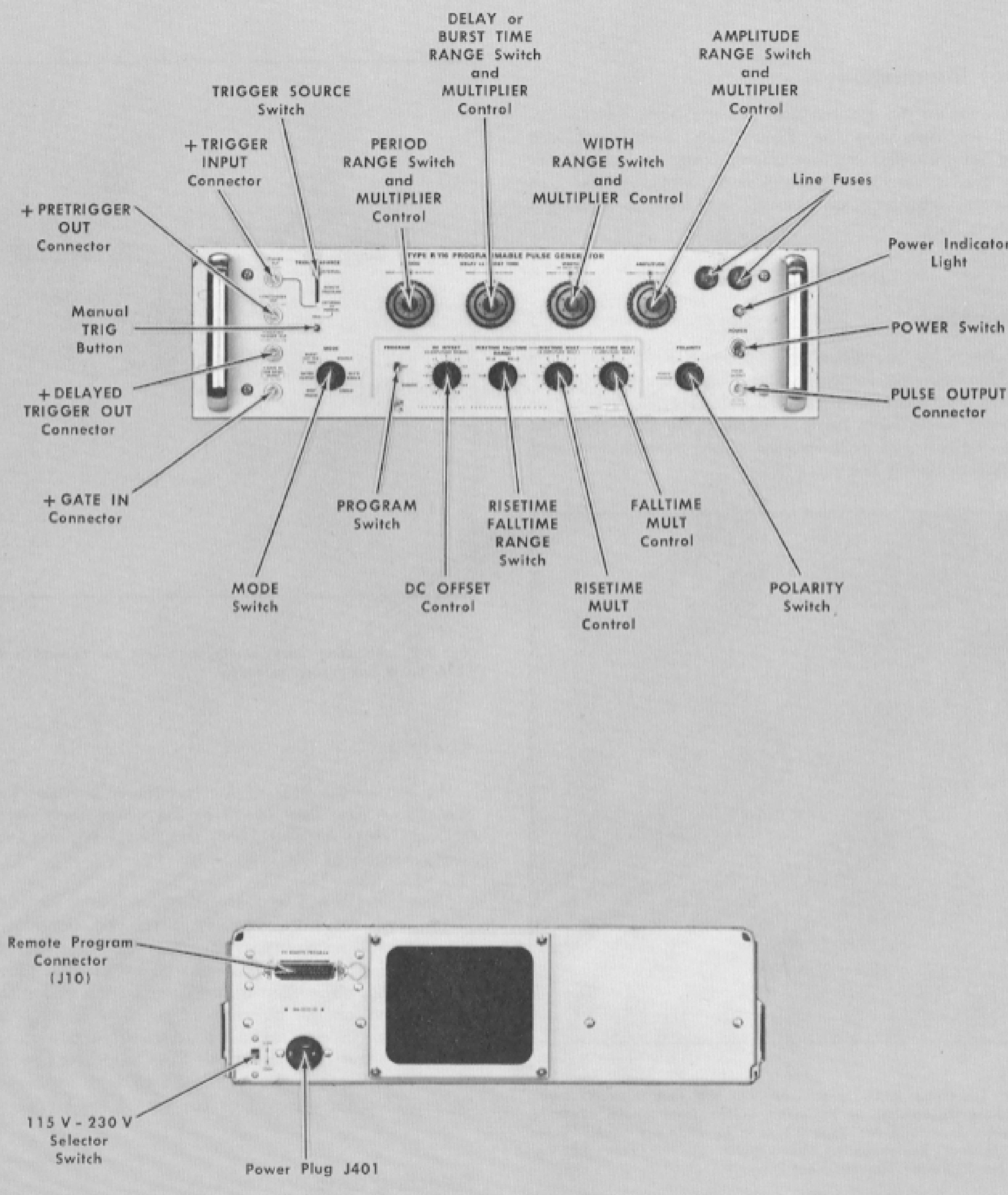


Fig. 2-3. Front- and rear-panel controls and connectors on the Type R116.

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CONTROLS AND CONNECTORS

All controls and connectors required for the normal operation of the Type R116 are located on the front and rear panels of the instrument (see Fig. 2-3). To use the instrument effectively, the operator should become familiar with the function and use of each of these controls and connectors. These functions are described briefly in the following table and in more detail later in this section.

MODE Switch — Selects operating mode of instrument to produce different types of output pulse signals, or permits mode to be selected remotely.

SINGLE—Sequence of single equally-spaced pulses with no adjustable delay following +Pretrigger Out pulses.

DLY'D SINGLE—Sequence of single equally-spaced pulses with start of each pulse delayed by adjustable delay interval following +Pretrigger Out pulse. Delay interval is set by DELAY OR BURST TIME controls.

DOUBLE—Sequence of double pulses consisting essentially of a combination of Single and Delayed Single pulses. Leading edges of pulses in pair separated by adjustable delay interval.

BURST—Bursts of output pulses for duration of interval set by DELAY OR BURST TIME controls. External triggering pulse applied through +TRIGGER INPUT connector or manual trigger pulse from TRIG button is required to start each burst (TRIGGER SOURCE switch may be in any position).

GATED OUTPUT—Bursts of output pulses for duration of interval set by external gate signal applied through +GATE IN (FOR GATED OUTPUT) connector.

REMOTE PROGRAM—Remote logic information applied through rear-panel REMOTE PROGRAM connector provides selection of operating mode.

TRIGGER SOURCE Switch — Selects triggering source either from internal signal, external signal or manual trigger (in Single, Dly'd Single or Double mode), or permits trigger source to be selected remotely. TRIGGER SOURCE switch is held functionally at EXTERNAL OR MANUAL in Burst mode and at INTERNAL in Gated Output mode.

INTERNAL—Free-running internal period generator provides triggering of output pulses.

REMOTE PROGRAM—External logic information applied through REMOTE PROGRAM connector provides selection of trigger source.

EXTERNAL OR MANUAL—External triggering signal applied through +TRIGGER INPUT connector, or pulse from manual TRIG button, provides triggering of output pulses.

Manual TRIG Button — Provides single pulse or pair of pulses in Single, Double or Dly'd Single mode with TRIGGER SOURCE switch set to EXTERNAL OR MANUAL. Provides single burst in Burst mode (regardless of setting of TRIGGER SOURCE switch). Press button for manual trigger; release to re-arm.

PERIOD RANGE Switch and MULTIPLIER Control — Select length of time interval between start of one cycle of output pulse (or double pulse) and start of next cycle, or permit remote selection of period interval. Period is continuously variable and calibrated from 100 ns through 11 ms in 5 decade ranges. MULTIPLIER control provides ×1 through ×11 multiplication of range selected by PERIOD RANGE control. (In Single, Dly'd Single and Double modes, pulse period is determined by external triggering signal when TRIGGER SOURCE switch is set to EXTERNAL OR MANUAL.) When PERIOD RANGE switch is set to REMOTE, period range and multiplication factor are determined by remote logic and analog infomation.

DELAY OR BURST TIME RANGE Switch and MULTIPLIER Control — Select length of delay interval between +Pretrigger Out pulse and start of delayed output pulse (or second pulse Double waveform) or permit remote selection of delay interval. Also determine duration of burst time and time interval between +Pretrigger Out and +Delayed Trigger Out pulses. Delay interval is continuously variable and calibrated from 50 ns through 550 μs in 4 decade ranges. MULTIPLIER control provides ×5 through ×55 multiplication of range selected by DELAY OR BURST TIME RANGE switch. When set to REMOTE, delay or burst time range and multiplication factor are determined by remote logic and analog information.

WIDTH RANGE Switch and MULTIPLIER Control — Select width of output pulses, or permit remote selection of pulse width. Width is continuously variable from 50 ns through 550 μs in 4 decade ranges. MULTIPLIER control provides ×5 through ×55 multiplication of range selected by WIDTH RANGE switch. Width calibration applies only when risetime and falltime are at a minimum. When risetime and falltime are longer than minimum but are equal to each other, width dial reading is approximately correct. See Selecting Output Pulse Characteristics later in this section for other conditions. When WIDTH RANGE switch is set to REMOTE, width range and multiplication factor are determined by remote logic and analog information.

AMPLITUDE RANGE Switch and MULTIPLIER Control	Select amplitude of output pulses, or permit remote selection of pulse amplitude. Amplitude is continuously variable and calibrated (into a 50 Ω load) from ±400 mV through ±10 volts in 3 ranges. MULTIPLIER control provides ×2 through ×10 multiplication of amplitude range selected by RANGE switch: 400 mV to 2 volts in .2 V range; 1 to 5 volts in .5 V range and 2 to 10 volts in 1 V range. When set to REMOTE, amplitude range and multiplication factor are determined by remote logic and analog information.
POLARITY Switch	Selects either positive-going (+) or negative-going (—) output pulses, or permits remote selection of polarity. When set to REMOTE PROGRAM, polarity of output pulses is determined by remote logic information.
PROGRAM Switch	Selects either internal or remote control of offset, risetime and falltime of output pulses. When set to INT position, front-panel controls determine these pulse characteristics; when set to REMOTE, the characteristics are determined by remote logic and analog information.
DC OFFSET Control	Adjusts dc voltage level of output pulse baseline over range set by AMPLITUDE RANGE switch: —1 to +1 volt on 2 V amplitude range; —2.5 to +2.5 volts on .5 V amplitude range; —5 to +5 volts on 1 V amplitude range.
RISETIME FALLTIME RANGE Switch	Selects operating range of risetime and falltime controls. Switch setting must be multiplied by AMPLITUDE MULTIPLIER and RISETIME MULT or FALLTIME MULT control settings. Ratio of risetime to falltime can be varied from 1:11 to 11:1.[1]
RISETIME MULT Control	Adjusts risetime multiplication factor from ×1 to ×11 over range set by RISETIME FALLTIME RANGE switch and AMPLITUDE MULTIPLIER control.
FALLTIME MULT Control	Adjusts falltime multiplication factor from ×1 to ×11 over range set by RISETIME FALLTIME RANGE switch and AMPLITUDE MULTIPLIER control.
+TRIGGER INPUT Connector	Permits application of external +2 to +20-volt dc-coupled signal for triggering output pulses in Single, Dly'd Single and Double modes with TRIGGER SOURCE switch set to EXTERNAL OR MANUAL. Permits application of signal for triggering burst in Burst mode (regardless of setting of TRIGGER SOURCE switch). Input impedance is approximately 60 kΩ.
+PRETRIGGER OUT Connector	Provides approximate +2-volt trigger pulse output into 1 kΩ load approximately 30 ns (or more) before leading edge of each output pulse (or double pair) for triggering external equipment such as display oscilloscope. Time interval between +Pretrigger pulse and output pulse is affected by selected output pulse risetime.
+DELAYED TRIGGER OUT Connector	Provides approximate +2-volt trigger pulse output into 1 kΩ load a selected interval of time (delay time) following +Pretrigger Out pulse and approximately 30 ns (or more) before leading edge of delayed output pulse. Time interval between +Pretrigger Out and +Delayed Trigger Out pulses is set by DELAY OR BURST TIME controls. Time interval between +Delayed Trigger Out pulse and delayed output pulse is affected by selected output pulse risetime.
+GATE IN (FOR GATED OUTPUT) Connector	Permits application of external +2 to +10-volt dc-coupled gate signal for determining time interval of output pulse bursts in Gated Output mode. Output pulse burst starts approximately 100 ns after gate exceeds +2-volt level (above chassis ground) and continues until approximately 100 ns after gate drops below +2-volt level. Input impedance is approximately 1 kΩ.
PULSE OUTPUT Connector	Provides dc-coupled output pulse signal of from ±400 mV to ±10 volts as set by AMPLITUDE RANGE switch and MULTIPLIER control, when applied to a 50 Ω load.
POWER Switch	Applies power to transformer for operation of instrument with switch set to upward position; disconnects power in downward position.
Power Indicator Light	Indicates when power is applied to power transformer primary.
Fuses	Limit current through power transformer primary for protection of instrument. Fuse(s) selected for correct operating range by 115 V-230 V selector switch: two fuses for nominal 115-volt operation; one fuse for nominal 230-volt operation.
115 V-230 V Selector Switch (on rear panel)	Selects either nominal 115-volt or 230-volt operation of instrument, as indicated by rear-panel marking: upward for 115 volts; downward for 230 volts. Also selects correct fuse arrangement for selected operating voltage.
REMOTE PROGRAM Connector J10 (on rear panel)	Permits application of remote logic and analog information for remote programming of instrument. Provides chassis ground connection for remote switch logic and all necessary power supply voltages for remote analog functions. See Remote Programming section of this manual for required connections.
Power Plug J401 (on rear panel)	Permits application of line power to instrument power transformer.

[1]Risetime-falltime ratio can be extended at a sacrifice of linearity by using remote operation of risetime and/or falltime multipliers.

FIRST-TIME OPERATION

The Type R116 is ready to be installed and operated when received. The following procedure illustrates the use of the front-panel controls in the various pulse modes to familiarize the operator with the instrument. This procedure may also be used at any time to set up the instrument or to check for an apparent malfunction. Since remote operation of the instrument merely duplicates front-panel operation, it will not be demonstrated here. Section 3 of this manual discusses the special considerations of programming.

1. With the Type R116 installed in a rack or placed on a test bench, apply power to it and to a 15-MHz (or faster) test oscilloscope.

2. Allow the instruments to warm up for a few minutes.

3. Install a 50-Ω in-line termination on the vertical input connector of the test oscilloscope.

4. Connect a 50-Ω coaxial cable from the Type R116 PULSE OUTPUT connector to the termination on the test oscilloscope input.

5. Set the instrument controls as follows:

Type R116

MODE	SINGLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	10 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	1 μS
MULTIPLIER	10
WIDTH RANGE	1 μS
MULTIPLIER	5
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	100 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	10 μs/cm
Vertical Deflection Factor	2 volts/cm
Input Coupling	Dc
Triggering	Internal +
Amplitude Calibrator	Off

1. Adjust the test oscilloscope triggering, crt and positioning controls to obtain a stable display of the pulse output signal, as shown in Fig. 2-4A.

2. Turn the Type R116 PERIOD MULTIPLIER control throughout its range and note the time interval change

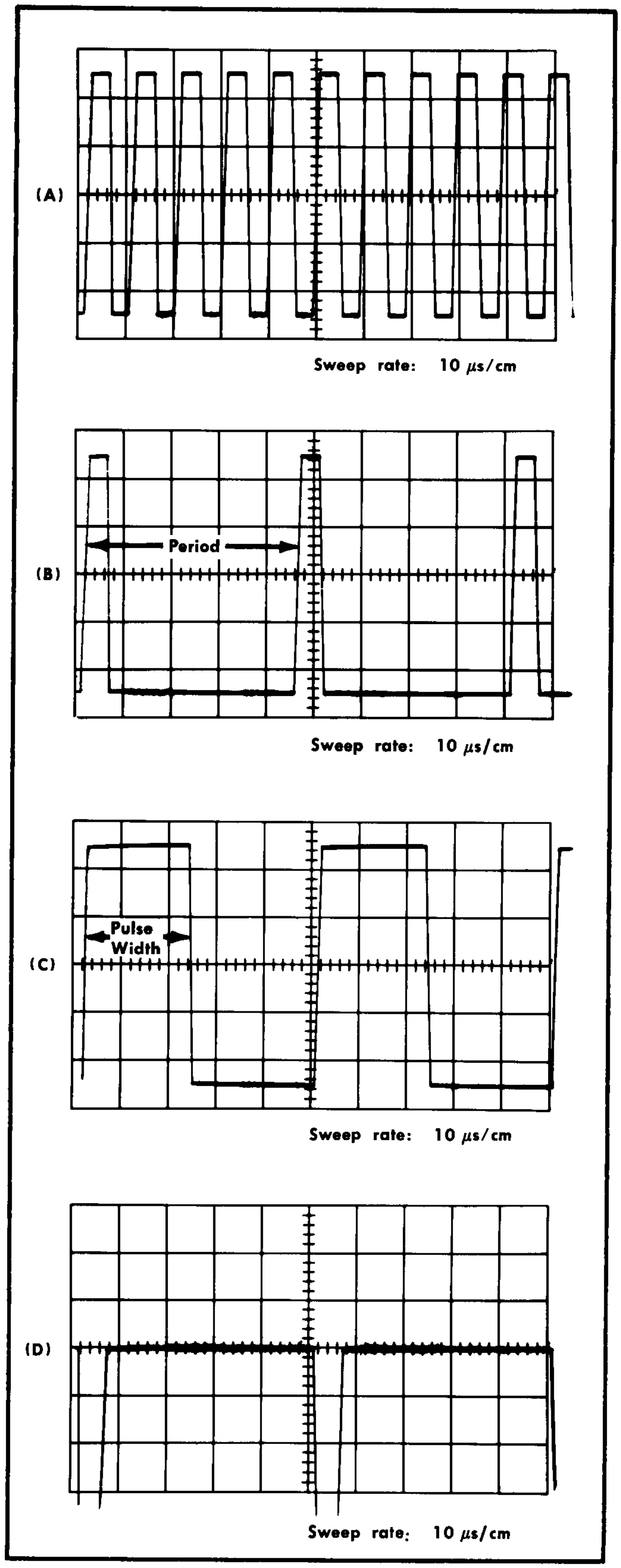


Fig. 2-4. Test oscilloscope displays obtained during first-time operation: (A) 10 μs period, 5 μs width; (B) effect of Period control; (C) effect of Width control; (D) —polarity pulse.

between leading edges of adjacent pulses in the waveform (see Fig. 2-4B).

3. Set the PERIOD MULTIPLIER control to the 5 position.

4. Turn the WIDTH MULTIPLIER control throughout its range and observe the change in pulse width (see Fig. 2 4C). Note that as the pulse width approaches the time interval between pulses, the waveform changes as the pulse generator begins to count down.

5. Return the WIDTH MULTIPLIER control to the 5 position.

6. Turn the AMPLITUDE MULTIPLIER control throughout its range and observe the change in display amplitude.

7. Set the AMPLITUDE MULTIPLIER control to 10.

8. Connect a coaxial cable from the +PRETRIGGER OUT connector to the External Trigger Input of the test oscilloscope.

9. Set the oscilloscope for external triggering.

10. With the oscilloscope Vertical Position control, position the baseline of the waveform to the horizontal centerline of the crt graticule.

11. Set the Type R116 POLARITY switch to —. Since the oscilloscope is triggered with the +Pretrigger Out signal, no re-adjustment of triggering controls is required (see Fig. 2-4D).

12. Return the POLARITY switch to +.

13. Turn the Type R116 DC OFFSET control throughout its range and observe the dc positioning capability of the DC OFFSET control.

14. Set the DC OFFSET control to 0.

15. Center the waveform on the crt screen with the oscilloscope Vertical Position Control.

16. Set the RISETIME FALLTIME RANGE switch to 10 nS.

17. Set the oscilloscope sweep rate to 2 μs/cm.

18. Turn the RISETIME MULT control clockwise and observe the change in the pulse rise (see Fig. 2-5A). Note that the width of the pulse appears to decrease as the risetime is increased. This effect will be discussed later under Selecting Output Pulse Characteristics.

19. Set the RISETIME MULT control to the 11 position.

20. Turn the FALLTIME MULT control clockwise and observe the change in the falling edge of the pulse. Note that the width of the pulse increases as the falltime is increased.

21. Set the FALLTIME MULT control to the 11 position. The pulse width at the 50% amplitude with both controls at 11 should be approximately the same as the original width with both controls at 1.

22. Return the RISETIME MULT and FALLTIME MULT controls to the 1 position.

23. Set the RISETIME FALLTIME RANGE switch to 100 nS.

24. Turn the RISETIME MULT control slowly clockwise. Notice that the pulse disappears as the risetime becomes as long as the pulse width (see Fig. 2-5B). This demonstrates

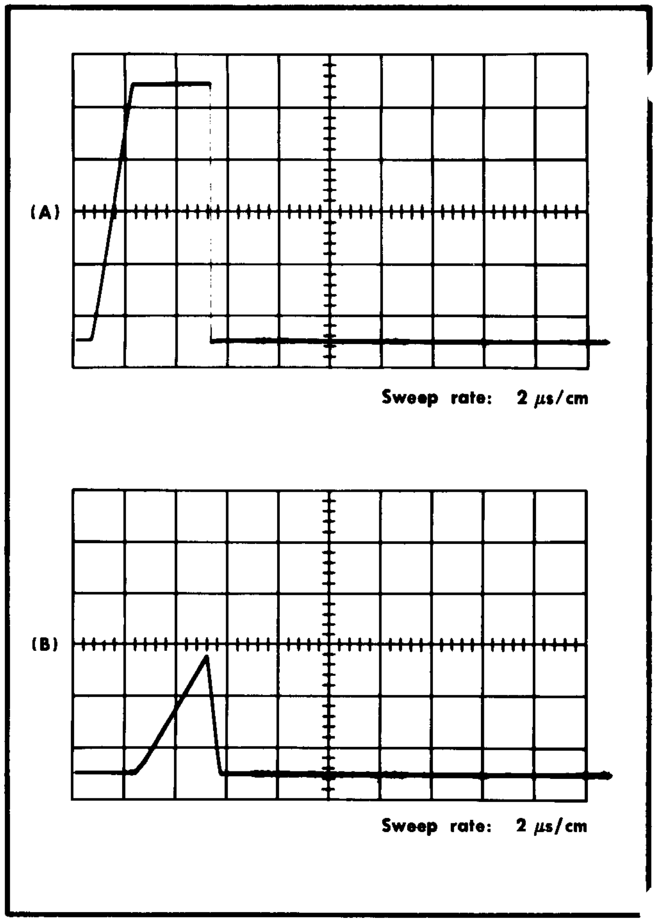


Fig. 2-5. Effects of Risetime Mult control: (A) Risetime is increased as control is turned clockwise; (B) pulse disappears if risetime is made too long.

one of the control operations that can produce an apparent condition of no output signal.

25. Return the RISETIME MULT control to the 1 position.

26. Set the oscilloscope sweep rate to 10 μs/cm.

27. Set the MODE switch to DLY'D SINGLE.

28. Turn the DELAY OR BURST TIME MULTIPLIER control slowly through its range of operation. Note that the waveform moves across the crt screen as the delay time changes between the triggering pulses and the output pulses. Also note that the waveform changes when the delay time becomes as great as the time interval between pulses, and the pulse generator begins to count down.

29. Set the DELAY OR BURST TIME MULTIPLIER control to the 10 position.

30. Set the MODE switch to DOUBLE and observe that the displayed waveform now consists of pairs of pulses.

31. Turn the MODE switch between the SINGLE, DLY'D SINGLE and DOUBLE positions. Note that the left pulse of each pair is at the position of the undelayed Single pulse and the right pulse of each pair is at the Dly'd Single pulse position (see Fig. 2-6).

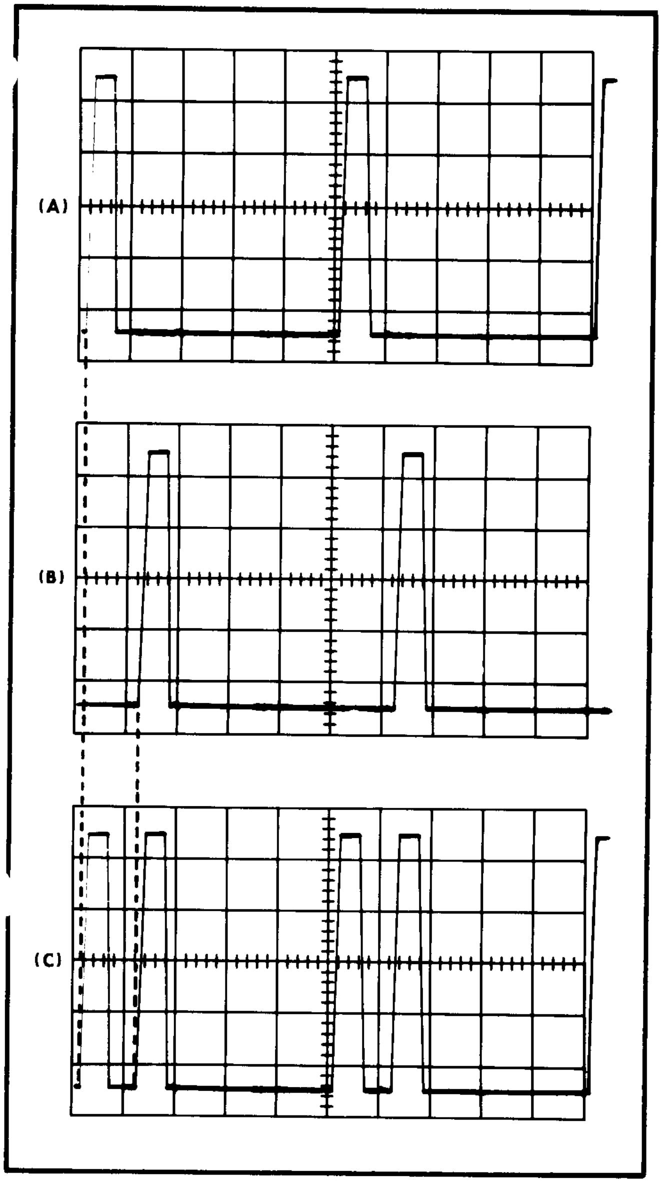


Fig. 2-6. Time comparison of output signals in three modes of operation: (A) Single; (B) Dly'd Single; and (C) Double.

32. With the MODE switch at DOUBLE, turn the DELAY OR BURST TIME MULTIPLIER control slowly through its range and observe the change in pulse separation. Note that the second pulse disappears as the delay time is decreased to minimum, and that the delay generator begins to count down when the delay time is increased to equal the time interval between pulses.

33. Return the DELAY OR BURST TIME MULTIPLIER control to 10.

34. Set the oscilloscope sweep rate to 0.2 ms/cm.

35. Reset the following Type R116 controls:

MODE	SINGLE
PERIOD RANGE	100 μS
MULTIPLIER	1

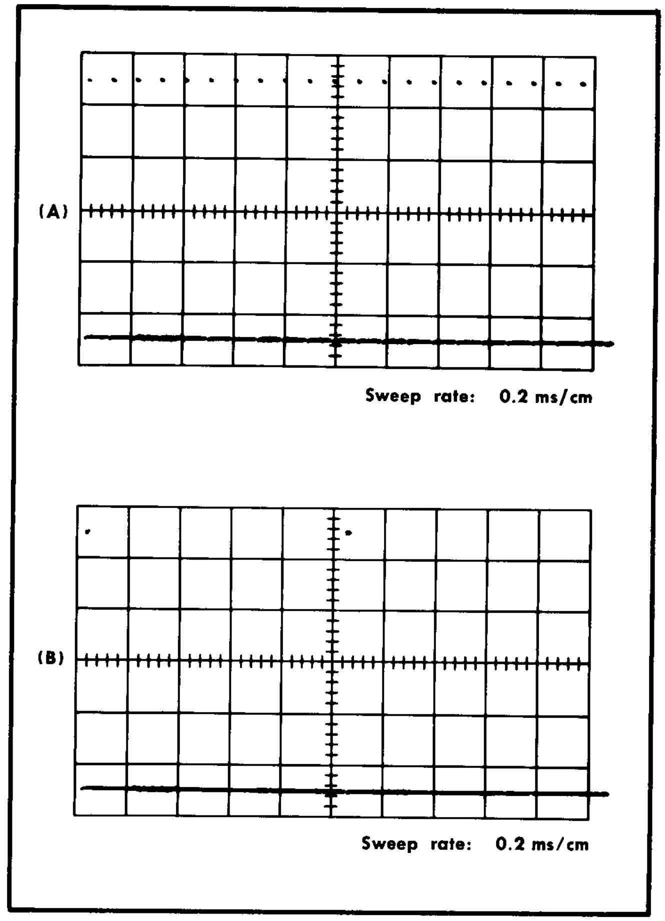


Fig. 2-7. Appearance of 10 μs-wide pulse. (A) Triggered internally by period generator at 100 μs period and (B) triggered externally by ≈1 kHz calibrator signal.

DELAY OR BURST TIME RANGE	10 μS
WIDTH RANGE	1 μS
MULTIPLIER	10

36. Note the appearance of the internally triggered waveform (see Fig. 2-7A).

37. Set the Type R116 TRIGGER SOURCE switch to EXTERNAL OR MANUAL.

38. Connect the oscilloscope calibrator waveform (≈1 kHz) to the +TRIGGER INPUT connector of the Type R116.

39. Set the calibrator amplitude to 5 volts and note that the period of the output waveform is now controlled by the triggering signal from the calibrator (see Fig. 2-7B).

40. Set the MODE switch to the DLY'D SINGLE and DOUBLE positions. Note that the operation of the pulse generator is essentially the same, whether it is triggered from the free-running period generator or from an external triggering source.

41. Disconnect the +Pretrigger Out cable.

42. Connect the oscilloscope calibrator signal through a T connector and two coaxial cables to the Type R116 +TRIGGER INPUT and the oscilloscope External Trigger Input.

43. Reset the following Type R116 controls:

MODE	BURST
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	10 μS
DELAY OR BURST TIME	
RANGE	10 μS
MULTIPLIER	15
WIDTH RANGE	100 nS
MULTIPLIER	15
RISETIME FALLTIME	
RANGE	10 nS

44. Note the bursts of output pulses triggered at the frequency of the amplitude calibrator (Fig. 2-8A).

45. Turn the DELAY OR BURST TIME MULTIPLIER control and note the change in the burst width.

46. Set the DELAY OR BURST TIME MULTIPLIER control to 25.

47. Increase the oscilloscope sweep rate to 20 μs/cm and observe the pulse waveform making up the bursts. Characteristics of the waveform during the burst time are controlled by the Period, Width, etc. controls in the usual manner.

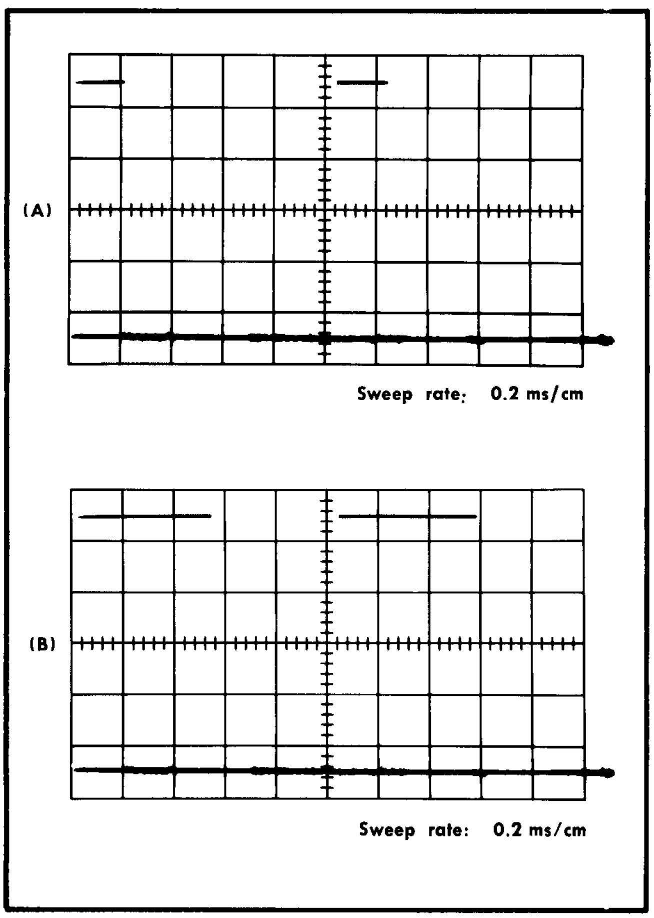


Fig. 2-8. Output pulse bursts (A) in Burst mode; (B) in Gated Output mode.

48. Set the MODE switch to GATED OUTPUT.

49. Disconnect the calibrator signal from the Type R116 +TRIGGER INPUT connector and connect it to the +GATE IN connector.

50. Reset the oscilloscope sweep rate to 0.2 ms/cm.

51. Note the bursts of output pulses during the + gate intervals provided by the calibrator waveform. The pulses within these bursts are controlled by the Period, Width, etc. controls as in Burst mode.

52. Set the MODE switch to SINGLE. This completes the demonstration of front-panel controls. The input and output signal cables may now be disconnected.

PULSE DEFINITIONS

The following pulse terms are defined here and illustrated in Fig. 2-9 as they are used in this manual with respect to the Type R116.

Period: The interval of time between corresponding points on the leading (or trailing) edges of adjacent pulses or pairs of pulses.

Risetime (T_r): The time interval required for the amplitude to move from the 10% level to the 90% level on the leading edge of a pulse.

Falltime (T_r): The time interval required for the amplitude to move from the 90% level to the 10% level on the trailing edge of a pulse.

Width: The time interval between the 50% amplitude level on the leading edge of a pulse and the 50% level on the trailing edge.

Delay Time: The duration of the time interval between the start of the undelayed output pulse and the start of the delayed output pulse, or between the +Pretrigger Out pulse and the +Delayed Trigger Out pulse.

Burst Time: The time duration of a burst of pulses.

Amplitude: The voltage displacement between the pulse baseline and the maximum excursion of the pulse (excluding overshoot).

Polarity: The direction of the initial pulse excursion from the baseline, either positive-going (+) or negative-going (—).

Overshoot: The extent of pulse rise above the normal pulse amplitude and pulse fall below the baseline.

Rounding or Undershoot: The amount of the pulse rise that is rounded off at the end of the rise (relative to the normal amplitude) or of the pulse fall that is rounded off at the end of the fall.

Aberrations: Deviations from an ideal square-cornered pulse shape, often appearing as short-duration irregularities following the pulse rise and fall.

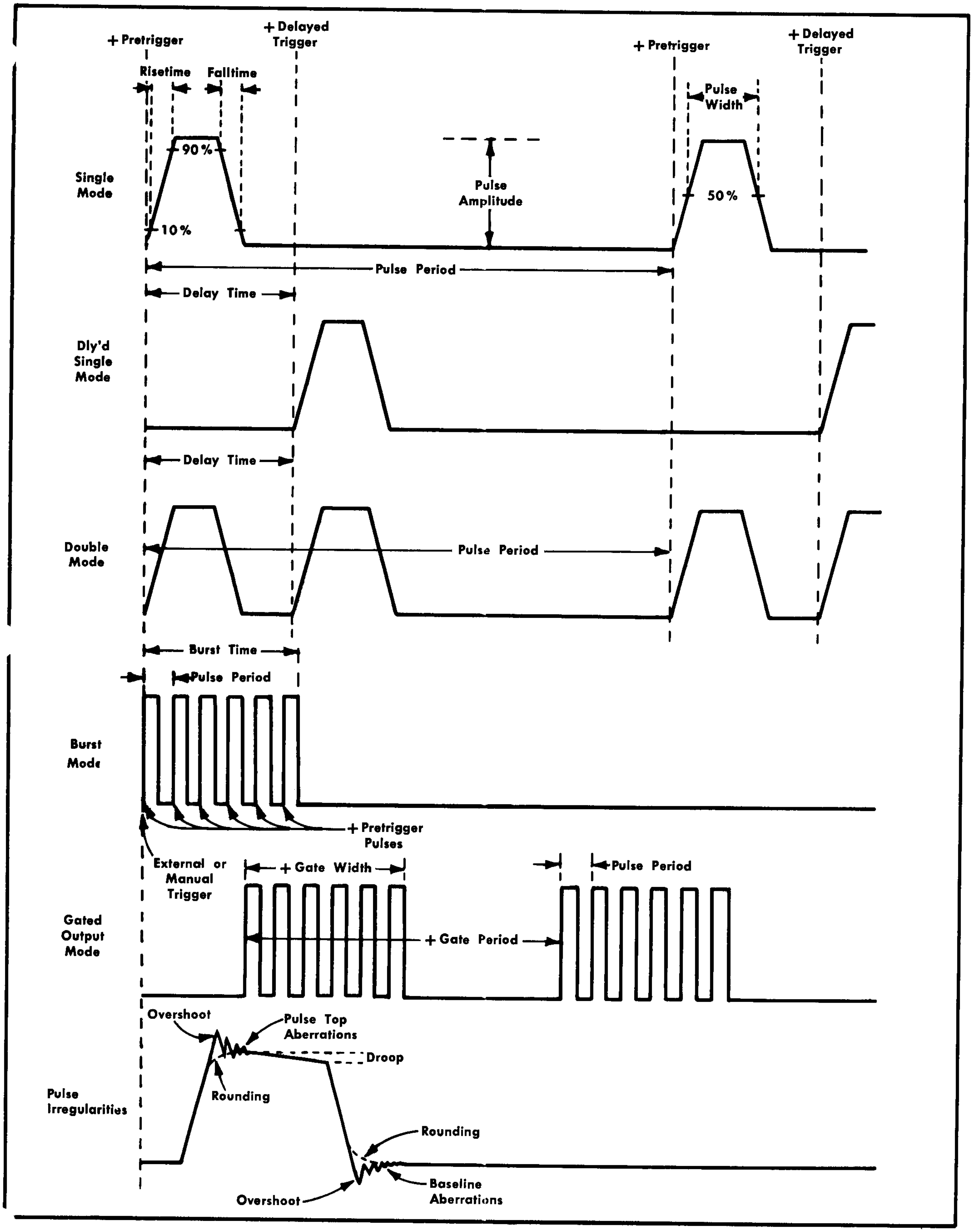


Fig 2-9. Pulse waveforms illustrating the use of pulse terms.

Tilt or Droop: The amount of change in pulse amplitude between the end of the pulse rise and the start of the pulse fall.

SELECTING OUTPUT PULSE CHARACTERISTICS

Since there are many possible combinations of control settings that will produce no Pulse Output signal, the following points should be kept in mind whenever setting up the pulse characteristics:

1. The pulse risetime must be less than the pulse width.

2. The falltime must be less than the interval between pulses (period minus width).

3. The pulse width must be at least 50 ns less than the period.

4. The delay time must be less than the period, but at least 50 ns longer than the pulse width.

When setting the controls while monitoring the output pulse with a test oscilloscope, it is often helpful to set the risetime and falltime controls to minimum until the other pulse characteristics have been established. This eleminates the problem of having no output pulse as a result of a slow risetime and/or falltime.

Mode

Five different operating modes are available with the Type R116, each one providing a different type of output pulse signal:

Single—A sequence of single equally-spaced pulses.

Dly'd Single—A sequence of single equally-spaced pulses, each pulse occurring after a delay interval following the pretrigger pulse.

Double—A sequence of double pulses, essentially a combination of the Single and Dly'd Single pulse signals.

Burst—A sequence of pulse bursts, with each burst initiated by an external or manual triggering pulse and lasting for a duration set by the delay or burst time controls. Characteristics of each pulse within the burst are set by other controls.

Gated Output—A sequence of pulse bursts determined by an external + gate signal.

When the MODE switch is set to the REMOTE PROGRAM position, the operating mode is determined by remote logic information received through the rear-panel REMOTE PROGRAM connector.

Period

The period between output pulses is determined either by an internal free-running period generator or by an external or manual triggering signal.

When operated internally in Single, Dly'd Single or Double mode with the TRIGGER SOURCE switch set to INTERNAL, the pulse period is selected by means of the PERIOD RANGE switch and MULTIPLIER control. The period is continuously variable and calibrated from 100 ns to 11 ms in five ranges. The MULTIPLIER control provides ×1 to ×11 multiplication of the PERIOD RANGE switch setting, with calibrated dial readings within 3% (5% on the 100 ns range). In Burst or Gated Output modes, the period of the pulse signal during each burst is also set by the PERIOD RANGE switch and MULTIPLIER control.

Example: If the PERIOD RANGE switch is set to 1 μS and the MULTIPLIER control is set to 5.5, the pulse period is 5.5 μs (providing the width controls are set to be less than the pulse period).

Since the pulse period is the reciprocal of its frequency, any pulse frequency from 91 Hz to 10 MHz can be obtained by calculating the period of the signal and setting the period controls for that frequency.

With the TRIGGER SOURCE switch set to EXTERNAL OR MANUAL (in Single, Dly'd Single or Double mode), the period is set by the period of an external triggering signal applied through the +TRIGGER INPUT connector. Single pulses (or pairs) may also be obtained by means of the manual TRIG button.

When the PERIOD RANGE switch is set to REMOTE position, the period range and multiplication factor are determined by remote logic and analog information applied through the REMOTE PROGRAM connector.

Risetime and Falltime

The risetime and falltime of the output pulses are determined by the settings of the RISETIME FALLTIME RANGE switch, the RISETIME MULT or FALLTIME MULT control and the AMPLITUDE MULTIPLIER control. The reason the amplitude must be considered is that the Type R116 output pulse has an essentially linearly rising leading edge and linearly falling trailing edge; thus, the risetime and falltime are affected by the amplitude to which the pulse is allowed to rise.

Risetime and falltime are continuously variable and calibrated (at maximum AMPLITUDE MULTIPLIER setting) from 10 ns to 110 μs in four ranges. Within each of these ranges, the risetime and falltime are independently variable from ×1 to ×11 multiplication, with risetime-falltime ratios from 1:11 to 11:1. Calibration of the switch and dial readings is within 5% (10% on the 1 nS range).

Example: If the RISETIME FALLTIME RANGE switch is set to 100 nS, the RISETIME MULT control set to 2, the FALLTIME MULT control set to 4 and the AMPLITUDE MULTIPLIER control set to 5, the pulse risetime will be 100 nS × 2 × 5 equals 1 μs and the falltime will be 100 ns ×4 × 5 equals 2 μs.

When the PROGRAM switch is set to REMOTE position, the risetime-falltime range is determined by remote logic information and the risetime and falltime multiplication factors are determined by remote analog information received through the REMOTE PROGRAM connector.

Width

The output pulse width is determined primarily by the settings of the WIDTH RANGE and MULTIPLIER controls, but is affected in some cases by the risetime, the falltime an the pulse amplitude. Calibration of the width controls applies only when the risetime and falltime are set for minimum;

but if the risetime and falltime are equal, the width reading is still approximately correct.

Example: With the RISETIME FALLTIME RANGE switch set to 1 nS and the RISETIME MULT and FALLTIME MULT controls set to 1, if the WIDTH RANGE switch is at 100 nS and the WIDTH MULTIPLIER is at 30, the pulse width at the 50% level is 3 μs.

If the risetime and falltime are not equal, the pulse width may be quite different from the width reading. Each pulse is produced by a linear rise following a triggering event, then a linear fall after a specific time interval (width gate). Thus, the pulse width is decreased if only the risetime is lengthened, and is increased if only the falltime is lengthened. This effect is emphasized slightly by an apparent time shift of the more slowly rising or falling edge (see Fig. 2-10), as a result of the increased amount of time required for the slower rise or fall to overcome the amplitude clamp. In addition, with unequal rates of rise and fall, the amplitude of the pulse will also affect the width.

The easiest way of setting a precise pulse width when the risetime and falltime are not minimum and the AMPLITUDE MULTIPLIER control is not at maximum, is by displaying the output pulse on a test oscilloscope and adjusting the controls for the desired characteristics. However, to set up the width controls (or remote program values) without the use of an oscilloscope, purely numerical calculations can be used to establish the approximate settings (±10%-20%), as follows:

If the risetime is longer than the falltime, the pulse width (with the AMPLITUDE MULTIPLIER at 10) is **decreased** by an amount approximately equal to ½ the difference between the risetime and the falltime.

If the risetime is shorter than the falltime, the pulse width (with the AMPLITUDE MULTIPLIER at 10) is **increased** by an amount approximately equal to ½ the difference between the risetime and the falltime.

If the AMPLITUDE MULTIPLIER control is to be set to a position less than 10 and the risetime and falltime are not equal, the pulse width at the 50% level is changed by an additional amount, approximately equal to ½ the difference between the risetime and the falltime, times ⅛ the difference between 10 and the desired AMPLITUDE MULTIPLIER setting. This change is in addition to the decrease or increase just mentioned. If the risetime is longer than the falltime, the additional change is:

Width increase $= \frac{1}{2} (T_r - T_f) \times \frac{1}{8}$ (10 — AMPLITUDE MULT)

If the risetime is shorter than the falltime, the additional change is:

Width decrease $= \frac{1}{2} (T_f - T_r) \times \frac{1}{8}$ (10 — AMPLITUDE MULT)

When the WIDTH RANGE switch is set to REMOTE position, the width range and multiplication factor are determined by remote logic and analog information received through the rear-panel REMOTE PROGRAM connector.

Amplitude

Pulse amplitude is determined by the settings of the AMPLITUDE RANGE switch and MULTIPLIER control. The amplitude into 50 Ω is continuously variable and calibrated from 400 mV to 10 volts in three ranges. The calibration does not apply if the impedance of the output load is other

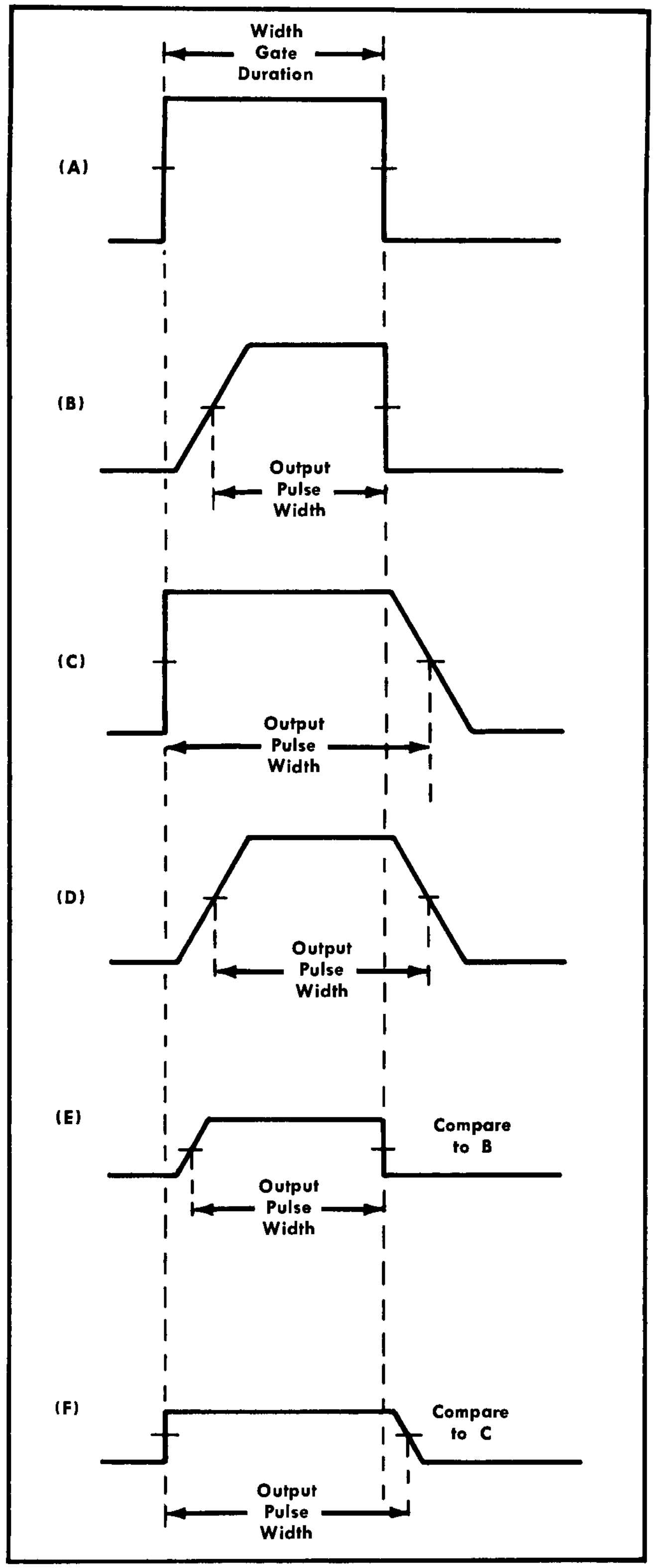


Fig. 2-10. Effects of risetime, falltime and amplitude on pulse width; (A) 3 μs pulse with AMPLITUDE MULTIPLIER at 10 and risetime and falltime at minimum; (B) pulse width is decreased by increase in risetime; (C) width is increased by increase in falltime; (D) width is approximately equal to initial pulse width with equal risetime and falltime; (E) width is increased by decrease in amplitude if risetime is greater than falltime; (F) width is decreased by decrease in amplitude if risetime is shorter than falltime.

than 50 Ω.[2] The MULTIPLIER control provides ×2 to ×10 multiplication of the PERIOD RANGE switch setting, with calibrated dial readings within 3%.

Example: If the AMPLITUDE RANGE switch is set to .5 V and the MULTIPLIER control is set to 4, the pulse amplitude is 2 volts.

When the AMPLITUDE RANGE switch is set to the REMOTE position, the amplitude range and multiplication factor are determined by remote logic and analog information applied through the REMOTE PROGRAM connector.

Delay or Burst Time

The DELAY OR BURST TIME RANGE switch and MULTIPLIER control set the delay time (see Fig. 2-9) or the burst time, depending on the mode of operation, as follows:

In Double mode, these controls adjust the delay time between the start of the undelayed output pulse and the start of the delayed output pulse.

In Dly'd Single mode, these controls adjust the delay time before the start of the delayed output pulse, corresponding to the time of the delayed pulse in Double mode.

In Single, Dly'd Single and Double modes, these controls adjust the approximate delay time between the +Pretrigger Out pulse and the +Delayed Trigger Out pulse.

In Burst mode, the controls adjust the duration of the burst of output pulses, following an externally-applied trigger pulse.

The delay or burst time is continuously variable and calibrated from 50 ns to 550 μs in 4 ranges. The MULTIPLIER control provides ×5 to ×55 multiplication of the DELAY OR BURST TIME RANGE switch setting, with calibrated dial readings within 3%.

Example 1: With the MODE switch set to DOUBLE, if the DELAY OR BURST TIME RANGE switch is set to 100 nS and the MULTIPLIER control is set to 10, the time interval between corresponding points on the two pulses of each pair is 1 μs.

Example 2: With the MODE switch set to BURST, if the DELAY OR BURST TIME RANGE switch is set to 100 nS and the MULTIPLIER control is set to 10, the time duration of the burst will be approximately 1 μs and the number of output pulses within the burst will be determined by the setting of the period controls.

In Gated Output mode, the duration of the output burst is not determined by the DELAY OR BURST TIME controls, but rather by the width of an external + gate signal applied through the +GATE IN connector. The width of the + gate signal is measured at the +2-volt level.

When the DELAY OR BURST TIME RANGE switch is set to REMOTE position, the delay or burst time range and multiplication factor are determined by remote logic and analog information applied through the REMOTE PROGRAM connector.

[2] **Pulse output current is from 40 mA to 200 mA on the 1 V amplitude range (proportionately less on other ranges) regardless of the load impedance, as long as the output amplitude is no greater than ±10 volts.**

Polarity

Selection of the output pulse polarity is made by means of the POLARITY switch. When set to the + position, the first excursion of each output pulse is positive-going from the baseline. When set to the — position, the first excursion is negative-going.

When the POLARITY switch is set to the REMOTE PROGRAM position, logic information applied through the rear-panel REMOTE PROGRAM connector determines the polarity of the output pulses.

DC Offset

The DC OFFSET control provides dc positioning of the pulse baseline up to ±5 volts (in the 1 V amplitude range). The dial reading of the DC OFFSET control must be multiplied by the setting of the AMPLITUDE RANGE switch to obtain the dc baseline offset added to the output pulse signal. That is, when the AMPLITUDE RANGE switch is in the .2 V position, the range of the DC OFFSET control is from —1 volt to +1 volt; when the switch is in the .5 V position, the offset range is from —2.5 volts to +2.5 volts, and when the switch is in the 1 V position, the dc offset range is from —5 volts to +5 volts. Accuracy of the DC OFFSET control calibration is within 150 mV of the switch and dial readings, and within 50 mV at the 0 position of the control. This calibration applies only when the output load is 50 Ω.[3]

Through use of the DC OFFSET control, the output pulse can be positioned with respect to voltage on a dc-coupled oscilloscope or other display device, or the dc level of the pulse signal can be made positive or negative with respect to ground for application to a test device.

When the PROGRAM switch is set to the REMOTE position, the dc offset function is provided by remote analog information applied through the REMOTE PROGRAM connector.

OPERATION WITH AN OSCILLOSCOPE

One of the primary uses of the Type R116 is in conjunction with an oscilloscope when testing an external device. In the usual application, the +Pretrigger Out signal from the Type R116 triggers the sweep of the oscilloscope while the Pulse Output signal from the Type R116 is applied to some test device. The output signal from the test device is then connected to the oscilloscope vertical input where the waveform is monitored. Fig. 2-11 shows the connections between the Type R116 and the other equipment.

In some cases, it may be desirable to use internal triggering of the test oscilloscope, but often external triggering is preferred to assure that the oscilloscope sweep is started before the signal arrives from the test device. The external trigger also provides the convenience of a constant-amplitude triggering signal that eliminates the need for readjusting the triggering controls, and provides a time reference for making time-relation measurements between signals at various points within the test device.

[3] **Offset current is from 0 to ±100 mA on the 1 V amplitude range (proportionately less on lower ranges) regardless of the load impedance, as long as the offset voltage is no greater than ±5 volts.**

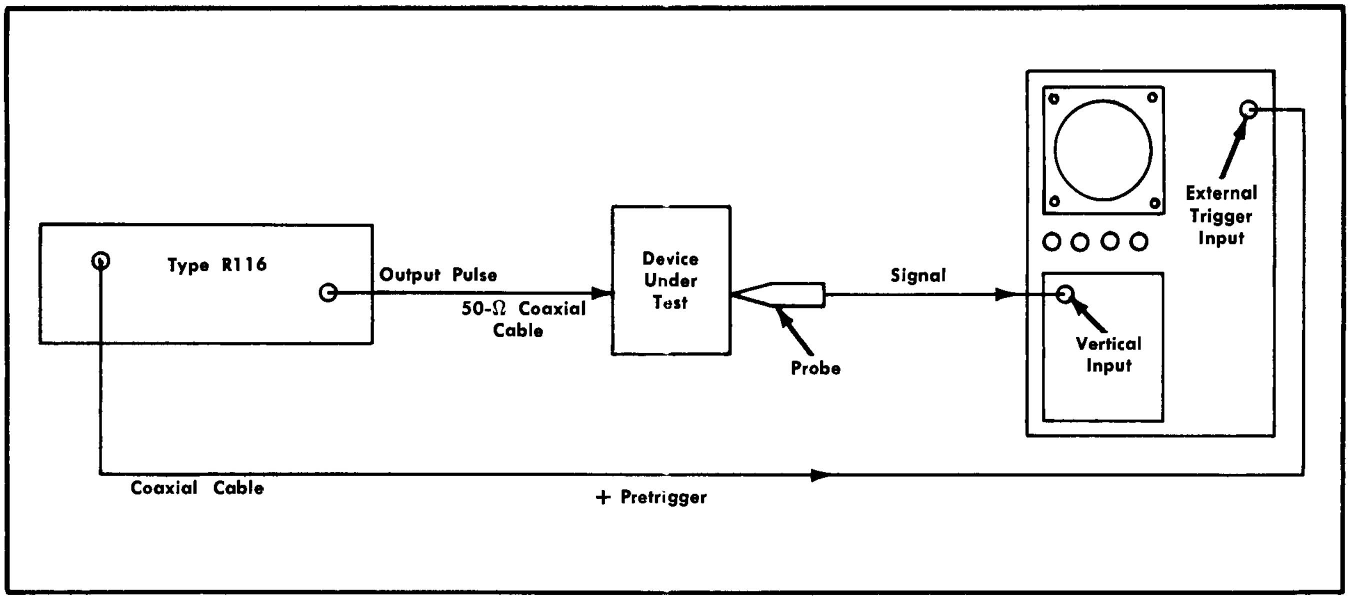


Fig. 2-11. Normal test setup using the +Pretrigger Out pulse for triggering the display oscilloscope.

TRIGGERING

The Type R116 can be triggered either internally, externally or manually, depending on the particular mode of operation and on the setting of the TRIGGER SOURCE switch. In addition, the Type R116 can trigger external equipment using either the +Pretrigger Out pulse or the +Delayed Trigger Out pulse.

Triggering the Type R116

In Single, Dly'd Single and Double modes, when the TRIGGER SOURCE switch is set to INTERNAL, triggering of the output pulses is done by a free-running period generator within the Type R116. Repetition rates available with internal triggering are from approximately 90 Hz to 10 MHz (100 ns to 11 ms period). In these modes, when the TRIGGER SOURCE switch is set to EXTERNAL OR MANUAL position, triggering is provided by an external signal applied through the front-panel +TRIGGER INPUT connector or by a manual trigger pulse from the manual TRIG button. With external triggering, repetition rates from dc to 10 MHz (100 ns period) can be obtained.

In Burst mode, triggering of the bursts is accomplished by an external signal applied through the +TRIGGER INPUT connector, but the internal free-running period generator still determines the triggering of each of the pulses within the bursts. If the duration of the burst is longer than the time between trigger pulses, each burst occurs following the first trigger after the end of the preceding burst.

In Gated Output mode, each burst is started and ended by the gating signal, but the triggering of each pulse within the gated burst is determined by the internal period generator as in Burst mode.

+TRIGGER INPUT. A +2 to +20-volt signal is required o externally trigger the operation of the pulse generator. ıf the triggering signal has a dc component that prevents it from passing through the +2-volt level, a coupling capacitor must be used. The time constant of the coupling should be quite fast if the full repetition rate of the instrument is to be used. Input impedance of the +TRIGGER INPUT is 1 kΩ or more.

The external signal may be applied to the +TRIGGER INPUT through a 50-Ω coaxial cable and attenuators as necessary to bring the amplitude into the 2 to 20-volt range. For some applications, a trigger probe can be connected directly to the +TRIGGER INPUT connector and the probe tip connected to a desired triggering source. A 1× probe should be used for triggering signals from 2 volts to 20 volts and a 10× probe for signals from 20 volts to 200 volts in amplitude. For best results, the 10× probe should be compensated after installation. (This may be done by connecting the probe tip to a 20-volt square-wave source and adjusting the probe compensation while monitoring the signal with another probe connected just inside the +TRIGGER INPUT connector.)

+GATE IN. With the MODE switch set to GATED OUTPUT position, an input + gate signal applied to the +GATE IN connector provides gated bursts of output pulses. Amplitude of the input signal may be from +2 to +10 volts. Each burst begins approximately 100 ns after the gate signal exceeds the +2-volt level and stops approximately the same length of time after the gate returns below +2 volts.

The input signal should be applied through a 50-Ω coaxial cable, but a patch cord may be used if necessary. Since the input is dc coupled, any signal with an associated dc voltage will have to be applied through a coupling capacitor. The time constant of the coupling must be long enough to keep the level above +2 volts for the duration of the gate. Input impedance of the +GATE IN is 1 kΩ or more.

Manual Triggering. In Single, Dly'd Single and Double modes, when the TRIGGER SOURCE switch is set to EXTERNAL OR MANUAL position and no external signal is applied to the +TRIGGER INPUT, a single output pulse (or pair of pulses) may be obtained by pressing the manual TRIG button. In Burst mode, a single burst of output pulses is obtained when the manual TRIG button is pressed, with no external signal applied. For Burst mode, the TRIGGER SOURCE switch is not operational and may be in any position.

Remote Operation. When the TRIGGER SOURCE switch is set to REMOTE PROGRAM, selection of the trigger source is provided by remote logic information applied through the rear-panel REMOTE PROGRAM connector. Remote trigger selection in the various modes is the same as for front-panel operation. For example, the external triggering signal is still applied through the front-panel +TRIGGER INPUT connector.

Triggering External Equipment

Either the +Pretrigger Out pulse or the +Delayed Trigger Out pulse may be used to trigger a test oscilloscope or other external device. When the +pretrigger is used, the oscilloscope sweep is time-referenced to the start of the undelayed output pulse. In Dly'd Single mode, for example, when the oscilloscope display is triggered by the +Pretrigger Out signal, the delayed pulse will move across the crt screen as the DELAY OR BURST TIME MULTIPLIER control is operated.

If the +Delayed Trigger pulse is used for triggering, the oscilloscope sweep is time-referenced to the start of the delayed output pulse, and an undelayed pulse will move across the crt display as the DELAY OR BURST TIME MULTIPLIER control is turned.

Since the amplitude of each of these trigger outputs is approximately 2 volts into 1 kΩ, it can be connected directly to the External Trigger Input of a conventional oscilloscope. Into 50 Ω the amplitude is approximately 1 volt, therefore it should be attenuated approximately 20 times before applying it to the 50 Ω trigger input of a sampling oscilloscope.

+Pretrigger Out. The +Pretrigger Out signal is a positive-going pulse which occurs 30 ns or more before the start of the rise of each non-delayed output pulse in Single and Double modes, at the beginning of each pulse within a burst in Burst and Gated Output modes, and at approximately the delay interval preceding the start of the delayed output pulse in Dly'd Single mode. The +Pretrigger Out also precedes the +Delayed Trigger Out by approximately the delay time selected by the DELAY OR BURST TIME controls. Amplitude into 1 kΩ is at least 2 volts and risetime is typically 10 ns. The +Pretrigger Out serves as a good time-reference signal for other output signals from the Type R116 and for internal signals within the instrument. Connect the +Pretrigger Out pulse to the External Trigger Input of the oscilloscope or other device through a coaxial cable and attenuators if necessary.

+Delayed Trigger Out. The +Delayed Trigger Out signal is a positive-going pulse occurring 30 ns or more before the start of the rise of each delayed pulse in Dly'd Single and Double modes and at approximately the delay time following the +Pretrigger Out pulse in Single, Dly'd Single and Double modes. In Burst mode, the +Delayed Trigger Out occurs at the end of each burst. Amplitude of the +Delayed Trigger Out pulse is at least 2 volts into 1 kΩ and risetime is typically 10 ns.

The +Delayed Trigger Out signal provides a convenient time reference for viewing delayed output pulses from the Type R116 and for time-positioning non-delayed output pulses on the display oscilloscope crt screen. Connect the +Delayed Trigger Out signal to the External Trigger Input of the oscilloscope through a coaxial cable and attenuators if necessary.

OUTPUT PULSE CONNECTIONS

The PULSE OUTPUT circuit of the Type R116 is designed to work into a 50-Ω load and is calibrated in amplitude only into 50 Ω. Higher impedances will produce higher voltage amplitudes and greater dc offset, but may also cause reflections and ringing in the output connecting cables. Lower impedances will produce lower amplitudes and less offset, but will not overload the output circuit.

Basic Precautions

Certain precautions should always be observed when connecting the PULSE OUTPUT signal to a test device or when connecting the test device output to a display oscilloscope.

1. Use high-quality coaxial cables and connectors for all signal connections.

2. Make sure that all connections are tight and that all connectors are tightly assembled.

3. Keep signal cables as short as possible to preserve the signal quality.

4. Use attenuators as needed to limit the signal amplitude into sensitive circuits.

5. Use terminations and impedance-matching devices to suit the application.

6. Use only attenuators, terminations, etc., that have power ratings suitable for the 4.5 watts maximum output from the Type R116. (Power output is determined by offset current and duty factor of pulse current.)

Risetime Considerations

If the output pulse signal from the Type R116 is to be used for determining the risetime of a test device, the risetime of the Type R116 output pulse may have to be taken into consideration.

In general, if the risetime of the test device is at least 10 times as long as the combined risetimes of the Type R116 and the monitoring oscilloscope and cables, the error introduced into the measurement will not be more than about 1%, and therefore can be considered negligible. However, if the risetime of the test device is less than 10 times as long as the combined risetime of the testing system, the observed risetime will not give a true measurement of the test device. In this case, the risetime of the test device will have to be determined from the risetimes of the various components making up the system.

Normally the overall risetime of the system is equal to the square root of the sum of the squares of the individual risetimes. Thus the risetime of the test device can be determined if the risetimes of all of the other components are known. Since the minimum risetime of the Type R116 is slightly less than 10 ns, the practical lower limit of risetime measurements is approximately 10 ns.

Cabling Considerations

The cables that conduct the output pulse to the device under test should be low-loss 50-Ω coaxial cables to assure that all information contained in the pulse will be delivered to the test point without distortion. The physical and electrical characteristics of the cable determine the characteristic impedance, velocity of propagation and nature of signal loss. Since the signal losses caused by energy dissipation in the dielectric are proportional to the signal frequency, any very high frequency information in a fast-rise pulse will be lost in a very few feet of cable. Therefore it is important to use cables that are as short as possible.

When making signal-comparison measurements or time-difference determinations, the two response signals from the test device should travel through coaxial cables that have identical loss characteristics and identical time delay.

If there is a dc voltage across the output load, a coupling capacitor should be used to prevent offset compression of the output pulse. Be sure the recovery time constant of the coupling is short enough to prevent signal distortion. If a coupling capacitor is not used, the output pulse amplitude will be compressed if the dc voltage is less than ±10 volts and will possibly be shorted out if the voltage present exceeds ±10 volts.

Impedance Matching

To provide a smooth transition between devices of different characteristic impedance, each device must encounter a total impedance that is equal to its own characteristic impedance at the input or output point. A simple resistive impedance-matching network that provides minimum attenuation is illustrated in Fig. 2-12. To match impedances with the illustrated network, the following conditions must exist:

$$\frac{(R_1 + Z_2)\,R_2}{(R_1 + Z_2) + R_2} \text{ must equal } Z_1$$

and $$R_1 + \frac{Z_1 R_2}{Z_1 + R_2} \text{ must equal } Z_2$$

Therefore:

$$R_1R_2 = Z_1Z_2; \text{ and } R_1Z_1 = R_2(Z_2 - Z_1)$$

$$\text{or } R_1 = \sqrt{Z_2(Z_2 - Z_1)};$$

$$\text{and } R_2 = Z_1\sqrt{\frac{Z_2}{Z_2 - Z_1}}$$

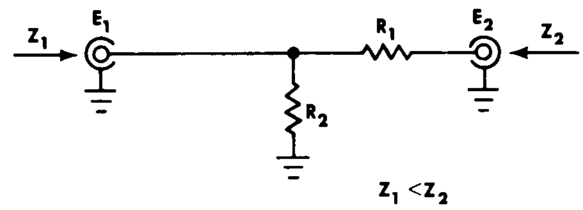
As an example, to match a 50-Ω system to a 125-Ω system, Z_1 equals 50 Ω and Z_2 equals 125 Ω.

Therefore:

$$R_1 = \sqrt{125\,(125 - 50)} = 96.8 \text{ ohms}$$

$$\text{and } R_2 = 50\sqrt{\frac{125}{125 - 50}} = 64.6 \text{ ohms}$$

When constructing such a device, the environment surrounding the components should also be designed to provide a transition between the impedances. Keep in mind that the characteristic impedance of a coaxial device is determined by the ratio between the outside diameter of the inner conductor and the inside diameter of the outer conductor ($Z_o = 138 \log_{10} D_1/D_2$).



To match impedances:

$$R_1 R_2 = Z_1 Z_2 \text{ and } R_1 Z_1 = R_2 (Z_2 - Z_1)$$

$$\text{or: } R_1 = \sqrt{Z_2 (Z_2 - Z_1)} \text{ and } R_2 = Z_1\sqrt{\frac{Z_2}{Z_2 - Z_1}}$$

Fig. 2-12. Simple impedance-matching network providing minimum attenuation.

Though the network in Fig. 2-12 provides minimum attenuation for a purely resistive impedance-matching device, the attenuation as seen from one end does not equal that seen from the other end. A signal applied from the lower impedance source (E_1) encounters a voltage attenuation (A_1) which is greater than 1 and less than 2, as follows:

$$A_1 = \frac{E_1}{E_2} = \frac{R_1}{Z_2} + 1$$

A signal applied from the higher impedance source (Z_2) encounters a greater voltage attenuation (A_2) which is greater than 1 and less than 2 Z_2/Z_1:

$$A_2 = \frac{E_2}{E_1} = \frac{R_1}{R_2} + \frac{R_1}{Z_1} + 1$$

In the example of matching 50 Ω to 125 Ω,

$$A_1 = \frac{96.8}{125} + 1 = 1.77$$

$$\text{and } A_2 = \frac{96.8}{64.6} + \frac{96.8}{50} + 1 = 4.44$$

The illustrated network can be modified to provide different attenuation ratios by adding another resistor (less than R_1) between Z_1 and the junction of R_1 and R_2.

CONTROL SETUP CHART

Fig. 2-13 shows the front- and rear-panel controls and connectors of the Type R116. This chart may be reproduced and used as a test-setup record for special measurements, applications or procedures, or may be used as a training aid for familiarization with the Type R116.

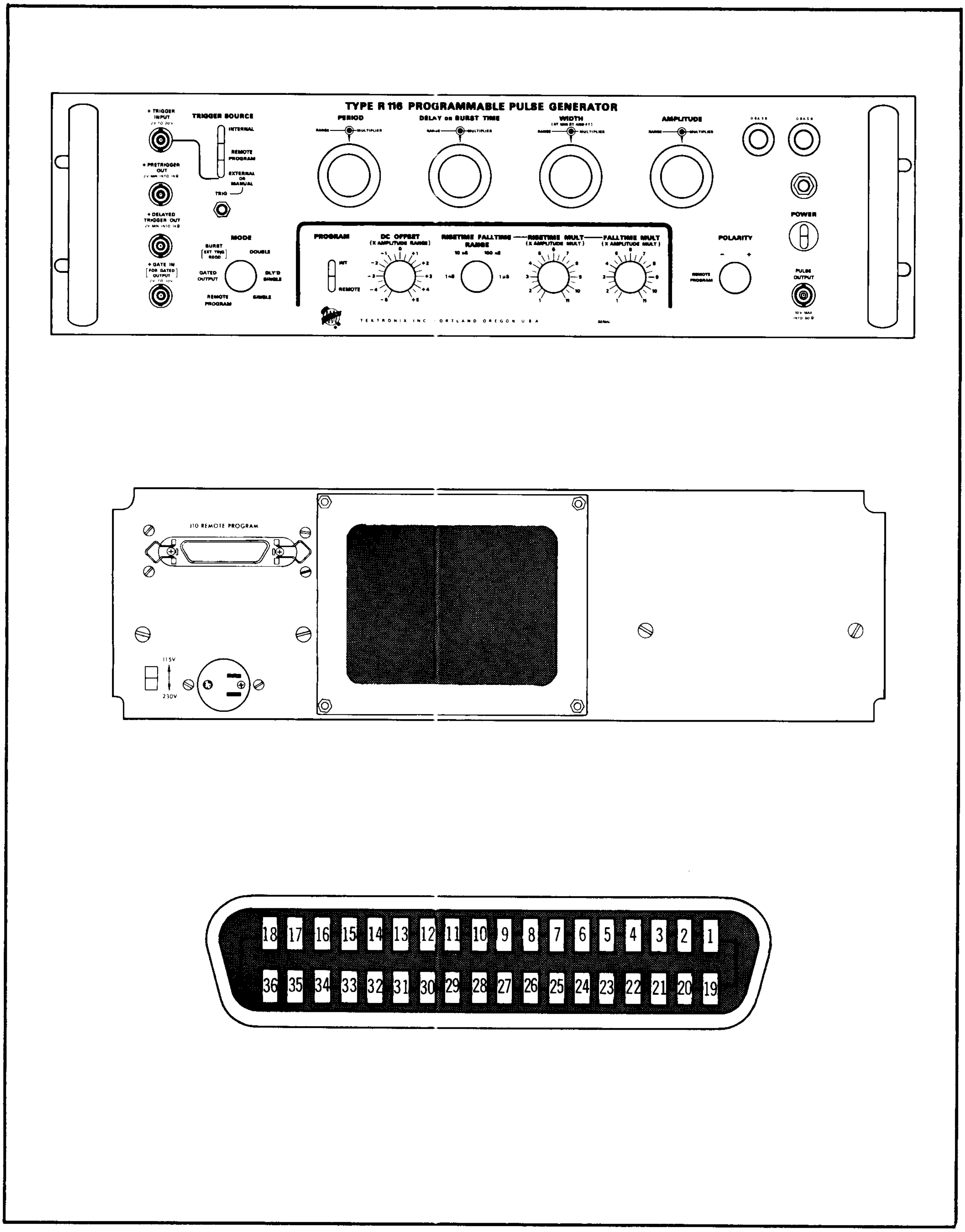


Fig. 2-13. Control setup chart for the Type R116.

SECTION 3
REMOTE PROGRAMMING

Introduction

General principles of external programming with the Type R116 are discussed in this section. Since each programming system will depend on the particular application of the instrument, the information presented here should be used only as a system guide.

General Information

The Type R116 is designed to be used either as part of a program system or as an independent instrument. All front-panel operations can be remotely programmed by information received through the 36-terminal Remote Program connector on the rear panel. Schematic No. 10 shows the connections to the Remote Program connector (J10). Since all front-panel switches are independent of other switches, any combination of front-panel operation and remote operation can be used. Any characteristic that does not need to be changed during the program can be set with the front-panel control and left at that preset value. Unnecessary program connections can be avoided by programming only the functions that need to be changed. Very few applications will require **all** functions to be remotely programmed.

The Type R116 can be programmed by means of auxiliary program cards in the Tektronix Type 262 Remote Programmer or by other external programming devices. When it is automatically sequenced, the Type R116 is able to operate up to a rate of approximately 25 programs per second.

Front-panel switch functions are programmed by means of contact closures to ground, and front-panel variable functions are programmed by analog resistance connected through the rear-panel REMOTE PROGRAM connector. Whenever one of the Range switches is set to the REMOTE position, both the range and the multiplier must be controlled remotely. If completely digital remote operation is desired, the analog information required for programming the variable controls must be supplied by a digital-to-analog converter. A simple type of converter that may be used for this purpose is described later in this section.

PROGRAMMING SWITCH FUNCTIONS

For each switch function that is to be programmed, one or more program lines are required from the Type R116 to the programming unit. One program line is needed for each mode or range to be programmed; thus a total of 21 program lines must be used if all front-panel switch functions are to be programmed (see Table 3-1). In addition, a current-return path is required from the programmer to the Type R116 chassis ground (connected through terminal #36 of the Remote Program connector). In some cases, diode switching may be designed into the programmer to reduce the number of contact closures required. The program lines may be connected with insulated #22 stranded copper wire and the return lead to ground may be insulated #18 stranded copper wire.

A contact closure to ground or a dc voltage level within 0.8 volt of ground constitutes a logical 1, and an open circuit of the program line or a dc voltage level of from +12 to +20 volts above ground constitutes a logical 0. For each group of program lines associated with a single switch, only one logical 1 is permissible. Each group may have 0's on all program lines or a 1 on one line and 0's on all other lines, but may not have 1 on more than one line. Table 3-1 gives the necessary logic information required to program the switch operations. Since each of the switch program lines connects into the Type R116 through a buffer amplifier, less than 1 mA of current is required for a logical 1.

PROGRAMMING ANALOG FUNCTIONS

Each front-panel variable (multiplier) control operation that is to be programmed requires one program resistance connected between an analog program line and a dc voltage supplied by the Type R116 through the REMOTE PROGRAM connector. The program resistors may be $\frac{1}{8}$-watt resistors with the tolerance selected on the basis of the desired multiplier accuracy. A total of 7 variable functions can be remotely programmed by means of analog resistances, requiring a total of 7 program lines and 4 power supply leads. Each of the program lines and power supply leads may be connected with insulated #22 stranded copper wire. Table 3-2 gives the REMOTE PROGRAM terminal connections for the analog functions.

Determination of Resistance Values

Conversion graphs and formulas for each of the analog functions are given in Fig. 3-1. These graphs and formulas provide quick determination of the remote resistance required for a desired multiplication factor. Approximate resistance values can be read directly from the graphs and more precise values can be calculated from the resistance formulas. Each resistance bears a linear relationship to the corresponding multiplication factor.

Determination of Multiplication Factors

Due to the interdependence of several pulse characteristics (amplitude, risetime, falltime and width), it is sometimes difficult to determine exactly what multiplication factors are required to produce a desired display. An easy way to determine the required multiplication factors is by setting up the display through the use of front-panel controls and reading the multiplication factors from the calibrated dial settings. The numerical values thus obtained can then be used to calculate the remote program resistor values from the graphs or formulas.

Simple Digital to Analog Converter

Relay-operated networks of series resistors may be used to convert the programming of the Type R116 to completely

TABLE 3-1

Switch and Range Operations

Switch	Desired Operation	Logic Digital Information Through REMOTE PROGRAM Connector (J10)				
PERIOD RANGE		#5 (1 μS)	#6 (10 μS)	#7 (100 μS)	#8 (1 mS)	Terminal
	100 nS	0	0	0	0	Logic
	1 μS	1	0	0	0	
	10 μS	0	1	0	0	
	100 μS	0	0	1	0	
	1 mS	0	0	0	1	
DELAY OR BURST TIME RANGE		#10 (100 nS)	#11 (1 μS)	#12 (10 μS)		Terminal
	10 nS	0	0	0		Logic
	100 nS	1	0	0		
	1 μS	0	1	0		
	10 μS	0	0	1		
WIDTH RANGE		#14 (100 nS)	#15 (1 μS)	#16 (10 μS)		Terminal
	10 nS	0	0	0		Logic
	100 nS	1	0	0		
	1 μS	0	1	0		
	10 μS	0	0	1		
AMPLITUDE RANGE		#24 (.5 V)	#25 (1 V)			Terminal
	.2 V	0	0			Logic
	.5 V	1	0			
	1 V	0	1			
MODE		#20 (Dly'd Single)	#21 (Double)	#22 (Burst)	#23 (Gated Output)	Terminal
	SINGLE	0	0	0	0	Logic
	DLY'D SINGLE	1	0	0	0	
	DOUBLE	0	1	0	0	
	BURST	0	0	1	0	
	GATED OUTPUT	0	0	0	1	
TRIGGER SOURCE		#19 (External or Manual)				Terminal
	INTERNAL	0				Logic
	EXTERNAL OR MANUAL	1				
POLARITY		#18 (—Polarity)				Terminal
	+	0				Logic
	—	1				
RISETIME FALLTIME RANGE		#28 (10 nS)	#29 (100 nS)	#30 (1 μS)		Terminal
	1 nS	0	0	0		Logic
	10 nS	1	0	0		
	100 nS	0	1	0		
	1 μS	0	0	1		

Logical 0—Open circuit; Logical 1—Contact closure to chassis ground.

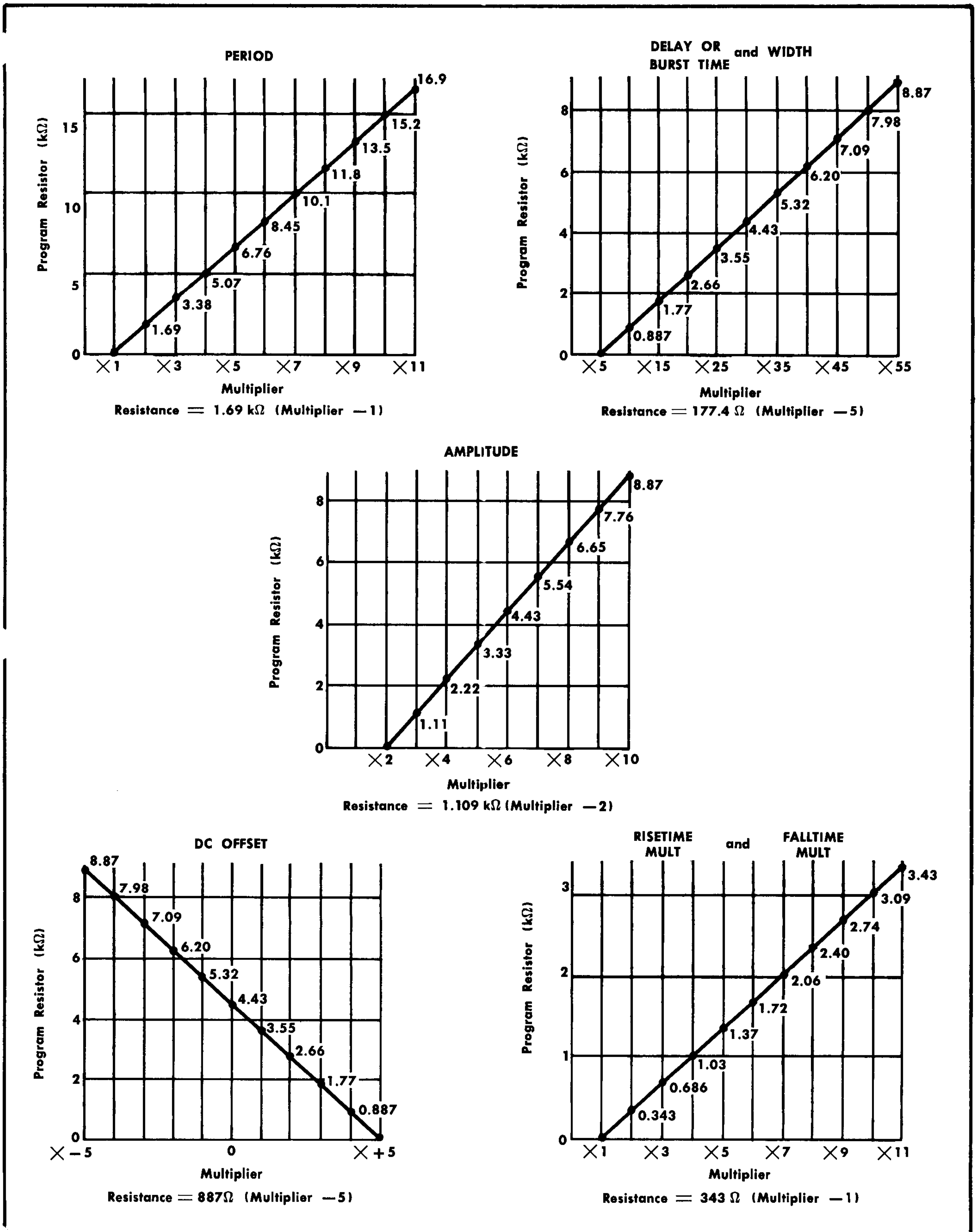


Fig. 3-1. Conversion factors for determining values of external analog program resistors.

TABLE 3-2

Analog Program Lines to REMOTE PROGRAM Connector

Analog Function	Program Terminal (J10)	Type R116 Supply Voltage	Supply Voltage Terminal (J10)
Period Multiplier	#9	−6 volts	#34
Delay or Burst Time Multiplier	#13	−27 volts	#3
Width Multiplier	#17	−27 volts	#3
Amplitude Multiplier	#27	Signal Ground	#1
DC Offset Control	#33	Signal Ground	#1
Risetime Multiplier	#31	+25 volts	#2
Falltime Multiplier	#32	−27 volts	#3

NOTE

Since the analog program voltages must be referenced to the Type R116, the program resistors must be connected to the power supply voltages from the Type R116. External voltage supplies cannot be used for this purpose.

digital operation. By using a shorting switch across each resistor, any combination of values in the series can be chosen. One such series is required for each analog function to be programmed. The number of resistors to be used is determined by the desired resolution. For example, with 8 resistors, as many as 256 increments can be obtained between the minimum and maximum multiplication factors of the control.

Various resistance-ratio codes can be used in the digital-to-analog converter. For any given number of bits (resistors), maximum resolution is obtained with straight binary code. There are also several binary coded decimal (BCD) conversion codes that can be used. Table 3-3 gives the conversion values for the 1-2-4-8 BCD code.

Multiplication factors in × 0.1 steps can be obtained by selecting resistor values such that the total series resistance is maximum for the particular function when the code total is 100. Fig. 3-2 shows a simple digital-to-analog converter connected for remote selection of multiplication factors with 1% resolution (multiplication factor steps of × 0.1), and Table 3-4 gives the binary equivalents of the various multiplication factors for the converter to show which of the relays should be activated to obtain any desired multiplication factor. The amplitude analog network in this converter is designed with the maximum resistance value for the function at the 80 code position so that each of the 8 major divisions (from ×2 to ×10) can be divided into 10 minor divisions (see Table 3-4). Most applications will not require the degree of resolution provided by the illustrated converter nor the degree of accuracy that is implied by the use of exact resistance values. Since the accuracy of each programmed function is specified to be within 2% of the front-panel calibration plus any program resistance error, it is not practical to use program resistors with closer than 1% tolerance unless the instrument is calibrated in Remote Program mode.

In addition to the required degree of resolution (number of steps) and accuracy (resistor tolerance), consideration

TABLE 3-3

1-2-4-8 Binary Coded Decimal Conversion

Decimal Value	BCD Value
1	1
2	2
3	2 and 1
4	4
5	4 and 1
6	4 and 2
7	4, 2 and 1
8	8
9	8 and 1
10	10
11	10 and 1
12	10 and 2
13	10, 2 and 1
...	...
20	20
30	20 and 10
40	40
50	40 and 10
60	40 and 20
70	40, 20 and 10
80	80
90	80 and 10
100	80 and 20

should also be given to the normal state of the converter when no activating power is applied to the program relays. In the illustrated converter, the period, delay or burst time, width, risetime and falltime multipliers are all at minimum multiplication factors with no relay power applied. This is accomplished by using all normally-closed relays for zero resistance. Notice, however, that the amplitude and dc offset networks have normally-open relay switches in series to open the circuits when no power is applied.

This takes advantage of the Type R116 circuitry that is designed to provide zero pulse output when the amplitude analog line is open and zero volts offset (±1 volt) when the dc offset analog line is open.

If other values of resistance are desired when no relay power is applied, normally-open relays may be used across the appropriate resistances. For example, to obtain a pulse amplitude of 10 volts with no relay power, omit the series relay switch in the amplitude network and place a normally-open switch across the resistor in the 80 position of the network (see Table 3-3). This provides 0.87 kΩ (×10) when no relay power is applied.

NOTE

If both normally-open and normally-closed relay-operated switches are used, the relay-actuating logic circuits (not shown in the illustrated converter) will have to be designed accordingly.

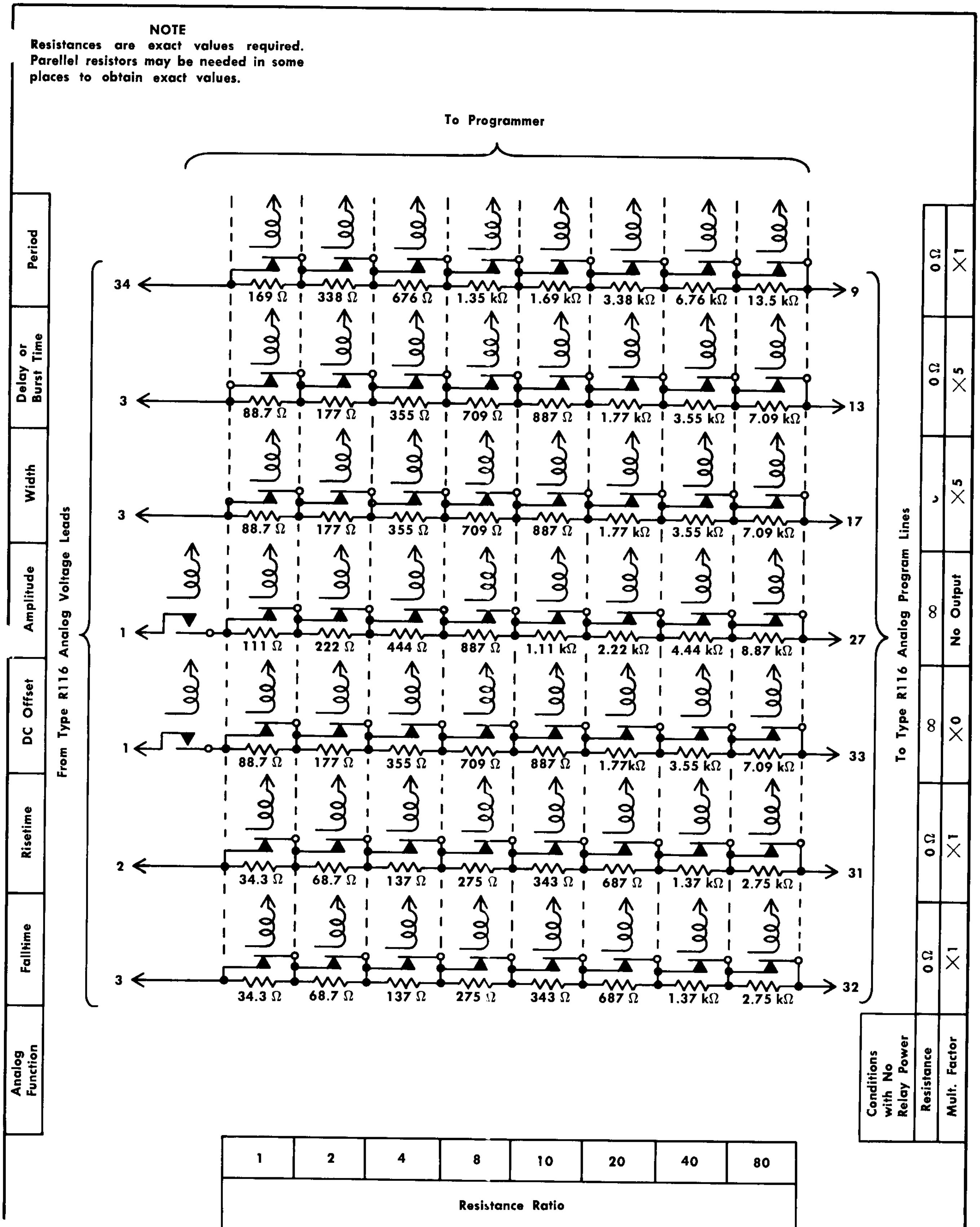


Fig. 3-2. Simple 1-2-4-8 BCD (Binary Coded Decimal) digital to analog converter with X0.1 multiplier increments and 1% accuracy as described in text. Power for relay coils should be provided from external power supply through small series resistors (≈270 Ω).

TABLE 3-4

Correlation of multiplication factors and binary equivalents for simple digital to analog converter shown in Fig. 3-2.

PERIOD		DELAY OR BURST TIME and WIDTH		AMPLITUDE		DC OFFSET		RISETIME and FALLTIME			
Mult. Factor	Resistance	Mult. Factor	Resistance	Mult. Factor	Resistance	Mult. Factor	Resistance	Mult. Factor	Resistance	Decimal Equivalent	Binary Equivalent
×1.0	0 Ω	×5.0	0 Ω	×2.0	0 Ω	×+5.0	0 Ω	×1.0	0 Ω	0	0
×1.1	169 Ω	×5.5	88.7 Ω	×2.1	111 Ω	×+4.9	88.7 Ω	×1.1	34.3 Ω	1	1
×1.2	338 Ω	×6.0	177 Ω	×2.2	222 Ω	×+4.8	177 Ω	×1.2	68.7 Ω	2	2
×1.3	507 Ω	×6.5	266 Ω	×2.3	333 Ω	×+4.7	266 Ω	×1.3	103 Ω	3	2,1
×1.4	676 Ω	×7.0	355 Ω	×2.4	443 Ω	×+4.6	355 Ω	×1.4	137 Ω	4	4
×1.5	845 Ω	×7.5	443 Ω	×2.5	554 Ω	×+4.5	443 Ω	×1.5	172 Ω	5	4,1
×1.6	1.01 kΩ	×8.0	532 Ω	×2.6	665 Ω	×+4.4	532 Ω	×1.6	206 Ω	6	4,2
×1.7	1.13 kΩ	×8.5	620 Ω	×2.7	776 Ω	×+4.3	620 Ω	×1.7	240 Ω	7	4,2,1
×1.8	1.35 kΩ	×9.0	709 Ω	×2.8	887 Ω	×+4.2	709 Ω	×1.8	275 Ω	8	8
×1.9	1.52 kΩ	×9.5	798 Ω	×2.9	998 Ω	×+4.1	798 Ω	×1.9	309 Ω	9	8,1
×2.0	1.69 kΩ	×10.0	887 Ω	×3.0	1.11 kΩ	×+4.0	887 Ω	×2.0	343 Ω	10	10
×3.0	3.38 kΩ	×15.0	1.77 kΩ	×4.0	2.22 kΩ	×+3.0	1.77 kΩ	×3.0	687 Ω	20	20
×4.0	5.07 kΩ	×20.0	2.66 kΩ	×5.0	3.33 kΩ	×+2.0	2.66 kΩ	×4.0	1.03 kΩ	30	20,10
×5.0	6.76 kΩ	×25.0	3.55 kΩ	×6.0	4.43 kΩ	×+1.0	3.55 kΩ	×5.0	1.37 kΩ	40	40
×6.0	8.45 kΩ	×30.0	4.43 kΩ	×7.0	5.54 kΩ	× 0	4.43 kΩ	×6.0	1.72 kΩ	50	40,10
×7.0	10.1 kΩ	×35.0	5.32 kΩ	×8.0	6.65 kΩ	×−1.0	5.32 kΩ	×7.0	2.06 kΩ	60	40,20
×8.0	11.3 kΩ	×40.0	6.20 kΩ	×9.0	7.76 kΩ	×−2.0	6.20 kΩ	×8.0	2.40 kΩ	70	40,20,10
×9.0	13.5 kΩ	×45.0	7.09 kΩ	×10.0	8.87 kΩ	×−3.0	7.09 kΩ	×9.0	2.75 kΩ	80	80
×10.0	15.2 kΩ	×50.0	7.98 kΩ	. . .	. . .	×−4.0	7.98 kΩ	×10.0	3.09 kΩ	90	80,10
×11.0	16.9 kΩ	×55.0	8.87 kΩ	. . .	. . .	×−5.0	8.87 kΩ	×11.0	3.43 kΩ	100	80,20

SAMPLE PROGRAM

To demonstrate the use of remote programming, consider setting up the display using all remote control to obtain a Pulse Output signal with the following characteristics:

Mode	Single
Triggering Source	Internal (free run)
Period	50 μs
Width	1 μs
Amplitude	10 volts
Polarity	+
Dc Offset	0
Risetime	200 ns
Falltime	400 ns

1. With the Type R116 Power switch turned off, set all front-panel switches to the REMOTE or REMOTE PROGRAM positions. (The DELAY OR BURST TIME RANGE switch may be left in any position for this program.)

2. Program the switch functions by referring to Table 3-1 and to the front panel of the Type R116. Connect the following terminals of the Remote Program connector to the chassis ground lead:

#6 (10 μS Period Range)

#10 (100 nS Width Range)

#25 (1 V Amplitude Range)

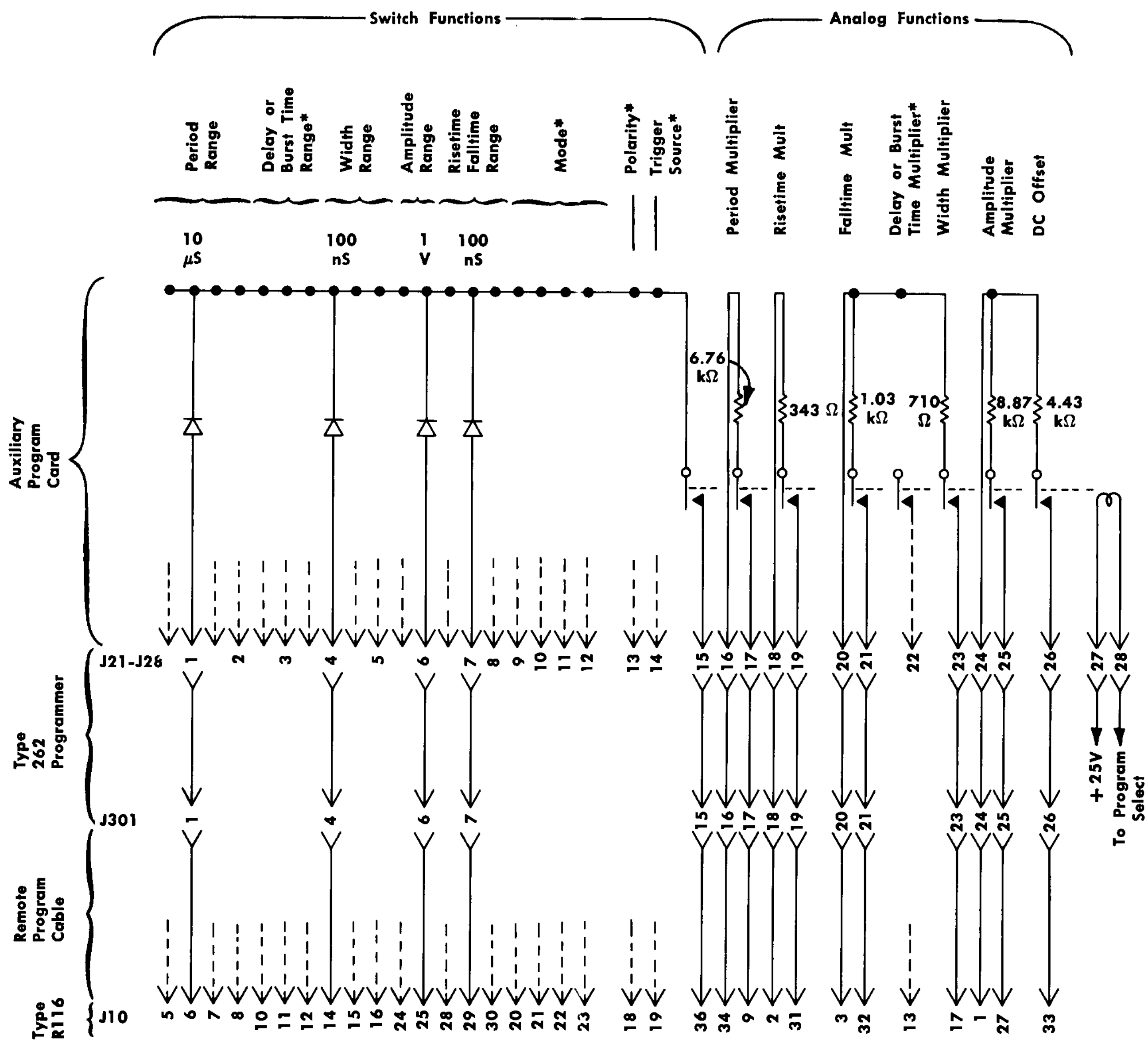
#28 (10 nS Risetime Falltime Range)

All other switch logic should be 0. Note that the 100 nS Width Range must be selected because of the ×5-×55 range of the Width Multiplier control. Note also that the 10 nS Risetime Falltime Range must be selected because of the 10 setting of the Amplitude Multiplier control.

3. Select the correct analog program resistance values by referring to the conversion graphs and formulas in Fig. 3-1, as follows:

Period. A multiplication factor of ×5 is required. As determined from the graph, the required resistance is 6.76 kΩ, to be connected between terminals #9 and #34 on the Remote Program connector as indicated in Table 3-2.

Width. Since the 100 ns Width Range is being used and the width is to be 1 μs, the apparent multiplication factor is ×10. However, since the risetime is shorter than the falltime, the 50% level width will be somewhat greater than the indicated value. (If the amplitude were less than 10 volts, this would also have to be considered.) To approximatel compensate for the difference in risetime and falltime, subtract one-half of the risetime-falltime difference from the



NOTE

If all switch functions are to be programmed, 7 lettered terminals (connected to J302 in the Type 262) will have to be used. This will require special internal connections in the Type 262 between J302 and unused terminals of J301. On the auxiliary program cards, avoid the use of terminals N, P, R, W, X, and Y, since these terminals are sometimes connected for special use in the Type 262.

*No connection required for this sample program.

Fig. 3-3. Suggested auxiliary program card wiring diagram for the sample program described in the text, using a Tektronix Type 262 Remote Programmer.

indicated pulse width. The resulting value of 100 ns indicates that the multiplication factor should be reduced by (100 ns/100 ns) or 1. Thus the width multiplication factor should be ×9. Referring to the width formula in Fig. 3-1, the corresponding resistance value is found to be (4 × 177.4 Ω) or approximately 710 Ω, to be connected between terminals #17 and #3 of the Remote Program connector (see Table 3-2).

Amplitude. The multiplication factor of ×10 requires a program resistance of 8.87 kΩ for the amplitude, to be connected between terminals #27 and #1 of the Remote Program connector.

Dc Offset. The dc offset of zero volts requires 4.43 kΩ of program resistance, to be connected between terminals #33 and #1 of the Remote Program connector. (If some other offset voltage were desired, the effect of the Amplitude Range would also have to be considered.)

Risetime and Falltime. Since the required Risetime Falltime Range is 10 nS and the Amplitude Multiplier control is set at 10, the required multiplication factors for risetime and falltime are ×2 and ×4 respectively for 200 ns and 400 ns. Thus the remote program resistance for risetime is 343 Ω, to be connected between terminals #31 and #2 of the Remote Program connector, and for falltime is 1.03 kΩ, to be connected between terminals #23 and #3.

4. After connecting the contact closures and program resistors, turn on the Type R116 and connect the output pulse through a 50 Ω termination and coaxial cable to the input of a test oscilloscope. Trigger the oscilloscope and observe the output pulse signal at a sweep rate of about 10 μs/cm.

Wired Program Cards

Fig. 3-3 shows a suggested wiring diagram for using a Tektronix Type 262 Remote Programmer to obtain the sample program just described. In addition to the special considerations required for this sample program, the illustrated diagram is laid out for a more comprehensive program system that can be used if other programs are to be sequenced in the Type 262, requiring the use of other program lines. If all 33 leads required for complete programming are to be connected from the Type 262 to the Type R116, seven of the lettered terminals on the auxiliary program card will have to be used. Since these terminals are connected to J302 (rather than J301) in the Type 262, it will be necessary either to use cables from both J301 and J302 on the Type 262 to the REMOTE PROGRAM connector (J10) on the Type R116, or to provide special wiring in the Type 262 so that all 33 leads can be connected through J301 and a single remote program cable to the Type R116.

If both J301 and J302 are to be used, the two remote program cables can be brought together into a single 36-terminal plug for connecting to J10 on the Type R116. This double cable would avoid the necessity of making modifications inside the programmer. (In general it is best to avoid internal modifications if the programmer is to be used later with other equipment.)

If a single 33-wire (or 36-wire) cable is to be used from the Type 262 to the Type R116, insulated jumper wire can be connected from appropriate auxiliary program bus wires to some unused terminals on J301. It should be noted that these connections would use up the availability of the terminals on J302 that are connected to the lettered auxiliary program card terminals to be used. The particular application would dictate the connections to be made. One possible arrangement would be to connect the A bus wire to terminal #27 of J301, the B bus wire to terminal #28, etc., through the H bus wire connected to terminal #33 of J301.

SECTION 4
CIRCUIT DESCRIPTION

Introduction

This section of the manual provides brief descriptions of the five basic modes of operation of the Type R116, then describes the various circuits of the instrument in greater detail. In the circuit analysis, each major section of the circuitry is treated separately. Portions of the circuitry that are mounted on the instrument chassis are discussed in conjunction with the most closely related major circuits. Portions that are mounted on the Function Program cards are shown in the block diagrams with their associated circuits and are discussed following the Period Generator description.

Basic Block Diagram

A simple block diagram of the Type R116 is provided at the start of the Diagrams section at the rear of the manual. As shown in the block diagram, the Period Generator is the circuit that starts the pulse-generation cycle. In normal Single mode operation of the instrument, a single output pulse appears at the PULSE OUTPUT connector for each cycle started by the Period Generator. Various output signal configurations are available through the use of the various pulse modes as described in the following paragraphs.

Modes of Operation

The simplified block diagrams in Fig. 4-1 show the five basic modes of operation of the Type R116: Single; Dly'd Single; Double; Burst and Gated Output. The pulse mode may be selected by the front-panel MODE switch, or it may be selected by means of remote logic information when the MODE switch is set to REMOTE PROGRAM. The basic operating mode is the Single mode. All other pulse modes are variations or modifications of the Single mode.

Single. When the MODE switch is set to SINGLE position and the TRIGGER SOURCE switch is set to INTERNAL, the period generator free runs at a calibrated repetition rate set by the PERIOD RANGE switch and PERIOD MULTIPLIER control. Each cycle of the Period Generator produces a negative-going trigger pulse that is sent to the Width Generator and the Delay Generator, and a positive-going trigger output pulse at the +PRETRIGGER OUT connector.

The Delay Generator begins its operation as soon as it receives a trigger pulse from the Period Generator and runs for the calibrated time duration selected by the DELAY OR BURST TIME controls (if the delay time is set shorter than the pulse period). At the end of the delay period, a positive-going delayed trigger output pulse is provided at the +DELAYED TRIGGER OUT connector.

The Width Generator is started at the same time as the Delay Generator. If the WIDTH controls are set properly, each trigger from the Period Generator initiates a positive-going width gate pulse which continues for a calibrated length of time set by the WIDTH controls. The rising and falling edges of the width gate are relatively fast transitions. The width gate is applied to the Pulse Shape Generator circuit to start the rise, then the fall, of the output pulse. The width gate thus determines the width of each output pulse.

The Pulse Shape Generator determines the rate of rise, rate of fall and variable amplitude of the output pulses as set by the risetime and falltime controls and the AMPLITUDE MULTIPLIER control. For — polarity pulses, the shaped pulse signal is inverted before being applied to the output amplifier. The pulse shape is maintained in the Output Amplifier which provides current for driving the output load.

Dc offset current may be added to the output pulse signal by the Offset Current Generator. The amount of offset that is added is determined by the setting of the DC OFFSET control. The signal and offset currents are then attenuated by a factor selected by the AMPLITUDE RANGE switch and applied to the output load through the PULSE OUTPUT connector.

Dly'd Single Mode. Basic operation of the Type R116 in Dly'd Single mode is nearly the same as in Single mode except that a delayed trigger from the Delay Generator (rather than the period trigger) starts the operation of the Width Generator. The output pulse signal, therefore, is delayed with respect to the pretrigger output by an amount that is adjustable by means of the DELAY OR BURST TIME controls. A delayed trigger output pulse is provided at the +DELAYED TRIGGER OUT connector at the end of the delay period, just prior to the start of the delayed pulse.

Double Mode. The Double mode of operation essentially combines the Single and Dly'd Single modes to produce a double-pulse output signal. The time interval separating the two pulses of each pair is adjustable with the DELAY OR BURST TIME controls. In this mode, the delayed trigger output pulse occurs just before the start of the second pulse of the double pair.

Burst Mode. When the MODE switch is set to BURST, the Period Generator circuit is disabled except during the time it is gated on by the Delay Generator. An external triggering pulse is required to start the operation of the Delay Generator. The burst gate output from the Delay Generator is similar to the width gate signal, except that the delay time interval usually lasts for several cycles of the Period Generator operation. The duration of the burst gate following the application of an external triggering signal is adjusted by the DELAY OR BURST TIME controls. Period trigger pulses are only applied to the Width Generator during the burst intervals; therefore, the width gate and subsequent output pulses also appear in the form of bursts. The interval between bursts is determined by the repetition rate of the external triggering signal, and the duration of each burst is set by the DELAY OR BURST TIME controls. Within each burst, the characteristics of the individual pulses are set by the other front-panel controls. At the end of each burst, an output trigger pulse is provided at the +DELAYED TRIGGER OUT connector.

Gated Output. Operation of the Type R116 in the Gated Output mode is quite similar to that in Burst mode. In Gated Output, however, the burst gate to be applied to the

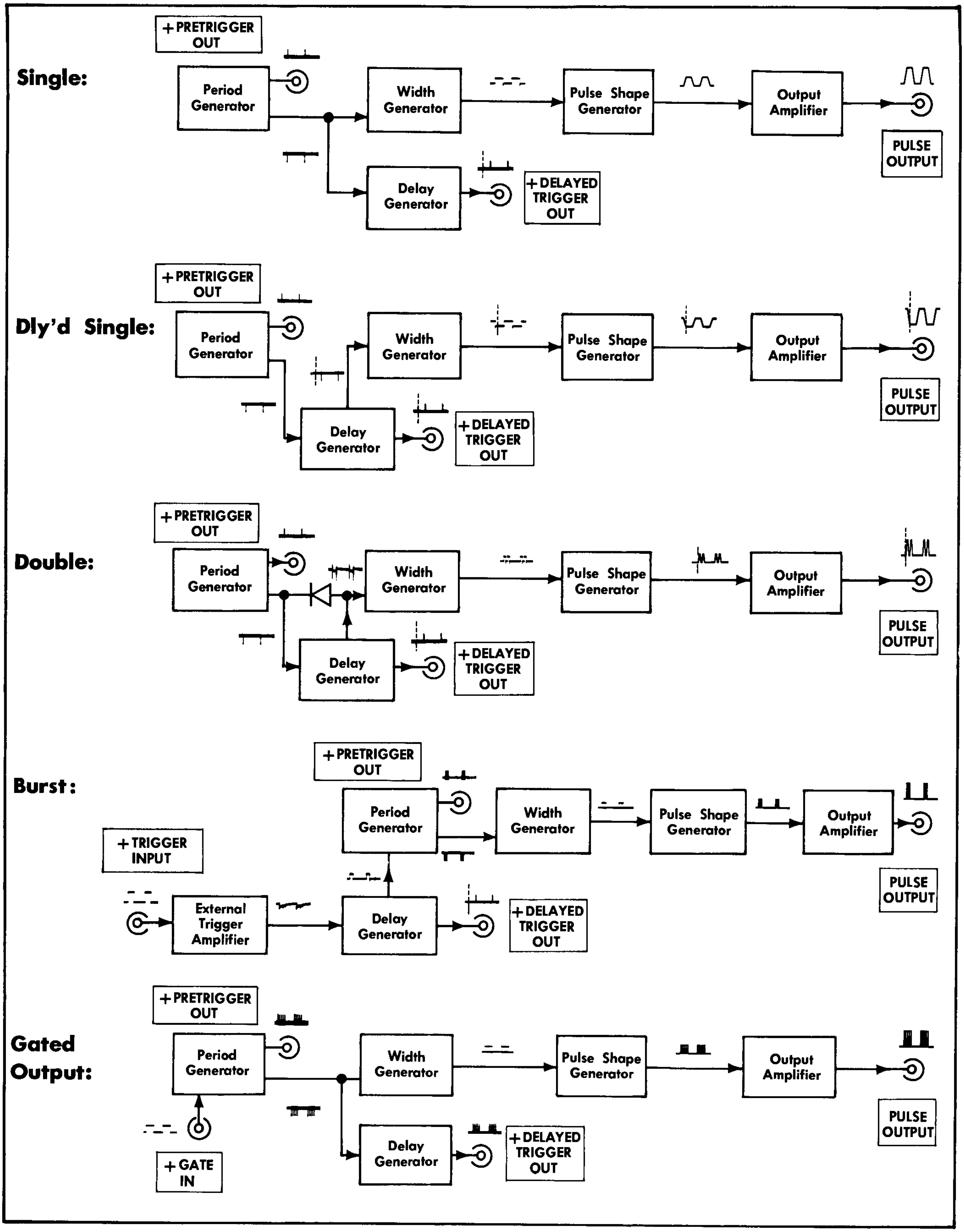


Fig. 4-1. Simplified block diagrams illustrating the five basic pulse modes.

Period Generator is produced by an externally-applied gate signal, rather than by the externally-triggered Delay Generator. A delayed output trigger pulse appears at the end of each delay interval, following a period trigger, if the DELAY OR BURST TIME controls are set properly. Thus, the delay trigger pulses are also in the form of gated bursts.

Remote Program. When the MODE switch is set to REMOTE PROGRAM position, selection of the pulse mode is made by means of remote logic information applied through the rear-panel REMOTE PROGRAM connector. Each of the five modes described previously can be selected by this means.

CIRCUIT ANALYSIS

The following circuit analysis is intended to aid in the understanding of the various circuits in the Type R116, but does not describe in detail the operation of conventional circuit configurations. During the following discussion, refer to the detailed block diagrams in the text and to the applicable schematics at the rear of the manual.

PERIOD GENERATOR AND MODE SWITCHING

Since the operation of the Period Generator is related closely to the operation of pulse mode selection, the mode switching circuits will be discussed in conjunction with the description of the Period Generator. Refer to the block diagram in Fig. 4-2 and to the Period Generator, Function Program #1, Remote Program Connector and Function Program #2 schematics for the circuits involved.

The Period Generator consists primarily of an astable multivibrator (Q55 and Q65), a constant current source (Q38), an on-off switching transistor (Q24), a voltage-level clamp (D44 and Q43), an output trigger amplifier (Q74 and Q84) and a pretrigger output amplifier (Q93 and Q94). Gating amplifier Q4 and Q14 permits an input gate signal to enable and disable the period multivibrator in Gated Output mode.

When the Type R116 is set for internal operation, the period multivibrator free runs at a rate determined by the value of the period timing capacitor (C52 to C60), selected by the PERIOD RANGE switch, and by the amount of available current supplied to the multivibrator through Q38, adjusted by the PERIOD MULTIPLIER control (see Fig. 4-2).

Operation of the multivibrator is non-symmetrical, with Q65 being in the conducting state most of the time and Q55 turned off. We will assume this initial condition for consideration of the circuit operation. Under these conditions, the period timing capacitor is charging from the constant current source, Q38. Transistor Q65 completes the charging current path for the timing capacitor and also conducts current from Q24 and R24. Clamp transistor Q43 is conducting, but does not affect the multivibrator, since D44 is reverse biased by the +25 volts at the collector of Q55.

As the period timing capacitor charges linearly from the constant-current source, the voltage at the emitter of Q55 becomes increasingly less positive and eventually forward biases the base-emitter junction of that transistor, turning it on. When Q55 turns on, the negative-going voltage at its collector is applied through Zener diode D50 to the base of Q65, causing Q65 to turn off.

The negative-going transition at the collector of Q55 forward biases D44, diverting the current through Q43 and keeping Q55 from going into saturation. With Q55 turned on, the period timing capacitor discharges through the current path of Q24, Q55, D44 and Q43. This discharge is relatively fast compared to the previous rate of charge.

When the voltage at the emitter of Q65 has dropped low enough to forward bias its base-emitter junction, that transistor turns on again, diverting current from the timing capacitor. The decrease in current through Q55 causes its collector to begin going positive, allowing the collector voltage to become unclamped as D44 is reverse biased. The positive-going voltage transition at the collector of Q55 is applied to the base of Q65, through Zener diode D50, causing both the base and the emitter of Q65 to move several volts positive. This voltage transition is coupled through the timing capacitor to the emitter of Q55, causing Q55 to turn off. The period timing capacitor then begins to charge through Q38 and Q65 again, starting another cycle of the Period Generator.

The negative-going pulse applied to the base of Q74 in the trigger amplifier as Q55 turns on is amplified and inverted by Q74, then amplified and inverted again by Q84. The negative-going output pulse from the trigger amplifier is applied through SW44 and D46 (see Fig. 4-2) to the Width Generator and is also passed through C82 to Q94. The period trigger turns on both Q94 and Q93 in the pretrigger output amplifier, producing a positive-going pretrigger pulse that is capacitively coupled to the +PRETRIGGER OUT connector. Following the period trigger pulse, Q94 and Q93 return to their normal non-conducting state.

The repetition rate of the Period Generator is determined within the selected period range by adjusting the current supply through Q38 by means of the PERIOD MULTIPLIER control. The PERIOD TIMING and PERIOD MULT CAL adjustments (R34 and R502) are set to calibrate the PERIOD controls for correct timing.

For normal free-running operation, period switch transistor Q24 is held in conduction by a positive voltage at its base, resulting from current through D22 and R22. In Burst mode, D22 is reverse biased, cutting off the bias current for Q24 and thus disabling the Period Generator. The MODE switch keeps the Period Generator in the disabled condition by means of reed switch SW75 (see Fig. 4-2) which forward biases D76 and essentially connects the junction of R22 and D22 to signal ground. The emitter of Q24 in the external trigger amplifier (shown on the Function Program #1 schematic) is also connected to signal ground by SW75, enabling the external trigger amplifier circuit. An external trigger (+2 to +20 volts) which is then applied to the +TRIGGER INPUT connector, is shaped by the external trigger amplifier. The external trigger then triggers the Delay Generator to start the pulse burst. The burst gate from the Delay Generator is applied to the Period Generator through SW55, turning on Q24 and allowing the Period Generator to free run for the duration of the gate.

Similarly, in Gated Output mode, the MODE switch causes D22 to be reverse biased by connecting the junction of D22 and R22 to signal ground through SW78 (see Fig. 4-2),

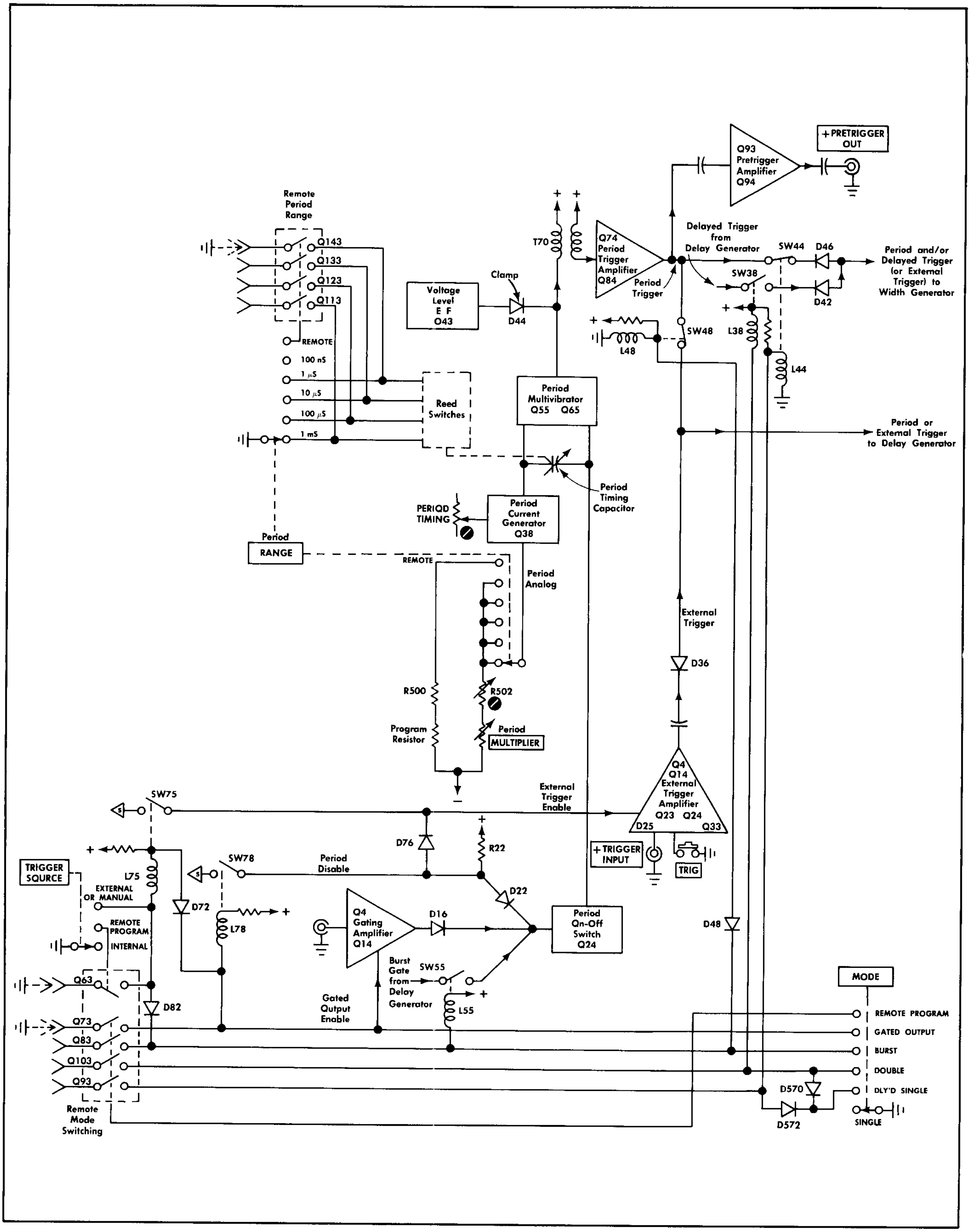


Fig. 4-2. Block diagram of the Period Generator circuit, mode switching and External Trigger Amplifier.

turning off Q24. With the MODE switch set to GATED OUTPUT, the emitter of Q4 is connected to chassis ground through the MODE switch, enabling the gating amplifier. Then, when an external gate signal (+2 volts to +10 volts) is applied through the +GATE INPUT connector, the signal is amplified by Q4 and Q14 and applied as a positive-going gate through D16 to turn on Q24 and enable the Period Generator for the duration of the gate. In addition to amplifying the input gate, transistors Q4 and Q14 also shift the dc reference level of the signal from chassis ground at the input to a voltage that is referenced to signal ground and suitable for driving Q24.

Dly'd Single mode is provided by opening SW44, by shorting out L44 through the MODE switch and D572, and by closing SW38 by current through L38. This disconnects the period triggers from the Width Generator and connects the delayed trigger pulses in their place.

Double mode is similarly accomplished by closing only SW38 by current through L38 and the MODE switch. Both the period trigger and the delayed trigger can then pass to the Width Generator.

When the TRIGGER SOURCE switch is set to EXTERNAL OR MANUAL, the Period Generator is disabled by connecting the junction of R22 and D22 to signal ground through D76, as in Burst mode, and the external trigger amplifier is enabled by connecting the emitter of Q24 to signal ground. Any external triggering signal then applied through the trigger amplifier and shaper circuit is sent through D36 to the trigger input lines of the Width and Delay Generator circuits. The MODE switch then operates SW48, SW44 and SW38 to determine whether the externally-applied triggering signal produces a single pulse, a delayed pulse, a pair of pulses or a burst.

External connections for remote operation of the period ranges, period analog, trigger source selection and mode switching are shown in the block diagram. The switching buffer amplifiers used for remote operation are located on the Function Program circuit cards and are described in the following paragraphs under Function Program circuits. The analog operations for remote operation merely parallel the front-panel PERIOD MULTIPLIER control as can be seen in the block diagram.

FUNCTION PROGRAM CIRCUITS

The input buffer amplifier transistors used for remote operation are shown on the two Function Program schematics and in the block diagrams of the various circuits throughout this section of the manual. The external trigger amplifier circuit is shown on the Function Program #1 diagram and in the block diagram of the Period Generator and mode switching (Fig. 4-2).

Buffer Amplifiers

In order to provide remote operation of the switching functions of the Type R116 without requiring external power inputs, buffer amplifier transistors are provided for all the programmable switch functions. For example, refer to the period range portion of the Function Program #1 schematic and to the block diagram in Fig. 4-2.

To enable this remote switching function, the PERIOD RANGE switch is set to REMOTE, connecting the collectors of the period range buffer amplifiers to chassis ground through the MODE switch. Since the bases of the transistors are connected through resistors to +25 volts, they are held in cutoff until one of the base circuits is connected to ground. To enable the 10 μS period range, for example, the base circuit of Q133 is connected to ground through the REMOTE PROGRAM connector and an external contact closure, dropping the voltage at the base low enough to forward bias the base-emitter junction (with the emitter initially set at about +2 volts by the voltage applied through the relay coil). Current through Q133 thus actuates the relay connected to the 10 μs period timing capacitor, selecting this range of operation for the Period Generator.

Each of the other buffer amplifiers operates in the same manner, actuating a relay that controls a particular switching function.

In addition to connecting the switching buffer amplifiers into the circuit, the four range switches and the PROGRAM switch connect analog program resistors into the various circuits by way of the REMOTE PROGRAM connector. These inputs control current through the constant-current generator circuits or control current division within the circuits, in the same manner as the front-panel MULTIPLIER controls function when internal operation is used, to provide variable control of the various functions.

External Trigger Amplifier

The external trigger amplifier shown on the Function Program #1 schematic, consists of an input dc level-shifting circuit (Q4 and Q14), a tunnel diode trigger shaper (D25), an output amplifier (Q24) and an output complementary emitter follower circuit (Q23 and Q33).

When a positive-going trigger pulse or transition (+2 to +20 volts) is applied through the +TRIGGER INPUT connector, Q4, which is normally non-conducting, turns on. The negative-going pulse at the collector of Q4 turns on Q14. Quiescently, tunnel diode D25 is biased in its low-voltage state near its switching level by current through D21, R23, L20, R20 and R29. When Q14 turns on, the tunnel diode switches to its high voltage state, applying a fast positive-going pulse to the base of Q24. If the external trigger circuit is enabled by connecting the emitter of Q24 to signal ground (see Fig. 4-2), the pulse at the base of this transistor turns it on. The resulting negative-going transition at the bases of complementary emitter followers Q23 and Q33 is coupled to the output of the circuit through these transistors and through C33 and D36. The transition is then applied to the Delay Generator (through R36) or to the Width Generator (through SW48, SW44, D46 and R46). The complementary emitter follower output stage provides a fast trigger output pulse and a rapid recovery of the output coupling capacitor, C33. Diode D33 also aids in the quick recovery of C33.

When the input triggering signal drops below the 2-volt level, the input transistors turn off, reducing current to the tunnel diode. The voltage pulse that appears across L20 as the current is cut off resets D25 to its low-voltage state.

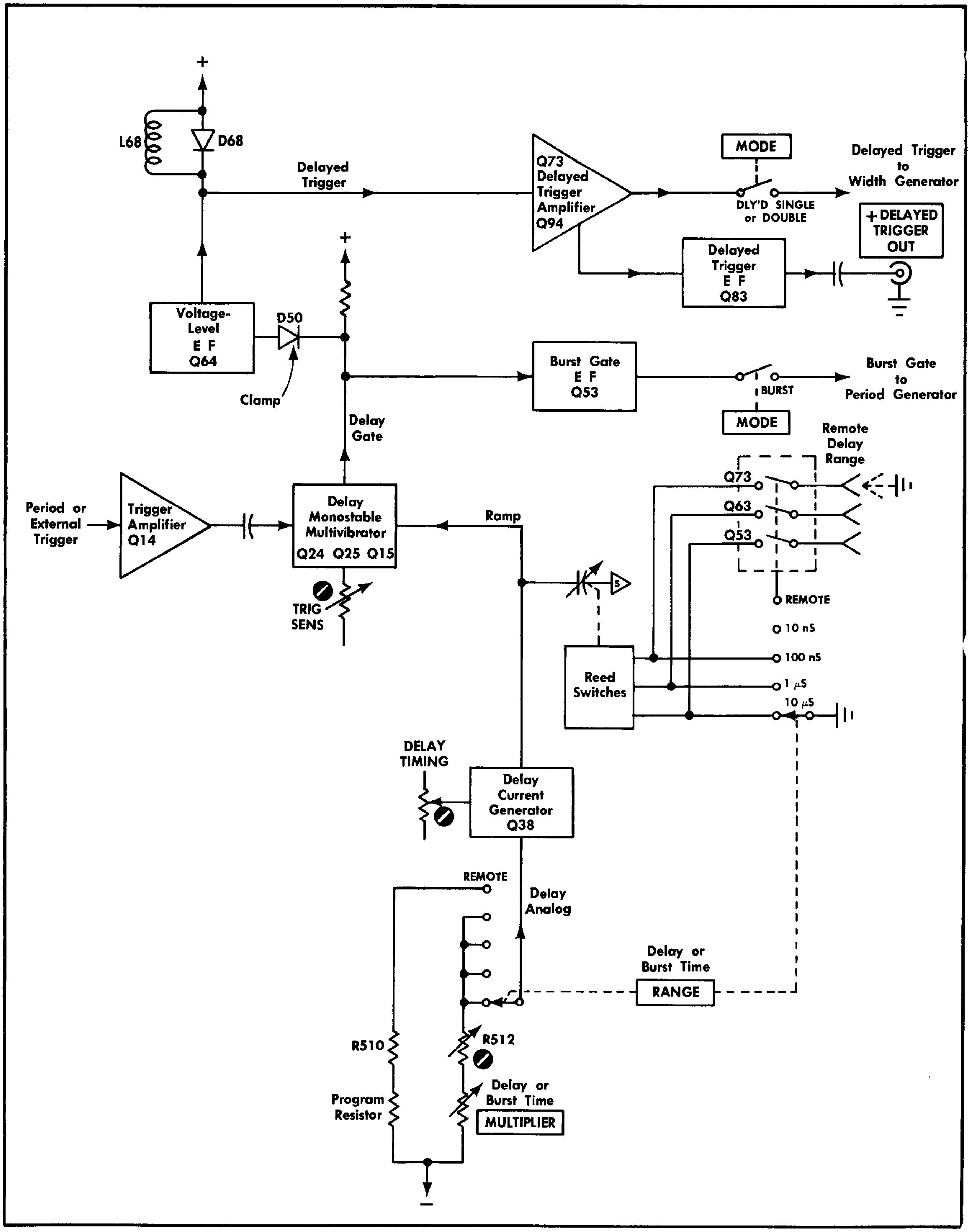


Fig. 4-3. Block diagram of the Delay Generator circuit.

DELAY GENERATOR

A block diagram of the Delay Generator is shown in Fig. 4-3. Refer also to the Delay Generator schematic diagram during the circuit discussion.

The period trigger from the Period Generator or the external trigger pulse from the external trigger amplifier is amplified by the common-base amplifier (Q14) and applied through C14 to the monostable delay multivibrator, Q24 and Q15.

Quiescently between pulses Q24 is conducting moderately, Q15 is turned off and comparator transistor Q25 is conducting both the current through Q24 and that from the constant-current source Q38. The TRIG SENS adjustment (R22) in the base circuit of Q24 sets the multivibrator for monostable operation, so that it will trigger properly but not free run. The non-saturated clamp transistor, Q64, is conducting part of the current from Q25, keeping D50 forward biased and clamping the output voltage level of the burst gate. The delay timing capacitor that is selected by the reed switch is kept charged to the voltage at the junction of R24 and R25 (approximately —1 volt).

When the negative-going trigger pulse is applied to the bases of Q24 and Q25, those transistors turn off, causing Q15 to turn on. The negative-going voltage at the base of Q25 turns off the comparator transistor, removing the current discharge path from the delay timing capacitor. The current from Q38 then is diverted into the timing capacitor which begins to charge producing a negative-going ramp voltage. The rate of fall of the ramp is thus determined by the value of the timing capacitor and by the charging current, which is adjustable by means of the DELAY OR BURST TIME MULTIPLIER resistance in the emitter circuit of Q38. Current from the constant-current source is adjusted for correct delay timing by means of R512 (DELAY CAL) in the current path and by R41 (DELAY TIMING) which adjusts bias on the transistor. Capacitor C32, which is in the circuit on all ranges, is adjusted for correct timing on the fastest range.

When Q25 turns off as the multivibrator switches, the positive-going voltage at the collector of Q25 reverse biases diode D50 and applies a 3-volt transition to the base of Q53. This forms the start of the burst gate that is coupled through Q53 back to the Period Generator when SW55 is closed (in Burst mode only).

When comparator transistor Q25 is turned on again following the ramp rundown, the negative-going voltage at its collector ends the burst gate and also forward biases clamp diode D50. As D50 turns on, current increases through Q64, causing a momentary voltage pulse across L68 that appears as a negative trigger at the base of Q73. The trigger pulse is amplified at the collector of Q73 as a positive-going delayed trigger pulse that is connected through emitter-follower Q83 and coupling capacitor C85 to the +DELAYED TRIGGER OUT connector. The negative-going pulse at the emitter of Q73 is applied to the emitter of Q94 resulting in a negative-going output at the collector of Q94 that is sent through C95 and trigger-switching circuits to the Width Generator. This is the pulse that starts the delayed output pulse or the second pulse of a double pair.

WIDTH GENERATOR

Fig. 4-4 is a block diagram of the Width Generator. Refer also to the Width Generator schematic during the following discussion. Since operation of the Width Generator is nearly identical to that of the Delay Generator, the Width Generator will be described only briefly.

The period trigger from the Period Generator and/or the delayed trigger from the Delay Generator, or the external trigger from the external trigger amplifier are amplified by Q14 and applied through C14 to the width multivibrator, Q24, Q25 and Q15.

The negative-going trigger pulse applied to the bases of Q24 and Q25 switches the multivibrator, producing the start of the positive-going width gate at the collector of Q25. This positive-going transition is applied through Q53 to the Pulse Shape Generator circuit to start the formation of the output pulse.

As the width capacitor charges, a negative-going voltage ramp applied to the emitter of Q25 eventually turns on that transistor, causing the multivibrator to reset to its stable state. As Q25 turns on, the negative-going transition at its collector ends the width gate and forward biases D50, clamping the output voltage level.

When the MODE switch is set to DOUBLE, one pulse is initiated by a period trigger and a second pulse is initiated by a delayed trigger from the Delay Generator if the DELAY OR BURST TIME controls are set within the proper range. A minimum of 50 ns is required between the end of one width gate pulse and the start of the next pulse.

PULSE SHAPE GENERATOR

The main sections of the Pulse Shape Generator are shown in the block diagram in Fig. 4-5. Also refer to the Pulse Shape Generator and Output Amplifier schematics during the circuit analysis.

The fast-rising and fast-falling width gate is applied through Zener diodes D12 and D22 to the bases of current-steering transistors Q14 and Q24. Two of the transistors in the current-steering gate are normally conducting and two are normally cut off, with current division determined by the input width gate. Total current through the risetime pair of transistors (Q14 and Q34) is held constant by Q68, and is adjusted by the resistance in the emitter circuit of Q68 as set by the RISETIME MULT control. Total current through the falltime pair (Q24 and Q44) is held constant by Q58 and is adjusted by the resistance in its emitter circuit as set by the FALLTIME MULT control.

The voltage output level from the current-steering gate is determined by the input width gate signal. As the width gate goes positive, Q24 turns on and Q14 turns off, switching the current from Q58 into Q24 and switching the current through Q68 to Q34. Since the width gate rises rapidly and falls rapidly, current switching through the input transistors is also rapid. The rate at which the output at the junction of R38 and R48 can move its voltage is determined by the amount of capacitance connected onto the output by the RISETIME FALLTIME RANGE switch, and by the amount of current that is permitted to flow into or out of this capacitance from the risetime and falltime current sources.

When the width gate is at its lower voltage level, Q44 is conducting and Q34 is turned off. The output amplitude level is clamped just below signal ground by clamp diode D72. When the width gate switches to its higher voltage

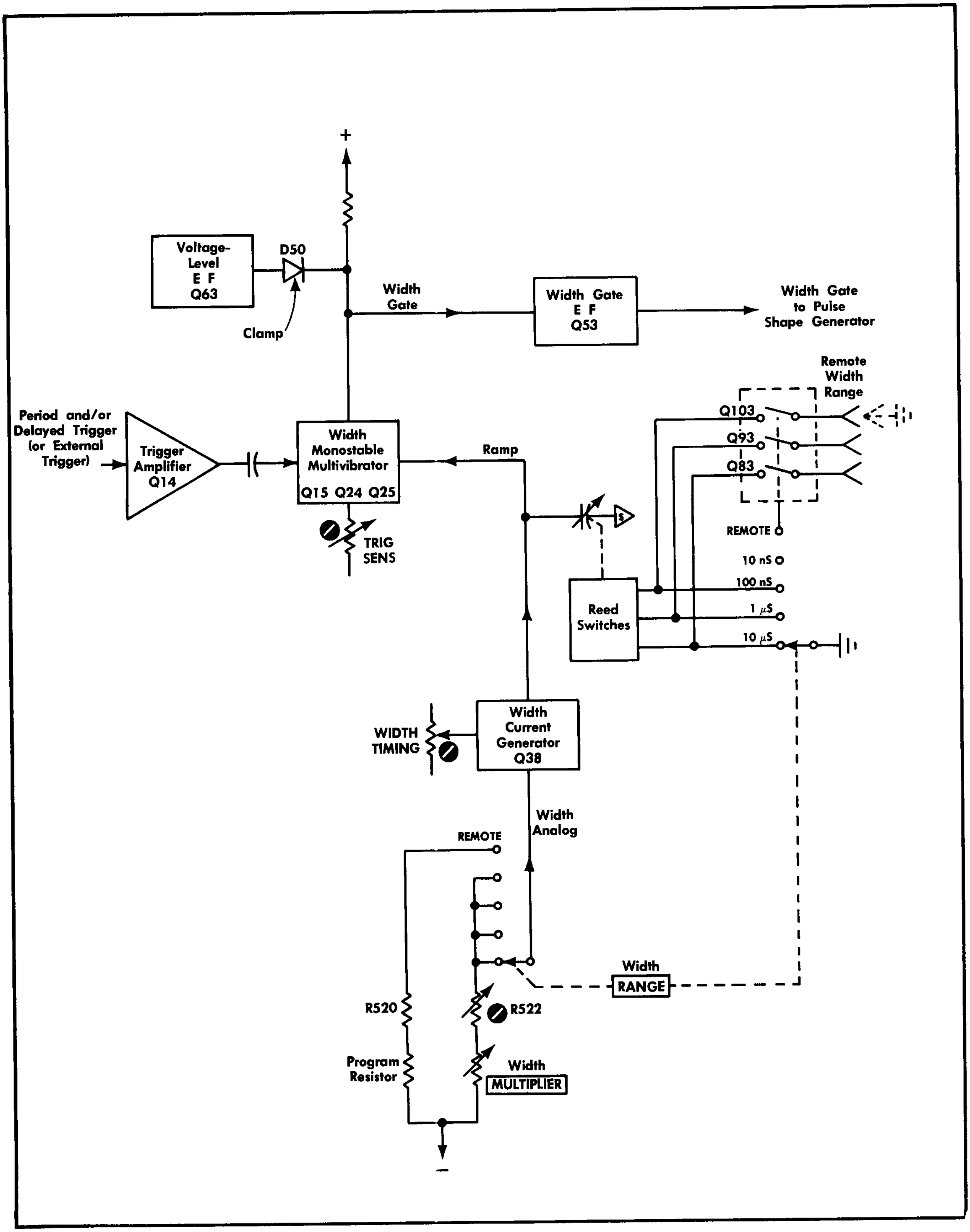


Fig. 4-4. Block diagram of the Width Generator circuit.

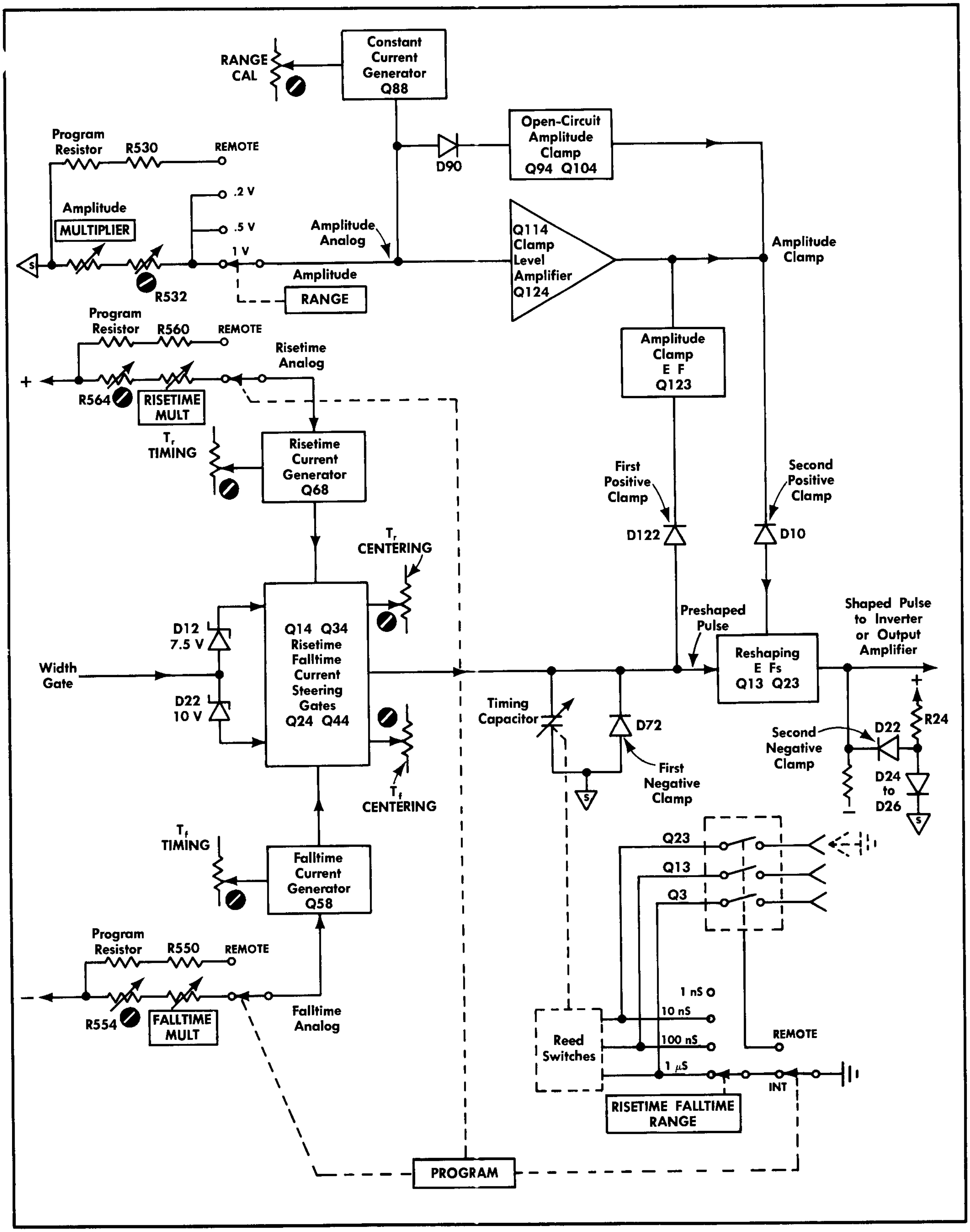


Fig. 4-5. Block diagram of the Pulse-Shaping circuits.

level, Q44 cuts off and Q34 turns on. The amplitude level is unclamped as D72 becomes reverse biased, and current through Q34 moves the output voltage in a positive direction. The current required by the risetime current source is then obtained from the ramp timing capacitor. The resulting rate of rise of the output voltage is determined by the size of the risetime-falltime capacitor and by the amount of current flowing through Q34. The RISETIME MULT control sets the rate of rise within the selected risetime-falltime range by varying the amount of resistance in the emitter circuit of Q68.

As soon as the output voltage amplitude causes amplitude clamp diode D122 to become forward biased, the amplitude stops rising and is held at the level set by the amplitude clamp circuit. At this voltage level, the current through Q44 and Q68 is obtained from the amplitude clamp transistor and diode, Q123 and D122. The level of the amplitude excursion is adjusted by the AMPLITUDE MULTIPLIER control. Feedback transistor pair Q114 and Q124, which has a gain of 1, provides a high impedance input to avoid loading the AMPLITUDE MULTIPLIER control and a low impedance output for clamp diodes D122 and D10.

An open-circuit amplitude clamp consisting of Q94 and Q104, is provided to keep the output voltage from going excessively positive if and when the amplitude analog program line becomes open. This prevents a large output voltage from appearing at the PULSE OUTPUT connector while programs are being switched or while the amplitude range is being switched. If an open circuit appears in the line, the voltage at the base of Q114 begins to go positive very rapidly, tending to cut off that transistor and Q124. This operational amplifier attempts to follow the signal, but the voltage at the emitter of Q114 can only move as fast as C120 can charge. The rapid transition at the emitter of Q94 turns on that transistor as soon as the emitter voltage exceeds the 10-volt level at its base, set by R92 and R94. Transistor Q94 then turns on Q104, which goes into saturation and clamps the output voltage level (through Q123 and D122) very near signal ground.

When the width gate drops to its lower voltage level at the end of the pulse duration, Q24 is turned off and Q14 is turned on by the gate, causing current to switch from Q34 to Q44. With the output connected to the falltime current source, D122 is reverse biased and current flows into the timing capacitor through Q58 at a rate determined by the FALLTIME MULT control resistance. The output voltage drops at a linear rate until D72 is again forward biased by the voltage, clamping the output at the baseline level.

The preshaped pulse output waveform from the current-switching gate is applied to the base of emitter-follower Q13 (shown on the Output Amplifier diagram), which couples the signal through a second emitter follower, Q23, to the output amplifier. Both the top and the bottom of the pulse waveform are reshaped by this circuit to eliminate amplitude changes that may result from current changes through the clamp diodes in the preshaping circuits. The upper level is clamped again by D10 when the upper voltage level at the emitter of Q13 exceeds the collector voltage of Q124 in the first amplitude clamp circuit. The lower level of the waveform is clamped by current through D22 when the trailing edge of the pulse becomes more negative than the voltage at the junction of D24 and R24 (approximately 2 volts above signal ground).

INVERTER

The Inverter circuit, shown on the Output Amplifier schematic diagram, and the block diagram in Fig. 4-6, provides inversion of the shaped pulse signal when the POLARITY switch is set to — position.

The pulse signal applied to the base of Q44 through Zener diode D44 is inverted at the collector of the transistor and applied to the output amplifier. The Zener diode raises the input level at the base of Q44 by 10 volts to set the collector of Q44 at the correct dc voltage level. Gain of the inverter is adjusted to -1 by varying degeneration with the —AMPLITUDE adjustment, R42. Transistors Q33 and Q34 provide a low-impedance voltage source for setting the dc level at the output of the inverter. The output level is adjusted by means of the —DC LEVEL control (R34) so that the signal into the output amplifier varies between the same limits in — polarity as in + polarity, though the waveshape is inverted.

OUTPUT AMPLIFIER

The Output Amplifier consists of an input driver transistor (Q53), three emitter followers in parallel (Q54, Q64 and Q74) and three common-base amplifiers in parallel (Q84, Q94 and Q104). Refer to the block diagram in Fig. 4-6 and to the Output Amplifier schematic during the following discussion.

The pulse signal applied to the base of Q53 is coupled through this emitter follower, providing current drive to three more emitter followers in parallel. Transistors Q54, Q64 and Q74 are each connected in series with an output transistor. Voltage gain of the output stage is set at about 2 by the ratio of input resistors R84, R94 and R104 to the 50 ohms of the output load.

In + polarity, the output stage is nearly cut off in the quiescent condition and is turned on by the drive pulse to produce the output pulse. In — polarity, the output stage is conducting heavily during quiescence and the drive pulse cuts off (or decreases) current to produce the negative-going output pulse. The —Variable supply voltage is also changed when the pulse polarity is changed to permit the same dc level to be applied at the collectors of the Output Amplifier transistors and the Offset Current Generator in both polarities.

The output current pulse from the Output Amplifier and the offset current from the Offset Current Generator are then connected through the attenuator, shown on the Offset Current Generator schematic, to the PULSE OUTPUT connector. The attenuator consists of a straight-through connection (1×) and two 50-Ω attenuators that provide 2× and 5× attenuation. The selection of the attenuator that the signal passes through is made by the AMPLITUDE RANGE switch which operates the attenuator relays.

OFFSET CURRENT GENERATOR

The main portions of the Offset Current Generator are shown in the lower left section of Fig. 4-6.

In + polarity of the output pulse, when the pulse signal is at the baseline level, the Output Amplifier draws approximately zero current. If no current flows into or out of the

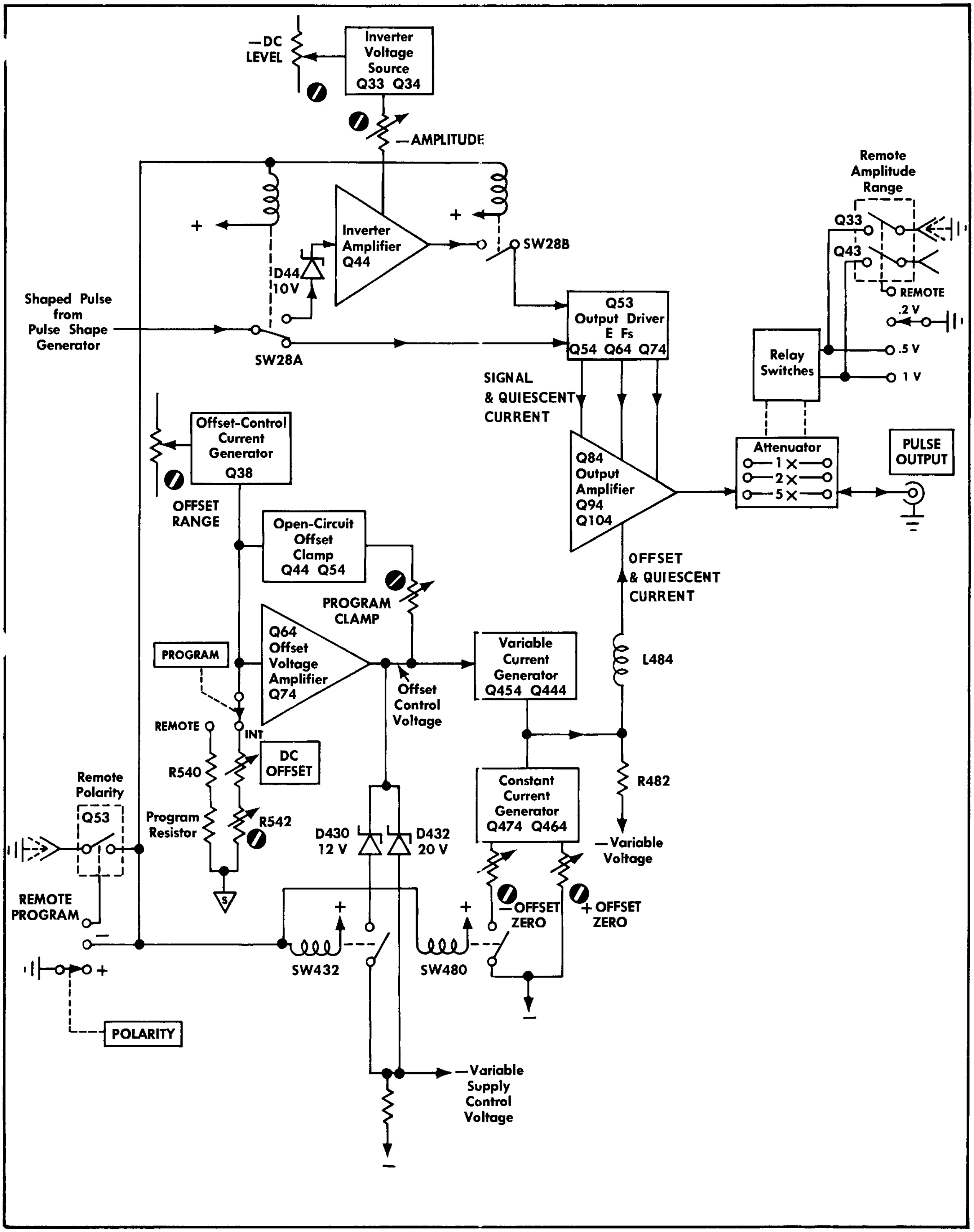


Fig. 4-6. Block diagram of the Inverter, Offset and Output circuits.

output load from the Offset Current Generator, the output baseline will be at zero volts. When a pulse is applied to the Output Amplifier, current through the circuit is increased (up to 200 mA with the AMPLITUDE MULTIPLIER control at 10), drawing current from the output load and producing a positive-going voltage pulse (up to 10 volts into 50 Ω) at the output.

A total of approximately 100 mA of current flows through Q464 and Q474 in + polarity, as determined by the +OFF-SET ZERO adjustment, R466. For zero volts offset, all of the 100 mA is conducted by Q444 and Q454, so that no current is delivered to the output load. To produce + or — dc offset in + polarity, current must be caused to flow from the current generator into the output load (and/or attenuator) or from the output load into the current generator. This is accomplished by varying current through the variable current generator by means of the DC OFFSET control. For + dc offset, current is increased through Q444 and Q454, drawing up to 100 mA of current from the output load, in addition to the 100 mA from Q464 and Q474. This offsets the dc voltage level of the output in the positive direction by as much as 5 volts (with the DC OFFSET control set at +5). For — dc offset, current is decreased through Q444 and Q454. The current from Q464 and Q474 that had been conducted through Q444 and Q454 is therefore allowed to flow into the output load, offsetting the dc voltage level of the output in a negative direction.

When the Type R116 is set for a — polarity output pulse, the Output Amplifier draws approximately 200 mA in the quiescent condition. To provide zero offset voltage at the output when the negative-going pulse baseline is at zero, the offset current generator must provide the 200 mA of quiescent current for the Output Amplifier. This is accomplished by supplying an additional 200 mA through SW480 and the —OFFSET ZERO control (R476), with the POLARITY switch in the — position (see Fig. 4-6), and by moving the —Variable supply so as to decrease the voltage between chassis ground and signal ground by connecting Zener diode D430 into the circuit (see Power Supply description).

In — polarity, when a pulse signal is applied to the Output Amplifier, the current may drop to nearly zero mA (with the AMPLITUDE MULTIPLIER control set to 10), causing current from the Offset Current Generator to flow into the output load. This current produces the negative-going voltage pulse at the output.

Offset in — polarity is produced in a similar manner to that in + polarity by increasing or decreasing current through Q444 and Q454. For + dc offset, current is increased through these transistors drawing additional current from the load, thus offsetting the output voltage in the positive direction. For — dc offset, current is decreased through Q444 and Q454, and the current that had been diverted by these transistors flows from Q464 and Q474 into the output load, offsetting the output voltage in a negative direction.

The offset control voltage at the bases of Q444 and Q454 is set by the low impedance output from Q74 and Q64, a ×1 amplifier. The input voltage to Q64 is in turn determined by the current through constant-current transistor Q38 and the setting of the DC OFFSET control (see Fig. 4-6). The range of the DC OFFSET control is adjusted by R32 (OFFSET RANGE). As the voltage to the bases of Q444 and Q454 is varied, the input voltage to the —Variable supply is also varied through D430 or D432, adjusting the output of that supply. This keeps the collector voltage of the Offset Current Generator and the Output Amplifiers nearly constant, regardless of dc offset, assuring that the pulse shape will not be affected by the offset.

Operation of the open-circuit offset clamp is similar to that of the open-circuit amplitude clamp. When the offset analog program line is open, the voltage at the emitter of Q44 tends to go rapidly in the positive direction. Transistor Q44 turns on, causing Q54 to saturate and clamp the output voltage at approximately zero volts, as set by current through R54 (PROGRAM CLAMP).

The inductors at the output of the offset generator circuit isolate the output amplifier from the collector capacitance of the current generator transistors to permit the output stage to switch rapidly.

POWER SUPPLY

The Power Supply circuit consists essentially of the power input and transformer, three full-wave bridge rectifiers, three regulator circuits and the —Variable voltage control circuit. A block diagram of the circuit is shown in Fig. 4-7. Reference voltage is signal ground for all circuits except the unregulated +12-volt supply, which is referenced to chassis ground. Since all voltages within the circuitry (except the relay coils and the offset) are referenced to signal ground, the voltages given on the schematic diagram and mentioned in the text are voltages measured with respect to signal ground.

Input Circuit

Input power to the circuit is applied from the ac power line to power transformer T401 through line filter FL401, thermal cutout TK402, power switch SW401, fuses F401 and F402 and the 115 V-230 V selector switch, SW402. The switching for selection of the line-voltage range also selects the correct fusing for the selected voltage. When SW402 is in the 115 V position, the two windings of the transformer primary are connected in parallel. In this case, F401 is connected in series with one winding of the primary and F402 is connected in series with the other winding.

When SW402 is set to the 230 V position, the two primary windings are connected in series and only one fuse is required. In this case, F402 is disconnected and only F401 is used. The fan and power indicator light (B403) are connected across one winding of the primary and thus are in the circuit (at a nominal 115 volts) regardless of the line voltage used.

+25-Volt Supply

Power for the +25-volt supply is provided by the diode bridge composed of D405A, B, C and D. Electronic regulation is provided by feedback from the supply output through a voltage divider that is returned to signal ground. The feedback voltage is compared by Q6 and Q16 to a voltage approximately 9 volts above signal ground, obtained through Zener diode D2. Any voltage change in the output of the supply resulting from a change in load, is amplified

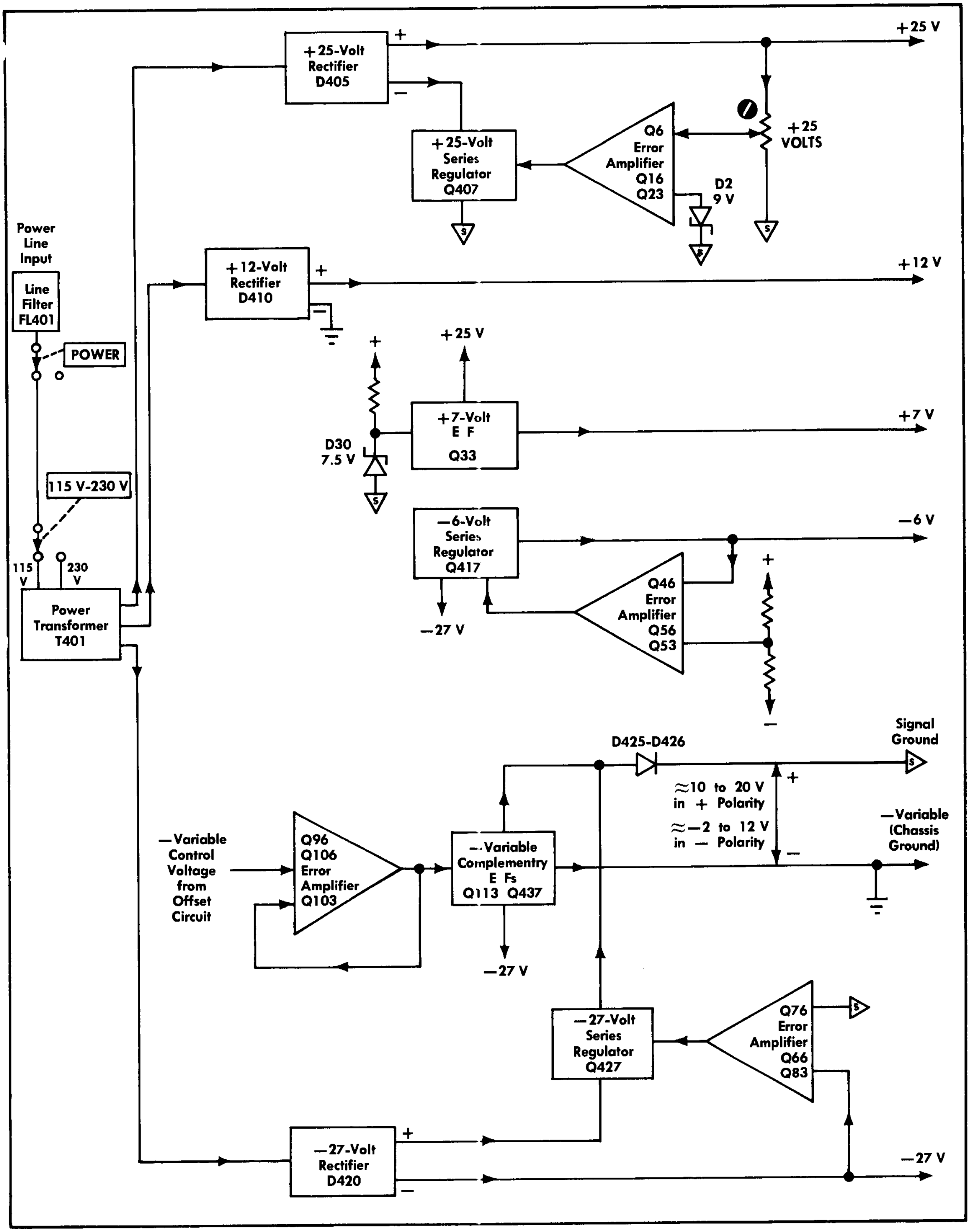


Fig. 4-7. Block diagram of the Power Supply circuit.

by Q23 impedance and applied to series regulator Q407. The resulting change in Q407 moves the voltage level of the collector of Q407, and thus the supply output (through the rectifier), either toward or away from signal ground to return the supply voltage to the correct value. The +25 VOLTS adjustment (R14) sets the feedback voltage so that the supply output is at +25 volts.

+12-Volt Supply

The unregulated +12-volt supply consists of a diode bridge rectifier, D410A, B, C and D and filter capacitor C410, with the negative output of the supply connected to chassis ground. The sole use of the +12-volt supply is for actuating the reed and relay contacts for switch operations and range selection in the circuitry.

Chassis ground is used as a reference voltage so that contact closures can be actuated conveniently in either internal or programmed operation by connecting one end of each relay coil to the chassis. A series resistor in each relay circuit reduces the applied voltage to the correct level (usually 6 volts) required by the relay coil.

+7-Volt Supply

Current for the +7-volt supply is obtained from the regulated +25-volt supply through R33 and emitter follower Q33. The reference voltage for this supply at the base of Q33 is approximately —7.5 volts obtained from signal ground through Zener diode D30. The constant emitter-base voltage of approximately 0.6 volt holds current through Q33 essentially constant. Thus the current division between R36 and the load on the supply keeps the output voltage constant.

—6-Volt Supply

Current for the —6-volt supply is obtained from the —27-volt supply through series-regulator transistor Q417. The error amplifier, consisting of Q56, Q46 and Q53 provides regulation by comparing a portion of the supply output to a voltage at approximately signal ground set by divider R42-R44 connected between +25 volts and —27 volts. The regulator action is essentially the same as that for the +25-volt supply.

—27-Volt Supply

Current for the —27-volt supply is provided by bridge rectifier D420A, B, C and D. Regulation is provided by the error amplifier, consisting of Q76, Q66 and Q83, which compares a portion of the output voltage to signal ground (at the base of Q66). Regulation is essentially the same as for the +25-volt supply.

—Variable Supply

In order to provide dc offset and inversion of the output pulse, the —Variable supply provides a means of varying the voltage difference between signal ground and chassis ground. The —Variable supply output, connected to chassis ground, can vary over a range of greater than 10 volts with respect to signal ground: approximately —10 to —20 volts in + polarity (of the output pulse) and approximately +1 to —10 volts in — polarity. When the DC OFFSET control is set to 0, the —Variable supply output voltage is approximately —15 volts in + polarity and —7 volts in — polarity.

The current source for the —Variable supply is the —27-volt supply, since the —Variable supply output is connected between the negative side of the —27-volt supply and the —27-volt series regulator, Q427. Voltage at the emitter of Q427 is held at about +1.2 volts by the drop across D425 and D426.

Comparator Q96 and Q106 compares the voltage at the error amplifier output to the input control voltage from the offset current circuit. The input comparison voltage at the base of Q96 varies from approximately —12 to —20 volts in + polarity and from —2.5 to —10.5 volts in — polarity, as determined by the settings of the front-panel DC OFFSET control and the POLARITY switch. The POLARITY switch sets the range of the comparison voltage by switching the 12-volt Zener diode (D430) into or out of the circuit (see Fig. 4-7).

As the input control voltage is varied, the comparator circuit and emitter follower Q103 couple the voltage change to the bases of complementary emitter followers Q437 and Q113. Transistor Q113 is usually non-conducting or conducting only slightly in + polarity and when the —Variable supply output is relatively negative in — polarity. However, when the supply output is very close to signal ground in — polarity (e.g., when —5 volts offset is used), Q113 provides the required output current for the supply.

SECTION 5
MAINTENANCE

This section of the manual provides preventive maintenance information for servicing the Type R116, and corrective maintenance procedures for locating trouble and repairing the instrument. Preventive maintenance performed on a regular basis helps prevent instrument failure and improves both the mechanical and electrical reliability of the instrument. If trouble does occur, corrective maintenance should be performed immediately to avoid additional damage and to restore the instrument to its proper operation. The physical locations of all circuit components located on the plug-in circuit cards are shown in full-sized illustrations at the rear of this section.

PREVENTIVE MAINTENANCE

Preventive maintenance consists of cleaning, lubrication, visual inspection and recalibration. The severity of the environment in which the instrument is used will determine the frequency of maintenance required.

Dust Cover Removal

The top and bottom dust covers of the Type R116 can be easily removed for access to the internal circuitry. The covers are fastened to the frame with small screwhead fasteners that can be released by turning each fastener 1/4 turn counterclockwise with a small coin. For normal operation, the covers should be left on the instrument to keep out dust and to correctly distribute the flow of air.

Cleaning

The Type R116 should be cleaned as often as operating conditions require. The top and bottom dust covers provide partial protection against dust accumulation in the interior of the instrument, but a certain amount is brought in by circulating air. Operation without the dust covers in place will require more frequent cleaning, especially if the instrument is left extended from the rack.

Air Filter. Under normal operating conditions, the air filter should be visually checked)every few weeks and cleaned if dirty. More frequent cleaning is required if the instrument is used in a smoky or dusty environment. The following procedure is suggested for cleaning the filter.

1. Remove the filter by pulling it carefully out of the retaining frame on the rear panel. Do not drop any accumulated dust into the instrument.

2. Flush the loose dirt from the filter with a stream of hot water.

3. Place the filter in a solution of hot water and mild detergent and let it soak for a few minutes.

4. Squeeze the filter in the detergent solution to wash out the remaining dirt and the old adhesive coating.

5. Rinse thoroughly in clear water.

6. Allow the filter to dry.

7. Coat the dry filter with an air-filter adhesive, available from air conditioner suppliers. (This adhesive may be ordered from Tektronix as part number 006-0580-00).

8. Let the adhesive dry thoroughly before re-installing the filter in the retaining frame.

Exterior. Loose dust accumulated on the outside of the dust covers and on the front and rear panels may be remove by wiping with a soft cloth. A small paint brush may be used for removing dust from the front-panel controls. Any remaining dirt can be removed with a soft cloth dampened in a solution of water and mild detergent. Abrasive cleaners should not be used.

Interior. Dust in the interior of the instrument should be removed occasionally to prevent electrical conductivity. Most of the dust can be removed by blowing it out with a low-velocity stream of dry air. Any dust or dirt remaining in the interior may be removed with a small cloth or cotton-tipped applicator dampened with a solution of water and mild detergent. The plug-in circuit cards may be removed for individual cleaning. After cleaning the interior, allow it to dry thoroughly before turning on the instrument.

CAUTION

Do not clean any plastic materials with organic chemical solvents such as benzene, acetone or denatured ethyl alcohol. These may damage the plastic. (Isopropanol is safe to use for cleaning.)

Lubrication

The reliability of rotary switches and other moving parts can be improved by keeping them properly lubricated with the correct type of lubricant. Never use more than the minimum amount of lubricant required.

Use a cleaning-type lubricant (e.g., Tektronix Part Number 006-0218-00) for shaft bushings, interconnecting plug contacts and switch contacts. Lubricate switch detents with a heavier grease (e.g., Tektronix Part Number 006-0219-00). Potentiometers used in the Type R116 are lubricated during manufacture, but if further lubrication is required, a lubricant (e.g., Tektronix Part Number 006-0220-00) which does not change the electrical characteristics of the component should be used. A kit containing instructions and a variety of lubricants is also available as Tektronix Part Number 003-0342-00.

Fan Oiling. During periodic servicing, the fan motor should be lubricated with a few drops of light machine oil (Anderol L826 available from Lehigh Company or Rotron Distributors is recommended.) An industrial hypodermic syringe and needle is used to insert the oil through the rubber seal, as shown in Fig. 5-1. With the needle held at a 45° angle, pierce the rubber seal, then insert the needle about 1/4 inch and depress the syringe plunger far

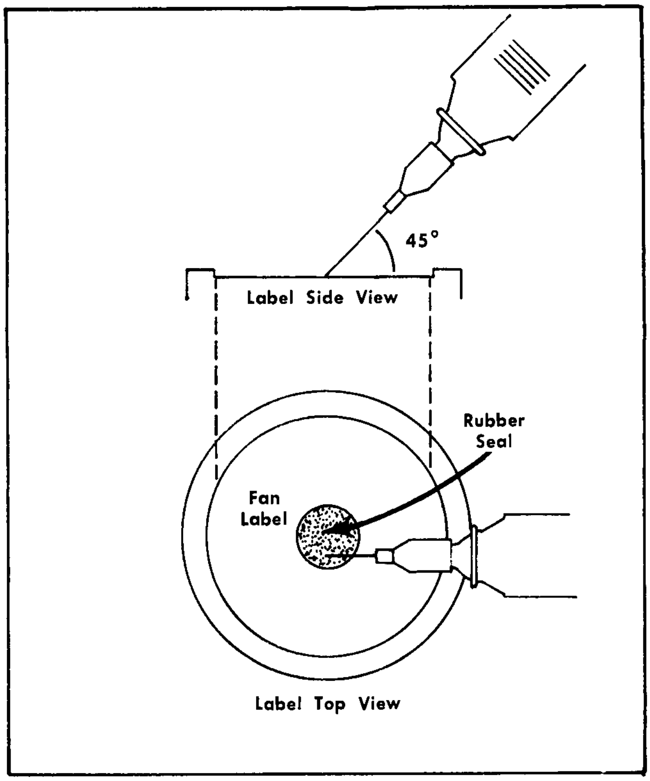


Fig. 5-1. Oiling the fan motor with a hypodermic.

enough to inject 3 or 4 drops of oil into the bearing. If a syringe and needle cannot be obtained locally, they may be ordered from Tektronix (Tektronix Part Number 003-0282-00 for the syringe; 003-0285-00 for the needle).

Visual Inspection

The Type R116 should be inspected occasionally for possible defects such as damaged connectors or components and improperly seated transistors or plug-in circuit cards. Corrective procedures for most visible defects are obvious but particular care should be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of the overheating be found and corrected to prevent a recurrence of the damage after the heat-damaged parts are replaced.

Transistor Checks

The transistors in the Type R116 should not be checked during periodic servicing of the instrument. The best determination of performance is the actual operation of the component in the circuit. However, if a circuit malfunction occurs, the transistors should be checked as a part of the troubleshooting procedure, as described later in this section of the manual.

Recalibration

To assure the correct and accurate operation of the Type R116, it should be checked after each 1000 hours of operation and recalibrated if necessary. Recalibration should be performed at least every 6 months. Performance Check and Calibration procedures are given in separate sections of this manual. In some cases, minor troubles that are not apparent during normal use may be corrected by recalibration.

CORRECTIVE MAINTENANCE

Corrective maintenance generally consists of component replacement and instrument repair. Special information required for replacing parts in the Type R116 is given here.

Replacement Parts

Standard Parts. All electrical and mechanical replacement parts used in the Type R116 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained in less time by purchasing them locally. Before ordering or purchasing any replacement parts, refer to the Electrical or Mechanical Parts Lists in this manual for the required characteristics and correct description.

NOTE

When obtaining replacement parts, remember that the physical size and position of a component may affect its circuit performance. Replace components only with identical parts unless it is known that substitute parts will not adversely affect the operation of the instrument.

Special Parts. In addition to the standard electronic components, some special components and parts are used in the Type R116. These parts are manufactured by or for Tektronix, or are selected to meet specific performance requirements. Each of the special electronic components is indicated in the Electrical Parts List by an asterisk preceding the part number. In addition, most of the mechanical parts used in the instrument are manufactured by Tektronix and are not available from other sources. Order all special parts directly from your Tektronix Field Office or representative.

Ordering Parts

When ordering replacement parts from Tektronix, always include the following information:

1. A complete description of the part as given in the Electrical or Mechanical Parts List. For an electrical part, also give its circuit number (e.g., Q14—Width Generator).
2. The instrument type (Type R116).
3. The instrument Serial Number, found on the front panel.

Soldering Techniques

CAUTION

Disconnect the instrument from the power line before soldering components mounted on the chassis.

Etched-Wiring Card Soldering. Use ordinary 60/40 tin-lead solder with a 35- to 40-watt pencil-type soldering iron. A hotter type of iron may separate the etched-wiring material from the laminate base. The tip of the iron should be clean and properly tinned for quick heat transfer to the solder joint. The following technique is suggested for replacing a component on an etched-wiring card.

Removal:

1. Remove the card from the Type R116 and place it on a work bench or table with the component side facing up. If possible, weight the card down so that it will not move.

2. Grip one lead of the component with a pair of long-nose pliers or a pair of tweezers. (If the component is known to be defective, the leads may be cut near the component body for individual removal.)

3. Touch the tip of the soldering iron to the lead at the solder connection (see Fig. 5-2). When the solder begins to melt, pull the lead out quickly.

4. Remove each of the other leads in the same manner.

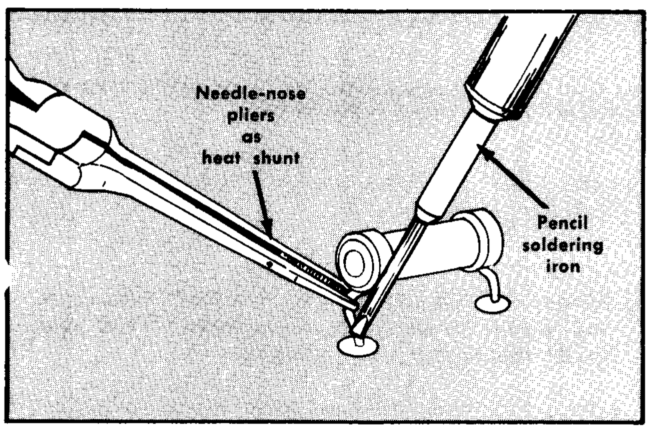


Fig. 5-2. Apply the soldering iron to the heat-shunted lead when removing a component from an etched-wiring card.

Installation:

1. Bend the leads of the new component to match the holes in the etched-wiring card. If the holes are not open, they can be opened by heating the solder to the melting point and quickly inserting a pointed tool or toothpick into the hole.

2. Clip the lead lengths of the new component to the same lengths as the leads of the removed component.

3. Pre-tin the leads of the component by applying the soldering iron and a small amount of solder to each (heat-shunted) lead.

4. Insert the leads into the holes in the card and position the component properly.

5. Heat-shunt each lead while applying the soldering iron and a small amount of solder to the connection.

6. Clip off any excess lead length extending beyond the solder connection on the reverse side of the etched-wiring card.

7. Clean the area around the solder connection with a flux-removing solvent. Be careful not to remove any information printed on the circuit card.

Ceramic Terminal Strip Soldering. Solder containing about 3% silver should be used for soldering components on ceramic terminal strips. Occasional use of ordinary 60/40 tin-lead solder is permissable, but its repeated use or the application of excessive heat may break the ceramic-to-silver bond at the terminal notch. Silver-bearing solder is available locally from electronic parts distributors or may be purchased in 1-pound rolls (Tektronix Part Number 251-0514-00) through your Tektronix Field Office or representative. Use a 40- to 75-watt soldering iron with a narrow chisel-shaped tip that has been cleaned and properly tinned.

Removal:

1. With a pair of long-nose pliers, take hold of one lead of the component to be removed.

2. Apply heat to the solder connection by touching the soldering iron tip to the base of the ceramic strip notch (see Fig. 5-3) while pulling gently on the lead. Do not apply pressure to the strip, as this may break or chip it.

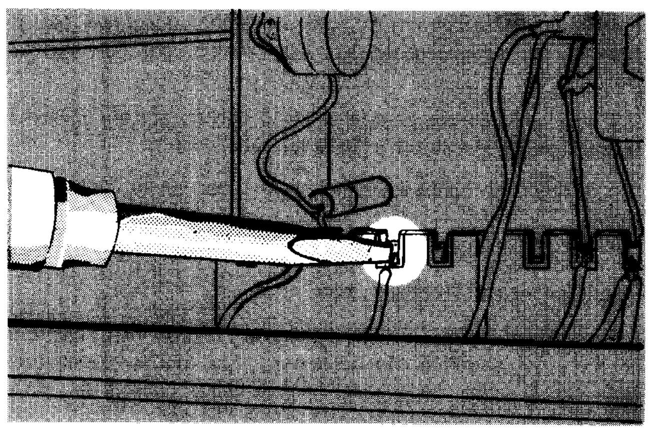


Fig. 5-3. Correct method of applying heat when soldering to a ceramic terminal strip.

3. As soon as the solder melts, pull the lead from the notch and remove the soldering iron. Avoid applying excessive heat to the ceramic strip.

4. In the same manner, remove each of the other leads of the component.

Installation:

1. Pre-tin each lead of the replacement component by heating the lead and applying a small amount of solder. If the component is small, heat-shunt the lead next to the component body with a pair of long-nose pliers.

2. Place the replacement component in the same position as the part that was removed.

3. Press the component lead lightly downward into the notch and apply the soldering iron (as for removal) until the solder melts. Press the lead as far as it will go into the notch without forcing.

4. Solder each of the other leads in the same manner.

5. Clip off any excess lead length extending past each solder connection.

6. If the leads in the notch are not sufficiently covered with solder, reheat the connection and add a small amount of solder. It is best not to fill the notch with solder unless this is required for a good connection.

7. Clean the flux from the ceramic strip with a flux-removing solvent.

Metal Terminal Soldering. Use ordinary 60/40 tin-lead solder for soldering to metal terminals such as connector jacks and switch terminals. A soldering iron with a 40- to 70-watt rating should be used and the tip of the iron should be properly cleaned and tinned. To remove a lead or to solder a lead to a metal terminal:

1. Hold the lead with a pair of long-nose pliers.

2. Apply the soldering iron tip directly to the connection until the solder begins to melt. Do not apply excessive heat.

3. Pre-tin all leads to be soldered to the terminal. Heat-shunt the leads for tinning.

4. Use the minimum amount of solder required for a good bond. Excessive solder may destroy the function of the part.

5. Clip off any lead length extending beyond the finished connection and remove it from the instrument.

6. Clean the solder connection with a flux-removing solvent.

Replacement Procedures

Fuse Replacement. The power-line fuses are located on the front panel of the instrument. For 115-volt operation both 0.6-A fuses are used. For 230-volt operation only one 0.6-A fuse (nearest the panel edge) is used.

CAUTION

Use only the correct value replacement fuses. A larger value will not provide adequate protection for the instrument; a smaller value will tend to blow out.

Transistor Replacement. Since each transistor has its own individual operating characteristics, transistors should not be replaced unless they are actually defective. If removed during routine maintenance, be sure they are returned to their original sockets. Unnecessary replacement or switching of transistors may affect the calibration of the instrument.

Any replacement transistor should be of the original or an equivalent type, and should be mounted in the same manner as the original. Bend the leads to fit the sockets correctly and cut off the leads at a length approximately 1½ times the height of the transistor case. Note the two electrode configurations shown in Fig. 5-4.

All of the chassis-mounted power transistors use silicone grease to aid in the dissipation of heat. Some of the socket-mounted transistors with heat sinks also use this grease. When replacing any of these transistors, also replace the grease.

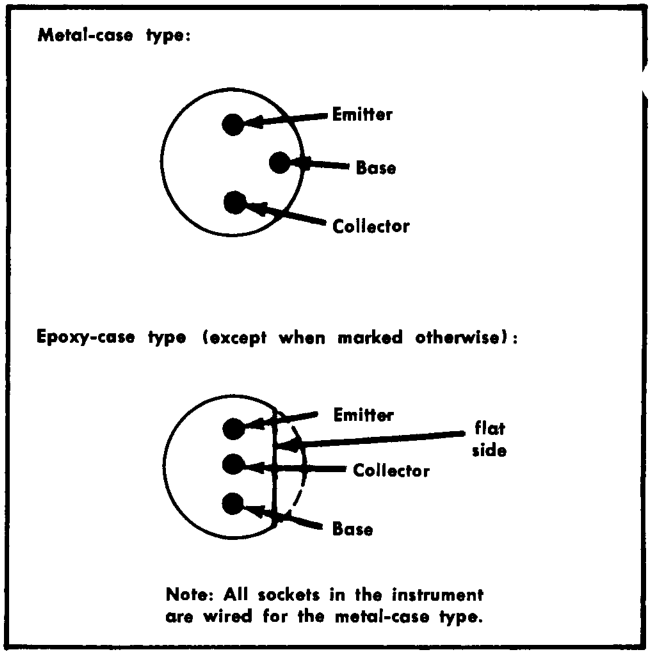


Fig. 5-4. Electrode configurations for socket-mounted transistors, as viewed from the bottom of the transistor.

WARNING

Silicone grease should be handled with care and should be kept out of the eyes. Wash your hands thoroughly after using it.

After any transistor has been replaced, the calibration of the particular circuit should be checked.

Circuit Card Replacement. If one of the plug-in circuit cards is damaged and cannot be repaired, it should be replaced with a new card assembly. Replacement cards may be ordered either with or without circuit components wired in place. The Tektronix Part Numbers are given in the Mechanical Parts List. To obtain a replacement card with the solder-on components in place, be sure to order the replacement card assembly. (An assembly does not include socket-mounted transistors.)

CAUTION

When replacing circuit cards in the Type R116 always observe the following:

1. Insert all cards into their holders with the components on the left side, as viewed from the front and top of the instrument. A CAUTION to this effect is printed on the chassis.

2. Install each card only in the correct series slot. The series letter (e.g., C) is printed on the top front corner of the card and on the instrument chassis adjacent to the card holder. Installation in any other position may damage the instrument. (The card may have any MODEL number, as long as the series letter is correct.)

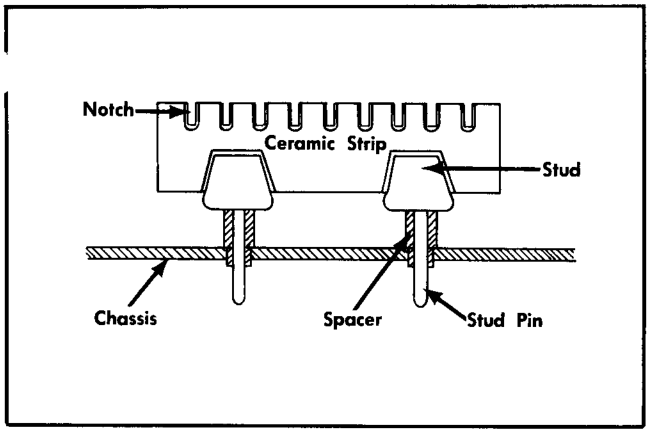


Fig. 5-5. Ceramic terminal strip assembly.

After any plug-in card has been replaced, that portion of the circuitry must be calibrated and any closely-related circuits should be checked. If a series G or series H card is replaced, be sure to reconnect the wire or coaxial cable to the connector on the card.

Ceramic Terminal Strip Replacement. Replacement ceramic strips are supplied with their mounting studs attached (see Fig. 5-5), but the mounting spacers must be ordered separately. If the old spacers are not damaged, they may be re-used with the new terminal strip assembly. Tektronix Part Numbers for various ceramic strips and spacers are given in the Mechanical Parts List.

The following procedure is suggested for replacing a damaged terminal strip.

Removal:

1. Unsolder all components and wire connections. It may be advisable to mark each lead with the corresponding notch number.

2. Pry or pull the damaged strip from the chassis.

3. If the spacers come out with the strip, remove them from the stud pins for use on the new strip.

Installation:

1. Place the undamaged or new spacers in the chassis holes.

2. Carefully press the studs into the spacers until they are completely seated. If it is necessary to use additional force to seat the mounting studs, tap the strip lightly with a soft mallet directly above each mounting stud.

3. Cut off the studs even with the spacers on the reverse side of the chassis.

4. Replace all wires and components (see Soldering Techniques).

Rotary Switch Replacement. Individual parts of a rotary switch are not normally replaceable. If a switch is defective, the entire assembly should be replaced. Refer to the Electrical Parts List for correct Tektronix Part Number.

When removing a switch, mark the leads and the switch contacts with corresponding identification tags, then use the old switch as a model for installing the new one. Do not let solder flow beyond the rivets on the switch terminals when soldering to the new switch. Spring tension of the switch contact will be destroyed by excessive solder.

Power Transformer Replacement. If a complete check of the instrument shows that the power transformer requires replacement, notify your local Tektronix Field Office or representative for a warranty replacement (see the Warranty note in the front of this manual). Be sure to use only the correct replacement for the power transformer.

When removing the transformer, tag the leads with the terminal numbers to aid in connecting the new transformer. After the new transformer has been installed and the leads soldered to the terminals, check the power-supply resistances to chassis ground as given in Table 5-1 before connecting the instrument to the power line. (The 115V-230V switch should be at the 115 V position.)

TABLE 5-1

Power Transformer Resistance Checks

Terminal Number	Approximate Resistance to Chassis Ground[1]
1	Infinite
2	Infinite
3	Infinite
4	Infinite
5	0
6	1.9 kΩ[2]
7	1.9 kΩ[2]
8	2.4 kΩ[2]
9	2.4 kΩ[2]
10	1.9 kΩ[2]
11	1.9 kΩ[2]

[1]Common lead connected to chassis ground.

[2]Using 1 kΩ scale on meter.

A complete performance check of the instrument will be required after replacement of the power transformer.

Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. Since the low-voltage supplies affect all circuits, calibration of the entire instrument should be checked if work has been done in the low-voltage supplies or if the power transformer has been replaced.

TROUBLESHOOTING

The following information is provided to aid in locating and correcting trouble in the Type R116. Information found in the Circuit Description, Calibration and Diagrams sections is also helpful when troubleshooting the instrument.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in the rear of the manual. The circuit numbers and electrical values of components, as well as significant voltages and waveforms, are shown on the diagrams. All front-panel and internal control names are given and all input and output connections are indicated. The components of each subcircuit are assigned related circuit numbers so they can be easily located on the diagram.

The sequence of diagrams is the same as that of the circuit cards in the instrument. Chassis-mounted components are shown on the related card diagrams. The portion of the circuitry that are mounted on circuit cards are outlined in blue.

Circuit Card Illustrations. Since the high-density spacing of components on the circuit cards permits only a few circuit numbers to be printed on the cards, Figs. 5-8 through 5-16 are provided to show the physical locations of all components mounted on the cards. Test points can be located where one or more of the components are soldered to the cards.

Wiring Color Code. All insulated wire in the Type R116 is color coded for convenience in circuit tracing. Signal carrying leads are identified with one or two colored stripes. Voltage supply leads are identified with three stripes to indicate the approximate voltage using thhe EIA resistor color code, as given in Table 5-2. A white background color indicates a positive voltage and a tan background indicates a negative voltage. All voltages except the +12-volt supply are referenced to signal ground. The +12-volt supply is referenced to chassis ground. All voltage supplies are connected to the plug-in cards through bus wires located on the bottom of the instrument.

TABLE 5-2

Power-Supply Leads

Supply	Background Color	1st Stripe (widest)	2nd Stripe	3rd Stripe (narrowest)	Bus-Wire Terminals (J1-J9)
Signal ground	White	Black	none	none	1 and A
—27-volt	Tan	Red	Black	Black	2 and B
—6-volt	Tan	Black	Blue	Black	3 and C
+7-volt	White	Black	Violet	none	26 and DD[3]
+25-volt	White	Red	Black	Black	4 and D
Chassis ground	White	none	none	none	28 and FF
+12-volt	White	Brown	Red	Brown	27 and EE

[3]Not connected to J6, J7 or J8.

Resistor Color Code. In addition to the brown composition resistors, some metal-film resistors (identifiable by their gray body color) and some wire-wound resistors (light blue or gray-green) are used in the Type R116. The resistance values of wire-wound resistors are marked on the body of the component. The resistance values of composition resistors and metal-film resistors are color coded on the components with the EIA color code. The code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes which consist of two significant figures, a multiplier and a tolerance value (see Fig. 5-6 and

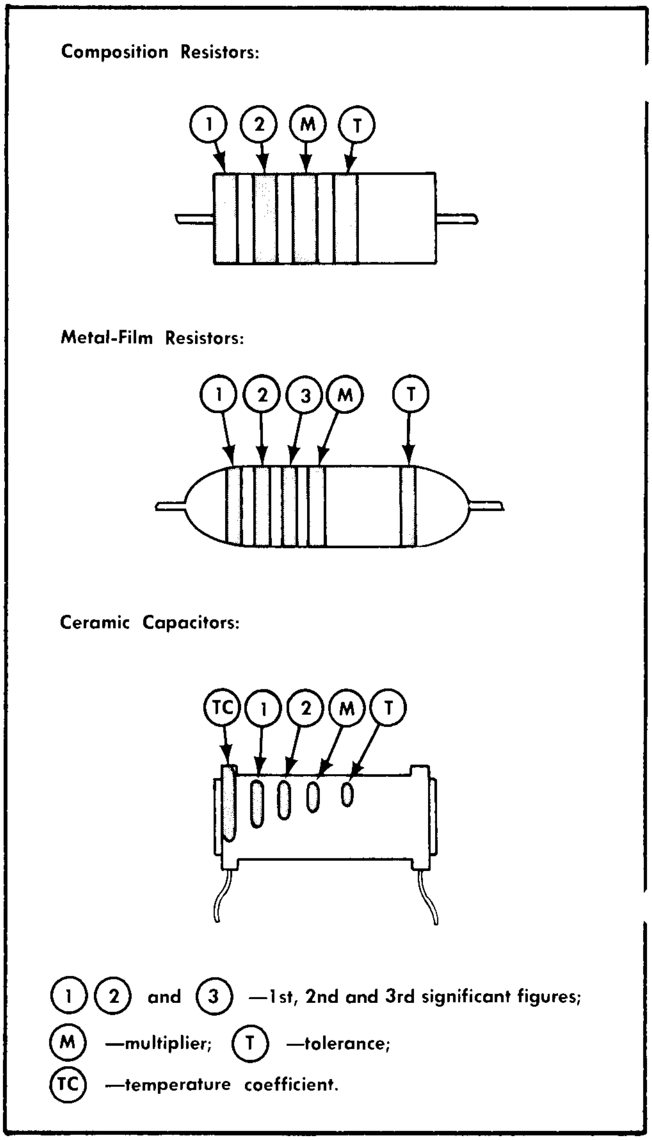


Fig. 5-6. Resistor and ceramic capacitor color code (see Table 5-3).

Table 5-3). Metal-film resistors have five stripes consisting of three significant figures, a multiplier and a tolerance value.

Capacitor Marking. The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the Type R116 are color coded in picofarads using a modified EIA code (see Fig. 5-6 and Table 5-3).

Diode Color Code. The cathode end of each glass-enclosed diode is indicated by a stripe, a dot or a series of stripes. For normal silicon or germanium diodes the stripes also indicate the type of diode, using the resistor color-code system (e.g., 6165 indicates the type of diode with Tektronix Part Number 152-0165-00). The cathode and anode ends of metal-encased diodes can be distinguished by the diode symbol marked on the body or by the flared end at the anode.

TABLE 5-3

Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier Resistors	Multiplier Capacitors	Tolerance	Temperature Coefficient
Silver	- - -	10^{-2}	- - -	10%	- - -
Gold	- - -	10^{-1}	- - -	5%	±0
Black	0	1	1	20% or 2 pF[4]	—0.033 parts/ million
Brown	1	10	10	1% or 0.1 pF[4]	—0.075 parts/ million
Red	2	10^2	10^2	2%	- - -
Orange	3	10^3	10^3	2.5%	- - -
Yellow	4	10^4	10^4	- - -	—0.330 parts/ million
Green	5	10^5	10^5	5% or 0.5 pF[4]	- - -
Blue	6	10^6	10^6	- - -	- - -
Violet	7	- - -	- - -	- - -	- - -
Gray	8	- - -	10^{-2}	0.25 pF	- - -
White	9	- - -	10^{-1}	10% or 1 pF[4]	General purpose-1
(none)	- - -	- - -	- - -	20%	- - -

[4]For values less than 10 pF.

Troubleshooting Checks

If apparent trouble occurs in the Type R116, consider the following preliminary checks before proceding with extensive troubleshooting. Often apparent malfunctions result from the improper use of controls or inadequate external connections to associated equipment.

Check Control Settings. Incorrect control settings can give an indication of trouble, even though no circuit trouble exists in the instrument. Many combinations of control settings in the Type R116 can prevent the formation of output pulses. Operate the front-panel controls to see if any operational problems are apparent. If there is any question about the correct purpose and use of a control or the correct relationship between controls settings, review the operating instructions in Section 2 of this manual. Familiarity with the normal operation of the instrument is of great assistance in locating trouble. This familiarity can be gained through actual use of the instrument and through the use of this manual.

Check Associated Equipment. Be sure the equipment used with the Type R116 is operating correctly. Check that input and output cables are not defective and that they are connected correctly for the desired mode of operation. Check that the display oscilloscope and programming units are operating properly.

If these checks do not correct the indication of trouble, the following Troubleshooting Procedure will help to locate the source of trouble.

Troubleshooting Procedure

The following procedure is provided to isolate trouble to a particular circuit in the Type R116 and to locate the trouble within that circuit. To arrive at the proper front-panel control settings for a known set of circuit conditions, set the controls as indicated under Test Conditions on the left page of the Period Generator diagram. These control settings should produce waveforms in all circuits.

Voltage measurements should be made with a 20,000 Ω/volt dc voltmeter, accurate to within 3% on all ranges.

NOTE

Signal ground in the Type R116 is not at zero volts with respect to chassis ground. Since all voltages except the +12-volt supply are referenced to signal ground, connect the common lead of the voltmeter to signal ground (black on white color-coded lead at filter capacitor C417).

Check for waveforms with a 30 MHz (or faster) test oscilloscope and a 10× attenuator probe (approximately 10 MΩ input resistance).

CAUTION

Connect the probe ground clip to chassis ground, not to signal ground. Connecting the signal ground to chassis ground may cause damage to the power-supply circuit. If it is necessary to reference the probe to signal ground, either use a differential input oscilloscope or connect the probe clip through a 1 μF capacitor to signal ground.

Be careful when checking inside the instrument with meter leads and probe tips. Careless shorting of leads can apply abnormal voltages or transients to the components and cause the destruction of semiconductors or other small components.

The plug-in circuit cards may be extended on a plug-in card extender (Tektronix Part Number 012-0078-00) for convenience in circuit tracing. When extending series G or series H cards, leave the plug-on connectors attached. The coaxial cable connected to the series H card may have to be pulled out from under the plastic retaining clip.

1. Check Front-Panel Output Signals. With a test oscilloscope, check for the correct output signals as shown on the schematics at the +PRETRIGGER OUT, the +DELAYED TRIGGER OUT and the PULSE OUTPUT connectors.

If the +Pretrigger Out signal is present, the Period Generator circuit is operating. If the +Pretrigger Out signal is not present or is not correct, check the power-supply voltages as described in the calibration procedure. If the supply voltages are found to be correct, check the Period Generator circuit in detail for voltages and waveforms.

If the +Delayed Trigger Out signal is present the Delay Generator is functioning. If the +Pretrigger Out signal is correct but the +Delayed Trigger Out signal is not present or is not correct, the trouble is either in the Delay Generator or in the trigger switching on the Function Program #1 card.

If the Pulse Output signal is now correct, the previous indication of trouble may have been due to incorrect control settings or to a circuit malfunction at one particular position of one of the Range switches. If the +Pretrigger Out and

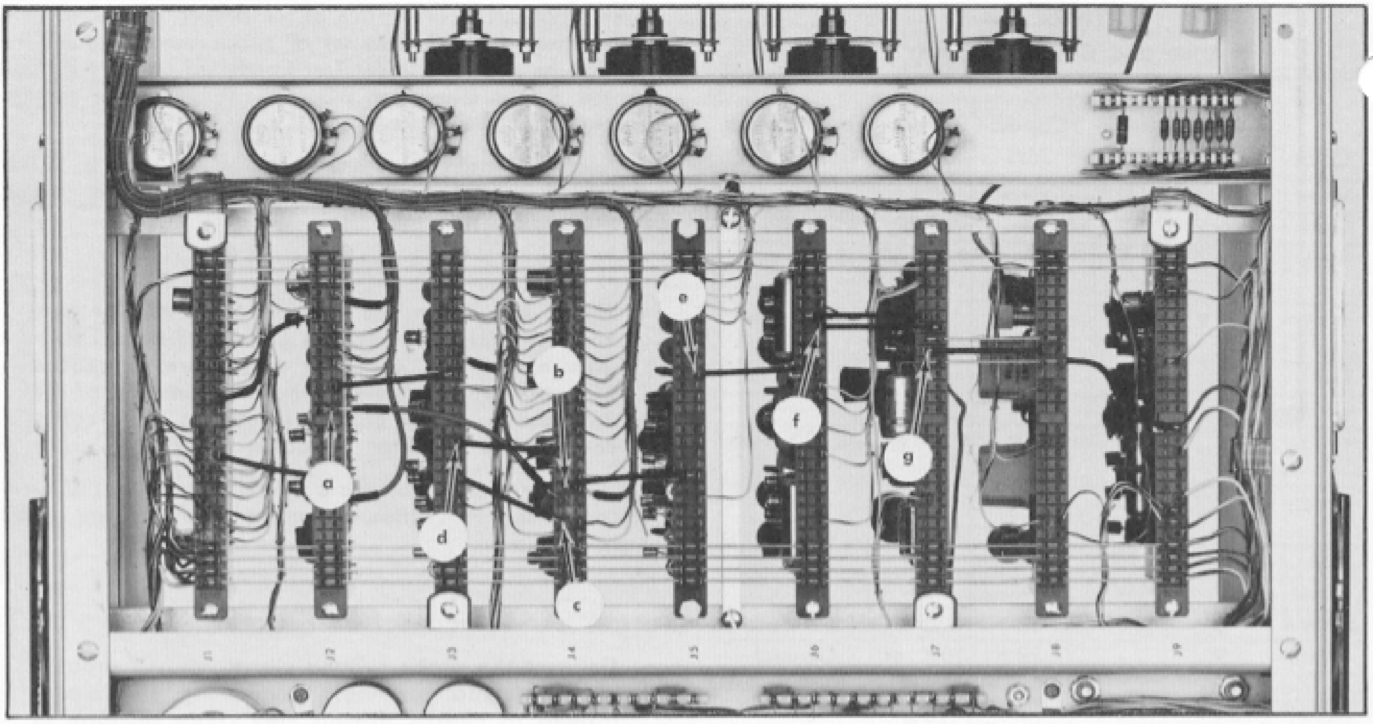


Fig. 5-7. Basic test points on the bottom of the Type R116 for tracing circuit waveforms through the instrument. See step 2 of the Troubleshooting Procedure.

the +Delayed Trigger Out signals are both correct but the Pulse Output signal is absent or is incorrect, proceed to step 2.

2. Check Circuit Output Signals. Place the Type R116 so that the circuitry on the bottom of the instrument is exposed. Check for waveforms through the circuitry at the test points shown in Fig. 5-7 and the Interconnecting diagram (#11) as follows:

a. Period trigger at J2, terminal S.

b. Width trigger at J4, terminal 9.

c. Delay trigger at J4, terminal 6.

d. Delayed trigger at J3, terminal P.

e. Width gate at J5, terminal V.

f. Pulse shape generator output at J6, terminal 23.

g. Output amplifier pulse at J7, terminal 20.

When a point is reached where the correct signal is not present, the trouble can be assumed to be in the circuitry immediately preceding that test point.

3. Check Internal Waveforms and Voltages. After locating the general area of trouble with the preceding waveform checks, trace through the circuitry with the test oscilloscope and dc voltmeter for correct waveforms and voltages as given on the schematics. The circuit cards that contain the suspected defective circuitry can be extended to gain access to test points. If the trouble is in either the Delay Generator or the Width Generator, check for the ramp waveform at the junction of R24-R25.

4. Check Circuit Calibration. If the preceding waveform and voltage checks indicate improper operation of a particular circuit, check the calibration of the circuit according to the procedure in the Calibration section of this manual. The improper setting of a calibration adjustment can often cause the incorrect operation of a circuit, and thus of subsequent circuits. If individual steps of the procedure are performed out of sequence, remember that any change in the setting of an adjustment control may affect the calibration of subsequent circuits.

5. Check the Circuit Visually. After isolating the trouble to a particular circuit, check the circuit for damaged parts or broken connections. A visual inspection can sometimes indicate the source of trouble. If another circuit card of the correct series is available, substitute it for the defective circuit card to check the operation of the Type R116. If the substitute card is left in the instrument, a performance check should be made of the instrument.

6. Check Semiconductors. Most circuit failures result from the failure of a transistor or diode due to normal aging and use. The recommended method of checking a transistor is by direct substitution, since static parameter testers do not indicate the circuit performance of a component.

Ordinary silicon or germanium diodes can be checked for an open or shorted condition by measuring the resistance between terminals after unsoldering one end. Use a resistance scale with an internal voltage of 3 volts or less. The resistance should measure very high in one direction and very low with the leads reversed.

CAUTION

Do not use an ohmmeter scale that uses a high voltage source, since this will give an incorrect reading and may also damage the diode.

A dynamic parameter tester such as a Tektronix Type 575 Oscilloscope may also be useful for checking transistors, signal diodes and tunnel or Zener diodes that are suspected of being defective. The components will have to be disconnected from the circuit for testing. Be sure to return the transistors and diodes to their original positions if they are found to be operating correctly.

Before installing a replacement component, be sure that the circuit voltages are not abnormal. If the circuit is not checked, the new component may be damaged by a defective circuit.

7. Check Passive Components. Soldered-in components such as resistors, capacitors and inductors can usually be checked quickly after unsoldering one end to eliminate incorrect measurements due to the surrounding circuitry.

A resistor can be checked with an ohmmeter or resistance bridge. The tolerance permitted for each resistor used in the instrument is given in the Electrical Parts List. The measuring device must have a tolerance that is more restrictive than the tolerance of the resistor being measured in order to check the value accurately. It is usually not necessary to replace a composition resistor unless the value is far out of tolerance. An inductor may be checked for an open condition with an ohmmeter, or for a shorted or partially shorted condition by checking waveforms in the circuit. To determine the inductance value, however, an inductance meter is required.

A capacitor can be checked for a shorted or leaky condition by means of an ohmmeter set to a high scale. The resistance reading should be very high after the capacitor has charged. An open capacitor can be detected by trying to pass an ac signal through it. The capacitance value can be calculated from RC time-constant data or measured with a capacitance meter.

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

NOTES

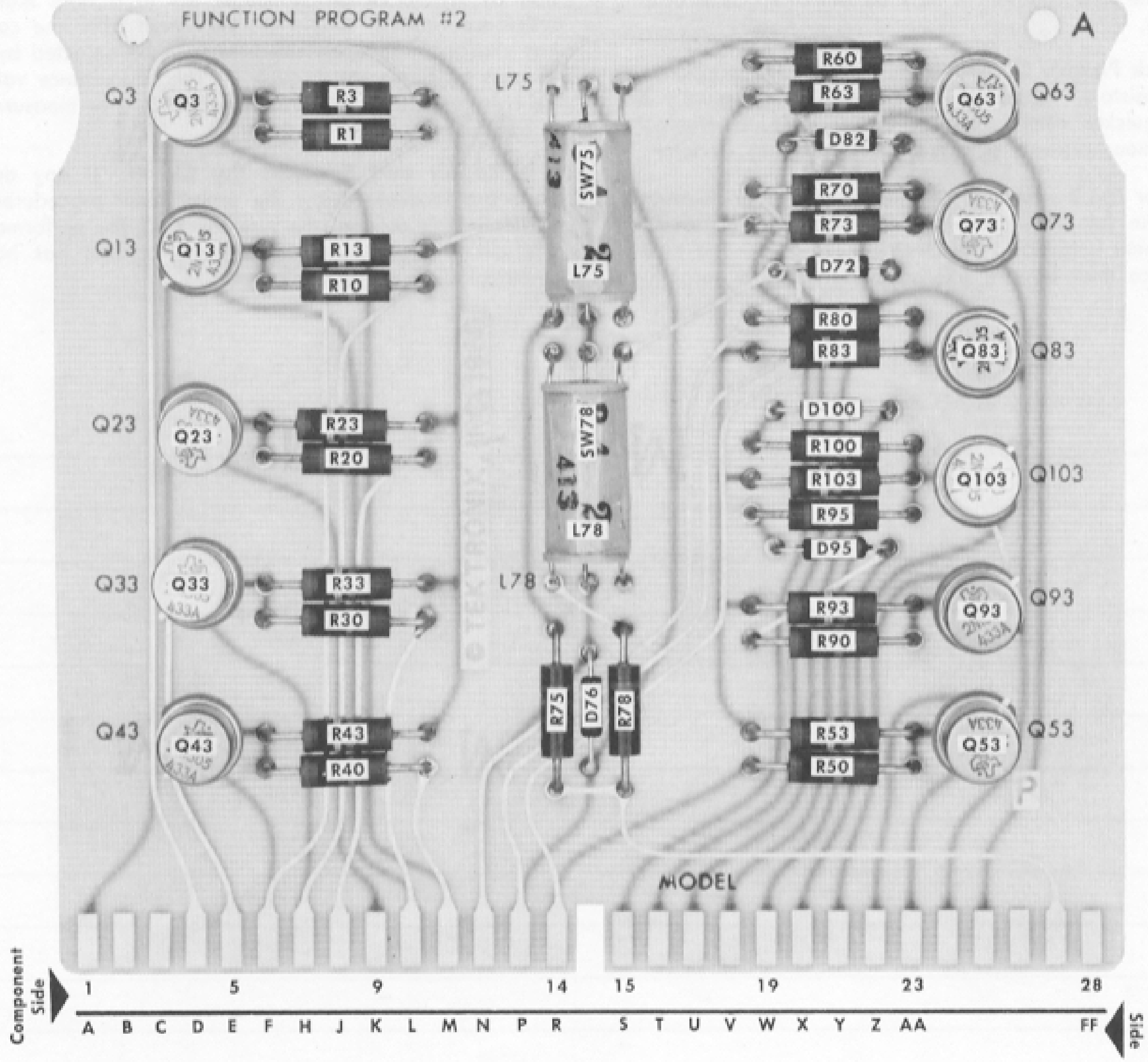


Fig. 5-8. Location of circuit components on Function Program #2 card.

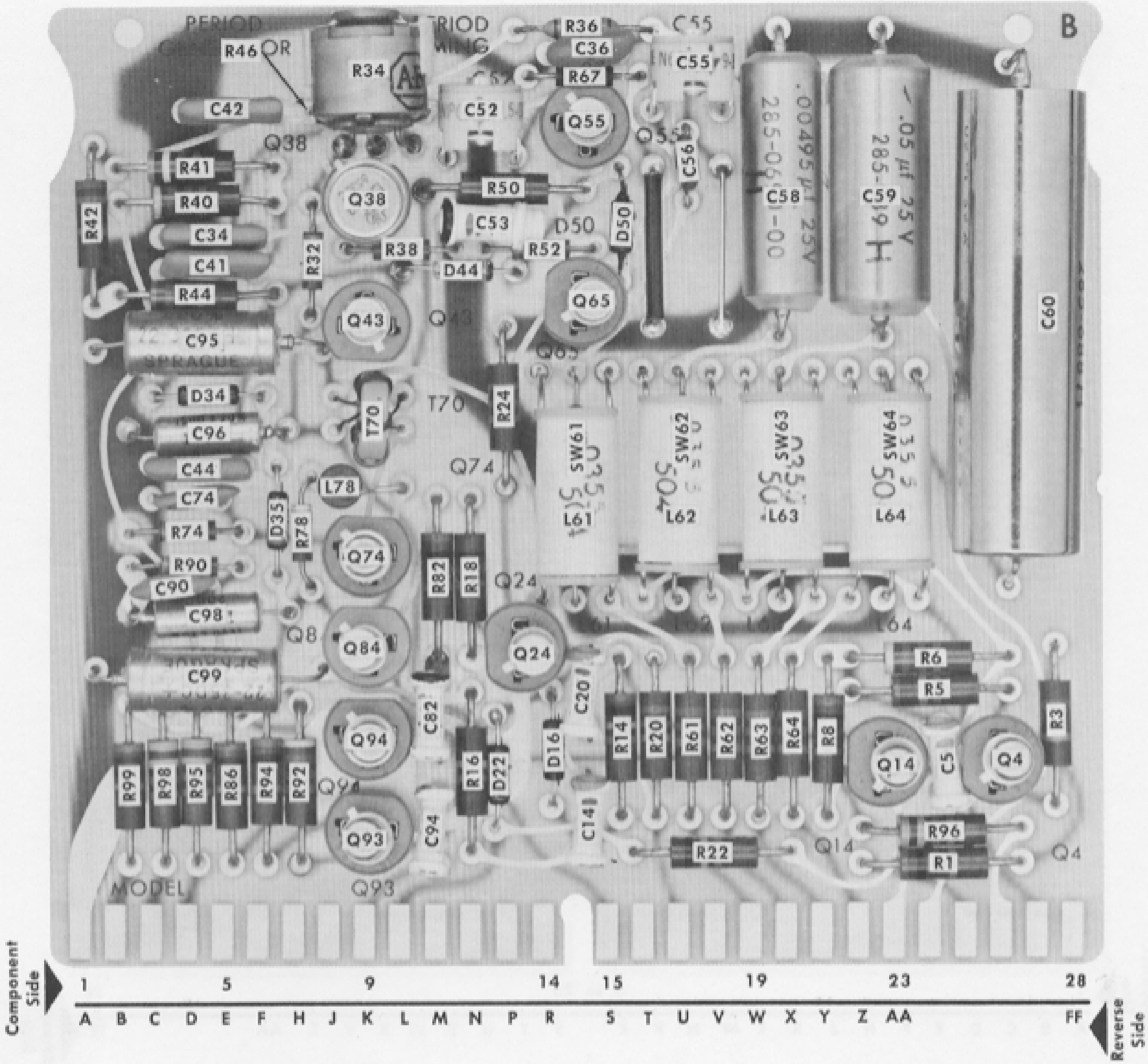


Fig. 5-9. Location of circuit components on Period Generator card.

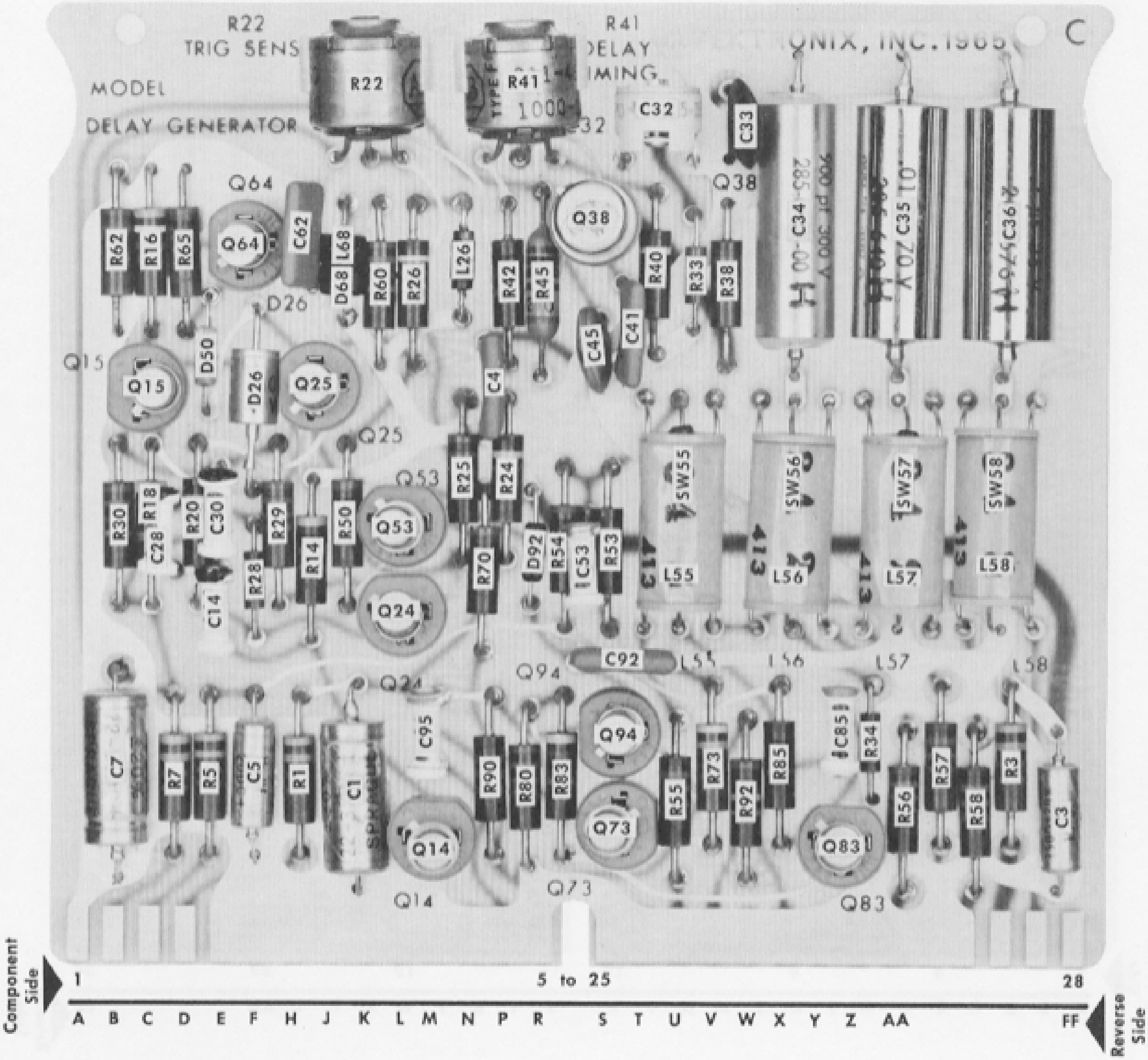


Fig. 5-10. Location of circuit components on Delay Generator card.

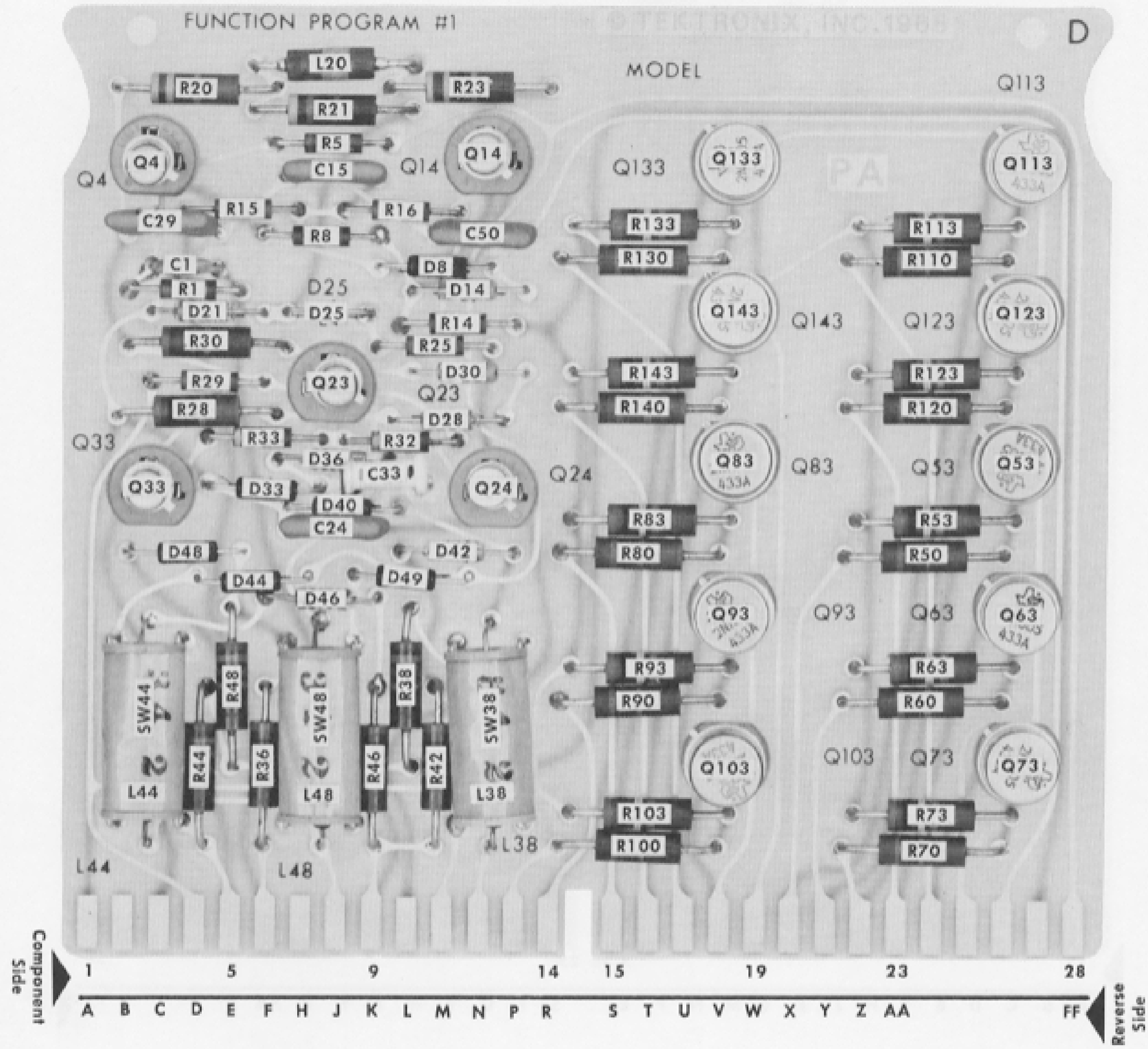


Fig. 5-11. Location of circuit components on Function Program #1 card.

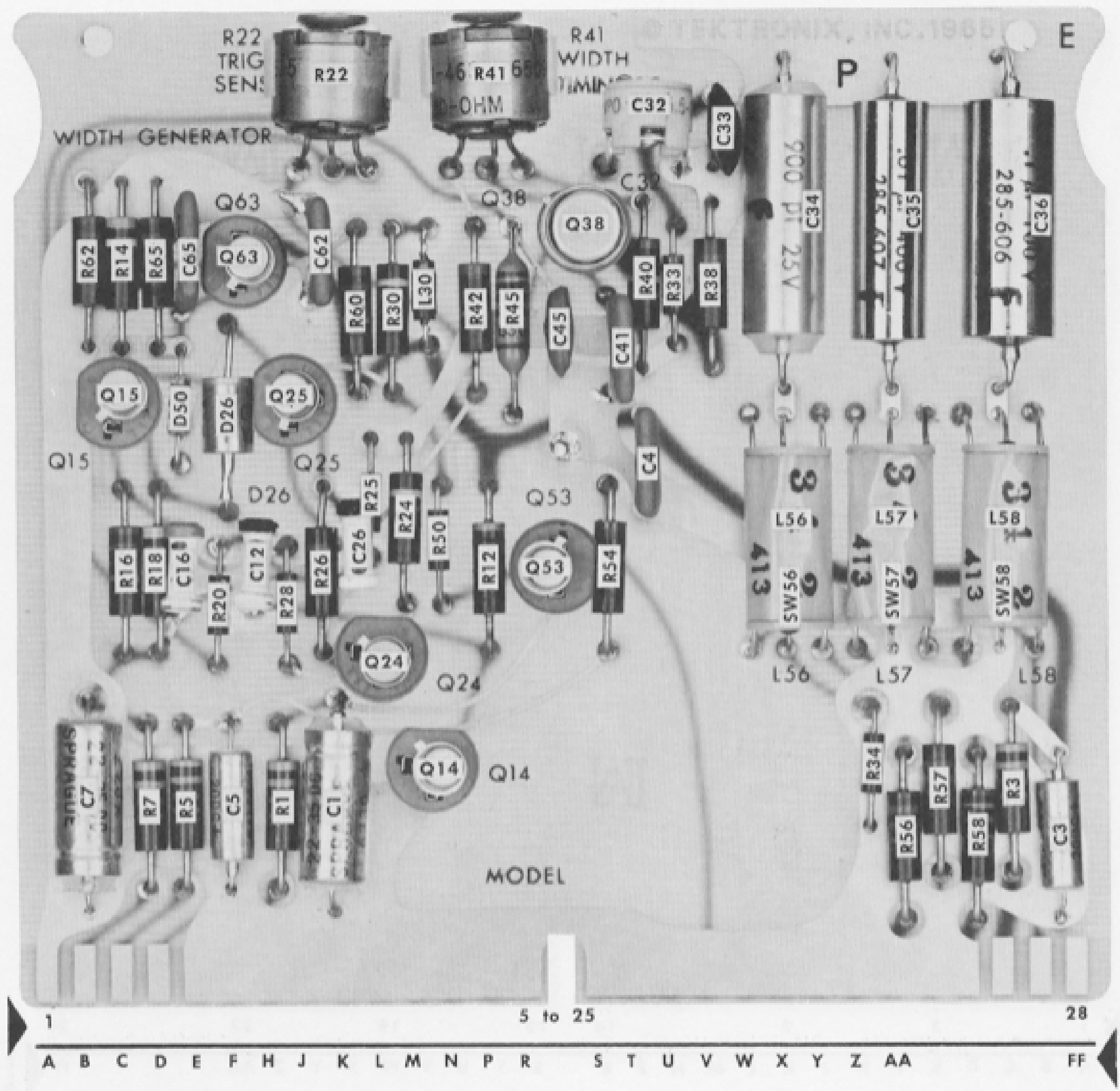


Fig. 5-12. Location of circuit components on Width Generator card.

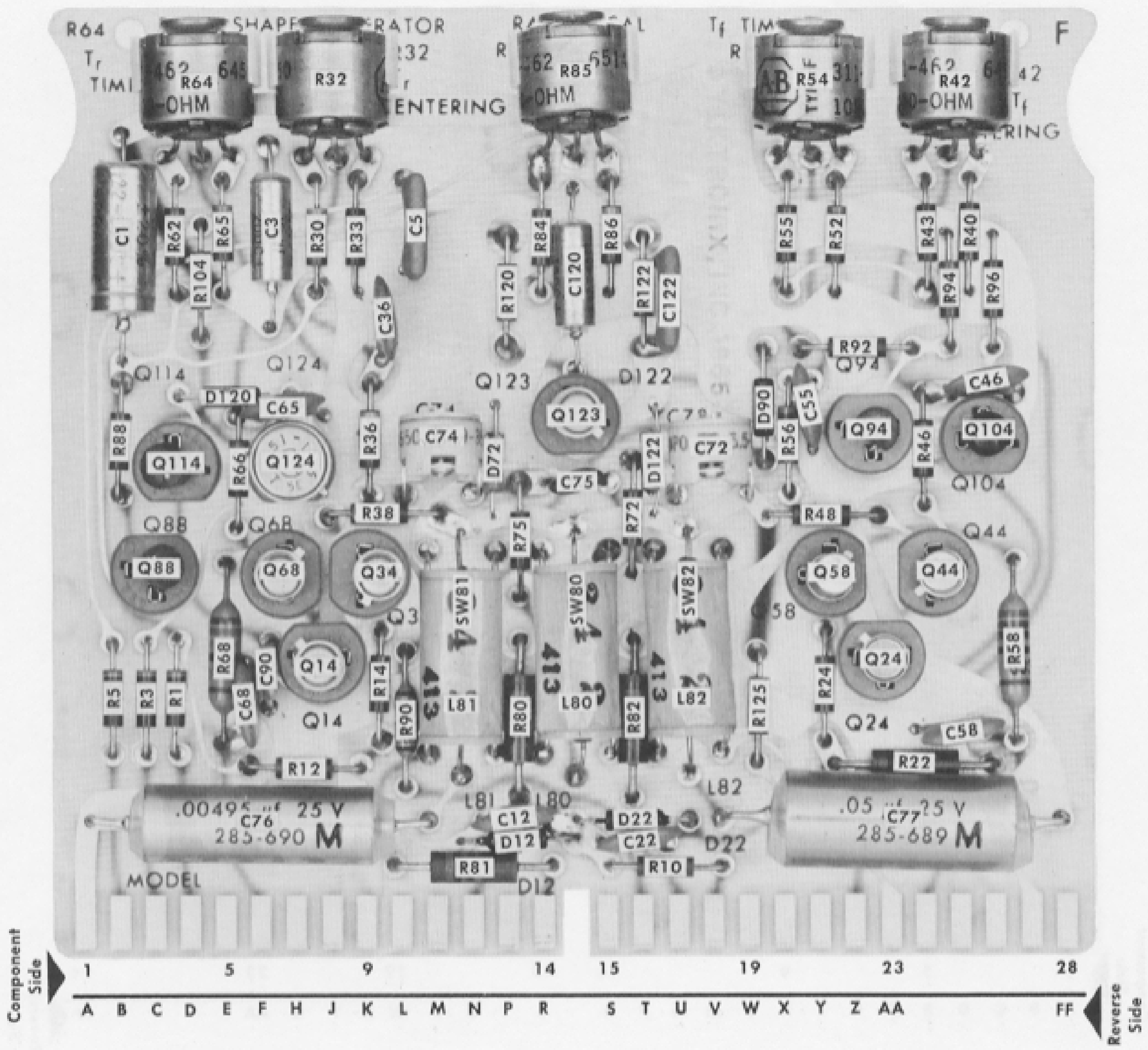


Fig. 5-13. Location of circuit components on Pulse Shape Generator card.

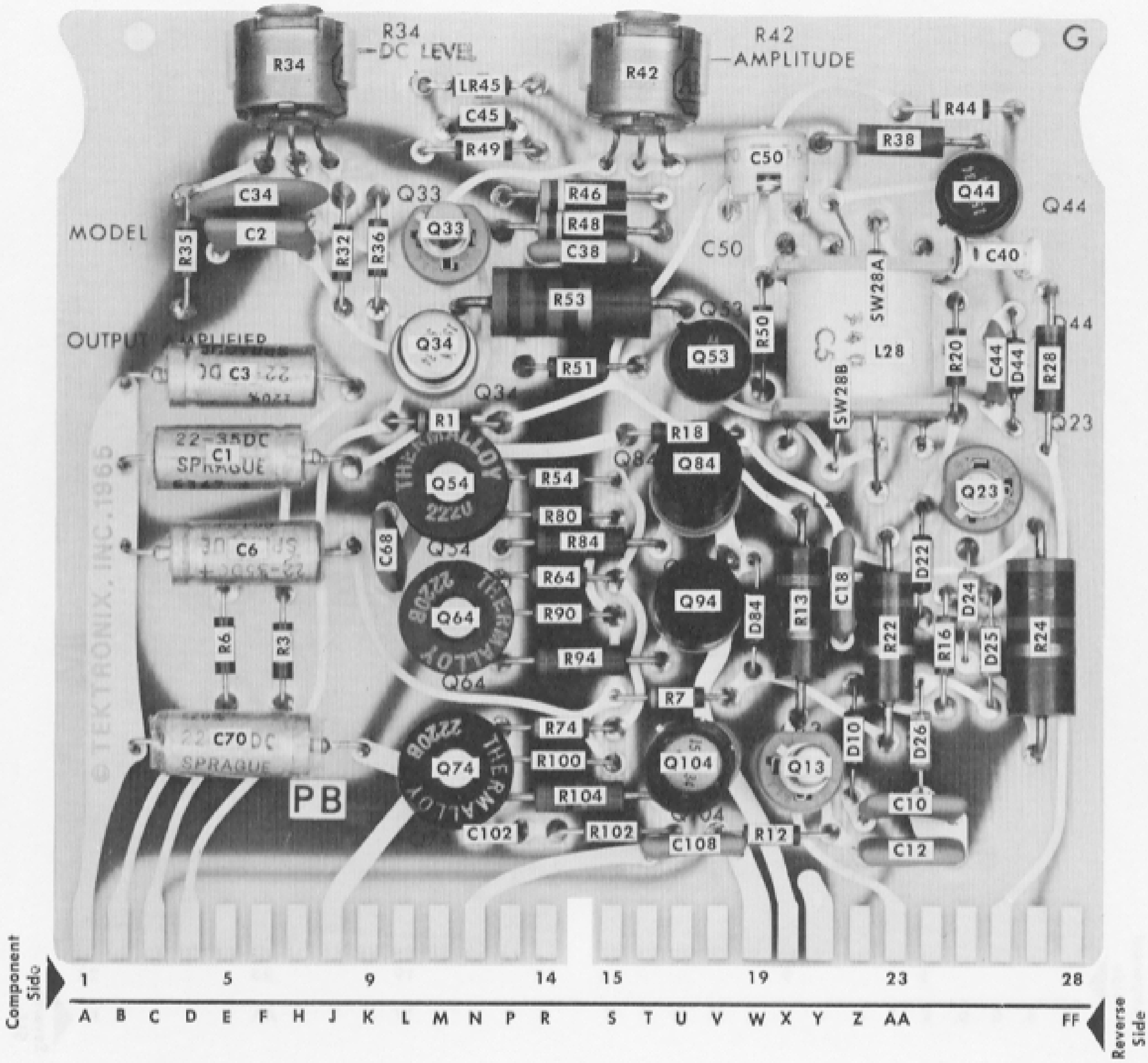


Fig. 5-14. Location of circuit components on Output Amplifier card.

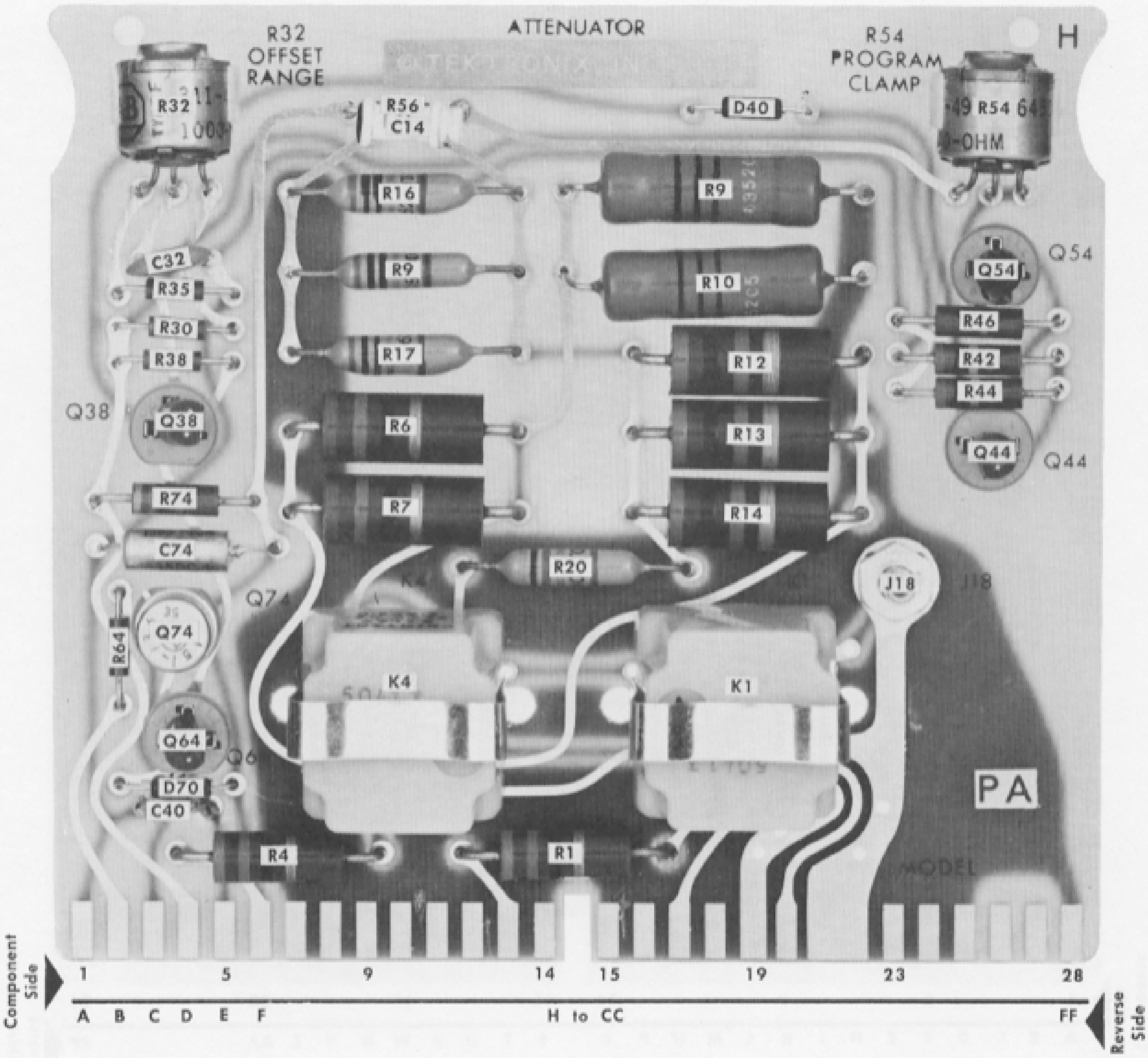


Fig. 5-15. Location of circuit components on Attenuator card.

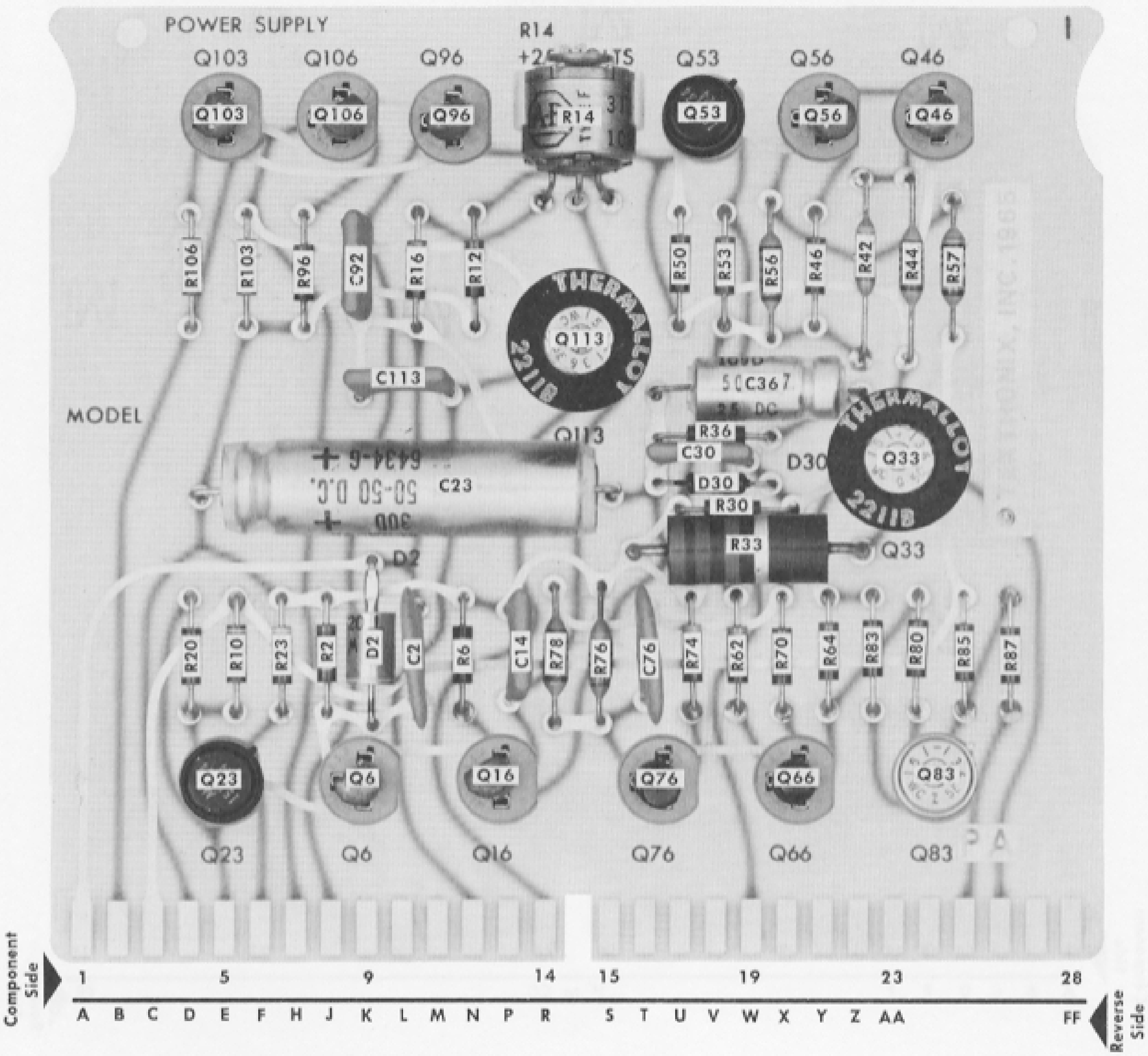


Fig. 5-16. Location of circuit components on Power Supply card.

SECTION 6
PERFORMANCE CHECK

Introduction

A complete performance check of the Type R116 is provided in this section. This procedure, which checks the operation of the Type R116 without removing the dust covers or making any internal adjustments, may be used for incoming inspection or for calibration verification.

If the Type R116 fails to meet the specified performance requirements given in this procedure, the instrument will require internal checks and/or adjustments as given in the Calibration section of this manual.

EQUIPMENT REQUIRED

The following (or equivalent) equipment is required for a complete performance check of the Type R116. Equipment specifications given here are the minimum requirements for making the performance check. All test instruments are assumed to be calibrated and operating within their rated specifications. If substitute equipment is used, it must meet or exceed the specifications of the recommended equipment.

1. Test oscilloscope, Tektronix Type 547 with Type W Differential Comparator Plug-In Unit. Minimum alternate requirements: Bandwidth from dc to 15 MHz; sweep rates rom 10 ms/cm to 10 ns/cm; vertical input deflection factors from 10 mV/cm to 2 V/cm; voltage and timing accuracy of display within 3%; internal comparison voltage provided with accuracy of 0.5%; ac and dc vertical input coupling; internal and external triggering; amplitude calibrator output waveform available (approximately 1 kHz).

2. Sampling oscilloscope, Tektronix Type 661 with Type 5T3 Timing Unit, Type 4S3 vertical unit and two P6038 direct-sampling probes. Minimum alternate requirements: Risetime of 350 ps; equivalent sweep rates from 20 μs/cm to 2 ns/cm; vertical deflection factors from 20 mV/cm to 200 mV/cm; external triggering; time-positioning capability (time delay); voltage and timing accuracy within 3%.

3. Dual-Trace Amplifier Wideband Plug-In Unit, Tektronix Type 1A1 or 1A2, compatible with Type 547 Oscilloscope. Minimum alternate requirements (with oscilloscope): Bandwidth from dc to 50 MHz; vertical input deflection factors of 1 V/cm and 2 V/cm; voltage accuracy within 3%; alternate-trace switching.

4. Time-Mark Generator, Tektronix Type 184. Minimum alternate requirements: Time-mark outputs from 0.1 μs to 10 ms; accuracy within 0.5%.

5. Three 42-inch coaxial cables. Characteristic impedance approximately 50 Ω; BNC connectors. Tektronix Part Number 012-0057-00.

6. Voltage Pickoff, Tektronix VP-2. Permits direct-sampling probe to obtain signal from 50-Ω system. Tektronix Part Number 017-0077-00.

7. 50-Ω in-line termination with BNC connectors. Tektronix Part Number 011-0049-00.

8. 50-Ω end-line termination with GR connector. Tektronix Part Number 017-0081-00.

9. Two 50-Ω 10× T attenuators with GR connectors. Tektronix Part Number 017-0078-00.

10. BNC plug to GR connector adapter. Tektronix Part Number 017-0064-00.

11. BNC jack to GR connector adapter. Tektronix Part Number 017-0063-00.

12. Coaxial T connector with BNC connectors. Tektronix Part Number 103-0030-00.

13. Plastic screwdriver-type adjustment tool. Tektronix Part Number 003-0000-00.

14. Four shorting straps, approximately 8 inches long, constructed of insulated stranded copper wire and alligator clips for use with item 15.

15. Special remote program checker, constructed as indicated in Fig. 7-2 and Table 7-1 in the Calibration section of this manual. Provides access to REMOTE PROGRAM connector terminals and includes minimum, intermediate and maximum resistance values for remote program analog checks.

16. BNC jack to sampling probe tip adapter. Tektronix Part Number 013-0084-00.

PERFORMANCE CHECK PROCEDURE

The following procedure uses the equipment listed under Equipment Required. If substitute equipment is used, connections and control settings may need to be altered to correspond to the characteristics of the equipment used.

Preliminary Procedure

1. Set the 115V-230V selector switch on the rear panel of the Type R116 to correspond to the line voltage to be used.

2. Connect the Type R116 and the test instrument to a suitable power source.

3. Install the special remote program checker on the rear-panel REMOTE PROGRAM connector.

4. Turn on the instrument and allow at least 20 minutes warm up at 25°C, ±5°C (77°F, ±9°F) before making any performance checks.

5. Connect the Type R116 output pulse through a terminated 50-Ω coaxial cable to the channel A vertical input of the test oscilloscope, as shown in Fig. 6-1.

6. After the 20-minute warm-up period, check the dc balance of the test oscilloscope.

7. Set the instrument controls as follows:

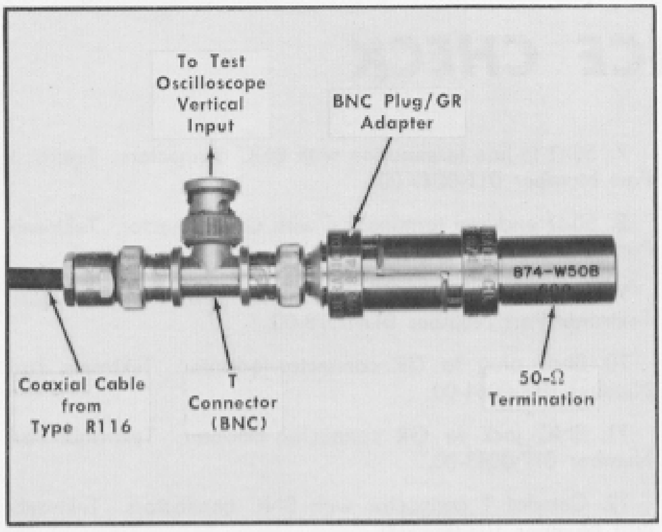


Fig. 6-1. Cable termination for connecting the Type R116 output pulse to the test oscilloscope vertical input.

Type R116

MODE	SINGLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	100 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	10
WIDTH RANGE	1 μS
MULTIPLIER	20
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	20 μs/cm
Triggering	+Internal, Normal
Vertical Display	A-Vc
Input Attenuation	100
Deflection Factor	20 mV/cm
Input Coupling	DC
Comparison Voltage	
Range	0
Multiplier	0.000
Amplitude Calibrator	Off

1. Check +Amplitude Accuracy

a. Requirement—Correct amplitude ±3% into a 50-Ω load over the range of the amplitude controls.

b. Set the AMPLITUDE RANGE, AMPLITUDE MULTIPLIER and test oscilloscope comparison voltage and deflection factor as given in Table 6-1.

c. For each check, position the pulse baseline to the horizontal centerline of the test oscilloscope crt screen (see Fig. 6-2A) with the Vc Range switch set to 0, then set the switch to +1.1.

d. Check for—Test oscilloscope display of the pulse tops with the flattest portion of the tops at the horizontal centerline (see Fig. 6-2B), with the Vc Range switch at +1.1.

2. Check —Amplitude Accuracy

a. Requirement—Correct amplitude ±3% into a 50-Ω load over the range of the amplitude controls.

b. Set the Type R116 POLARITY switch to —.

c. Set the AMPLITUDE RANGE, AMPLITUDE MULTIPLIER and test oscilloscope comparison voltage and deflection factor as given in Table 6-1.

d. For each check, position the pulse baseline to the horizontal centerline of the test oscilloscope screen with the Vc Range switch set to 0, then set the switch to —1.1.

e. Check for—Test oscilloscope display as indicated in the last column of Table 6-1.

Table 6-1
Amplitude Accuracy Check

AMPLITUDE RANGE	AMPLITUDE MULTIPLIER	Test Oscilloscope			Voltage	Maximum displacement from centerline
		Input Atten.	mV/cm	Comp. Voltage Mult.		
1 V	10	10	20	10.000	10 V, ±3%	±1.5 cm
.5 V	10	10	10	5.000	5 V, ±3%	±1.5 cm
.2 V	10	10	5	2.000	2 V, ±3%	±1.2 cm
.2 V	2	1	10	4.000	400 mV, ±3%	±1.5 cm
.5 V	2	10	2	1.000	1 V, ±3%	±1.5 cm
1 V	2	10	5	2.000	2 V, ±3%	±1.2 cm

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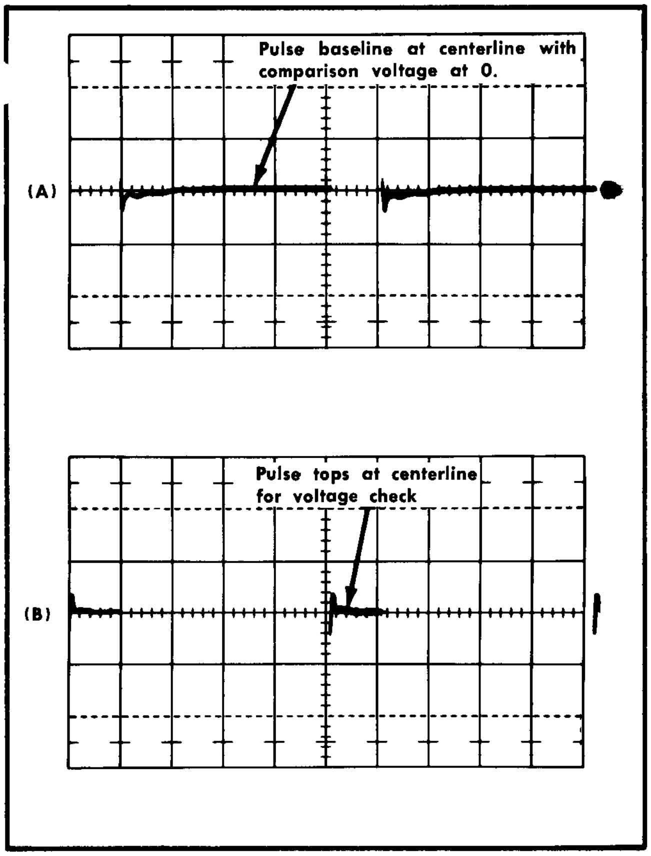

Fig. 6-2. Test oscilloscope displays for checking amplitude accuracy.

3. Check Remote Amplitude Ranges

a. Requirement—Correct remote operation of amplitude ranges, within 2% of front-panel operation.

b. Connect a shorting strap between terminal 1 of the REMOTE PROGRAM plug and the wire (not one of the program resistors) connected to terminal 27.

c. Reset the following Type R116 controls:

POLARITY	+
AMPLITUDE RANGE	REMOTE

d. Reset the test oscilloscope controls as follows:

Input Attenuation	10
Deflection Factor	10 mV/cm
Comparison Voltage Range	0

e. Position the base of the pulse display 1 cm above the bottom graticule line (see Fig. 6-3).

f. Check for—Test oscilloscope display of the pulse waveform with 4 cm of deflection, ±2 mm (400 mV, ±5%).

g. Connect a second shorting strap between terminal 36 and each of the terminals indicated in Table 6-2.

h. Check for—Test oscilloscope display as indicated in the last column of Table 6-2.

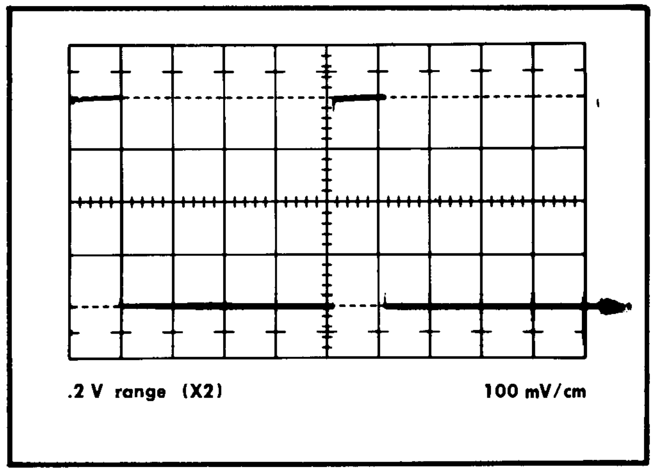

Fig. 6-3. Typical test oscilloscope display for checking remote amplitude range operation.

TABLE 6-2

Remote Amplitude Range Check

Short Between Terminals	Oscilloscope		Amplitude	
	Input Atten.	mV/cm	Voltage	Deflection
36 and 24	10	20	1 V, ±5%	5 cm, ±2.5 mm
36 and 25	10	50	2 V, ±5%	4 cm, ±2 mm

4. Check Remote Amplitude Analog

a. Requirement—Correct amplitude with program resistors, within 2% of front-panel operation (+1% remote program resistor tolerance).

b. Remove the shorting strap connected between terminals 36 and 25 of the REMOTE PROGRAM plug.

c. Reset the following test oscilloscope controls:

Input Attenuation	1
Deflection Factor	10 mV/cm
Comparison Voltage Multiplier	4.000

d. Position the pulse baseline to the horizontal centerline.

e. Set the test oscilloscope Vc Range switch to +1.1.

f. Check for—Test oscilloscope display of the pulse tops at the horizontal centerline, ±2 cm (400 mV, ±5%).

g. Reset the test oscilloscope controls as follows:

Input Attenuation	10
Deflection Factor	5 mV/cm
Comparison Voltage Range	0
Multiplier	1.200

h. Move the shorting strap from terminal 27 to the 4.42-kΩ resistor connected to the same terminal.

i. Position the pulse baseline to the horizontal centerline of the test oscilloscope.

j. Set the test oscilloscope Vc Range switch to +1.1.

k. Check for—Test oscilloscope display of the pulse tops at the horizontal centerline, ±1.4 cm (1.2 volts, ±6%).

l. Move the shorting strap from the 4.42-kΩ resistor to the 8.87-kΩ resistor connected to the same terminal (27).

m. Reset the following test oscilloscope controls:

Deflection Factor	10 mV/cm
Comparison Voltage	
Range	0
Multiplier	2.000

(The Input Attenuation switch should be at 10.)

n. Position the pulse baseline to the horizontal centerline of the test oscilloscope.

o. Set the test oscilloscope Vc Range switch to +1.1.

p. Check for—Test oscilloscope display with pulse tops at the horizontal centerline, ±1.2 cm (2 volts, ±6%).

q. Remove the shorting strap.

r. Set the test oscilloscope Vc Range switch to 0.

5. Check Remote Polarity Selection

a. Requirement—Correct remote operation of polarity selection.

b. Reset the following Type R116 controls:

AMPLITUDE RANGE	.2 V
POLARITY	REMOTE PROGRAM

c. Set the test oscilloscope Deflection Factor to 20 mV/cm. (The Input Attenuation switch should be at 10.)

d. Position the baseline of the pulse display to the horizontal centerline of the test oscilloscope crt screen.

e. Check for—Test oscilloscope display of the positive-going pulse.

f. Connect a shorting strap between terminals 36 and 18 of the REMOTE PROGRAM plug.

g. Check for—Test oscilloscope display of the negative-going pulse.

h. Remove the shorting strap.

6. Check External Triggering

a. Requirement—Correct external triggering of the output pulse, using a +2-volt to +20-volt input signal.

b. Connect a coaxial cable from the test oscilloscope calibrator output to the Type R116 +TRIGGER INPUT connector.

c. Set the following Type R116 controls:

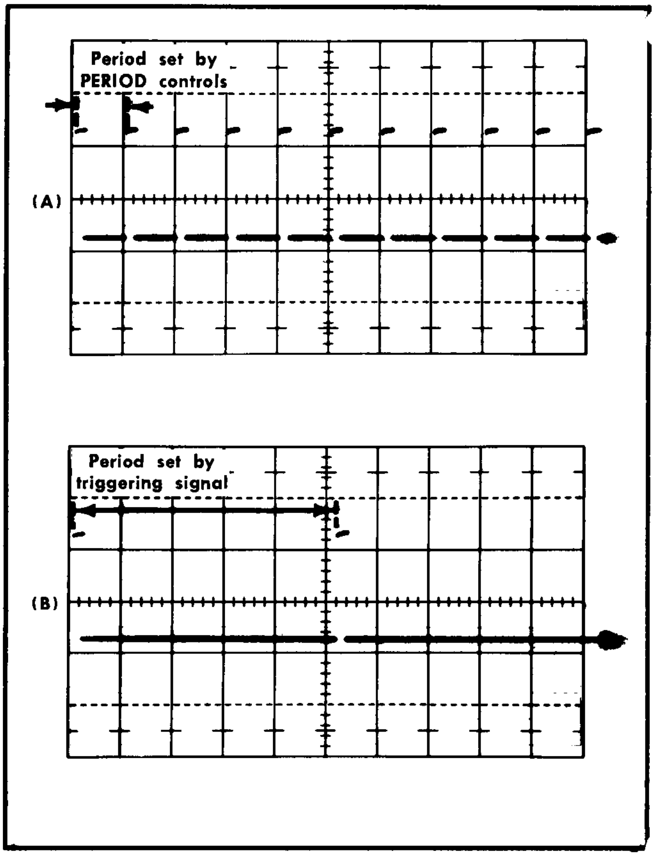

Fig. 6-4. Test oscilloscope displays for checking external triggering: (A) Normal Single mode waveform; (B) externally-triggered Single mode waveform.

POLARITY	+
PERIOD RANGE	100 μS
MULTIPLIER	2
WIDTH RANGE	1 μS
MULTIPLIER	40

d. Set the test oscilloscope sweep rate to 0.2 ms/cm.

e. Trigger the test oscilloscope sweep.

f. Observe the Single mode output pulse waveform, with the pulse period set by the PERIOD controls (see Fig. 6-4A).

g. Set the Type R116 TRIGGER SOURCE switch to EXTERNAL OR MANUAL.

h. Set the test oscilloscope calibrator output amplitude to 20 volts.

i. Check for—Test oscilloscope display of the externally-triggered Single mode waveform (see Fig. 6-4B), with a pulse period of approximately 1 ms set by the calibrator signal frequency.

j. Decrease the calibrator output amplitude to 2 volts.

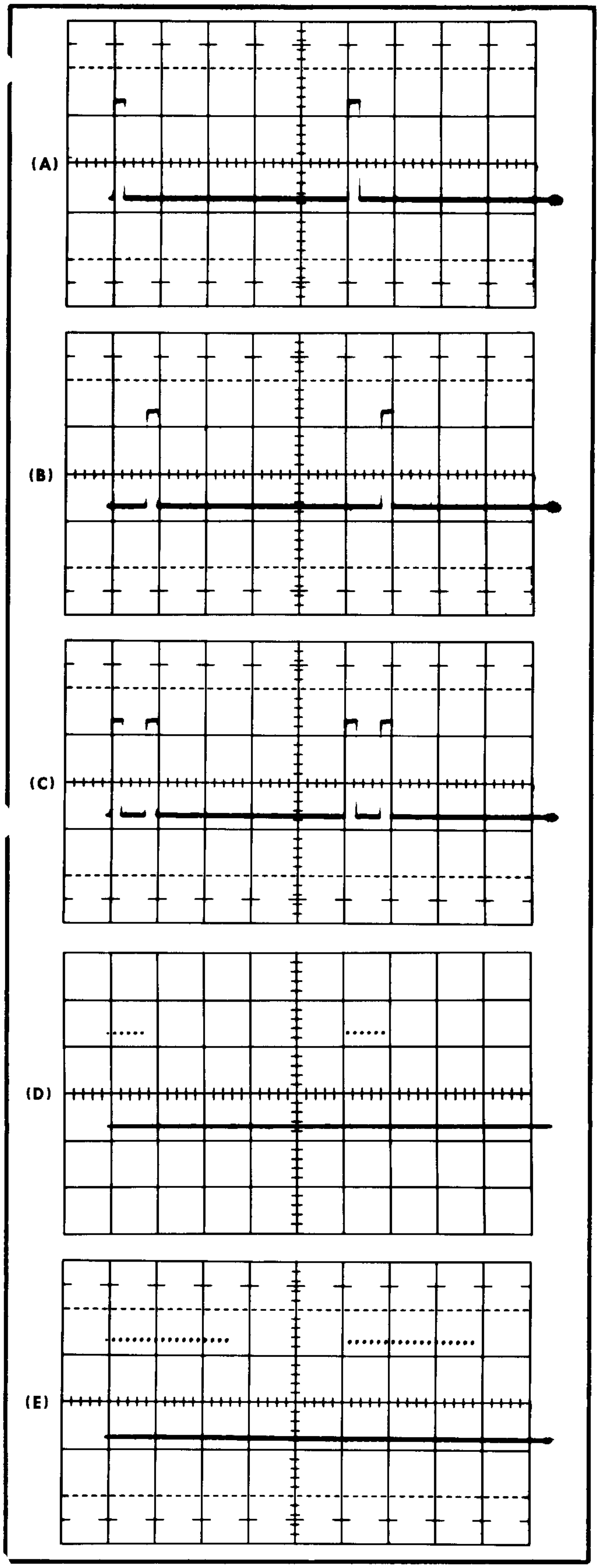

Fig. 6-5. Test oscilloscope displays for checking modes of operation: (A) Single; (B) Dly'd Single; (C) Double; (D) Burst; (E) Gated Output.

k. Check for—Test oscilloscope display of the externally-triggered waveform.

7. Check Remote Triggering Enable

a. Requirement—Correct remote operation of trigger signal selection.

b. Connect a shorting strap between terminals 36 and 19 of the REMOTE PROGRAM plug.

c. Set the TRIGGER SOURCE switch to REMOTE PROGRAM.

d. Check for—Test oscilloscope display of the externally-triggered Single mode waveform.

e. Remove the shorting strap.

f. Check for—Test oscilloscope display of the Single mode waveform with the pulse period set internally.

8. Check Mode Selection

a. Requirement—Correct output signal in each pulse mode, selected by front-panel MODE switch.

b. Connect a coaxial cable from the Type R116 +PRE-TRIGGER OUT connector to the test oscilloscope External Trigger Input.

c. Set the following Type R116 controls:

PERIOD RANGE	10 μS
MULTIPLIER	3
DELAY OR BURST TIME	
RANGE	100 nS
MULTIPLIER	15
WIDTH RANGE	100 nS
MULTIPLIER	5
TRIGGER SOURCE	INTERNAL

d. Reset the following test oscilloscope controls:

Sweep Rate	2 μs/cm
Triggering	+External, Normal

e. Check for—Test oscilloscope display of the non-delayed Single mode waveform.

f. Position the rise of the first displayed pulse to the 1-cm graticule line of the test oscilloscope screen (see Fig. 6-5A).

g. Set the Type R116 MODE switch to DLY'D SINGLE.

h. Check for—Test oscilloscope display of the delayed output pulse displaced by approximately the delay time (2 cm or 4 μs) from the 1-cm graticule line (see Fig. 6-5B).

i. Set the Type R116 MODE switch to DOUBLE.

j. Check for—Test oscilloscope display of the Double mode waveform with the first pulse at the 1-cm graticule line and the second pulse displaced by approximately the delay time from the first pulse (see Fig. 6-5C).

k. Temporarily disconnect the triggering cable from the test oscilloscope calibrator output, install a BNC T connector on the calibrator output, then connect the coaxial cable to one arm of the T.

l. Disconnect the trigger cable from the Type R116 +PRETRIGGER OUT connector and connect it to the second arm of the T.

m. Reset the following test oscilloscope controls:

Sweep Rate	0.2 ms/cm
Amplitude Calibrator	10 volts

n. Reset the following Type R116 controls:

MODE	BURST
DELAY OR BURST TIME	
RANGE	10 μS
WIDTH RANGE	1 μS

o. Trigger the test oscilloscope display.

p. Check for—Test oscilloscope display of the Burst mode waveform (see Fig. 6-5D) with the burst width set by the DELAY OR BURST TIME controls, the burst period set by the calibrator signal, and the pulse period and width set by the PERIOD and WIDTH controls.

q. Turn the DELAY OR BURST TIME MULTIPLIER control to the 5 position while observing the change in burst time.

r. Move the triggering signal cable from the +TRIGGER IN connector to the +GATE IN connector.

s. Set the Type R116 MODE switch to GATED OUTPUT.

t. Check for—Test oscilloscope display of the Gated Output mode waveform with the duration of the burst set by the calibrator square-wave signal (see Fig. 6-5E).

u. Set the test oscilloscope calibrator output amplitude to 2 volts.

v. Check for—Test oscilloscope display of the Gated Output waveform.

9. Check Remote Mode Selection

a. Requirement—Correct remote selection of pulse modes.

b. Disconnect the coaxial cable from the calibrator output (connected to the test oscilloscope External Trigger Input) and connect it to the Type R116 +PRETRIGGER OUT.

c. Reset the following Type R116 controls:

MODE	REMOTE PROGRAM
DELAY OR BURST TIME	
RANGE	100 nS
MULTIPLIER	40
WIDTH RANGE	100 nS

d. Set the test oscilloscope sweep rate to 2 μs/cm.

e. Check for—Test oscilloscope display of the Single mode waveform (see Fig. 6-5A).

f. Connect a shorting strap between terminals 36 and 20 of the REMOTE PROGRAM plug. (During the following checks, leave one end of the strap connected to terminal 36 and move only the other end of the strap.)

g. Check for—Test oscilloscope display of the Dly'd Single mode waveform (see Fig. 6-5B).

h. Move the end of the shorting strap from terminal 20 to terminal 21.

i. Check for—Test oscilloscope display of the Double mode waveform (see Fig. 6-5C).

j. Move the shorting strap from terminal 21 to terminal 23.

k. Set the test oscilloscope sweep rate to 0.2 ms/cm.

l. Reset the following Type R116 controls:

DELAY OR BURST TIME	
RANGE	10 μS
WIDTH RANGE	1 μS

m. Disconnect the signal cable from the +PRETRIGGER OUT (connected to the test oscilloscope External Trigger Input) and connect it to the T connector on the calibrator output.

n. Check for—Test oscilloscope display of the Gated Output waveform (see Fig. 6-5E).

o. Move the calibrator signal cable from the +GATE IN connector to the +TRIGGER IN connector.

p. Move the shorting strap from terminal 23 to terminal 22 of the REMOTE PROGRAM plug.

q. Check for—Test oscilloscope display of the Burst mode waveform (see Fig. 6-5D).

r. Remove the shorting strap.

s. Disconnect the triggering cables and remove the T connector from the calibrator output.

10. Check Manual Trigger

a. Requirement—Single pulse output with the manual TRIG button.

b. Reset the following Type R116 controls:

MODE	SINGLE
PERIOD RANGE	1 mS
MULTIPLIER	3
WIDTH RANGE	10 μS
MULTIPLIER	50

c. Reset the following test oscilloscope controls:

Sweep Rate	1 ms/cm
Triggering	+Internal (not Auto)

d. Trigger the test oscilloscope display and observe the repetitive waveform (see Fig. 6-6A).

e. Set the Type R116 TRIGGER SOURCE switch to EXTERNAL OR MANUAL.

f. Press the front-panel manual TRIG button while observing the test oscilloscope screen.

g. Check for—Test oscilloscope display of the single output pulse each time the TRIG button is pressed (see Fig. 6-6B). Readjust the test oscilloscope intensity if necessary.

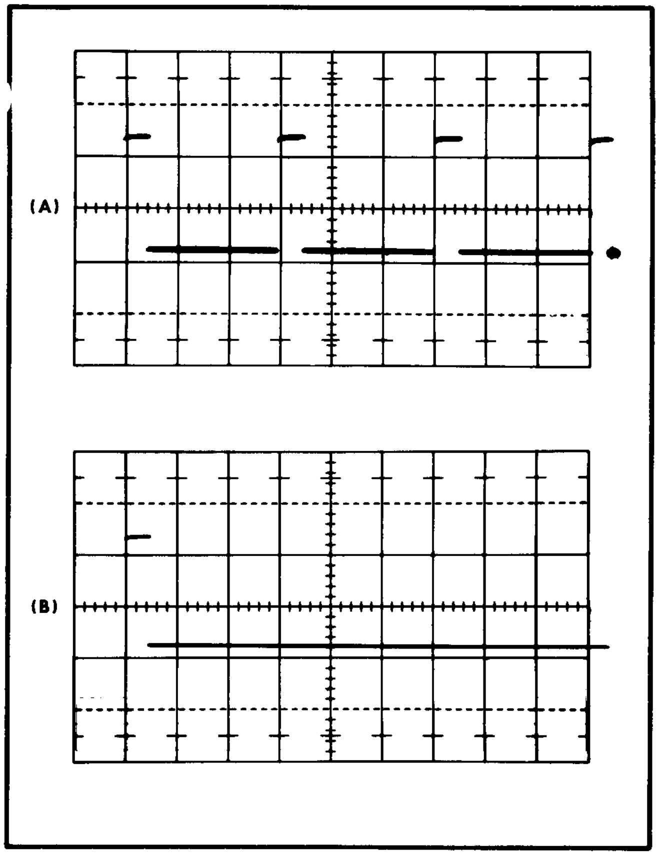

Fig. 6-6. Typical test oscilloscope displays for checking the manual trigger: (A) TRIGGER SOURCE switch at INTERNAL; (B) single pulse when TRIG button is pressed with TRIGGER SOURCE switch at EXTERNAL OR MANUAL.

11. Check Offset Accuracy

a. Requirement—Correct dc offset into a 50-Ω load, over the range of the DC OFFSET control, ±50 mV at 0 offset and ±150 mV at maximum offset (in + and — polarity).

b. Reset the following Type R116 controls:

TRIGGER SOURCE	INTERNAL
AMPLITUDE RANGE	1 V

c. Reset the following test oscilloscope controls:

Input Attenuation	1
Deflection Factor	50 mV/cm
Comparison Voltage	
Range	0
Multiplier	5.000
Input Coupling	Gnd

d. Set the Type R116 DC OFFSET control exactly to the 0 position.

e. Free run the test oscilloscope trace and position it to the horizontal centerline.

f. Set the test oscilloscope Input Coupling switch to DC.

g. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1 cm (50 mV).

h. Set the POLARITY switch to —.

i. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1 cm (50 mV).

j. Reset the following test oscilloscope controls:

Input Attenuation	10
Deflection Factor	10 mV/cm

k. Set the DC OFFSET control, the POLARITY switch and the test oscilloscope comparison voltage multiplier as given in Table 6-3.

l. For each check, position the trace to the horizontal centerline with the test oscilloscope Vc Range switch set to 0 and the Input Coupling switch to Gnd, then set the Input Coupling switch to DC and Vc Range switch as indicated in the table.

m. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1.5 cm (150 mV), as indicated in the Offset (Internal) column of Table 6-3. The checks on the 1 V amplitude range cover the .5 V and .2 V ranges as well, since the attenuator was checked previously.

TABLE 6-3

Offset Accuracy Check

DC OFFSET	POLARITY	Oscilloscope Comp. Voltage Mult.	Oscilloscope Vc Range	Offset Voltage	Baseline Displacement from Centerline Internal	Baseline Displacement from Centerline Remote
—5	+	5.000	—1.1	—5 V	±1.5 cm (150 mV)	±2.5 cm (250 mV)
—5	—	5.000	—1.1	—5 V	±1.5 cm	±2.5 cm
+5	—	5.000	+1.1	+5 V	±1.5 cm	±2.5 cm
+5	+	5.000	+1.1	+5 V	±1.5 cm	±2.5 cm

12. Check Remote Offset

a. Requirement—Correct dc offset using program resistors, within 100 mV of front-panel operation (+1% program resistor tolerance).

b. Connect shorting straps between the following terminals of the REMOTE PROGRAM plug: 2 and 31; 3 and 32; 36 and 28.

c. Connect a shorting strap from terminal 1 to the 4.42-kΩ resistor connected to terminal 33.

d. Reset the following test oscilloscope controls:

Vc Range	0
Comparison Voltage	
Multiplier	2.000
Input Coupling	Gnd

e. Free run the test oscilloscope trace and position it to the horizontal centerline.

f. Reset the following Type R116 controls:

PROGRAM	REMOTE
POLARITY	+

g. Set the test oscilloscope Input Coupling switch to DC.

h. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1.5 cm (150 mV).

i. Set the POLARITY switch to —.

j. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1.5 cm (150 mV).

k. Move the shorting strap from the 4.42-kΩ resistor connected to terminal 33 to the 8.87-kΩ resistor on the same terminal.

l. Set the POLARITY switch and the test oscilloscope comparison voltage multiplier as given for the —5 settings of the DC OFFSET control in Table 6-3.

m. For each check, position the trace to the horizontal centerline (with the test oscilloscope Vc Range switch set to 0 and the Input Coupling switch at Gnd), then set the Input Coupling switch to DC and the Vc Range switch as indicated in the table.

n. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline, ±2.5 cm (250 mV), as given in the Offset (Remote) column of Table 6-3.

o. Move the shorting strap from the 8.87-kΩ resistor to the wire connected to terminal 33.

p. Repeat steps l through n for the +5 settings of the DC OFFSET control given in Table 6-3.

13. Check Program Clamp

a. Requirement—No greater than 1 volt offset in remote program with open offset program line.

b. Reset the following test oscilloscope controls.

Vc Range	0
Input Attenuation	100
Input Coupling	Gnd

c. Remove the shorting strap connected between terminal 1 and terminal 33.

d. Free run the trace and position it to the horizontal centerline.

e. Set the test oscilloscope Input Coupling switch to DC.

f. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1 cm (±1 volt offset).

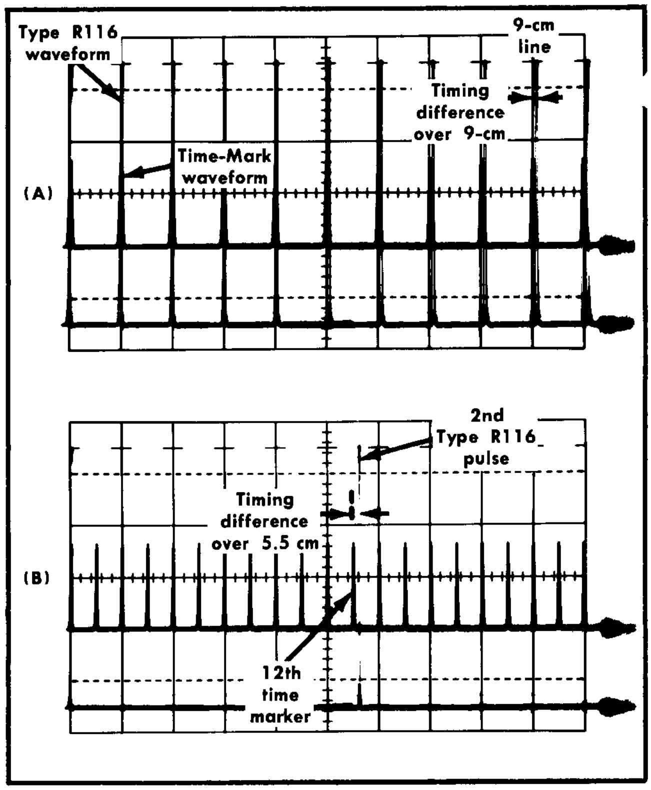

Fig. 6-7. Typical test oscilloscope displays for checking period timing accuracy: (A) At 1 position of PERIOD MULTIPLIER control; (B) at 11 position of control.

g. Set the Type R116 POLARITY switch to —.

h. Repeat step f for the negative-going pulse.

i. Set the PROGRAM switch to INT.

j. Remove the shorting straps.

14. Check Period Timing

a. Requirement—Correct timing ±3% over the range of the period controls, except ±5% on the 100 nS period range.

TABLE 6-4

Period Accuracy Check

PERIOD RANGE	PERIOD MULTIPLIER	WIDTH RANGE	Time Markers	Oscilloscope Sweep Rate	Period	
					Time	Difference from Reference Waveform
100 nS	1	10 nS	0.1 μs	0.1 μs/cm	100 ns, ±5%	±4.5 mm over 9 cm
1 μS	1	10 nS	1 μs	1 μs/cm	1 μs, ±3%	±2.7 mm over 9 cm
10 μS	1	10 nS	10 μs	10 μs/cm	10 μs, ±3%	±2.7 mm over 9 cm
100 μS	1	100 nS	0.1 ms	0.1 ms/cm	100 μs, ±3%	±2.7 mm over 9 cm
1 mS	1	1 μS	1 ms	1 ms/cm	1 ms, ±3%	±2.7 mm over 9 cm
100 nS	11	10 nS	0.1 μs	0.2 μs/cm	1.1 μs, ±5%	±2.75 mm over 5.5 cm
1 μS	11	10 nS	1 μs	2 μs/cm	11 μs, ±3%	±1.65 mm over 5.5 cm
10 μS	11	100 nS	10 μs	20 μs/cm	110 μs, ±3%	±1.65 mm over 5.5 cm
100 μS	11	1 μS	0.1 ms	0.2 ms/cm	1.1 ms, ±3%	±1.65 mm over 5.5 cm
1 mS	11	10 μS	1 ms	2 ms/cm	11 ms, ±3%	±1.65 mm over 5.5 cm

b. Disconnect the Type R116 output pulse signal from the test oscilloscope input.

c. Remove the Type W Plug-In Unit from the test oscilloscope and insert the Type 1A1 or Type 1A2 Plug-In Unit.

d. Allow the plug-in unit to warm up for a few minutes.

e. Set the plug-in unit controls as follows:

Vertical Mode	Alternate
Deflection Factor	
Channel 1	2 V/cm
Channel 2	2 V/cm
Input Coupling	DC

f. Reset the following Type R116 controls:

WIDTH MULTIPLIER	5
AMPLITUDE MULTIPLIER	10
POLARITY	+
DC OFFSET	0

g. Connect the terminated pulse output from the Type R116 to the Channel 1 vertical input of the test oscilloscope.

h. Connect the marker output from the time-mark generator through a 50-Ω in-line termination (BNC connectors) to the Channel 2 vertical input of the test oscilloscope.

i. Set the Type R116 controls, time-mark generator marker output and the test oscilloscope sweep rate as given in Table 6-4.

j. Trigger the test oscilloscope display and position both waveforms near the center of the crt screen.

k. Check for—Test oscilloscope displays: At the 1 position of the PERIOD MULTIPLIER, equal time-spacing of Type R116 pulses and time markers over the first 9 cm (Fig. 6-7A); at the 11 position of the PERIOD MULTIPLIER, second Type R116 pulse at 12th time marker (Fig. 6-7B).

15. Check Remote Period Ranges

a. Requirement—Correct remote operation of period ranges, within 2% of front-panel operation.

b. Connect a shorting strap between terminal 34 of the REMOTE PROGRAM plug and the wire (not one of the program resistors) connected to terminal 9 of the plug.

c. Set the test oscilloscope sweep rate to 0.1 μs/cm.

d. Set the time-mark generator for a 0.1-μs output.

e. Set the Type R116 PERIOD RANGE switch to REMOTE. (The WIDTH RANGE switch should be at 10 nS).

f. Check for—Test oscilloscope display with equal time intervals (±7%) between pulses in the Type R116 waveform and the time-mark waveform over the first 9 cm, ±6.3 mm.

g. Connect a second shorting strap between terminal 36 (chassis ground) and each of the terminals indicated in Table 6-5.

h. Check for—Test oscilloscope display as indicated in the last column of Table 6-5.

16. Check Remote Period Analog

a. Requirement—Correct period timing using program resistors within 2% of front-panel operation (+1% program resistor tolerance).

b. Set the WIDTH RANGE switch to 10 nS.

c. Remove both shorting straps, then reconnect them as follows: One between terminals 36 and 5; one between terminal 34 and 8.45-kΩ resistor connected to terminal 9.

d. Set the test oscilloscope sweep rate to 1 μs/cm.

e. Set the time-mark signal to 1 μs.

f. Check for—Test oscilloscope display with the second Type R116 pulse at the 7th time marker ±3.6 mm (6 μs ±6%).

g. Move the shorting strap from the 8.45-kΩ resistor to the 16.9-kΩ resistor on the same terminal. Leave the other end of the strap connected to terminal 34.

h. Set the test oscilloscope sweep rate to 2 μs/cm.

i. Check for—Test oscilloscope display with the second Type R116 pulse at the 12th time marker ±6.6 mm (11 μs ±6%).

j. Remove the shorting straps.

17. Check Delay and Width Trigger Sensitivity

a. Requirement—Stable Dly'd Single mode signal through range of DELAY OR BURST TIME MULTIPLIER and WIDTH MULTIPLIER controls.

b. Reset the following Type R116 controls:

MODE	DLY'D SINGLE
PERIOD RANGE	10 μS
MULTIPLIER	1

TABLE 6-5

Remote Period Range Check

Short Between Terminals	Oscilloscope Sweep Rate	WIDTH RANGE	Time Markers	Period: Time	Period: Difference from Reference Waveform
36 and 5	1 μs/cm	10 nS	1 μs	1 μs, ±5%	±4.5 mm over 9 cm
36 and 6	10 μs/cm	10 nS	10 μs	10 μs, ±5%	±4.5 mm over 9 cm
36 and 7	0.1 ms/cm	100 nS	0.1 ms	100 μs, ±5%	±4.5 mm over 9 cm
36 and 8	1 ms/cm	1 μS	1 ms	1 ms, ±5%	±4.5 mm over 9 cm

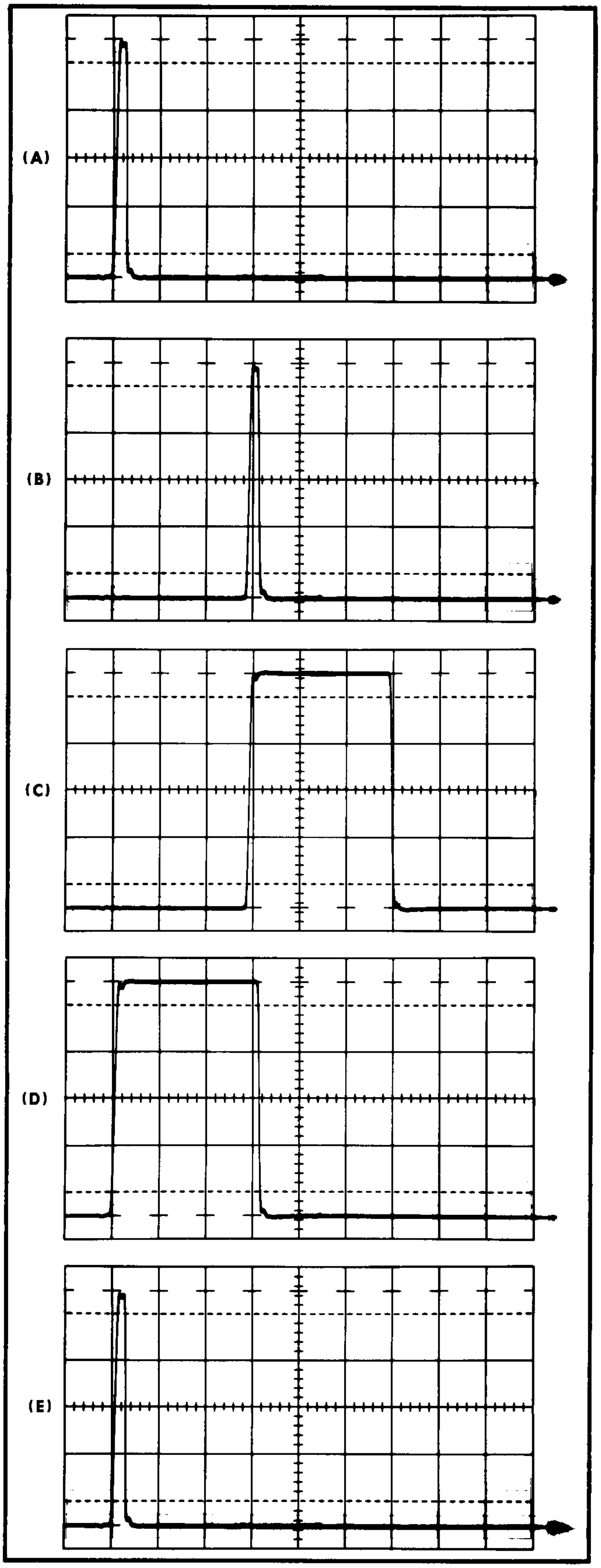

Fig. 6-8. Test oscilloscope displays for checking delay and width trigger sensitivity adjustments.

DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	5
WIDTH RANGE	10 nS
MULTIPLIER	5

c. Reset the following test oscilloscope controls:

Sweep Rate	0.2 μs/cm
Vertical Mode	Channel 1
Triggering	+External

d. Connect the Type R116 +Pretrigger Out signal to the test oscilloscope External Trigger Input.

e. Trigger the test oscilloscope.

f. Observe the test oscilloscope displays (see Fig. 6-8) while performing the following four operations:

1. Turn the DELAY OR BURST TIME MULTIPLIER control slowly clockwise to the fully clockwise position.

2. Turn the WIDTH MULTIPLIER control slowly clockwise to the fully clockwise position.

3. Turn the DELAY OR BURST TIME MULTIPLIER control slowly counterclockwise back to the 5 position.

4. Turn the WIDTH MULTIPLIER control slowly counterclockwise back to the 5 position.

g. Check for—Stable test oscilloscope display of the Type R116 delayed output pulse throughout the preceding checks.

h. Reset the following Type R116 controls:

PERIOD RANGE	1 mS
MULTIPLIER	Fully clockwise
DELAY OR BURST TIME	
RANGE	10 μS
WIDTH RANGE	10 μS

i. Set the test oscilloscope sweep rate to 0.2 ms/cm.

j. Repeat steps f and g.

18. Check Delay Timing

a. Requirement—Correct timing $\pm 3\%$ (+10 ns) over the range of the delay controls on the 100 nS, 1 μS and 10 μS ranges. (The 10 nS range is checked in step 24.)

b. Reset the following test oscilloscope controls:

Vertical Mode	Alternate
Triggering	+Internal

c. Reset the following Type R116 controls:

MODE	DOUBLE
PERIOD MULTIPLIER	10
WIDTH MULTIPLIER	5

d. Set the DELAY OR BURST TIME controls, the WIDTH RANGE, the PERIOD RANGE, the time-mark generator marker output and the test oscilloscope sweep rate as given in Table 6-6.

e. Check for—Test oscilloscope displays with a delay period between corresponding points on the two pulses (see Fig. 6-9), as indicated in the last column of Table 6-6.

TABLE 6-6

Delay or Burst Time Accuracy Check

PERIOD RANGE	DELAY OR BURST TIME RANGE	DELAY OR BURST TIME MULTIPLIER	WIDTH RANGE	Time Markers	Oscilloscope Sweep Rate	Delay Interval	
						Time	Difference from Reference Waveform
100 μS	10 μS	5	1 μS	5 μs	10 μs/cm	50 μs, ±3% (+10 ns)	±1.51 mm over 5 cm
10 μS	1 μS	5	100 nS	0.5 μs	1 μs/cm	5 μs, ±3% (+10 ns)	±1.6 mm over 5 cm
1 μS	100 nS	5	10 nS	50 ns	0.1 μs/cm	500 ns, ±3% (+10 ns)	±2.5 mm over 5 cm
10 μS	100 nS	55	100 nS	0.5 μs	1 μs/cm	5.5 μs, ±3% (+10 ns)	±1.75 mm over 5.5 cm
100 μS	1 μS	55	1 μS	5 μs	10 μs/cm	55 μs, ±3% (+10 ns)	±1.66 mm over 5.5 cm
1 mS	10 μS	55	10 μS	50 μs	0.1 ms/cm	550 μs, ±3% (+10 ns)	±1.65 mm over 5.5 cm

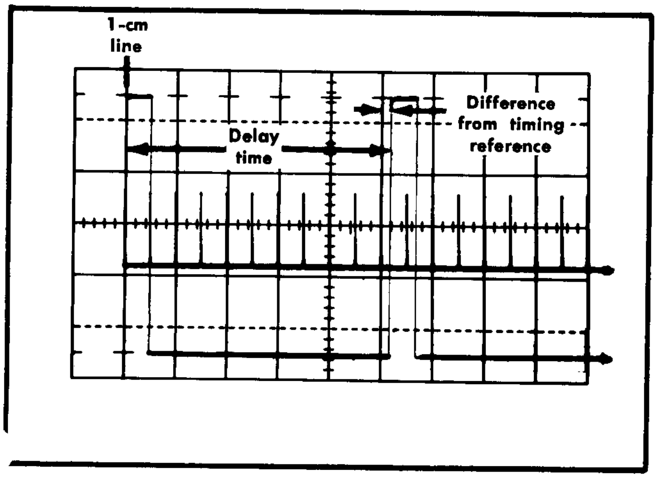

Fig. 6-9. Typical test oscilloscope display for checking delay timing accuracy.

19. Check Remote Delay Ranges

a. Requirement—Correct remote operation of delay ranges within 2% of front-panel operation.

b. Connect a shorting strap between terminals 3 and 13 of the REMOTE PROGRAM plug.

c. Set the test oscilloscope sweep rate to 10 ns/cm (0.1 μs/cm, magnified ×10).

d. Set the time-mark generator for a 10-ns output.

e. Reset the following Type R116 controls:

MODE	SINGLE
PERIOD RANGE	10 μS
MULTIPLIER	1
WIDTH RANGE	10 nS
MULTIPLIER	5
DELAY OR BURST TIME RANGE	REMOTE

f. Check the display timing for 1 cycle/cm of the timing signal and adjust the variable sweep rate control if necessary.

g. Set the test oscilloscope Trigger Source switch to External.

h. Position the rise of the displayed pulse at the 1-cm graticule line.

i. Set the MODE switch to DLY'D SINGLE.

j. Check for—Test oscilloscope display of the delayed pulse with the pulse rise at the 6-cm graticule line ±1.25 cm, indicating a delay interval of 50 ns ±5% (+10 ns).

k. Set the MODE switch to DOUBLE.

l. Set the test oscilloscope Trigger Source switch to Internal.

m. Connect a second shorting strap between terminal 36 and each of the terminals indicated in Table 6-7.

n. Check for—Test oscilloscope displays as indicated in the last column of Table 6-7.

20. Check Remote Delay Analog

a. Requirement—Correct delay timing with program resistors, within 2% of front-panel operation (+1% program resistor tolerance).

TABLE 6-7

Remote Delay or Burst Time Range Check

Short Between Terminals	PERIOD RANGE	WIDTH RANGE	Time Markers	Oscilloscope Sweep Rate	Delay Interval	
					Time	Difference from Reference
36 and 10	10 μS	10 nS	50 ns	0.1 μs/cm	500 ns, ±5% (+10 ns)	±3.5 mm over 5 cm
36 and 11	100 μS	100 nS	0.5 μs	1 μs/cm	5 μs, ±5% (+10 ns)	±2.6 mm over 5 cm
36 and 12	1 mS	1 μS	5 μs	10 μs/cm	50 μs, ±5% (+10 ns)	±2.5 mm over 5 cm

TABLE 6-8

Width Timing Accuracy Check

PERIOD RANGE	WIDTH RANGE	WIDTH MULTIPLIER	Time Markers	Oscilloscope Sweep Rate	Pulse Width	
					Time	Difference from Reference
1 mS	10 μS	5	5 μs	10 μs/cm	50 μs, ±3%	±1.5 mm over 5 cm
100 μS	1 μS	5	0.5 μs	1 μs/cm	5 μs, ±3%	±1.5 mm over 5 cm
10 μS	100 nS	5	50 μs	0.1 μs/cm	500 ns, ±3%	±1.5 mm over 5 cm
100 μS	100 nS	55	0.5 μs	1 μs/cm	5.5 μs, ±3%	±1.5 mm over 5 cm
1 mS	1 μS	55	5 μs	10 μs/cm	55 μs, ±3%	±1.5 mm over 5 cm
1 mS	10 μS	55	50 ms	0.1 ms/cm	55 μs, ±3%	±1.5 mm over 5 cm

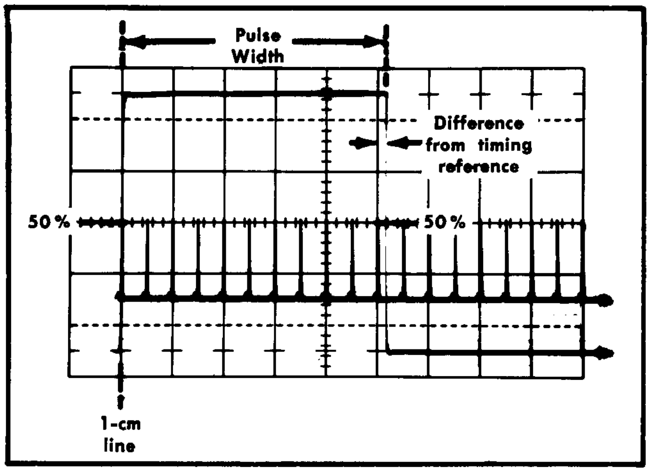

Fig. 6-10. Typical test oscilloscope display for checking pulse width.

b. Remove the shorting straps and connect them between the following points: Terminals 36 and 10; terminal 3 and the 4.42-kΩ resistor connected to terminal 13.

c. Reset the following Type R116 controls:

PERIOD RANGE	100 μS
WIDTH RANGE	10 nS

d. Set the test oscilloscope sweep rate to 0.5 μs/cm.

e. Set the time-mark generator for a 0.5-μs output.

f. Check for—Test oscilloscope display of the double pulse waveform with a delay interval within 3.6 mm of the reference waveform over 6 cm (3 μs, ±6% +10 ns).

g. Move the shorting strap from the 4.42-kΩ resistor to the 8.87-kΩ resistor on the same terminal (13).

h. Set the test oscilloscope sweep rate to 1 μs/cm.

i. Check for—Test oscilloscope display of the double pulse with a delay interval within 3.3 mm of the reference waveform over 5.5 cm (5.5 μs, ±6% +10 ns).

j. Remove the shorting straps.

k. Disconnect the trigger cable from the Type R116 +PRETRIGGER OUT connector and the test oscilloscope External Trigger Input.

21. Check Width Timing

a. Requirement—Correct timing ±3% over the range of the width controls on the 100 μS, 1 μS and 10 μS ranges, using minimum risetime and falltime and 10-volt output amplitude. (The 10 nS range is checked in step 25.)

b. Set the MODE switch to SINGLE.

c. Set the PERIOD RANGE, the WIDTH RANGE, the WIDTH MULTIPLIER, the time-mark generator output and the test oscilloscope sweep rate as given in Table 6-8.

d. Check for—Test oscilloscope display of the pulse width as indicated in the table, as measured at the 50% amplitude level. (See Fig. 6-10).

22. Check Remote Width Ranges

a. Requirement—Correct remote operation of width ranges, within 2% of front-panel operation.

b. Connect a shorting strap between terminal 3 of the REMOTE PROGRAM plug and the wire (not one of the program resistors) connected to terminal 17.

c. Reset the following test oscilloscope controls:

Sweep Rate	0.1 μs/cm
Magnifier	×10

d. Set the time-mark generator for a 10-ns sine-wave output.

e. Reset the following Type R116 controls:

PERIOD RANGE	1 μS
WIDTH RANGE	REMOTE

f. Center the sine-wave display and the Type R116 pulse on the crt screen. Increase the marker amplitude and readjust the triggering if necessary (see Fig. 6-11).

g. Check for—Test oscilloscope display with a pulse width of 50 ns, ±7% (within 3.5 mm of the reference signal over 5 cm).

h. Set the test oscilloscope Magnifier to Off.

i. Connect a second shorting strap between terminal 36 and each of the terminals indicated in Table 6-9.

j. Check for—Test oscilloscope displays as indicated in the last column of Table 6-9.

23. Check Remote Width Analog

a. Requirement—Correct width timing with program resistors, within 2% of front-panel operation (+1% program resistor tolerance).

b. Remove the shorting straps and connect them betweer the following points: Terminals 36 and 14; terminal 3 and the 4.42-kΩ resistor connected to terminal 17.

TABLE 6-9
Remote Width Range Check

Short Between Terminals	PERIOD RANGE	Time Markers	Oscilloscope Sweep Rate	Pulse Width	
				Time	Difference from Reference
36 and 14	10 μS	50 ns	0.1 μs/cm	500 ns, ±5%	±2.5 mm over 5 cm
36 and 15	100 μS	0.5 μs	1 μs/cm	5 μs, ±5%	±2.5 mm over 5 cm
36 and 16	1 mS	5 μs	10 μs/cm	50 μs, ±5%	±2.5 mm over 5 cm

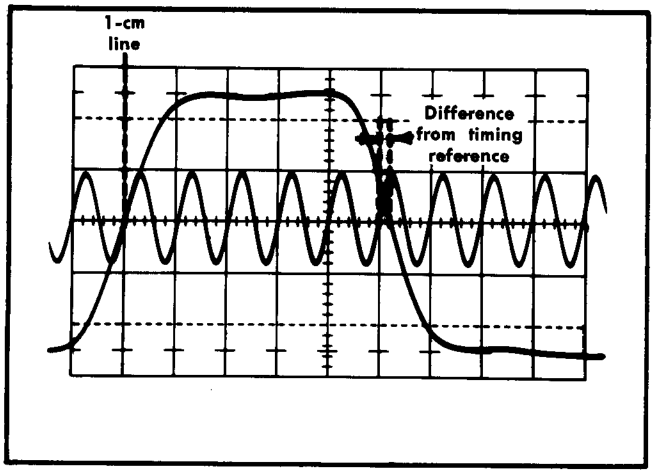

Fig. 6-11. Typical test oscilloscope display for checking remote width.

c. Set the test oscilloscope sweep rate to 0.5 μs/cm.

d. Set the time-mark generator for a 0.5 μs output.

e. Set the PERIOD RANGE switch to 100 μS.

f. Check for—Test oscilloscope display of a 3-μs pulse width, ±6% (within 3.6 mm of the reference over 6 cm).

g. Move the shorting strap from the 4.42-kΩ resistor to the 8.87-kΩ resistor on the same terminal (17).

h. Set the test oscilloscope sweep rate to 1 μs/cm.

i. Check for—Test oscilloscope display of a 5.5-μs pulse width, ±6% (within 3.3 mm of the reference over 5.5 cm).

j. Remove the shorting straps.

24. Check 10 nS Delay and Width Ranges

a. Requirement—Correct width timing ±5% and correct

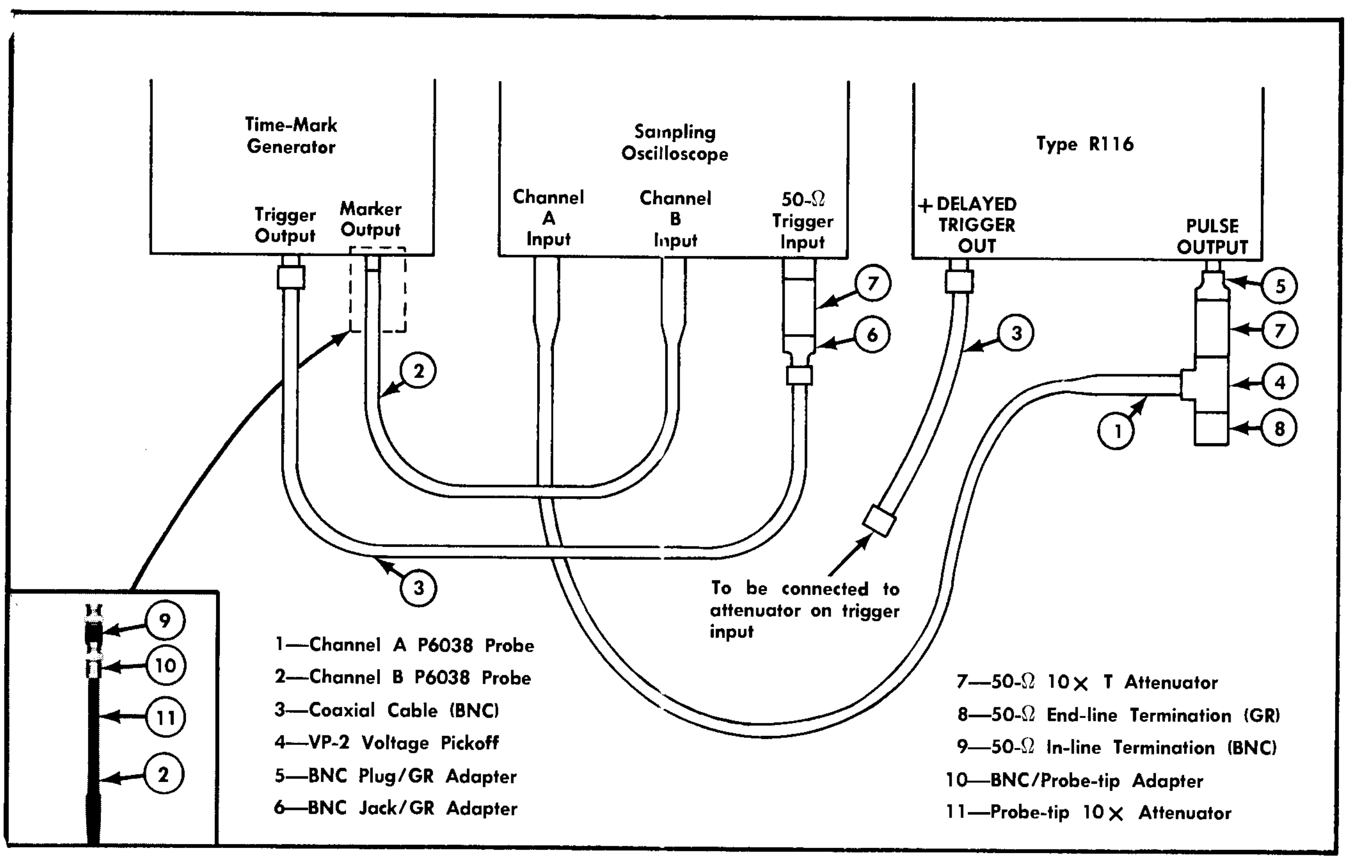

Fig. 6-12. Suggested connections for observing the time-mark signal and the Type R116 output pulse with the sampling oscilloscope.

delay timing ±5% (+10 ns) on the 10 nS range, using minimum risetime and falltime and 10-volt amplitude.

b. Disconnect the coaxial cable and termination from the Type R116 PULSE OUTPUT connector and test oscilloscope input.

c. Connect the Type R116 output pulse to the sampling oscilloscope Channel A vertical input as shown in Fig. 6-12.

d. Disconnect the coaxial cable and termination from the time-mark output and the test oscilloscope input.

e. Connect the marker output from the time-mark generator to the sampling oscilloscope Channel B vertical input as shown in Fig. 6-12.

f. Connect the trigger output from the time-mark generator to the sampling oscilloscope External Trigger Input as shown in Fig. 6-12.

g. Reset the following Type R116 controls:

MODE	DOUBLE
PERIOD RANGE	10 μS
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	55
WIDTH RANGE	10 nS
MULTIPLIER	5

h. Set the sampling oscilloscope controls as follows:

Horizontal Display	×1
Amplitude Calibrator	Off
Equivalent Sweep Rate	0.1 μs/cm, magnified from 0.2 μs/cm
Triggering	+External, 1 MΩ AC
Sample Density	50/cm
Sweep Mode	Normal
Vert. Deflection Factor	200 mV/cm
Vertical Mode	B Only
Smoothing (both channels)	Counterclockwise
Noise-Risetime	Low Noise
Display	Normal

i. Set the time-mark generator for a 0.1-μs marker output and a 1-μs trigger output.

j. Trigger the sampling oscilloscope and adjust the Channel B Smoothing control for unity gain (see the Type 4S3 Instruction Manual).

k. If the timing of the sampling oscilloscope does not provide 1 cycle/cm, adjust the variable sweep rate control to provide proper timing (see Fig. 6-13A).

l. Remove the time-mark trigger signal from the 10× attenuator on the sampling oscilloscope External Trigger Input and connect a coaxial cable from the Type R116 +DELAYED TRIGGER OUT connector to the 10× attenuator.

m. Set the sampling oscilloscope vertical Mode switch to A Only.

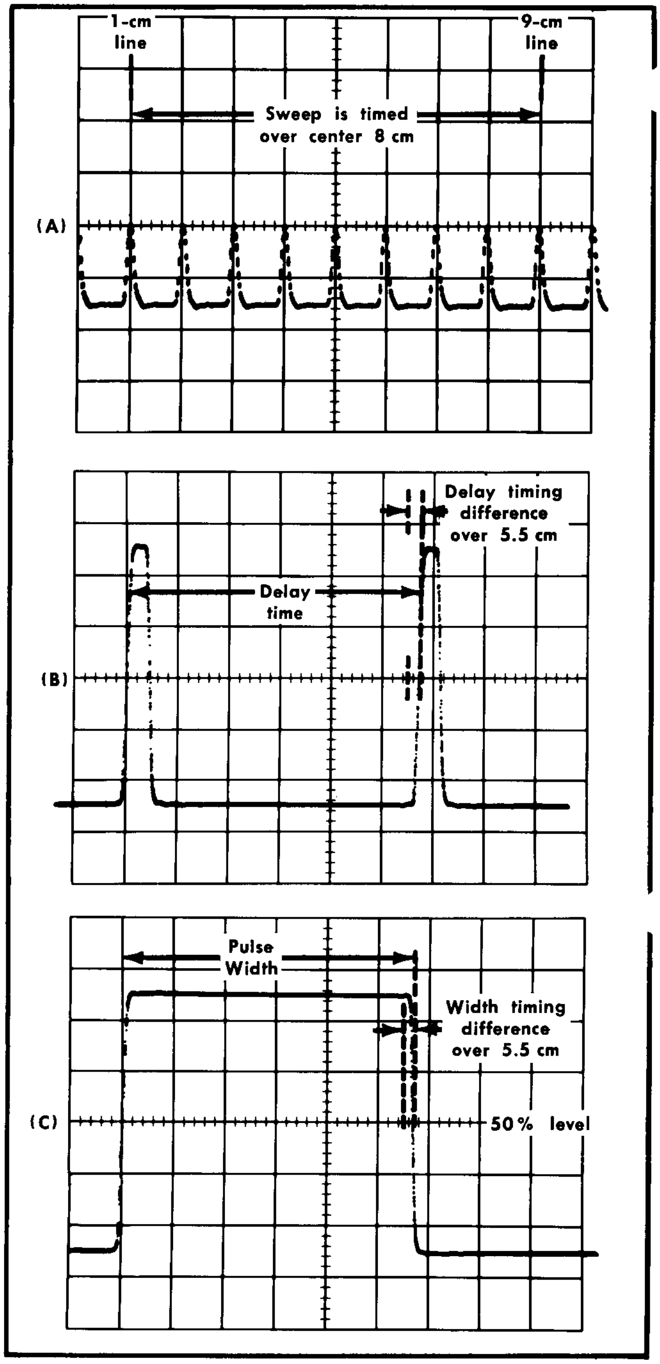

Fig. 6-13. Typical sampling oscilloscope displays for checking 10 nS delay and width ranges: (A) Time-mark signal for adjusting display timing; (B) 550-ns delay time; (C) 550-ns pulse width.

n. Trigger the sampling oscilloscope and adjust the Channel A Smoothing control for unity loop gain.

o. Adjust the oscilloscope Time Position control to position the rise of the first pulse of a pair on the 1-cm graticule line.

p. Check for—Sampling oscilloscope display with a delay interval of 550 ns between leading edges of the pulses, ±3% +10 ns (5.5 cm, ±2.65 mm). See Fig. 6-13B.

q. Set the MODE switch to SINGLE.

r. Set the WIDTH MULTIPLIER control to 55.

s. Check for—Sampling oscilloscope display with a pulse width of 550 ns, ±5% (5.5 cm, ±2.75 mm). See Fig. 6-13C.

t. Reset the following Type R116 controls:

PERIOD RANGE	1 μS
DELAY OR BURST TIME MULTIPLIER	5
WIDTH MULTIPLIER	5

u. Set the sampling oscilloscope equivalent sweep rate to 20 ns/cm (unmagnified), then magnify the sweep rate to 10 ns/cm.

v. Set the sampling oscilloscope vertical Mode switch to B Only.

w. Set the time-mark generator for a 10 ns marker output.

x. Temporarily substitute the time-mark trigger signal for the +Delayed Trigger Out signal and check the display for 1 cycle/cm. Adjust the variable sweep rate control if the display is not correct.

y. Reconnect the +Delayed Trigger Out signal and set the sampling oscilloscope vertical Mode switch to A Only.

z. Time-position the pulse rise to the 1-cm graticule line.

aa. Check for—Sampling oscilloscope display with a pulse width of 50 ns, ±5% (5 cm, ±2.5 mm).

bb. Set the MODE switch to DLY'D SINGLE.

cc. Check for—Sampling oscilloscope display with the pulse rise at the 6-cm graticule line ±3.5 mm, indicating a delay interval of 50 ns ±3% (+10 ns).

25. Check Output Pulse Transient Response

a. Requirement—3% or less of overshoot, aberrations or tilt in + and − polarity, using minimum risetime and falltime and 10-volt amplitude, as observed on 50-ns wide and 500-ns wide pulses.

b. Set the MODE switch to SINGLE.

c. Set the sampling oscilloscope equivalent sweep rate to 5 ns/cm.

d. Time-position the display to position the pulse rise at the left edge of the crt screen.

e. Increase the sampling oscilloscope vertical deflection factor to 20 mV/cm.

f. Vertically position the pulse top onto the crt screen.

g. Check for—Sampling oscilloscope display of the pulse top with no more than 1.5 cm (3%) of overshoot at the front corner of the pulse and no more than 1.5 cm (3%) of aberrations or tilt on the pulse top (see Fig. 6-14A).

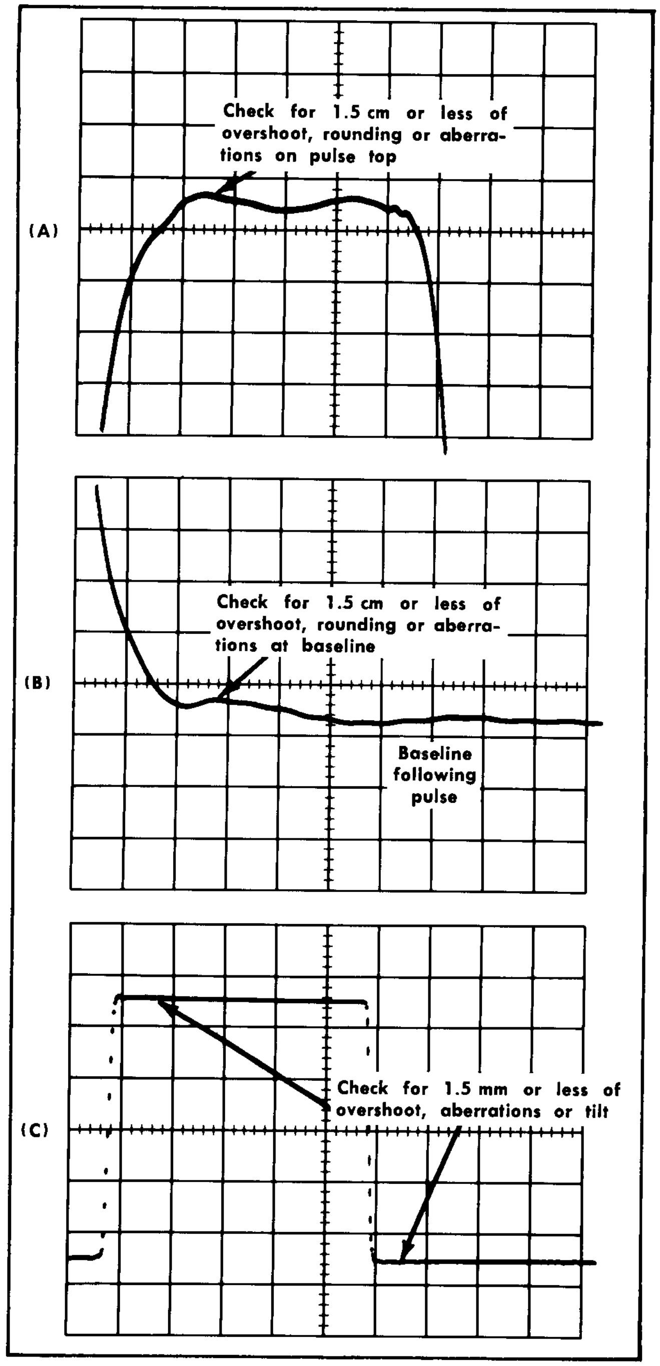

Fig. 6-14. Sampling oscilloscope displays for checking transient response of the Type R116 output pulse.

h. Position the pulse baseline on the crt screen with the sampling oscilloscope Time Position and DC Offset controls (see Fig. 6-14B).

i. Check for—Sampling oscilloscope display of the baseline with no more than 1.5 cm (3%) of overshoot and no more than 1.5 cm (3%) of aberrations or tilt on the baseline.

j. Set the Type R116 POLARITY switch to −.

k. Repeat steps f through i to check the negative-going pulse for overshoot, rounding, aberrations or tilt.

l. Reset the following Type R116 controls:

MODE	DLY'D SINGLE
POLARITY	+
WIDTH MULTIPLIER	50

m. Reset the following sampling oscilloscope controls:

Equivalent Sweep Rate	0.1 μs/cm
Deflection Factor	200 mV/cm

n. Position the pulse display onto the sampling oscilloscope crt screen.

o. Check for—Sampling oscilloscope display of the output pulse waveform with not more than 1.5 mm (3%) of overshoot, aberrations or tilt (see Fig. 6-14C).

p. Set the POLARITY switch to —.

q. Repeat steps n and o to check the negative-going pulse for overshoot, aberrations and tilt.

26. Check Risetime and Falltime Accuracy

a. Requirement—Correct risetime and falltime ±5% over the range of the risetime and falltime controls, except ±10% on the 10 nS range, using 10 volts output amplitude.

b. Set the POLARITY switch to +.

c. Set the Type R116 controls, the time-mark generator and the sampling oscilloscope sweep rate as given in Table 6-10. On each sweep rate, check the display timing by observing the time-mark signal (Channel B) while triggering with the time-mark generator trigger signal (see Fig. 6-15A), then display the Type R116 output pulse and trigger with the +Delayed Trigger Out pulse.

d. Time-position the display on each check to observe the pulse rise, then the pulse fall.

e. Check for—Sampling oscilloscope display of the output pulse waveform with risetimes and falltimes (see Fig. 6-15 B and C) as indicated in Table 6-10. (For the longest risetime and falltime (110 μs), set the WIDTH MULTIPLIER control to 25.)

27. Check Remote Risetime and Falltime Ranges

a. Requirement—Correct remote operation of risetime and falltime ranges, within 2% of front-panel operation.

b. Connect shorting straps between the following points on the REMOTE PROGRAM plug: Terminal 2 and the wire (not one of the program resistors) connected to terminal 31; terminal 3 and the wire connected to terminal 32.

c. Connect another shorting strap between terminal 1 and the 4.42-kΩ resistor connected to terminal 33 (for zero offset).

d. Reset the following Type R116 controls:

PROGRAM	REMOTE
WIDTH RANGE	10 nS

e. Set the sampling oscilloscope equivalent sweep rate to 2 ns/cm, with the Variable control in the Calibrated position.

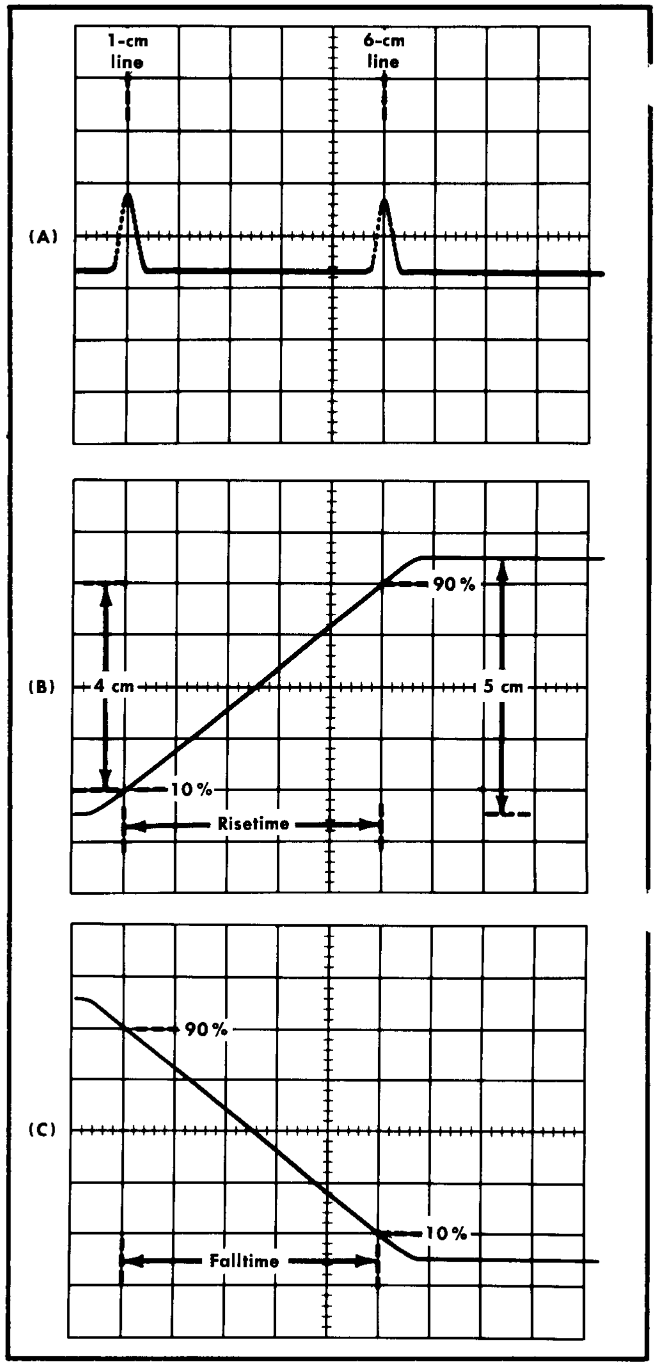

Fig. 6-15. Test oscilloscope displays for checking risetime and falltime of the Type R116 output pulse. (A) Typical time-mark display for adjusting display timing; (B) and (C) risetime and falltime displays (10-ns risetime and falltime are shown).

f. Time-position the display to observe the pulse rise.

g. Check for—Sampling oscilloscope display with a risetime of 10 ns, ±12% (5 cm, ±6 mm).

h. Time-position the display to observe the pulse fall.

i. Check for—Sampling oscilloscope display with a falltime of 10 ns, ±12% (5 cm, ±6 mm).

j. Set the PERIOD RANGE switch to 100 μS.

TABLE 6-10

Risetime and Falltime Accuracy Check

PERIOD RANGE	WIDTH RANGE	RISETIME AND FALLTIME MULT	RISETIME FALLTIME RANGE	Time-Mark Generator Markers	Time-Mark Generator Trigger	Equivalent Sweep Rate	Risetime or Falltime Time	Risetime or Falltime Display
1 μS	10 nS	1	1 nS	10 ns (100 MHz)	1 μs	2 ns/cm	10 ns, ±10%	5 cm, ±5 mm
10 μS	100 nS	1	10 nS	0.1 μs	1 μs	20 ns/cm	100 ns, ±5%	5 cm, ±2.5 mm
100 μS	1 μS	1	100 nS	1 μs	10 μs	0.2 μs/cm	1 μs, ±5%	5 cm, ±2.5 mm
1 mS	10 μS	1	1 mS	10 μs	0.1 ms	2 μs/cm	10 μs, ±5%	5 cm, ±2.5 mm
1 mS	10 μS	11	1 mS	10 μs	0.1 ms	20 μs/cm	110 μs, ±5%	5.5 cm, ±2.75 mm
1 mS	10 μS	11	100 nS	1 μs	10 μs	2 μs/cm	11 μs, ±5%	5.5 cm, ±2.75 mm
100 μS	1 μS	11	10 nS	0.1 μs	1 μs	0.2 μs/cm	1.1 μs, ±5%	5.5 cm, ±2.75 mm
10 μS	100 nS	11	1 nS	10 ns (100 MHz)	1 μs	20 ns/cm	110 ns, ±10%	5.5 cm, ±5.5 mm

TABLE 6-11

Remote Risetime-Falltime Range Check

Short Between Terminals	WIDTH RANGE	Equivalent Sweep Rate	Risetime and Falltime Time	Risetime and Falltime Display
36 and 28	100 nS	20 ns/cm	100 ns, ±7%	5 cm, ±3.5 mm
36 and 29	1 μS	0.2 μs/cm	1 μs, ±7%	5 cm, ±3.5 mm
36 and 30	10 μS	2 μs/cm	10 μs, ±7%	5 cm, ±3.5 mm

k. Connect a shorting strap between terminal 36 of the REMOTE PROGRAM plug and each of the terminals given in Table 6-11.

l. Set the equivalent sweep rate as listed in the table and time-position the display on each check to observe the pulse rise, then the pulse fall.

m. Check for—Sampling oscilloscope displays as indicated in the last column of Table 6-11.

28. Check Remote Risetime and Falltime Analog

a. Requirement—Correct risetime and falltime using program resistors, within 2% of front-panel operation (+1% program resistor tolerance), measured on the 10-nS risetime-falltime range.

b. Remove the shorting straps connected between the following terminals: 36 and 30; 2 and 31; 3 and 32.

c. Connect the shorting straps between the following points: Terminals 36 and 28, terminal 2 and the 1.74-kΩ resistor connected to terminal 31; terminal 3 and the 1.74-kΩ resistor connected to terminal 32.

d. Set the sampling oscilloscope equivalent sweep rate to 0.2 μs/cm, then magnify the sweep rate to 0.1 μs/cm.

e. Set the WIDTH RANGE switch to 1 μS.

f. Time-position the pulse rise, then the pulse fall onto the oscilloscope screen.

g. Check for—Sampling oscilloscope displays of pulse risetime and falltime of 600 ns, ±8% (6 cm, ±4.8 mm).

h. Move the shorting straps connected to the 1.74-kΩ resistors on terminals 31 and 32 to the 3.40-kΩ resistors connected to the same terminals.

i. Set the sampling oscilloscope equivalent sweep rate to 0.2 μs/cm.

j. Time-position the pulse rise, then the pulse fall onto the oscilloscope screen.

k. Check for—Sampling oscilloscope displays of the pulse risetime and falltime of 1.1 μs, ±8% (5.5 cm, ±4 mm).

l. Set the PROGRAM switch to INT.

m. Disconnect the shorting straps.

29. Check +Delayed Trigger Out

a. Requirement—Pulse amplitude of 2 volts or more and risetime of less than 20 ns into high impedance load (≥1 kΩ).

b. Disconnect the sampling probes from the voltage pick-off and time-mark generator output, and the triggering cables from the +DELAYED TRIGGER OUT connector and time-mark trigger output.

c. Connect a triggering cable from the Type R116 +PRE-TRIGGER OUT connector to the 10× attenuator on the sampling oscilloscope External Trigger Input.

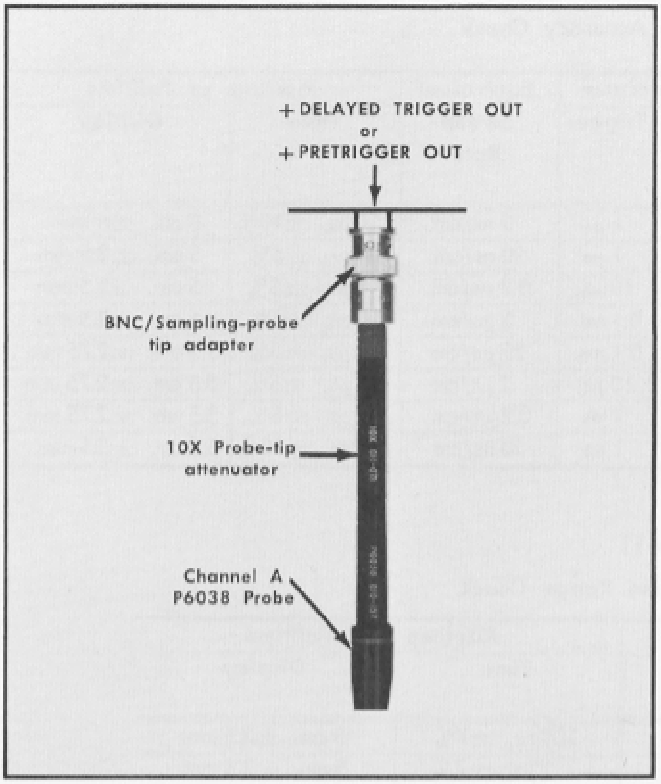

Fig. 6-16. Test connection for checking +Delayed Trigger Out and +Pretrigger Out signals.

d. Connect the Channel A sampling probe tip to the Type R116 +DELAYED TRIGGER OUT connector through an adapter, and a 10× probe-tip adapter as shown in Fig. 6-16.

e. Reset the following Type R116 controls:

MODE	SINGLE
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	10
WIDTH RANGE	10 nS
MULTIPLIER	5

f. Reset the following sampling oscilloscope controls:

Equivalent Sweep Rate	5 ns/cm
Deflection Factor	100 mV/cm

g. Trigger the sampling oscilloscope, then time-position the pulse rise onto the crt screen. Use the DELAY OR BURST TIME MULTIPLIER control if necessary.

h. Check for—Sampling oscilloscope display of the +Delayed Trigger Out pulse with an amplitude of at least 2 volts (2 cm) and a risetime of less than 20 ns (4 cm). See Fig. 6-17A.

i. Set the sampling oscilloscope equivalent sweep rate to 0.1 μs/cm.

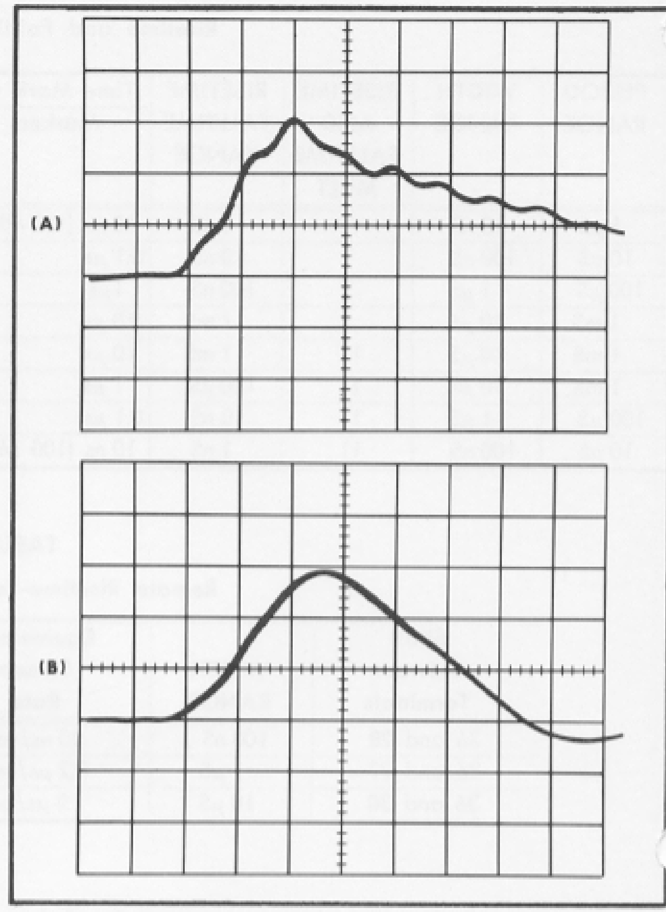

Fig. 6-17. Typical sampling oscilloscope displays of (A) the +Delayed Trigger Out pulse and (B) the +Pretrigger Out pulse.

j. Position the pulse rise to the 1-cm graticule line.

k. Turn the DELAY OR BURST TIME MULTIPLIER control to the 50 position while observing the pulse on the crt screen.

l. Check for—Sampling oscilloscope display of the +Delayed Trigger Out pulse moving with respect to the +Pretrigger Out signal. The pulse should move approximately 400 ns (8 cm) as the control is turned from the 10 position to the 50 position.

30. Check +Pretrigger Out

a. Requirement—Pulse amplitude of 2 volts or more and risetime of less than 20 ns into high-impedance load (≥1 kΩ).

b. Interchange the cable connected to the +PRETRIGGER OUT connector and the sampling-probe assembly connected to the +DELAYED TRIGGER OUT connector.

c. Reset the following Type R116 controls:

PERIOD RANGE	1 μS
MULTIPLIER	1
DELAY OR BURST TIME	
MULTIPLIER	10

d. Set the sampling oscilloscope equivalent sweep rate to 20 ns/cm.

e. Magnify the sweep rate to 5 ns.

f. Trigger the oscilloscope display and time-position the pulse rise onto the crt screen.

g. Check for—Sampling oscilloscope display of the +Pretrigger Out pulse with an amplitude of at least 2 volts (2 cm) and a risetime of less than 20 ns (4 cm). See Fig. 6-17B.

This completes the performance check procedure for the Type R116. Turn off the instrument to remove the special remote program checker from the rear-panel connector. All test instruments, cables, adapters, etc., may also be disconnected.

If the Type R116 has met the performance requirements given in the procedure, the calibration of the instrument is within the specified tolerances.

NOTES

SECTION 7
CALIBRATION

General Information

A complete calibration and verification procedure for the Type R116 is provided in this section. This procedure checks the instrument to the performance requirements given in the Characteristics section. A calibration record is included at the beginning of the procedure for use as a a checklist to verify correct calibration and operation of the Type R116 or as a guide for quick calibration by an experienced calibrator.

The Type R116 should be checked and recalibrated after each 500 hours of operation and at least once every 6 months to assure that it is operating properly and accurately. In addition, portions of the instrument will require calibration if components have been replaced or other electrical repairs have been made in the circuitry.

The step by step instructions in the calibration procedure furnish an orderly approach to the isolation of possible malfunctions and, thus, serve as an aid in troubleshooting and repairing the instrument. Any maintenance that is known to be needed should be performed before starting the calibration procedure. If any troubles become apparent during calibration, these also should be corrected before proceeding. Repair and servicing information is given in the Maintenance section of this manual.

EQUIPMENT REQUIRED

The following (or equivalent) items of equipment are required for a complete calibration of the Type R116. The equipment is illustrated in Fig. 7-1. If substitute equipment is used, it must equal or exceed the given requirements in order to calibrate the Type R116 to the given accuracy. If the equipment does not meet these requirements, the difference between the accuracy of the equipment used and the accuracy of the specified equipment must be added to the tolerance stated in the calibration step.

1. Test oscilloscope, Tektronix Type 547 with Type W Differential Comparator Plug-In Unit. Minimum alternate requirements: Bandwidth from dc to 15 MHz; sweep rates from 10 ms/cm to 0.1 μs/cm; vertical input deflection factors from 10 mV/cm to 2 V/cm; voltage and timing accuracy of display within 3%; differential inputs; internal comparison voltage provided with accuracy of 0.5%; ac and dc vertical input coupling; internal and external triggering; amplitude calibrator output waveform available (approximately 1 kHz).

2. Wideband Dual-Trace Amplifier Plug-In Unit, Tektronix Type 1A1 or 1A2, compatible with Type 547 Oscilloscope. Minimum alternate requirements (with oscilloscope): Bandwidth from dc to 50 MHz; vertical input deflection factors of 1 V/cm to 5 V/cm; voltage accuracy within 3%; alternate-trace switching.

3. Sampling oscilloscope, Tektronix Type 661 with Type 5T3 Timing Unit, Type 4S3 vertical unit and two P6038 direct-sampling probes. Minimum alternate requirements: Risetime of 350 ps; equivalent sweep rates from 0.2 μs/cm to 2 ns/cm; vertical deflection factors from 20 mV/cm to 200 mV/cm; external triggering; time-positioning capability (time delay); voltage and timing accuracy within 3%.

4. Time-mark generator, Tektronix Type 184. Minimum alternate requirements: Time-mark outputs from 0.1 μs to 10 ms; accuracy within 0.5%.

5. Variable autotransformer (e.g., General Radio, Variac Type W10MT3W). Minimum requirements: Output voltage variable from 94.5 volts to 137.5 volts ac rms for 115-volt operation or 189 volts to 275 volts ac rms for 230-volt operation; output power rating at least 0.1 kVA. If monitor voltmeter is not included, separate ac voltmeter is required with accuracy within 3% over required range.

6. Precision differential voltmeter (e.g., Fluke Model 801B). Minimum requirements: Voltage accuracy within 0.5% at 25 volts and 27 volts.

7. Two 1× test probes, Tektronix P6028, with BNC connectors. Tektronix Part Number 010-0074-00.

8. Three 42-inch coaxial cables. Characteristic impedance approximately 50 Ω; BNC connectors. Tektronix Part Number 012-0057-00.

9. 56-terminal circuit card extender. Tektronix Part Number 012-0078-00.

10. Voltage Pickoff, Tektronix VP-2. Permits direct-sampling probe to obtain signal from 50-Ω system. Tektronix Part Number 017-0077-00.

11. 50-Ω in-line termination with BNC connectors. Tektronix Part Number 011-0049-00.

12. 50-Ω end-line termination with GR connector. Tektronix Part Number 017-0081-00.

13. Two 50-Ω 10× T attenuators with GR connectors. Tektronix Part Number 017-0078-00.

14. BNC plug to GR connector adapter. Tektronix Part Number 017-0064-00.

15. BNC jack to GR connector adapter. Tektronix Part Number 017-0063-00.

16. Coaxial T connector with BNC connectors. Tektronix Part Number 103-0030-00.

17. Plastic screwdriver-type adjustment tool. Tektronix Part Number 003-0000-00.

18. Four shorting straps, approximately 8-inches long, constructed of insulated stranded copper wire and alligator clips, for use with item 19.

19. Special remote program checker, constructed according to schematic diagram in Fig. 7-2. Provides access to REMOTE PROGRAM connector terminals and includes minimum, intermediate, and maximum resistance values for remote program analog checks. Made of 36-terminal re-

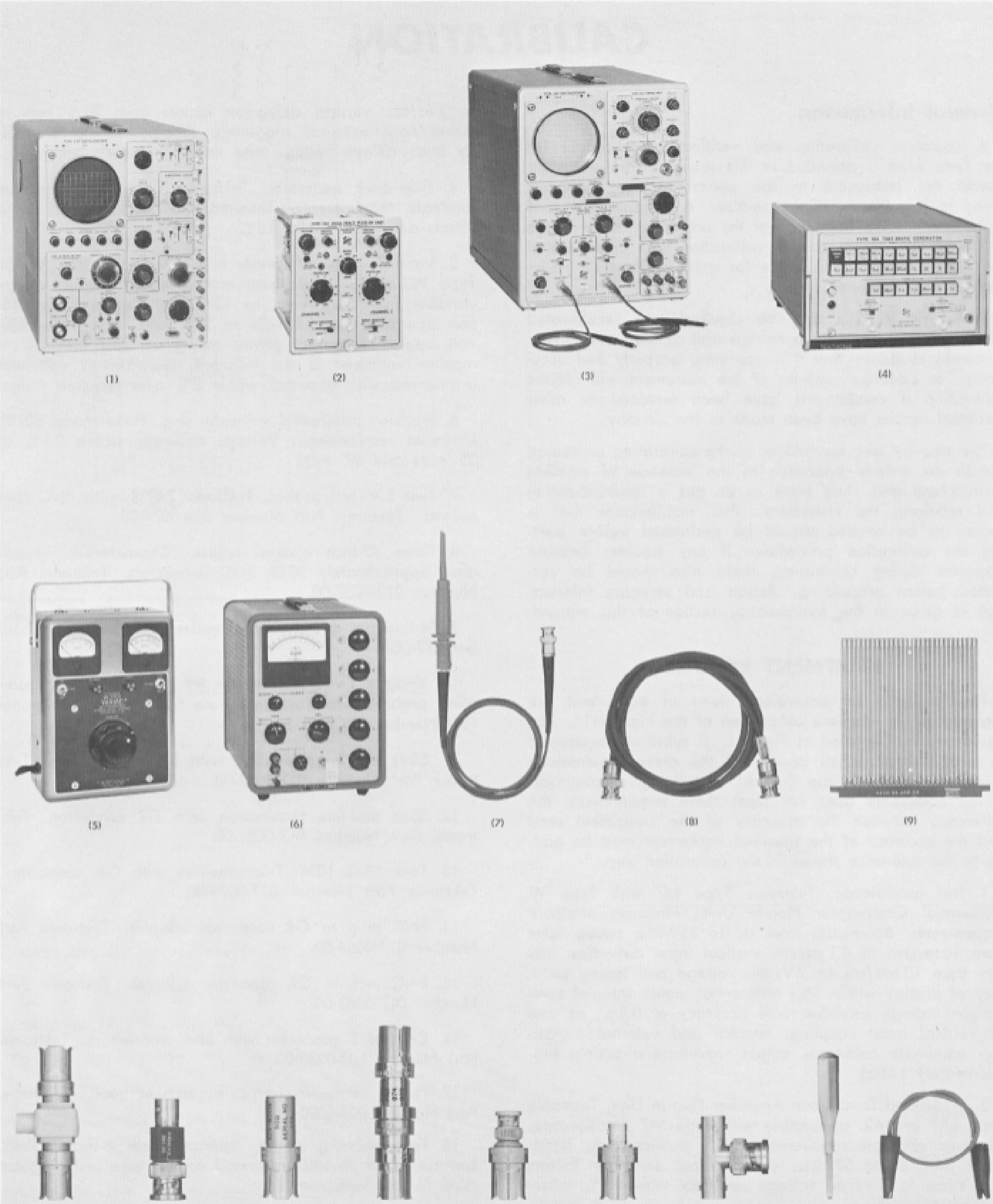

Fig. 7-1. Recommended calibration equipment.

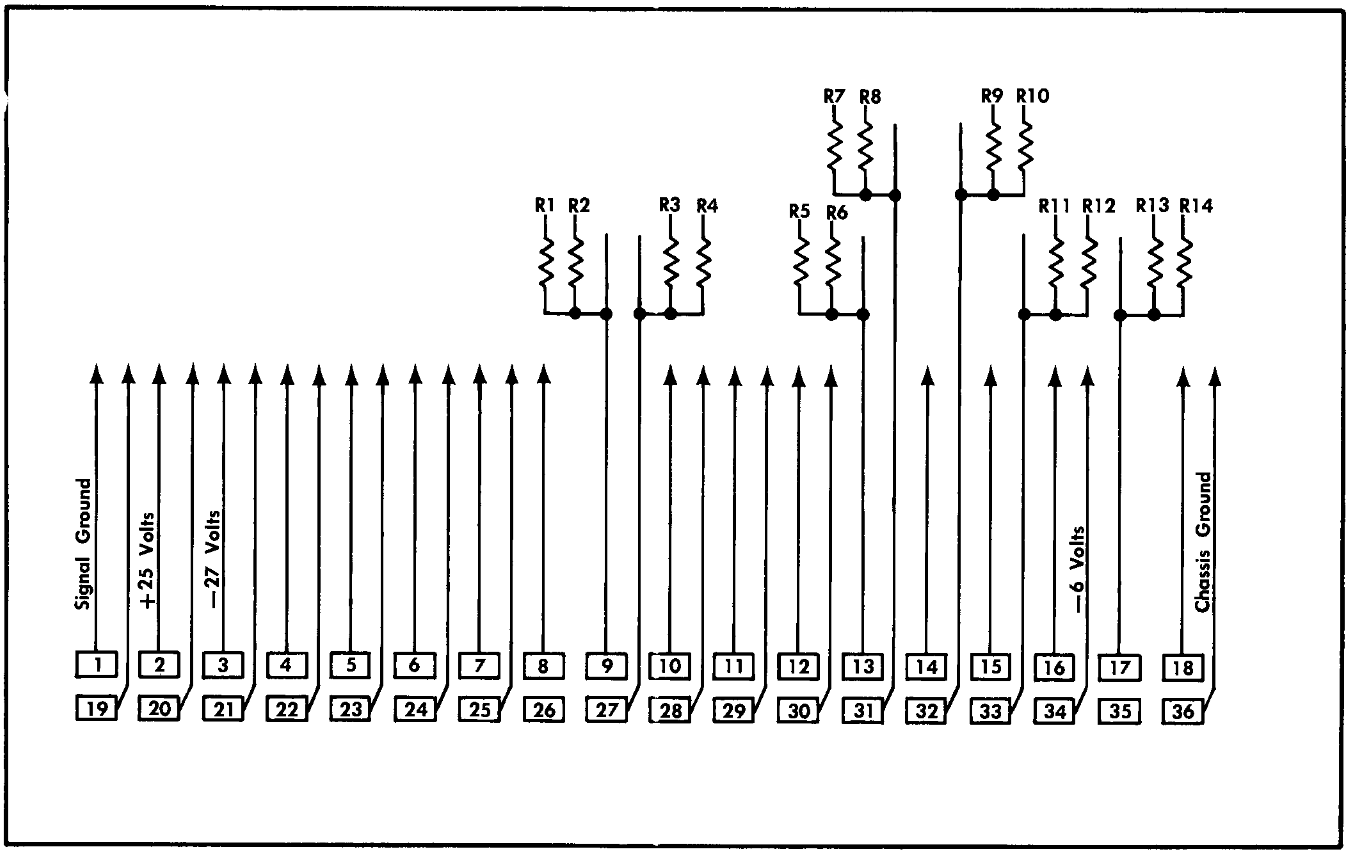

Fig. 7-2. Schematic diagram for remote program checker (item 19). Connect wires to all terminals except #26 and #35. See Table 7-1 for resistor values.

mote program plug (Tektronix Part Number 131-0293-00), insulated #22 solid or stranded copper wire and metal-film 1/8-watt, 1-% resistors as given in Table 7-1. Some means of support should be provided for the wires to keep them separated and in numerical order. (A more complex remote program checker can be devised, if desired, utilizing switches or patch cords instead of shorting straps.)

TABLE 7-1

Analog Resistor Values for Remote Program Checker

Terminal on REMOTE PROGRAM Plug	Resistor Number (Fig. 7-2)	Resistance	Tektronix Part Number
9	R1	8.45 kΩ	321-0282-00
(Period)	R2	16.9 kΩ	321-0311-00
27	R3	4.42 kΩ	321-0255-00
(Amplitude)	R4	8.87 kΩ	321-0284-00
13	R5	4.42 kΩ	Same as R3
(Delay)	R6	8.87 kΩ	Same as R4
31	R7	1.74 kΩ	321-0216-00
(Risetime)	R8	3.40 kΩ	321-0244-00
32	R9	1.72 kΩ	Same as R7
(Falltime)	R10	3.40 kΩ	Same as R8
33	R11	4.42 kΩ	Same as R3
(DC Offset)	R12	8.87 kΩ	Same as R4
17	R13	4.42 kΩ	Same as R3
(Width)	R14	8.87 kΩ	Same as R4

CALIBRATION RECORD AND INDEX

This outline is provided to serve as a verification and calibration record. It may also be used as a quick calibration guide for those familiar with the procedure.

Type R116 Serial Number ______________

Calibration Date ______________

Power Supply

☐ 1. Adjust +25-Volt Supply (Page 7-7)

+25 volts ±0.25 volt with respect to signal ground.

☐ 2. Check Power Supply Voltages (Page 7-8)

−27 volts ±0.6 volt with respect to signal ground.

−6.0 volts ±0.5 volt with respect to signal ground.

+7 volts ±1 volt with respect to signal ground.

—Variable range from approximately —10 to —20 volts, with respect to signal ground, varied by DC OFFSET control.

+12 volts ±2 volts with respect to chassis ground.

☐ 3. Check Regulation (Page 7-9)

≤15 mV ripple on −27-volt supply.

≤30 mV ripple on −6-volt supply.

$\leq$15 mV ripple on +25-volt supply.

$\leq$50 mV ripple on +7-volt supply.

$\leq$20 mV ripple on —Variable supply.

Ripple is measured differentially with respect to signal ground.

Preliminary Pulse Circuit Adjustments

☐ 4. Adjust Risetime Centering (Page 7-10)

+1 volt from Q14 base to Q34 base.

☐ 5. Adjust Falltime Centering (Page 7-11)

+1 volt from Q24 base to Q44 base.

☐ 6. Adjust Width and Delay Trigger Sensitivity (Page 7-11)

Stable Dly'd Single mode signal through range of DELAY OR BURST TIME MULTIPLIER and WIDTH MULTIPLIER controls.

Pulse Shape Generator (Amplitude Section)

☐ 7. Adjust +Amplitude (Page 7-13)

Correct amplitude ±3% at 10 volts and 2 volts.

☐ 8. Check Amplitude Accuracy (Page 7-14)

Correct amplitude ±3% over range of amplitude controls.

☐ 9. Check Remote Amplitude (Page 7-15)

Correct remote operation of amplitude ranges, within 2% of front-panel calibration.

Correct amplitude with program resistors, within 2% of front-panel calibration (+1% for program resistor tolerance).

Output Amplifier

☐ 10. Adjust —AMPLITUDE (Page 7-16)

Correct amplitude ±3% of negative-going pulse at 10 volts.

☐ 11. Adjust —DC LEVEL (Page 7-17)

Equal dc signal level (at Q53 emitter) in + and — polarity measured from signal ground.

☐ 12. Check Remote Polarity (Page 7-17)

Correct remote operation of polarity selection.

Offset Current Generator

☐ 13. Adjust Offset Range (Page 7-18)

Correct overall range of DC OFFSET control, checked with 400 mV pulse.

☐ 14. Adjust Offset Registration (Page 7-19)

Equal dc baseline level at approximately zero volt offset in internal and remote program.

☐ 15. Adjust Offset Zero Levels (Page 7-19)

Zero offset ±50 mV at 0 position of DC OFFSET control in + and — polarity.

☐ 16. Check Offset Accuracy (Page 7-20)

Correct dc offset over range of DC OFFSET control in + and — polarity: ±50 mV at 0 offset; ±150 mV at maximum offset.

☐ 17. Check Remote Offset (Page 7-20)

Correct dc offset using program resistors, within 100 mV of front-panel calibration (+1% for program resistor tolerance).

☐ 18. Adjust Program Clamp (Page 7-20)

$\leq$1-volt offset in remote program with open offset program line in + and — polarity.

Pulse Shape Generator (Ramp Section)

☐ 19. Adjust Slow Risetime and Falltime (Page 7-22)

Correct risetime and falltime ±5% at 110 μs and 10 μs.

☐ 20. Check Slow Risetime and Falltime Accuracy (Page 7-24)

Correct risetime and falltime ±5% over range from 1 μs to 110 μs.

☐ 21. Adjust + Pulse Overshoot (Page 7-24)

$\leq$3% overshoot, aberrations or tilt on front corner of minimum-risetime positive-going 50-ns width pulse.

☐ 22. Check Pulse Output Transient Response (Page 7-25)

$\leq$3% overshoot, aberrations or tilt in + and — polarity, using minimum risetime and falltime on 50-ns width and 500-ns width pulses.

☐ 23. Adjust Fast Risetime and Falltime (Page 7-26)

Correct risetime and falltime ±10% at 1 nS range, ×10 multiplier; ±5% at 10 nS range, ×10 multiplier.

☐ 24. Check Fast Risetime and Falltime Accuracy (Page 7-27)

Correct risetime and falltime ±10% from 10 ns to 110 ns on nS range: ±5% from 100 ns to 1.1 μs 10 nS range.

☐ 25. Check Remote Risetime and Falltime (Page 7-28)

Correct remote operation of risetime and falltime ranges, within 2% of front-panel calibration.

Correct risetime and falltime using program resistors, within 2% of front-panel calibration (+1% for program resistor tolerance), measured on the 10 nS risetime-falltime range.

Width Generator

☐ 26. Adjust Width Timing (Page 7-30)

Correct width timing ±3% at 50 μs width and 500 μs width; ±5% at 500 ns width.

☐ 27. Check Width Accuracy (Page 7-32)

Correct timing ±3% over range of width controls, except ±5% on 10 nS width range.

☐ 28. Check Remote Width (Page 7-32)

Correct remote operation of width ranges, within 2% of front-panel calibration.

Correct width timing with program resistors, within 2% of front-panel calibration (+1% for program resistor tolerance).

Delay Generator

☐ 29. Adjust Delay Timing (Page 7-33)

Correct delay timing ±3% (+10 ns) at 100 μs, 500 μs and 50 ns.

☐ 30. Check Delay Accuracy (Page 7-34)

Correct timing ±3% (+10 ns) over range of delay controls.

☐ 31. Check Remote Delay (Page 7-35)

Correct remote operation of delay ranges, within 2% of front-panel calibration.

Correct delay timing with program resistors, within 2% of front-panel calibration (+1% for program resistor tolerance).

☐ 32. Check +Delayed Trigger Out (Page 7-36)

Pulse amplitude of 2 volts or more and risetime of less than 20 ns into high-impedance load (≥1 kΩ).

Period Generator

☐ 33. Check +Pretrigger Out (Page 7-38)

Pulse amplitude of 2 volts or more and risetime of less than 20 ns into high-impedance load (≥1 kΩ).

☐ 34. Adjust Period Timing (Page 7-39)

Correct timing ±3% at 10 ms, 1 ms; ±5% at 100 ns; ±3% at 1 μs.

☐ 35. Check Period Accuracy (Page 7-39)

Correct timing ±3% over range of period controls, except ±5% on 100 nS period range.

☐ 36. Check Remote Period (Page 7-40)

Correct remote operation of period ranges, within 2% of front-panel calibration.

Correct period timing with program resistors, within 2% of front-panel calibration (+1% for program resistor tolerance).

Modes and Triggering

☐ 37. Check Single, Dly'd Single and Double Modes (Page 7-42)

Correct selection of Single, Dly'd Single and Double mode signals.

☐ 38. Check Remote Single, Dly'd Single and Double Modes (Page 7-42)

Correct remote selection of Single, Dly'd Single and Double modes.

☐ 39. Check Manual Trigger and Remote Manual (Page 7-42)

Single pulse output with manual TRIG button.

Correct remote operation of manual triggering.

☐ 40. Check External Triggering (Page 7-43)

Correct external triggering of Single mode waveform.

☐ 41. Check Remote Triggering Enable (Page 7-43)

Correct remote operation of trigger signal selection.

☐ 42. Check Burst Mode (Page 7-44)

Correct output signal operation in Burst mode.

☐ 43. Check Remote Burst Mode (Page 7-44)

Correct remote selection of Burst mode operation.

☐ 44. Check Gated Output Mode (Page 7-44)

Correct output signal operation in Gated Output mode.

☐ 45. Check Remote Gated Output Mode (Page 7-44)

Correct remote selection of Gated Output mode.

CALIBRATION PROCEDURE

The following procedure is arranged in a sequence that allows the Type R116 to be calibrated with a minimum of adjustment interaction. Each step contains complete information for executing that step. The sequence includes procedures for checking performance as well as those required for adjusting the calibration controls. The adjustment steps provide a check of the instrument performance before the adjustment is made. When doing a complete recalibration of the instrument, best overall performance will be provided if each adjustment is made to the exact setting, even if the observed performance is within the allowable tolerance. When doing only a partial recalibration, however, do not readjust any controls unless the performance requirements are not met in the checks.

To make only the control adjustments without completely checking performance of the instrument, carry out only the Adjust steps. The symbol ◐ is provided to locate these steps. Any equipment connections or control settings that are changed during the omitted steps must be noted and performed if necessary. If any adjustment steps are done individually or out of sequence, subsequent steps may also need to be checked since some adjustments affect the calibration of other circuits.

Do not preset any calibration adjustments unless they are known to be significantly out of adjustment or unless repairs have been made in the circuit. In these cases, set the particular controls to midrange.

An initial test equipment setup picture is shown for each major group of adjustments and/or checks. Beneath each setup picture is a complete list of front-panel control settings of the Type R116, plus significant control settings of other instruments. Any control that has been changed from the setting at the end of the preceding step is given in boldface type.

PRELIMINARY PROCEDURE

1. If the Type R116 is mounted in a rack, remove the securing screws and extend the instrument fully on the slide-out tracks, or remove the Type R116 from the rack.

2. Remove the top and bottom dust covers.

3. Connect the autotransformer and other test instruments to a suitable power source.

4. Set the 115 V-230 V selector switch on the Type R116 rear panel to correspond to the autotransformer output voltage.

5. Connect the autotransformer output to the Type R116.

6. Install the Type W Plug-In Unit in the Type 547 Oscilloscope.

7. Connect a terminated 50-Ω coaxial cable (see Fig. 7-3) to the Type R116 PULSE OUTPUT connector.

8. Turn on the autotransformer, the Type R116 and the test instruments.

9. Set the autotransformer for the nominal line voltage to be used (115 volts or 230 volts).

10. Allow at least 20 minutes warm up at 25°C ±5°C (77°F ±9°F) before making any checks or adjustments.

11. Connect the two 1× test probes to the vertical input of the test oscilloscope.

12. Check that the seven multiplier dials on the front panel of the Type R116 are correctly aligned (minimum reading) when turned fully counterclockwise. (The DC OFFSET control knob should be at the center of its range of rotation.) Realign any knob that is not correctly positioned.

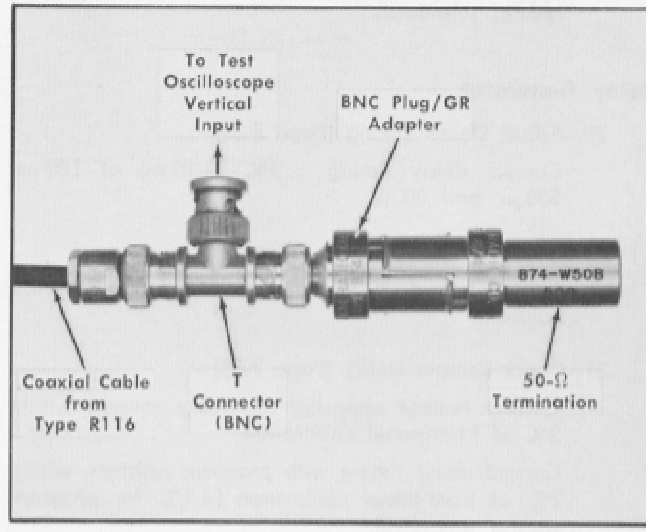

Fig. 7-3. Cable termination for connecting the Type R116 output pulse to the test oscilloscope vertical input.

13. After the 20-minute warm-up period, check the dc balance of the test oscilloscope.

14. Set the instrument controls as given under Fig. 7-3.

NOTES

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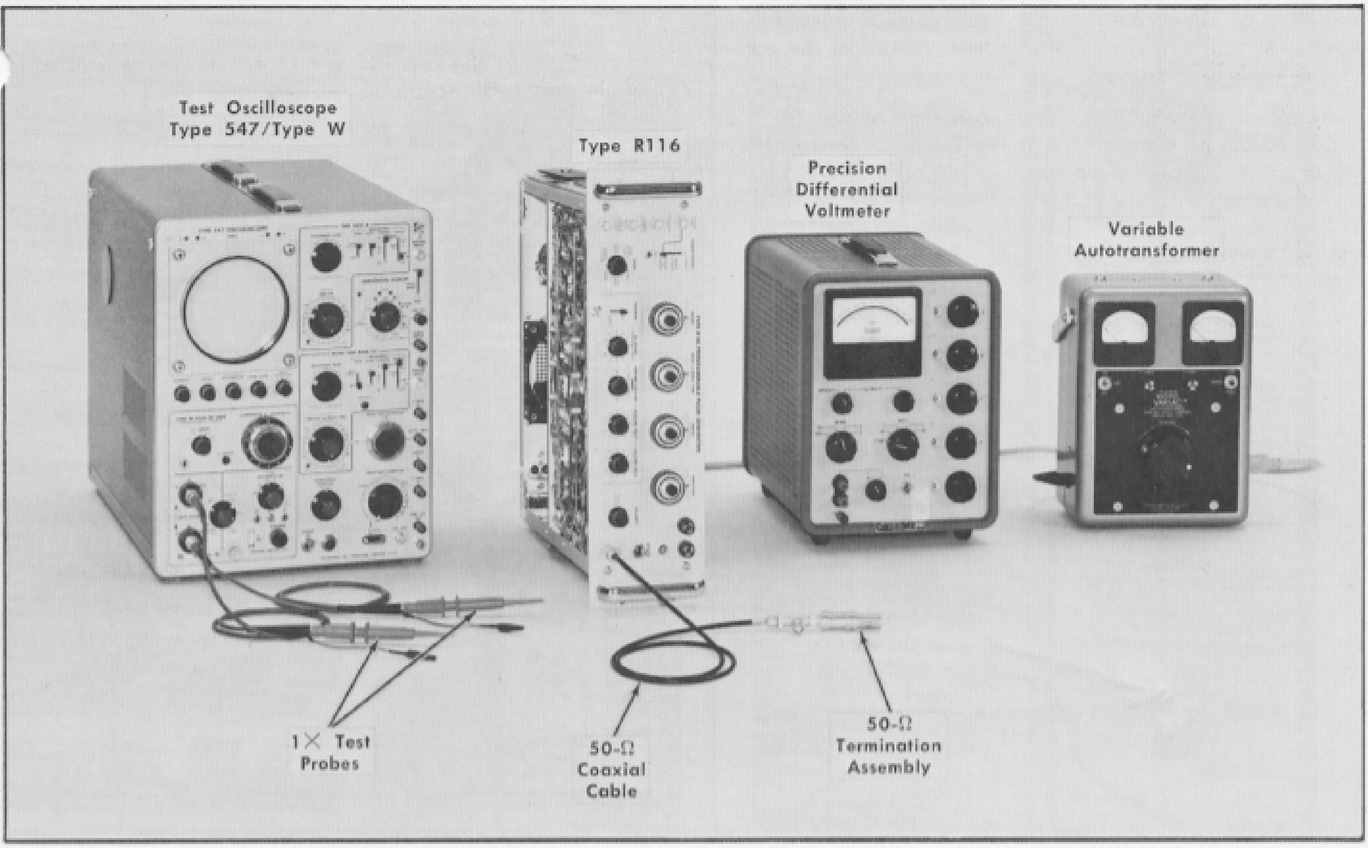

Fig. 7-4. Initial test equipment setup for calibration steps 1 through 3.

Control Settings

Type R116

MODE	SINGLE
TRIGGER SOURCE	EXTERNAL OR MANUAL
PERIOD RANGE	10 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	5
WIDTH RANGE	10 nS
MULTIPLIER	5
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Horizontal Display	A
Sweep Rate	5 ms/cm (calibrated)
Triggering	+Line, AC
Vertical Display	A-B
Input Attenuation	1
Millivolts/Cm	10 (calibrated)
Input Coupling	Gnd
Comparison Voltage	
Range	0
Multiplier	0.000
Amplitude Calibrator	Off

POWER SUPPLY

1. Adjust +25-Volt Supply ⓿

a. Test equipment setup is shown in Fig. 7-4.

b. Position the Type R116 so that both the top and bottom are accessible, as shown in the setup illustration.

c. Connect the negative lead of the differential voltmeter to the signal ground test point (see Fig. 7-5) and the positive lead to the +25-volt test point.[1]

d. Check for—Differential voltmeter reading of 25 volts ±0.25 volt with respect to signal ground.

NOTE

The +25 VOLTS adjustment affects the calibration of the entire instrument.

e. Adjust—R14 (+25 VOLTS) on the Power Supply circuit card (Series I) if the voltage is not correct. See Fig. 7-6 for the location of R14.

[1] If a precision differential voltmeter is not available, the +25-volt supply can be checked to the required accuracy with the Type W Unit by first setting the Type R116 signal ground voltage equal to chassis ground in — polarity by means of the front-panel DC OFFSET control.

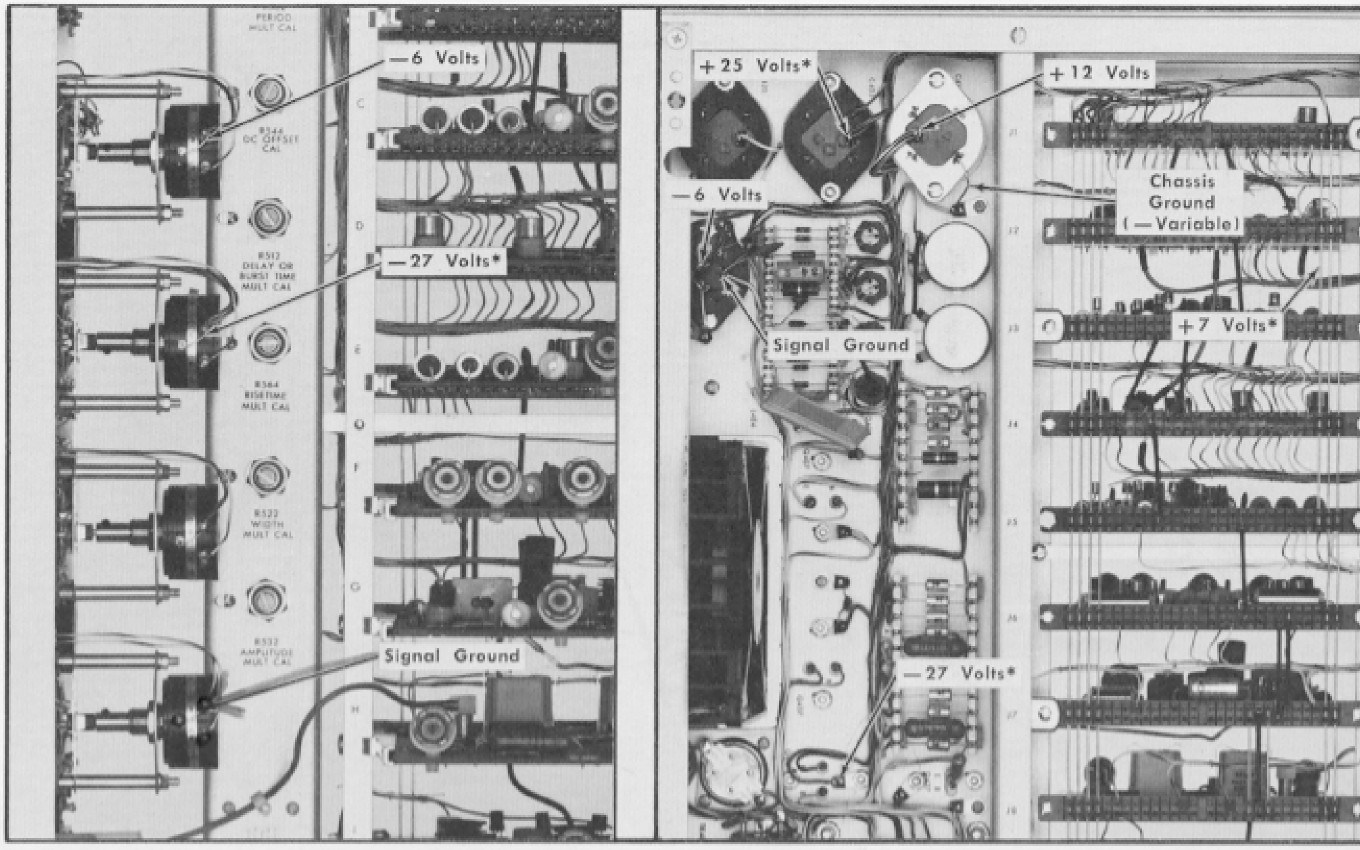

Fig. 7-5. Power-supply test points for checking voltages and regulation.

2. Check Power Supply Voltages

a. Move the positive lead of the differential voltmeter to the +7-volt test point (see Fig. 7-5).

b. Check for—Meter reading of 7 volts ±1 volt with respect to signal ground.[2]

c. Move the positive lead of the differential voltmeter to the signal ground test point (or reverse the polarity of the meter).

d. Move the negative lead to the −27-volt test point.

e. Check for—Meter reading of 27 volts ±0.6 volt with respect to signal ground.

f. Move the negative lead to the −6-volt test point.

g. Check for—Meter reading of 6 volts ±0.5 volt with respect to signal ground.[2]

h. Move the negative lead to the chassis ground (—Variable) test point (see Fig. 7-5).

i. Turn the Type R116 DC OFFSET control throughout its range.

j. Check for—Meter reading varying from approximately 10 volts to approximately 20 volts, with respect to signal ground.[2]

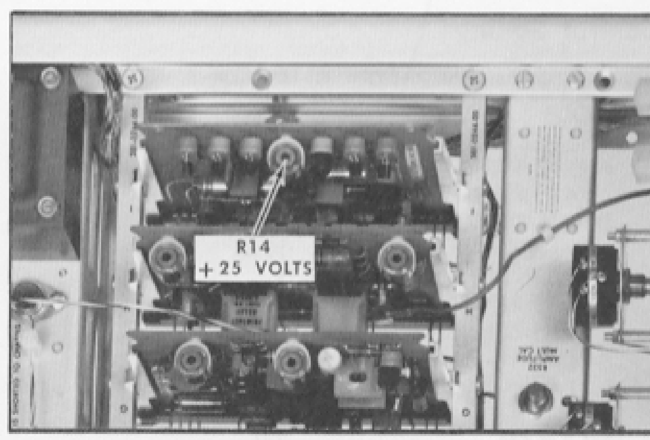

Fig. 7-6. Location of R14 (+25 VOLTS) on the Power Supply (Series I) circuit card.

k. Leave the negative lead of the meter connected to the chassis ground test point and move the positive lead of the meter to the +12-volt test point.

l. Check for — Meter reading of 12 volts ±2 volts, with respect to chassis ground.[2] → Sig. Gnd.

m. Disconnect the voltmeter.

n. Set the DC OFFSET control to the 0 position.

[2] This voltage may be measured with a 1% tolerance dc voltmeter.

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3. Check Regulation

a. Set the test oscilloscope Input Coupling switches (both channels) to AC.

b. Trigger the test oscilloscope on the internal line signal.

c. Connect the Channel B 1× test probe to the signal ground test point (see Fig. 7-5).

d. Connect the test probe ground clip to chassis ground.

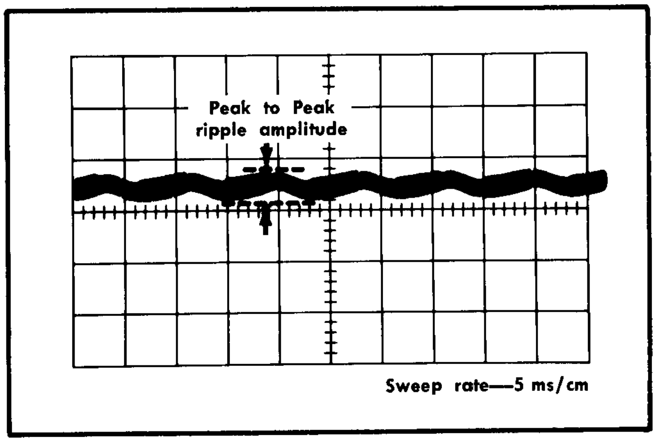


Fig. 7-7. Typical ripple display for checking power-supply regulation.

CAUTION

Never connect the probe ground clip to signal ground. This will ground the power supply and will probably damage the instrument.

e. Connect the Channel A test probe to each of the test points given in Table 7-2.

f. With the probe connected to each test point, observe the test oscilloscope display while varying the autotransformer output voltage from 137.5 volts to 94.5 volts (or from 275 volts to 189 volts for 230-volt operation).

g. Check for — Test oscilloscope display of power-supply ripple with line frequency ripple amplitude (see Fig. 7-7) not exceeding the maximum value given in Table 7-2.

TABLE 7-2

Power Supply Regulation Check

Voltage Test Point (Fig. 7-5)	Maximum Ripple Voltage (peak to peak)	Maximum Ripple Display Amplitude
+25 volts	15 mV	1.5 cm
+7 volts	50 mV	5.0 cm
−6 volts	30 mV	3.0 cm
−27 volts	15 mV	1.5 cm
Chassis Ground (−Variable)	20 mV	2.0 cm

h. Disconnect the probe tips and ground clips from the Type R116.

i. Remove the two 1× probes from the test oscilloscope vertical inputs.

j. Disconnect the Type R116 from the autotransformer and connect it directly to the power line, or set the autotransformer output voltage to the nominal line voltage of the Type R116 (115 volts or 230 volts).

NOTES

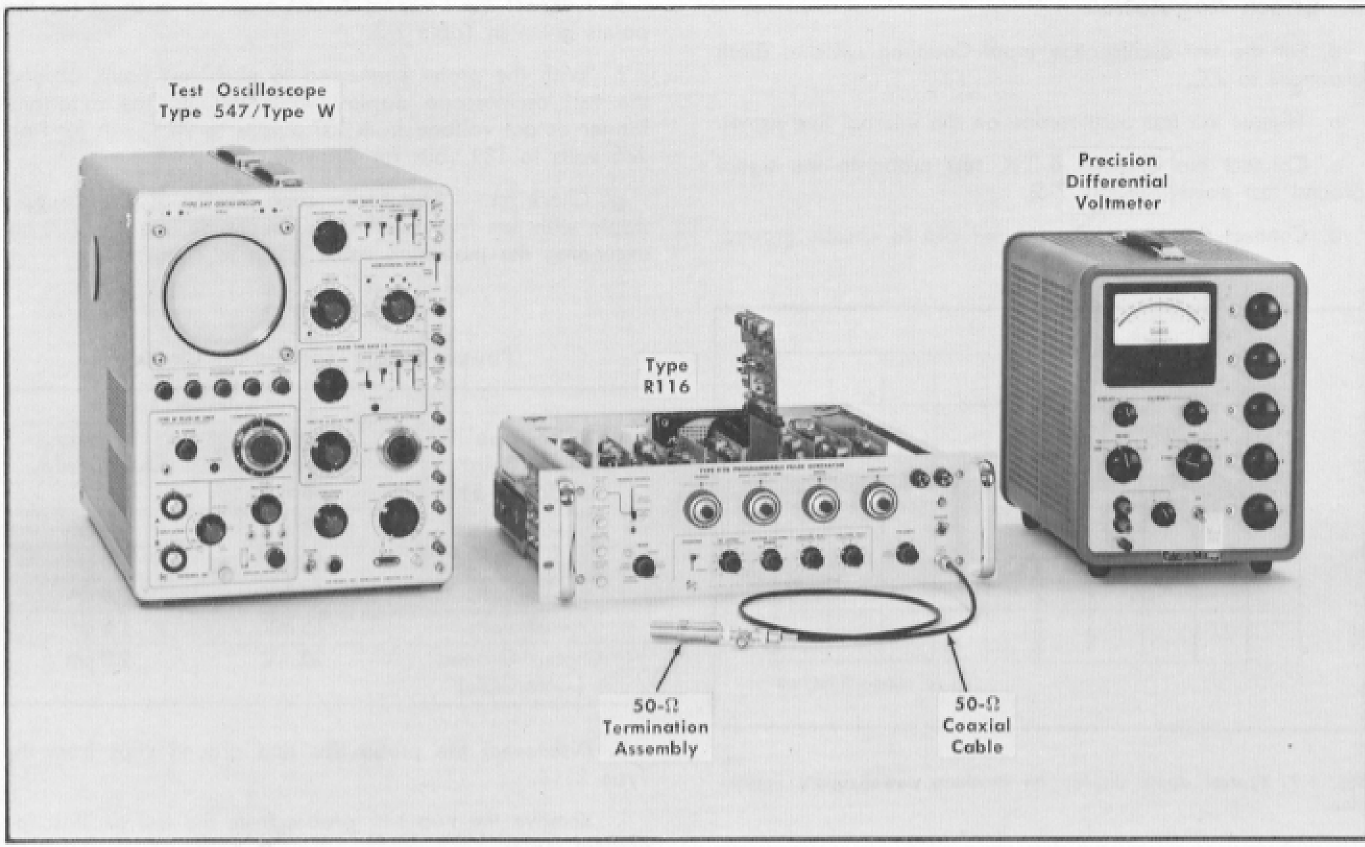


Fig. 7-8. Initial test equipment setup for calibration steps 4 through 6.

Control Settings

Type R116

MODE	SINGLE
TRIGGER SOURCE	EXTERNAL OR MANUAL
PERIOD RANGE	10 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	5
WIDTH RANGE	10 nS
MULTIPLIER	5
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Horizontal Display	A
Sweep Rate	**0.2 μs/cm**
Triggering	**+Internal, Normal**
Vertical Display	**A-B**
Input Attenuation	**100**
Millivolts/Cm	**20**

Input Coupling	**DC**
Comparison Voltage	
Range	0
Multiplier	0.000

PRELIMINARY PULSE CIRCUIT ADJUSTMENTS

4. Adjust Risetime Centering ⓿

a. Test equipment setup is shown in Fig. 7-8.

b. Turn off the Type R116 and position the instrument right side up.

c. Extend the Series F circuit card (Pulse Shape Generator) as shown in Figs. 7-8 and 7-9.

d. Turn on the Type R116.

e. Connect the negative lead of the voltmeter to the junction of R14 and the base of Q14 (see Fig. 7-9).

f. Connect the positive lead of the voltmeter to the junction of R36 and the base of Q34.

g. Check for — Meter reading of approximately 1 volt.

h. Adjust — R32 (T_r CENTERING) if the voltage is not correct.

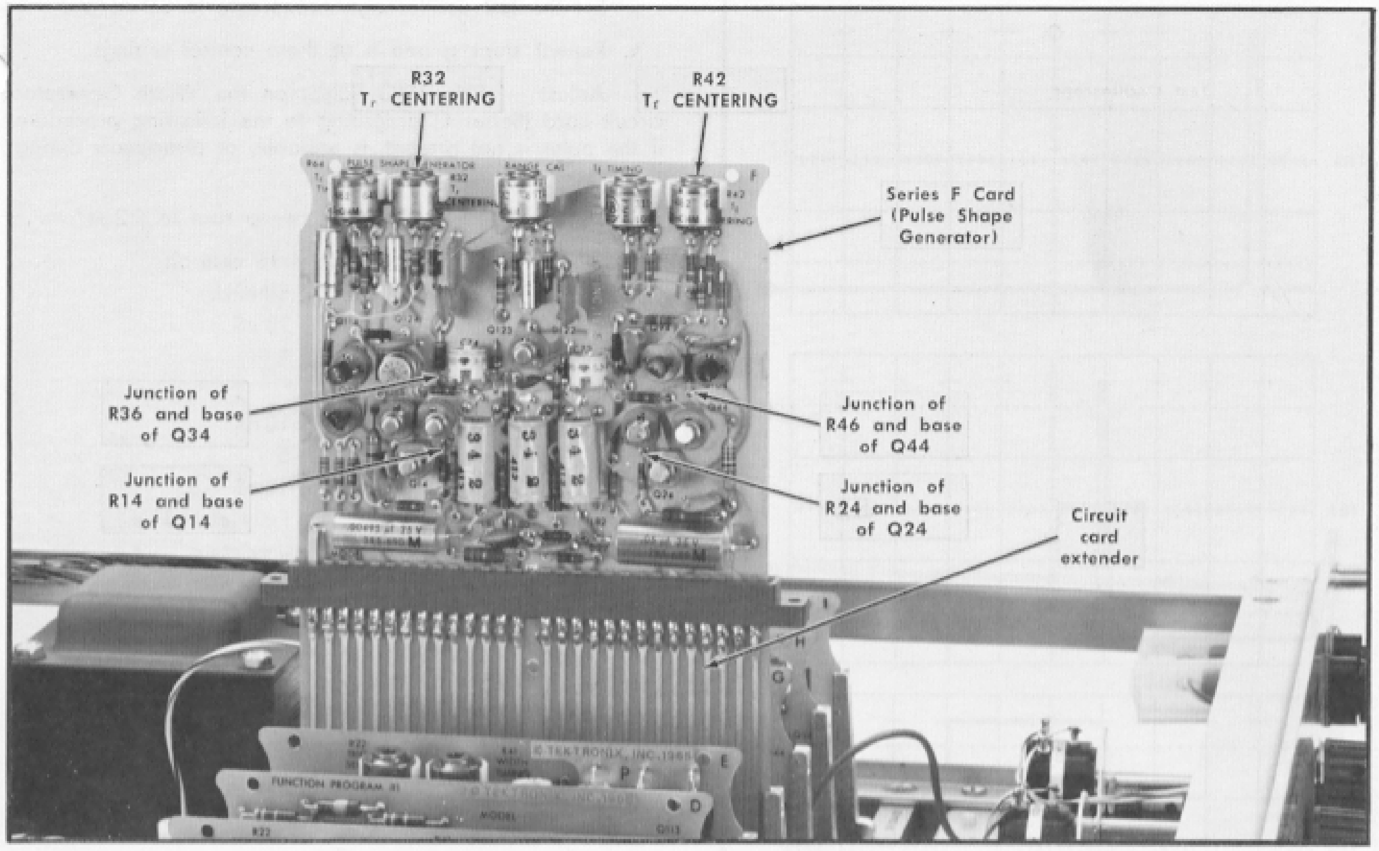


Fig. 7-9. Location of test points for setting risetime centering and falltime centering.

5. Adjust Falltime Centering

a. Connect the negative lead of the voltmeter to the junction of R24 and the base of Q24 (see Fig. 7-9).

b. Connect the positive lead of the voltmeter to the junction of R46 and the base of Q44.

c. Check for—Meter reading of approximately 1 volt.

d. Adjust — R42 (T_f CENTERING) if the voltage is not correct.

e. Disconnect the voltmeter.

f. Turn off the Type R116, remove the circuit card extender, re-insert the Series F card into its connector and turn on the Type R116.

6. Adjust Width and Delay Trigger Sensitivity

a. Set the Type R116 TRIGGER SOURCE switch to INTERNAL.

b. Set the test oscilloscope Trigger Source switch to External.

c. Connect the Type R116 output pulse signal through the terminated coaxial cable to the Channel 1 vertical input of the test oscilloscope.

d. Connect a coaxial cable from the Type R116 +PRETRIGGER OUT connector to the test oscilloscope External Trigger Input.

e. Trigger the test oscilloscope.

f. Set the Type R116 MODE switch to DLY'D SINGLE.

g. Observe the test oscilloscope display (see Fig. 7-10) while performing the following four operations:

1. Turn the DELAY OR BURST TIME MULTIPLIER control slowly clockwise to the fully clockwise position.

2. Turn the WIDTH MULTIPLIER control slowly clockwise to the fully clockwise position.

3. Turn the DELAY OR BURST TIME MULTIPLIER control slowly counterclockwise back to the 5 position.

4. Turn the WIDTH MULTIPLIER control slowly counterclockwise back to the 5 position.

h. Check for — Stable test oscilloscope display of the Type R116 delayed output pulse throughout the preceding checks.

i. Reset the following Type R116 controls:

PERIOD RANGE	1 mS
MULTIPLIER	Fully clockwise
DELAY OR BURST TIME	
RANGE	10 μS
WIDTH RANGE	10 μS

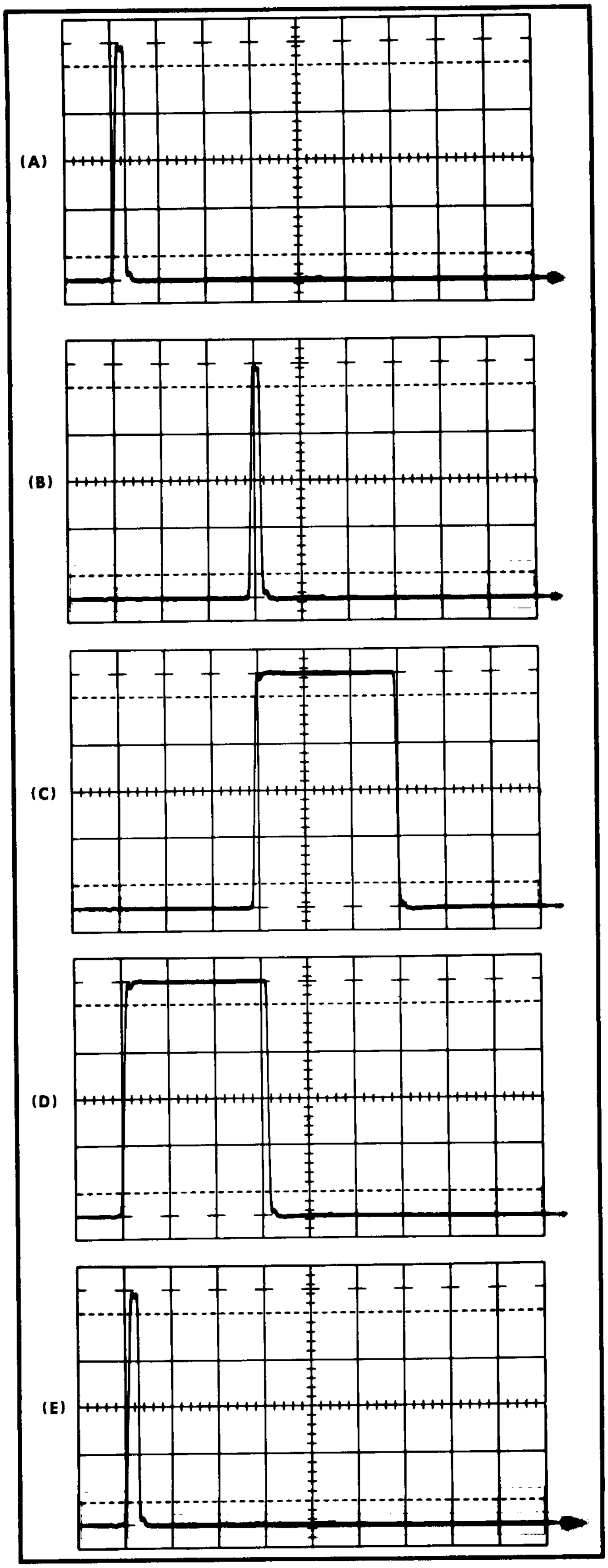


Fig. 7-10. Typical test oscilloscope displays obtained during check of width and delay trigger sensitivity adjustments (step 6g).

j. Set the test oscilloscope sweep rate to 0.2 ms/cm.

k. Repeat steps g and h at these control settings.

l. Adjust — R22 (TRIG SENS) on the Width Generator circuit card (Series E) according to the following procedure if the pulse is not present, is unstable, or disappears during the preceding checks.

1. Set the test oscilloscope sweep rate to 0.2 μs/cm.

2. Reset the following Type R116 controls:

MODE	SINGLE
PERIOD RANGE	10 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	5
WIDTH RANGE	10 nS
MULTIPLIER	Fully clockwise

3. Turn R22 (TRIG SENS) on the Series E card through its range of rotation and observe the region over which the Type R116 output pulse is present and stable.

4. Adjust R22 slowly clockwise through the stable pulse region and note the position of the falling edge of the pulse when the Width Generator just starts to free run.

5. Set R22 slightly short of the free-run position. The pulse width should just start to decrease from the maximum width present before free run, but should not decrease by more than 1 mm.

6. Turn the WIDTH MULTIPLIER to the 5 position. The pulse should still be present if the adjustment is correct.

7. Recheck the width and delay trigger sensitivity as given in steps f through k.

m. Adjust — R22 (TRIG SENS) on the Delay Generator circuit card (Series C) according to the following procedure if the delayed output pulse is still not stable after the width trigger sensitivity has been adjusted.

1. Set the test oscilloscope sweep rate to 0.2 μs/cm.

2. Reset the following Type R116 controls:

MODE	DLY'D SINGLE
PERIOD RANGE	10 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	5
WIDTH RANGE	10 nS
MULTIPLIER	Fully clockwise

3. Adjust R22 (on the Series C circuit card) through its range of rotation and note the region over which the pulse remains present and stable.

4. Set R22 as far counterclockwise as possible without causing the pulse to disappear.

5. Turn the WIDTH MULTIPLIER control to the 5 position. The pulse should still be present.

6. Recheck the width and delay trigger sensitivity as in steps g through k.

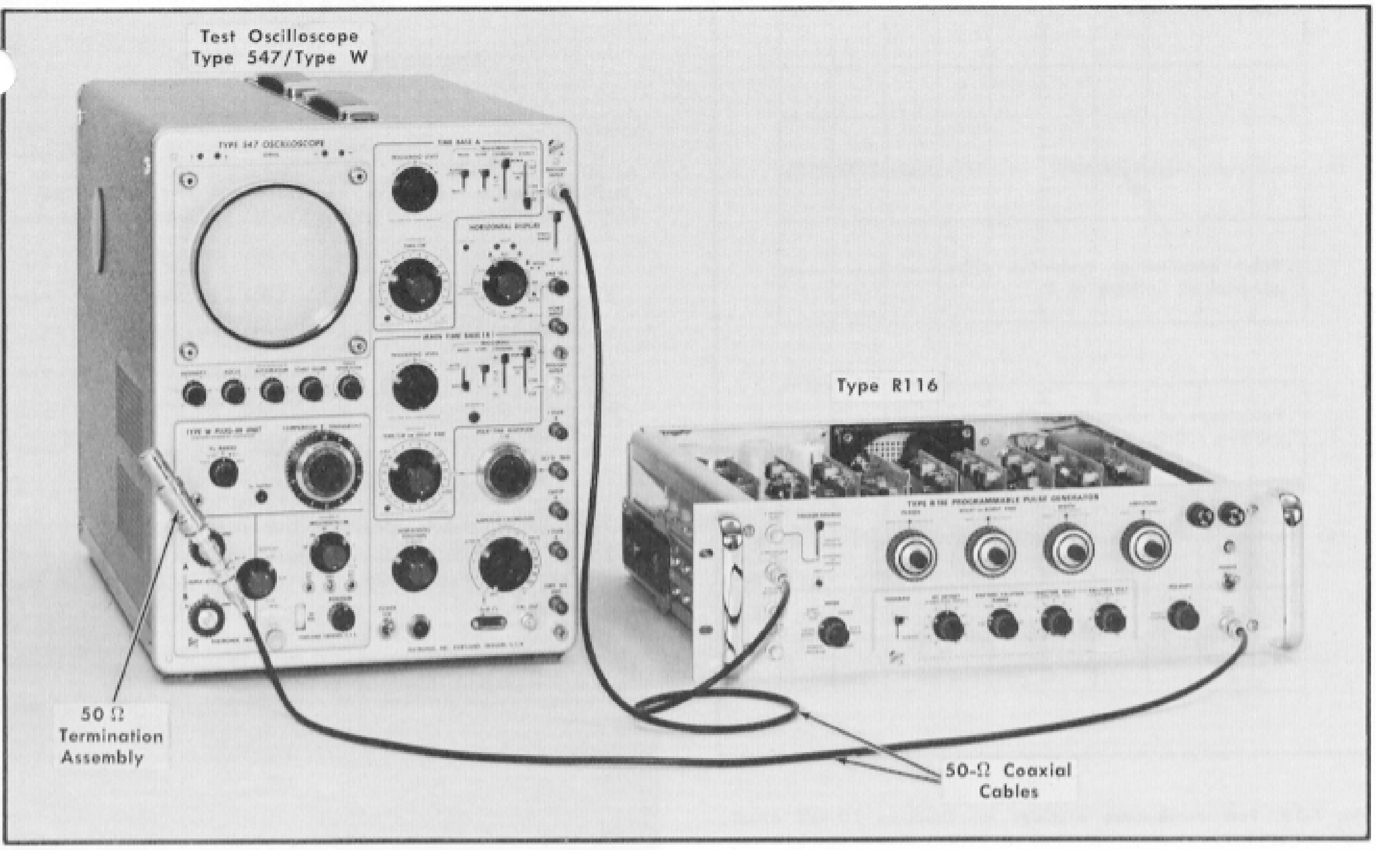


Fig. 7-11. Initial test equipment setup for calibration steps 7 through 9.

Control Settings

Type R116

MODE	**SINGLE**
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	**100 μS**
MULTIPLIER	**1**
DELAY OR BURST TIME	
RANGE	**10 μS**
MULTIPLIER	**5**
WIDTH RANGE	**10 μS**
MULTIPLIER	**5**
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	**20 μs/cm**
Triggering	+External, Normal
Vertical Display	**A-Vc**
Input Attenuation	**10**
Millivolts/Cm	20
Input Coupling	DC
Comparison Voltage	
Range	0
Multiplier	**10.000**

PULSE SHAPE GENERATOR (AMPLITUDE SECTION)

7. Adjust +Amplitude

a. Test equipment setup is shown in Fig. 7-11.

b. Trigger the test oscilloscope display.

c. Position the pulse baseline to the horizontal centerline of the test oscilloscope crt screen (see Fig. 7-12A).

d. Set the test oscilloscope Vc Range switch to +1.1.

e. Check for—Test oscilloscope display of pulse tops with the flattest portion of the tops at the horizontal centerline ±1.5 cm (10 volts ±3%). See Fig. 7-12B for the test oscilloscope display.

f. Adjust—R85 (RANGE CAL) on the Pulse Shape Generator circuit card (Series F) if the pulse amplitude is not correct. See Fig. 7-13 for the location of R85.

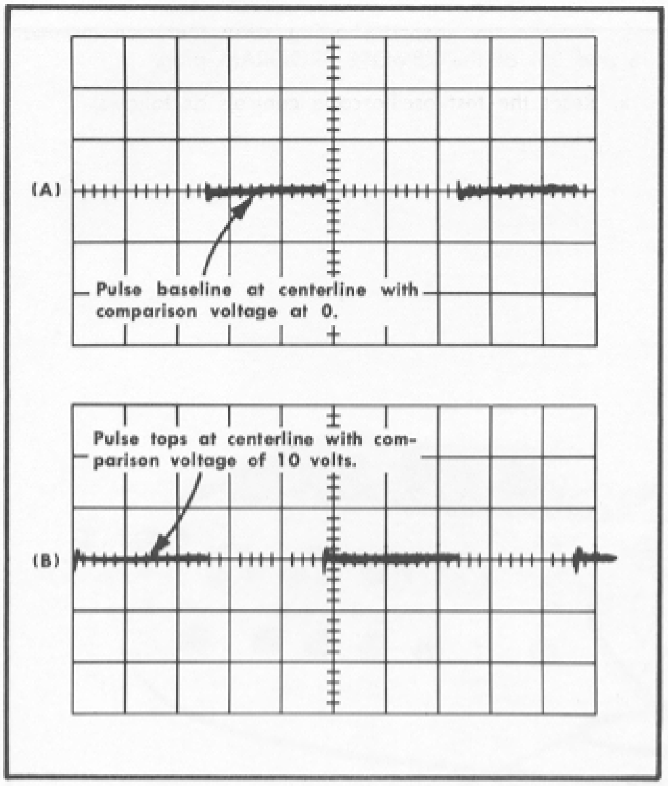


Fig. 7-12. Test oscilloscope displays for checking 10-volt amplitude adjustment.

g. Set the Type R116 AMPLITUDE MULTIPLIER control to 2.0.

h. Reset the following test oscilloscope controls:

Millivolts/Cm	5
Comparison Voltage	
RANGE	0
MULTIPLIER	2.000

i. Position the pulse baseline to the horizontal centerline of the test oscilloscope screen. (Use the Type R116 DC OFFSET control if necessary.)

j. Set the test oscilloscope Vc Range switch to +1.1.

k. Check for — Test oscilloscope display of the pulse tops with the flattest portion at the horizontal centerline ±1.2 cm (2 volts ±3%).

l. Adjust — R532 (AMPLITUDE MULT CAL) on the Type R116 chassis (see Fig. 7-13) if the display is not correct.

m. If R532 requires adjustment, reset the controls as given under Fig. 7-11 and recheck the amplitude adjustments as described in steps c through k.

8. Check Amplitude Accuracy

a. Set the AMPLITUDE RANGE, AMPLITUDE MULTIPLIER and test oscilloscope comparison voltage and deflection factor as given in Table 7-3.

TABLE 7-3

Amplitude Accuracy Check

AMPLITUDE RANGE	AMPLITUDE MULTIPLIER	Test Oscilloscope Input Atten.	mV/cm	Comp. Voltage Mult.	Voltage	Maximum displacement from centerline
1 V	10	10	20	10.000	10 V ±3%	±1.5 cm
.5 V	10	10	10	5.000	5 V ±3%	±1.5 cm
.2 V	10	10	5	2.000	2 V ±3%	±1.2 cm
.2 V	2	1	10	4.000	400 mV ±3%	±1.5 cm
.5 V	2	10	2	1.000	1 V ±3%	±1.5 cm
1 V	2	10	5	2.000	2 V ±3%	±1.2 cm

b. For each check, position the pulse baseline to the horizontal centerline of the test oscilloscope crt screen (see Fig. 7-12A) with the Vc Range switch set to 0, then set the switch to +1.1.

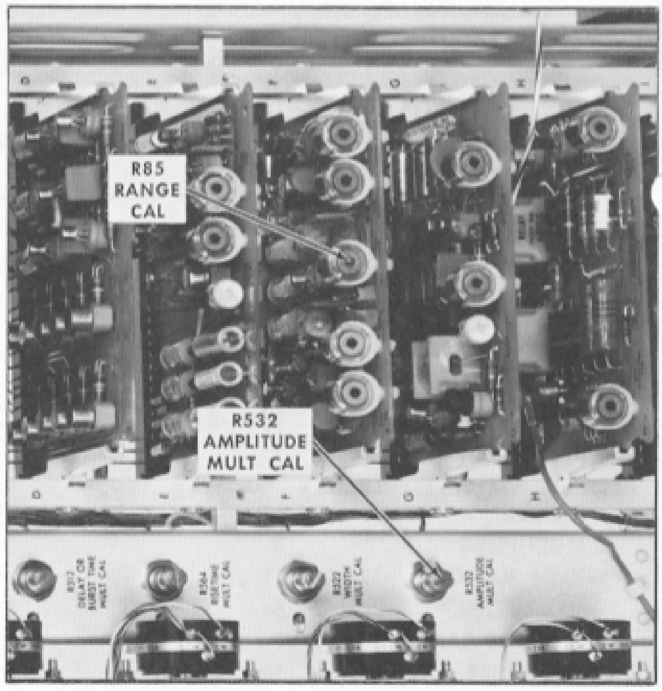


Fig. 7-13. Location of + amplitude calibration adjustments on the Pulse Shape Generator (Series F) card and the Type R116 chassis.

c. Check for — Test oscilloscope display of the pulse tops with the flattest portion of the tops at the horizontal centerline (see Fig. 7-12B), with the Vc Range switch at +1.1.

d. If the pulse amplitude is not within the required tolerance in any of the preceding checks, readjust R85 and/or R532 (see step 7) as necessary to bring the amplitude within tolerance on all ranges.

9. Check Remote Amplitude

a. Turn off the Type R116 and install the special remote program checker on the rear-panel REMOTE PROGRAM connector. Turn on the Type R116 again.

b. Connect a shorting strap between terminal 1 of the REMOTE PROGRAM plug and the wire (not one of the program resistors) connected to terminal 27.

c. Set the Type R116 AMPLITUDE RANGE switch to REMOTE.

d. Reset the test oscilloscope controls as follows:

Input Attenuation	1
Millivolts/Cm	10
Comparison Voltage	
Range	0
Multiplier	4.000

e. Position the base of the pulse display to the horizontal centerline.

f. Set the Vc Range switch to +1.1.

g. Check for—Test oscilloscope display of the pulse tops at the horizontal centerline ±2 cm (400 mV ±5%).

h. Connect a second shorting strap between terminal 36 and each of the terminals indicated in Table 7-4.

i. Check for—Test oscilloscope display as indicated in the last column of Table 7-4.

TABLE 7-4

Remote Amplitude Range Check

Short Between Terminals	Oscilloscope			Amplitude	
	Input Atten	mV/cm	Comp. Voltage Mult.	Voltage	Max. displacement from centerline
36 and 24	1	50	10.000	1 V ±5%	±1 cm
36 and 25	10	10	2.000	1 V ±5%	±1 cm

j. Remove the second shorting strap (between terminals 36 and 25) of the REMOTE PROGRAM plug.

k. Reset the test oscilloscope controls as follows:

Millivolts/Cm	5
Comparison Voltage	
Range	0
Multiplier	1.200

(The Input Attenuation switch should be at 10.)

l. Move the shorting strap from terminal 27 to the 4.42 kΩ resistor connected to the same terminal.

m. Position the pulse baseline to the horizontal centerline of the test oscilloscope.

n. Set the test oscilloscope Vc Range switch to +1.1.

o. Check for—Test oscilloscope display of the pulse tops at the horizontal centerline ±1.4 cm (1.2 volts ±6%).

p. Move the shorting strap from the 4.42-kΩ resistor to the 8.87-kΩ resistor connected to the same terminal (27).

q. Reset the following test oscilloscope controls:

Millivolts/Cm	10
Comparison Voltage	
Range	0
Multiplier	2.000

(The Input Attenuation switch should be at 10.)

r. Position the pulse baseline to the horizontal centerline of the test oscilloscope.

s. Set the test oscilloscope Vc Range switch to +1.1.

t. Check for—Test oscilloscope display with pulse tops at the horizontal centerline ±1.2 cm (2 volts ±6%).

u. Remove the shorting strap.

NOTES

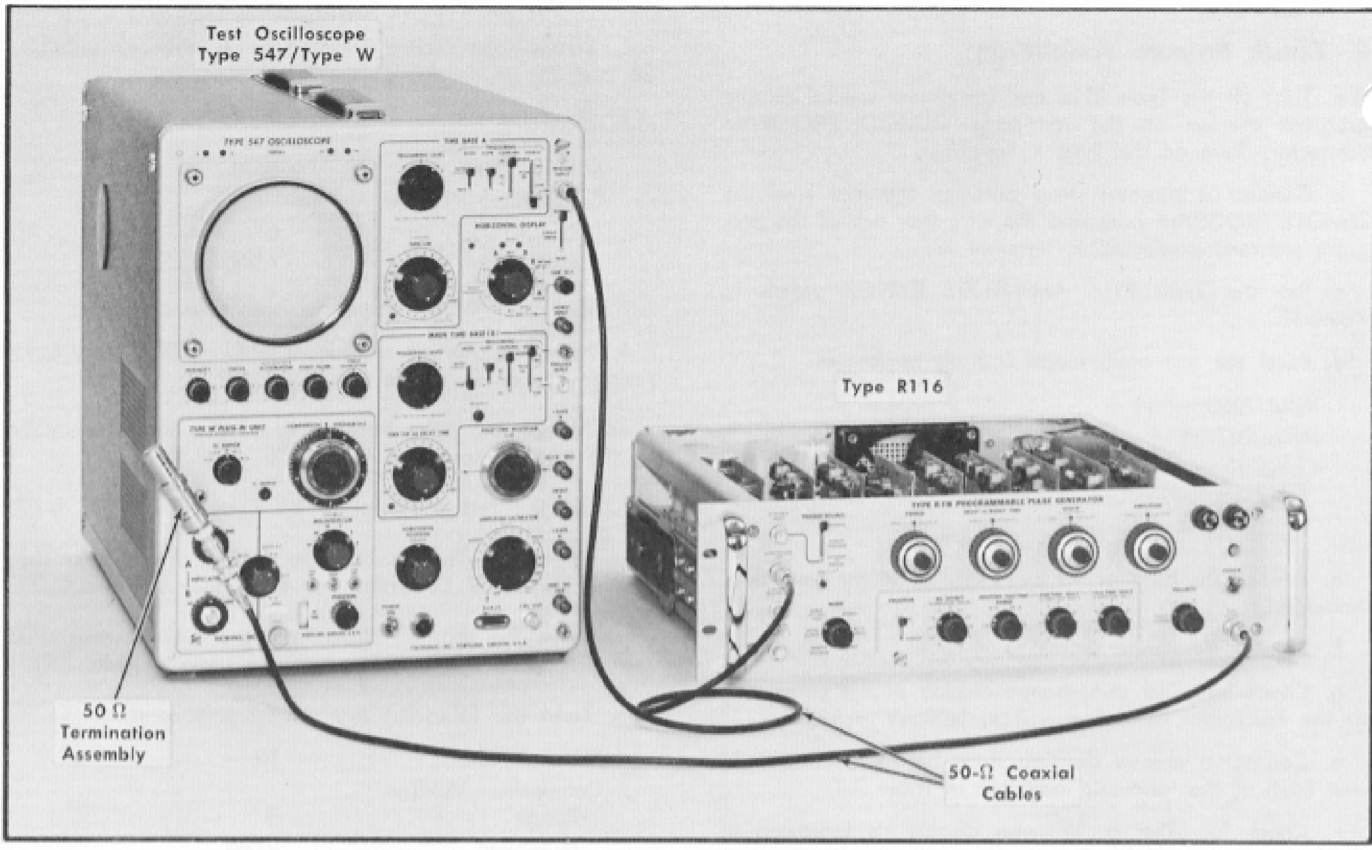


Fig. 7-14. Initial test equipment setup for calibration steps 10 through 12.

Control Settings

Type R116

MODE	SINGLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	**10 μS**
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 μS
MULTIPLIER	5
WIDTH RANGE	**100 nS**
MULTIPLIER	**20**
AMPLITUDE RANGE	**1 V**
MULTIPLIER	**10**
POLARITY	**—**
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	**2 μs/cm**
Triggering	+External, Normal
Vertical Display	A—Vc
Input Attenuation	10
Millivolts/Cm	**20**
Input Coupling	DC
Comparison Voltage	
Range	**0**
Multiplier	**10.000**

OUTPUT AMPLIFIER

10. Adjust —AMPLITUDE

a. Test equipment setup is shown in Fig. 7-14.

b. Position the pulse baseline to the horizontal centerline of the test oscilloscope.

c. Set the Vc Range switch to —1.1.

d. Check for—Test oscilloscope display of the negative-going pulse tops (most negative excursions) at the horizontal centerline ±1.5 cm (10 volts ±3%).

e. Adjust—R42 (—AMPLITUDE) on the Output Amplifier circuit card (Series G) if the negative-going amplitude is not correct. See Fig. 7-15 for the location of R42. Switch the Vc Range switch between the —1.1 and 0 positions while making the adjustment. When the —AMPLITUDE control is properly adjusted, the alternate appearances of the waveform top and baseline will be displayed at the same level on the graticule as the Vc Range switch is operated.

f. If R42 requires adjustment, recheck steps b through d.

g. Set the Vc Range switch to 0.

h. Disconnect the terminated cable from the vertical input of the test oscilloscope.

11. Adjust —DC LEVEL 0

a. Install two 1× probes on the test oscilloscope vertical input connectors.

b. Reset the following test oscilloscope controls:

Display Mode	A-B
Input Attenuation	100
Deflection Factor	20

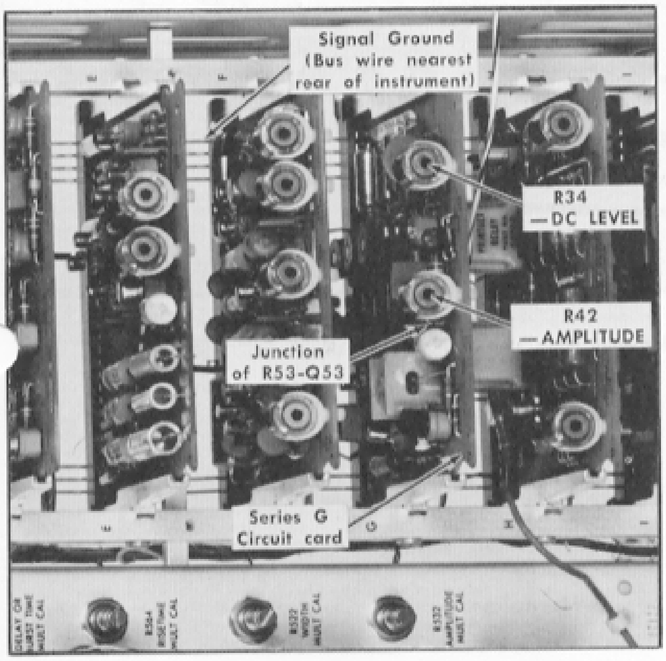


Fig. 7-15. Location of test points for checking — amplitude and — dc level adjustments.

c. Set the Type R116 POLARITY switch to +.

d. Connect the Channel B test probe tip to signal ground (terminal 1 of the REMOTE PROGRAM checker).

e. Connect the Channel A test probe tip to the end of R53 (the emitter of Q53) on the Output Amplifier circuit card (Series G). See Fig. 7-15.

f. Position the pulse baseline 1 cm below the horizontal centerline of the test oscilloscope.

g. Set the POLARITY switch to —.

h. Check for—Test oscilloscope display with the signal envelope of the negative-going pulse at the same level as that of the positive-going pulse ±1 mm (see Fig. 7-16).

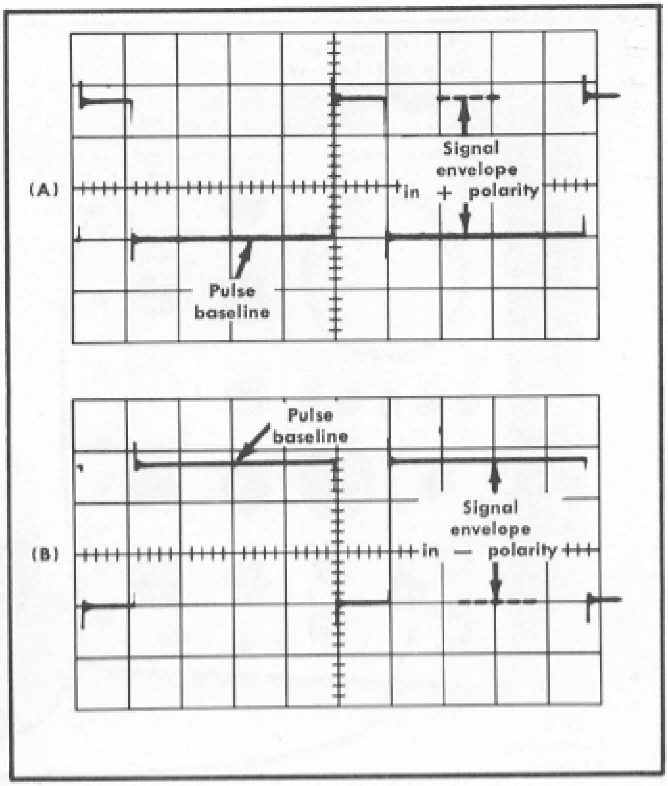


Fig. 7-16. Test oscilloscope displays for checking — polarity dc level at the emitter of Q53 (see step 11), with respect to signal ground.

i. Adjust—R33 (—DC LEVEL) on the Series G card if the signal level is not correct.

j. Disconnect the two probe tips from the Type R116 and remove the probes from the vertical input connectors of the test oscilloscope.

12. Check Remote Polarity

a. Connect the terminated Type R116 pulse to the Channel A vertical input of the test oscilloscope.

b. Set the POLARITY switch to REMOTE PROGRAM.

c. Set the test oscilloscope Millivolts/Cm switch to 50. The Input Attenuation switch should still be at 100.

d. Position the baseline of the pulse display at the horizontal centerline of the test oscilloscope crt screen.

e. Check for—Test oscilloscope display of the positive-going pulse.

f. Connect a shorting strap between terminals 36 and 18 of the REMOTE PROGRAM plug.

g. Check for—Test oscilloscope display of the negative-going pulse.

h. Remove the shorting strap.

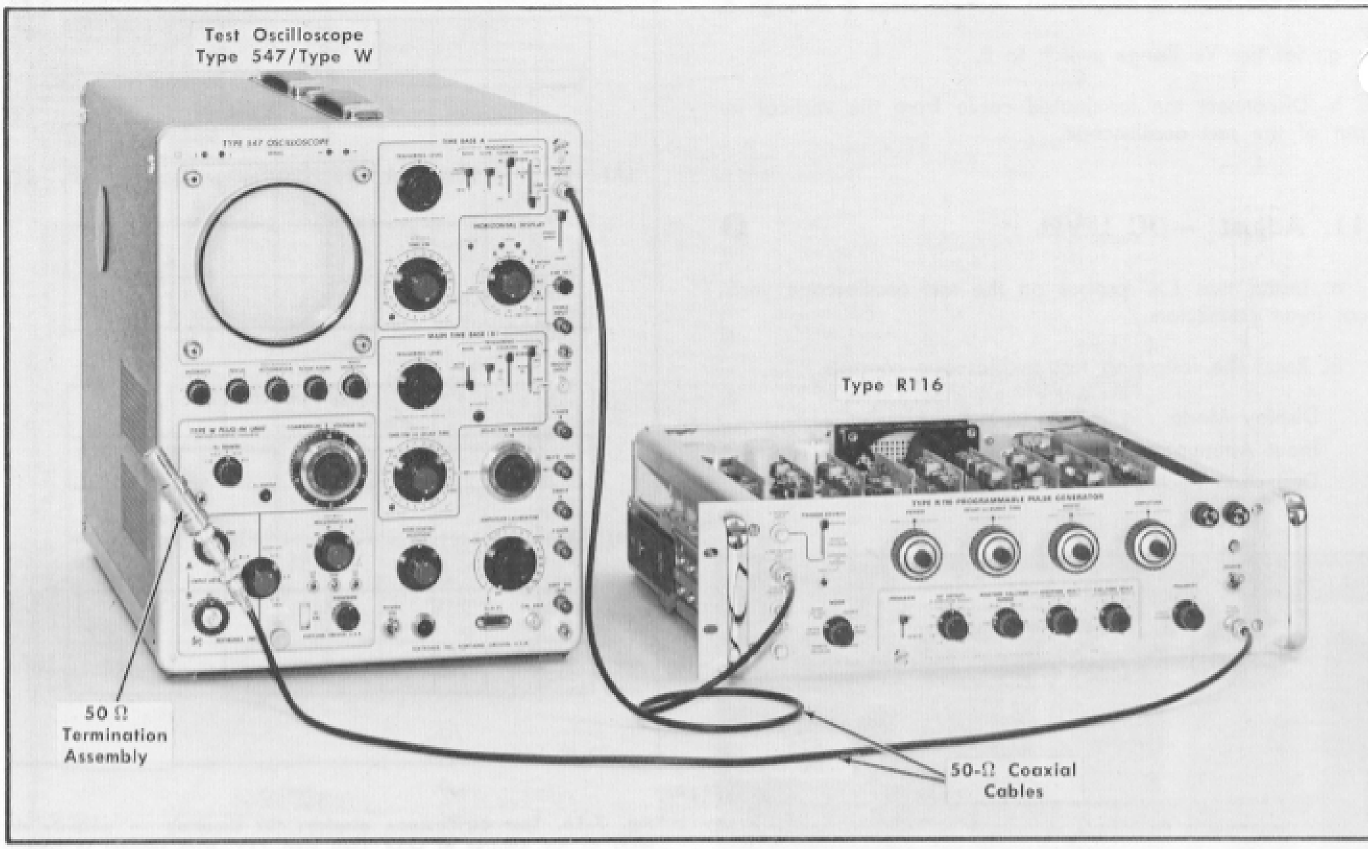


Fig. 7-17. Initial test equipment setup for calibration steps 13 through 18.

Control Settings

Type R116

MODE	SINGLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	10 μs
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 μS
MULTIPLIER	5
WIDTH RANGE	100 nS
MULTIPLIER	20
AMPLITUDE RANGE	1 V
MULTIPLIER	2
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	2 μs/cm
Triggering	+External, Normal
Vertical Display	A-Vc
Input Attenuation	10
Millivolts/Cm	20
Input Coupling	DC
Comparison Voltage	
Range	+1.1
Multiplier	5.000

OFFSET CURRENT GENERATOR

13. Adjust Offset Range

a. Test equipment setup is shown in Fig. 7-17.

b. Set the front-panel DC OFFSET control exactly to the +5 position.

c. Trigger the test oscilloscope display.

d. Position the baseline of the pulse display to the horizontal centerline of the test oscilloscope.

e. Set the DC OFFSET control exactly to the −5 position.

f. Set the test oscilloscope Vc Range switch to −1.1.

g. Check for—Test oscilloscope display of the pulse waveform with the pulse baseline at the horizontal centerline ±0.5 cm.

Ⓐ

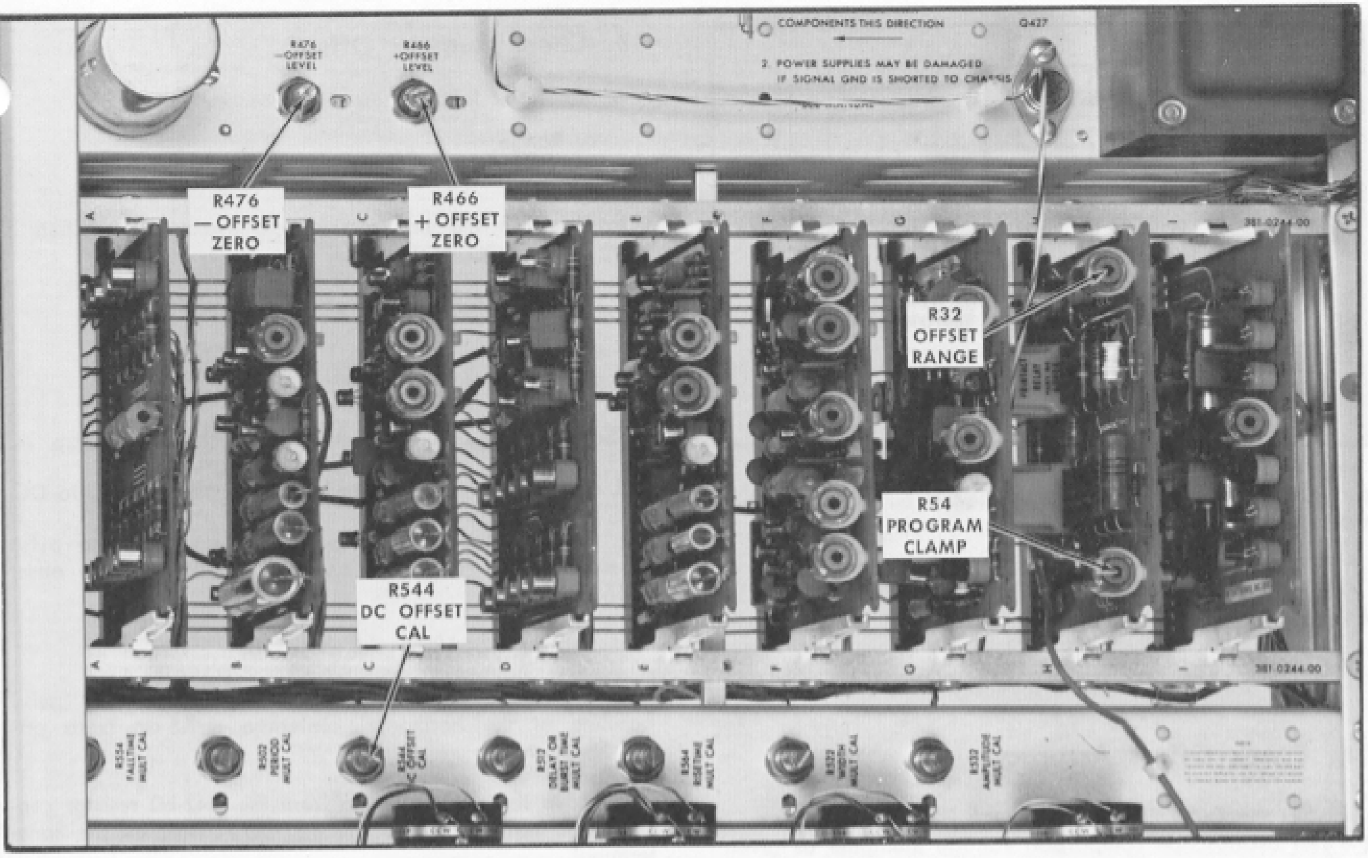


Fig. 7-18. Location of offset current adjustments on the Attenuator (Series H) card and on the Type R116 chassis.

h. Adjust—R32 (OFFSET RANGE) on the attenuator circuit card (Series H) if the offset range is not correct. See Fig. 7-18 for the location of R32.

i. If R32 requires adjustment, recheck the offset range as in steps b through g.

14. Adjust Offset Registration

a. Reset the following test oscilloscope controls:

Millivolts/Cm	10
Comparison Voltage Range	0

b. Connect shorting straps between the following terminals of the REMOTE PROGRAM plug: 2 and 31; 3 and 32; 36 and 28.

c. Connect a shorting strap from terminal 1 to the 4.42-kΩ resistor connected to terminal 33 (for zero offset).

d. Set the PROGRAM switch to REMOTE.

e. Position the baseline of the pulse display to the horizontal centerline of the test oscilloscope.

f. Set the front-panel DC OFFSET control exactly to the 0 position.

g. Set the PROGRAM switch to INT.

h. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline ±5 mm (see Fig. 7-19).

i. Adjust—R544 (DC OFFSET CAL) on the Type R116 chassis (see Fig. 7-18) if the baseline level is not correct.

j. Leave the shorting straps on the REMOTE PROGRAM plug for the remote offset check (step 17).

15. Adjust Offset Zero Levels

a. Set the test oscilloscope Input Coupling switch to Gnd.

b. Free run the trace and position it to the horizontal centerline.

c. Set the test oscilloscope Input Coupling switch to DC.

d. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline ±5 mm (zero volts ±50 mV) with the DC OFFSET control set exactly at 0.

e. Adjust—R466 (+OFFSET ZERO) on the Type R116 chassis (see Fig. 7-18) if the offset zero level is not correct.

f. Set the Type R116 front-panel POLARITY switch to —.

g. Check for—Test oscilloscope display with the baseline of the negative-going pulse at the horizontal centerline ±5 mm (zero volts ±50 mV).

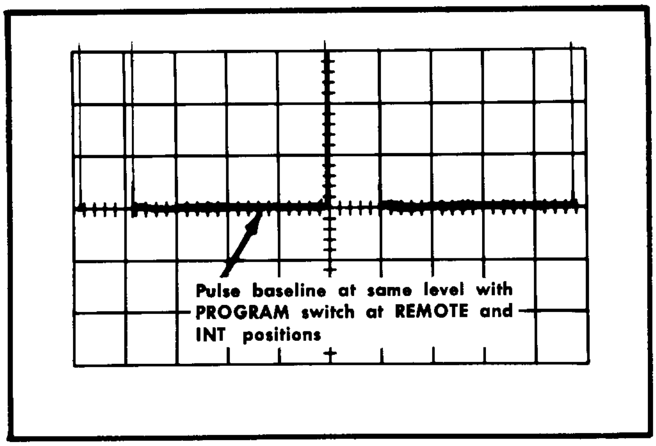


Fig. 7-19. Typical test oscilloscope display for checking offset registration (see step 14).

h. Adjust—R476 (—OFFSET ZERO) on the Type R116 chassis (see Fig. 7-18) if the offset zero level is not correct.

i. Set the POLARITY switch to +.

16. Check Offset Accuracy

a. Set the DC OFFSET control, the POLARITY switch and the test oscilloscope comparison voltage multiplier as given in Table 7-5.

b. For each check, position the trace to the horizontal centerline with the test oscilloscope Vc Range switch set to 0 and the Input Coupling switch at Gnd, then set the Input Coupling switch to DC and the Vc Range switch as indicated in the table.

c. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline ±1.5 cm (150 mV), as indicated in the Offset (Internal) column of Table 7-5. The checks on the 1 V amplitude range cover the .5 V and .2 V ranges as well, since the attenuator was checked previously.

TABLE 7-5

DC OFFSET	POLARITY	Oscilloscope: Comp. Voltage Mult.	Oscilloscope: Vc Range	Oscilloscope: Voltage	Offset Baseline Displacement from Centerline: Internal	Offset Baseline Displacement from Centerline: Remote
—5	+	5.000	—1.1	—5 V	±1.5 cm (150 mV)	±2.5 cm (250 mV)
—5	—	5.000	—1.1	—5 V	±1.5 cm	±2.5 cm
+5	—	5.000	+1.1	+5 V	±1.5 cm	±2.5 cm
+5	+	5.000	+1.1	+5 V	±1.5 cm	±2.5 cm

d. If the offset is outside the required tolerance limits in any of the preceding checks, readjust R32 (step 13), R466 (step 15) or R476 (step 15) as required to bring all offset levels within tolerance. If R32 is readjusted, recheck the setting of R544 (step 14).

17. Check Remote Offset

a. Reset the following test oscilloscope controls:

Vc Range	0
Input Coupling	Gnd

b. Free run the test oscilloscope trace and position it to the horizontal centerline.

c. Reset the following Type R116 controls:

PROGRAM	REMOTE
POLARITY	+

Shorting straps should still be connected as in step 14.

d. Set the test oscilloscope Input Coupling switch to DC.

e. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline ±1.5 cm (zero offset ±150 mV).

f. Set the POLARITY switch to —.

g. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline ±1.5 cm (zero offset ±150 mV).

h. Move the shorting strap from the 4.42-kΩ resistor connected to terminal 33 to the 8.87-kΩ resistor on the same terminal.

i. Set the POLARITY switch and the test oscilloscope comparison voltage multiplier as given for the —5 settings of the DC OFFSET control in Table 7-5.

j. For each check, position the trace to the horizontal centerline (with the test oscilloscope Vc Range switch set to 0 and the Input Coupling switch at Gnd), then set the Input Coupling switch to DC and the Vc Range switch as indicated in the table.

k. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline ±2.5 cm (250 mV), as given in the Offset (Remote) column of Table 7-5.

l. Move the shorting strap from the 8.87-kΩ resistor to the wire connected to terminal 33.

m. Repeat steps i through k for the +5 settings of the DC OFFSET control given in Table 7-5.

18. Adjust Program Clamp ❶

a. Remove the shorting strap connected between terminal 1 and terminal 33.

b. Reset the following test oscilloscope controls:

Input Attenuation	100
Input Coupling	Gnd
Comparison Voltage Range	0

c. Free run the trace and position it to the horizontal centerline.

d. Set the oscilloscope Input Coupling switch to DC.

e. Check for—Test oscilloscope display with the pulse baseline at the horizontal centerline ±1 cm (±1 volt offset).

f. Set the Type R116 POLARITY switch to —.

g. Repeat step e for the negative-going pulse.

h. Adjust—R54 (PROGRAM CLAMP) on the Series H card (see Fig. 7-24) for a compromise setting between the two polarities if the program clamp level is not correct in + and/or — polarity.

i. Remove the shorting straps.

j. Disconnect the 50-Ω termination from the vertical input of the test oscilloscope.

k. Remove the Type W Plug-In Unit from the test oscilloscope and insert the Type 1A1 or 1A2 Plug-In Unit.

l. Allow several minutes for the plug-in unit to warm up before continuing with the calibration procedure.

NOTES

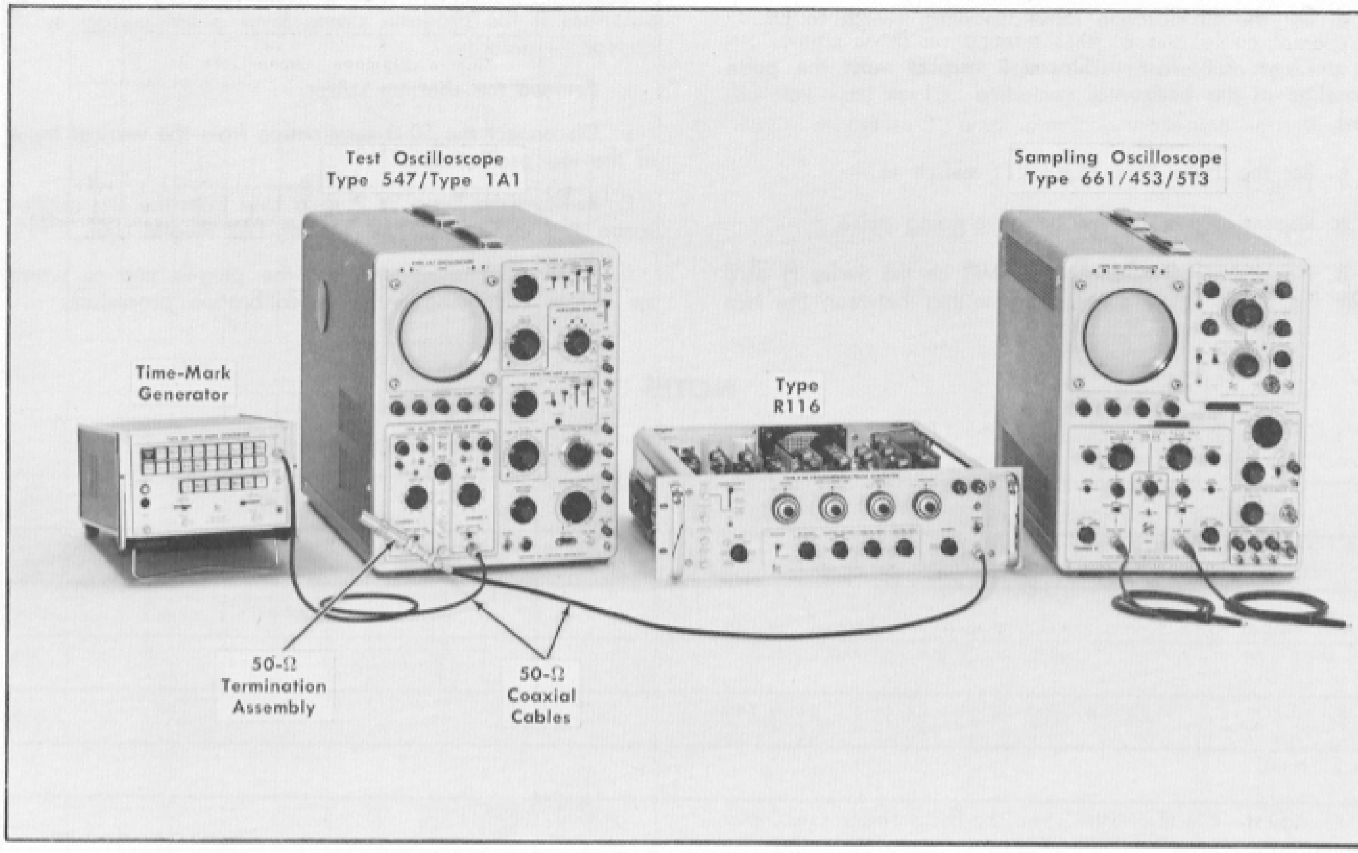


Fig. 7-20. Initial test equipment setup for calibration steps 19 through 25.

Control Settings

Type R116

MODE	SINGLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	**1 mS**
MULTIPLIER	**5**
DELAY OR BURST TIME	
RANGE	10 μS
MULTIPLIER	5
WIDTH RANGE	**10 μS**
MULTIPLIER	**50**
AMPLITUDE RANGE	**1 V**
MULTIPLIER	**10**
POLARITY	**+**
PROGRAM	**INT**
DC OFFSET	**0**
RISETIME FALLTIME RANGE	**1 μS**
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	**20 μs/cm**
Triggering	**Internal, Normal**
Vertical Mode	**Channel 2**
Deflection Factor	
Channel A	**2 V/cm**
Channel B	**2 V/cm**
Input Coupling	**DC**

Sampling Oscilloscope

Horizontal Display	×1
Amplitude Calibrator	Off
Equivalent Sweep Rate	20 ns/cm
Triggering	+ External 50 Ω AC
Sampling Density	100/cm
Sweep Mode	Normal
Vert. Deflection Factor	200 mV/cm
Vertical Mode	A Only
Smoothing (Both Channels)	Counterclockwise
Noise-Risetime	Low Noise
Display	Normal
Time Position	Minimum Delay

PULSE SHAPE GENERATOR (RAMP SECTION)

19. Adjust Slow Risetime and Falltime ⓘ

a. Test equipment setup is shown in Fig. 7-20.

b. Connect the terminated Type R116 output pulse to the test oscilloscope Channel 1 vertical input.

Ⓐ

c. Connect the time-mark generator marker output through a coaxial cable and a 50-Ω termination (BNC connectors) to the test oscilloscope Channel 2 vertical input.

d. Set the time-mark generator or a 10-μs marker output.

e. Trigger the test oscilloscope display.

f. If the test oscilloscope display does not contain exactly 2 markers/cm over the center 8 cm, adjust the variable sweep rate control to provide correct timing (see Fig. 7-21A).

g. Set the test oscilloscope Vertical Mode switch to Channel 1.

h. Set the RISETIME MULT and FALLTIME MULT controls exactly to the 10 position.

i. If the display amplitude is not exactly 5 cm, adjust the test oscilloscope variable Volts/Cm control to provide the correct amplitude for measuring risetime and falltime.

j. Trigger the test oscilloscope display to observe the rise of the Type R116 output pulse, as shown in Fig. 7-21B.

k. Check for — Test oscilloscope display of the pulse rise (see Fig. 7-21B) with a risetime of 100 μs ±5% (5 cm ±2.5 mm).

l. Adjust—R64 (T_r TIMING) on the Pulse Shape Generator circuit card (Series F) if the display is not correct. See Fig. 7-22 for the location of R64.

m. Set the test oscilloscope trigger slope switch to —.

n. Trigger the test oscilloscope on the negative-going slope of the waveform.

o. Check for — Test oscilloscope display of the pulse fall (see Fig. 7-21C) with a falltime of 100 μs ±5% (5 cm ±2.5 mm).

p. Adjust — R54 (T_f TIMING) on the Series F card if the falltime is not correct.

q. Set the RISETIME MULT and FALLTIME MULT controls to the 1 position.

r. Reset the following test oscilloscope controls:

Sweep Rate	2 μs/cm
Trigger Slope	+

s. Set the time-mark generator for a 1-μs marker output.

t. Set the test oscilloscope Vertical Mode switch to Channel 2.

u. Check the test oscilloscope display for exactly 2 markers/cm over the center 8 cm and adjust the variable sweep rate control if necessary.

v. Set the test oscilloscope Vertical Mode switch to Channel 1.

w. Trigger the test oscilloscope on the pulse rise.

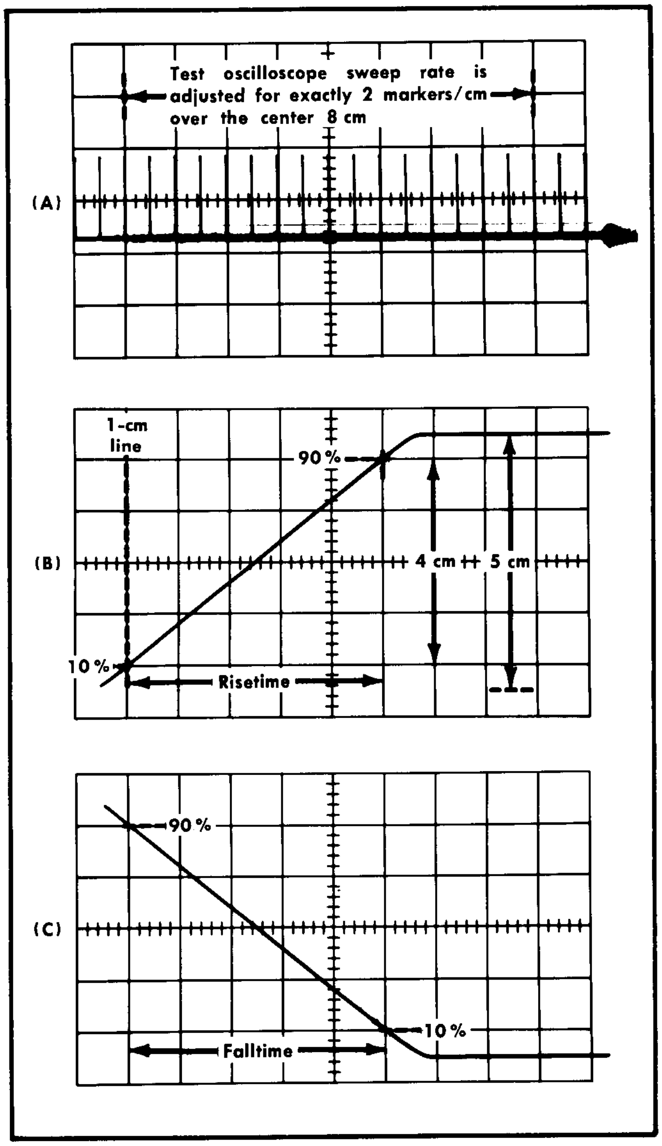


Fig. 7-21. Typical test oscilloscope displays for checking risetime and falltime of the Type R116 output pulse. (100 μs risetime and falltime are shown.)

x. Check for — Test oscilloscope display showing risetime of 10 μs ±5% (5 cm ±2.5 mm).

y. Adjust — R564 (RISETIME MULT CAL) on the Type R116 chassis (see Fig. 7-22) if the risetime is not correct.

z. Set the test oscilloscope trigger slope switch to —.

aa. Adjust the test oscilloscope triggering to display the negative-going portion of the waveform.

bb. Check for — Test oscilloscope display of the pulse fall with a falltime of 10 μs ±5% (5 cm ±2.5 mm).

cc. Adjust — R554 (FALLTIME MULT CAL) if the falltime is not correct.

dd. If R564 and/or R554 are adjusted, set the test oscilloscope Vertical Mode switch to Channel 2, then recheck the adjustment of R64 and R54 in steps d through p.

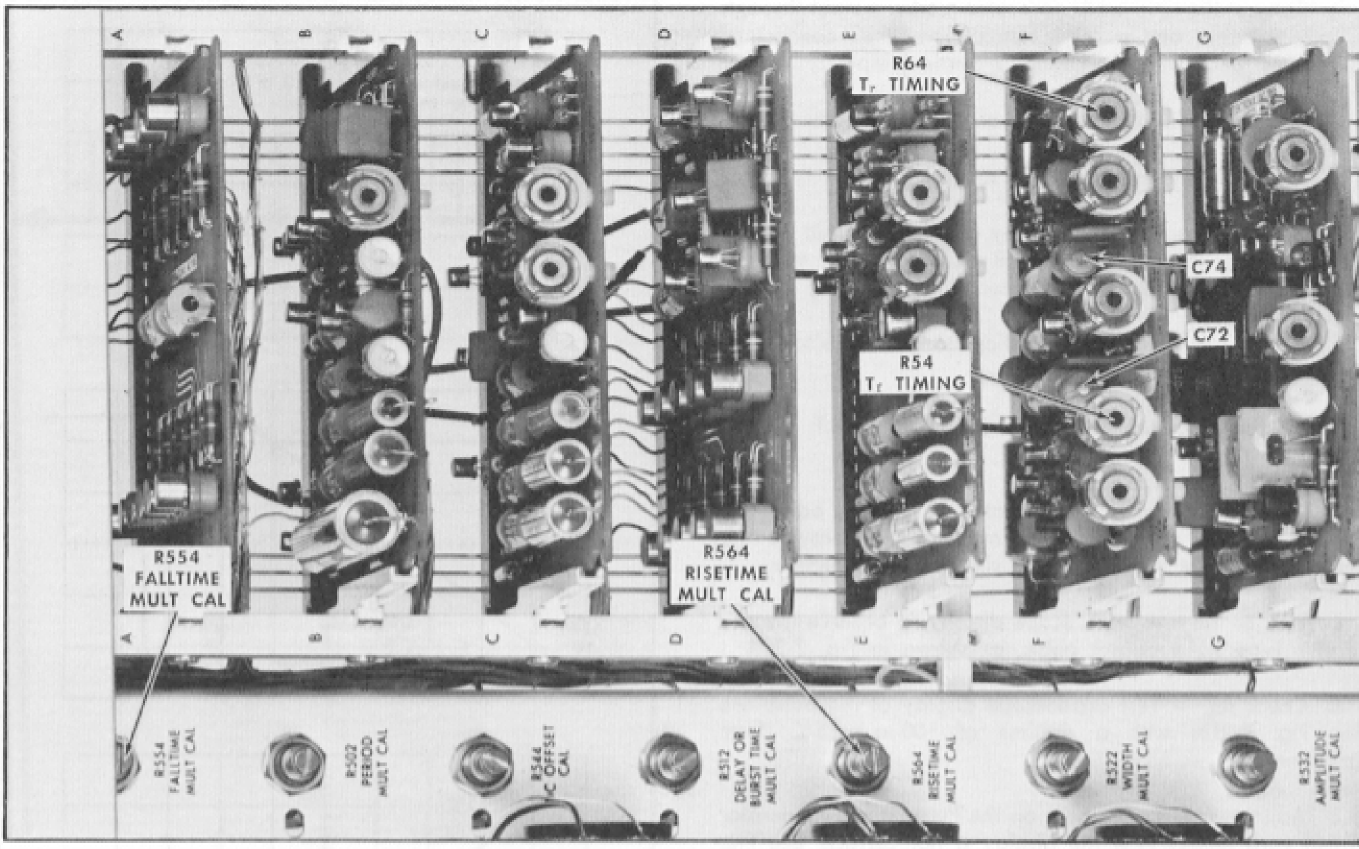


Fig. 7-22. Location of risetime and falltime adjustments on the Pulse Shape Generator (Series F) card and on the Type R116 chassis.

TABLE 7-6

Slow Risetime and Falltime Accuracy Check

PERIOD RANGE	WIDTH RANGE	RISETIME MULT and FALLTIME MULT	RISETIME FALLTIME RANGE	Time Markers	Oscilloscope Sweep Rate	Oscilloscope Trig-gering	Risetime or Falltime Time	Risetime or Falltime Display
1 mS	10 μS	11	1 μS	10 μs	20 μs/cm	+ —	110 μs ±5% 110 μs ±5%	5.5 cm ±2.75 mm 5.5 cm ±2.75 mm
1 mS	10 μS	11	100 nS	1 μs	2 μs/cm	+ —	11 μs ±5% 11 μs ±5%	5.5 cm ±2.75 mm 5.5 cm ±2.75 mm
1 mS	10 μS	1	1 μS	1 μs	2 μs/cm	+ —	10 μs ±5% 10 μs ±5%	5 cm ±2.5 mm 5 cm ±2.5 mm
100 μS	1 μS	1	100 nS	0.1 μs	0.2 μs/cm	+ —	1 μs ±5% 10 μs ±5%	5 cm ±2.5 mm 5 cm ±2.5 mm

20. Check Slow Risetime and Falltime Accuracy

a. Set the PERIOD MULTIPLIER control to 2.

b. Set the Type R116 controls, the time-mark generator and the test oscilloscope controls as given in Table 7-6. On each sweep rate, check the display timing by observing the time-mark signal (Channel 2) and adjusting the variable sweep rate control if necessary, then display the Type R116 output pulse.

c. Check for — Test oscilloscope displays of the pulse rise or pulse fall with risetimes and falltimes as indicated in the table.

d. If the risetime and/or falltime are out of tolerance in any of the preceding checks, readjust R64, R54, R564 or R554 (see step 19) as required to bring the timing within tolerance over the 1-μs to 110-μs range.

21. Adjust +Pulse Overshoot

a. Disconnect the Type R116 output pulse and +Pretrigger Out pulse from the test oscilloscope.

b. Connect the Type R116 output pulse to Channel A of the sampling oscilloscope as shown in Fig. 7-23.

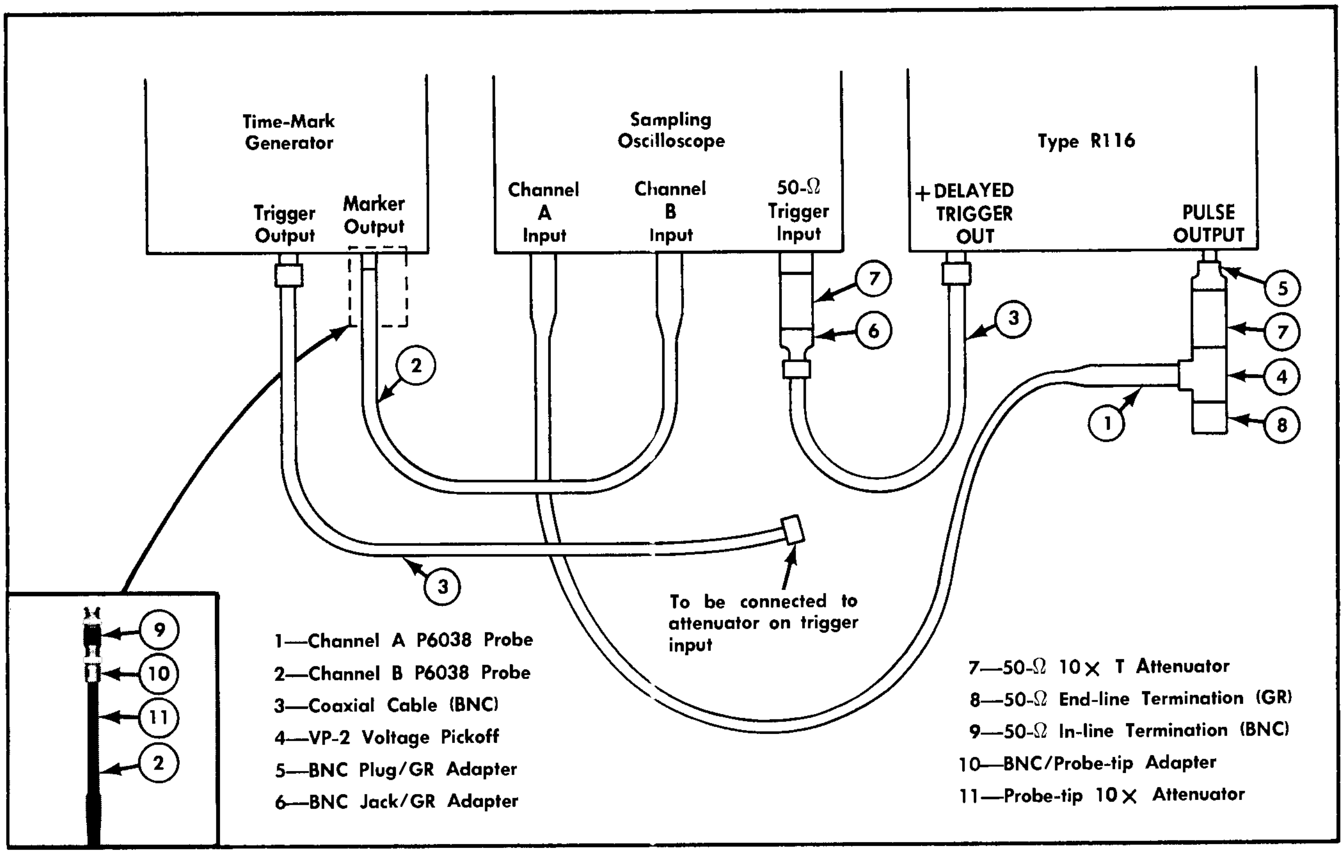


Fig. 7-23. Suggested initial connections for observing the Type R116 output pulse and timing signal on the sampling oscilloscope.

c. Connect the Type R116 +Delayed Trigger Out pulse to the sampling oscilloscope 50-Ω External Trigger Input as shown in Fig. 7-23.

d. Reset the following Type R116 controls:

PERIOD RANGE	100 nS
MULTIPLIER	3
DELAY OR BURST TIME RANGE	10 nS
MULTIPLIER	5
WIDTH RANGE	10 nS
MULTIPLIER	5
RISETIME FALLTIME RANGE	1 nS

e. Trigger the sampling oscilloscope display.

f. Adjust the Channel A Smoothing control for unity gain (see the Type 4S3 manual).

g. Position one pulse into the sampling oscilloscope screen with the Type R116 DELAY OR BURST TIME MULTIPLIER control. The DELAY OR BURST TIME MULTIPLIER control should be set for the most stable sampling display.

h. Magnify the sweep rate to 5 ns/cm.

i. Time-position the pulse onto the screen with the sampling oscilloscope Time Position control.

j. Increase the sampling oscilloscope vertical deflection factor to 20 mV/cm.

k. Vertically position the pulse top onto the crt screen.

l. Check for — Sampling oscilloscope display of the pulse top with no more than 1.5 cm (3%) of overshoot or short-time rounding at the front corner of the pulse and no more than 1.5 cm (3%) of aberrations or tilt on the pulse top (see Fig. 7-24A).

m. Adjust — C50 on the Type R116 Output Amplifier card (see Fig. 7-25) if necessary to obtain the fastest rise possible and the squarest front corner on the pulse without causing overshoot at the front corner or aberrations on the pulse top.

22. Check Pulse Output Transient Response

a. Position the baseline immediately following the pulse on the crt screen with the sampling oscilloscope Time Position and Vertical Position controls (see Fig. 7-24B).

b. Check for — Sampling oscilloscope display of the baseline with no more than 1.5 cm (3%) of overshoot and no more than 1.5 cm (3%) of aberrations or tilt on the baseline.

c. Set the Type R116 POLARITY switch to —.

d. Position the pulse top (most negative excursion) on the crt screen.

e. Check for — Sampling oscilloscope display of the leading corner of the pulse with no more than 1.5 cm (3%)

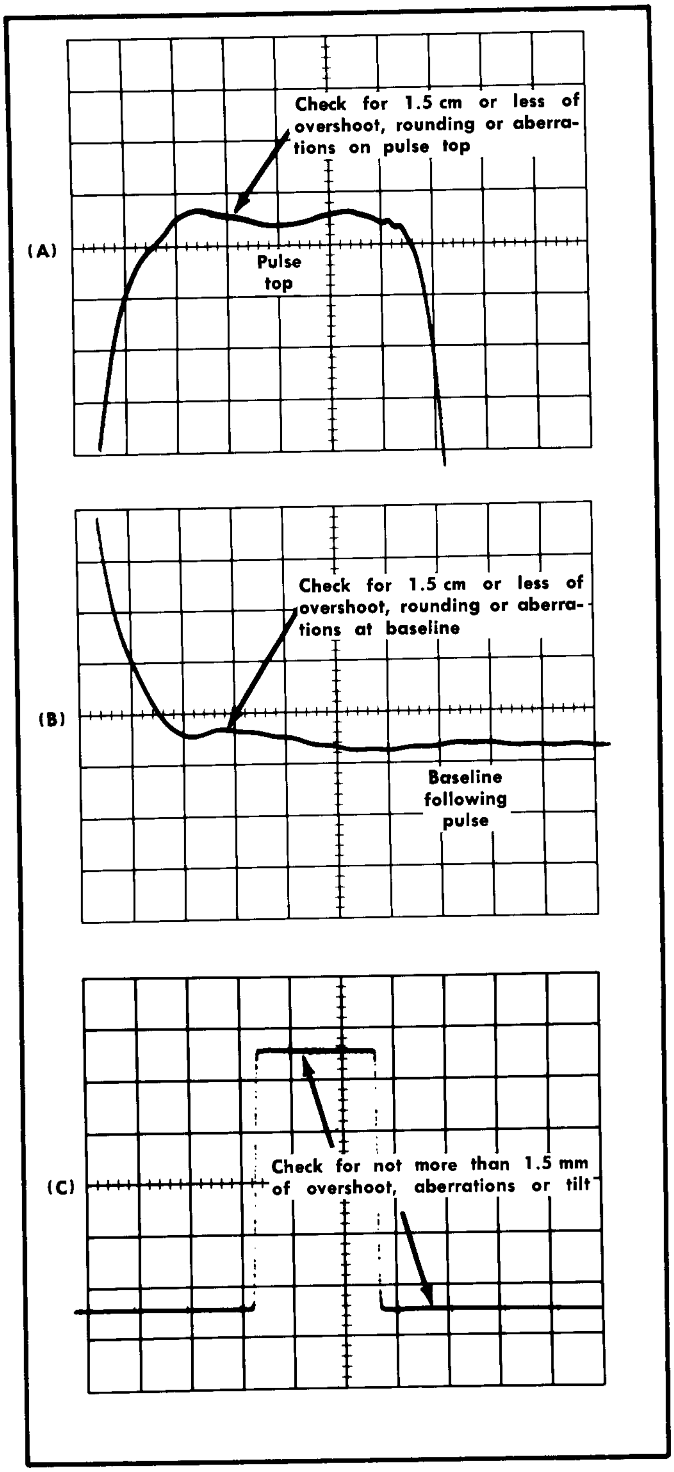


Fig. 7-24. Typical sampling oscilloscope displays for adjusting + pulse overshoot (A only), and for checking transient response of the Type R116 output pulse.

of overshoot at the front corner of the pulse and no more than 1.5 cm (3%) of aberrations or tilt on the pulse top (most negative portion).

f. Repeat steps a and b to check the negative-going pulse for overshoot, aberrations or tilt following the pulse.

g. Reset the following Type R116 controls:

POLARITY	+
PERIOD RANGE	1 μS
WIDTH MULTIPLIER	50

h. Reset the following sampling oscilloscope controls:

Equivalent Sweep Rate	0.2 μs/cm
Deflection Factor	200 mV/cm

i. Center the pulse display on the sampling oscilloscope crt screen.

j. Check for — Sampling oscilloscope display of the output pulse waveform with no more than 1.5 mm (3%) of overshoot, aberrations or tilt (see Fig. 7-24C).

k. Set the Type R116 POLARITY switch to −.

l. Repeat steps i and j to check the negative-going pulse for overshoot, aberrations and tilt.

m. Set the POLARITY switch to +.

23. Adjust Fast Risetime and Falltime ⓿

a. Reset the following Type R116 controls:

RISETIME MULT	10
FALLTIME MULT	10
PERIOD RANGE	100 nS
MULTIPLIER	6
WIDTH MULTIPLIER	25

b. Connect the time-mark generator marker output to the sampling oscilloscope Channel B vertical input as shown in Fig. 7-23.

c. Disconnect the Type R116 +Delayed Trigger Out signal from the 10× attenuator on the sampling oscilloscope External Trigger Input.

d. Connect the time-mark generator trigger output to the External Trigger Input through the 10× attenuator.

e. Set the time-mark generator for a 10 ns marker output and a 1 μs trigger output.

f. Reset the following sampling oscilloscope controls:

Equivalent Sweep Rate	20 ns/cm
Vertical Mode	B Only

g. Trigger the sampling oscilloscope and adjust the Channel B Smoothing control for unity gain

h. Check the sampling oscilloscope display for exactly 2 cycles/cm and adjust the variable sweep rate control, if necessary, to obtain proper timing.

i. Disconnect the time-mark generator trigger signal from the 10× attenuator on the sampling oscilloscope External Trigger Input and reconnect the +Delayed Trigger Out signal.

j. Set the sampling oscilloscope Vertical Mode switch to A Only.

k. Trigger the sampling oscilloscope display.

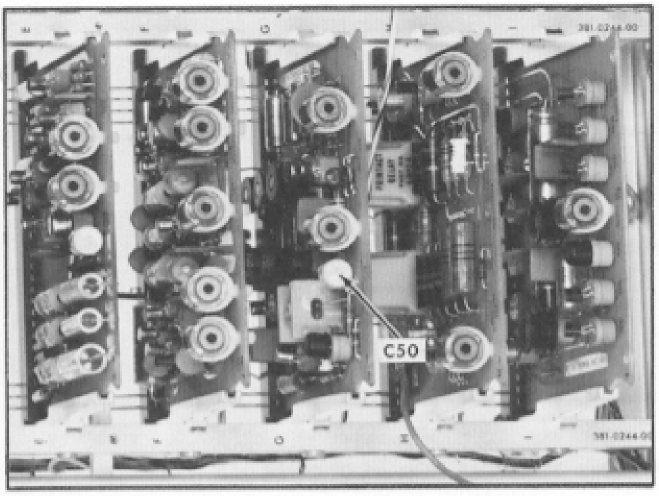


Fig. 7-25. Location of C50 on the Output Amplifier (Series G) card for adjusting + pulse overshoot.

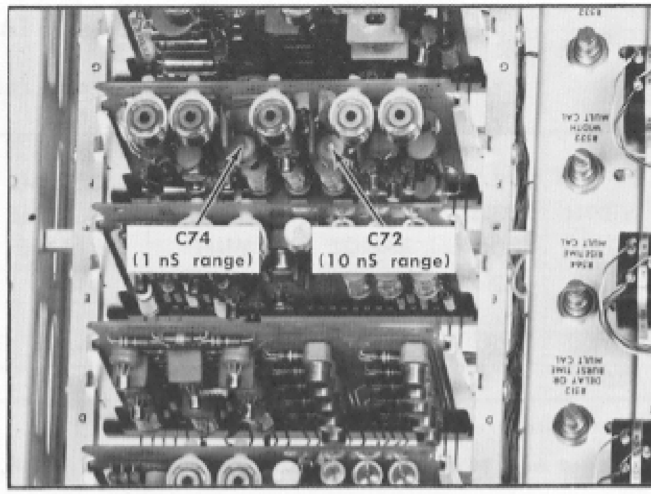


Fig. 7-26. Location of C72 and C74 on Pulse Shape Generator (Series F) card for setting fast risetime-falltime rates.

l. Check that the display amplitude is exactly 5 cm and adjust the Variable Millivolts/Cm control, if necessary, for correct deflection to measure risetime.

m. Time-position the display to observe the pulse rise.

n. Check for — Sampling oscilloscope display of the pulse rise with a risetime of 100 ns ±10% (5 cm ±5 mm).

o. Adjust—C72 on the Series F card (see Fig. 7-26) if the risetime is not correct. Remove the adjustment tool while observing the risetime.

p. Time-position the display to observe the falling edge of the pulse.

q. Check for — Sampling oscilloscope display of the pulse fall with a falltime of 100 ns ±10% (5 cm ±5 mm).

r. If the falltime is not correct, readjust C72 for a compromise setting so that both the risetime and falltime are within specification.

s. Reset the following Type R116 controls:

RISETIME FALLTIME RANGE	10 nS
PERIOD RANGE	1 μS
WIDTH RANGE	100 nS

t. Set the sampling oscilloscope equivalent sweep rate to 0.2 μs/cm.

u. Substitute the time-mark generator trigger signal for the +Delayed Trigger Out signal at the sampling oscilloscope External Trigger Input.

v. Set the time-mark generator for a 0.1 μs marker output.

w. Set the sampling oscilloscope Vertical Mode switch to B Only.

x. Trigger the sampling oscillosope.

y. Check for a display of 2 markers/cm and adjust the sampling oscilloscope variable sweep rate control, if necessary, for proper timing.

z. Disconnect the time-mark generator trigger signal and reconnect the Type R116 +Delayed Trigger Out to the sampling oscilloscope.

aa. Set the sampling oscilloscope Vertical Mode switch to A Only.

bb. Trigger the oscilloscope display.

cc. Time-position the display to observe the pulse rise.

dd. Check for — Sampling oscilloscope display with a risetime of 1 μs ±5% (5 cm ±2.5 mm).

ee. Adjust — C74 on the Series F card (see Fig. 7-26) if the risetime is not correct. Remove the adjustment tool while checking the risetime.

ff. Time-position the display to observe the falling edge of the pulse.

gg. Check for — Sampling oscilloscope display with a falltime of 1 μs ±5% (5 cm ±2.5 mm).

hh. If the falltime is not correct, readjust C74 for a compromise setting so that both the risetime and falltime are within specification.

24. Check Fast Risetime and Falltime Accuracy

a. Set the Type R116 controls, the time-mark generator and the sampling oscilloscope as given in Table 7-7. On each sweep rate, check the display timing with the time-mark signal (Channel 2) and adjust the sweep rate if necessary, then display the Type R116 output pulse. Time-position the pulse on each check to observe the pulse rise then the pulse fall.

b. Check for — Sampling oscilloscope displays of the output pulse waveform with risetimes and falltimes as indicated in the table.

TABLE 7-7

Risetime and Falltime Accuracy Check

WIDTH RANGE	WIDTH MULTI-PLIER	PERIOD RANGE	RISETIME MULT and FALLTIME MULT	RISETIME FALLTIME RANGE	Time Markers	Equivalent Sweep Rate	Risetime or Falltime	
							Time	Display
100 nS	25	1 μS	11	10 nS	0.1 μs	0.2 μs/cm	1.1 μs ±5%	5.5 cm ±2.75 mm
10 nS	25	100 nS	11	1 nS	10 ns	20 ns/cm	110 ns ±10%	5.5 cm ±5.5 mm
10 nS	25	100 nS	1	10 nS	10 ns	20 ns/cm	100 ns ±5%	5 cm ±2.5 mm
10 nS	5	100 nS	1	1 nS	10 ns[3]	2 ns/cm[4]	10 ns ±10%	5 cm ±5 mm

[3] Set sweep for 1 cycle/5 cm.

[4] Magnified from 20 ns/cm. Adjust DELAY OR BURST TIME controls, if necessary, to position pulse on crt screen.

c. If the risetime and/or falltime are out of tolerance in any of the preceding checks, readjust C72 or C74 (see step 23) as required to bring the timing within tolerance over the 10 ns to 1.1 μs range.

25. Check Remote Risetime and Falltime

a. Connect shorting straps between the following points on the REMOTE PROGRAM plug: terminal 2 and the wire (not the program resistors) connected to terminal 31; terminal 3 and the wire connected to terminal 32.

b. Connect another shorting strap between terminal 1 and the 4.42 kΩ resistor connected to terminal 33 (for zero offset).

c. Set the PROGRAM switch to REMOTE.

d. Time-position the display to observe the pulse rise. (The sampling oscilloscope sweep rate should still be set to exactly 2 ns/cm as in the last part of Table 7-7).

e. Check for — Sampling oscilloscope display with a risetime of 10 ns ±12% (5 cm ±6 mm).

f. Time-position the display to observe the pulse fall.

g. Check for — Sampling oscilloscope display with a falltime of 10 ns ±12% (5 cm ±6 mm).

h. Disconnect the Type R116 output pulse and +Delayed Trigger Out pulse and the time-mark marker output signal from the sampling oscilloscope.

i. Connect the Type R116 output pulse to the Channel 1 vertical input of the non-sampling test oscilloscope through the terminated 50-Ω cable, as was done in the earlier portion of the procedure.

j. Connect the time-mark generator marker output to the Channel 2 vertical input of the test oscilloscope through a coaxial cable and 50-Ω termination (BNC connectors).

k. Connect a shorting strap between terminal 36 of the REMOTE PROGRAM plug and each of the terminals indicated in Table 7-8.

l. Set the Type R116 controls, the time-mark generator and the test oscilloscope as given in Table 7-8. On each sweep rate, check the display timing with the time-mark signal, then display the Type R116 output pulse.

m. Check for — Test oscilloscope displays as indicated in the last column of Table 7-8.

TABLE 7-8

Remote Risetime-Falltime Range Check

Short Between Terminals	PERIOD RANGE	WIDTH RANGE	Time Markers	Oscilloscope		Risetime and Falltime	
				Sweep Rate	Triggering	Time	Display
36 and 28	1 μS	100 nS	10 ns	20 ns/cm[5]	+	100 ns ±7%	5 cm ±3.5 mm
					−	100 ns ±7%	5 cm ±3.5 mm
36 and 29	10 μS	1 μS	0.1 μs	0.2 μs/cm	+	1 μs ±7%	5 cm ±3.5 mm
					−	1 μs ±7%	5 cm ±3.5 mm
36 and 30	100 μS	10 μS	1 μs	2 μs/cm	+	10 μs ±7%	5 cm ±3.5 mm
					−	10 μs ±7%	5 cm ±3.5 mm

[5] 0.1 μs/cm, magnified ×5.

n. Remove all shorting straps except the one between terminal 1 and the 4.42-kΩ resistor connected to terminal 33.

o. Reconnect the shorting straps between the following points: Terminals 36 and 28; terminal 2 and the 1.74-kΩ resistor connected to terminal 31; terminal 3 and the 1.74-kΩ resistor connected to terminal 32.

p. Set the test oscilloscope sweep rate to 0.1 μs/cm.

q. Check the test oscilloscope display timing with a 50 ns marker signal from the time-mark generator, applied to Channel 2.

r. Observe the rise, then the fall of the Type R116 output pulse by triggering the test oscilloscope on + polarity, then — polarity.

s. Check for — Test oscilloscope displays of the pulse indicating a risetime and falltime of 600 ns ±8% (6 cm ±4.8 mm).

t. Move the shorting straps connected to the 1.62-kΩ resistors on terminals 31 and 32 to the 3.40-kΩ resistors connected to the same terminals.

u. Set the test oscilloscope sweep rate to 0.2 μs/cm.

v. Check the test oscilloscope display timing with a 0.1-μs marker signal applied to Channel 2.

w. Observe the pulse rise, then the fall by triggering the test oscilloscope on + polarity, then — polarity.

x. Check for — Test oscilloscope display indicating a pulse risetime and falltime of 1.1 μs ±8% (5.5 cm ±4.4 mm).

y. Set the PROGRAM switch to INT.

z. Disconnect the shorting straps.

NOTES

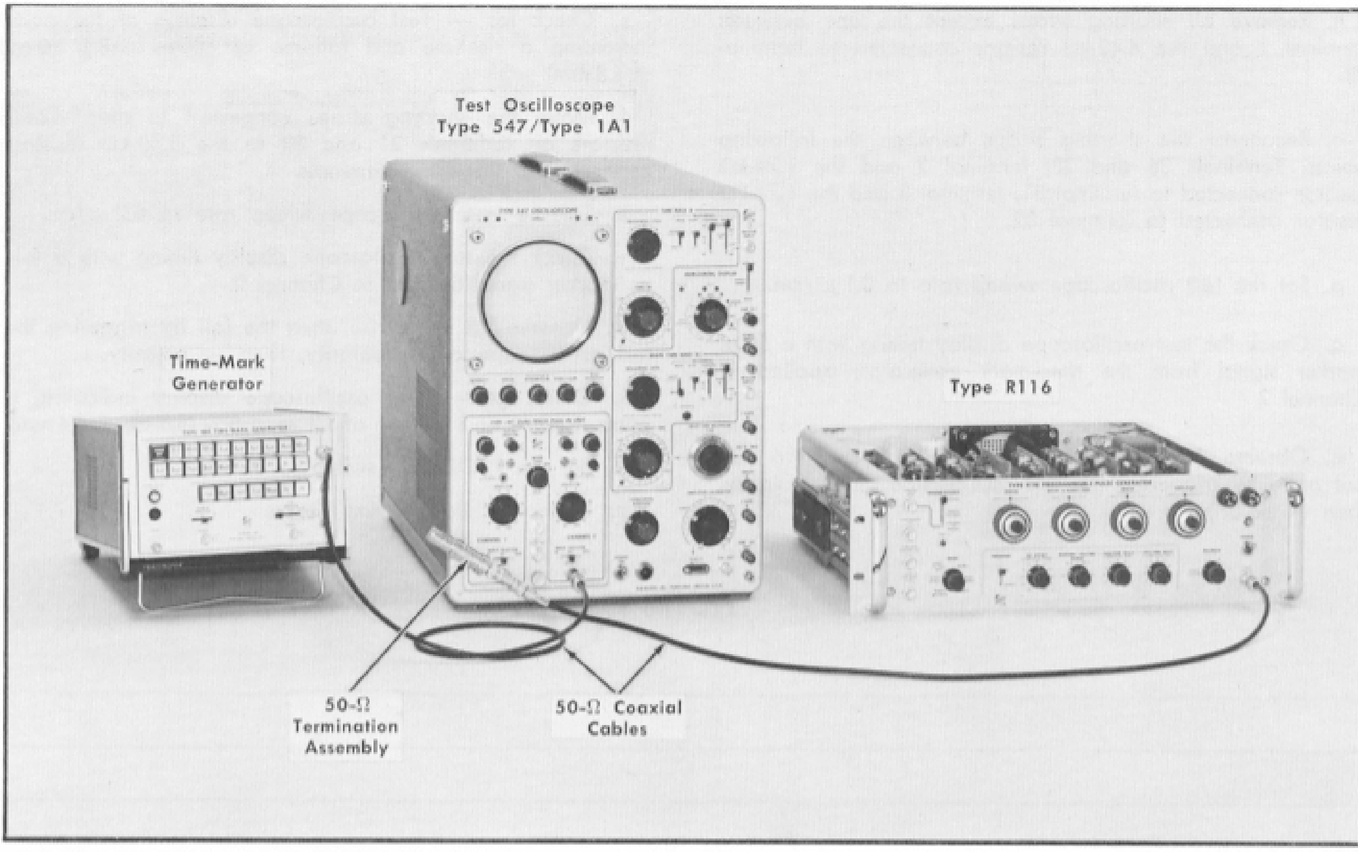


Fig. 7-27. Initial test equipment setup for calibration steps 26 through 28.

Control Settings

Type R116

MODE	SINGLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	**1 mS**
MULTIPLIER	**1**
DELAY OR BURST TIME RANGE	10 nS
MULTIPLIER	10
WIDTH RANGE	10 μS
MULTIPLIER	5
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	**INT**
DC OFFSET	0
RISETIME FALLTIME RANGE	**1 nS**
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	**10 μs/cm**
Triggering	**+Internal, Normal**
Vertical Mode	**Alternate**
Deflection Factor	
Channel 1	2 V/cm
Channel 2	2 V/cm
Input Coupling	DC

WIDTH GENERATOR

26. Adjust Width Timing

a. Test equipment setup is shown in Fig. 7-27.

b. Set the time-mark generator for a 5-μs marker output.

c. Trigger the test oscilloscope display.

d. Center the two displayed waveforms vertically and position the pulse rise at the 1-cm graticule line (see Fig. 7-28A).

e. Check for — Test oscilloscope display of a 50-μs pulse width at the 50% level, within 3% of the time mark waveform (±1.5 mm over 5 cm).

f. Adjust — R522 (WIDTH MULT CAL) on the Type R116 chassis (see Fig. 7-29) if the display is not correct.

g. Set the test oscilloscope sweep rate to 0.1 ms/cm.

h. Set the WIDTH MULTIPLIER control to 50.

i. Set the time-mark generator for a 50-μs marker output.

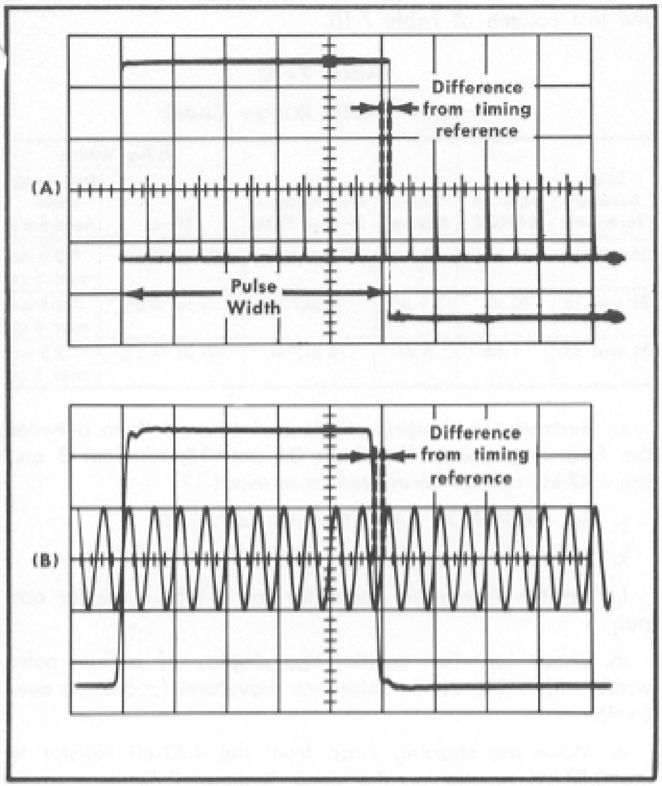


Fig. 7-28. Typical test oscilloscope displays for checking pulse width: (A) 50-μs pulse width; (B) 500-ns pulse width.

j. Check for — Test oscilloscope display of a 500-μs pulse width, within 3% of the time reference waveform (±1.5 mm over 5 cm).

k. Adjust — R41 (WIDTH TIMING) on the Width Generator circuit card (Series E) if the display is not correct. See Fig. 7-29 for the location of R41.

l. If R41 is adjusted, reset the WIDTH MULTIPLIER control and the test oscilloscope sweep rate as given under Fig. 7-27 and recheck the width timing as in steps b through f.

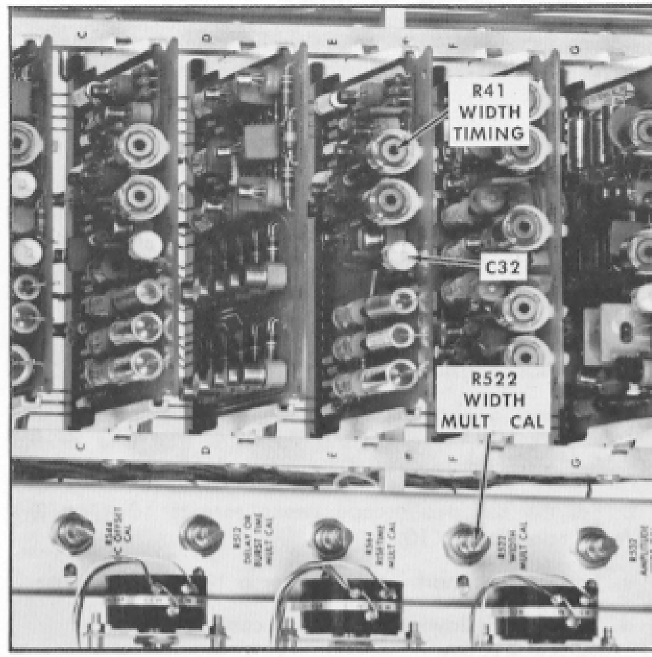


Fig. 7-29. Location of width timing adjustments on the Width Generator (Series E) card and on the Type R116 chassis.

m. Set the test oscilloscope sweep rate to 0.1 μs/cm.

n. Set the time-mark generator for a 50-ns marker output.

o. Reset the following Type R116 controls:

PERIOD RANGE	1 μS
WIDTH RANGE	10 nS
WIDTH MULTIPLIER	50

p. Check for — Test oscilloscope display of a 500-ns pulse width (see Fig. 7-28B) within 5% of the reference waveform (±2.5 mm over 5 cm).

q. Adjust — C32 on the Series E circuit card if the display is not correct.

TABLE 7-9

Width Timing Accuracy Check

PERIOD RANGE	WIDTH RANGE	WIDTH MULTIPLIER	Time Markers	Oscilloscope Sweep Rate	Pulse Width: Time	Pulse Width: Difference from Reference
1 mS	10 μS	5	5 μs	10 μs/cm	50 μs ±3%	±1.5 mm over 5 cm
100 μS	1 μS	5	0.5 μs	1 μs/cm	5 μs ±3%	±1.5 mm over 5 cm
10 μS	100 nS	5	50 ns	0.1 μs/cm	500 ns ±3%	±1.5 mm over 5 cm
1 μS	10 nS	5	10 ns	10 ns/cm[6]	50 ns ±5%	±2.5 mm over 5 cm
1 μS	10 nS	55	50 ns	0.1 μs/cm	550 ns ±5%	±2.75 mm over 5.5 cm
100 μS	100 nS	55	0.5 μs	1 μs/cm	5.5 μs ±3%	±1.65 mm over 5.5 cm
1 mS	1 μS	55	5 μs	10 μs/cm	55 μs ±3%	±1.65 mm over 5.5 cm
1 mS	10 μS	55	50 μs	0.1 ms/cm	550 μs ±3%	±1.65 mm over 5.5 cm

[6] **0.1 μs/cm, magnified ×10.**

27. Check Width Accuracy

a. Set the Type R116 controls, the time-mark generator output and the test oscilloscope sweep rate as indicated in Table 7-9.

b. Check for — Test oscilloscope displays of the pulse width as indicated in the last column of Table 7-9.

c. If the width timing is out of tolerance in any of the preceding checks, readjust R522, R41 or C32 (see step 26) as required to bring the width timing within tolerance on all ranges.

28. Check Remote Width

a. Connect a shorting strap between terminal 3 of the REMOTE PROGRAM plug and the wire (not one of the program resistors) connected to terminal 17.

b. Set the test oscilloscope sweep rate to 10 ns/cm (0.1 μs/cm, magnified ×10).

c. Set the time-mark generator for a 10-ns marker output.

d. Reset the following Type R116 controls:

PERIOD RANGE	1 μS
WIDTH RANGE	REMOTE

e. Check for—Test oscilloscope display of a 50-ns pulse width, within 7% of the marker reference waveform (±3.5 mm over 5 cm).

f. Connect a second shorting strap between terminal 36 and each of the terminals indicated in Table 7-10.

g. Set the Type R116 controls, the time-mark generator output and the test oscilloscope sweep rate, as given in Table 7-10.

h. Check for—Test oscilloscope displays as indicated in the last column of Table 7-10.

TABLE 7-10

Remote Width Range Check

Short Between Terminals	PERIOD RANGE	Time Marker	Oscilloscope Sweep Rate	Pulse Width: Time	Pulse Width: Difference from Reference
36 and 14	10 μS	50 ns	0.1 μs/cm	500 ns ±5%	±2.5 mm over 5 cm
36 and 15	100 μS	0.5 μs	1 μs/cm	5 μs ±5%	±2.5 mm over 5 cm
36 and 16	1 mS	5 μs	10 μs/cm	50 μs ±5%	±2.5 mm over 5 cm

i. Remove the shorting straps and connect them between the following points: Terminals 36 and 14; terminal 3 and the 4.42-kΩ resistor connected to terminal 17.

j. Set the PERIOD RANGE switch to 100 μS.

k. Set the test oscilloscope sweep rate to 0.5 μs/cm.

l. Set the time-mark generator for a 0.5-μs marker output.

m. Check for—Test oscilloscope display of a 3-μs pulse width within 6% of the reference waveform (±3.6 mm over 6 cm).

n. Move the shorting strap from the 4.42-kΩ resistor to the 8.87-kΩ resistor on the same terminal (17).

o. Set the test oscilloscope sweep rate to 1 μs/cm.

p. Check for—Test oscilloscope display of a 5.5-μs pulse width within 6% of the reference waveform (±3.3 mm over 5.5 cm).

q. Remove the shorting straps.

NOTES

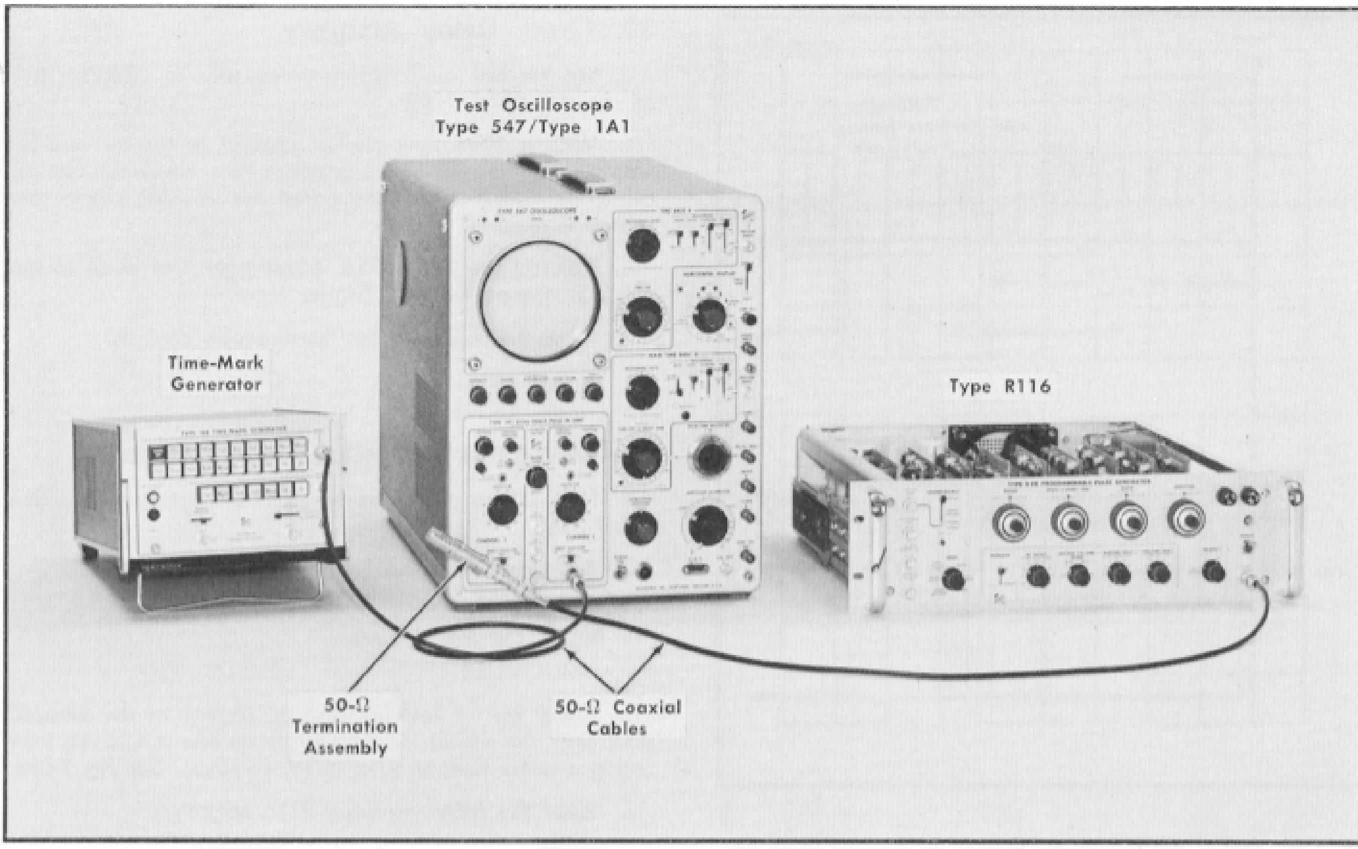


Fig. 7-30. Initial test equipment setup for calibration steps 29 through 32.

Control Settings

Type R116

MODE	**DOUBLE**
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	**1 mS**
MULTIPLIER	**10**
DELAY OR BURST TIME	
RANGE	**10 μS**
MULTIPLIER	**5**
WIDTH RANGE	**1 μS**
MULTIPLIER	**25**
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	**10 μs/cm**
Triggering	+Internal, Normal
Vertical Mode	Alternate
Deflection Factor	
Channel 1	2 V/cm
Channel 2	2 V/cm
Input Coupling	DC

DELAY GENERATOR

29. Adjust Delay Timing

a. Test equipment setup is shown in Fig. 7-30.

b. Set the time-mark generator for a 5-μs marker output.

c. Trigger the test oscilloscope display.

d. Check for—Test oscilloscope display of the double pulse waveform with a delay period of 50 μs between corresponding points on the two pulses (see Fig. 7-31), within 3% (+10 ns) of the reference waveform (±1.5 mm over 5 cm).

e. Adjust—R512 (DELAY OR BURST TIME MULT CAL) on the Type R116 chassis (see Fig. 7-32) if the delay interval is not correct.

f. Set the DELAY OR BURST TIME MULTIPLIER control to 50.

g. Set the test oscilloscope sweep rate to 0.1 ms/cm.

h. Set the time-mark generator for a 50-μs marker output.

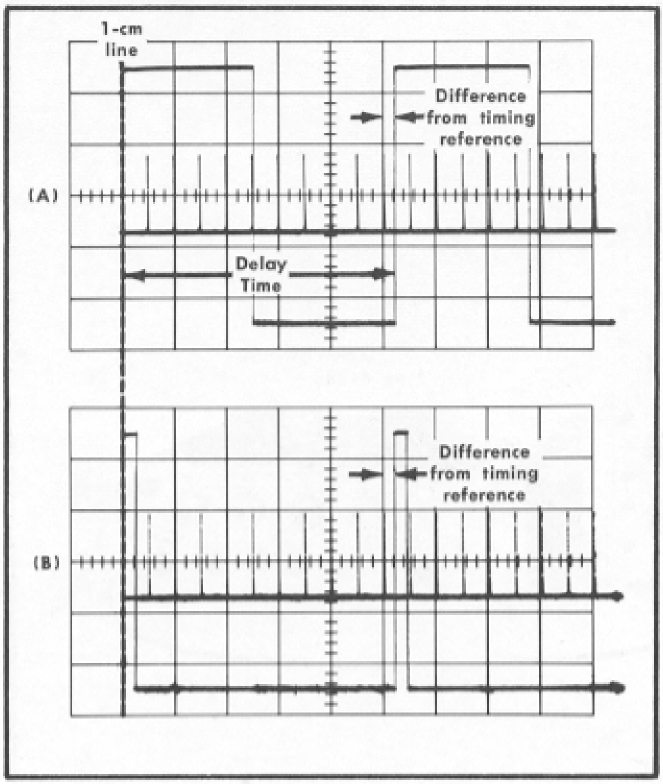


Fig. 7-31. Typical test oscilloscope dispays for checking delay timing adjustments: (A) 50 μs delay; (B) 500-μs delay.

i. Check for—Test oscilloscope display of the double pulse with a delay period of 500 μs, within 3% (+10 ns) of the reference waveform (±1.5 mm over 5 cm).

j. Adjust—R41 (DELAY TIMING) on the Delay Generator circuit card (Series C) if the delay interval is not correct. See Fig. 7-32 for the location of R41.

k. If R41 requires adjustment, reset the delay multiplier and the test oscilloscope sweep rate as given under Fig. 7-30 and recheck the delay timing adjustments as in steps b through i.

l. Set the test oscilloscope sweep rate to 20 ns/cm (0.1 μs/cm, magnified ×5).

m. Reset the following Type R116 controls:

PERIOD RANGE	10 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	10 nS
MULTIPLIER	10
WIDTH RANGE	10 nS
MULTIPLIER	5

n. Set the time-mark generator for a 10-ns marker output.

o. Check for—Test oscilloscope display of the double pulse with a delay time of 100 ns, within 3% (+10 ns) of the reference waveform (±6.5 mm over 5 cm).

p. Adjust—C32 on the Series C card (see Fig. 7-30) if the delay time interval is not correct.

30. Check Delay Accuracy

a. Set the test oscilloscope sweep rate to 10 ns/cm (0.1 μs/cm magnified ×10).

b. With a 10-ns time marker applied to the test oscilloscope as at the end of the previous step, check the test oscilloscope sweep timing and adjust the variable sweep rate control if required.

c. Connect the Type R116 +Pretrigger Out pulse to the test oscilloscope External Trigger Input.

d. Reset the following test oscilloscope controls:

Vertical Mode	Channel 1
Trigger Source	External

e. Set the Type R116 MODE switch to SINGLE.

f. Position the pulse rise to the 1-cm graticule line (see Fig. 7-33A).

g. Reset the following Type R116 controls:

MODE	DLY'D SINGLE
DELAY OR BURST TIME	
MULTIPLIER	5

h. Check for — Test oscilloscope display of the delayed pulse with the rise at the 6-cm graticule line ±1.15 cm, indicating a delay time of 50 ns ±3% (+10 ns). See Fig. 7-33B.

i. Reset the following Type R116 controls:

MODE	DOUBLE
PERIOD MULTIPLIER	10

j. Reset the following test oscilloscope controls:

Vertical Mode	Alternate
Trigger Source	Internal

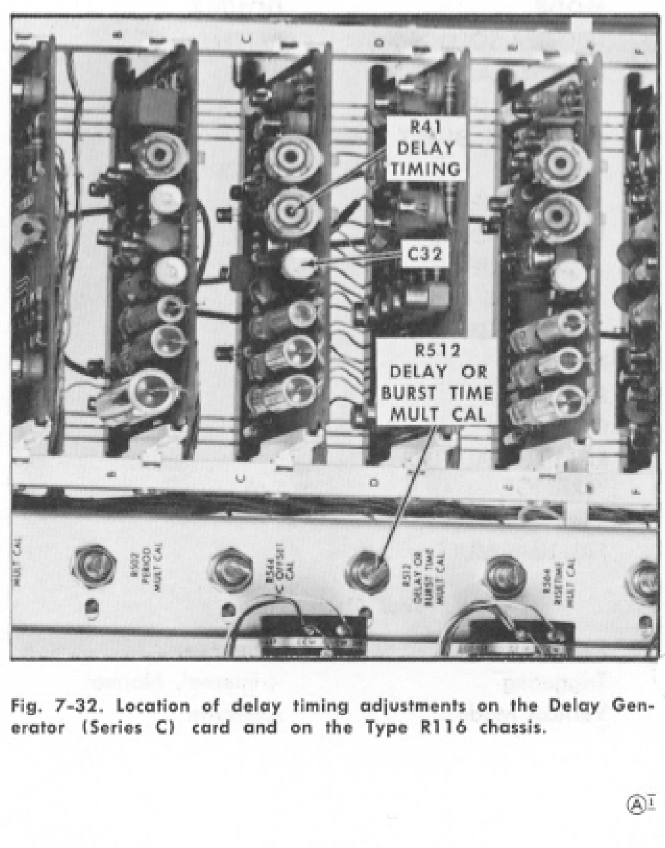


Fig. 7-32. Location of delay timing adjustments on the Delay Generator (Series C) card and on the Type R116 chassis.

TABLE 7-11

Delay or Burst Time Accuracy Check

PERIOD RANGE	DELAY OR BURST TIME RANGE	DELAY OR BURST TIME MULTIPLIER	WIDTH RANGE	Time Markers	Oscilloscope Sweep Rate	Delay Interval	
						Time	Difference from Reference Waveform
1 μS	100 nS	5	10 nS	50 ns	0.1 μs/cm	500 ns ±3% (+10 ns)	±2.5 mm over 5 cm
10 μS	1 μS	5	100 nS	0.5 μs	1 μs/cm	5 μs ±3% (+10 ns)	±1.6 mm over 5 cm
100 μS	10 μS	5	1 μS	5 μs	10 μs/cm	50 μs ±3% (+10 ns)	±1.51 mm over 5 cm
1 mS	10 μS	55	10 μS	50 μs	0.1 ms/cm	550 μs ±3% (+10 ns)	±1.65 mm over 5.5 cm
100 μS	1 μS	55	1 μS	5 μs	10 μs/cm	55 μs ±3% (+10 ns)	±1.66 mm over 5.5 cm
10 μS	100 nS	55	100 nS	0.5 μs	1 μs/cm	5.5 μs ±3% (+10 ns)	±1.75 mm over 5.5 cm
1 μS	10 nS	55	10 nS	50 ns	0.1 μs/cm	550 ns ±3% (+10 ns)	±2.65 mm over 5.5 cm

k. Set the Type R116 controls, the time-mark generator output and the test oscilloscope sweep rate as given in Table 7-11.

l. Check for — Test oscilloscope displays with a delay period between corresponding points on the two pulses (see Fig. 7-31), as indicated in the last column of Table 7-11.

m. If the delay time is out of tolerance in any of the preceding checks, readjust R512, R41 or C32 (see step 29) as necessary to bring the delay time within tolerance on all ranges.

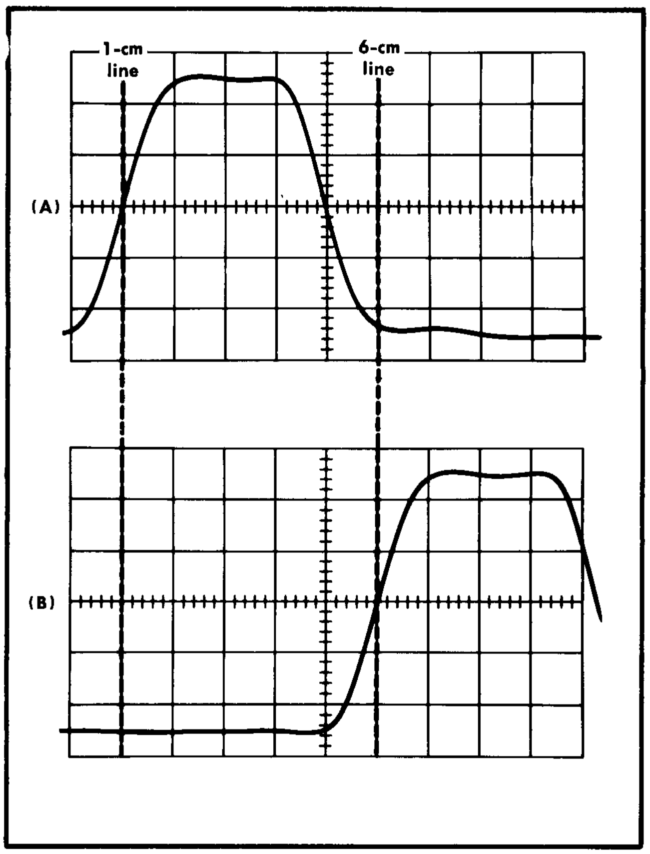


Fig. 7-33. Test oscilloscope displays for checking the 50-ns delay time, after checking display time.

31. Check Remote Delay

a. Connect a shorting strap between terminals 3 and 13 of the REMOTE PROGRAM plug.

b. Set the test oscilloscope sweep rate to 10 ns/cm (0.1 μs/cm magnified ×10).

c. Reset the following Type R116 controls:

MODE	SINGLE
PERIOD MULTIPLIER	1
WIDTH RANGE	10 nS
MULTIPLIER	5
DELAY OR BURST TIME RANGE	REMOTE

d. Set the time-mark generator for a 10-ns marker output.

e. Check the display timing for 1 cycle/cm of the timing signal and adjust the variable sweep rate control if necessary.

f. Set the test oscilloscope Trigger Source switch to External.

g. Position the rise of the displayed pulse at the 1-cm graticule line.

h. Set the MODE switch to DLY'D SINGLE.

i. Check for — Test oscilloscope display of the delayed pulse with the pulse rise at the 6-cm graticule line ±1.25 cm, indicating a delay interval of 50 ns ±5% (+10 ns).

j. Set the MODE switch to DOUBLE.

k. Set the test oscilloscope Trigger Source switch to Internal.

l. Connect a second shorting strap between terminal 36 and each of the terminals indicated in Table 7-12.

m. Check for — Test oscilloscope displays as indicated in the last column of Table 7-12.

TABLE 7-12

Remote Delay or Burst Time Range Check

Short Between Terminals	PERIOD RANGE	WIDTH RANGE	Time Markers	Oscilloscope Sweep Rate	Delay Interval	
					Time	Difference from Reference
36 and 10	10 μS	10 nS	50 ns	0.1 μs/cm	500 ns ±5% (+10 ns)	±3.5 mm over 5 cm
36 and 11	100 μS	100 nS	0.5 μs	1 μs/cm	5 μs ±5% (+10 ns)	±2.6 mm over 5 cm
36 and 12	1 mS	1 μS	5 μs	10 μs/cm	50 μs ±5% (+10 ns)	±2.5 mm over 5 cm

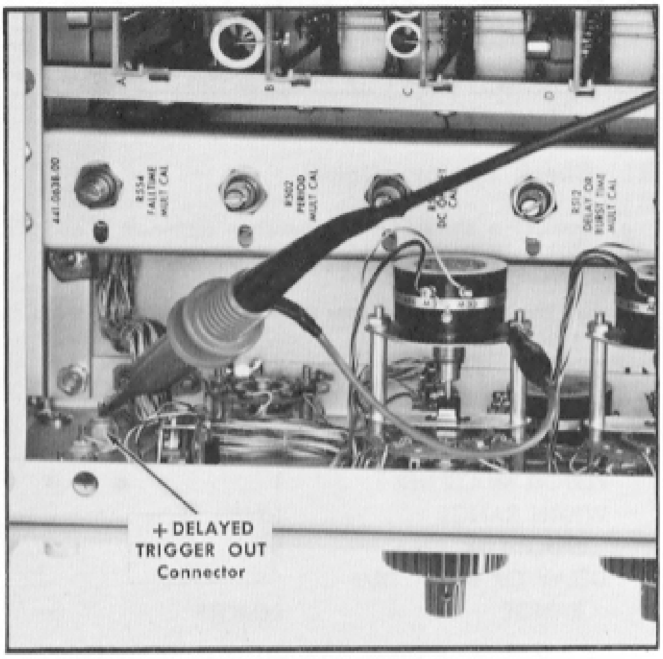


Fig. 7-34. Probe connection to the +DELAYED TRIGGER OUT connector inside the front panel.

n. Remove the shorting straps and connect them between the following points: Terminals 36 and 10; terminal 3 and the 4.42-kΩ resistor connected to terminal 13.

o. Reset the following Type R116 controls

PERIOD RANGE	100 μs
WIDTH RANGE	10 ns

p. Set the test oscilloscope sweep rate to 0.5 μs/cm.

q. Set the time-mark generator for a 0.5-μs marker output.

r. Check for — Test oscilloscope display of the double pulse waveform with a delay interval of 3 μs ±6% (+10 ns), or within 3.6 mm of the reference waveform over 6 cm.

s. Move the shorting strap from the 4.42-kΩ resistor to the 8.87-kΩ resistor on the same terminal (13).

t. Set the test oscilloscope sweep rate to 1 μs/cm.

u. Check for — Test oscilloscope display of the double pulse with a delay interval of 5.5 μs ±6% (+10 ns), or within 3.3 mm of the reference waveform over 5.5 cm.

v. Remove the shorting straps.

32. Check +Delayed Trigger Out

a. Disconnect the terminated pulse output cable from the test oscilloscope Channel 1 vertical input.

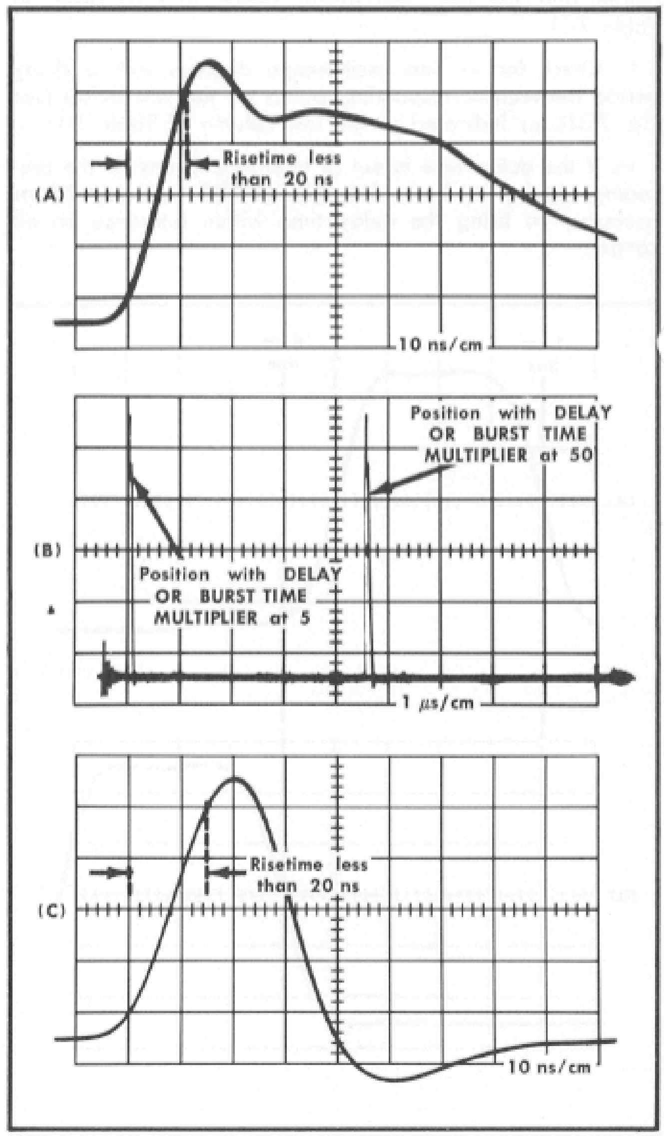


Fig. 7-35. Test oscilloscope displays for checking trigger output pulses: (A) +Delayed Trigger Out; (C) +Pretrigger Out pulse.

b. Install a 1× test probe on the Channel 1 input.

c. Connect the probe tip to the +DELAYED TRIGGER OUT connector just inside the front panel of the instrument (see Fig. 7-34) and connect the probe ground clip to chassis ground.

d. Reset the following test oscilloscope controls:

Trigger Source	External
Sweep Rate	10 ns/cm (0.1 μs/cm magnified ×10)
Vertical Mode	Channel 1
Deflection Factor	1 V/cm (calibrated)

e. Reset the following Type R116 controls:

PERIOD RANGE	10 μS
DELAY OR BURST TIME	
RANGE	100 nS
MULTIPLIER	5

f. Trigger the test oscilloscope and position the pulse onto the crt screen.

g. Check for — Test oscilloscope display of the +Delayed Trigger Out signal with an amplitude of at least 2 volts (2 cm).

h. Adjust the vertical size of the display for a risetime measurement (see Fig. 7-35A).

i. Check for — Test oscilloscope display of the +Delayed Trigger Out pulse with a risetime of less than 20 ns. For a 50-MHz oscilloscope, the displayed risetime should be 21 ns (2.1 cm) or less.

j. Set the test oscilloscope sweep rate to 1 μs/cm.

k. Position the pulse rise to the 1-cm graticule line (see Fig. 7-35B).

l. Observe the test oscilloscope display while turning the DELAY OR BURST TIME MULTIPLIER control to the 50 position.

m. Check for — Test oscilloscope display of the +Delayed Trigger Out pulse moving with respect to the +Pretrigger Out pulse. The pulse should move approximately 4.5 μs (4.5 cm) as the control is turned from 5 to 50.

NOTES

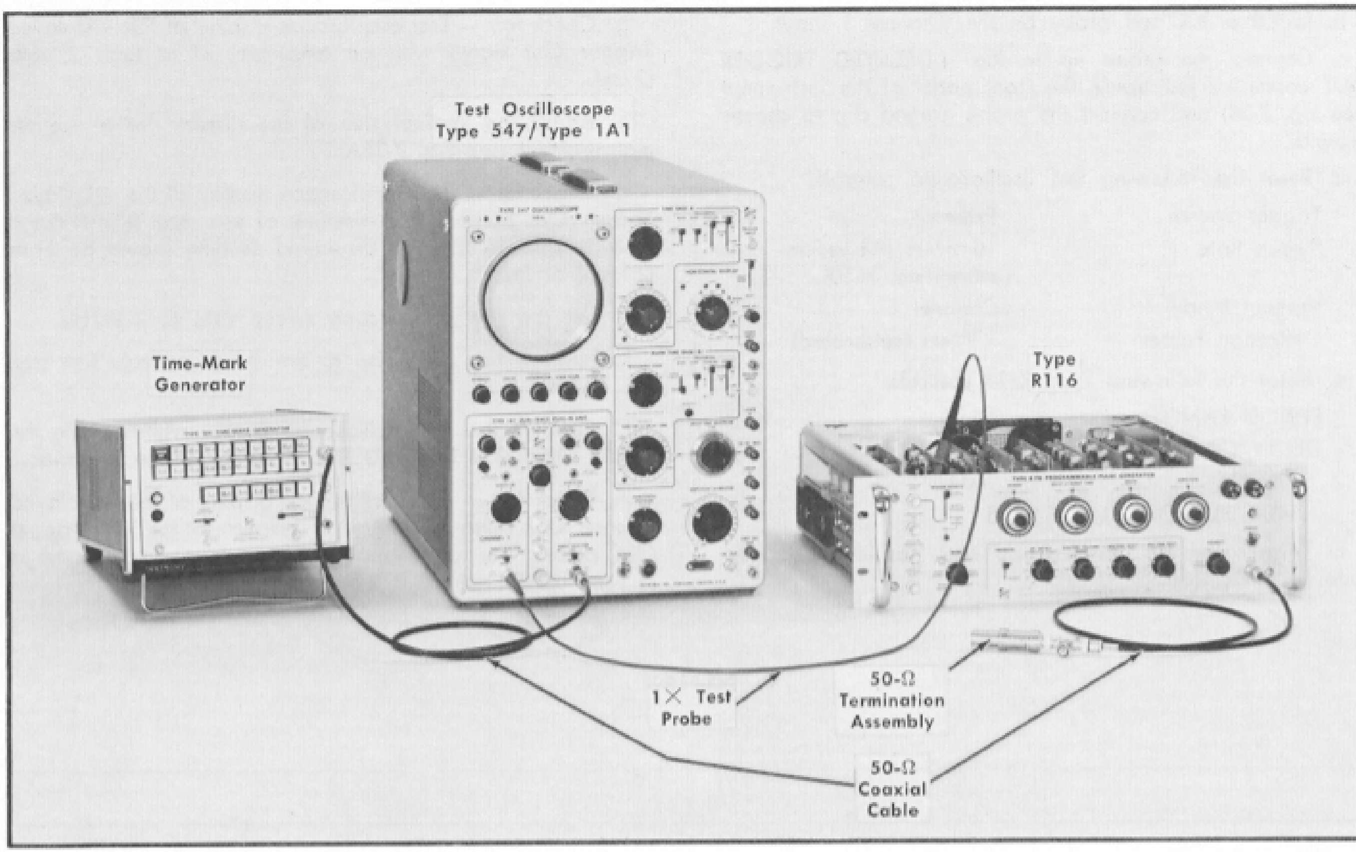


Fig. 7-36. Initial test equipment setup for calibration steps 33 through 36.

Control Settings

Type R116

MODE	**SINGLE**
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	10 μS
MULTIPLIER	1
DELAY OR BURST TIME	
RANGE	100 nS
MULTIPLIER	**5**
WIDTH RANGE	**1 μS**
MULTIPLIER	**5**
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	**10 ns/cm (0.1 μs magnified ×10)**
Triggering	**+Internal, Normal**
Vertical Mode	Channel 1
Deflection Factor	1 V/cm
Input Coupling	DC

PERIOD GENERATOR

33. Check +Pretrigger Out

a. Test equipment setup is shown in Fig. 7-36.

b. Disconnect the coaxial cable from the Type R116 +PRETRIGGER OUT connector and the test oscilloscope External Trigger Input.

c. Move the probe tip to the +PRETRIGGER OUT connector, just inside the front panel.

d. Trigger the test oscilloscope display and position the pulse onto the crt screen.

e. Check for — Test oscilloscope display of the +Pretrigger Out pulse with an amplitude of at least 2 volts (2 cm).

f. Adjust the vertical size of the display for a risetime measurement.

g. Check for — Test oscilloscope display of the +Pretrigger Out pulse with a risetime of less than 20 ns (2.1 cm).

h. Disconnect the probe tip from the Type R116.

i. Remove the probe from the test oscilloscope input.

34. Adjust Period Timing

a. Reset the following Type R116 controls:

PERIOD RANGE	1 mS
PERIOD MULTIPLIER	10

b. Connect the terminated output pulse from the Type R116 to the Channel 1 vertical input of the test oscilloscope.

c. Reset the following test oscilloscope controls:

Sweep Rate	10 ms/cm
Vertical Mode	Alternate
Deflection Factor (Channel 1)	2 V/cm

d. Set the time-mark generator for a 10-ms marker output.

e. Trigger the test oscilloscope display.

f. Check for — Test oscilloscope display with equal time interval between the pulses in the Type R116 waveform and those in the reference time-mark signal, ±2.7 mm over the first 9 cm of the test oscilloscope graticule (10 ms ±3%). See Fig. 7-37 for the display.

g. Adjust — R34 (PERIOD TIMING) on the Period Generator circuit card (Series B) if the display is not correct. See Fig. 7-38 for the location of R34.

h. Set the test oscilloscope sweep rate to 1 ms/cm.

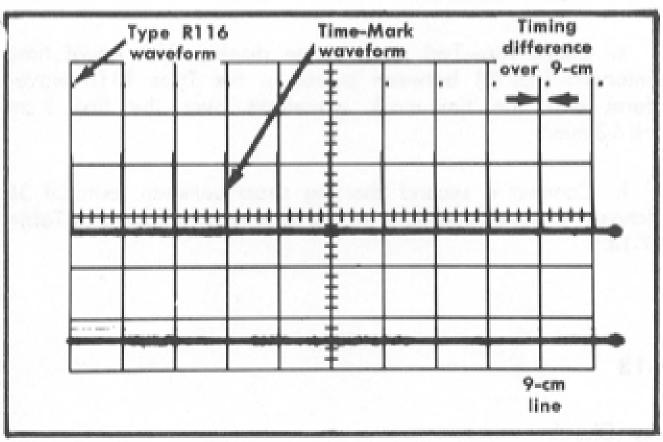


Fig. 7-37. Typical test oscilloscope display for checking period timing.

i. Set the time-mark generator for a 1-ms marker output.

j. Set the PERIOD MULTIPLIER control to 1.

k. Check for — Test oscilloscope display of equal time intervals of the two waveforms, ±2.7 mm over the first 9 cm (1 ms ±3%).

l. Adjust — R502 (PERIOD MULT CAL) on the Type R116 chassis (see Fig. 7-38) if the display is not correct.

m. If R502 is adjusted, reset the period multiplier and oscilloscope sweep rate controls as given under Fig. 7-36 and recheck the period timing adjustments as in steps d through k.

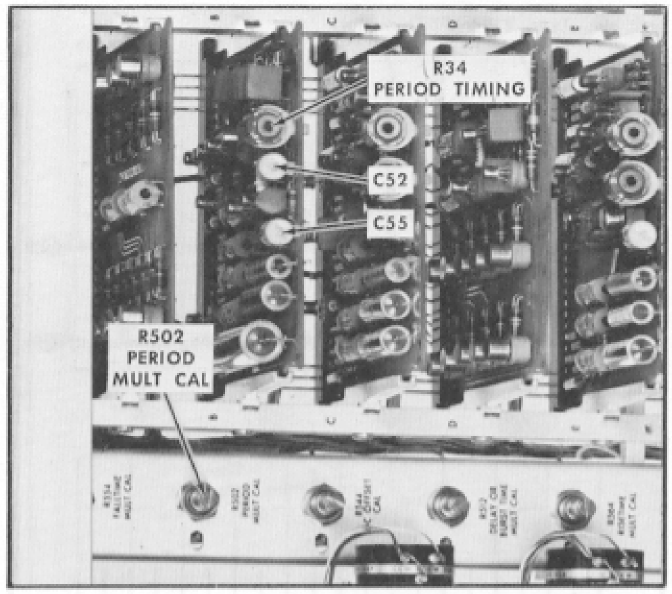


Fig. 7-38. Location of period timing adjustments on the Period Generator (Series B) card and the Type R116 chassis.

n. Reset the following Type R116 controls:

PERIOD RANGE	100 nS
MULTIPLIER	1
WIDTH RANGE	10 nS

o. Set the test oscilloscope sweep rate to 0.1 μs/cm.

p. Set the time-mark generator for a 0.1-μs marker output.

q. Check for — Test oscilloscope display of equal intervals in the two waveforms ±4.5 mm over the first 9 cm (100 ns ±5%).

r. Adjust — C52 on the Series B card (see Fig. 7-38) if the display is not correct. Remove the adjusting tool from the capacitor while checking the display.

s. Set the PERIOD RANGE switch to 1 μS.

t. Set the test oscilloscope sweep rate to 1 μs/cm.

u. Set the time-mark generator for a 1-μs marker output.

v. Check for — Test oscilloscope display of equal time intervals of the two waveforms, ±2.7 mm over the first 9 cm (1 μs ±3%).

w. Adjust — C55 on the Series B card (see Fig. 7-38) if the display is not correct.

35. Check Period Accuracy

a. Leave the WIDTH MULTIPLIER control set at the 5 position during the following checks.

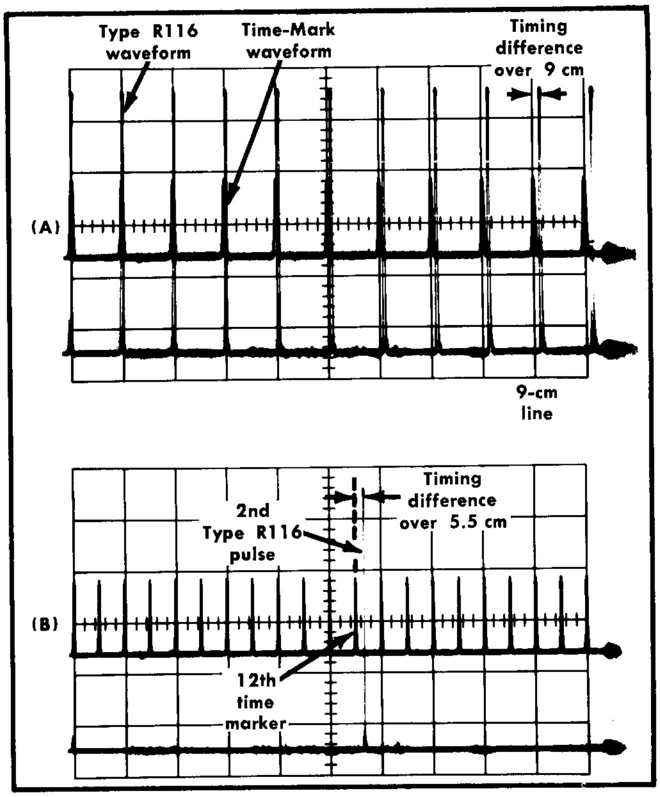


Fig. 7-39. Typical test oscilloscope displays for checking period timing accuracy: (A) at 1 position of PERIOD MULTIPLIER control; (B) at 11 position of control.

b. Set the Type R116 controls, the time-mark generator marker output and the test oscilloscope sweep rate as given in Table 7-13.

c. Trigger the test oscilloscope display and position both waveforms near the center of the crt screen.

d. Check for — Test oscilloscope display with equal time intervals between the pulses in the Type R116 waveform and those in the reference time-mark signal (over the first 9 cm) for the 1 position of the PERIOD MULTIPLIER (see Fig. 7-39A), and displays with the second Type R116 pulse at the 12th time marker for the 11 position of the MULTIPLIER (see Fig. 7-39B).

e. If the period timing is out of tolerance in any of the preceding checks, readjust R34, R502, C52 or C55 (see step 34) as necessary to bring the timing within tolerance on all ranges.

36. Check Remote Period

a. Connect a shorting strap between terminal 34 of the REMOTE PROGRAM plug and the wire (not one of the program resistors) connected to terminal 9 of the plug.

b. Set the test oscilloscope sweep rate to 0.1 μs/cm.

c. Set the time-mark generator for a 0.1-μs output.

d. Reset the following Type R116 controls:

PERIOD RANGE	REMOTE
WIDTH RANGE	10 nS

e. Check for—Test oscilloscope display with equal time intervals (±7%) between pulses in the Type R116 waveform and the time-mark waveform over the first 9 cm ±6.3 mm.

f. Connect a second shorting strap between terminal 36 (chassis ground) and each of the terminals indicated in Table 7-14.

TABLE 7-13

Period Accuracy Check

PERIOD RANGE	PERIOD MULTIPLIER	WIDTH RANGE	Time Markers	Oscilloscope Sweep Rate	Period Time	Period Difference from Reference Waveform
100 nS	1	10 nS	0.1 μs	0.1 μs/cm	100 ns ±5%	±4.5 mm over 9 cm
1 μS	1	10 nS	1 μs	1 μs/cm	1 μs ±3%	±2.7 mm over 9 cm
10 μS	1	10 nS	10 μs	10 μs/cm	10 μs ±3%	±2.7 mm over 9 cm
100 μS	1	100 nS	0.1 ms	0.1 ms/cm	100 μs ±3%	±2.7 mm over 9 cm
1 mS	1	1 μS	1 ms	1 ms/cm	1 ms ±3%	±2.7 mm over 9 cm
100 nS	11	10 nS	0.1 μs	0.2 μs/cm	1.1 μs ±5%	±2.75 mm over 5.5 cm
1 μS	11	10 nS	1 μs	2 μs/cm	11 μs ±3%	±1.65 mm over 5.5 cm
10 μS	11	100 nS	10 μs	20 μs/cm	110 μs ±3%	±1.65 mm over 5.5 cm
100 μS	11	1 μS	0.1 ms	0.2 ms/cm	1.1 ms ±3%	±1.65 mm over 5.5 cm
1 mS	11	10 μS	1 ms	2 ms/cm	11 ms ±3%	±1.65 mm over 5.5 cm

g. Check for—Test oscilloscope display as indicated in the last column of Table 7-14.

TABLE 7-14

Remote Period Range Check

Short Between Terminals	Oscilloscope Sweep Rate	WIDTH RANGE	Time Markers	Period	
				Time	Difference from Reference Waveform
36 and 5	1 μs/cm	10 nS	1 μs	1 μs ±5%	±4.5 mm over 9 cm
36 and 6	10 μs/cm	10 nS	10 μs	10 μs ±5%	±4.5 mm over 9 cm
36 and 7	0.1 ms/cm	100 nS	100 μs	100 μs ±5%	±4.5 mm over 9 cm
36 and 8	1 ms/cm	1 μS	1 ms	1 ms ±5%	±4.5 mm over 9 cm

h. Set the WIDTH RANGE switch to 10 nS.

i. Remove both shorting straps, then reconnect them as follows: One between terminals 36 and 5; one between terminal 34 and the 8.45 kΩ resistor connected to terminal 9.

j. Set the test oscilloscope sweep rate to 1 μs/cm.

k. Set the time-mark signal to 1 μs.

l. Check for—Test oscilloscope display with the second Type R116 pulse at the 7th time marker ±3.6 mm (6 μs ±6%).

m. Move the shorting strap from the 8.45 kΩ resistor to the 16.9 kΩ resistor on the same terminal. Leave the other end of the strap connected to terminal 34.

n. Set the test oscilloscope sweep rate to 2 μs/cm.

o. Check for—Test oscilloscope display with the second Type R116 pulse at the 12th time marker ±6.6 mm (11 μs ±6%).

p. Remove the shorting straps.

q. Disconnect the time-mark signal from the test oscilloscope.

NOTES

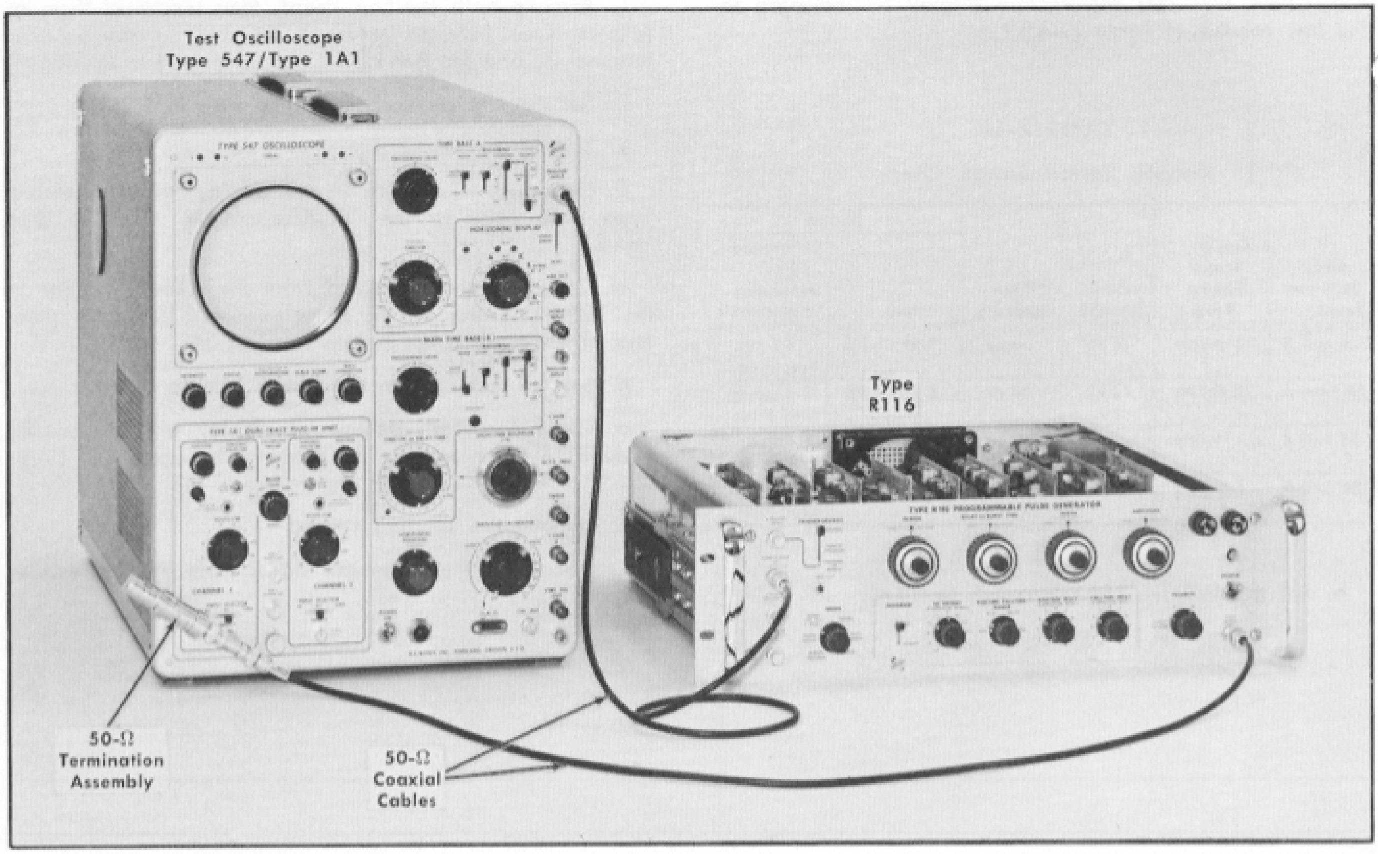


Fig. 7-40. Initial test equipment setup for calibration steps 37 through 41.

Control Settings

Type R116

MODE	SINGLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	**10 μS**
MULTIPLIER	**1**
DELAY OR BURST TIME	
RANGE	**100 nS**
MULTIPLIER	**5**
WIDTH RANGE	10 nS
MULTIPLIER	5
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME	
RANGE	1 nS
RISETIME MULT	1
FALLTIME MULT	1

Test Oscilloscope

Sweep Rate	**2 μs/cm**
Triggering	**+External, Normal**
Vertical Mode	**Channel 1**
Deflection Factor	2 V/cm
Input Coupling	DC

MODES AND TRIGGERING

37. Check Single, Dly'd Single and Double Modes

a. Test equipment setup is shown in Fig. 7-40.

b. Connect a coaxial cable from the Type R116 +PRE-TRIGGER OUT connector to the External Trigger Input of the test oscilloscope.

c. Trigger the test oscilloscope sweep.

d. Position the 50% level of the first displayed pulse to the 1-cm graticule line of the test oscilloscope (see Fig. 7-41A).

e. Observe the non-delayed Single mode output pulse waveform.

f. Set the Type R116 MODE switch to DLY'D SINGLE.

g. Check for—Test oscilloscope display of the delayed output pulse displaced by approximately the delay time (2.5 mm or 500 ns) from the 1-cm graticule line (see Fig. 7-41B).

h. Set the Type R116 MODE switch to DOUBLE.

Ⓐ

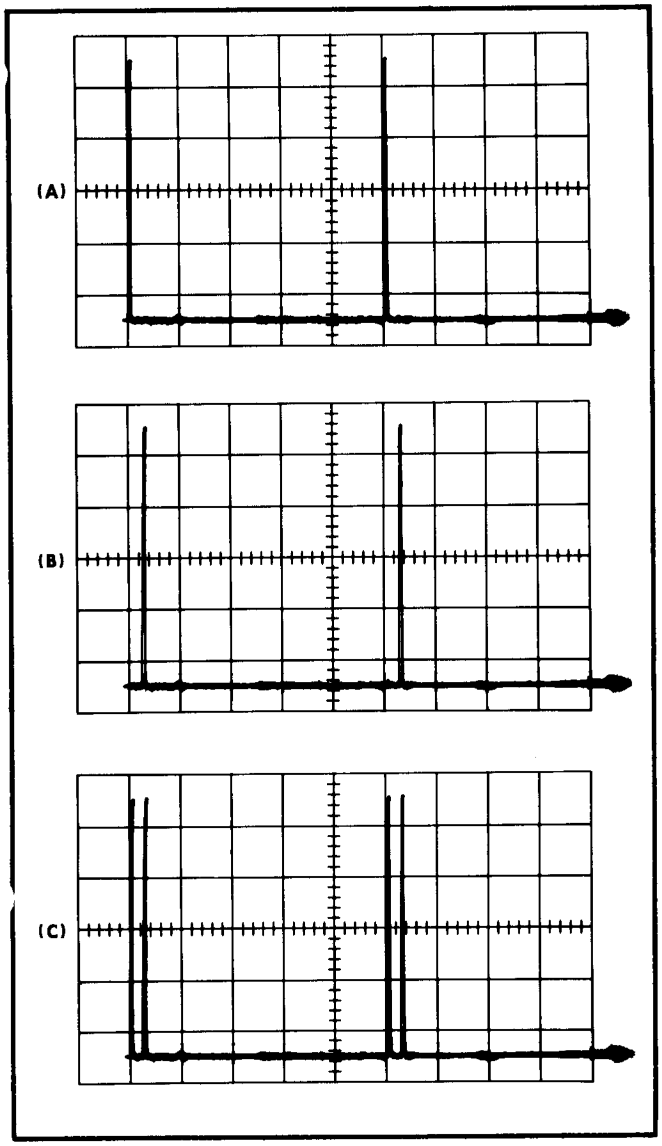


Fig. 7-41. Test oscilloscope displays for checking Single, Dly'd Single and Double modes of operation.

i. Check for—Test oscilloscope display of the double pulse waveform with the first pulse at the 1-cm graticule line and the second pulse displaced by approximately the delay time (2.5 mm or 500 ns) from the 1-cm graticule line.

38. Check Remote Single, Dly'd Single and Double Modes

a. Set the Type R116 MODE switch to REMOTE PROGRAM.

b. Check for—Test oscilloscope display of the Single mode waveform (see Fig. 7-41A).

c. Connect a shorting strap between terminals 36 and 20 of the REMOTE PROGRAM plug.

d. Check for—Test oscilloscope display of the Dly'd Single mode waveform (see Fig. 7-41B).

e. Move the shorting strap from terminal 20 to terminal 21.

f. Check for—Test oscilloscope display of the Double mode waveform (see Fig. 7-41B).

g. Remove the shorting strap.

h. Disconnect the trigger cable from the +PRETRIGGER OUT connector.

39. Check Manual Trigger and Remote Manual

a. Connect a shorting strap between terminals 36 and 19 of the REMOTE PROGRAM plug.

b. Reset the following Type R116 controls:

MODE	SINGLE
PERIOD RANGE	1 mS
MULTIPLIER	1
WIDTH RANGE	10 μS
MULTIPLIER	10

c. Reset the following test oscilloscope controls:

Sweep Rate	0.2 ms/cm
Triggering	+Internal (not Auto)

d. Trigger the test oscilloscope display and observe the repetitive waveform.

e. Set the Type R116 TRIGGER SOURCE switch to EXTERNAL OR MANUAL.

f. Observe the test oscilloscope display while pressing the Type R116 front-panel manual TRIG button.

g. Check for—Test oscilloscope display of the single output pulse each time the TRIG button is pressed. Readjust the test oscilloscope intensity if necessary.

h. Set the Type R116 TRIGGER SOURCE switch to REMOTE PROGRAM.

i. Press the manual TRIG button.

j. Check for—Test oscilloscope display of the single output pulse from the Type R116, remotely enabled.

k. Leave the shorting strap connected for the external triggering check. (If the intensity is increased for this check, decrease it again after completion of the check.)

40. Check External Triggering

a. Connect a BNC T connector to the test oscilloscope calibrator output.

b. Connect a coaxial cable from one arm of the T connector to the External Trigger Input of the test oscilloscope.

c. Connect a coaxial cable from the second arm of the T connector to the Type R116 +TRIGGER INPUT connector.

d. Reset the following Type R116 controls:

PERIOD RANGE	100 μS
PERIOD MULTIPLIER	2

DELAY OR BURST TIME	
RANGE	10 µS
WIDTH RANGE	1 µS
MULTIPLIER	10
TRIGGER SOURCE	INTERNAL

e. Reset the following test oscilloscope controls:

Sweep Rate	0.2 ms/cm
Triggering	+External

f. Trigger the test oscilloscope sweep.

g. Observe the Single mode output pulse waveform, with the pulse period set by the PERIOD controls (see Fig. 7-42A).

h. Set the Type R116 TRIGGER SOURCE switch to EXTERNAL OR MANUAL.

i. Set the test oscilloscope calibrator output amplitude to 20 volts.

j. Check for—Test oscilloscope display of the externally triggered single mode waveform (see Fig. 7-42B), with a pulse period of approximately 1 ms set by the calibrator signal frequency.

k. Decrease the calibrator output amplitude to 2 volts.

l. Check for—Test oscilloscope display of the externally-triggered waveform.

41. Check Remote Triggering Enable

a. With the shorting strap connected as in step 39 (terminals 36 and 19), set the TRIGGER SOURCE switch to REMOTE PROGRAM.

b. Check for—Test oscilloscope display of the externally triggered Single mode waveform.

c. Remove the shorting strap from the REMOTE PROGRAM plug.

d. Check for—Test oscilloscope display of the Single mode waveform with the pulse period set internally.

42. Check Burst Mode

a. Reset the following Type R116 controls:

TRIGGER SOURCE	INTERNAL
MODE	BURST
PERIOD RANGE	10 µS
MULTIPLIER	5
DELAY OR BURST TIME	
RANGE	10 µS
MULTIPLIER	50
WIDTH RANGE	1 µS
MULTIPLIER	20

b. Trigger the test oscilloscope.

c. Check for—Test oscilloscope display of the Burst mode waveform (see Fig. 7-42C) with the burst period set by the

(A)

(B)

(C)

(D)

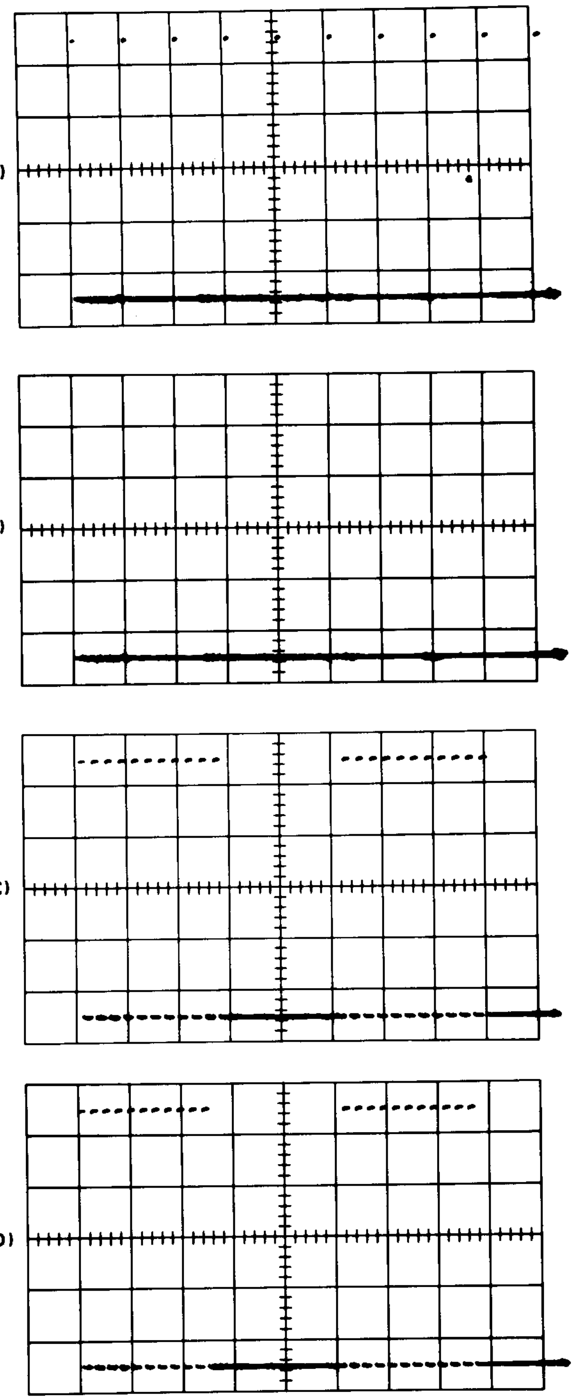


Fig. 7-42. Typical test oscilloscope displays for checking external triggering and gating: (A) Normal Single mode waveform; (B) externally-triggered Single mode waveform; (C) externally-triggered Burst waveform; (D) Gated Output waveform.

calibrator signal, the burst width set by the DELAY OR BURST TIME controls and the pulse period and width set by the PERIOD and WIDTH controls.

d. Set the DELAY OR BURST TIME MULTIPLIER control to the 5 position while observing the change in burst time.

43. Check Remote Burst Mode

a. Set the MODE switch to REMOTE PROGRAM.

b. Connect a shorting strap between terminals 36 and 22 of the REMOTE PROGRAM plug.

c. Check for—Test oscilloscope display of the Burst mode waveform, remotely enabled.

d. Remove the shorting strap.

44. Check Gated Output Mode

a. Move the triggering signal cable from the +TRIGGER INPUT connector to the +GATE IN connector.

b. Set the Type R116 MODE switch to GATED OUTPUT.

c. Set the test oscilloscope calibrator output amplitude to 10 volts.

d. Check for—Test oscilloscope display of the Gated Output mode waveform with the duration of the burst set by the calibrator squarewave signal (see Fig. 7-42D).

e. Decrease the calibrator amplitude to 2 volts.

f. Check for—Test oscilloscope display of the Gated Output waveform.

45. Check Remote Gated Output Mode

a. Set the MODE switch to REMOTE PROGRAM.

b. Connect a shorting strap between terminals 36 and 23 of the REMOTE PROGRAM plug.

c. Check for—Test oscilloscope display of the Gated Output waveform, remotely enabled.

d. Remove the shorting strap.

e. Disconnect the two triggering cables and remove the T connector from the calibrator output.

f. Disconnect the output pulse signal cable from the test oscilloscope vertical input.

This completes the calibration procedure for the Type R116. Turn off and disconnect all test equipment. Turn off the Type R116, remove the special remote program checker and replace the top and bottom dust covers.

NOTES

NOTES

ABBREVIATIONS AND SYMBOLS

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

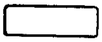
PARTS ORDERING INFORMATION

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.

SECTION 8
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Bulb				
B403	150-0019-00	Neon, w/translucent lens in holder				
		Capacitors				

Tolerance ±20% unless otherwise indicated.

C110	290-0137-00	100 μF	EMT	30 V	+75%—15%	
C405	290-0122-00	1000 μF	EMC	50 V		
C410	290-0084-00	4000 μF	EMC	15 V		
C417A,B,C	290-0068-00	3 x 75 μF	EMC	150 V		
C420	290-0122-00	1000 μF	EMC	50 V		
C437	283-0000-00	0.001 μF	Cer	500 V		
C460	283-0059-00	1 μF	Cer	25 V	+80%—20%	

Diodes

D405A,B,C,D(4)	152-0066-00	Silicon	1N3194	
D407	152-0089-00	Zener	10M12.6Z5 10 W, 12.6 V, 5%	
D410A,B,C,D(4)	152-0066-00	Silicon	1N3194	
D420A,B,C,D(4)	152-0066-00	Silicon	1N3194	
D426	152-0066-00	Silicon	1N3194	
D430	152-0236-00	Zener	0.4 W, 12.5 V, 4%	
D432	152-0119-00	Zener	1N969A 0.4 W, 22 V, 10%	
D460	152-0127-00	Zener	1N755A 0.4 W, 7.5 V, 5%	
D570	*152-0075-00	Germanium	Tek Spec	
D572	*152-0075-00	Germanium	Tek Spec	

Fuses

F401	159-0043-00	0.6 A, 3AG, Slo-Blo	
F402	159-0043-00	0.6 A, 3AG, Slo-Blo	

Filter

FL401	119-0028-00	Line filter	

Connectors

J1	131-0292-00	56 pin, for circuit card	
J2	131-0292-00	56 pin, for circuit card	
J3	131-0292-00	56 pin, for circuit card	
J4	131-0292-00	56 pin, for circuit card	
J5	131-0292-00	56 pin, for circuit card	
J6	131-0292-00	56 pin, for circuit card	
J7	131-0292-00	56 pin, for circuit card	
J8	131-0292-00	56 pin, for circuit card	
J9	131-0292-00	56 pin, for circuit card	

Connectors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
J10	131-0294-00	36 pin, female	
J15	131-0352-00	BNC	
J20	131-0352-00	BNC	
J28	131-0352-00	BNC	
J80	131-0352-00	BNC	
J90	131-0352-00	BNC	
J401	131-0430-00	Motor Base Assembly	

Inductors

L432	*108-0355-00	Coil, Reed Drive	
L480	*108-0355-00	Coil, Reed Drive	
L484A	108-0344-00	8.6 mH	
L484B	*108-0354-00	5 mH	
L484C	*108-0353-00	1.3 mH	

Plug

P18	131-0375-00	Connector, coaxial, right angle, female	

Transistors

Q407	151-0165-00	2N3614	
Q417	151-0165-00	2N3614	
Q427	*151-0148-00	Selected (RCA 40250)	
Q437	151-0165-00	2N3614	
Q444	*151-0134-00	Replaceable by 2N2905	
Q454	*151-0134-00	Replaceable by 2N2905	
Q464	*151-0136-00	Replaceable by 2N3053	
Q474	*151-0136-00	Replaceable by 2N3053	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R403	301-0104-00	100 kΩ	½ W			5%	
R405	308-0165-00	0.5 Ω	5 W		WW	5%	
R410	307-0093-00	1.2 Ω	½ W			5%	
R420	308-0165-00	0.5 Ω	5 W		WW	5%	
R431	301-0271-00	270 Ω	½ W			5%	
R432	315-0103-00	10 kΩ	¼ W			5%	
R440	*310-0628-00	85 Ω	8 W		Prec	1%	
R442	*310-0526-00	102.9 Ω	2 W		Prec	0.2%	
R444	307-0110-00	3 Ω	¼ W			5%	
R450	307-0110-00	3 Ω	¼ W			5%	
R460	301-0202-00	2 kΩ	½ W			5%	
R462	315-0101-00	100 Ω	¼ W			5%	
R464	307-0110-00	3 Ω	¼ W			5%	
R466	311-0262-00	50 Ω		Var	WW		
R468	306-0330-00	33 Ω	2 W				

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R474	307-0110-00	3 Ω	¼ W			5%	
R476	311-0238-00	30 Ω		Var	WW	5%	
R478	304-0180-00	18 Ω	1 W				
R480	301-0271-00	270 Ω	½ W			5%	
R482	301-0822-00	8.2 kΩ	½ W			5%	
R484	315-0222-00	2.2 kΩ	¼ W			5%	
R488	315-0622-00	6.2 kΩ	¼ W			5%	
R500	321-0135-00	249 Ω	⅛ W		Prec	1%	
R502	311-0006-00	1 kΩ		Var			
R504	*311-0537-00	20 kΩ		Var	WW	3%	
R510	Use 321-0154-00	392 Ω	⅛ W		Prec	1%	
R512	311-0006-00	1 kΩ		Var			
R514	*311-0536-00	10 kΩ		Var	WW	3%	
R520	321-0149-00	348 Ω	⅛ W		Prec	1%	
R522	311-0006-00	1 kΩ		Var			
R524	*311-0536-00	10 kΩ		Var	WW	3%	
R530	321-0174-00	634 Ω	⅛ W		Prec	1%	
R532	311-0006-00	1 kΩ		Var			
R534	*311-0536-00	10 kΩ		Var	WW	3%	
R540	321-0197-00	1.1 kΩ	⅛ W		Prec	1%	
R542	*311-0536-00	10 kΩ		Var	WW	3%	
R544	311-0006-00	1 kΩ		Var			
R550	321-0095-00	95.3 Ω	⅛ W		Prec	1%	
R552	*311-0543-00	4 kΩ		Var	WW	3%	
R554	311-0521-00	250 Ω		Var			
R560	321-0094-00	93.1 Ω	⅛ W		Prec	1%	
R562	*311-0543-00	4 kΩ		Var	WW	3%	
R564	311-0521-00	250 Ω		Var			

Switches

	Unwired	Wired		
SW1	260-0705-00		Rotary	PERIOD
SW2	260-0706-00		Rotary	DELAY OR BURST TIME
SW3	260-0706-00		Rotary	WIDTH
SW4	260-0707-00		Rotary	AMPLITUDE
SW5	260-0708-00		Rotary	MODE
SW6	260-0490-00		Lever	TRIGGER SOURCE
SW7	260-0709-00		Rotary	POLARITY
SW8	260-0710-00		Rotary	RISETIME FALLTIME RANGE
SW9	260-0711-00		Lever	PROGRAM
SW10	260-0247-00		Push-Button	TRIG
SW401	260-0199-00		Toggle	POWER ON
SW402	260-0675-00		Slide	
SW432	260-0552-00		Reed	
SW480	260-0552-00		Reed	

Thermal Cutout

TK402	260-0246-00	Thermal Cutout 123°F

Transformer

Ckt. No.	Tektronix Part No.	Description	S/N Range
T401	*120-0416-00	Power	

FUNCTION PROGRAM #2 CARD

Series A

Ckt. No.	Tektronix Part No.	Description	Model No.
	*670-0213-00	Complete Card	

Diodes

D72	*152-0185-00	Silicon	Replaceable by 1N3605
D76	*152-0185-00	Silicon	Replaceable by 1N3605
D82	*152-0185-00	Silicon	Replaceable by 1N3605
D95	*152-0185-00	Silicon	Replaceable by 1N3605
D100	*152-0185-00	Silicon	Replaceable by 1N3605

Inductors

L75	*108-0355-00	Coil, Reed Drive
L78	*108-0355-00	Coil, Reed Drive

Transistors

Q3	151-0182-00	2N1307
Q13	151-0182-00	2N1307
Q23	151-0182-00	2N1307
Q33	151-0182-00	2N1307
Q43	151-0182-00	2N1307
Q53	151-0182-00	2N1307
Q63	151-0182-00	2N1307
Q73	151-0182-00	2N1307
Q83	151-0182-00	2N1307
Q93	151-0182-00	2N1307
Q103	151-0182-00	2N1307

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1	301-0512-00	5.1 kΩ	½ W	5%
R3	301-0104-00	100 kΩ	½ W	5%
R10	301-0512-00	5.1 kΩ	½ W	5%
R13	301-0104-00	100 kΩ	½ W	5%
R20	301-0512-00	5.1 kΩ	½ W	5%
R23	301-0104-00	100 kΩ	½ W	5%
R30	301-0102-00	1 kΩ	½ W	5%
R33	301-0104-00	100 kΩ	½ W	5%
R40	301-0102-00	1 kΩ	½ W	5%
R43	301-0104-00	100 kΩ	½ W	5%

FUNCTION PROGRAM #2 CARD—Series A *(Cont'd)*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description		Model No.
R50	301-0102-00	1 kΩ	½ W	5%	
R53	301-0104-00	100 kΩ	½ W	5%	
R60	301-0512-00	5.1 kΩ	½ W	5%	
R63	301-0104-00	100 kΩ	½ W	5%	
R70	301-0102-00	1 kΩ	½ W	5%	
R73	301-0104-00	100 kΩ	½ W	5%	
R75	301-0271-00	270 Ω	½ W	5%	
R78	301-0271-00	270 Ω	½ W	5%	
R80	301-0102-00	1 kΩ	½ W	5%	
R83	301-0104-00	100 kΩ	½ W	5%	
R90	301-0102-00	1 kΩ	½ W	5%	
R93	301-0104-00	100 kΩ	½ W	5%	
R95	301-0512-00	5.1 kΩ	½ W	5%	
R100	301-0512-00	5.1 kΩ	½ W	5%	
R103	301-0104-00	100 kΩ	½ W	5%	

Switches

	Unwired	Wired	
SW75	260-0552-00		Reed
SW78	260-0552-00		Reed

PERIOD GENERATOR CARD Series B

*670-0214-00 Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C5	281-0516-00	39 pF	Cer		500 V	10%
C14	281-0509-00	15 pF	Cer		500 V	10%
C20	281-0509-00	15 pF	Cer		500 V	10%
C34	283-0059-00	1 μF	Cer		500 V	+80%—20%
C36	283-0004-00	0.02 μF	Cer		150 V	
C41	283-0059-00	1 μF	Cer		500 V	+80%—20%
C42	283-0059-00	1 μF	Cer		500 V	+80%—20%
C44	283-0059-00	1 μF	Cer		500 V	+80%—20%
C52	281-0096-00	5.5-18 pF	Air	Var		
C53	281-0512-00	27 pF	Cer		500 V	10%
C55	281-0097-00	9-35 pF	Cer	Var		
C56	283-0032-00	470 pF	Cer		500 V	5%
C58		0.005 μF				
C59	*295-0091-00	0.05 μF		(matched set)		
C60		0.5 μF				

PERIOD GENERATOR CARD—Series B *(Cont'd)*

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				Model No.
C74	283-0003-00	0.01 μF	Cer	150 V		
C82	281-0511-00	22 pF	Cer	500 V	10%	
C90	283-0003-00	0.01 μF	Cer	150 V		
C94	281-0543-00	270 pF	Cer	500 V	10%	
C95	290-0162-00	22 μF	EMT	35 V		
C96	290-0135-00	15 μF	EMT	20 V		
C98	290-0135-00	15 μF	EMT	20 V		
C99	290-0162-00	22 μF	EMT	35 V		

Diodes

D16	*152-0185-00	Silicon	Replaceable by 1N3605
D22	*152-0185-00	Silicon	Replaceable by 1N3605
D34	*152-0185-00	Silicon	Replaceable by 1N3605
D35	*152-0185-00	Silicon	Replaceable by 1N3605
D44	152-0071-00	Germanium	ED-2007
D50	152-0034-00	Zener	1N753 0.4 W, 6.2 V, 10%

Inductors

L61	*108-0355-00	Coil, Reed Drive
L62	*108-0355-00	Coil, Reed Drive
L63	*108-0355-00	Coil, Reed Drive
L64	*108-0355-00	Coil, Reed Drive
L78	276-0541-00	Core, Ferrite

Transistors

Q4	*151-0108-00	Replaceable by 2N2501
Q14	*151-0133-00	Selected from 2N3251
Q24	*151-0127-00	Selected from 2N2369
Q38	*151-0103-00	Replaceable by 2N2219
Q43	*151-0127-00	Selected from 2N2369
Q55	*151-0127-00	Selected from 2N2369
Q65	*151-0127-00	Selected from 2N2369
Q74	*151-0133-00	Selected from 2N3251
Q84	*151-0127-00	Selected from 2N2369
Q93	*151-0108-00	Replaceable by 2N2501
Q94	*151-0133-00	Selected from 2N3251

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1	301-0102-00	1 kΩ	½ W	5%
R3	301-0512-00	5.1 kΩ	½ W	5%
R5	301-0153-00	15 kΩ	½ W	5%
R6	301-0471-00	470 Ω	½ W	5%
R8	301-0102-00	1 kΩ	½ W	5%

PERIOD GENERATOR CARD—Series B *(Cont'd)*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				Model No.
R14	301-0103-00	10 kΩ	½ W			5%	
R16	301-0223-00	22 kΩ	½ W			5%	
R18	301-0202-00	2 kΩ	½ W			5%	
R20	301-0511-00	510 Ω	½ W			5%	
R22	301-0203-00	20 kΩ	½ W			5%	
R24	301-0561-00	560 Ω	½ W			5%	
R32	315-0302-00	3 kΩ	¼ W			5%	
R34	311-0496-00	2.5 kΩ		Var			
R36	321-0204-00	1.3 kΩ	⅛ W		Prec	1%	
R38	307-0108-00	6.8 Ω	¼ W			5%	
R40	301-0471-00	470 Ω	½ W			5%	
R41	301-0391-00	390 Ω	½ W			5%	
R42	301-0162-00	1.6 kΩ	½ W			5%	
R44	301-0682-00	6.8 kΩ	½ W			5%	
R46	315-0820-00	82 Ω	¼ W			5%	
R50	301-0751-00	750 Ω	½ W			5%	
R52	307-0108-00	6.8 Ω	¼ W			5%	
R61	301-0271-00	270 Ω	½ W			5%	
R62	301-0271-00	270 Ω	½ W			5%	
R63	301-0271-00	270 Ω	½ W			5%	
R64	301-0271-00	270 Ω	½ W			5%	
R67	315-0123-00	12 kΩ	¼ W			5%	
R74	315-0302-00	3 kΩ	¼ W			5%	
R78	315-0910-00	91 Ω	¼ W			5%	
R82	301-0102-00	1 kΩ	½ W			5%	
R86	301-0102-00	1 kΩ	½ W			5%	
R90	315-0471-00	470 Ω	¼ W			5%	
R92	301-0471-00	470 Ω	½ W			5%	
R94	301-0102-00	1 kΩ	½ W			5%	
R95	307-0053-00	3.3 Ω	½ W			5%	
R96	307-0053-00	3.3 Ω	½ W			5%	
R98	307-0053-00	3.3 Ω	½ W			5%	
R99	301-0100-00	10 Ω	½ W			5%	

Switches

	Unwired	Wired	
SW61	260-0552-00		Reed
SW62	260-0552-00		Reed
SW63	260-0552-00		Reed
SW64	260-0552-00		Reed

Transformer

T70	*120-0417-00	Toroid, 6 Turns, bifilar

DELAY GENERATOR CARD

Series C

Ckt. No.	Tektronix Part No.	Description				Model No.
	*670-0215-00	Complete Card				

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description					Model No.
C1	290-0162-00	22 μF	EMT		35 V		
C3	290-0135-00	15 μF	EMT		20 V		
C4	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C5	290-0135-00	15 μF	EMT		20 V		
C7	290-0162-00	22 μF	EMT		35 V		
C14	281-0504-00	10 pF	Cer		500 V	10%	
C28	281-0592-00	4.7 pF	Cer			±0.5 pF	
C30	281-0558-00	18 pF	Cer		500 V		
C32	281-0096-00	5.5-18 pF	Air	Var			
C33	283-0113-00	56 pF	Cer		500 V	1%	
C34	*295-0092-00	925 pF		(matched set)			
C35		0.01 μF					
C36		0.1 μF					
C41	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C45	283-0004-00	0.02 μF	Cer		150 V		
C53	281-0540-00	51 pF	Cer			5%	
C62	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C85	281-0523-00	100 pF	Cer		500 V		
C92	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C95	281-0523-00	100 pF	Cer		500 V		

Diodes

Ckt. No.	Tektronix Part No.	Description		Model No.
D26	152-0060-00	Zener	1N3027A 1 W, 20 V, 10%	
D50	152-0141-00	Silicon	1N3605	
D68	152-0008-00	Germanium		
D92	*152-0185-00	Silicon	Replaceable by 1N3605	

Inductors

Ckt. No.	Tektronix Part No.	Description	Model No.
L26	*108-0170-01	0.5 μH	
L55	*108-0355-00	Coil, Reed Drive	
L56	*108-0355-00	Coil, Reed Drive	
L57	*108-0355-00	Coil, Reed Drive	
L58	*108-0355-00	Coil, Reed Drive	
L68 (2)	276-0541-00	Core, Ferrite	

Transistors

Ckt. No.	Tektronix Part No.	Description	Model No.
Q14	*151-0108-00	Replaceable by 2N2501	
Q15	*151-0127-00	Selected from 2N2369	
Q24	*151-0127-00	Selected from 2N2369	

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DELAY GENERATOR CARD—Series C *(Cont'd)*

Inductors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	Model No.
Q25	*151-0127-00	Selected from 2N2369	
Q38	*151-0103-00	Replaceable by 2N2219	
Q53	*151-0108-00	Replaceable by 2N2501	
Q64	*151-0127-00	Selected from 2N2369	
Q73	*151-0133-00	Selected from 2N3251	
Q83	*151-0127-00	Selected from 2N2369	
Q94	*151-0127-00	Selected from 2N2369	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description				
R1	307-0053-00	3.3 Ω	½ W			5%
R3	307-0053-00	3.3 Ω	½ W			5%
R5	307-0053-00	3.3 Ω	½ W			5%
R7	307-0053-00	3.3 Ω	½ W			5%
R14	301-0301-00	300 Ω	½ W			5%
R16	301-0391-00	390 Ω	½ W			5%
R18	301-0472-00	4.7 kΩ	½ W			5%
R20	301-0242-00	2.4 kΩ	½ W			5%
R22	311-0496-00	2.5 kΩ		Var		
R24	301-0241-00	240 Ω	½ W			5%
R25	307-0060-00	6.8 Ω	½ W			5%
R26	301-0331-00	330 Ω	½ W			5%
R28	315-0272-00	2.7 kΩ	¼ W			5%
R29	301-0111-00	110 Ω	½ W			5%
R30	301-0681-00	680 Ω	½ W			5%
R33	315-0101-00	100 Ω	¼ W			5%
R34	315-0220-00	22 Ω	¼ W			5%
R38	301-0510-00	51 Ω	½ W			5%
R40	301-0242-00	2.4 kΩ	½ W			5%
R41	311-0462-00	1 kΩ		Var		
R42	301-0202-00	2 kΩ	½ W			5%
R45	322-0612-00	500 Ω	¼ W		Prec	1%
R50	301-0101-00	100 Ω	½ W			5%
R53	301-0511-00	510 Ω	½ W			5%
R54	301-0102-00	1 kΩ	½ W			5%
R55	301-0271-00	270 Ω	½ W			5%
R56	301-0271-00	270 Ω	½ W			5%
R57	301-0271-00	270 Ω	½ W			5%
R58	301-0271-00	270 Ω	½ W			5%
R60	301-0681-00	680 Ω	½ W			5%
R62	301-0112-00	1.1 kΩ	½ W			5%
R65	301-0821-00	820 Ω	½ W			5%
R70	301-0820-00	82 Ω	½ W			5%
R73	301-0432-00	4.3 kΩ	½ W			5%

DELAY GENERATOR CARD—Series C *(Cont'd)*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description		Model No.
R80	301-0101-00	100 Ω	½ W	5%	
R83	301-0470-00	47 Ω	½ W	5%	
R85	301-0202-00	2 kΩ	½ W	5%	
R90	301-0511-00	510 Ω	½ W	5%	
R92	301-0123-00	12 kΩ	½ W	5%	

Switches

	Unwired	Wired	
SW55	260-0552-00		Reed
SW56	260-0552-00		Reed
SW57	260-0552-00		Reed
SW58	260-0552-00		Reed

FUNCTION PROGRAM #1 CARD Series D

	*670-0216-00	Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C1	283-0000-00	0.001 μF	Cer	500 V	
C15	283-0059-00	1 μF	Cer	25 V	+80%—20%
C24	283-0059-00	1 μF	Cer	25 V	+80%—20%
C29	283-0059-00	1 μF	Cer	25 V	+80%—20%
C33	281-0638-00	240 pF	Cer	500 V	5%
C50	283-0059-00	1 μF	Cer	25 V	+80%—20%

Diodes

D8	*152-0185-00	Silicon	Replaceable by 1N3605
D14	152-0141-00	Silicon	1N3605
D21	*152-0075-00	Germanium	Tek Spec
D25	152-0093-00	Tunnel	1N3716 4.7 mA
D28	152-0141-00	Silicon	1N3605
D30	152-0141-00	Silicon	1N3605
D33	*152-0185-00	Silicon	Replaceable by 1N3605
D36	*152-0075-00	Germanium	Tek Spec
D40	*152-0185-00	Silicon	Replaceable by 1N3605
D42	*152-0075-00	Germanium	Tek Spec
D44	*152-0185-00	Silicon	Replaceable by 1N3605
D46	*152-0075-00	Germanium	Tek Spec
D48	152-0079-00	Germanium	HD1841
D49	*152-0185-00	Silicon	Replaceable by 1N3605

FUNCTION PROGRAM #1 CARD—Series D *(Cont'd)*

Inductors

Ckt. No.	Tektronix Part No.	Description			Model No.
L20	*108-0148-00	2.5 μH			
L38	*108-0355-00	Coil, Reed Drive			
L44	*108-0355-00	Coil, Reed Drive			
L48	*108-0355-00	Coil, Reed Drive			

Transistors

Ckt. No.	Tektronix Part No.	Description			Model No.
Q4	*151-0108-00	Replaceable by 2N2501			
Q14	*151-0133-00	Selected from 2N3251			
Q23	*151-0108-00	Replaceable by 2N2501			
Q24	*151-0127-00	Selected from 2N2369			
Q33	*151-0133-00	Selected from 2N3251			
Q53	151-0182-00	2N1307			
Q63	151-0182-00	2N1307			
Q73	151-0182-00	2N1307			
Q83	151-0182-00	2N1307			
Q93	151-0182-00	2N1307			
Q103	151-0182-00	2N1307			
Q113	151-0182-00	2N1307			
Q123	151-0182-00	2N1307			
Q133	151-0182-00	2N1307			
Q143	151-0182-00	2N1307			

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description			Model No.
R1	315-0102-00	1 kΩ	1/4 W	5%	
R5	315-0152-00	1.5 kΩ	1/4 W	5%	
R8	315-0222-00	2.2 kΩ	1/4 W	5%	
R14	315-0272-00	2.7 kΩ	1/4 W	5%	
R15	315-0152-00	1.5 kΩ	1/4 W	5%	
R16	315-0152-00	1.5 kΩ	1/4 W	5%	
R20	301-0332-00	3.3 kΩ	1/2 W	5%	
R21	301-0360-00	36 Ω	1/2 W	5%	
R23	301-0330-00	33 Ω	1/2 W	5%	
R25	315-0110-00	10 Ω	1/4 W	5%	
R28	301-0102-00	1 kΩ	1/2 W	5%	
R29	315-0100-00	10 Ω	1/4 W	5%	
R30	301-0152-00	1.5 kΩ	1/2 W	5%	
R32	315-0100-00	10 Ω	1/4 W	5%	
R33	315-0100-00	10 Ω	1/4 W	5%	
R36	301-0101-00	100 Ω	1/2 W	5%	
R38	301-0271-00	270 Ω	1/2 W	5%	
R42	301-0101-00	100 Ω	1/2 W	5%	
R44	301-0271-00	270 Ω	1/2 W	5%	
R46	301-0101-00	100 Ω	1/2 W	5%	

FUNCTION PROGRAM #1 CARD—Series D *(Cont'd)*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description		Model No.
R48	301-0271-00	270 Ω	½ W	5%	
R50	301-0512-00	5.1 kΩ	½ W	5%	
R53	301-0104-00	100 kΩ	½ W	5%	
R60	301-0512-00	5.1 kΩ	½ W	5%	
R63	301-0104-00	100 kΩ	½ W	5%	
R70	301-0512-00	5.1 kΩ	½ W	5%	
R73	301-0104-00	100 kΩ	½ W	5%	
R80	301-0512-00	5.1 kΩ	½ W	5%	
R83	301-0104-00	100 kΩ	½ W	5%	
R90	301-0512-00	5.1 kΩ	½ W	5%	
R93	301-0104-00	100 kΩ	½ W	5%	
R100	301-0512-00	5.1 kΩ	½ W	5%	
R103	301-0104-00	100 kΩ	½ W	5%	
R110	301-0512-00	5.1 kΩ	½ W	5%	
R113	301-0104-00	100 kΩ	½ W	5%	
R120	301-0512-00	5.1 kΩ	½ W	5%	
R123	301-0104-00	100 kΩ	½ W	5%	
R130	301-0512-00	5.1 kΩ	½ W	5%	
R133	301-0104-00	100 kΩ	½ W	5%	
R140	301-0512-00	5.1 kΩ	½ W	5%	
R143	301-0104-00	100 kΩ	½ W	5%	

Switches

	Unwired	Wired	
SW38	260-0552-00		Reed
SW44	260-0552-00		Reed
SW48	260-0552-00		Reed

WIDTH GENERATOR CARD Series E

*670-0217-00 Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C1	290-0162-00	22 μF	EMT		35 V	
C3	290-0135-00	15 μF	EMT		20 V	
C4	283-0059-00	1 μF	Cer		25 V	+80%—20%
C5	290-0135-00	15 μF	EMT		20 V	
C7	290-0162-00	22 μF	EMT		35 V	
C12	281-0504-00	10 pF	Cer		500 V	10%
C16	281-0509-00	15 pF	Cer		500 V	10%
C26	281-0592-00	4.7 pF	Cer			±0.5 pF
C32	281-0096-00	5.5-18 pF	Air	Var		
C33	283-0113-00	56 pF	Cer		500 V	1%

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WIDTH GENERATOR CARD—Series E *(Cont'd)*

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				Model No.
C34 }		925 pF				
C35 }	*295-0092-00	0.01 μF		(matched set)		
C36 }		0.1 μF				
C41	283-0059-00	1 μF	Cer	25 V	+80%—20%	
C45	283-0004-00	0.02 μF	Cer	150 V		
C62	283-0059-00	1 μF	Cer	25 V	+80%—20%	
C65	283-0059-00	1 μF	Cer	25 V	+80%—20%	

Diodes

D26	152-0060-00	Zener	1N3027A 1 W, 20 V, 10%
D50	152-0141-00	Silicon	1N3605

Inductors

L30	*108-0170-01	0.5 μH
L56	*108-0355-00	Coil, Reed Drive
L57	*108-0355-00	Coil, Reed Drive
L58	*108-0355-00	Coil, Reed Drive

Transistors

Q14	*151-0108-00	Replaceable by 2N2501
Q15	*151-0127-00	Selected from 2N2369
Q24	*151-0127-00	Selected from 2N2369
Q25	*151-0127-00	Selected from 2N2369
Q38	*151-0103-00	Replaceable by 2N2219
Q53	*151-0108-00	Replaceable by 2N2501
Q63	*151-0127-00	Selected from 2N2369

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1	307-0053-00	3.3 Ω	½ W		5%
R3	307-0053-00	3.3 Ω	½ W		5%
R5	307-0053-00	3.3 Ω	½ W		5%
R7	307-0053-00	3.3 Ω	½ W		5%
R12	301-0301-00	300 Ω	½ W		5%
R14	301-0391-00	390 Ω	½ W		5%
R16	301-0681-00	680 Ω	½ W		5%
R18	301-0472-00	4.7 kΩ	½ W		5%
R20	315-0242-00	2.4 kΩ	¼ W		5%
R22	311-0496-00	2.5 kΩ		Var	
R24	301-0241-00	240 Ω	½ W		5%
R25	307-0108-00	6.8 Ω	¼ W		5%
R26	301-0272-00	2.7 kΩ	½ W		5%

WIDTH GENERATOR CARD—Series E *(Cont'd)*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				Model No.
R28	315-0111-00	110 Ω	¼ W			5%	
R30	301-0331-00	330 Ω	½ W			5%	
R33	315-0510-00	51 Ω	¼ W			5%	
R34	315-0100-00	10 Ω	¼ W			5%	
R38	301-0510-00	51 Ω	½ W			5%	
R40	301-0123-00	12 kΩ	½ W			5%	
R41	311-0463-00	5 kΩ		Var			
R42	301-0822-00	8.2 kΩ	½ W			5%	
R45	322-0612-00	500 Ω	¼ W		Prec	1%	
R50	315-0271-00	270 Ω	¼ W			5%	
R54	301-0751-00	750 Ω	½ W			5%	
R56	301-0271-00	270 Ω	½ W			5%	
R57	301-0271-00	270 Ω	½ W			5%	
R58	301-0271-00	270 Ω	½ W			5%	
R60	301-0681-00	680 Ω	½ W			5%	
R62	301-0112-00	1.1 kΩ	½ W			5%	
R65	301-0182-00	1.8 kΩ	½ W			5%	

Switches

	Unwired	Wired	
SW56	260-0552-00		Reed
SW57	260-0552-00		Reed
SW58	260-0552-00		Reed

PULSE SHAPE GENERATOR CARD

Series F

	*670-0218-00		Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C1	290-0162-00	22 μF	EMT		35 V	
C3	290-0135-00	15 μF	EMT		20 V	
C5	283-0059-00	1 μF	Cer		25 V	+80% −20%
C12	283-0003-00	0.01 μF	Cer		150 V	
C22	283-0003-00	0.01 μF	Cer		150 V	
C36	283-0003-00	0.01 μF	Cer		150 V	
C46	283-0003-00	0.01 μF	Cer		150 V	
C55	283-0003-00	0.01 μF	Cer		150 V	
C58	283-0003-00	0.01 μF	Cer		150 V	
C65	283-0003-00	0.01 μF	Cer		150 V	
C68	283-0003-00	0.01 μF	Cer		150 V	
C72	281-0096-00	5.5-18 pF	Air	Var		
C74	281-0097-00	9-35 pF	Cer	Var		

PULSE SHAPE GENERATOR CARD—Series F *(Cont'd)*

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				Model No.
C75	Use 283-0622-00	450 pF	Mica	300 V	1%	
C76 }	*295-0093-00	0.005 μF		(matched set)		
C77 }		0.05 μF				
C90	283-0000-00	0.001 μF	Cer	500 V		
C120	290-0134-00	22 μF	EMT	15 V		
C122	283-0059-00	1 μF	Cer	25 v	+80%—20%	

Diodes

D12	152-0127-00	Zener	1N755A, 0.4 W, 7.5 V, 5%
D22	152-0149-00	Zener	1N961B 0.4 W, 10 V, 5%
D72	152-0141-00	Silicon	1N3605
D90	*152-0185-00	Silicon	Replaceable by 1N3605
D120	*152-0185-00	Silicon	Replaceable by 1N3605
D122	*152-0161-00	Tek	GaAs

Inductors

L80	*108-0355-00	Coil, Reed Drive
L81	*108-0355-00	Coil, Reed Drive
L82	*108-0355-00	Coil, Reed Drive

Transistors

Q14	*151-0133-00	Selected from 2N3251
Q24	*151-0127-00	Selected from 2N2369
Q34	*151-0133-00	Selected from 2N3251
Q44	*151-0127-00	Selected from 2N2369
Q58	*151-0127-00	Selected from 2N2369
Q68	*151-0133-00	Selected from 2N3251
Q88	151-0164-00	2N3702
Q94	151-0164-00	2N3702
Q104	*151-0153-00	Replaceable by 2N3923
Q114	151-0164-00	2N3702
Q123	*151-0133-00	Selected from 2N3251
Q124	*151-0136-00	Replaceable by 2N3053

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1	307-0104-00	3.3 Ω	1/4 W		5%
R3	307-0104-00	3.3 Ω	1/4 W		5%
R5	307-0104-00	3.3 Ω	1/4 W		5%
R10	315-0220-00	22 Ω	1/4 W		5%
R12	315-0152-00	1.5 kΩ	1/4 W		5%
R14	315-0101-00	100 Ω	1/4 W		5%
R22	301-0202-00	2 kΩ	1/2 W		5%
R24	315-0101-00	100 Ω	1/4 W		5%
R30	315-0332-00	3.3 kΩ	1/4 W		5%
R32	311-0462-00	1 kΩ		Var	

PULSE SHAPE GENERATOR CARD—Series F *(Cont'd)*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					Model No.
R33	315-0222-00	2.2 kΩ	¼ W			5%	
R36	315-0470-00	47 Ω	¼ W			5%	
R38	315-0180-00	18 Ω	¼ W			5%	
R40	315-0221-00	220 Ω	¼ W			5%	
R42	311-0462-00	1 kΩ		Var			
R43	315-0222-00	2.2 kΩ	¼ W			5%	
R46	315-0470-00	47 Ω	¼ W			5%	
R48	315-0180-00	18 Ω	¼ W			5%	
R52	315-0302-00	3 kΩ	¼ W			5%	
R54	311-0462-00	1 kΩ		Var			
R55	315-0751-00	750 Ω	¼ W			5%	
R56	315-0330-00	33 Ω	¼ W			5%	
R58	322-0136-00	255 Ω	¼ W		Prec	1%	
R62	315-0751-00	750 Ω	¼ W			5%	
R64	311-0462-00	1 kΩ		Var			
R65	315-0302-00	3 kΩ	¼ W			5%	
R66	315-0330-00	33 Ω	¼ W			5%	
R68	322-0133-00	237 Ω	¼ W		Prec	1%	
R72	315-0510-00	51 Ω	¼ W			5%	
R75	315-0220-00	22 Ω	¼ W			5%	
R80	301-0271-00	270 Ω	½ W			5%	
R81	301-0271-00	270 Ω	½ W			5%	
R82	301-0271-00	270 Ω	½ W			5%	
R84	315-0102-00	1 kΩ	¼ W			5%	
R85	311-0462-00	1 kΩ		Var			
R86	315-0302-00	3 kΩ	¼ W			5%	
R88	315-0153-00	15 kΩ	¼ W			5%	
R90	321-0217-00	1.78 kΩ	⅛ W		Prec	1%	
R92	315-0153-00	15 kΩ	¼ W			5%	
R94	315-0103-00	10 kΩ	¼ W			5%	
R96	315-0222-00	2.2 kΩ	¼ W			5%	
R104	315-0223-00	22 kΩ	¼ W			5%	
R120	315-0103-00	10 kΩ	¼ W			5%	
R122	315-0122-00	1.2 kΩ	¼ W			5%	
R125	315-0271-00	270 Ω	¼ W			5%	

Switches

	Unwired	Wired	Description
SW81	260-0552-00		Reed
SW82	260-0552-00		Reed
SW83	260-0552-00		Reed

OUTPUT AMPLIFIER CARD

Series G

Ckt. No.	Tektronix Part No.	Description				Model No.
	*670-0019-00	Complete Card				

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description				
C1	290-0162-00	22 μF	EMT		35 V	
C2	283-0059-00	1 μF	Cer		25 V	+80%—20%
C3	290-0162-00	22 μF	EMT		35 V	
C6	290-0162-00	22 μF	EMT		35 V	
C10	283-0059-00	1 μF	Cer		25 V	+80%—20%
C12	283-0059-00	1 μF	Cer		25 V	+80%—20%
C18	283-0059-00	1 μF	Cer		25 V	+80%—20%
C34	283-0081-00	0.1 μF	Cer		25 V	+80%—20%
C38	283-0059-00	1 μF	Cer		25 V	+80%—20%
C40	281-0621-00	12 pF	Cer		500 V	1%
C44	283-0003-00	0.01 μF	Cer		150 V	
C45	283-0065-00	0.001 μF	Cer		100 V	5%
C50	281-0096-00	5.5-18 pF	Air	Var		
C68	283-0004-00	0.02 μF	Cer		150 V	
C70	290-0162-00	22 μF	EMT		35 V	
C102	283-0051-00	0.0033 μF	Cer		100 V	5%
C108	283-0059-00	1 μF	Cer		25 V	+80%—20%

Diodes

Ckt. No.	Tektronix Part No.	Description	
D10	*152-0153-00	Silicon	Replaceable by 1N4244
D22	*152-0153-00	Silicon	Replaceable by 1N4244
D24	152-0141-00	Silicon	1N3605
D25	152-0141-00	Silicon	1N3605
D26	152-0141-00	Silicon	1N3605
D44	152-0149-00	Zener	1N961B 0.4 W, 10 V, 5%
D84	*152-0185-00	Silicon	Replaceable by 1N3605

Inductors

Ckt. No.	Tektronix Part No.	Description
L28	*108-0340-00	Coil, Reed Drive, Double
L84	276-0543-00	Core, Ferrite
L94	276-0543-00	Core, Ferrite
L104	276-0543-00	Core, Ferrite
LR45	*108-0352-00	0.1 μH (wound on a 3.6 Ω resistor)

Transistors

Ckt. No.	Tektronix Part No.	Description
Q13	*151-0133-00	Selected from 2N3251
Q23	*151-0127-00	Selected from 2N2369
Q33	*151-0108-00	Replaceable by 2N2501
Q34	*151-0134-00	Replaceable by 2N2905
Q44	*151-0134-00	Replaceable by 2N2905
Q53	*151-0134-00	Replaceable by 2N2905
Q54	*151-0127-00	Selected from 2N2369
Q64	*151-0127-00	Selected from 2N2369
Q74	*151-0127-00	Selected from 2N2369
Q84	*151-0134-00	Replaceable by 2N2905
Q94	*151-0134-00	Replaceable by 2N2905
Q104	*151-0134-00	Replaceable by 2N2905

OUTPUT AMPLIFIER CARD—Series G *(Cont'd)*

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description				Model No.
R1	307-0106-00	4.7 Ω	¼ W		5%	
R3	307-0103-00	2.7 Ω	¼ W		5%	
R6	307-0113-00	5.1 Ω	¼ W		5%	
R7	307-0106-00	4.7 Ω	¼ W		5%	
R12	315-0100-00	10 Ω	¼ W		5%	
R13	303-0132-00	1.3 kΩ	1 W		5%	
R16	315-0101-00	100 Ω	¼ W		5%	
R18	315-0100-00	10 Ω	¼ W		5%	
R20	315-0121-00	120 Ω	¼ W		5%	
R22	304-0182-00	1.8 kΩ	1 W			
R24	305-0751-00	750 Ω	2 W		5%	
R28	301-0101-00	100 Ω	½ W		5%	
R32	315-0221-00	220 Ω	¼ W		5%	
R34	311-0462-00	1 kΩ		Var		
R35	315-0392-00	3.9 kΩ	¼ W		5%	
R36	315-0751-00	750 Ω	¼ W		5%	
R40	301-0151-00	150 Ω	½ W		5%	
R42	311-0433-00	100 Ω		Var		
R44	315-0302-00	3 kΩ	¼ W		5%	
R46	301-0391-00	390 Ω	½ W		5%	
R48	301-0391-00	390 Ω	½ W		5%	
R49	315-0203-00	20 kΩ	¼ W		5%	
R50	315-0181-00	180 Ω	¼ W		5%	
R51	315-0510-00	51 Ω	¼ W		5%	
R53	305-0621-00	620 Ω	2 W		5%	
R54	315-0330-00	33 Ω	¼ W		5%	
R64	315-0330-00	33 Ω	¼ W		5%	
R74	315-0330-00	33 Ω	¼ W		5%	
R80	315-0183-00	18 kΩ	¼ W		5%	
R84	301-0750-00	75 Ω	½ W		5%	
R90	315-0183-00	18 kΩ	¼ W		5%	
R94	301-0750-00	75 Ω	½ W		5%	
R100	315-0183-00	18 kΩ	¼ W		5%	
R102	315-0432-00	4.3 kΩ	¼ W		5%	
R104	301-0750-00	75 Ω	½ W		5%	

Switches

	Unwired	Wired	
SW28A	260-0721-00		Reed, Double
SW28B	260-0721-00		Reed, Double

ATTENUATOR CARD

Series H

Ckt. No.	Tektronix Part No.	Description				Model No.
	*670-0220-00	Complete Card				

Bulbs

Ckt. No.	Tektronix Part No.	Description
B1	150-0046-00	Incandescent #21070
B4	150-0046-00	Incandescent #21070

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description			
C14	281-0512-00	27 pF	Cer	500 V	10%
C32	283-0003-00	0.01 μF	Cer	150 V	
C40	283-0000-00	0.001 μF	Cer	500 V	
C74	290-0121-00	2 μF	EMT	25 V	

Diodes

Ckt. No.	Tektronix Part No.	Description	
D40	*152-0185-00	Silicon	Replaceable by 1N3605
D70	*152-0185-00	Silicon	Replaceable by 1N3605

Connector

Ckt. No.	Tektronix Part No.	Description
J18	131-0391-00	50 Ω, coaxial, male

Relays

Ckt. No.	Tektronix Part No.	Description	
K1	148-0025-00	Armature Relay	6 V DC
K4	148-0025-00	Armature Relay	6 V DC

Transistors

Ckt. No.	Tektronix Part No.	Description
Q38	151-0164-00	2N3702
Q44	151-0164-00	2N3702
Q54	*151-0153-00	Replaceable by 2N2923
Q64	151-0164-00	2N3702
Q74	*151-0136-00	Replaceable by 2N3053

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description				
R1	303-0750-00	75 Ω	1 W			5%
R4	303-0750-00	75 Ω	1 W			5%
R6	305-0510-00	51 Ω	2 W			5%
R7	305-0510-00	51 Ω	2 W			5%
R9	324-0097-00	100 Ω	1 W	Prec		1%
R10	324-0097-00	100 Ω	1 W	Prec		1%
R12	305-0101-00	100 Ω	2 W			5%
R13	305-0101-00	100 Ω	2 W			5%
R14	305-0101-00	100 Ω	2 W			5%
R16	323-0606-00	60 Ω	½ W		Prec	1%
R17	323-0606-00	60 Ω	½ W		Prec	1%
R18	323-0606-00	60 Ω	½ W		Prec	1%
R20	323-0047-00	30.1 Ω	½ W		Prec	1%
R30	315-0202-00	2 kΩ	¼ W			5%
R32	311-0462-00	1 kΩ		Var		

ATTENUATOR CARD—Series H *(Cont'd)*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			Model No.
R35	315-0272-00	2.7 kΩ	¼ W	5%	
R38	315-0103-00	10 kΩ	¼ W	5%	
R42	301-0103-00	10 kΩ	½ W	5%	
R44	301-0103-00	10 kΩ	½ W	5%	
R46	301-0222-00	2.2 kΩ	½ W	5%	
R54	311-0496-00	2.5 kΩ	Var		
R56	315-0152-00	1.5 kΩ	¼ W	5%	
R64	315-0273-00	27 kΩ	¼ W	5%	
R74	301-0362-00	3.6 kΩ	½ W	5%	

POWER SUPPLY CARD

Series I

	*670-0221-00	Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C2	283-0081-00	0.1 μF	Cer	25 V	+80%—20%
C14	283-0059-00	1 μF	Cer	25 V	+80%—20%
C23	290-0117-00	50 μF	EMT	50 V	
C30	283-0059-00	1 μF	Cer	25 V	+80%—20%
C36	290-0158-00	50 μF	EMT	25 V	+75%—15%
C76	283-0081-00	0.1 μF	Cer	25 V	+80%—20%
C92	283-0059-00	1 μF	Cer	25 V	+80%—20%
C113	283-0059-00	1 μF	Cer	25 V	+80%—20%

Diodes

D2	152-0105-00	Zener	1N2620	TC
D30	152-0127-00	Zener	1N755A,	0.4 W, 7.5 V, 5%

Transistors

Q6	151-0164-00	2N3702
Q16	151-0164-00	2N3702
Q23	*151-0134-00	Replaceable by 2N2905
Q33	*151-0136-00	Replaceable by 2N3053
Q46	151-0164-00	2N3702
Q53	*151-0134-00	Replaceable by 2N2905
Q56	151-0164-00	2N3702
Q66	*151-0153-00	Replaceable by 2N2923
Q76	*151-0153-00	Replaceable by 2N2923
Q83	*151-0136-00	Replaceable by 2N3053

POWER SUPPLY CARD—Series I *(Cont'd)*

Transistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	Model No.
Q96	151-0164-00	2N3702	
Q103	151-0164-00	2N3702	
Q106	151-0164-00	2N3702	
Q113	*151-0136-00	Replaceable by 2N3053	

Resistors

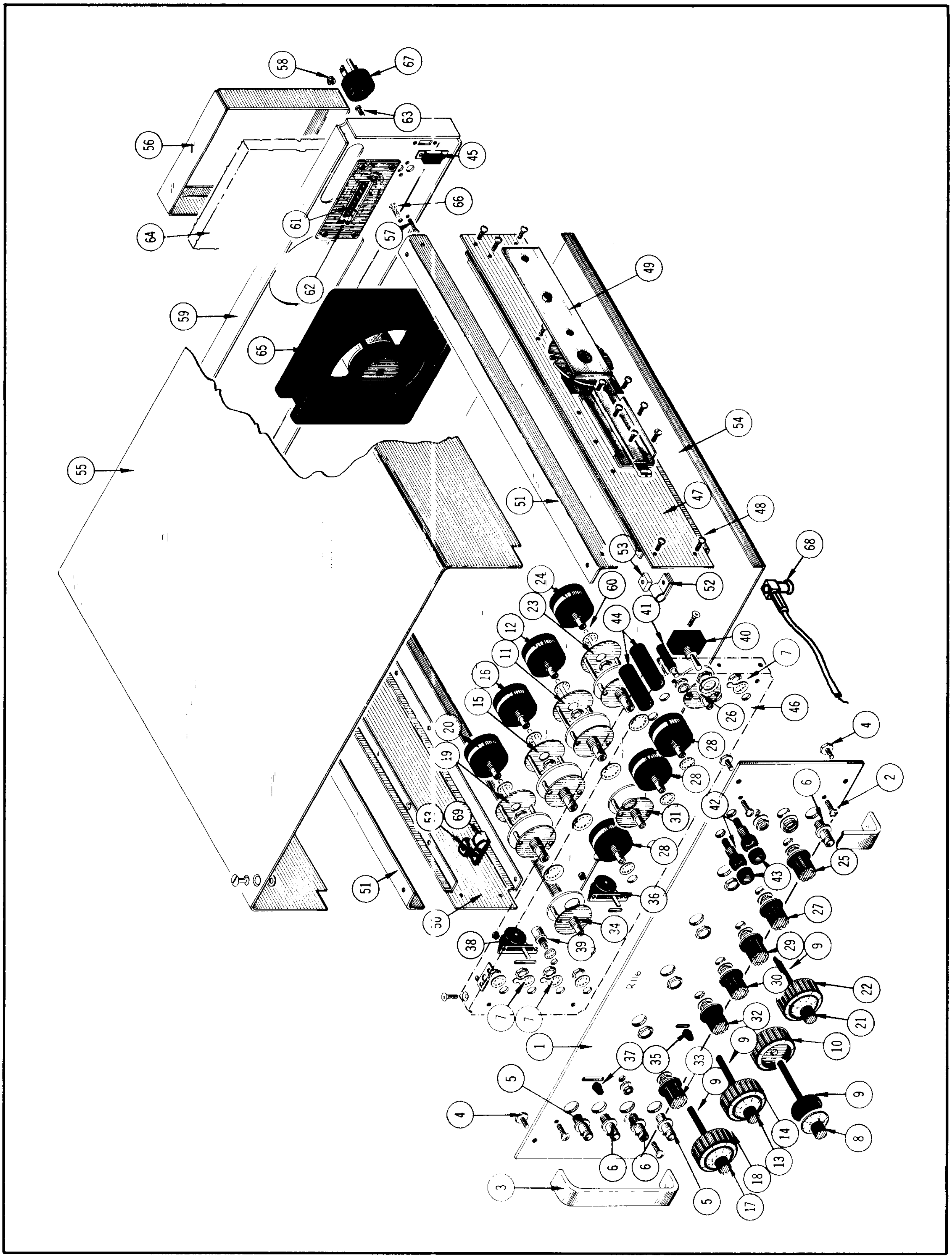
Resistors are fixed, composition, ±10% unless otherwise indicated.

R2	315-0152-00	1.5 kΩ	¼ W			5%
R6	315-0242-00	2.4 kΩ	¼ W			5%
R10	315-0432-00	4.3 kΩ	¼ W			5%
R12	315-0682-00	6.8 kΩ	¼ W			5%
R14	311-0462-00	1 kΩ		Var		
R16	315-0392-00	3.9 kΩ	¼ W			5%
R20	315-0563-00	56 kΩ	¼ W			5%
R23	315-0472-00	4.7 kΩ	¼ W			5%
R30	315-0182-00	1.8 kΩ	¼ W			5%
R33	306-0121-00	120 Ω	2 W			
R36	315-0751-00	750 Ω	¼ W			5%
R42	322-0258-00	4.75 kΩ	¼ W		Prec	1%
R44	322-0261-00	5.11 kΩ	¼ W		Prec	1%
R46	315-0752-00	7.5 kΩ	¼ W			5%
R50	315-0103-00	10 kΩ	¼ W			5%
R53	315-0682-00	6.8 kΩ	¼ W			5%
R56	321-0631-00	12.5 kΩ	⅛ W		Prec	1%
R57	321-0239-00	3.01 kΩ	⅛ W		Prec	1%
R62	315-0302-00	3 kΩ	¼ W			5%
R64	315-0123-00	12 kΩ	¼ W			5%
R70	315-0622-00	6.2 kΩ	¼ W			5%
R74	315-0472-00	4.7 kΩ	¼ W			5%
R76	321-0258-00	4.75 kΩ	⅛ W		Prec	1%
R78	321-0261-00	5.11 kΩ	⅛ W		Prec	1%
R80	315-0751-00	750 Ω	¼ W			5%
R83	315-0221-00	220 Ω	¼ W			5%
R85	315-0152-00	1.5 kΩ	¼ W			5%
R87	315-0101-00	100 Ω	¼ W			5%
R96	315-0822-00	8.2 kΩ	¼ W			5%
R103	315-0682-00	6.8 kΩ	¼ W			5%
R106	315-0103-00	10 kΩ	¼ W			5%

SECTION 9
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 8. 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 8.

FRONT & FRAME



FRONT & FRAME

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	333-0890-00			1	PANEL, front
	- - - - - -			-	mounting hardware: (not included w/panel)
2	212-0068-00			4	SCREW, 8-32 x 5/16 inch, THS, phillips
3	367-0032-00			2	HANDLE, chrome, 4 9/16 inches
	- - - - - -			-	mounting hardware for each: (not included w/handle)
4	213-0090-00			2	SCREW, hex., 10-32 x 1/2 inch
	210-0010-00			2	LOCKWASHER, internal, #10
5	131-0352-00			2	CONNECTOR, coaxial, 1 contact, BNC
6	131-0352-00			3	CONNECTOR, coaxial, 1 contact, BNC
	- - - - - -			-	mounting hardware for each: (not included w/connector)
7	210-0255-00			1	LUG, solder, 3/8 inch
	210-1000-00			1	WASHER, BNC connector
8	366-0334-00			1	KNOB, charcoal—WIDTH
	- - - - - -			-	knob includes:
	213-0075-00			1	SCREW, set, 4-40 x 3/32 inch, HSS
9	358-0269-00			4	BUSHING, index mount dial
10	366-0335-00			1	KNOB, charcoal—WIDTH
	- - - - - -			-	knob includes:
	213-0004-00			2	SCREW, set, 6-32 x 3/16 inch, HSS
11	260-0706-00			1	SWITCH, unwired—WIDTH
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0049-00			1	LOCKWASHER, internal, 5/8 ID x 0.867 inch OD
	210-0579-00			1	NUT, hex., 5/8-24 x 3/4 inch
12	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	resistor includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
13	366-0334-00			1	KNOB, charcoal—DELAY OR BURST TIME
	- - - - - -			-	knob includes:
	213-0075-00			1	SCREW, set, 4-40 x 3/32 inch, HSS
14	366-0335-00			1	KNOB, charcoal—DELAY OR BURST TIME
	- - - - - -			-	knob includes:
	213-0004-00			2	SCREW, set, 6-32 x 3/16 inch, HSS
15	260-0706-00			1	SWITCH, unwired—DELAY OR BURST TIME
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0049-00			1	LOCKWASHER, internal, 5/8 ID x 0.867 inch OD
	210-0579-00			1	NUT, hex., 5/8-24 x 3/4 inch

FRONT & FRAME *(Cont)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
16	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	resistor includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
17	366-0334-01			1	KNOB, charcoal—PERIOD
	- - - - - -			-	knob includes:
	213-0075-00			1	SCREW, set, 4-40 x 3/32 inch, HSS
18	366-0335-02			1	KNOB, charcoal—PERIOD
	- - - - - -			-	knob includes:
	213-0004-00			2	SCREW, set, 6-32 x 3/16 inch, HSS
19	260-0705-00			1	SWITCH, unwired—PERIOD
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0049-00			1	LOCKWASHER, internal, 5/8 ID x 0.867 inch OD
	210-0579-00			1	NUT, hex., 5/8-24 x 3/8 inch
20	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	resistor includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
21	366-0334-02			1	KNOB, charcoal—AMPLITUDE
	- - - - - -			-	knob includes:
	213-0075-00			1	SCREW, set, 4-40 x 3/32 inch, HSS
22	366-0335-01			1	KNOB, charcoal—AMPLITUDE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
23	260-0707-00			1	SWITCH, unwired—AMPLITUDE
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0049-00			1	LOCKWASHER, internal, 5/8 ID x 0.867 inch OD
	210-0413-00			1	NUT, hex., 5/8-24 x 3/4 inch
24	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	resistor includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch

FRONT & FRAME *(Cont)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
25	366-0173-00			1	KNOB, charcoal—POLARITY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
26	260-0709-00			1	SWITCH, unwired—POLARITY
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0840-00			1	WASHER, 0.390 ID x $^9/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
27	366-0173-00			1	KNOB, charcoal—FALLTIME MULT
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^9/_{16}$ inch, HSS
28	- - - - - -			3	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	210-0840-00			1	WASHER, 0.390 ID x $^9/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
	210-0012-00			1	LOCKWASHER, internal, $^3/_8$ ID x $^1/_2$ inch OD
29	366-0173-00			1	KNOB, charcoal—RISETIME MULT
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
30	366-0173-00			1	KNOB, charcoal—RISETIME FALLTIME RANGE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
31	260-0710-00			1	SWITCH, unwired—RISETIME FALLTIME RANGE
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0840-00			1	WASHER, 0.390 ID x $^9/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
32	366-0173-00			1	KNOB, charcoal—DC OFFSET
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
33	366-0173-00			1	KNOB, charcoal—MODE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
34	260-0708-00			1	SWITCH, unwired—MODE
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0840-00			1	WASHER, 0.390 ID x $^9/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
	210-0012-00			1	LOCKWASHER, internal, $^3/_8$ ID x $^1/_2$ inch OD
	210-0207-00			1	LUG, solder, $^3/_8$ ID x $^5/_8$ inch OD, SE
35	366-0215-01			1	KNOB, charcoal—PROGRAM
36	260-0711-00			1	SWITCH, unwired—PROGRAM
	- - - - - -			-	mounting hardware: (not included w/switch)
	220-0413-00			2	NUT, hex., 4-40 x 0.187 x 0.562 inch long
37	366-0215-01			1	KNOB, charcoal—TRIGGER SOURCE
38	260-0490-00			1	SWITCH, unwired—TRIGGER SOURCE
	- - - - - -			-	mounting hardware: (not included w/switch)
	220-0413-00			2	NUT, hex., 4-40 x 0.187 x 0.562 inch long

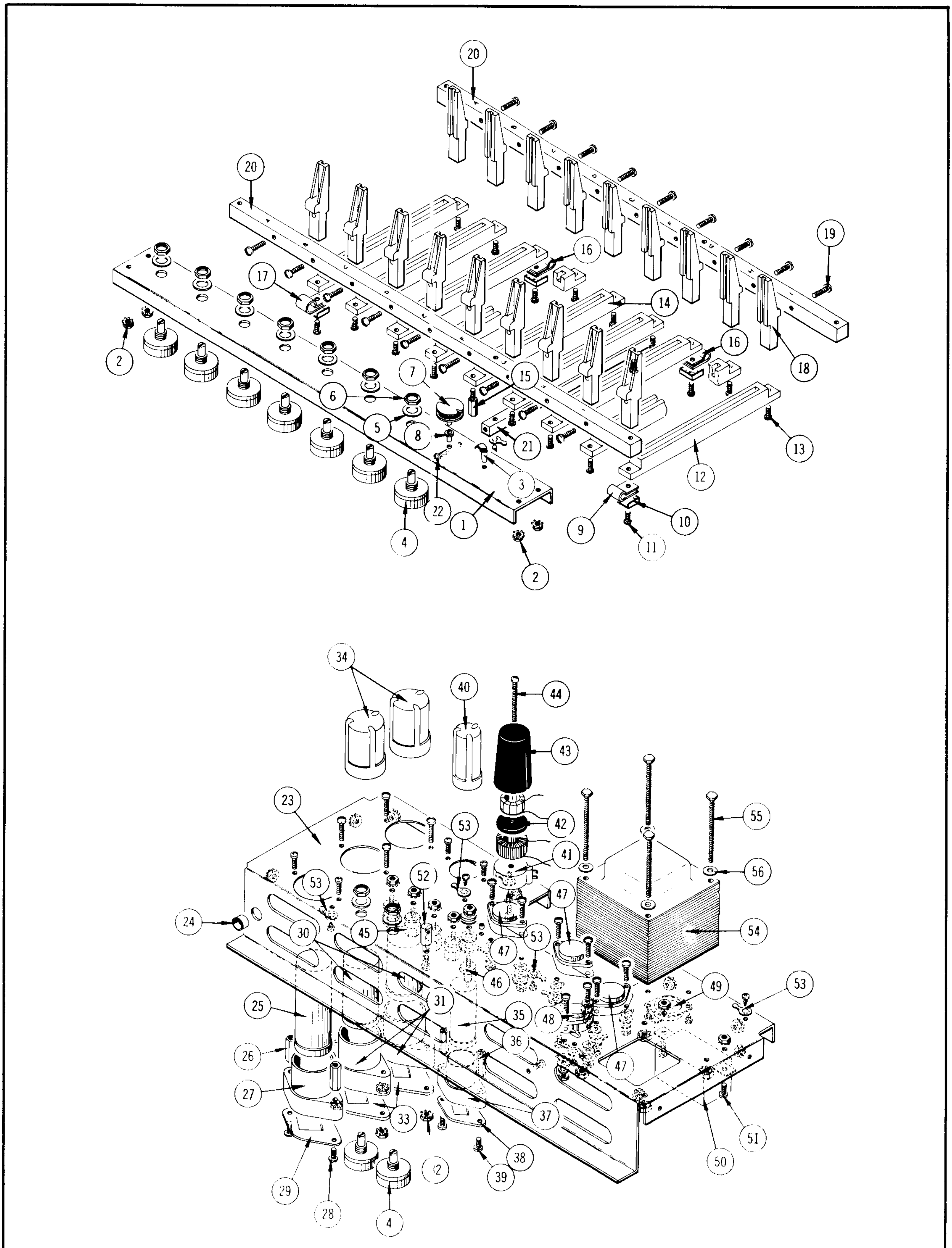
FRONT & FRAME *(Cont)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
39	260-0247-00			1	SWITCH, unwired—TRIG
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
40	260-0199-00			1	SWITCH—POWER
	- - - - - -			-	mounting hardware: (not included w/switch)
	354-0055-00			1	RING, locking switch
	210-0902-00			1	WASHER, flat, 0.470 ID x 21/32 inch OD
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
	210-0414-00			1	NUT, hex., 15/32-32 x 9/16 inch
41	- - - - - -			1	LIGHT, pilot
	- - - - - -			-	mounting hardware: (not included w/light)
	210-0978-00			1	WASHER, flat, 3/16 ID x 1/2 inch OD
	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
42	352-0010-00			2	HOLDER, fuse
	- - - - - -			-	mounting hardware for each: (not included w/holder)
	210-0873-00			1	WASHER, rubber, 1/2 ID x 11/16 inch OD
	- - - - - -			1	NUT, fuse holder
43	200-0582-00			2	CAP, fuse
44	200-0237-00			2	COVER, insulation, fuse holder
45	260-0675-00			1	SWITCH, screwdriver slot
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS, phillips
46	386-0223-00			1	PLATE, sub-panel, front
47	122-0131-01			1	ANGLE, right rail
	- - - - - -			-	mounting hardware: (not included w/angle)
48	212-0023-00			4	SCREW, 8-32 x 3/8 inch, PHS, phillips
49	351-0027-00			1	TRACK, slideout chassis (pair)
	- - - - - -			-	mounting hardware: (not included w/track)
	212-0518-00			6	SCREW, 10-32 x 5/16 inch, PHB, phillips
50	122-0131-00			1	ANGLE, left rail
	- - - - - -			-	mounting hardware: (not included w/angle)
	212-0023-00			4	SCREW, 8-32 x 3/8 inch, PHS, phillips

FRONT & FRAME *(Cont)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
51	122-0114-00			2	ANGLE, top rail
	- - - - - -			-	mounting hardware for each: (not included w/angle)
	212-0040-00			4	SCREW, 8-32 x 3/8 inch, 100° CSK, FHS, phillips
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
52	343-0005-00			1	CLAMP, cable, plastic, 7/16 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
	211-0014-00			1	SCREW, 4-40 x 1/2 inch, PHS, phillips
53	210-0863-00			1	WASHER, D shape, 0.191 ID x 33/64 w x 33/64 inch long
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
54	200-0542-00			1	COVER, dust, bottom
55	200-0540-00			1	COVER, dust, top
56	200-0541-00			1	COVER, filter
	- - - - - -			-	mounting hardware: (not included w/cover)
57	211-0516-00			4	SCREW, 6-32 x 7/8 inch, PHS, phillips
	210-0407-00			4	NUT, hex., 6-32 x 1/4 inch
58	210-0401-00			4	NUT, cap., hex., 6-32 x 5/16 inch
59	386-0222-00			1	PLATE, frame rear
60	384-0380-00			4	ROD, extension
61	131-0294-00			1	CONNECTOR, 36 pin
	210-0001-00			2	LOCKWASHER, internal #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
	211-0001-00			2	SCREW, 2-56 x 1/4 inch, RHS, phillips
62	386-0221-00			1	PLATE, connector
63	- - - - - -			-	mounting hardware: (not included w/plate)
	211-0504-00			4	SCREW, 6-32 x 1/4 inch, PHS, phillips
64	378-0029-00			1	FILTER, air foam
65	119-0031-00			1	FAN
	- - - - - -			-	mounting hardware: (not included w/fan)
66	211-0511-00			4	SCREW, 6-32 x 1/2 inch, PHS, phillips
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
67	131-0430-00			1	ASSEMBLY, motor base connector
	- - - - - -			-	assembly includes:
	129-0041-00			1	POST, ground, 4-40 one end
	211-0015-00			1	SCREW, 4-40 x 1/2 inch, RHS, phillips
	200-0185-00			1	COVER, motor base, black
	214-0078-00			2	PIN, brass, connecting
	377-0041-00			1	INSERT, black
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
	386-1044-00			1	PLATE, aluminum, mounting (not shown)
	- - - - - -			-	mounting hardware: (not included w/assembly)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS (not shown)
68	175-0360-00			1	ASSEMBLY, 50 Ω cable
69	343-0006-00			1	CLAMP, cable, plastic, 1/2 inch

BRACKETS & CHASSIS



BRACKETS & CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	441-0638-00			1	CHASSIS, pot
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0510-00			4	SCREW, 6-32 x 3/8 inch, PHS, phillips
2	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
3	343-0088-00			1	CLAMP, small, snap-in
4	- - - - - -			7	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
5	210-0840-00			1	WASHER, 0.390 ID x 9/16 inch OD
6	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
7	214-0210-00			1	SPOOL, solder
	- - - - - -			-	mounting hardware: (not included w/spool)
8	361-0007-00			1	SPACER, plastic, 0.188 inch long
9	343-0001-00			1	CLAMP, cable, plastic, 1/8 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
10	210-0863-00			1	WASHER, D shape, 0.191 ID x 33/64 w x 33/64 inch long
11	211-0014-00			1	SCREW, 4-40 x 1/2 inch, PHS, phillips
12	131-0292-00			6	CONNECTOR, 56 pin
	- - - - - -			-	mounting hardware for each: (not included w/connector)
13	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS, phillips
14	131-0292-00			3	CONNECTOR, 56 pin
	- - - - - -			-	mounting hardware for each: (not included w/connector)
15	129-0079-00			2	POST, cover support
16	343-0003-00			2	CLAMP, cable, plastic, 1/4 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
	210-0863-00			1	WASHER, D shape, 0.191 ID x 33/64 w x 33/64 inch long
	211-0014-00			1	SCREW, 4-40 x 1/2 inch, PHS, phillips
17	343-0005-00			2	CLAMP, cable, plastic, 7/16 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
	210-0863-00			1	WASHER, D shape, 0.191 ID x 33/64 w x 33/64 inch long
	211-0014 00			1	SCREW, 4-40 x 1/2 inch, PHS, phillips
18	351-0059-00			18	GUIDE, circuit card
	- - - - - -			-	mounting hardware for each: (not included w/guide)
19	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS, phillips
20	381-0244-00			2	BAR, guide, board support
	- - - - - -			-	mounting hardware for each: (not included w/bar)
	212-0040-00			2	SCREW, 8-32 x 3/8 inch, 100° CSK, FHS, phillips
21	381-0245-00			1	BAR, aluminum, support
	- - - - - -			-	mounting hardware: (not included w/bar)
	210-0202-00			1	LUG, solder, SE #6
	211-0514-00			2	SCREW, 6-32 x 3/4 inch, PHS, phillips
22	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS, phillips

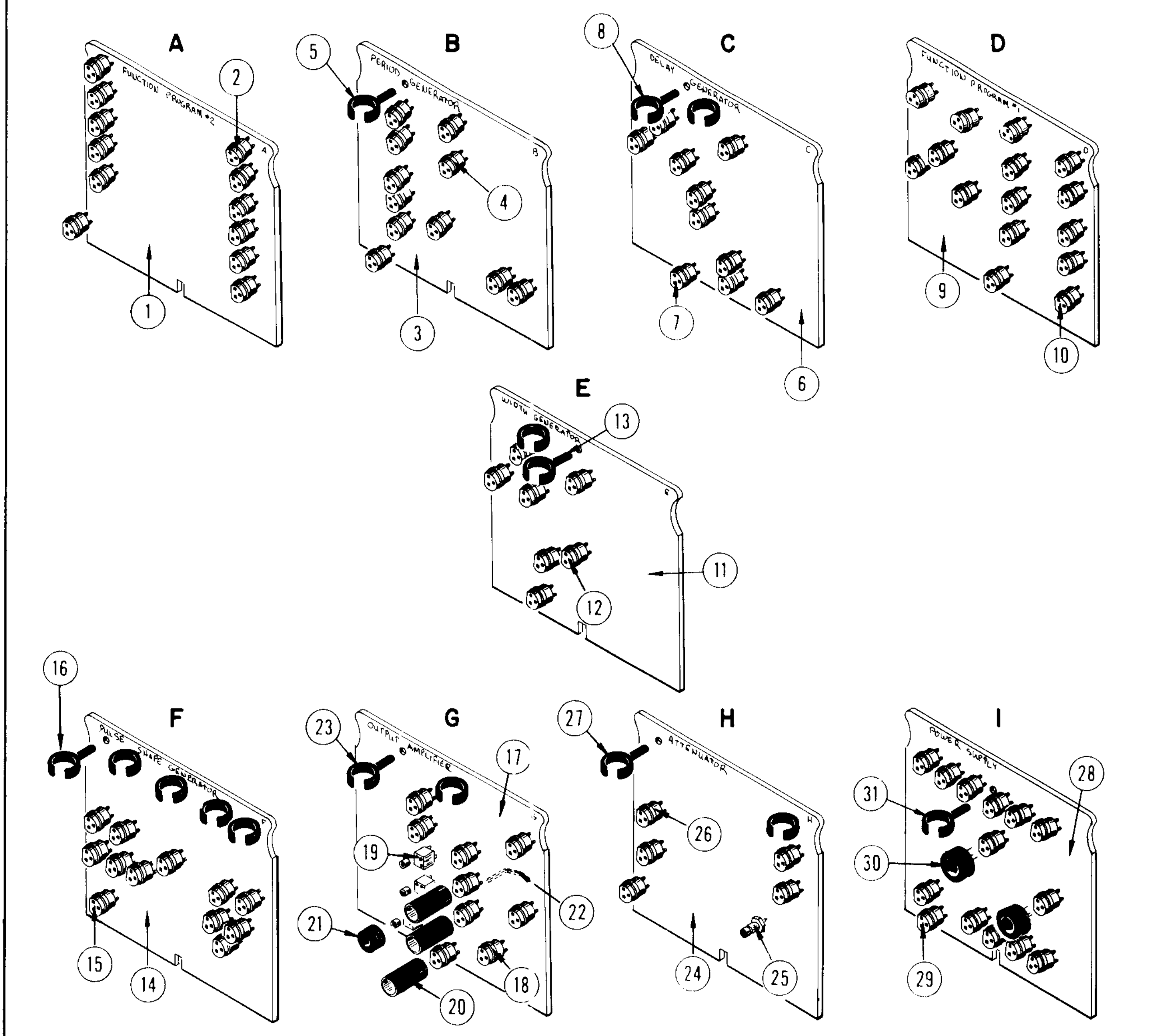
BRACKETS & CHASSIS *(Cont)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
23	441-0637-00			1	CHASSIS, power
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS, phillips
	212-0023-00			8	SCREW, 8-32 x 3/8 inch, PHS, phillips
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
	210-0458-00			8	NUT, keps, 8-32 x 11/32 inch
24	348-0063-00			1	GROMMET, plastic, 1/2 inch
25	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
26	385-0146-00			2	ROD, hex., 1/4 OD x 11/16 inch long
27	432-0048-00			1	BASE, large capacitor mounting
28	211-0514-00			2	SCREW, 6-32 x 3/4 inch, PHS, phillips
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
29	386-0255-00			1	PLATE, metal, flange
30	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
31	432-0048-00			1	BASE, large capacitor mounting
	211-0516-00			2	SCREW, 6-32 x 7/8 inch, PHS, phillips
32	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
33	386-0254-00			1	PLATE, fiber, flange
34	200-0538-00			2	COVER, capacitor, plastic
35	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
36	385-0146-00			2	ROD, hex., 1/4 OD x 11/16 inch long
37	432-0047-00			1	BASE, small capacitor mounting
38	386-0252-00			1	PLATE, fiber, flange
39	211-0514-00			2	SCREW, 6-32 x 3/4 inch, PHS, phillips
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
40	200-0256-00			1	COVER, capacitor, plastic
41	- - - - - -			1	COIL
	- - - - - -			-	mounting hardware: (not included w/coil)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
42	210-1007-00			1	WASHER, non metallic
43	200-0659-00			1	COVER, inductor
44	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS, phillips
45	214-0289-00			4	SINK, heat, transistor
	- - - - - -			-	mounting hardware: (not included w/sink)
	220-0410-00			1	NUT, keps, 10-32 x 3/8 inch
46	- - - - - -			1	DIODE
46	- - - - - -			-	mounting hardware: (not included w/diode)
	210-0206-00			1	LUG, solder, SE #10 long
	210-0813-00			2	WASHER, fiber, #10
	220-0410-00			1	NUT, keps, 10-32 x 3/8 inch
	210-0805-00			2	WASHER, flat, 0.204 ID x 0.438 inch OD

BRACKETS & CHASSIS *(Cont)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
47	- - - - - -			3	TRANSISTOR
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS, phillips
	386-0978-00			1	PLATE, mica, insulator
	210-0983-00			2	WASHER, aluminum, black anodized
	210-0802-00			2	WASHER, flat, 0.150 ID x 5/16 inch OD
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0202-00			1	LUG, solder, SE #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
48	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: (not included w/transistor)
	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS, phillips
	386-0143-00			1	PLATE, mica, insulator
	210-0983-00			2	WASHER, aluminum, black anodized
	210-0802-00			2	WASHER, flat, 0.150 ID x 5/16 inch OD
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0202-00			1	LUG, solder, SE #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
49	260-0246-00			1	SWITCH, thermal cutout
	- - - - - -			-	mounting hardware: (not included w/switch)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS, phillips
50	- - - - - -			1	FILTER, line
	- - - - - -			-	mounting hardware: (not included w/filter)
51	212-0004-00			2	SCREW, 8-32 x 5/16 inch, PHS, phillips
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
52	385-0134-00			2	ROD, delrin, 5/16 OD x 5/8 inch long
	- - - - - -			-	mounting hardware for each: (not included w/rod)
	213-0041-00			1	SCREW, thread cutting, #6 x 3/8 inch, THS, phillips
53	210-0201-00			6	LUG, solder, SE #4
	- - - - - -			-	mounting hardware for each: (not included w/lug)
	213-0044-00			1	SCREW, thread fofrming, 5-32 x 3/16 inch, PHS, phillips
54	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: (not included w/transformer)
55	212-0515-00			4	SCREW, 10-32 x 2 1/4 inches, HHS
56	210-0812-00			4	WASHER, fiber, #10
	220-0410-00			4	NUT, keps, 10-32 x 3/8 inch

CIRCUIT CARDS



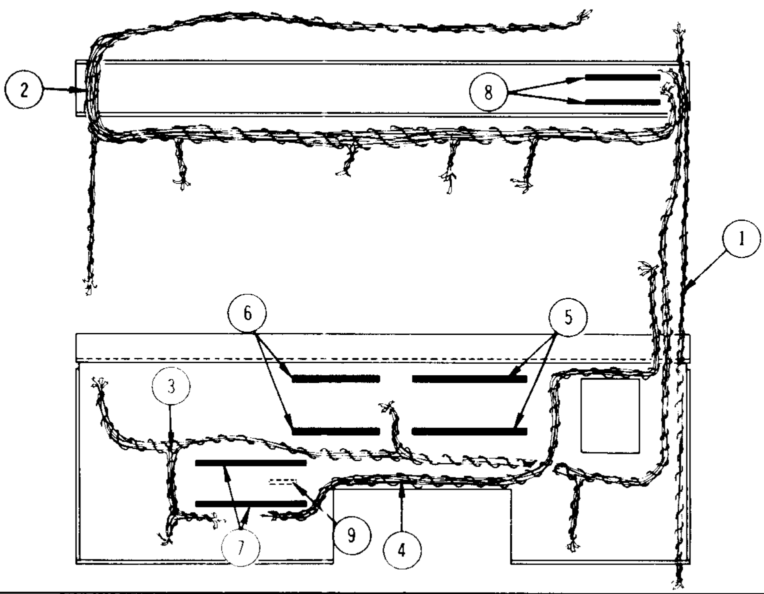
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	Q T Y.	DESCRIPTION
1	670-0213-00			1	ASSEMBLY, circuit card, FUNCTION PROGRAM #2
	- - - - - -			-	assembly includes:
	388-0663-00			1	CARD, circuit, FUNCTION PROGRAM #2
2	136-0183-00			11	SOCKET, transistor, 3 pin
	260-0552-00			2	SWITCH, not shown

Ⓐ I

CIRCUIT CARDS *(Cont)*

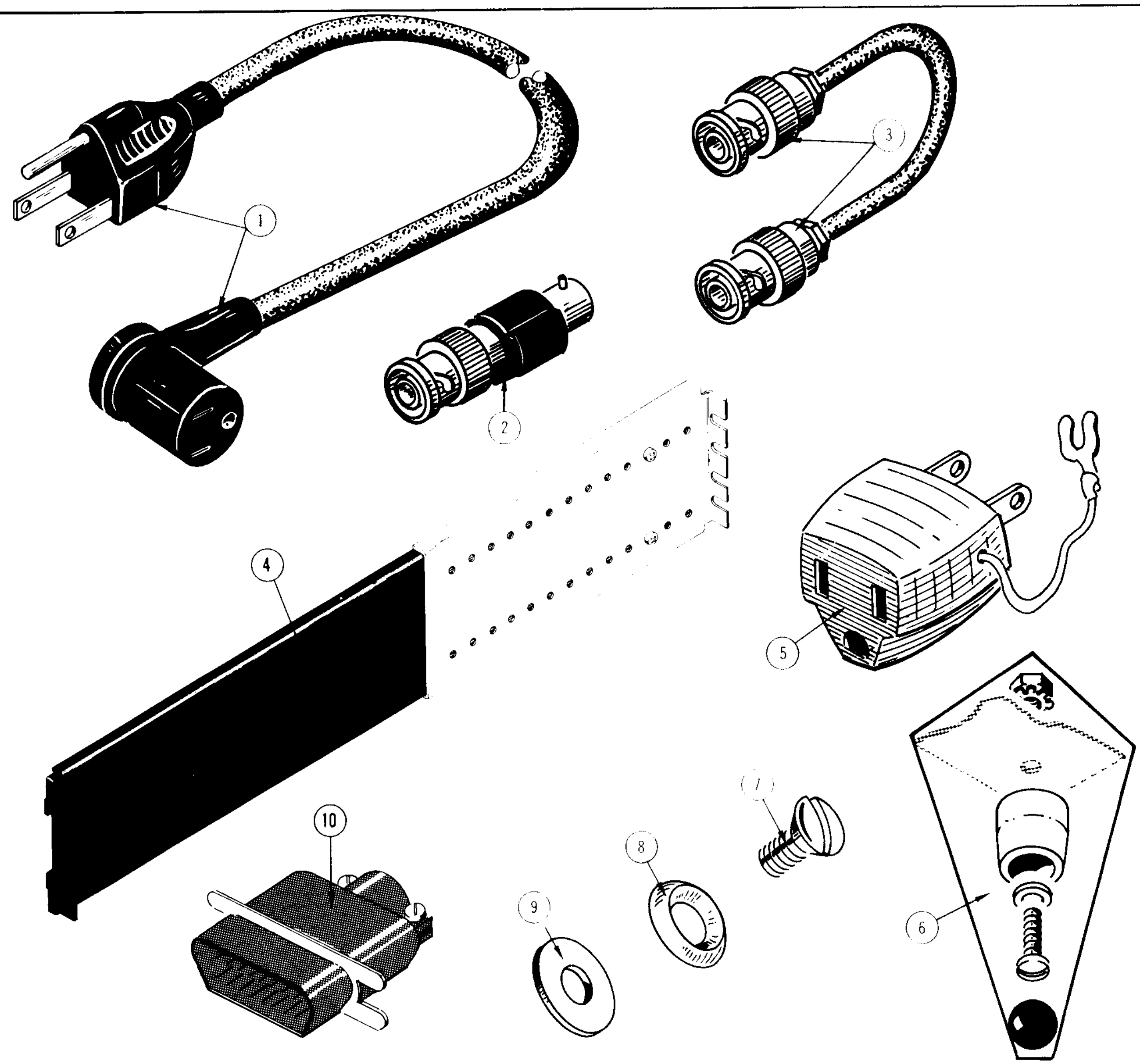
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	Q T Y.	DESCRIPTION
3	670-0214-00			1	ASSEMBLY, circuit card, PERIOD GENERATOR
	- - - - - -			-	assembly includes:
	388-0664-00			1	CARD, circuit, PERIOD GENERATOR
4	136-0183-00			11	SOCKET, transistor, 3 pin
	260-0552-00			4	SWITCH, not shown
5	352-0086-00			1	HOLDER, delrin, ½ inch
6	670-0215-00			1	ASSEMBLY, circuit card, DELAY GENERATOR
	- - - - - -			-	assembly includes:
	388-0665-00			1	CARD, circuit, DELAY GENERATOR
7	136-0183-00			10	SOCKET, transistor, 3 pin
	260-0552-00			4	SWITCH, not shown
8	352-0086-00			2	HOLDER, delrin, ½ inch
9	670-0216-00			1	ASSEMBLY, circuit card, FUNCTION PROGRAM #1
	- - - - - -			-	assembly includes:
	388-0666-00			1	CARD, circuit, FUNCTION PROGRAM #1
10	136-0183-00			15	SOCKET, transistor, 3 pin
	260-0552-00			3	SWITCH, not shown
11	670-0217-00			1	ASSEMBLY, circuit card, WIDTH GENERATOR
	- - - - - -			-	assembly includes:
	388-0667-00			1	CARD, circuit, WIDTH GENERATOR
12	136-0183-00			7	SOCKET, transistor, 3 pin
13	352-0086-00			2	HOLDER, delrin, ½ inch
14	670-0218-00			1	ASSEMBLY, circuit card, PULSE SHAPE GENERATOR
	- - - - - -			-	assembly, includes:
	388-0668-00			1	CARD, circuit, PULSE SHAPE GENERATOR
15	136-0183-00			12	SOCKET, transistor, 3 pin
	260-0552-00			3	SWITCH, not shown
16	352-0086-00			5	HOLDER, delrin, ½ inch
17	670-0219-00			1	ASSEMBLY, circuit card, OUTPUT AMPLIFIER
	- - - - - -			-	assembly includes:
	388-0669-00			1	CARD, circuit, OUTPUT AMPLIFIER
18	136-0183-00			9	SOCKET, transistor, 3 pin
19	136-0220-00			3	SOCKET, transistor, square, 3 pin
20	214-0269-00			3	SINK, heat, transistor
21	214-0667-00			3	SINK, heat, transistor
22	214-0507-00			1	PIN, connector
23	352-0086-00			2	HOLDER, delrin, ½ inch
24	670-0220-00			1	ASSEMBLY, circuit card, ATTENUATOR
	- - - - - -			-	assembly, includes:
	388-0670-00			1	CARD, circuit, ATTENUATOR
25	131-0391-00			1	CONNECTOR, 50 Ω, coaxial, male
26	136-0183-00			5	SOCKET, transistor, 3 pin
27	352-0086-00			2	HOLDER, delrin, ½ inch
28	670-0221-00			1	ASSEMBLY, circuit card, POWER SUPPLY
	- - - - - -			-	assembly includes:
	388-0671-00			1	CARD, circuit, POWER SUPPLY
29	136-0183-00			14	SOCKET, transistor, 3 pin
30	214-0668-00			2	SINK, heat, transistor
31	352-0086-00			1	HOLDER, delrin, ½ inch

CABLE HARNESS & CERAMIC STRIP DETAIL



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	179-1013-00			1	CABLE HARNESS, connector
2	179-1010-00			1	CABLE HARNESS, switch
3	179-1011-00			1	CABLE HARNESS, power #1
4	179-1012-00			1	CABLE HARNESS, power #2
5	124-0091-00			2	STRIP, ceramic, 3/4 inch h, w/11 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
6	124-0090-00			2	STRIP, ceramic, 3/4 inch h, w/9 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
7	124-0145-00			2	STRIP, ceramic, 7/16 inch h, w/20 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
8	124-0147-00			2	STRIP, ceramic, 7/16 inch h, w/13 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
9	124-0162-00			1	STRIP, ceramic, 7/16 inch h, w/4 notches
	- - - - - -			-	each strip includes:
	355-0046-00			1	STUD, plastic
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0009-00			1	SPACER, plastic, 0.406 inch long

ACCESSORIES

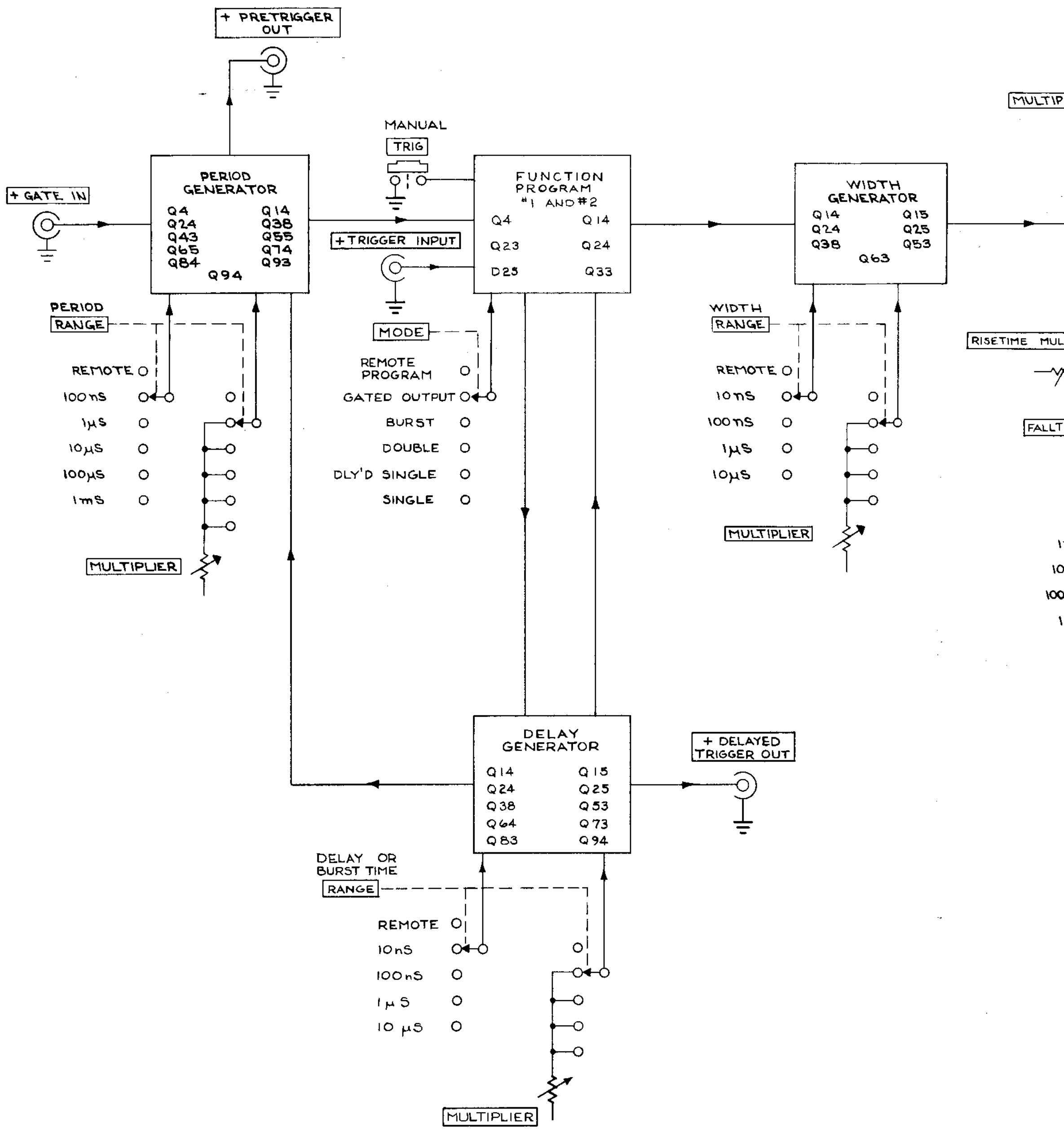


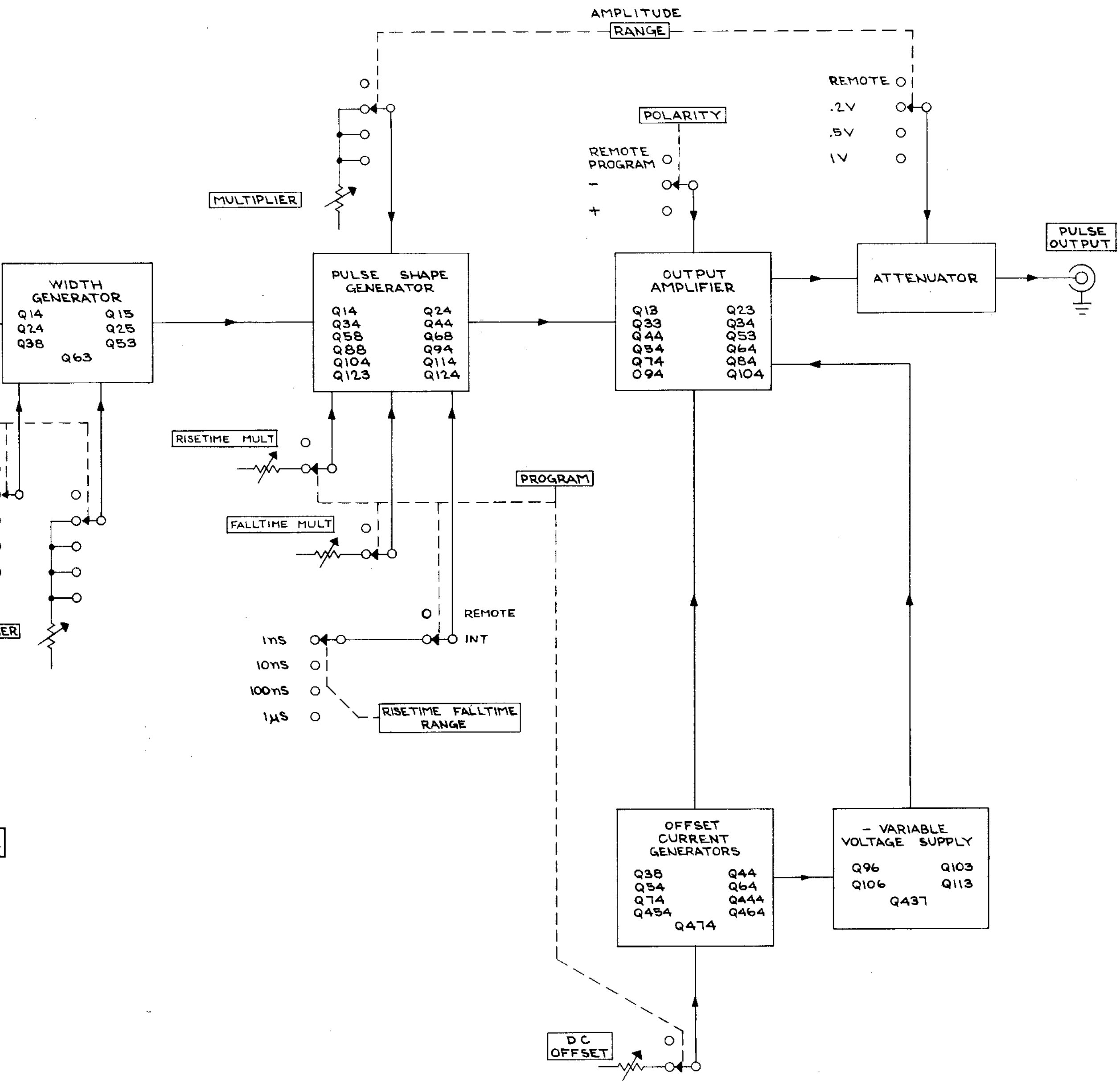
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	161-0024-00			1	CORD, power, 3-conductor, 8-foot, right angle, female
2	011-0049-00			1	TERMINATION, 50 Ω, in-line, w/BNC connectors
3	012-0057-00			1	ASSEMBLY, cable, 50 Ω, coaxial, 42 inches, w/BNC connectors
4	351-0084-00			1	TRACK, slide, 18 x 3$^3/_8$ inches, left & right, w/2 brackets
5	103-0013-00			1	ADAPTER, power cord, 3 wire to 2 wire
6	016-0052-00			1	KIT, cabinet feet
7	212-0512-00			4	SCREW, 10-32 x $^1/_2$ inch, OHS
8	210-0833-00			4	WASHER, finishing, plated, #10
9	210-0917-00			4	WASHER, plastic, 0.191 ID x $^5/_8$ inch OD
10	131-0293-00			1	CONNECTOR, 36 terminal, cable end, male
	070-0498-00			2	MANUAL, instruction (not shown)

SECTION 10
DIAGRAMS

The following symbols are used on the schematic diagrams:

	(black box around name)	Front-panel control, switch or connector
		Clockwise rotation of control
		Screwdriver adjustment
	(blue line)	Electrical limit of circuit card


+ PRETRIGGER OUT
+ GATE IN
PERIOD GENERATOR
Q4 Q24 Q43 Q65 Q84 Q94 Q14 Q38 Q55 Q74 Q93
PERIOD RANGE
REMOTE
100nS
1μS
10μS
100μS
1mS
MULTIPLIER
MANUAL
TRIG
+ TRIGGER INPUT
MODE
REMOTE PROGRAM
GATED OUTPUT
BURST
DOUBLE
DLY'D SINGLE
SINGLE
FUNCTION PROGRAM #1 AND #2
Q4 Q23 D25 Q14 Q24 Q33
WIDTH GENERATOR
Q14 Q24 Q38 Q63 Q15 Q25 Q53
WIDTH RANGE
REMOTE
10nS
100nS
1μS
10μS
MULTIPLIER
DELAY GENERATOR
Q14 Q24 Q38 Q64 Q83 Q15 Q25 Q53 Q73 Q94
+ DELAYED TRIGGER OUT
DELAY OR BURST TIME
RANGE
REMOTE
10nS
100nS
1μS
10μS
MULTIPLIER



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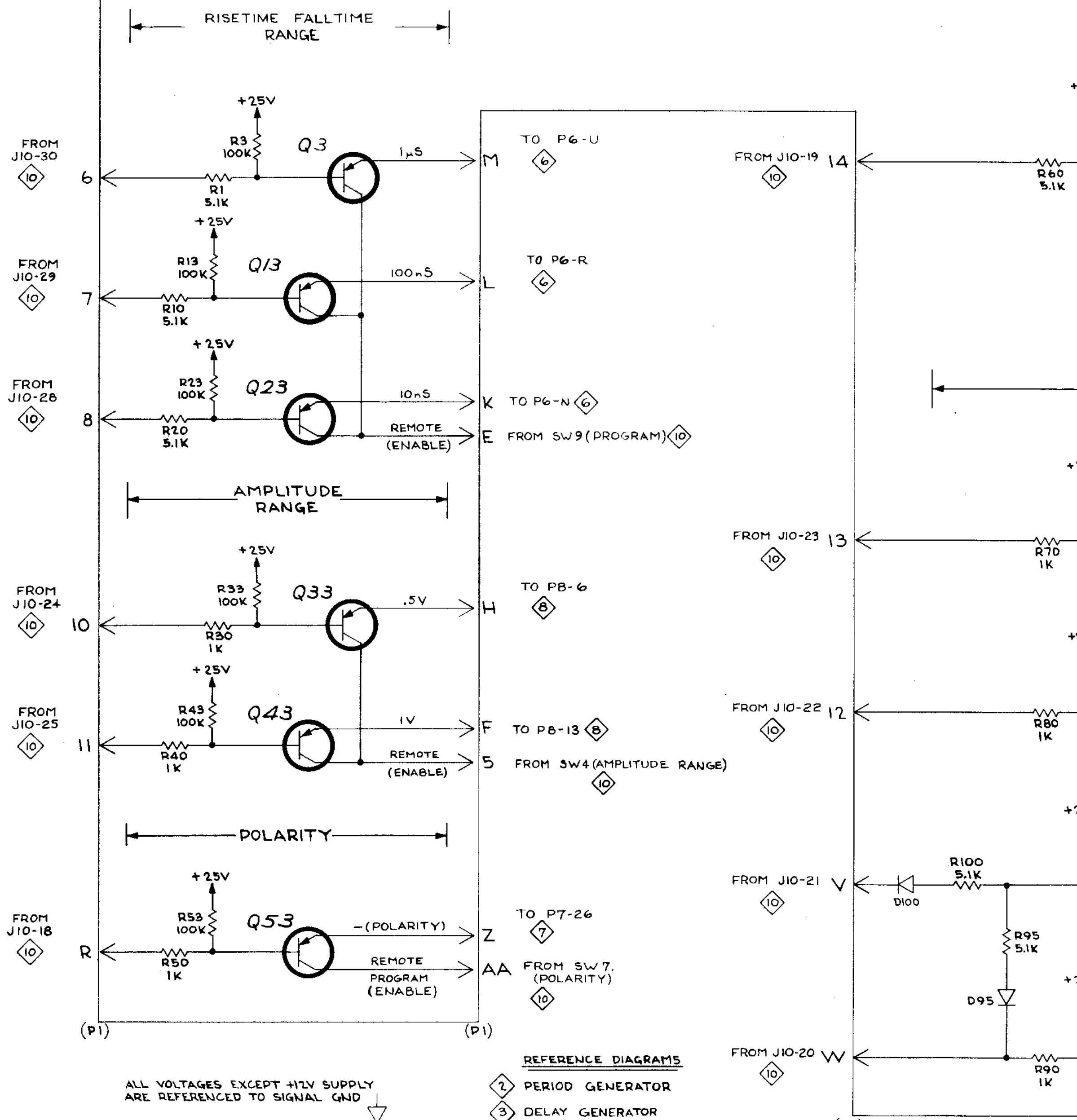
166

A

BLOCK DIAGRAM



REFERENCE DIAGRAMS

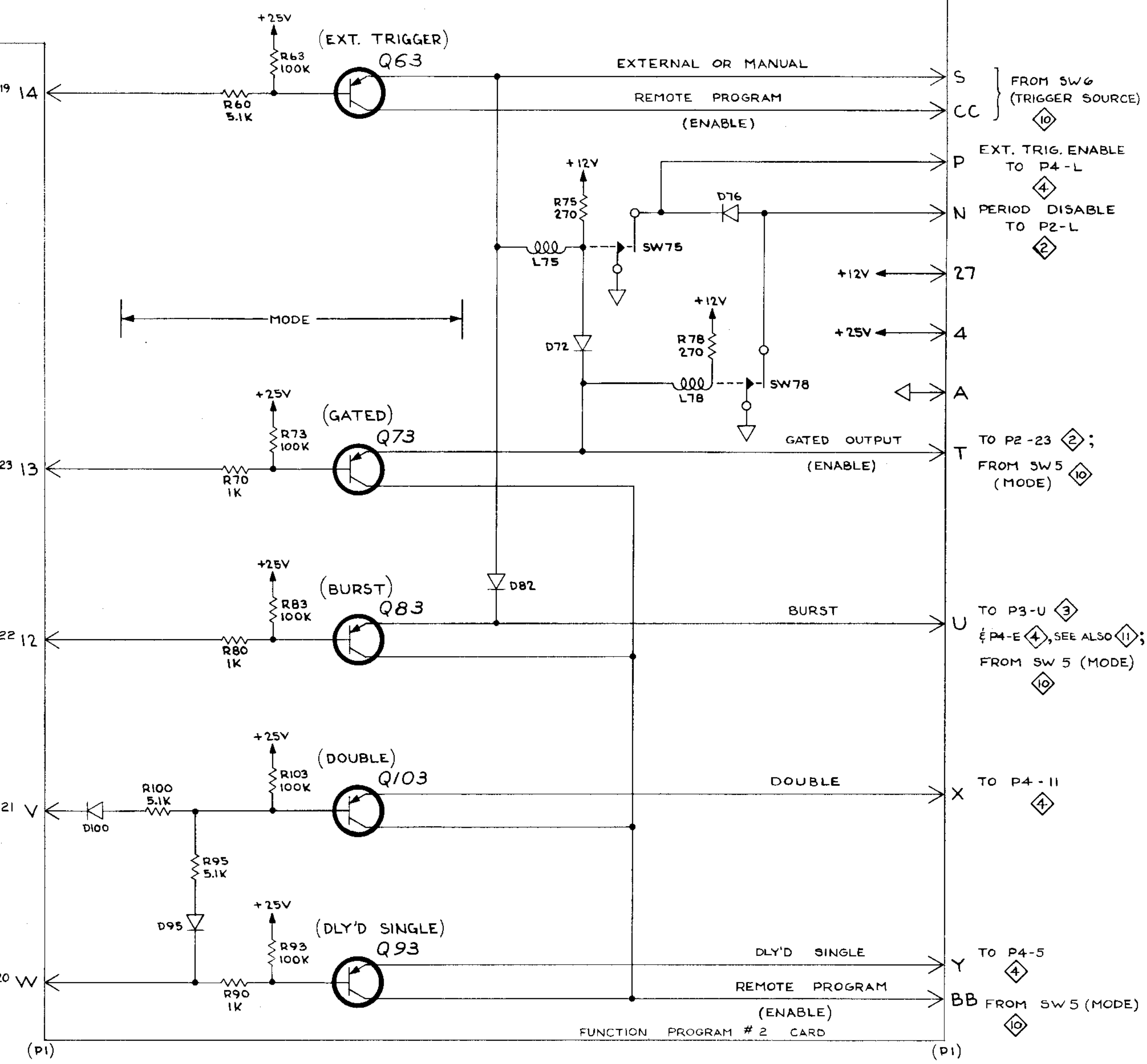
- ⟨2⟩ PERIOD GENERATOR
- ⟨3⟩ DELAY GENERATOR
- ⟨4⟩ FUNCTION PROGRAM #1
- ⟨6⟩ PULSE SHAPE GENERATOR
- ⟨7⟩ OUTPUT AMPLIFIER
- ⟨8⟩ ATTENUATOR & OFFSET CURRENT GENERATOR
- ⟨10⟩ SWITCH DETAILS & REMOTE PROGRAM CONNECTOR
- ⟨11⟩ INTERCONNECTING DIAGRAM

ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

+12V SUPPLY IS REFERENCED TO CHASSIS GND

TYPE R116 PROGRAMMABLE PULSE GENERATOR

A



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

A

B
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FUNCTION PROGRAM #2 ⟨1⟩

SERIES A MODEL 1

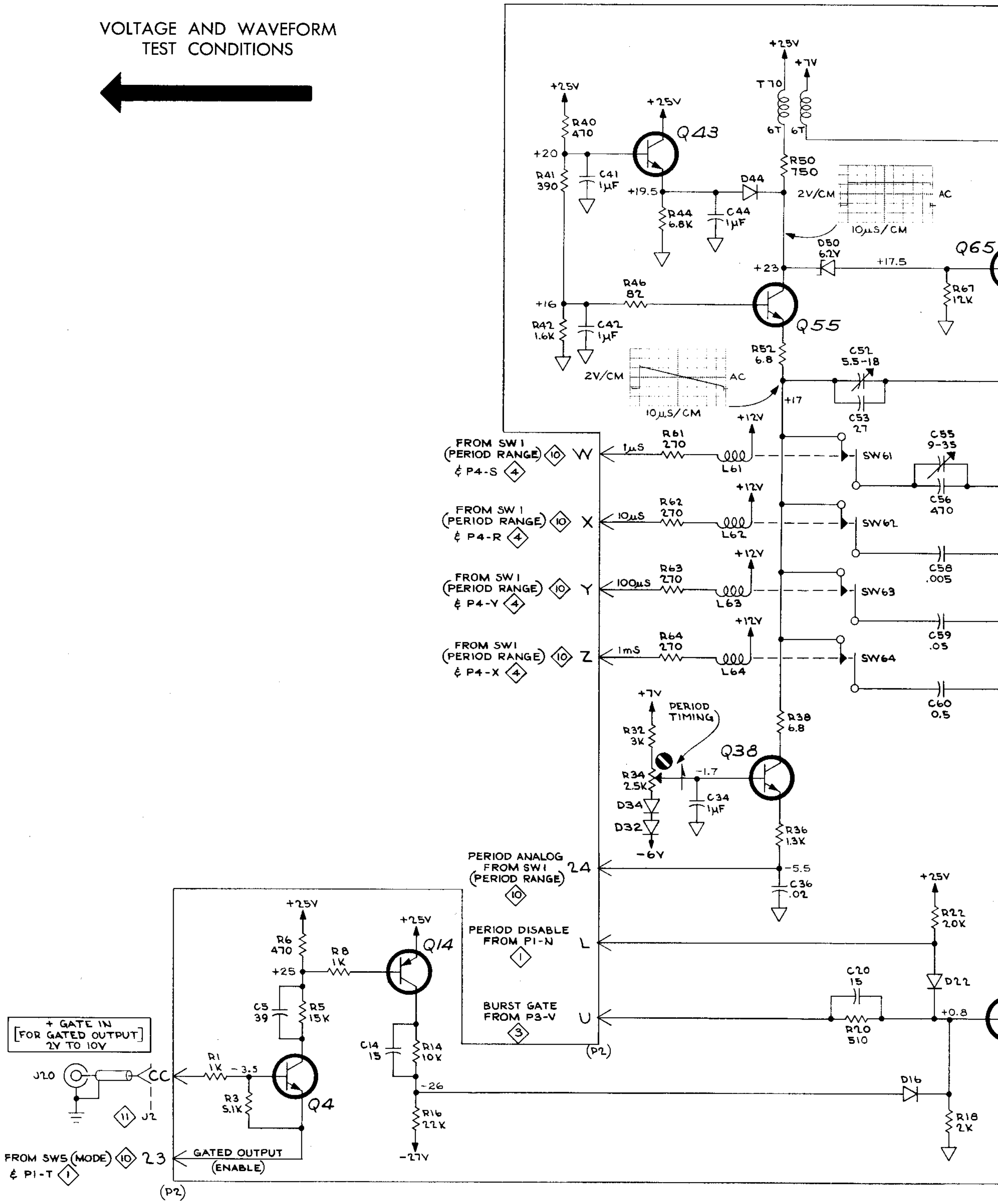
VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical voltage measurements and waveform photographs (shown in blue) were obtained under the following conditions unless noted otherwise on the individual diagrams:

Test Oscilloscope, with 10X Probe:	
Bandwidth	Dc to 50 MHz
Probe Input Impedance	10 Megohms, 7 picofarads
Probe Ground	Clipped to Type R116 chassis ground.
Triggering	External from point indicated on diagram (to show time relationship between signals)
Dc Voltmeter:	
Type	Volt-Ohmmeter
Sensitivity	20,000 ohms/volt
Reference Voltage	Signal ground
Type R116 Conditions:	
PULSE OUTPUT Connector	Terminated in 50 ohms
Other Connectors	No connections
Circuit Card Installation	Each card extended on plug-in card extender for voltages and waveforms

(Test Conditions continued on Delay Generator diagram)

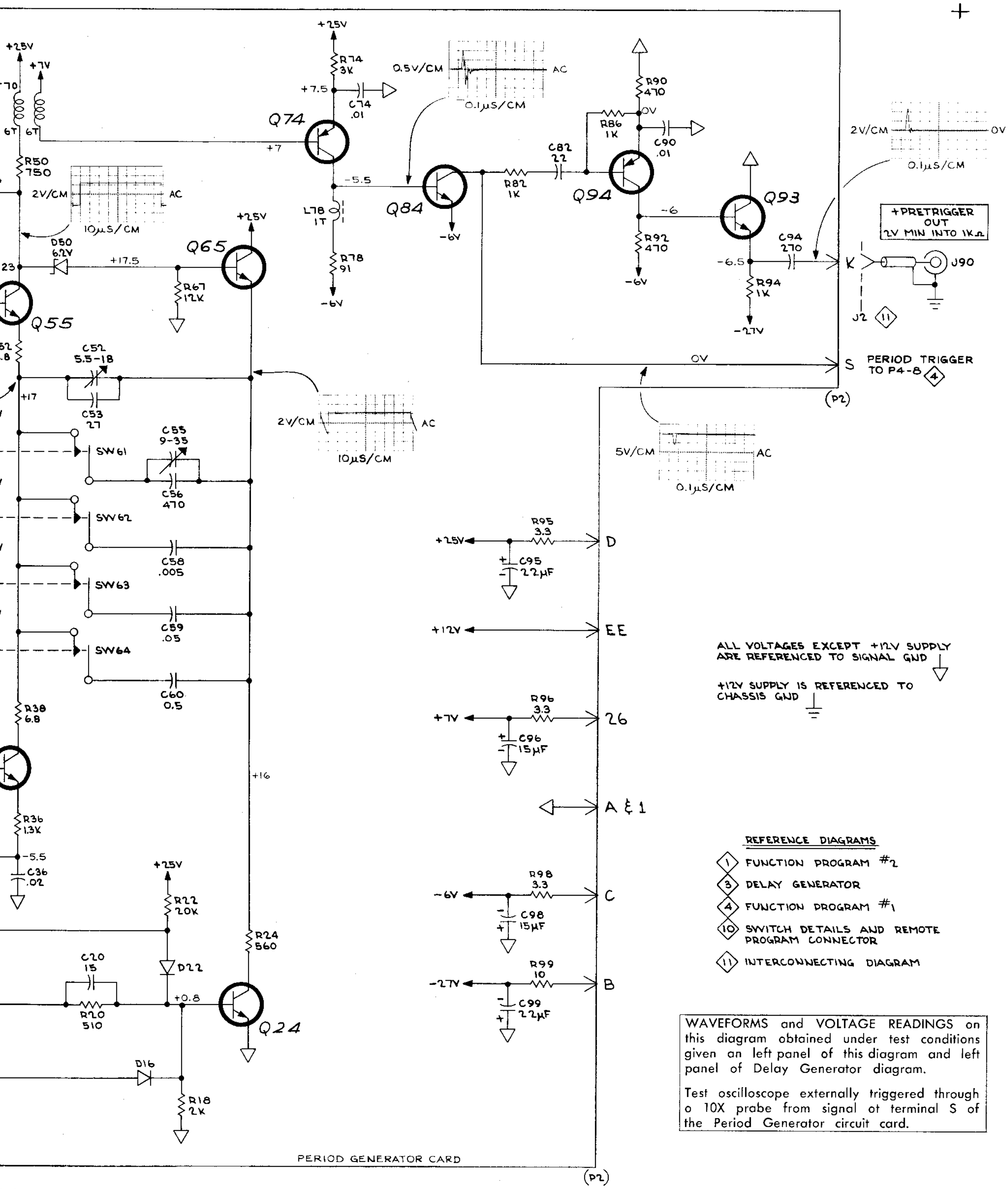
VOLTAGE AND WAVEFORM
TEST CONDITIONS



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE R116 PROGRAMMABLE PULSE GENERATOR

A



ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

+12V SUPPLY IS REFERENCED TO CHASSIS GND

REFERENCE DIAGRAMS

- ⟨1⟩ FUNCTION PROGRAM #2
- ⟨3⟩ DELAY GENERATOR
- ⟨4⟩ FUNCTION PROGRAM #1
- ⟨10⟩ SWITCH DETAILS AND REMOTE PROGRAM CONNECTOR
- ⟨11⟩ INTERCONNECTING DIAGRAM

WAVEFORMS and VOLTAGE READINGS on this diagram obtained under test conditions given on left panel of this diagram and left panel of Delay Generator diagram.

Test oscilloscope externally triggered through a 10X probe from signal at terminal S of the Period Generator circuit card.

CTOR TYPES

A

166

PERIOD GENERATOR ⟨2⟩
SERIES B MODEL I

VOLTAGE AND WAVEFORM TEST CONDITIONS

(Cont'd from Period Generator diagram)

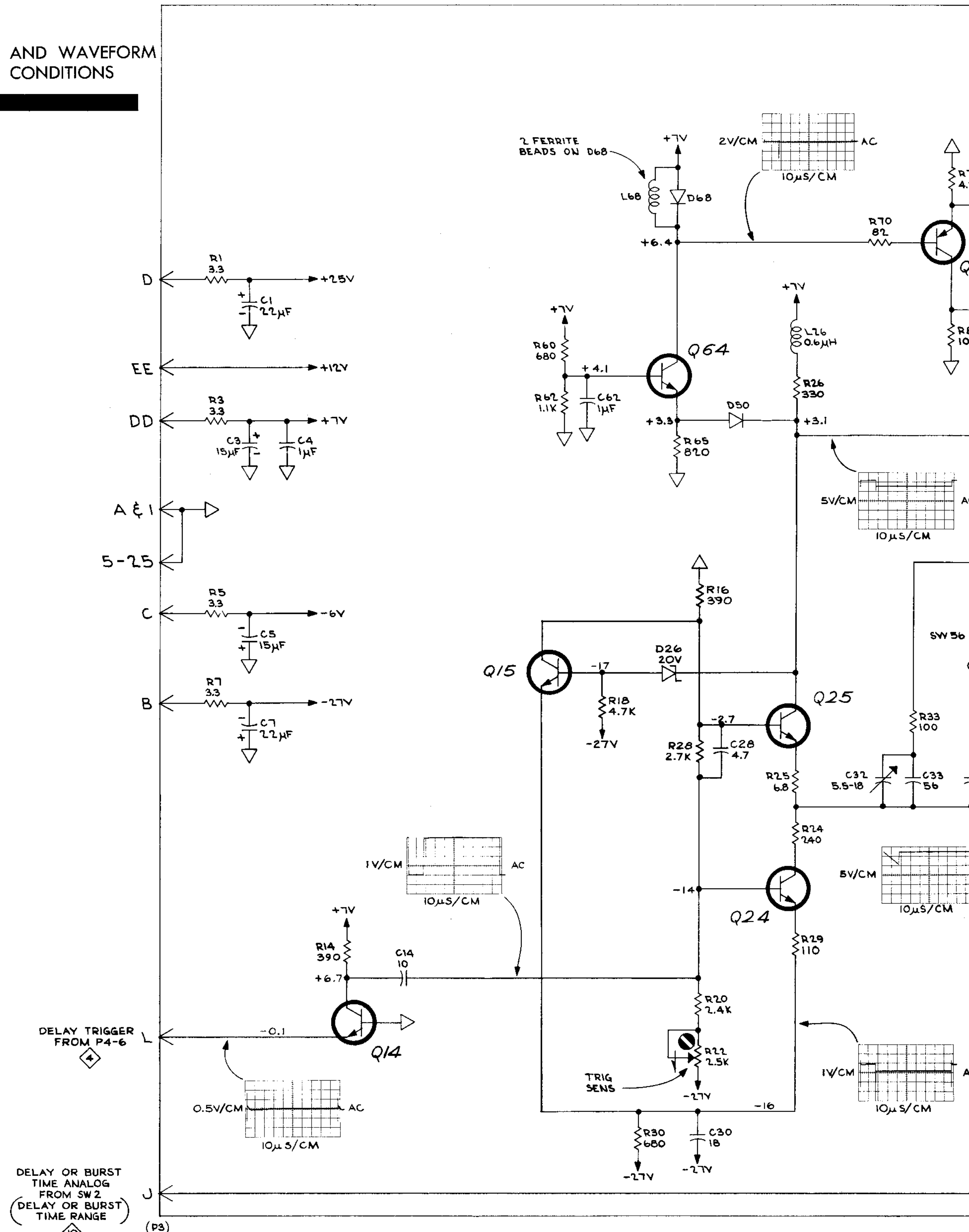
Type R116 Control Settings:

MODE	DOUBLE
TRIGGER SOURCE	INTERNAL
PERIOD RANGE	100 μS
MULTIPLIER	1
DELAY OR BURST TIME RANGE	1 μS
MULTIPLIER	15
WIDTH RANGE	1 μS
MULTIPLIER	5
AMPLITUDE RANGE	1 V
MULTIPLIER	10
POLARITY	+
PROGRAM	INT
DC OFFSET	0
RISETIME FALLTIME RANGE	100 nS
RISETIME MULT	1
FALLTIME MULT	1

Voltages are given in volts DC, measured with respect to **signal ground.** (The +12-volt supply is referenced to chassis ground.) Voltage measurements taken in any particular Type R116 may vary somewhat from those given, due to normal differences in component characteristics.

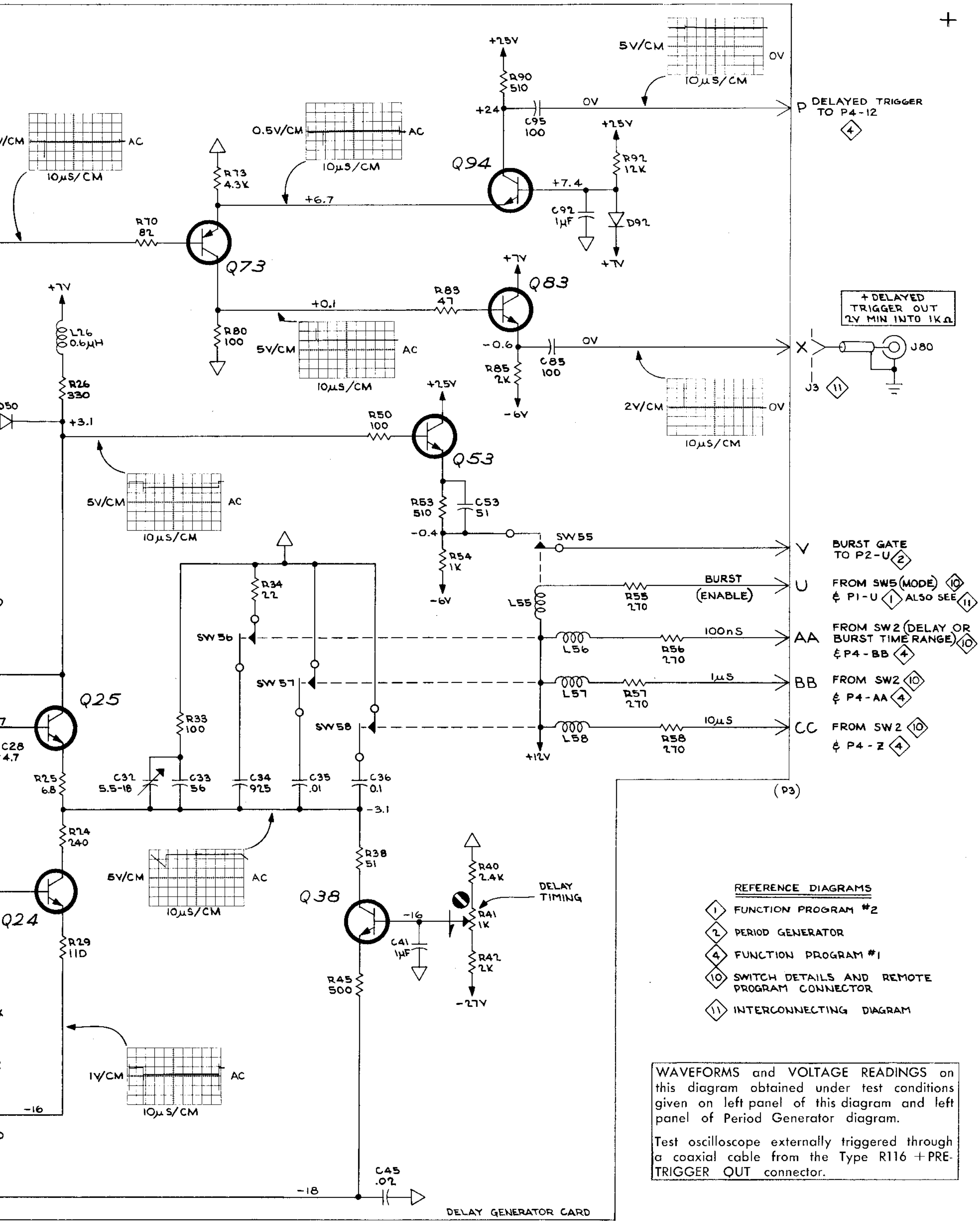
Waveform photographs were taken with a Tektronix Oscilloscope Camera System and Projected Graticule. DC voltage levels, where shown on waveforms, are measured with respect to chassis ground.

VOLTAGE AND WAVEFORM TEST CONDITIONS



ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

+12V SUPPLY IS REFERENCED TO CHASSIS GND



REFERENCE DIAGRAMS

- ⟨1⟩ FUNCTION PROGRAM #2
- ⟨2⟩ PERIOD GENERATOR
- ⟨4⟩ FUNCTION PROGRAM #1
- ⟨10⟩ SWITCH DETAILS AND REMOTE PROGRAM CONNECTOR
- ⟨11⟩ INTERCONNECTING DIAGRAM

WAVEFORMS and VOLTAGE READINGS on this diagram obtained under test conditions given on left panel of this diagram and left panel of Period Generator diagram.

Test oscilloscope externally triggered through a coaxial cable from the Type R116 + PRE-TRIGGER OUT connector.

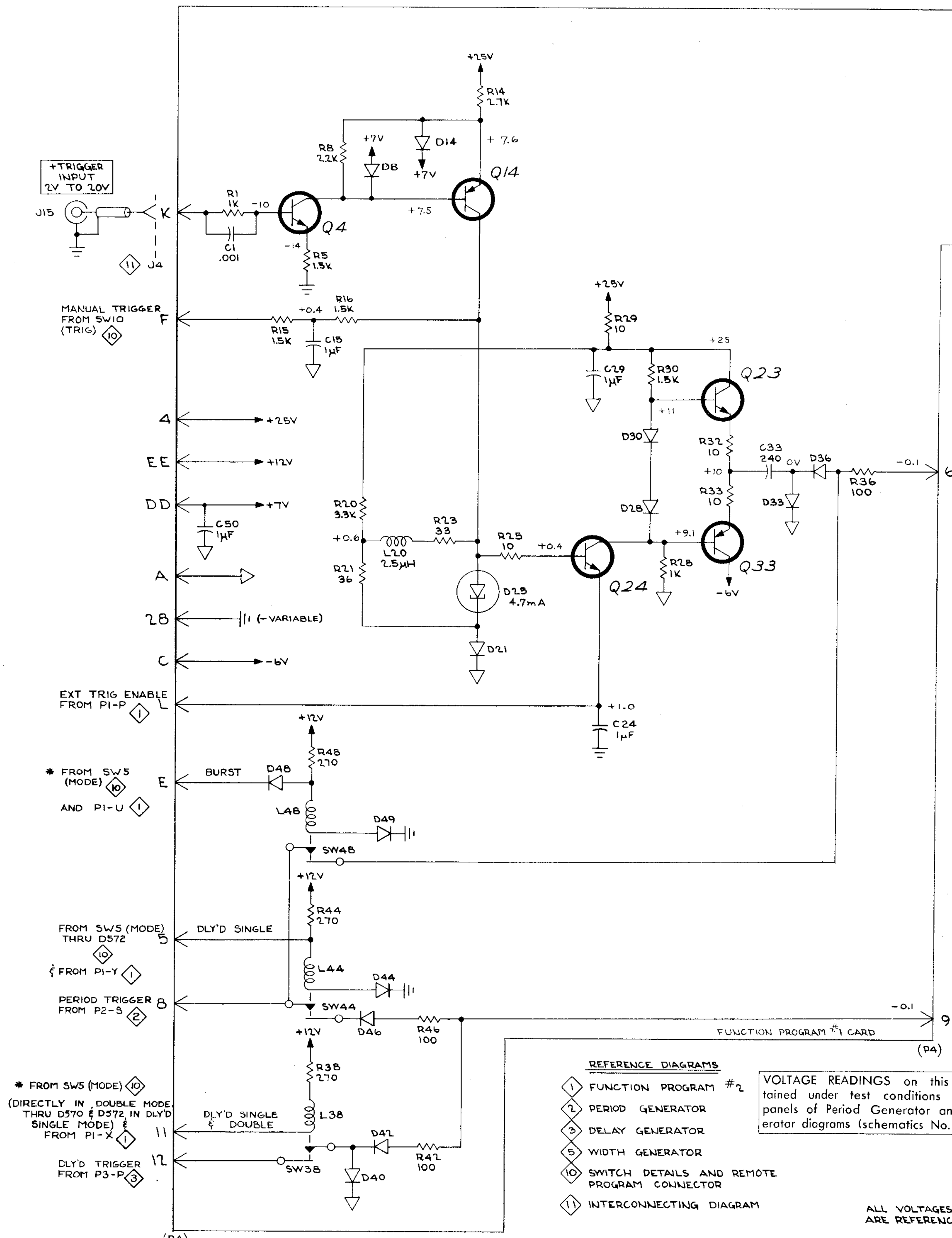
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

166

DELAY GENERATOR ⟨3⟩

SERIES C MODEL 1

A

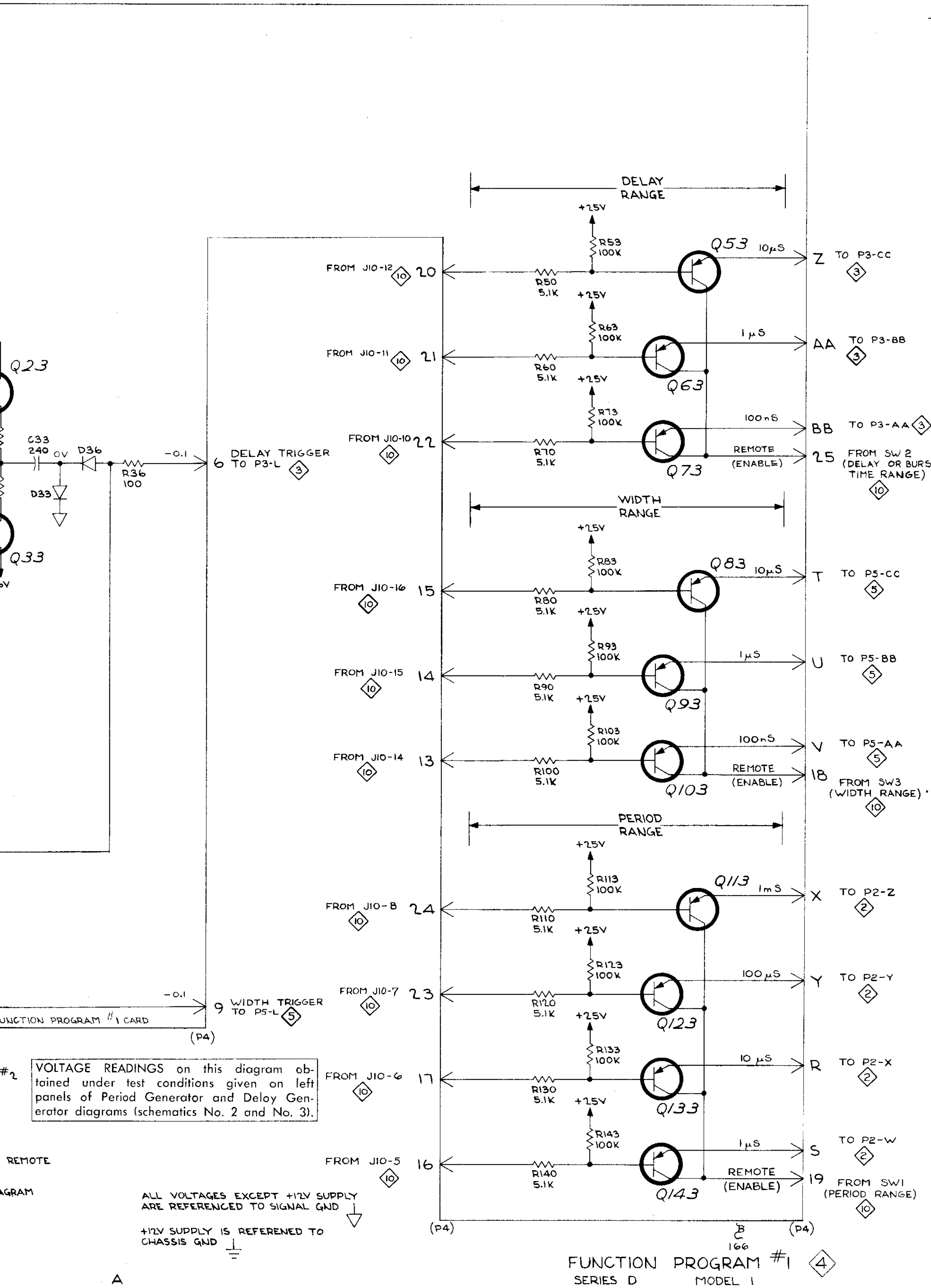


* SEE ALSO (11) INTERCONNECTING DIAGRAM

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

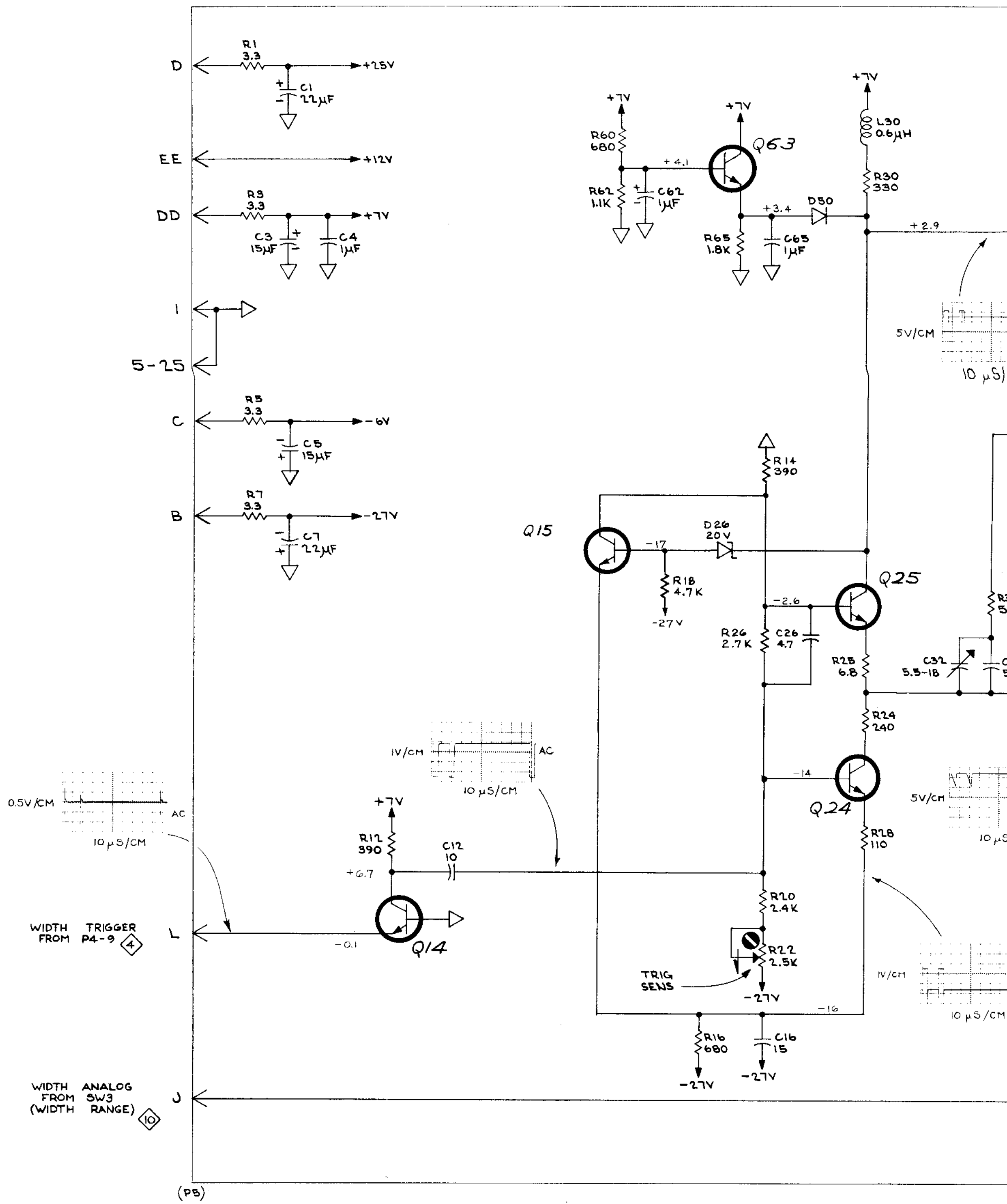
TYPE R116 PROGRAMMABLE PULSE GENERATOR

A



B 166

FUNCTION PROGRAM #1 (4)
SERIES D MODEL 1

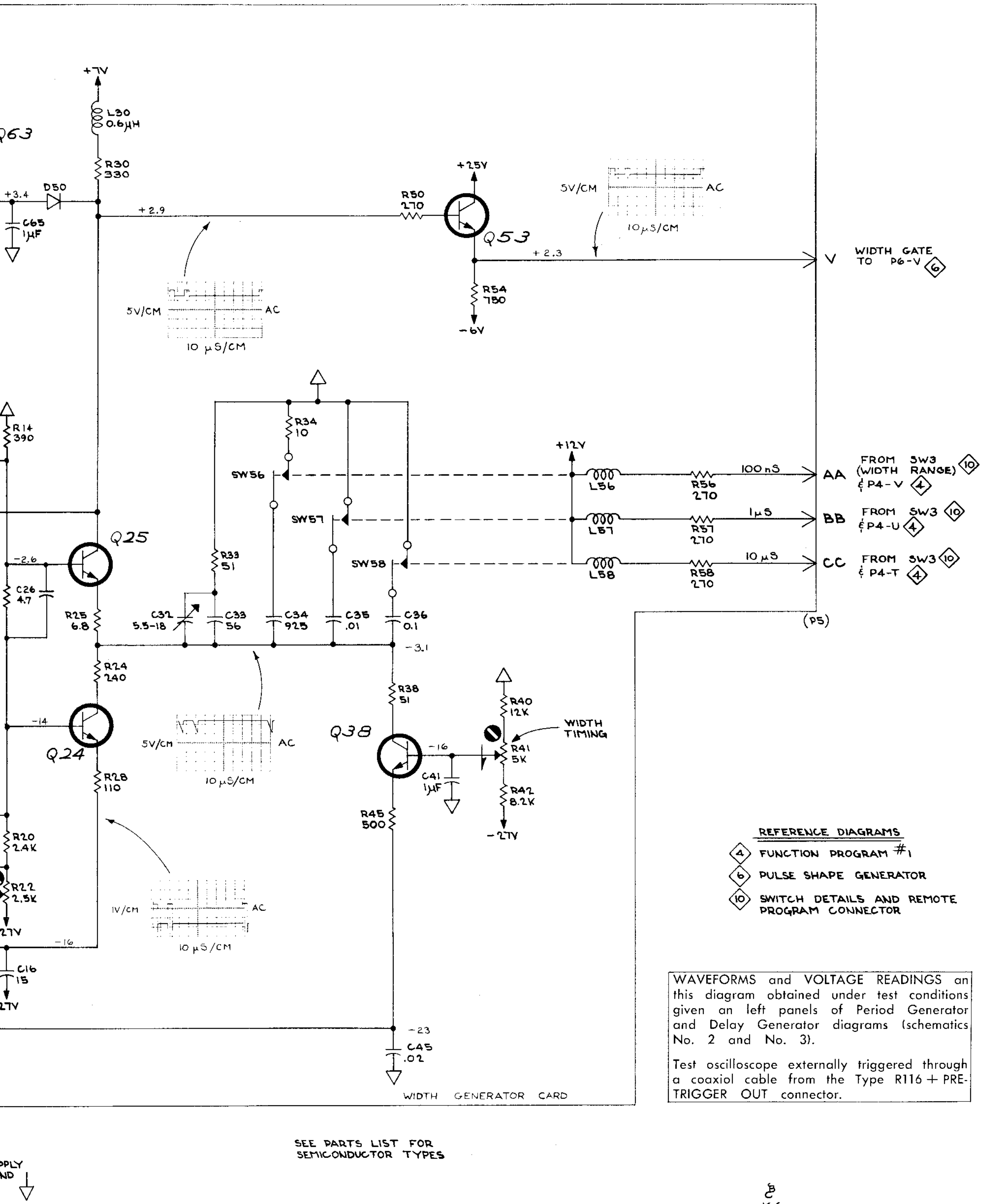


ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

+12V SUPPLY IS REFERENCED TO CHASSIS GND

TYPE R116 PROGRAMMABLE PULSE GENERATOR

A



REFERENCE DIAGRAMS

- 4 FUNCTION PROGRAM #1
- 6 PULSE SHAPE GENERATOR
- 10 SWITCH DETAILS AND REMOTE PROGRAM CONNECTOR

WAVEFORMS and VOLTAGE READINGS on this diagram obtained under test conditions given on left panels of Period Generator and Delay Generator diagrams (schematics No. 2 and No. 3).

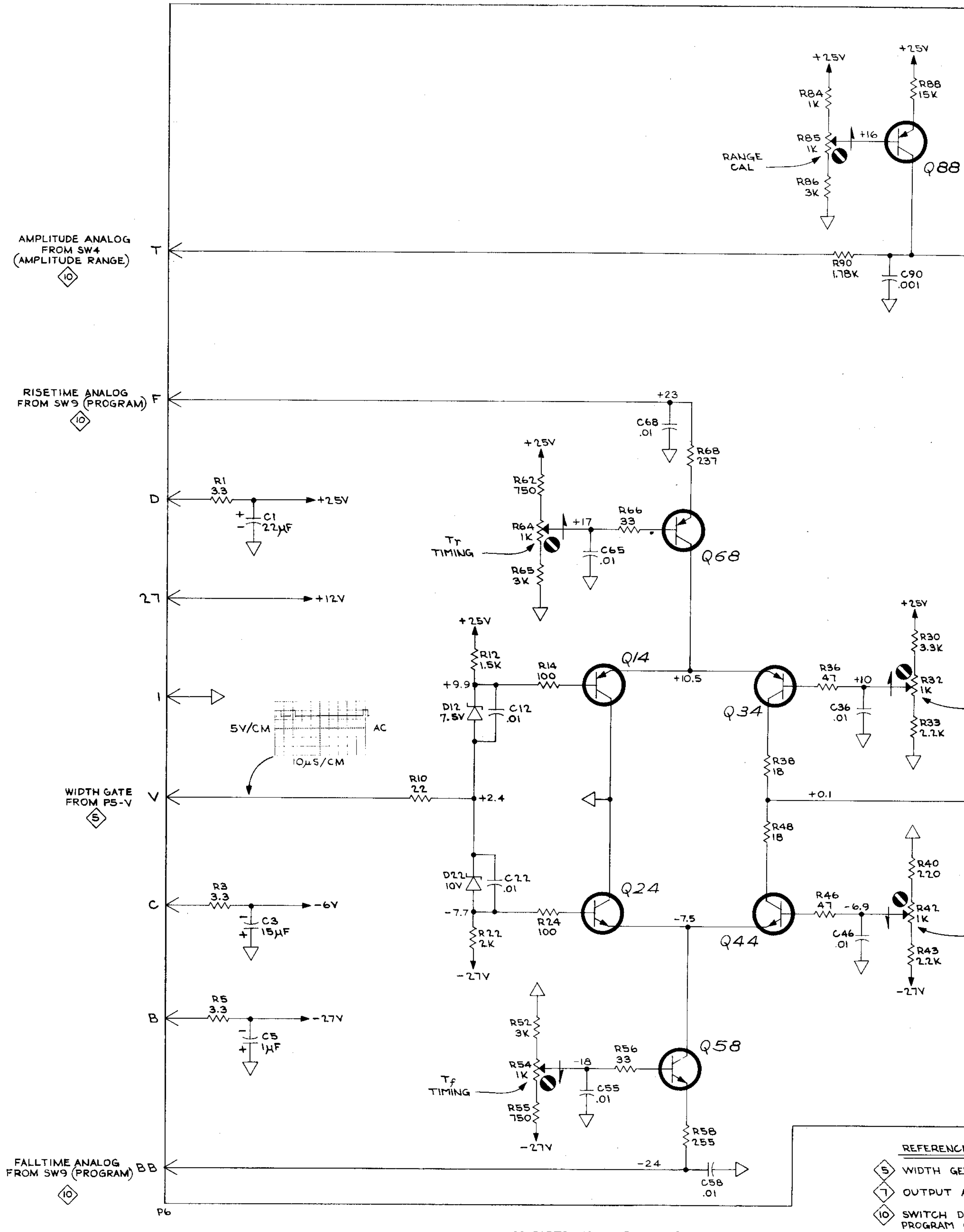
Test oscilloscope externally triggered through a coaxial cable from the Type R116 + PRE-TRIGGER OUT connector.

&B 166

A

WIDTH GENERATOR 5

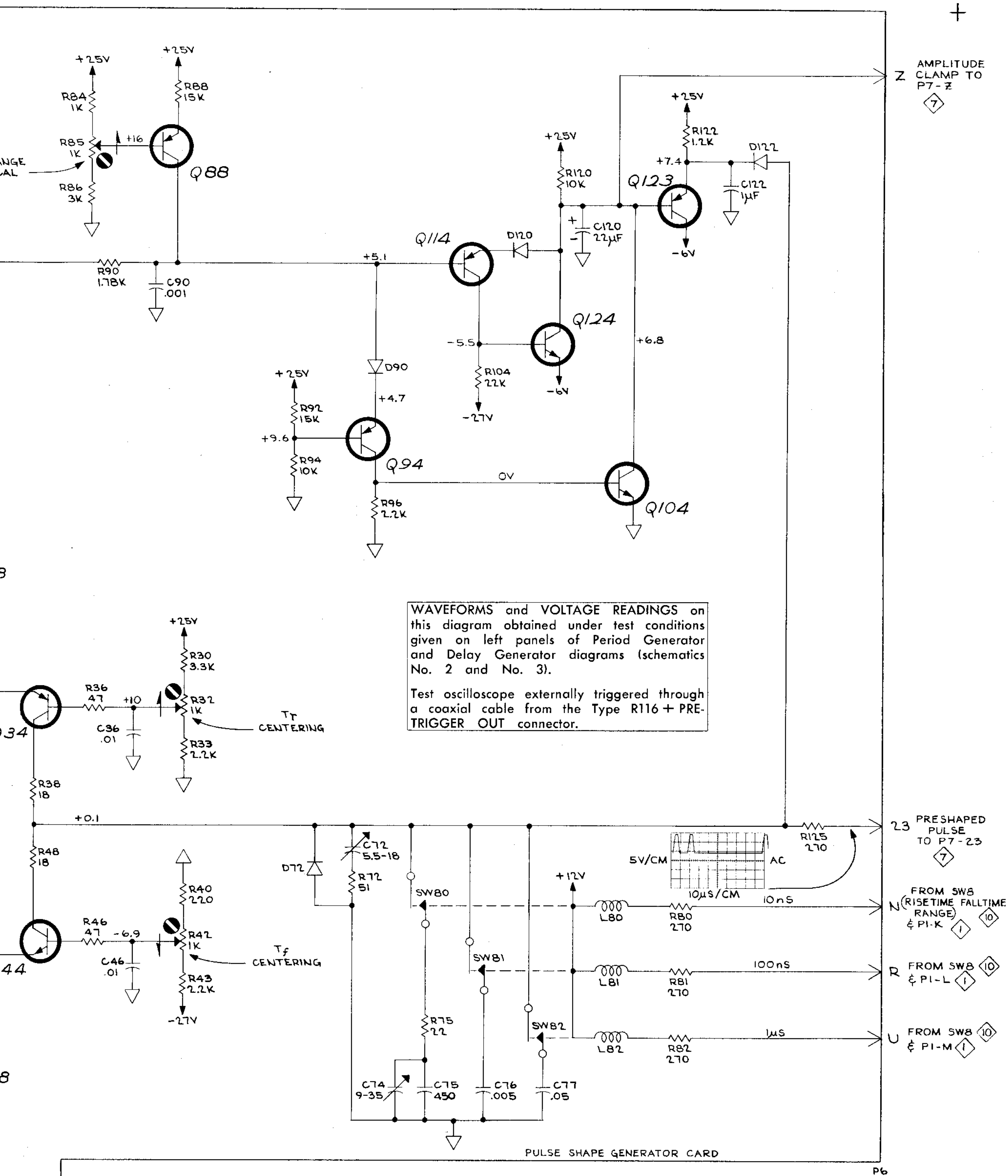
SERIES E MODEL 1



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE R116 PROGRAMMABLE PULSE GENERATOR

A1



WAVEFORMS and VOLTAGE READINGS on this diagram obtained under test conditions given on left panels of Period Generator and Delay Generator diagrams (schematics No. 2 and No. 3).

Test oscilloscope externally triggered through a coaxial cable from the Type R116 + PRE-TRIGGER OUT connector.

REFERENCE DIAGRAMS

5 WIDTH GENERATOR

7 OUTPUT AMPLIFIER

10 SWITCH DETAILS AND REMOTE PROGRAM CONNECTOR

ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

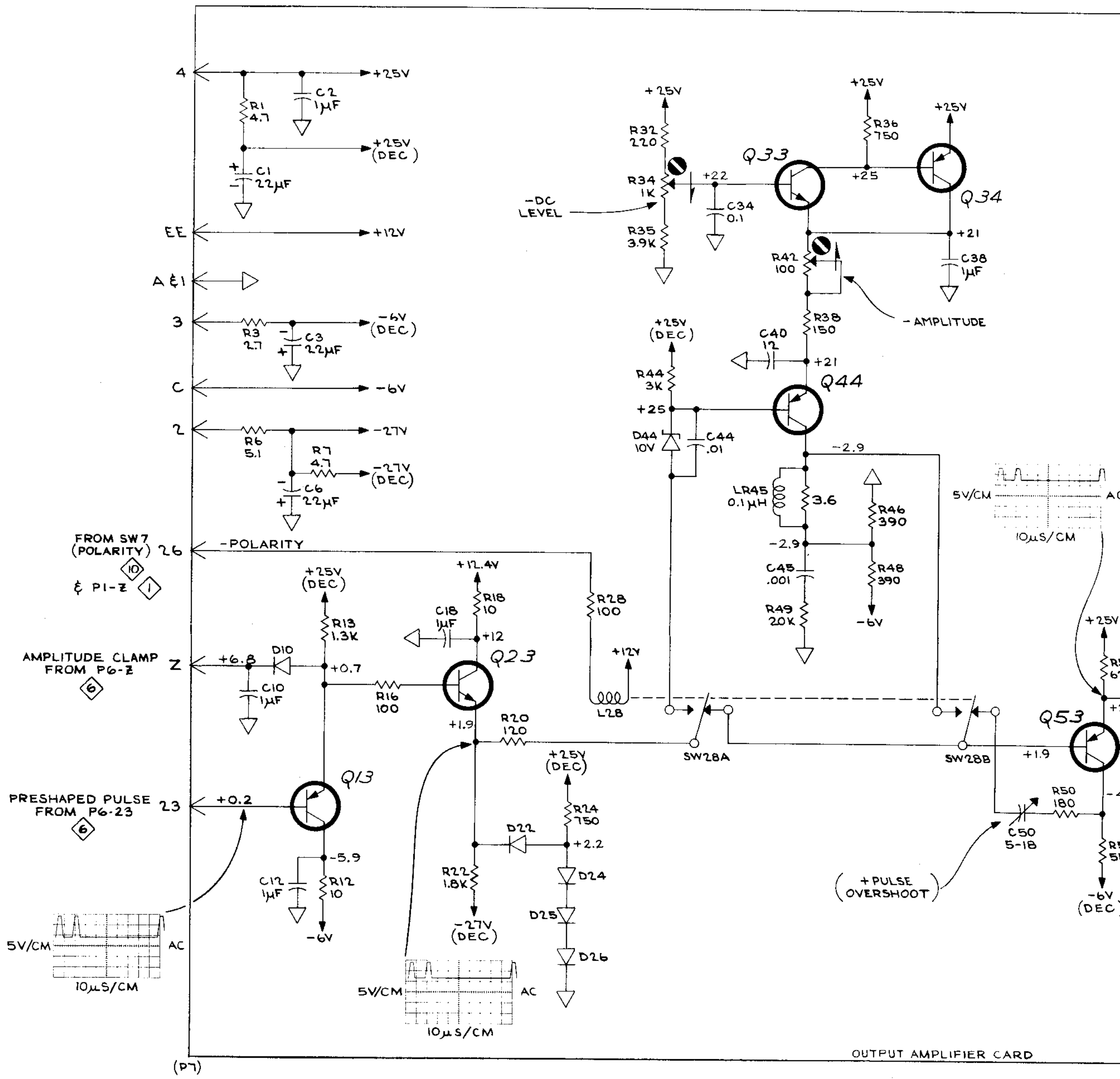
+12V SUPPLY IS REFERENCED TO CHASSIS GND

R TYPES

A

PULSE SHAPE GENERATOR 6

SERIES F MODEL 1



REFERENCE DIAGRAMS

- ⟨1⟩ FUNCTION PROGRAM # 2
- ⟨6⟩ PULSE SHAPE GENERATOR
- ⟨8⟩ ATTENUATOR AND OFFSET CURRENT GENERATOR
- ⟨9⟩ POWER SUPPLY
- ⟨10⟩ SWITCH DETAILS AND REMOTE PROGRAM CONNECTOR
- ⟨11⟩ INTERCONNECTING DIAGRAM

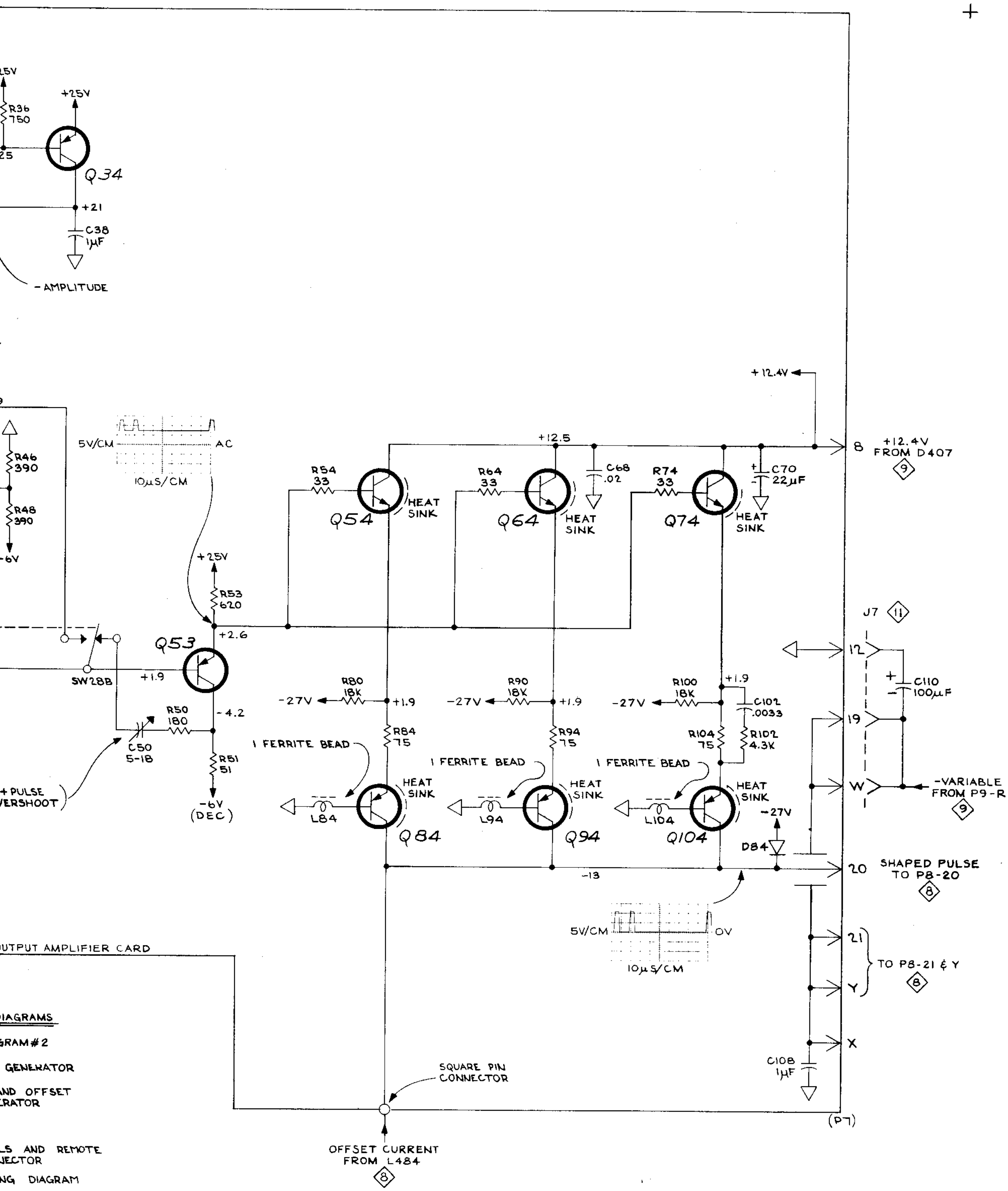
ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

+12V SUPPLY IS REFERENCED TO CHASSIS GND

WAVEFORMS and VOLTAGE READINGS on this diagram obtained under test conditions given on left panels of Period Generotor and Delay Generotor diagrams (schematics No. 2 and No. 3).

Test oscilloscope externally triggered through a coaxiol cable from the Type R116 + PRE-TRIGGER OUT connector.

SEE PAR



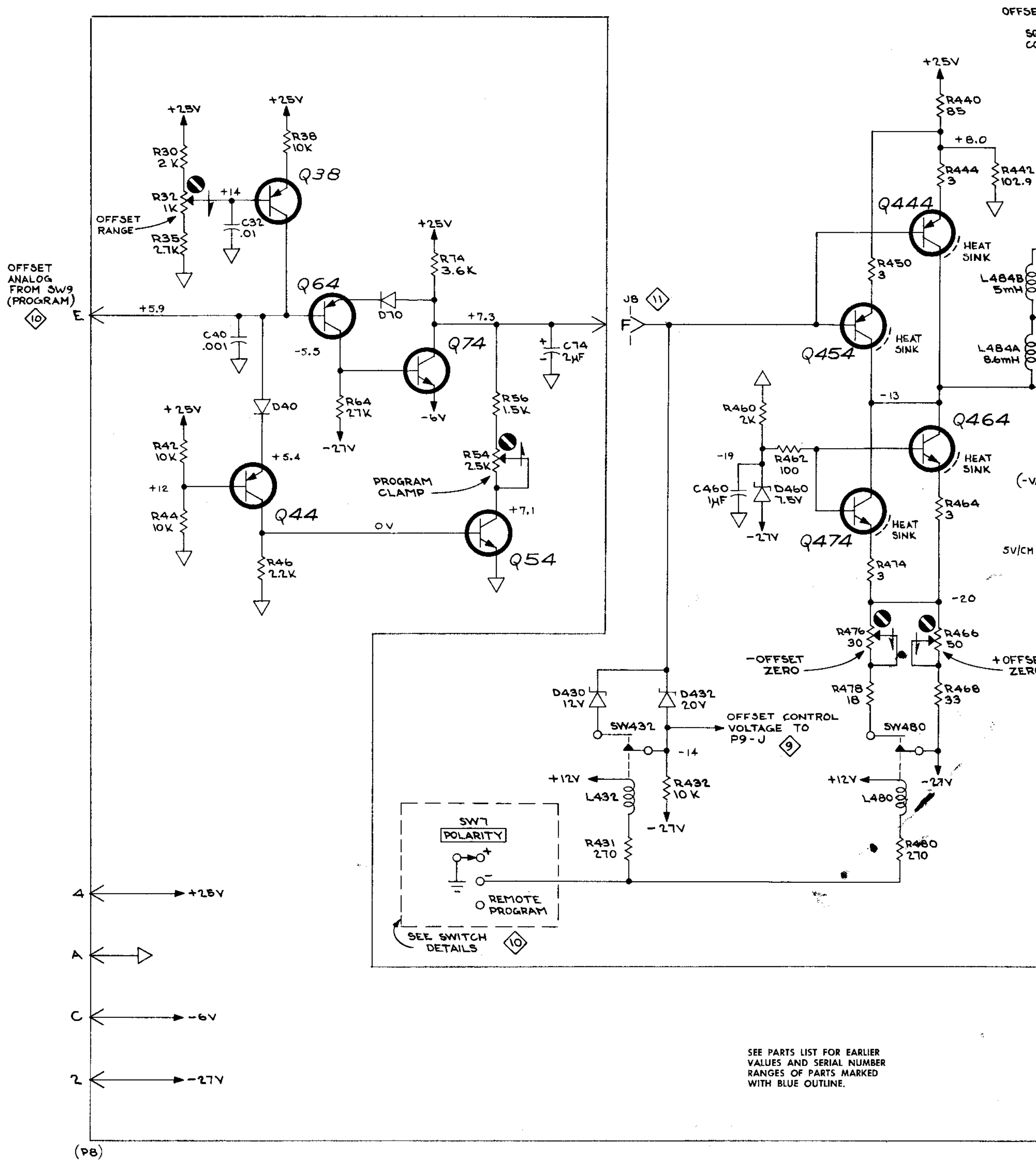
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

B
166

OUTPUT AMPLIFIER 7

SERIES G MODEL 1

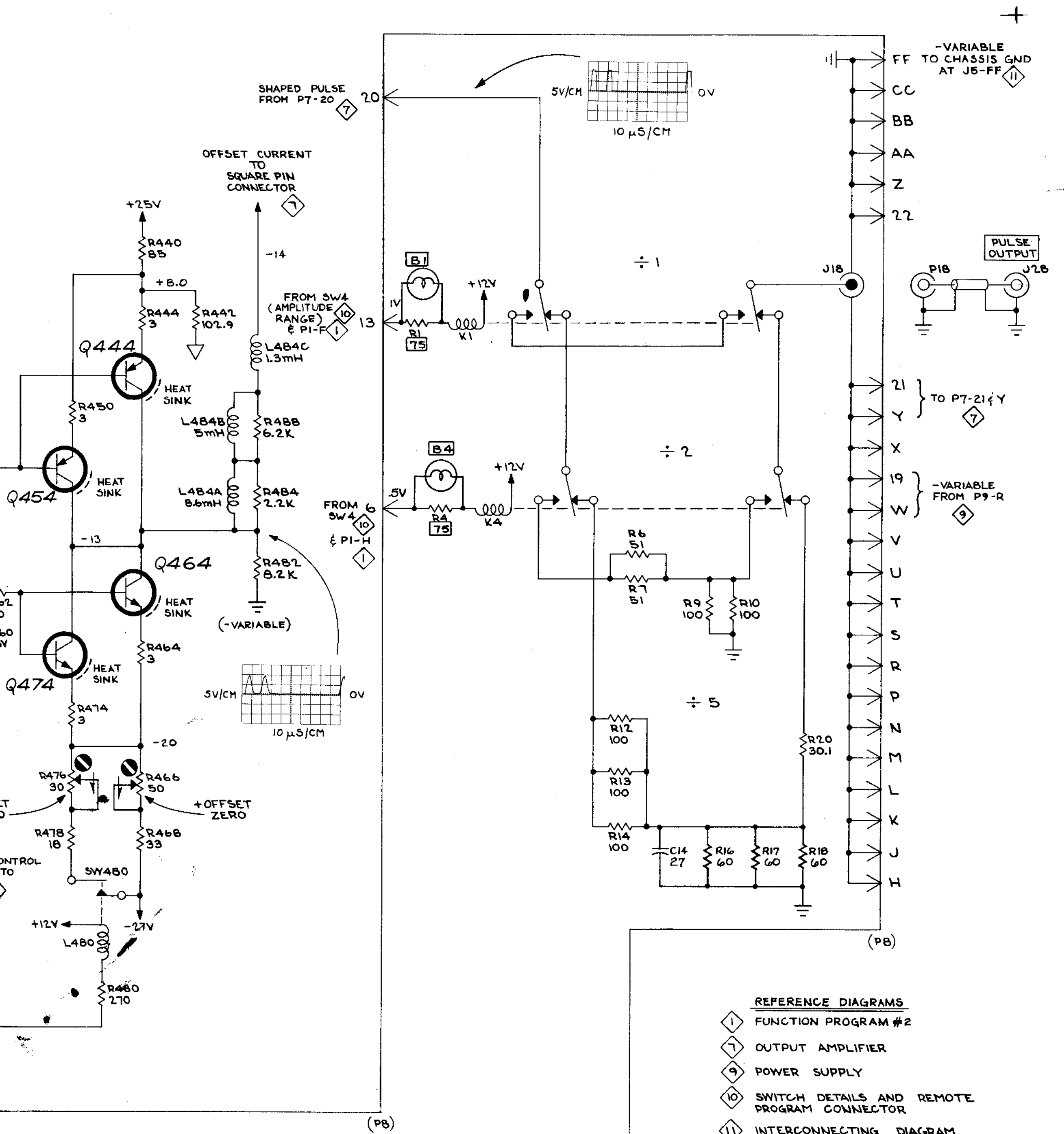
A



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE R116 PROGAMMABLE PULSE GENERATOR

B



WAVEFORMS and VOLTAGE READINGS on this diagram obtained under test conditions given on left panels of Period Generator and Delay Generator diagrams (schematics No. 2 and No. 3).

Test oscilloscope externally triggered through a coaxial cable from the Type R116 + PRE-TRIGGER OUT connector.

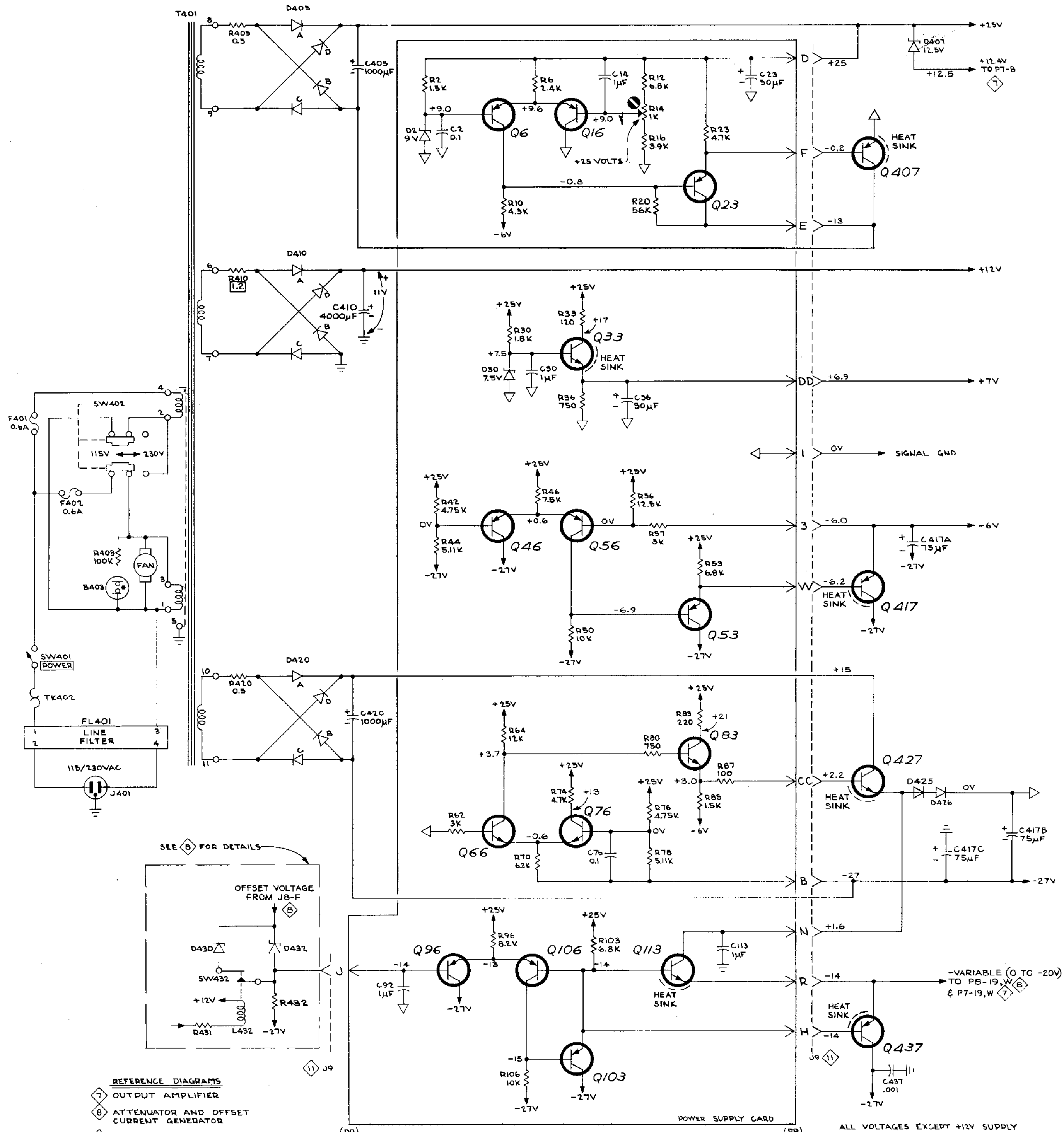
ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

+12V SUPPLY IS REFERENCED TO CHASSIS GND

566

ATTENUATOR AND OFFSET CURRENT GENERATOR (8)

B



REFERENCE DIAGRAMS
- 7 OUTPUT AMPLIFIER
- 8 ATTENUATOR AND OFFSET CURRENT GENERATOR
- 10 SWITCH DETAILS AND REMOTE PROGRAM CONECTOR
- 11 INTERCONNECTING DIAGRAM

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGE READINGS on this diagram obtained under test conditions given on left panels of Period Generator and Delay Generator diagrams (schematics No. 2 and No. 3).

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

ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GROUND

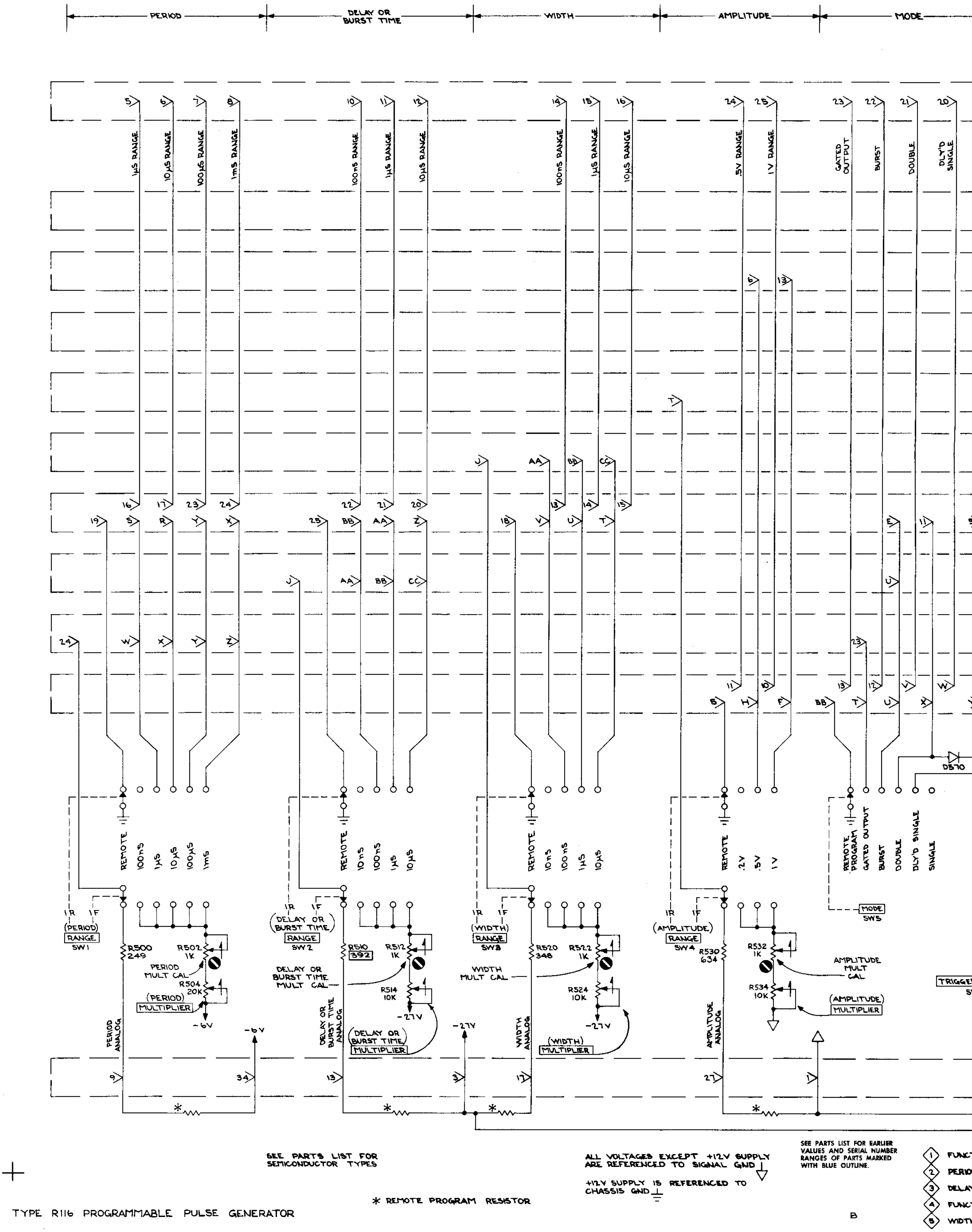
+12V SUPPLY IS REFERENCED TO CHASSIS GROUND

566

POWER SUPPLY 9
SERIES I MODEL I

TYPE R116 PROGRAMMABLE PULSE GENERATOR

B



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

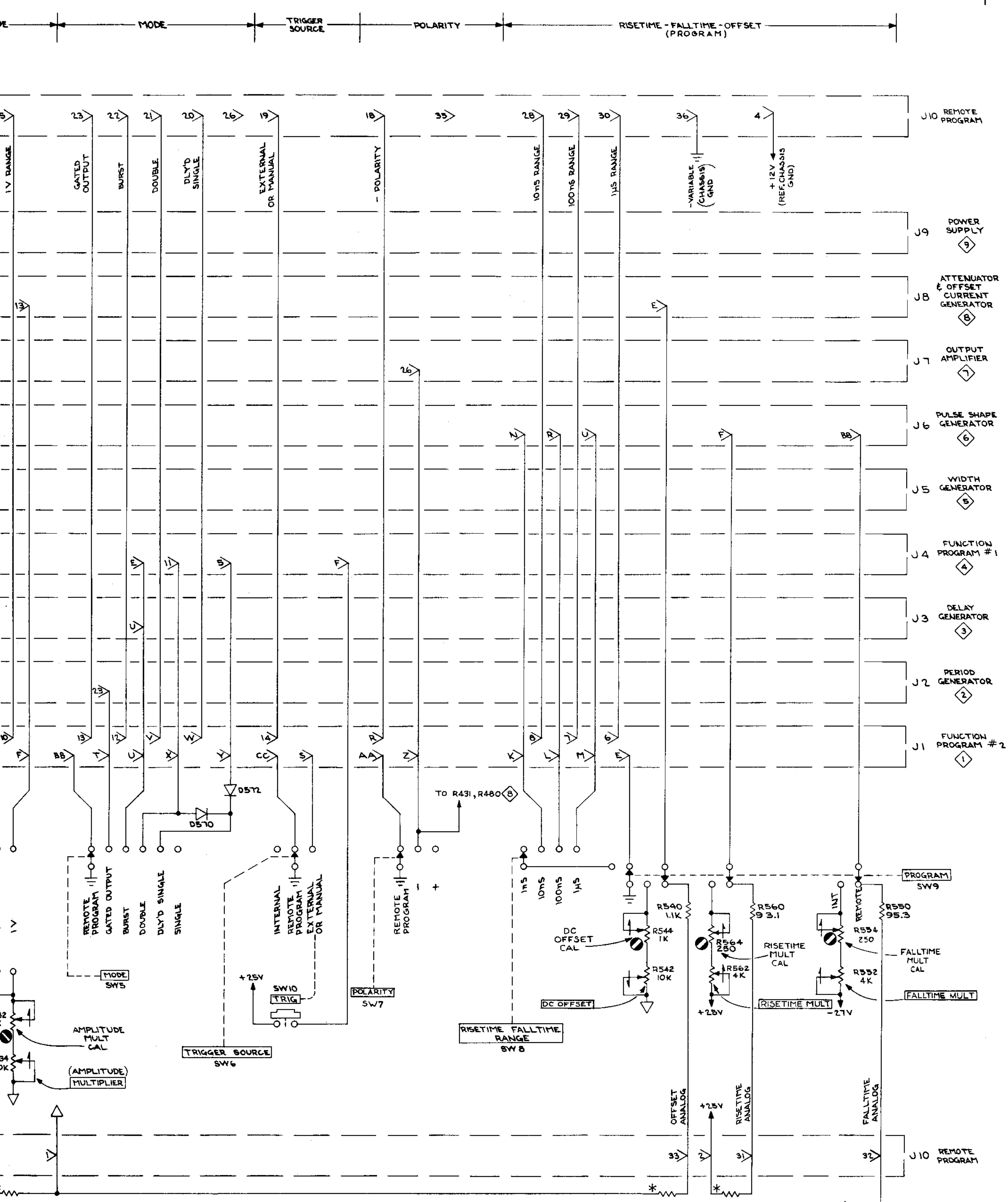
+12V SUPPLY IS REFERENCED TO CHASSIS GND

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

* REMOTE PROGRAM RESISTOR

TYPE R116 PROGRAMMABLE PULSE GENERATOR

B



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

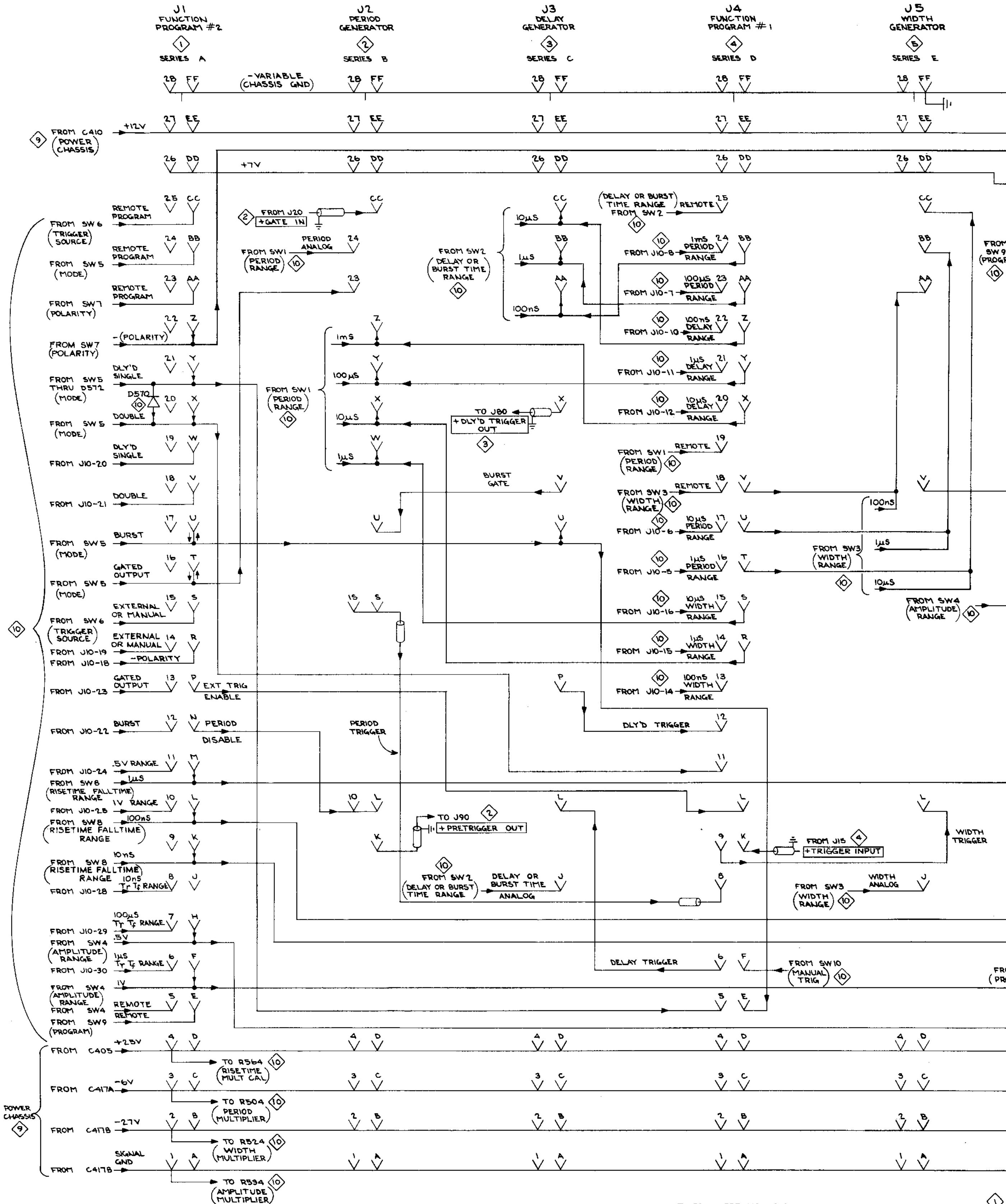
REFERENCE DIAGRAMS

1. FUNCTION PROGAM #2
2. PERIOD GENERATOR
3. DELAY GENERATOR
4. FUNCTION PROGRAM #1
5. WIDTH GENERATOR
6. PULSE SHAPE GENERATOR
7. OUTPUT AMPLIFIER
8. ATTENUATOR & OFFSET CURRENT GENERATOR
9. POWER SUPPLY
11. INTERCONNECTING DIAGRAM

B

B 566

SWITCH DETAILS AND REMOTE PROGRAM CONNECTOR (10)

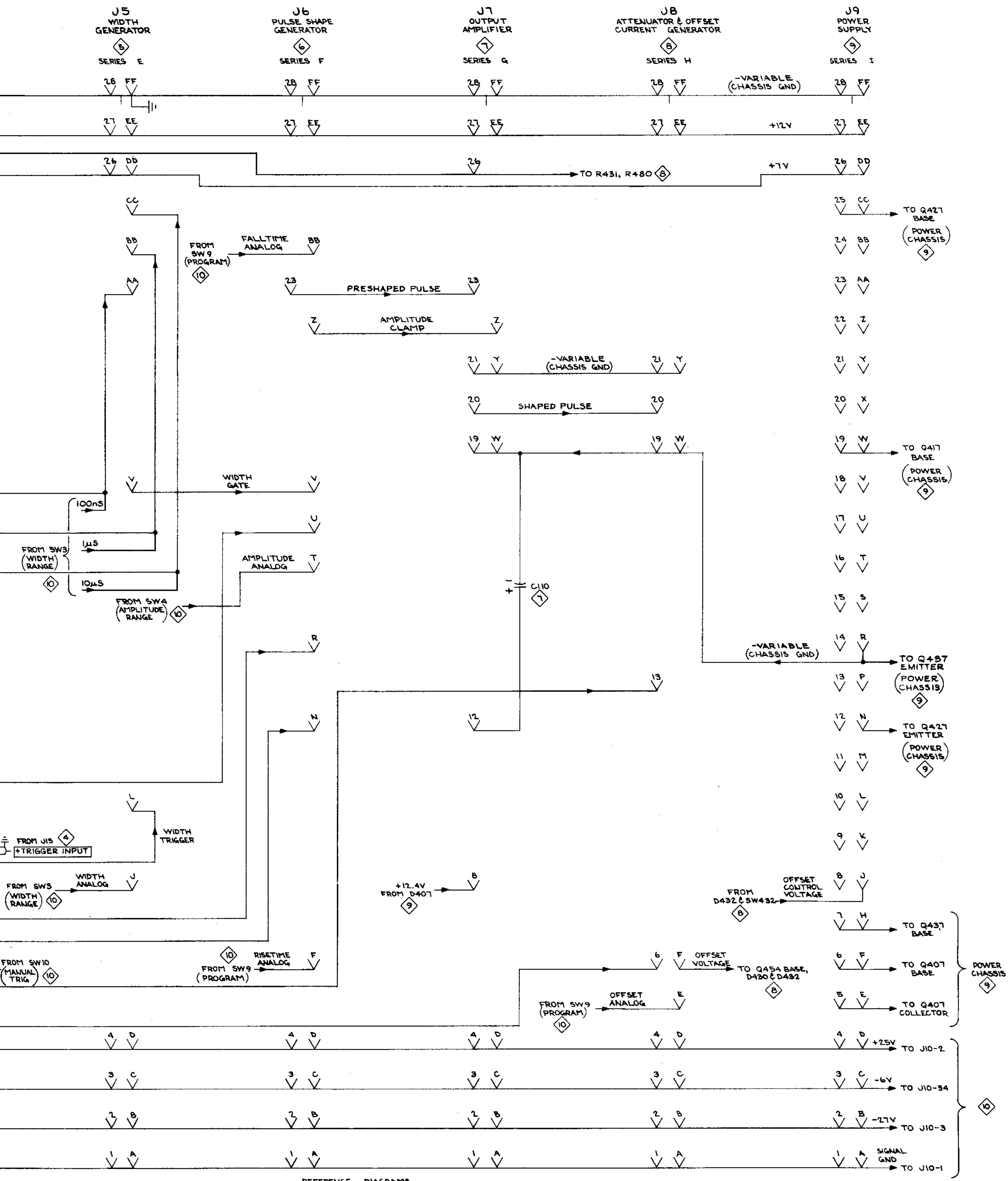


ALL VOLTAGES EXCEPT +12V SUPPLY ARE REFERENCED TO SIGNAL GND

+12V SUPPLY IS REFERENCED TO CHASSIS GND

TYPE R116 PROGRAMMABLE PULSE GENERATOR

A



REFERENCE DIAGRAMS

1. FUNCTION PROGRAM #2
2. PERIOD GENERATOR
3. DELAY GENERATOR
4. FUNCTION PROGRAM #1
5. WIDTH GENERATOR
6. PULSE SHAPE GENERATOR
7. OUTPUT AMPLIFIER
8. ATTENUATOR & OFFSET CURRENT GENERATOR
9. POWER SUPPLY
10. SWITCH DETAILS & REMOTE PROGRAM CONNECTOR

INTERCONNECTING DIAGRAM 11

SECTION 11
RACKMOUNTING

General Information

The Type R116 is designed to be mounted on slideout tracks in any 19-inch wide rack that has both front and rear rails and conforms to standard EIA universal rack dimensions. A complete dimensional drawing of the Type R116 is provided on a separate foldout page of this section. If a rack with alternate hole spacing is used, 2 mounting holes will have to be drilled in each rail.

Minimum width of the opening between the left and right front rails (see Fig. 11-1) is either 17⅝ inches or 17¾ inches depending on the mounting position to be used, as described later in this section. At least 5½ 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 R116 and 3 inches or more for power and program cables and for the circulation of air. Refer to the Operating Instructions section of this manual for cooling requirements.

Slideout Tracks

Fig. 11-1 shows the Type R116 installed in a cabinet-type rack with the side panels removed. The slideout tracks provided with the Type R116 permit it to be extended for maintenance and calibration without removing the instrument from the rack. At the fully extended position, the Type R116 can be tilted and locked in any one of seven positions—horizontal or 45°, 90° or 105° above or below the horizontal position. If the Type R116 is expected to be operated in an extended position, it should be installed with power and program cables that are long enough for that purpose. When not extended, the instrument is held into the rack with four securing screws that screw into the front rails of the rack (see Fig. 11-1B).

The slideout tracks consist of two assemblies—one for the left side of the instrument and one for the right side. Fig. 11-2 shows the parts of the slideout track assemblies. 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 R116 to be extended fully 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 right and left tracks can be identified by noting the position of the automatic stop flanges (see Fig. 11-2). The automatic stop on each track should be at the top when mounted in the rack. The chassis sections of both assemblies are installed on the instrument and adjusted at the factory prior to shipment.

The small hardware components provided for mounting the stationary sections to the rack are shown in Fig. 11-3. Since this hardware is intended to make the tracks compatible with a variety of racks, not all of it will be needed for this installation and some parts will be left over. Use only the hardware that is required for the particular method of mounting.

Mounting Positions

The front flanges of the stationary sections may be mounted in front of or behind the front rails of the rack. The mounting position to be used is selected on the basis of the desired effective panel thickness from the surface of the panel to the front rail, on the **width** of the opening between the rails of the rack and on 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. 11-4A the minimum effective panel thickness of approximately ⅛ inch may be obtained. In this case, the effective thickness is the actual thickness of the Type R116 front panel. (Do not countersink the holes if the rails are made of thin metal.) If BHS screws are used instead of countersunk flathead screws, the effective panel thickness will be approximately 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 distance required between the two front rails is 17⅝ inches and the minimum distance required from the front rails to the back rails is 17⅝ inches (maximum depth between rails is about 26 inches). This mounting position 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 17¾ inches. If this mounting position is desired but the holes are tapped for 10-32, the threads may be drilled out with a 3/16-inch bit.

Maximum Panel Thickness. When the flanges of the stationary sections are mounted **in front** of the rails with BHS screws as shown in Fig. 11-5, the maximum effective panel thickness of approximately ¼ inch is obtained. If the tracks are to be mounted in this position, the minimum width of the opening between the two front rails is 17¾ inches. This is the normal mounting position if the mounting holes in the front rails are tapped for 10-32 screws. If the width of the opening between the rear rails is also 17¾ inches or more, depth of the rack between front and rear rails may be from 10½ to 26 inches.

NOTE

The mounting position shown in Fig. 11-5 for use with tapped mounting holes may also be used with untapped holes by placing bar nuts behind the front rails in a manner similar to the method shown in Fig. 11-4.

Instrument Installation

Use the following procedure to install the Type R116 in a rack:

1. Select the proper front-rail mounting holes for the stationary sections using the measurements shown in Fig. 11-6.

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. 11-4 for the left track.

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. 11-5 for the left track.

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

4. Referring to Fig. 11-9, 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 the best possible operation, adjust the slideout tracks as follows:

1. Position the instrument as shown in Fig. 11-7.

2. Adjust the front ends of the stationary sections according to the procedure outlined in Fig. 11-7.

3. After adjusting the front ends 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, then push the instrument all the way into the rack and tighten the screws. The front panel of the Type R116 should now be parallel with the front rails. If the instrument still does not slide easily in the rack or if the front panel does not fit correctly, one or both of the chassis sections of the tracks may require readjustment as shown in Fig. 11-8.

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. 11-9.

Removing or Inserting the Type R116

After the slideout tracks have initially been installed and adjusted in the rack, the Type R116 can be removed or reinserted at any time by following the procedures given in Fig. 11-9. No further adjustments are normally required.

Maintenance

The slideout tracks require no lubrication. The special finish on the sliding surfaces provides permanent lubrication. If the tracks tend to become harder to operate after a period of use, a thin coating of paraffin may be rubbed onto the sliding surfaces for additional lubrication.

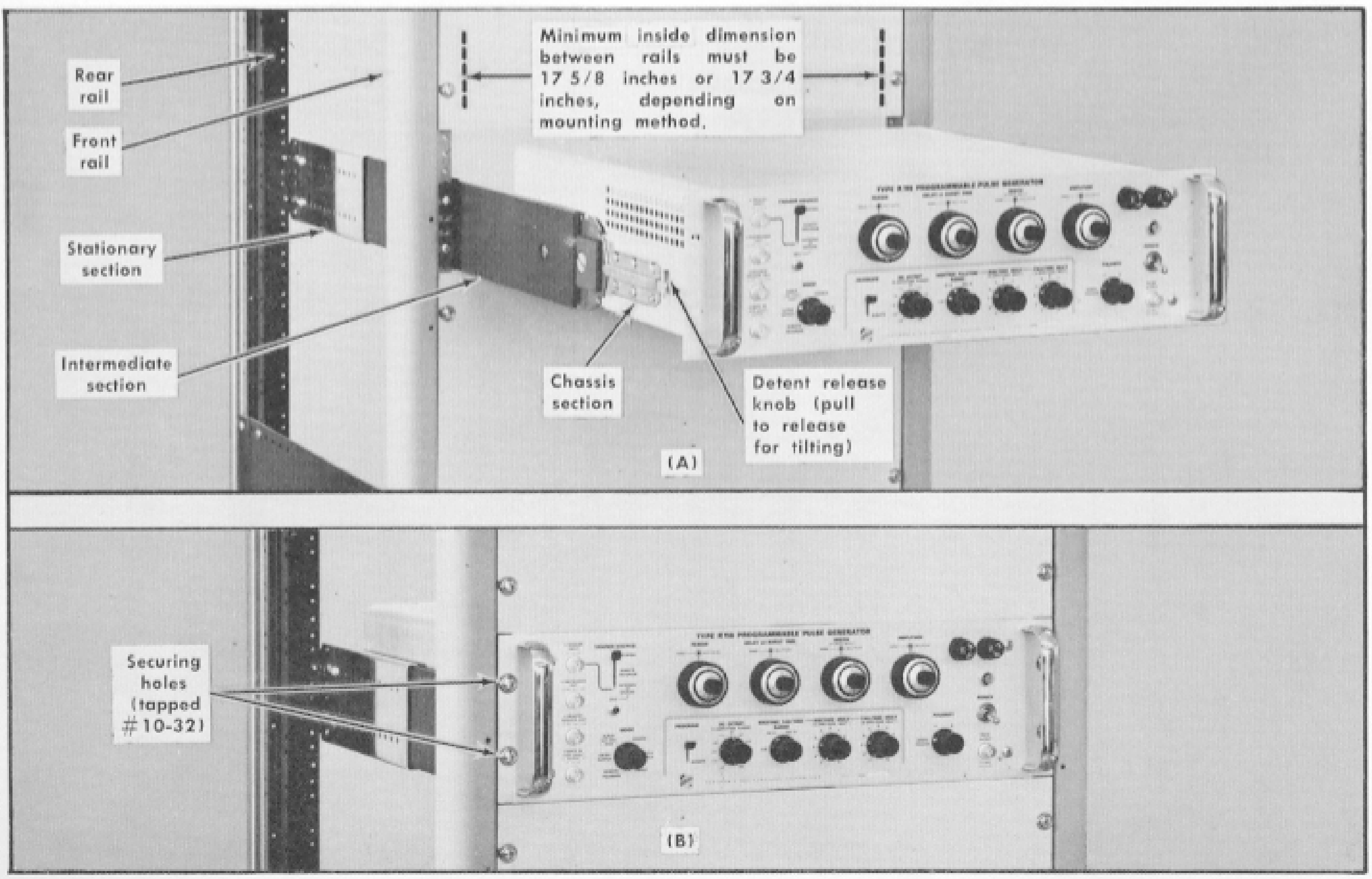


Fig. 11-1. The Type R116 installed in a cabinet-type rack with the sides removed; (A) Extended on the slideout tracks; (B) held into the rack with securing screws.

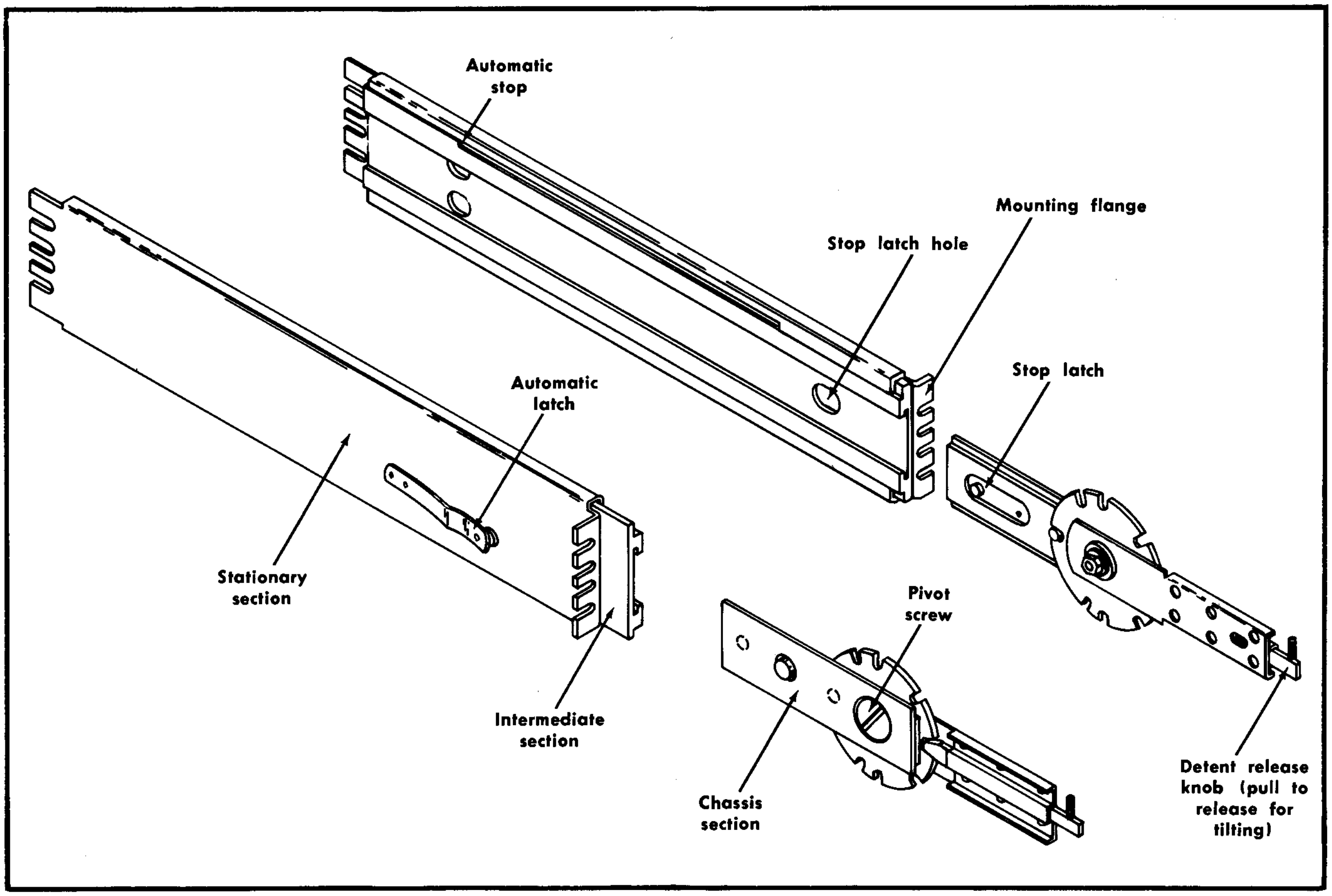


Fig. 11-2. Slideout track assembly for the left side of the instrument.

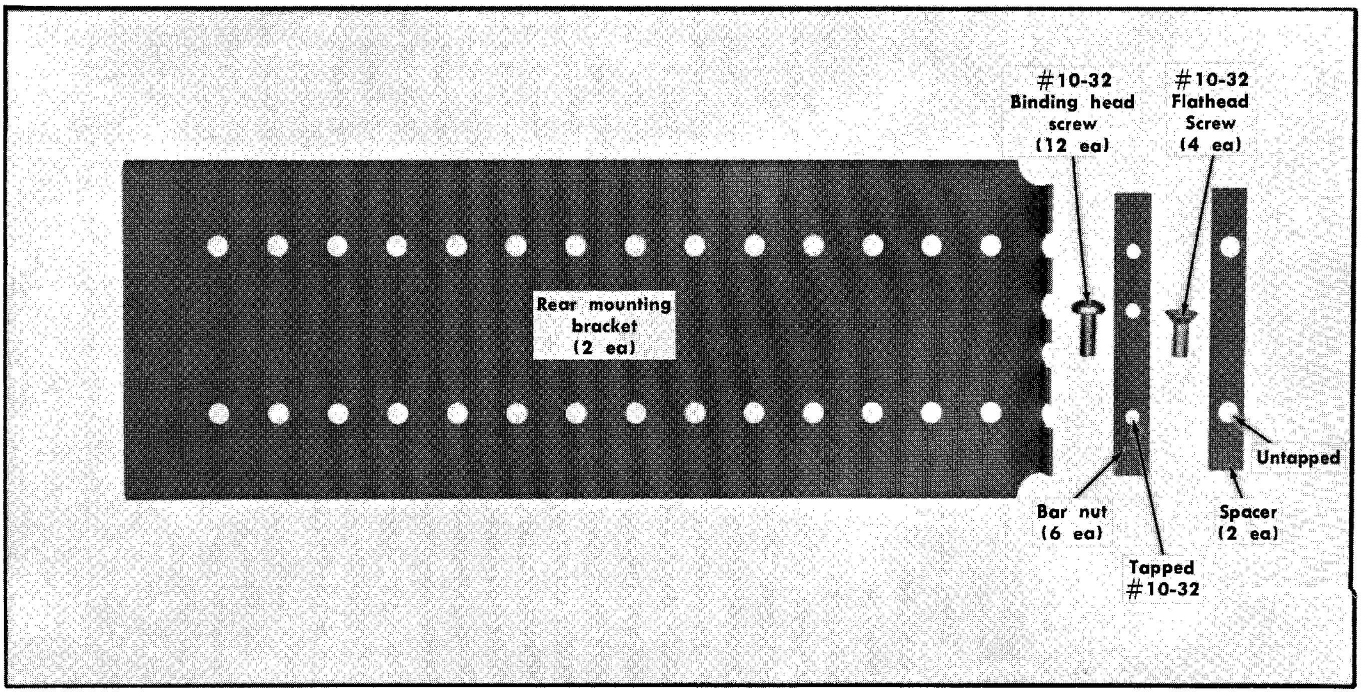


Fig. 11-3. Small hardware components provided for attaching the stationary sections of the slideout tracks to the cabinet-rack rails.

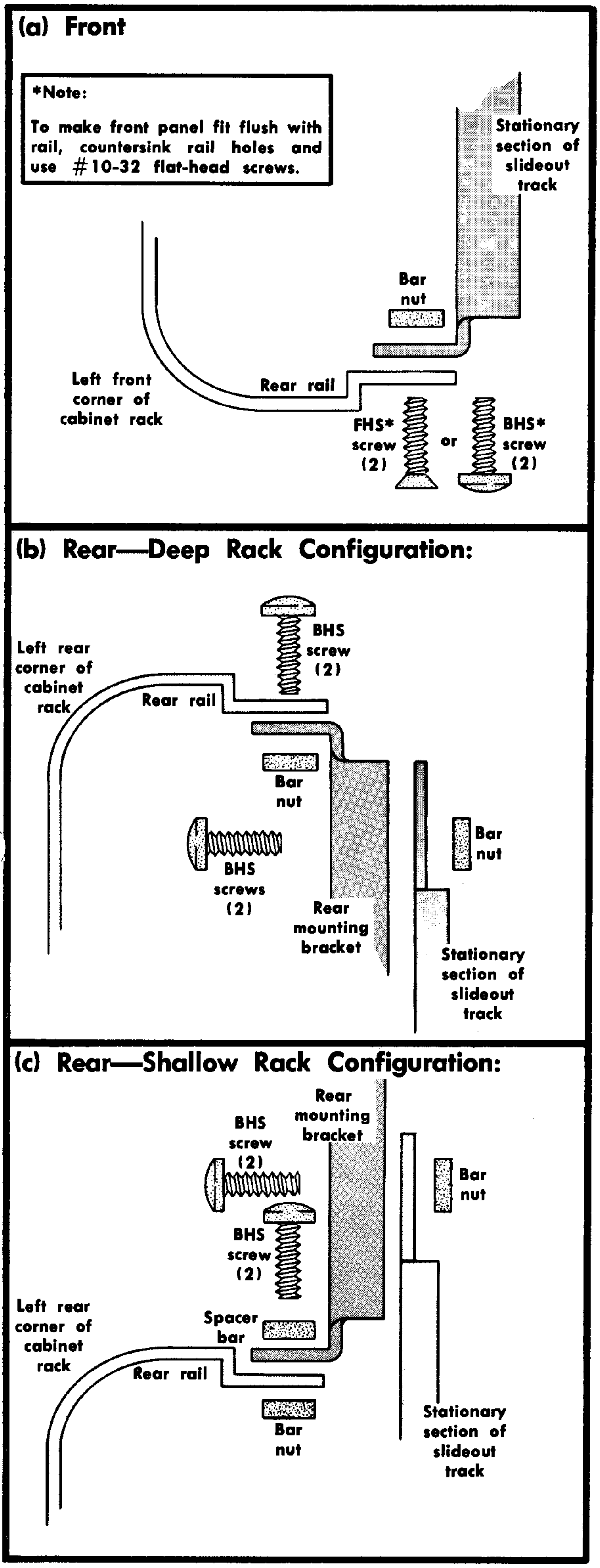


Fig. 11-4. Normal mounting position of the left stationary section for the minimum panel thickness.

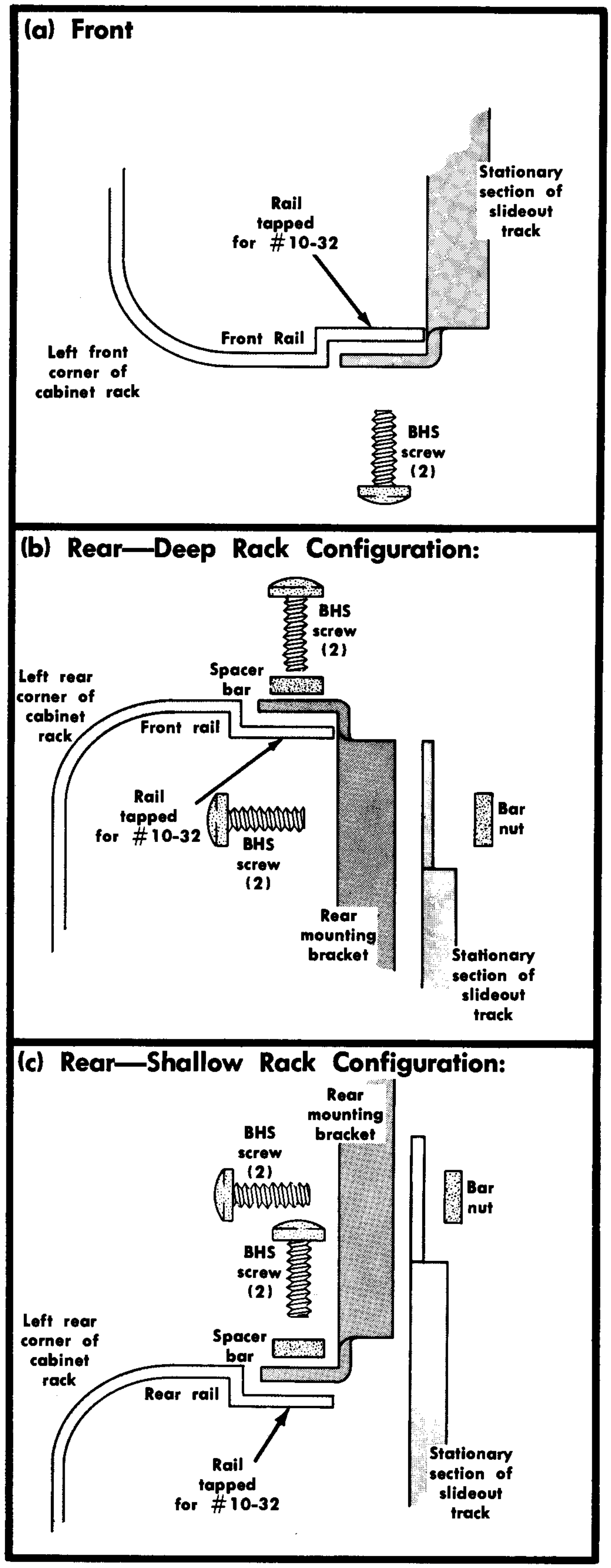


Fig. 11-5. Normal mounting position of the left stationary section if the mounting holes are tapped for 10-32 screws.

RACKMOUNTING

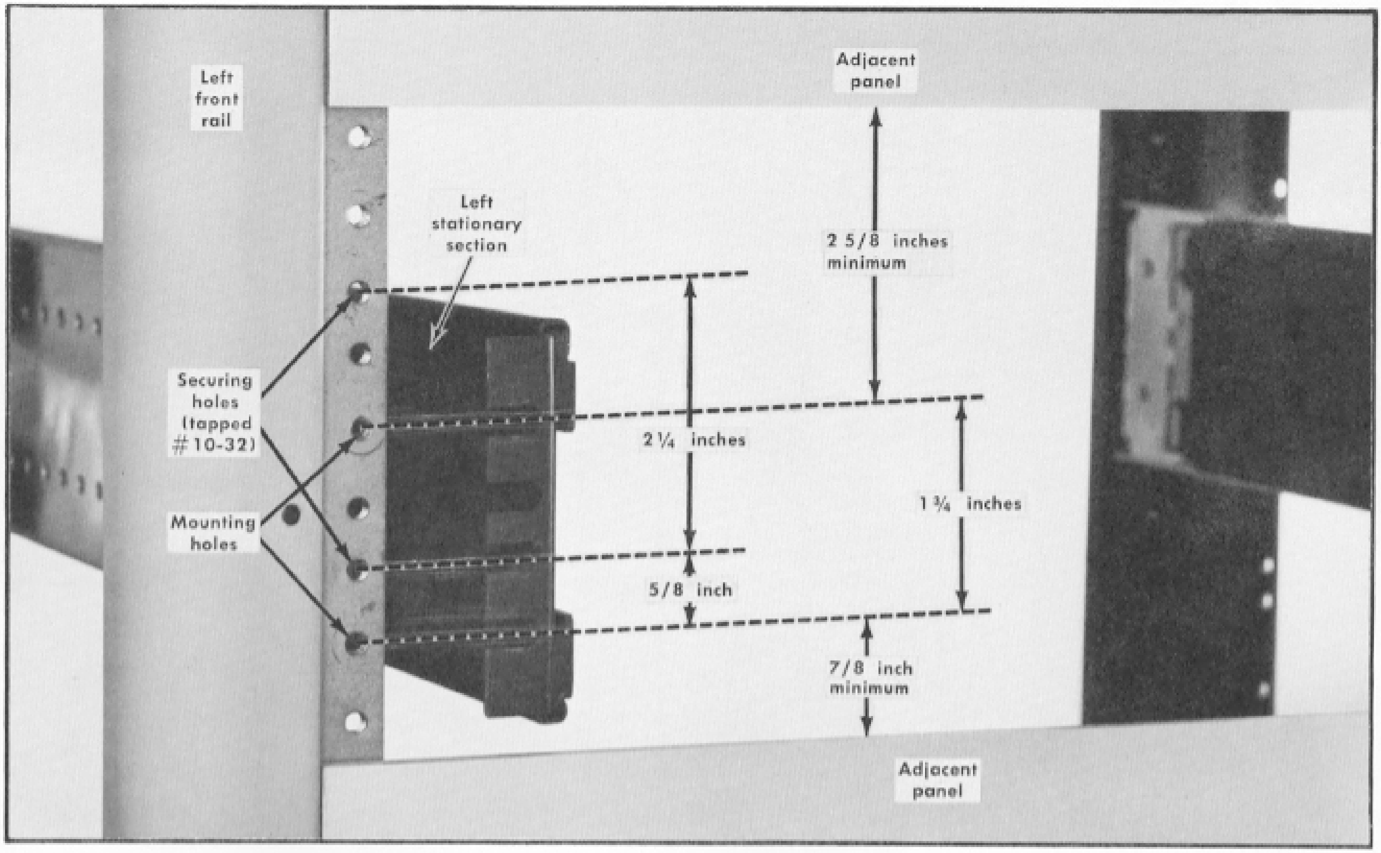


Fig. 11-6. Vertical mounting position of the left stationary section. The same dimensions apply for mounting the right stationary section.

To adjust the front-end alignment:

1. Position the instrument with the pivot screws approximately even with the front rails.
2. Loosen the mounting screws at the front end of both stationary sections (only the left side is shown).
3. Allow the two slides to seek their normal width positions with the instrument centered in the rack.
4. Tighten the mounting screws.
5. Push the instrument all the way into the rack.
6. Check the vertical positioning of the Type R116 front panel with respect to adjacent instruments or panels. If the position is not correct, readjust the mounting screws as necessary.

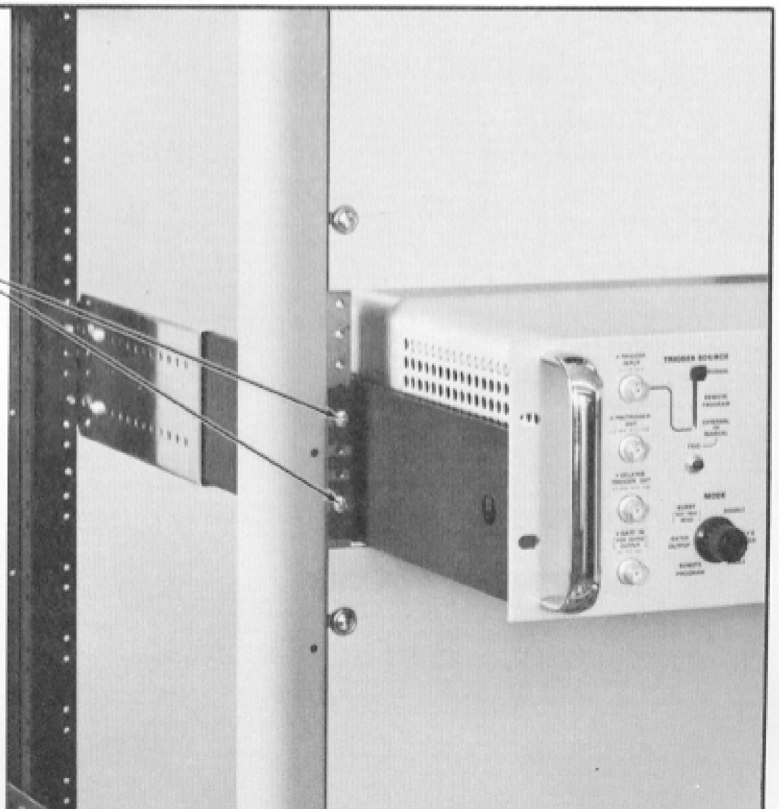


Fig. 11-7. Stationary section front-end adjustments.

To adjust a chassis section:

1. Remove the bottom dust cover from instrument.
2. Loosen the eccentric pivot screw nut (located inside the instrument) so the 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 or to obtain additional adjustment of the stationary sections.)
4. Hold the pivot screw in position and retighten 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 bottom dust cover.

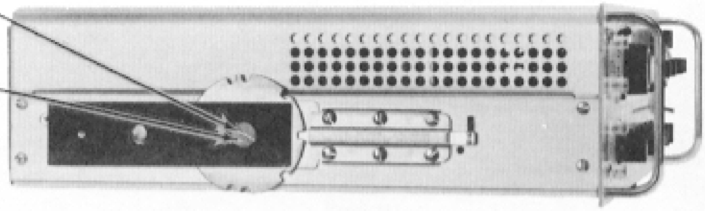
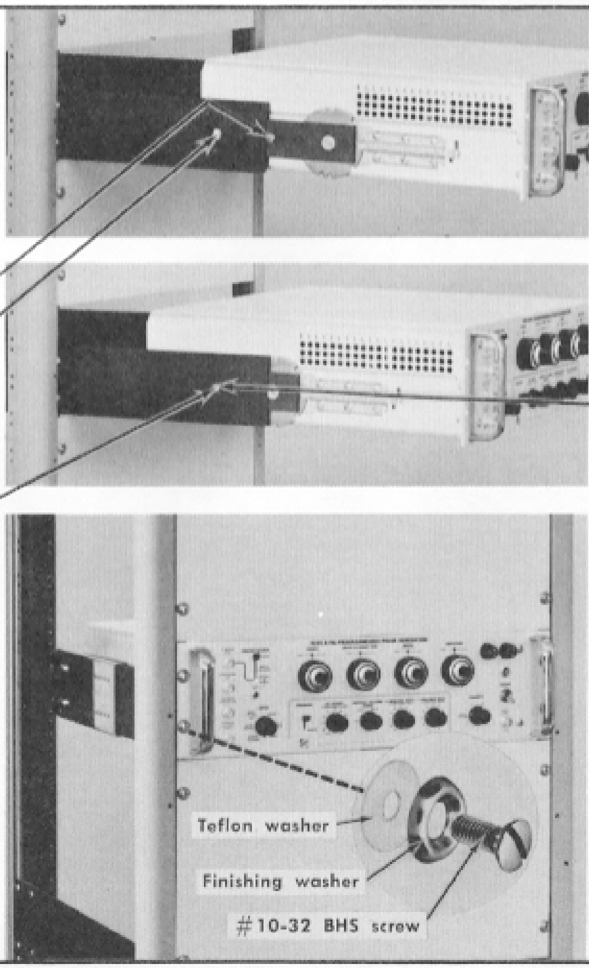


Fig. 11-8. Chassis section adjustments (if required). Perform only if proper positioning is not obtained with stationary section adjustments.

To insert the Type R116:

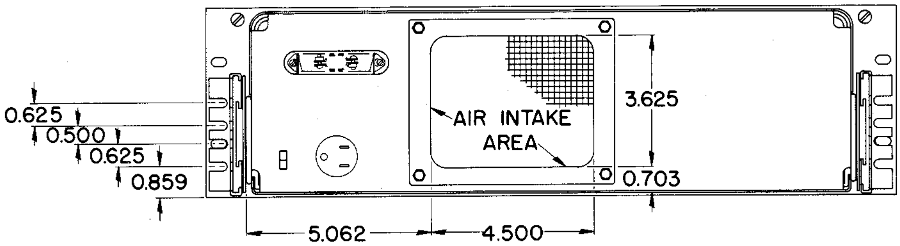
1. Pull the intermediate section of each slideout track out to its fully extended position.
2. Insert the chassis sections (fastened to the instrument) into the intermediate sections.
3. Press both stop latches and push the instrument into the rack until the latches snap into their holes.
4. Connect 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. The automatic stop latches will disengage when the instrument is pushed in.
6. To secure the Type R116 into the rack, insert the 4 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 R116:

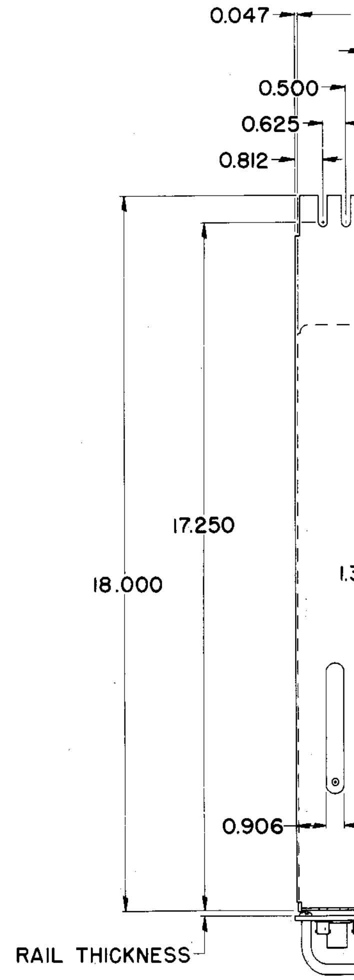
1. Remove the securing screws and washers.
2. Pull the instrument outward until the automatic stops catch and the stop latches snap into their holes.
3. Disconnect the power cord and program cable from the instrument.
4. Press both stop latches and pull the instrument out of the rack.
5. Press the automatic stop latches and push the intermediate sections into the rack.

Fig. 11-9. Procedures for inserting the instrument and for removing it from the rack after the slideout tracks have been installed.

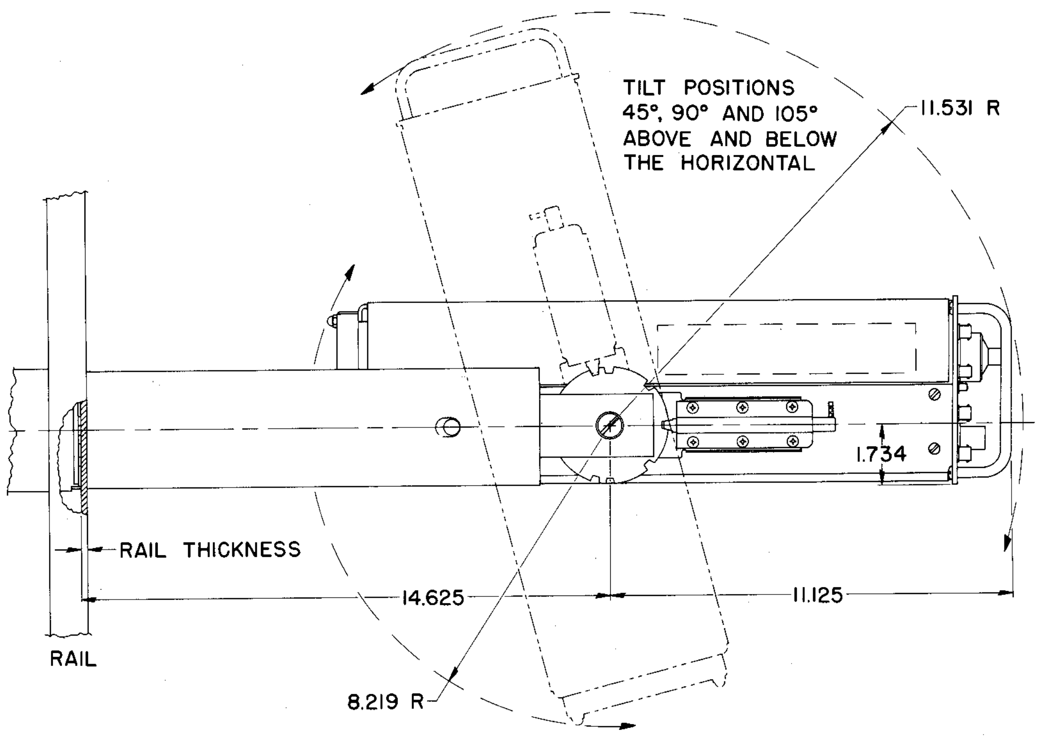


0.625
0.500
0.625
0.859
AIR INTAKE AREA
3.625
0.703
5.062
4.500

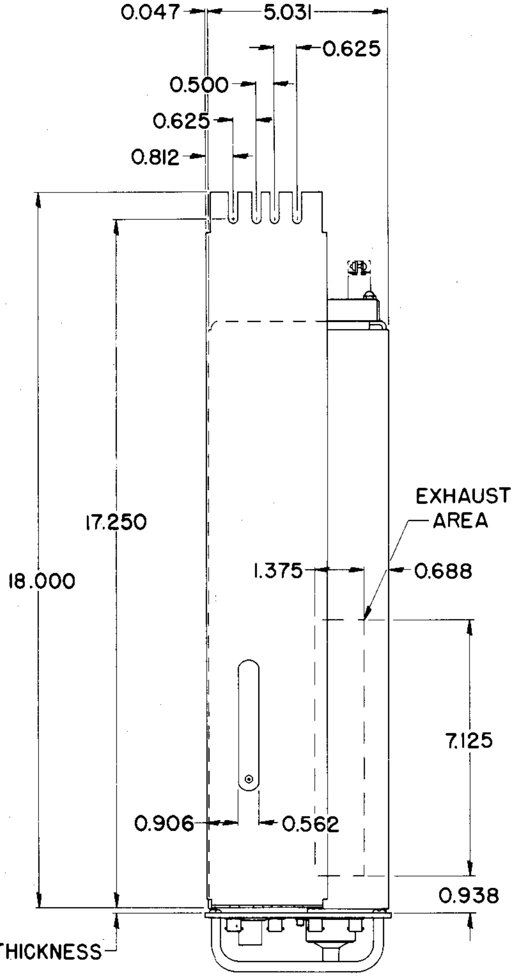
REAR VIEW

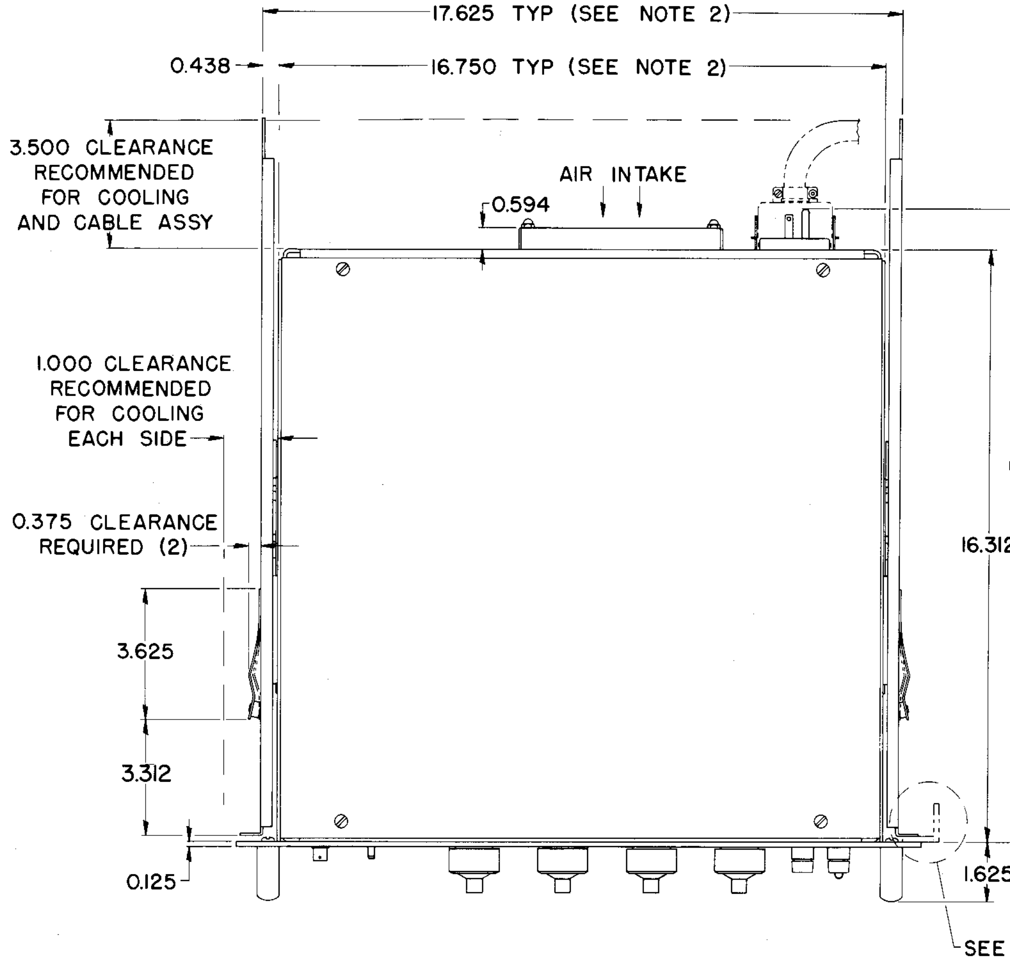


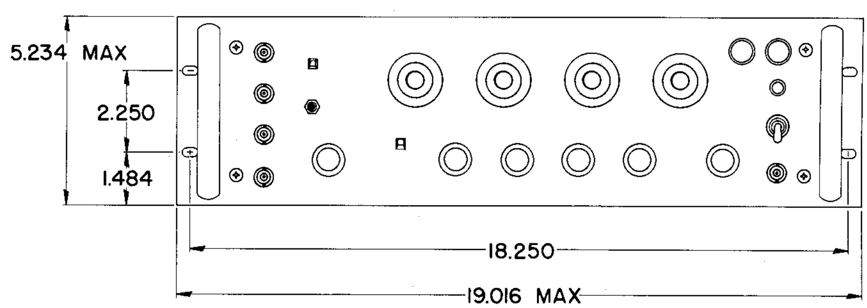
0.047
0.500
0.625
0.812
17.250
18.000
0.906
RAIL THICKNESS

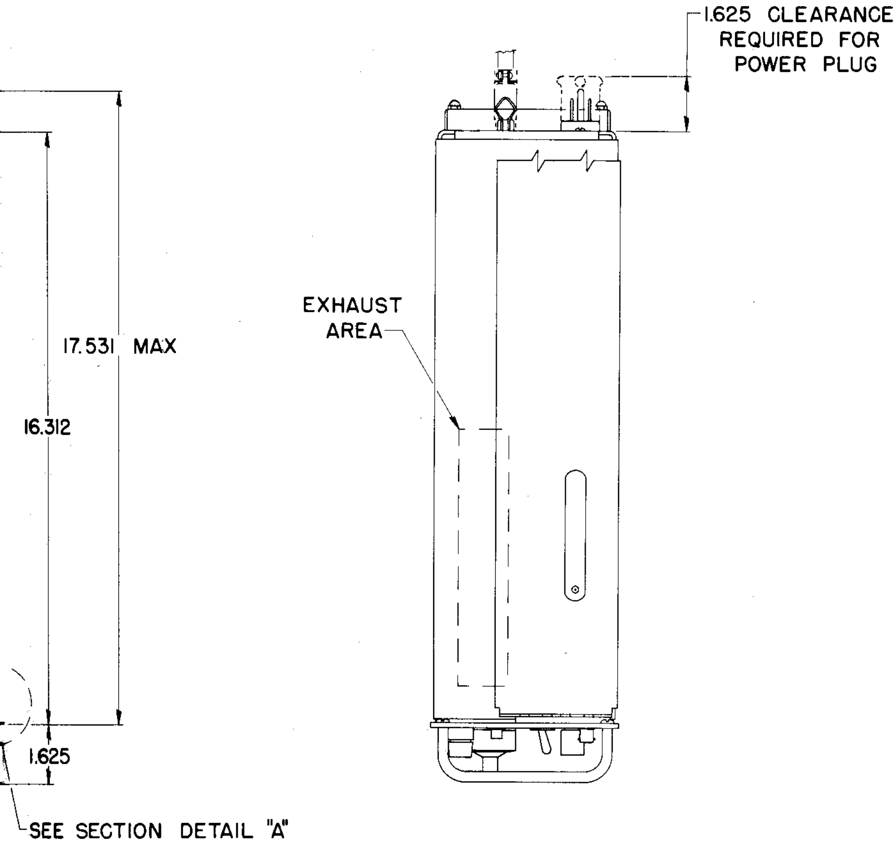


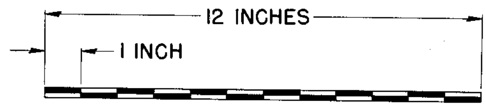
TILT POSITIONS
45°, 90° AND 105°
ABOVE AND BELOW
THE HORIZONTAL
11.531 R
1.734
RAIL THICKNESS
14.625
11.125
RAIL
8.219 R


0.047
5.031
0.625
0.500
0.625
0.812
17.250
18.000
EXHAUST
AREA
1.375
0.688
7.125
0.906
0.562
0.938
THICKNESS


17.625 TYP (SEE NOTE 2)
0.438
16.750 TYP (SEE NOTE 2)
3.500 CLEARANCE
RECOMMENDED
FOR COOLING
AND CABLE ASSY
AIR INTAKE
0.594
1.000 CLEARANCE
RECOMMENDED
FOR COOLING
EACH SIDE
0.375 CLEARANCE
REQUIRED (2)
3.625
3.312
0.125
16.312
1.625
SEE

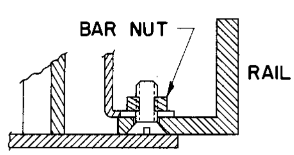

5.234 MAX
2.250
1.484
18.250
19.016 MAX





NOTES:
1. ALL DIMENSIONS ARE REFERENCE DIMENSIONS EXCEPT AS NOTED
2. SUBJECT TO APPROXIMATELY ±0.047 DEVIATION

TYPE R116 PROGRAMMABLE PULSE GENERATOR



SECTION DETAIL "A"

RECOMMENDED MOUNTING

A

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.

OFFSET CURRENT GENERATOR PROTECTION AND OUTPUT THERMAL DRIFT REDUCTION

##

Type R116 -- SN 1000-1083

Installed in Type R116 SN__________ Date__________

GENERAL INFORMATION

This modification replaces transistors and changes circuitry in the Offset Current Generator to eliminate damage to these transistors when the instrument is operated without a 50Ω load on the PULSE OUTPUT. It significantly reduces thermal drift in the Offset Current Generator.

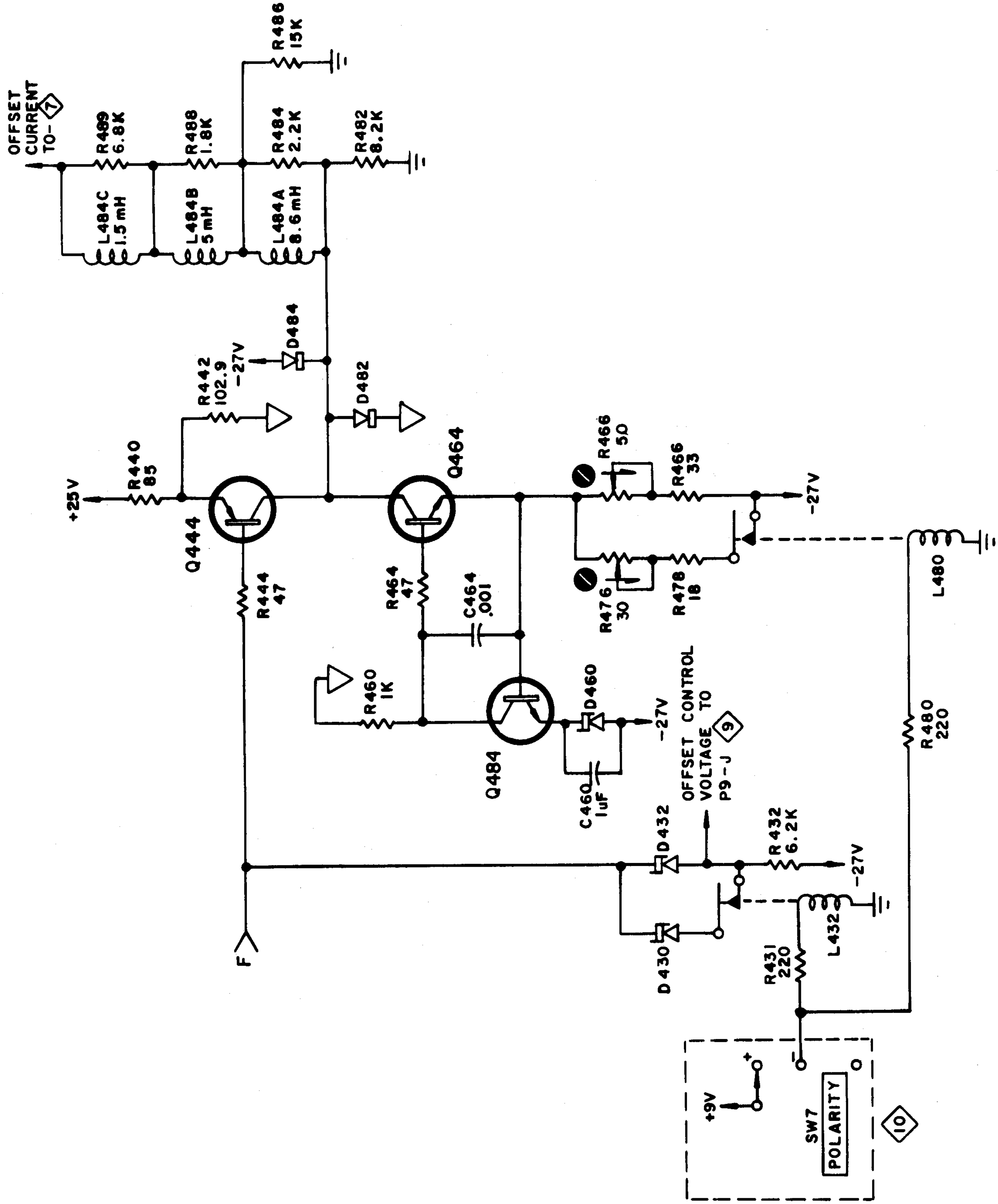
Installation involes replacing six transistors in the Offset Current Generator circuit with three transistors and associated circuitry. The two power transistors are mounted on a bracket that mounts in the old transistor mounting holes.

ELECTRICAL PARTS LIST

Ckt.No.	Part Number	Description		
		DIODES		
D482	152-0185-00	Signal	6185	
D484	152-0185-00	Signal	6185	
		RESISTORS		
Resistors are 1/2 W 5% composition unless otherwise indicated.				
R430	301-0221-00	220Ω		
R432	301-0622-00	6.2 k		
R444	315-0470-00	47Ω	1/4 W	
R450	Delete			
R460	303-0102-00	1 k	1 W	
R464	315-0470-00	47Ω	1/4 W	
R474	Delete			
R480	301-0221-00	220Ω		
		TRANSISTORS		
Q434	Delete			
Q444	151-0226-00	2N3741		
Q454	Delete			
Q464	151-0227-00	2N3767		
Q474	Delete			
		RESISTORS (Attenuator Card)		
R56	315-0221-00	220Ω	1/4 W	5%
R74	301-0222-00	2.2 k	1/2 W	5%

MECHANICAL PARTS LIST

Part Number	Description
407-0395-00	Bracket, angle, transistor mounting
210-0006-00	Lockwasher, int #6
210-0202-00	Lug, solder, SE-6
210-0407-00	Nut, hex, 6-32 x 1/4
210-0485-00	Nut, Keps, 8-32 x 11/32
386-0143-00	Plate, mica, insulating
211-0510-00	Screw, 6-32 x 3/8 PHS
212-0023-00	Screw, 8-32 x 3/8 PHS
210-0802-00	Washer, 6S x 5/16
210-0811-00	Washer, fiber, #6 shouldered


OFFSET CURRENT TO- 7
R489 6.8K
R488 1.8K
R484 2.2K
R482 8.2K
R486 15K
L484C 1.5 mH
L484B 5 mH
L484A 8.6 mH
D484
-27V
D482
R442 102.9
R440 85
+25V
Q444
Q464
R444 47
R464 47
C464 .001
R466 50
R466 33
R476 30
R478 18
L480
R480 220
R460 1K
Q484
D460
C460 1uF
OFFSET CONTROL VOLTAGE TO 9 P9-J
D432
R432 6.2K
D430
R431 220
L432
F
+9V
SW7
POLARITY
10

040-0461-00

PARTS LIST CORRECTIONS

INSTRUMENT CHASSIS

CHANGE TO:

R410	307-0093-00	1.2 Ω	1/2 W	5%	
R488	315-0182-00	1.8 kΩ	1/4 W	5%	
R530	Selected	< 1 kΩ	1/8 W	1%	Prec

REMOVE:

D425	152-0066-00	Silicon	1N3194

ADD:

L485	108-0237-00	80 µH	Inductor	
R486	301-0153-00	15 kΩ	1/2 W	5%

DELAY GENERATOR CARD -- Series C

CHANGE TO:

R14	301-0391-00	390 Ω	1/2 W	5%

FUNCTION PROGRAM No. 1 CARD -- Series D

ADD:

C14	283-0000-00	0.001 µF	Cer	500 V

WIDTH GENERATOR CARD -- Series E

CHANGE TO:

R12	301-0391-00	390 Ω	1/2 W	5%

PULSE SHAPE GENERATOR CARD -- Series F

REMOVE:

C74	281-0097-00	9-35 pF	Cer	Var

OUTPUT AMPLIFIER CARD -- Series G

CHANGE TO:

C40	Selected	< 30 pF	Cer	500 V	1%
C44	283-0026-00	0.2 µF	Cer	25 V	
R44	315-0103-00	10 kΩ	1/4 W	5%	

ADD:

R43	315-0103-00	10 kΩ	1/4 W	5%

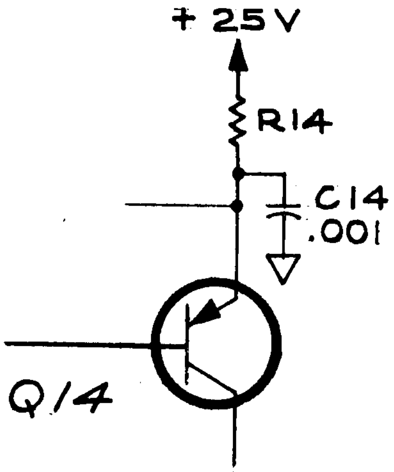
ATTENUATOR CARD -- Series H

CHANGE TO:

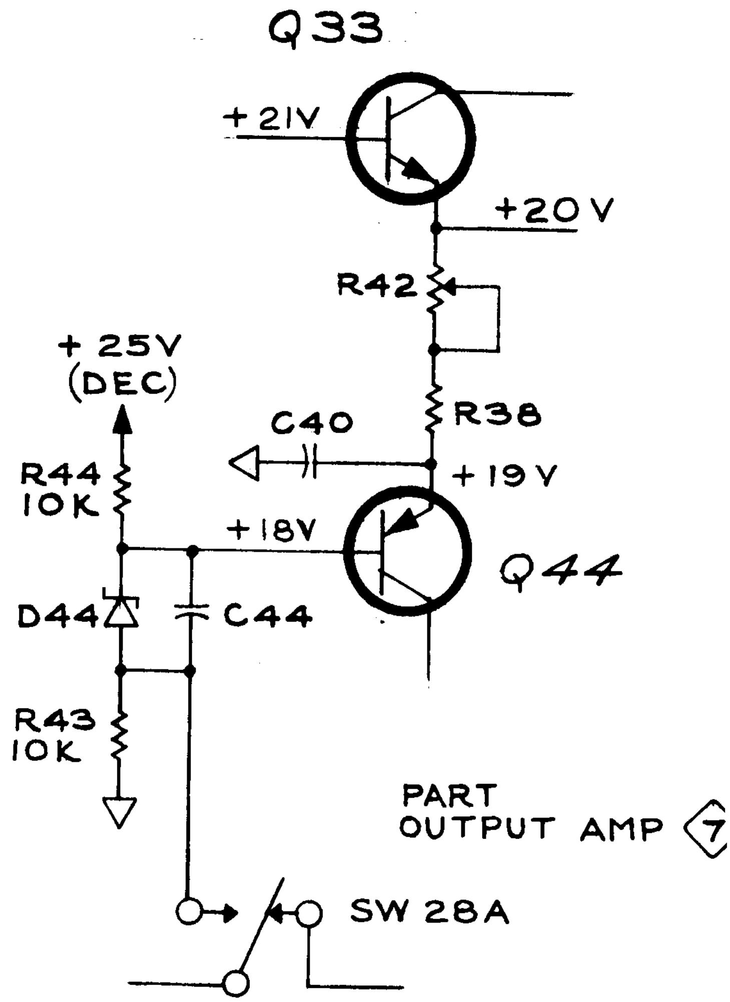
R1	303-0750-00	75 Ω	1 W	5%
R4	303-0750-00	75 Ω	1 W	5%

ADD:

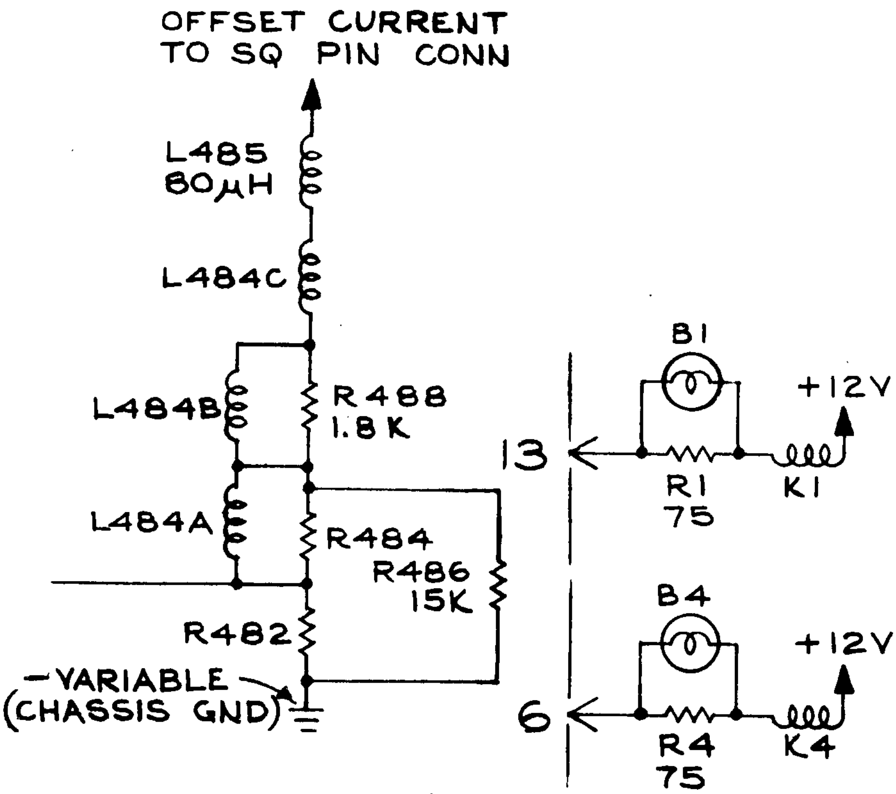
B1	150-0046-00	Bulb, Incandescent
B4	150-0046-00	Bulb, Incandescent



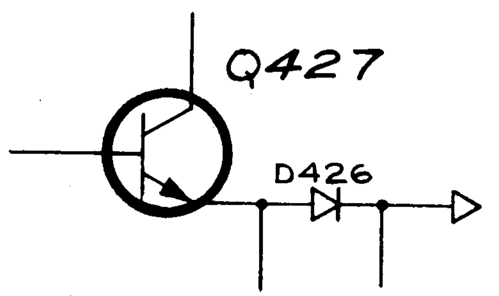
PART FUNCTION PROGRAM #1 ④



PART OUTPUT AMP ⑦



PART ATTEN & OFFSET CURRENT GEN ⑧



PART PWR SUPPLY ⑨

TEXT CORRECTIONS

CHARACTERISTICS

Page 1-1, column 2,

Under Input Signal Requirements, +Gate In Amplitude, change the Supplemental Information to read:

Accidental overload +100 volts maximum.

Page 1-2, column 2,

Under Output Signal Characteristics, Risetime and falltime, change the Performance Requirement to read:

10 ns to 100 μs: Accuracy within 5% ±1 ns of switch and dial readings on all ranges.

Page 1-3, column 1,

Under Output Signal Characteristics, Dc Offset, change the Performance Requirement to read:

-5 volts to +5 volts: Accuracy within 5% ±100 mV of switch and dial readings over range of DC OFFSET control.

Page 1-4, column 2,

Under Programming, Dc Offset Analog, delete the following phrase from the Performance Requirement:

Accuracy within (100 mV of front-panel calibration plus error in program resistor). (NOTE: The accuracy requirement is covered by the Variable Operations Performance Requirement in column 1.)

Under Power Supply, Voltage Requirements, 115 Volts, change the Performance Requirement to read:

103.5 volts to 137.5 volts ac rms.

Under Power Supply, Voltage Requirements, 230 Volts, change the Performance Requirement to read:

207 volts to 275 volts ac rms.

OPERATING INSTRUCTIONS

Page 2-1, column 2,

Under Selecting Line Voltage, on line 5 change the parenthesis: (94.5 volts to 137.5 volts) to read: (103.5 volts to 137.5 volts).

On line 7 of the same paragraph, change the parenthesis: (189 volts to 275 volts) to read: (207 volts to 275 volts).

CIRCUIT DESCRIPTION

Page 4-13,

In Fig. 4-7, delete the reference to D425 which has been removed.

Page 4-14, column 2,

Under -Variable Supply, paragraph 2, change the last sentance to read: Voltage at the emitter of Q427 is held at about +0.6 volt by the drop across D426.

MAINTENANCE

Page 5-13,

Fig. 5-11. (Capacitor C14 is located on the reverse side of the Function Program No. 1 card, between the anode end of D14 and the signal ground end of C50.)

Page 5-15,

Fig. 5-13. (Capacitor C74 has been removed from the Pulse Shape Generator card.)

Page 5-17,

Fig. 5-15. (Bulbs B1 and B4 have been added across resistors R1 and R4, respectively, on the Attenuator card.)

PERFORMANCE CHECK

Substitute the following steps and tables for those given in the performance check procedure. Paragraphs that are not mentioned here should be left unchanged.

Page 6-7,

11 a. Requirement--Correct dc offset ±5% ±100 mV into a 50 Ω load, over the range of the DC OFFSET control, in + and - polarity.

11 g. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±2 cm (100 mV).

11 i. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±2 cm (100 mV).

11 j. Reset the following test oscilloscope controls:

Input Attenuation	10
Deflection Factor	20 mV/Cm

11 m. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1.75 cm (5% +100 mV), as indicated in the Offset (Internal) column of Table 6-3. The checks on the 1V amplitude range cover the .5V and .2V ranges as well, since the attenuator was checked previously.

TABLE 6-3

Offset Accuracy Check

DC OFF-SET	POLAR-ITY	Oscilloscope Comp Voltage Mult.	Oscilloscope Vc Range	Offset Voltage	Offset Baseline Displacement from Centerline Internal	Offset Baseline Displacement from Centerline External
-5	+	5.000	-1.1	-5V	±1.75 cm (5% +100mV)	±2.5 cm (8% +100mV)
-5	-	5.000	-1.1	-5V	±1.75 cm	±2.5 cm
+5	-	5.000	+1.1	+5V	±1.75 cm	±2.25 cm (7% +100mV)
+5	+	5.000	+1.1	+5V	±1.75 cm	±2.25 cm

12 a. Requirement--Correct dc offset using program resistors, within 2% of front-panel operation (+1% program resistor tolerance).

12 h. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±0.5 cm (103 mV).

Page 6-8,

12 j. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±0.5 cm (103 mV).

12 n. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±2.5 cm (8% +100 mV), as given in the Offset (Remote) column of Table 6-3.

12 p. Repeat steps 1 through n for the +5 settings of the DC OFFSET control given in Table 6-3. (The tolerances here are different from those in - polarity since the analog resistor is not in the circuit at maximum + offset.)

13 b. Reset the following test oscilloscope controls:

Vc Range	0
Input Attenuation	100
Deflection Factor	10 mV/cm
Input Coupling	Gnd

Page 6-16,

26 a. Requirement--Correct risetime and falltime ±5% ±1 ns over the range of the risetime and falltime controls, using 10 volts output amplitude.

27 g. Check for--Sampling oscilloscope display with a risetime of 10 ns, ±7% ±1 ns (5 cm, ±8.5 mm).

27 i. Check for--Sampling oscilloscope display with a falltime of 10 ns, ±7% ±1 ns (5cm, ±8.5 mm).

Page 6-17,

TABLE 6-10
Risetime and Falltime Accuracy Check
(Change last 2 columns only)

Risetime or Falltime	
Time	Display
10 ns, ±5% ±1 ns	5 cm, ±7.5 mm
100 ns, ±5% ±1 ns	5 cm, ±3.0 mm
1 µs, ±5% ±1 ns	5 cm, ±2.55 mm
10 µs, ±5% ±1 ns	5 cm, ±2.5 mm
110 µs, ±5% ±1 ns	5.5 cm, ±2.75 mm
11 µs, ±5% ±1 ns	5.5 cm, ±2.75 mm
1.1 µs, ±5% ±1 ns	5.5 cm, ±2.76 mm
110 ns, ±5% ±1 ns	5.5 cm, ±3.25 mm

TABLE 6-11
Remote Risetime-Falltime Range Check
(Change last 2 columns only)

Risetime and Falltime	
Time	Display
100 ns, ±7% ±1 ns	5 cm, ±4.0 mm
1 µs, ±7% ±1 ns	5 cm, ±3.55 mm
10 µs, ±7% ±1 ns	5 cm, ±3.5 mm

28 g. Check for--Sampling oscilloscope displays of pulse risetime and falltime of 600 ns, ±8% ±1 ns (6 cm, ±4.9 mm).

28 k. Check for--Sampling oscilloscope displays of pulse risetime and falltime of 1.1 µs, ±8% ±1 ns (5.5 cm, ±4.4 mm).

CALIBRATION

Substitute the following steps and tables for those given in the calibration procedure. Paragraphs that are not mentioned here should be left unchanged.

Page 7-1, column 2,

5. Variable autotransformer (e. g., General Radio, Variac Type W10MT3W). Minimum requirements: Output voltage variable from 103.5 volts to 137.5 volts ac rms for 115-volt operation or 207 volts to 275 volts ac rms for 230-volt operation; output power rating at least 0.1 kVA. If monitor voltmeter is not included, separate ac voltmeter is required with accuracy within 3% over the required range.

Page 7-3,

(On Fig. 7-2, add the following note:)

CAUTION

Whenever working with the supply voltages at the REMOTE PROGRAM connector, be careful not to short the supplies together or to signal or chassis ground. These lines are not fused and, if shorted, can damage the power supply circuit.

Page 7-4,

15. Adjust Offset Zero Levels (Page 7-19)
Zero offset ±100 mV at 0 position of DC OFFSET control in + and - polarity.

16. Check Offset Accuracy (Page 7-20)
Correct dc offset ±5% ±100 mV over range of DC OFFSET control in + and - polarity.

17. Check Remote Offset (Page 7-20)
Correct dc offset using program resistors, within 2% of front-panel calibration (+1% for program resistor tolerance).

19. Adjust Slow Risetime and Falltime(Page 7-22)
Correct risetime and falltime ±5% ±1 ns at 110 μs and 10 μs.

20. Check Slow Risetime and Falltime Accuracy (Page 7-24)
Correct risetime and falltime ±5% ±1 ns over range from 1 μs to 110 μs.

23. Adjust Fast Risetime and Falltime (Page 7-26)
Correct risetime and falltime ±5% ±1 ns at 1 nS range, X10 multiplier.

24. Check Fast Risetime and Falltime Accuracy (Page 7-27)
Correct risetime and falltime ±5% ±1 ns over range from 10 ns to 1.1 μs.

Page 7-8,

Fig. 7-5. (Delete the asterisks from this illustration and add the following:)

NOTE

All voltages except the +12-volt supply are measured with respect to signal ground. The +12-volt supply is measured with respect to chassis ground.

Page 7-9,

3 f. With the probe connected to each test point, observe the test oscilloscope display while varying the autotransformer output voltage from 137.5 volts to 103.5 volts (or from 275 volts to 207 volts for 230-volt operation).

Page 7-19,

15 d. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±1 cm (zero volts ±100 mV) with the DC OFFSET control set exactly at 0.

15 g. Check for--Test oscilloscope display with the baseline of the negative-going pulse at the horizontal centerline ±1 cm (zero volts ±100 mV).

Page 7-20,

(Add) 15 j. Set the test oscilloscope Millivolts/Cm switch to 20.

16 c. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±1.75 cm (5% +100 mV), as indicated in the Offset (Internal) column of Table 7-5. The checks on the 1V amplitude range cover the .5V and .2V ranges as well, since the attenuator was checked previously.

TABLE 7-5

Offset Accuracy Check

(Same as Table 6-3 on page 3 of this insert)

17 e. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±0.5 cm (zero offset ±103 mV).

17 k. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±2.5 cm (8% +100 mV), as given in the Offset (Remote) column of Table 7-5.

17 m. Repeat steps i through k for the +5 settings of the DC OFFSET control given in Table 7-5. The tolerances here are different from those in - polarity since the analog resistor is not in the circuit at maximum + offset.

18 b. Reset the following test oscilloscope controls:

Input Attenuation	100
Deflection Factor	10 mV/cm
Input coupling	Gnd
Comparison Voltage Range	0

Page 7-24,

Fig. 7-22. (Delete the reference to C74 in the illustration. C74 has been removed.)

21 a. Disconnect the Type R116 output pulse from the test oscilloscope vertical input.

Page 7-27,

23 n. Check for--Sampling oscilloscope display of the pulse rise with a risetime of 100 ns ±5% ±1 ns (5 cm ±3 mm).

23 q. Check for--Sampling oscilloscope display of the pulse fall with a falltime of 100 ns ±5% ±1 ns (5cm ±3 mm).

Fig. 7-26. Location of C72 on the Pulse Shape Generator (Series F) card for setting 1 nS risetime-falltime range. (Delete the reference to C74 in the illustration and change the C72 reference to read (1 nS range).)

23 dd through 23 hh. Delete these steps.

Page 7-28,

TABLE 7-7
Risetime and Falltime Accuracy Check
(Change last 2 columns only)

Risetime or Falltime	
Time	Display
1.1 µs ±5% ±1 ns	5.5 cm ±2.76 mm
110 ns ±5% ±1 ns	5.5 cm ±3.25 mm
100 ns ±5% ±1 ns	5 cm ±3.0 mm
10 ns ±5% ±1 ns	5 cm ±7.5 mm

24 c. If the risetime and/or falltime are out of tolerance in any of the preceding checks, readjust C72 (see step 23) as required to bring the timing within tolerance over the 10 ns to 1.1 µs range.

25 e. Check for--Sampling oscilloscope display with a risetime of 10 ns ±7% ±1 ns (5 cm ±8.5 mm).

25 g. Check for--Sampling oscilloscope display with a falltime of 10 ns ±7% ±1 ns (5 cm ±8.5 mm).

TABLE 7-8
Remote Risetime-Falltime Range Check
(Change last 2 columns only)

Risetime and Falltime	
Time	**Display**
100 ns ±7% ±1 ns 100 ns ±7% ±1 ns	5 cm ±4.0 mm 5 cm ±4.0 mm
1 µs ±7% ±1 ns 1 µs ±7% ±1 ns	5 cm ±3.55 mm 5 cm ±3.55 mm
10 µs ±7% ±1 ns 10 µs ±7% ±1 ns	5 cm ±3.5 mm 5 cm ±3.5 mm

Page 7-29,

25 s. Check for--Test oscilloscope displays of the pulse indicating a risetime and falltime of 600 ns ±8% ±1 ns (6 cm ±4.9 mm).

25 x. Check for-Test oscilloscope display indicating a pulse risetime and falltime of 1.1 µs ±8% ±1 ns (5.5 cm ±4.5 mm).

Page 7-34,

29 i. Check for--Test oscilloscope display of the double pulse with a delay period of 500 µs, within 3% (+10 ns) of the reference waveform (±1.5 mm over 5 cm).

PARTS LIST CORRECTIONS

INSTRUMENT CHASSIS

CHANGE TO:

R488	315-0182-00	1.8 kΩ	1/4 W	5%	
R530	Selected	< 1 kΩ	1/8 W	1%	Prec

ADD:

L485	108-0237-00	80 μH	Inductor	
R486	301-0153-00	15 kΩ	1/2 W	5%

DELAY GENERATOR CARD -- Series C

CHANGE TO:

R14	301-0391-00	390 Ω	1/2 W	5%

FUNCTION PROGRAM No. 1 CARD -- Series D

ADD:

C14	283-0000-00	0.001 μF	Cer	500 V

WIDTH GENERATOR CARD -- Series E

CHANGE TO:

R12	301-0391-00	390 Ω	1/2 W	5%

PULSE SHAPE GENERATOR CARD -- Series F

REMOVE:

C74	281-0097-00	9-35 pF	Cer	Var

OUTPUT AMPLIFIER CARD -- Series G

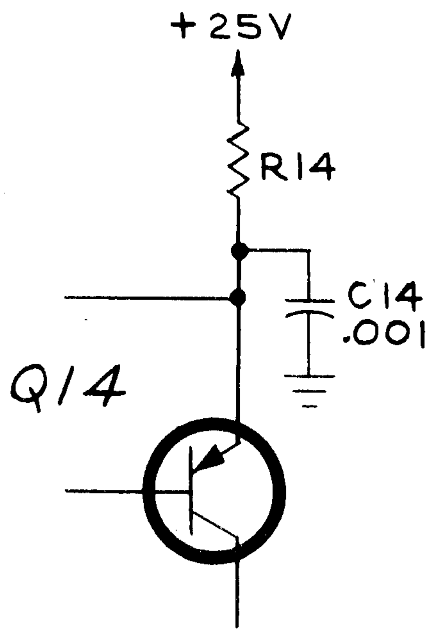
CHANGE TO:

C40	Selected	< 30 pF	Cer	500 V	1%
C44	283-0026-00	0.2 μF	Cer	25 V	
R44	315-0103-00	10 kΩ	1/4 W	5%	

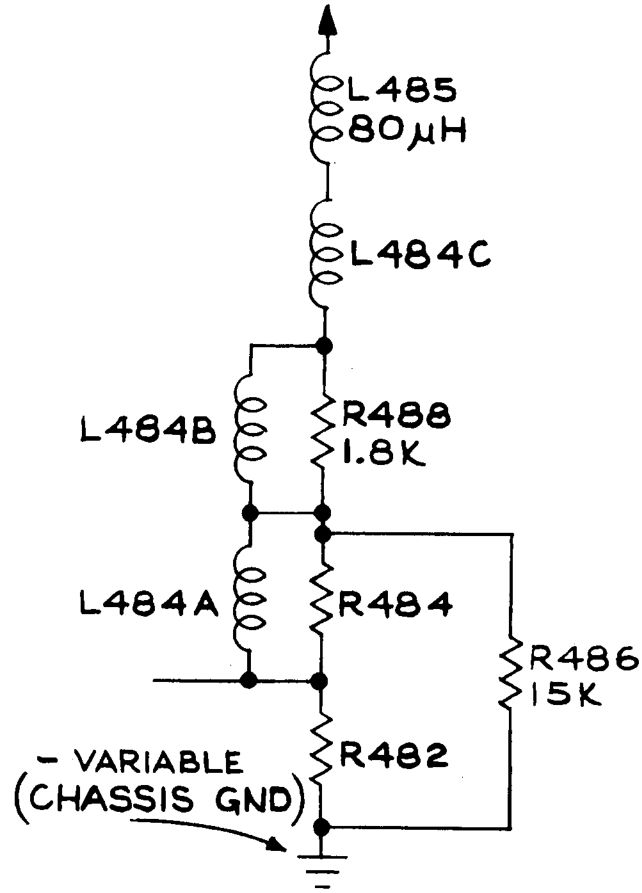
ADD:

R43	315-0103-00	10 kΩ	1/4 W	5%

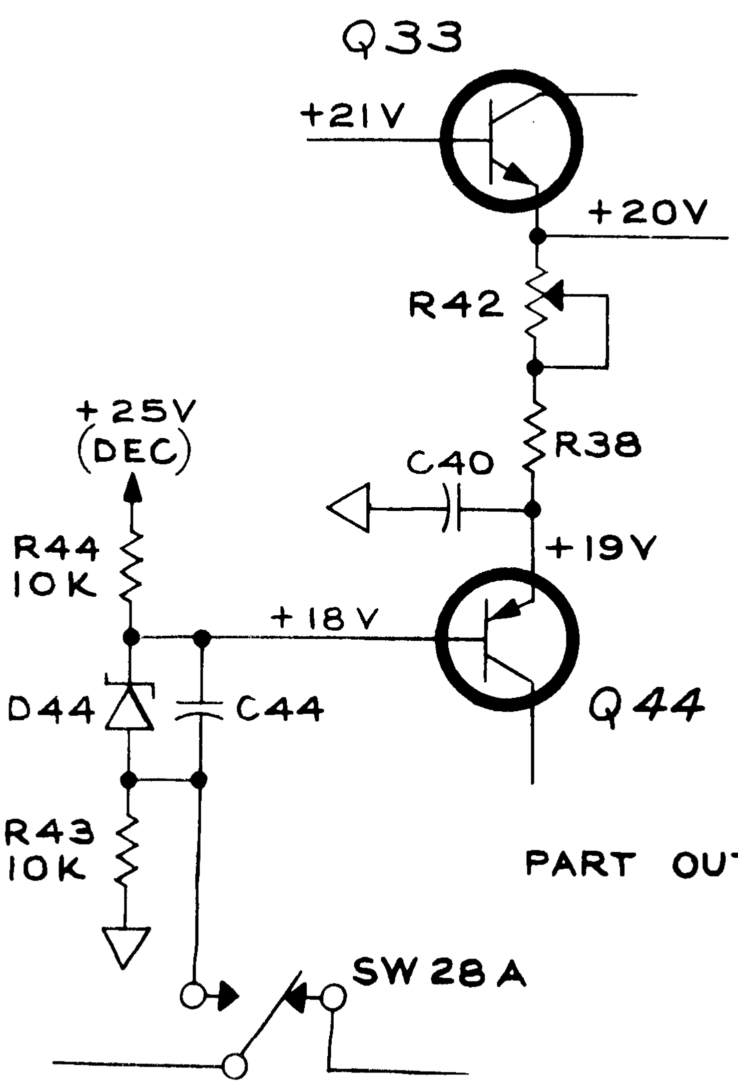
SCHEMATIC CORRECTION



PART FUNCTION PPOGRAM #1 ④



PART ATTEN. & OFFSET CURRENT GEN. ⑧



PART OUTPUT AMP. ⑦

C1/266

TEXT CORRECTIONS

CHARACTERISTICS

Page 1-1, column 1,

Under Modes of Operation, Double, change the Supplemental Information to read:

First pulse of pair starts at same time as pulse in Single mode: second pulse starts at end of delay interval; 100 ns minimum separation required between end of first pulse and start of second pulse (at baseline); characteristics of each pulse same as for Single mode.

Page 1-1, column 2,

Under Input Signal Requirements, +Gate In Amplitude, change the Supplemental Information to read:

Accidental overload +100 volts maximum.

Page 1-2, column 2,

Under Output Signal Characteristics, Risetime and falltime, change the Performance Requirement to read:

10 ns to 100 μs: Accuracy with respect to risetime or falltime switch and dial readings: Within 5% on 1 μS and 100 ns ranges; within 10% on 10 nS and 1 nS ranges.

Dial indications less than 10 ns on the 1 nS range are uncalibrated.

Page 1-3, column 1,

Under Output Signal Characteristics, Dc Offset, change the Performance Requirement to read:

-5 volts to +5 volts: Accuracy within 5% ±100 mV of switch and dial readings over range of DC OFFSET control.

Page 1-4, column 2,

Under Programming, Dc Offset Analog, delete the following phrase from the Performance Requirement:

Accuracy within (100 mV of front-panel calibration plus error in program resistor). (NOTE: The accuracy requirement is covered by the Variable Operations Performance Requirement in column 1.)

TEXT CORRECTIONS (cont)

CIRCUIT DESCRIPTION

Page 4-12, Column 1,

Under paragraph 3, add the following:

Transistors Q434 and Q484 provide current regulation for constant-current transistors Q464 and Q474. Transistor Q484 controls the base voltage of Q464 and Q474 by comparing the voltage at the junction of R466 and R476 to the reference voltage set by zener diode D460. If conduction through Q464 and Q474 tends to change as a result of a change in temperature or load, the change is felt at the base of Q484. Transistor Q484 amplifies and inverts this change, which is then applied through Q434 to the base circuit of Q464 and Q474, thus controlling their conduction and regulating the output current. For example, if conduction increases through Q464 and Q474, a positive-going voltage change is seen at the junction of R466 and R476. This positive change is inverted and amplified by Q484 and applied through Q434 as a negative-going signal to the bases of Q464 and Q474, decreasing their conduction and returning the current to normal.

Page 4-13,

In Fig. 4-7, delete the reference to D425 which has been removed.

Page 4-14, column 1,

Change +12-Volt Supply to Relay-Power Supply, delete paragraph 1 and replace with:

The current for the relay-power supply is provided by a diode bridge rectifier D410A, B, C and D and filter capacitor C410, with the negative lead connected to chassis ground. The reference voltage of Q423 is set by the Zener diode, D413 (also connected to chassis ground) and transistor Q413. Any change in the supply load will change the bias of Q423 and cause more or less collector current to flow. The supply voltage is thus held to approximately +9.5 volts.

Page 4-14, column 2,

Under -Variable Supply, delete the last sentence of paragraph 2, and replace with:

Voltage at the emitter of Q427 is held at about +0.6 volt by the drop across D426.

TEXT CORRECTIONS (cont)

CIRCUIT DESCRIPTION (cont)

Page 4-14, column 2,

Also under -Variable Supply, delete the first sentence of paragraph 3 and replace with:

Comparator Q96 and Q106 compares the output of the -Variable supply to the input control voltage from the offset current circuit.

Delete paragraph 4 and replace with:

The input control voltage variations are coupled by the comparator circuit and emitter follower Q103 to the bases of complementary emitter followers Q437 and Q113. Diode D108 provides about 0.6 volt more base to collector voltage in Q106, and diode D103 produces a voltage difference between the bases of the complementary emitter followers. Transistor Q113 usually does not conduct or conducts only slightly. However, in -polarity, when the -Variable supply output is very close to signal ground, Q113 provides the required output current to the load.

MAINTENANCE

Page 5-12, Fig. 5-10, Delay Generator Card.

(Series C, Model 2: Ferrite bead L68 has been moved to the anode lead of D68. This is located at the lower end of D68 in the component-location photo.)

Page 5-13, Fig. 5-11, Function Program #1 Card

(The Series letter of Function Program #1 card has changed from D to J. Series J, Model 1: Capacitor C14 has been added between the anode end of D14 and chassis ground and C5 between the emitter of Q4 and chassis ground. D1 has been added from the base of Q4 to chassis ground. C15 and C29 have been moved slightly on the Function Program #1 card to accommodate these additions.)

CAUTION

Install only plug-in circuit cards with the correct Series letter. The Series letter (e.g.,J) is printed on the top front corner of the card and on the instrument chassis adjacent to the card holder. All other Series should be considered incompatible. Installation in any other position may damage the instrument or cause it to malfunction. Each Series may have various Model numbers, which indicate that minor changes have been made in the circuitry. All cards with the same Series letter, regardless of Model number, are electrically interchangeable in the Type R116.

TEXT CORRECTIONS (cont)

MAINTENANCE (cont)

Page 5-15, Fig. 5-13, Pulse Shape Generator Card

(Series F, Model 2 Ferrite beads, L14, L24, L58 and L68 have been added around the collector leads of Q14, Q24, Q58 and Q68, respectively, on the transistor sockets. Capacitor C74 has been removed from the Pulse Shape Generator Card.)

Page 5-18, Fig. 5-16, Power Supply Card

(Series I, Model 2: Resistor R92 has been added between Capacitor C92 and the base of Q96 on the Power Supply card. R102 has been added between the base of Q106 and the emitter of Q113. R105 is between the collector of Q106 and base of Q103. Diodes D108 and D103 have been added in series between the emitter of Q103 and the negative end of R103. R108 is between the anode of D108 and pin H and R104 is between the anode of D103 and the base of Q113. R103, R16 and R12 have been moved to make room for these changes.)

PERFORMANCE CHECK

Substitute the following steps and tables for those given in the performance check procedure. Paragraphs that are not mentioned here should be left unchanged.

Page 6-5:

8 c. Set the following Type R116 controls:

Period Range	10 μs
Multiplier	1
Delay or Brust Time	
Range	100 ns
Multiplier	5
Width Range	100 ns
Multiplier	5
Trigger Source	Internal

8 h. Check for--Test oscilloscope display of the delayed output pulse displaced by approximately the delay time (0.75 cm or 1.5 μs) from the 1-cm graticule line (see Fig. 6-5b).

TEXT CORRECTIONS (cont)

PERFORMANCE CHECK (cont)

Page 6-6:

9 c. Reset the following Type R116 controls:

MODE	Remote Program
DELAY OR BURST	
TIME RANGE	100 ns
MULTIPLIER	15
WIDTH RANGE	100 ns

Page 6-7:

11 a. Requirement--Correct dc offset ±5% ±100 mV into a 50 Ω load over the range of the DC OFFSET control, in + and - polarity.

11 g. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±2 cm (100 mV).

11 i. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±2 cm (100 mV).

11 j. Reset the following test oscilloscope controls:

Input Attenuation	10
Millivolts/Cm	20

11 m. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±1.75 cm (5% +100 mV), as indicated in the Offset (Internal) column of Table 6-3. The checks on the 1V amplitude range cover the .5 V and .2 V ranges as well, since the attenuator was checked previously.

TABLE 6-3

Offset Accuracy Check

DC OFF-SET	POLAR-ITY	Oscilloscope		Offset		
		Comp Voltage Mult.	Vc Range	Voltage	Baseline Displacement from Centerline Internal	Baseline Displacement from Centerline External
-5	+	5.000	-1.1	-5 V	±1.75 cm (5% +100 mV)	±2.5 cm (8% +100 mV)
-5	-	5.000	-1.1	-5 V	±1.75 cm	±2.5 cm
+5	-	5.000	+1.1	+5 V	±1.75 cm	±2.25 cm (7% +100 mV)
+5	+	5.000	+1.1	+5 V	±1.75 cm	±2.25 cm

PERFORMANCE CHECK (cont)

Page 6-7: (cont)

12 a. Requirement--Correct dc offset using program resistors, within 2% of front-panel operation (+1% program resistor tolerance).

12. h. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±0.5 cm (103 mV).

Page 6-8:

12 j. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline, ±0.5 cm (103 mV).

12 n. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±2.5 cm (8% +100 mV), as given in the Offset (Remote) column of Table 6-3.

12 p. Repeat steps l through n for the +5 settings of the DC OFFSET control given in Table 6-3. (The tolerances here are different from those in - polarity since the analog resistor is not in the circuit at maximum + offset.)

13 b. Reset the following test oscilloscope controls:

Vc Range	0
Input Attenuation	100
Millivolts/Cm	10
Input Coupling	Gnd

Page 6-12:

TABLE 6-8

Width Timing Accuracy Check

(Change Time Markers and Pulse Width Only)

Time Markers	Pulse Width	
	Time	Difference from Reference
5 μs	50 μs, ±3%	±1.5 mm over 5 cm
0.5 μs	5 μs, ±3%	±1.5 mm over 5 cm
50 ns	500 ns, ±3%	±1.5 mm over 5 cm
0.5 μs	5.5 μs, ±3%	±1.65 mm over 5.5 cm
5 μs	55 μs, ±3%	±1.65 mm over 5.5 cm
50 μs	550 μs, ±3%	±1.65 mm over 5.5 cm

TEXT CORRECTIONS (cont)

PERFORMANCE CHECK (cont)

Page 6-14:

24 h. Set the sampling oscilloscope controls as follows:

Horizontal Display	X1
Amplitude Calibrator	Off
Equivalent Sweep Rate	0.1 µs/cm, magnified from 0.2 µs/cm
Triggering	+ External, 50 Ω AC
Sample Density	50/cm
Sweep Mode	Normal
Vert. Deflection Factor	200mV/cm
Vertical Mode	B Only
Smoothing(both channels)	Counterclockwise
Noise-Risetime	Low Noise
Display	Normal

Page 6-15:

25 c. Set the sampling oscilloscope equivalent sweep rate to 5 ns/cm (still magnified from 20 ns/cm).

26 a. Requirement--Correct risetime and falltime over the range of the risetime and falltime controls, using 10 volt output amplitude. Within ±10% on 1 nS and 10 nS ranges, within ±5% on 100 ns and 1 µS ranges.

27 g. Check for--Sampling oscilloscope display with a risetime of 10 ns, ±12% (5 cm, ±6.0 mm).

27 i. Check for--Sampling oscilloscope display with a falltime of 10 ns, ±12% (5 cm, ±6.0 mm).

Page 6-17,

TABLE 6-10

Risetime and Falltime Accuracy Check
(Change Risetime Falltime Range and Risetime or Falltime)

Risetime Falltime Range	Risetime or Falltime	
	Time	Display
1 ns	10 ns, ±10%	5 cm, ±5.0 mm
10 ns	100 ns, ±10%	5 cm, ±5.0 mm
100 ns	1 µs, ±5%	5 cm, ±2.5 mm
1 µs	10 µs, ±5%	5 cm, ±2.5 mm
1 µs	110 µs, ±5%	5.5 cm, ±2.75 mm
100 ns	11 µs, ±5%	5.5 cm, ±2.75 mm
10 ns	1.1 µs, ±10%	5.5 cm, ±5.5 mm
1 ns	110 ns, ±10%	5.5 cm, ±5.5 mm

TEXT CORRECTIONS (cont)

PERFORMANCE CHECK (cont)

Page 6-17 (cont):

TABLE 6-11

Remote Risetime-Falltime Range Check
(Change last 2 columns only)

Risetime and Falltime	
Time	Display
100 ns, ±12%	5 cm, ±6.0 mm
1 µs, ±7%	5 cm, ±3.5 mm
10 µs, ±7%	5 cm, ±3.5 mm

28 c. Connect the shorting straps between the following points: Terminals 36 and 28, terminal 2 and the 1.74-kΩ resistor connected to terminal 31; terminal 3 and the 1.72-kΩ resistor connected to terminal 32.

Page 6-18:

29 e. Reset the following Type R116 controls:

Mode	Single
Period	10 µs
Multiplier	1
Delay or Burst Time	
Range	10 ns
Multiplier	10
Width Range	10 ns
Multiplier	5

29 i. Set the sampling oscilloscope equivalent sweep rate to 50 ns/cm.

CALIBRATION

Substitute the following steps and tables for those given in the calibration procedure. Paragraphs that are not mentioned here should be left unchanged.

TEXT CORRECTIONS (cont)

CALIBRATION (cont)

Page 7-3,

(On Fig. 7-2, add the following note:)

CAUTION

Whenever working with the supply voltages at the REMOTE PROGRAM connector, be careful not to short the supplies together or to signal or chassis ground. These lines are not fused and, if shorted can damage the power supply circuit.

(In Table 7-1, the resistance of R9 should be 1.74 kΩ)

2. Check Power Supply Voltages (Page 7-8).

-27 volts ±0.6 volt with respect to signal ground.

-6.0 volts ±0.5 volt with respect to signal ground.

+7 volts ±1 volt with respect to signal ground.

-Variable range from approxiamtely -10 to -20 volts, with respect to signal ground, varied by DC OFFSET control.

+9.5 volts ±0.7 volts with respect to chassis ground.

15. Adjust Offset Zero Levels (Page 7-19)

Zero offset ±100 mV at 0 position of DC OFFSET control in + and - polarity.

16. Check Offset Accuracy (Page 7-20)

Correct DC offset ±5% ±100 mV over range of DC OFFSET control in + and - polarity.

17. Check Remote Offset (Page 7-20)

Correct DC offset using program resistors, within 2% of front-panel calibration (+1% for program resistor tolerance).

19. Adjust Slow Risetime and Falltime (page 7-22)

Correct risetime and falltime ±5% at 110 μs and 10 μs.

20. Check Slow Risetime and Falltime Accuracy (page 7-24)

Correct risetime and falltime ±5% over range from 1 μs to 110 μs.

23. Adjust Fast Risetime and Falltime (Page 7-26)

Correct risetime and falltime ±10% at 1 ns range X10 multiplier.

24. Check Fast Risetime and Falltime Accuracy (Page 7-27)

Correct risetime and falltime ±10% over range from 10 ns to 1.1 μs.

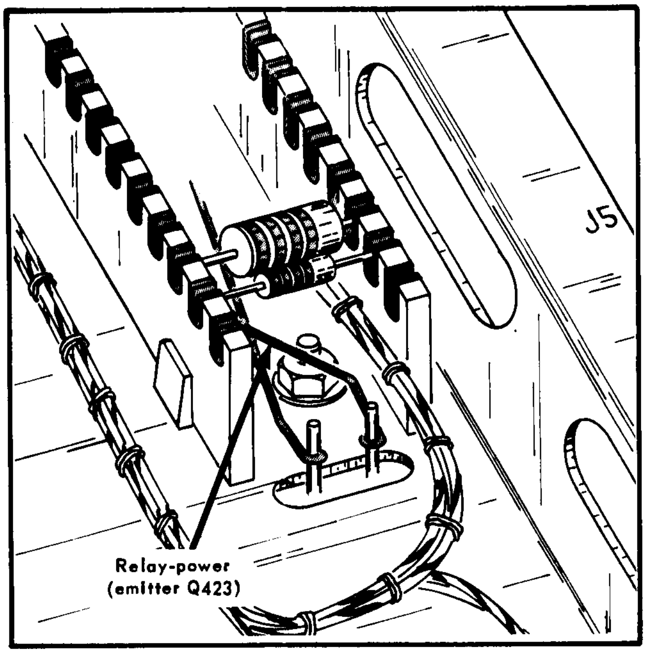
TEXT CORRECTIONS (cont)

CALIBRATION (cont)

Page 7-8

Fig. 7-5. (Delete the asterisks and "+12 Volts" from this illustration and add the following:)

Relay-power supply (located between signal ground and -27 volts as shown in the following drawing:)



(Also add the following to Fig. 7-5:)

NOTE

All voltages except the relay-power supply are measured with respect to signal ground. The relay-power supply is measured with respect to chassis ground.

2 k. Leave the negative lead of the meter connected to the chassis ground test point and move the positive lead of the meter to the relay-power test point.

2 l. Check for--Meter reading of +9.5 volts ±0.7 volts, with respect to chassis ground.[2]

---

[2] This voltage may be measured with a 1% tolerance dc voltmeter.

Page 7-17,

11 i. Adjust R34 (-DC LEVEL) on the Series G card if the signal level is not correct.

TEXT CORRECTIONS(cont)

CALIBRATION (cont)

Page 7-19,

15 d. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±1 cm (zero volts ±100 mV) with the DC OFFSET control set exactly at 0.

15 g. Check for--Test oscilloscope display with the baseline of the negative-going pulse at the horizontal centerline ±1 cm (zero volts ±100 mV).

Page 7-20,

(Add) 15 j. Set the test oscilloscope Millivolts/Cm switch to 20.

16 c. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±1.75 cm (5% +100 mV), as indicated in the Offset (Internal) column of Table 7-5. The checks on the 1 V amplitude range cover the .5 V and .2 V ranges as well, since the attenuator was checked previously.

TABLE 7-5

Offset Accuracy Check

(Same as Table 6-3 on page 5 of this insert).

17 e. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±0.5 cm (zero offset ±103 mV).

17 k. Check for--Test oscilloscope display with the pulse baseline at the horizontal centerline ±2.5 cm (8% +100 mV), as given in the Offset (Remote) column of Table 7-5.

17 m. Repeat steps i through k for the +5 settings of the DC OFFSET control given in Table 7-5. The tolerances here are different from those in - polarity since the analog resistor is not in the circuit at maximum + offset.

18 b. Reset the following test oscilloscope controls:

Input Attenuation	100
Millivolts/Cm	10
Input coupling	Gnd
Comparison Voltage Range	0

Page 7-21,

18 h. Adjust--R54 (PROGRAM CLAMP) on the Series H card (see Fig. 7-18) for a compromise setting between the two polarities if the program clamp level is not correct in + and/or - polarity.

TEXT CORRECTIONS (cont)

CALIBRATION (cont)

Page 7-24,

21 a. Disconnect the Type R116 output pulse from the test oscilloscope vertical input.

Page 7-27,

23 s through 23 hh. Delete these steps.

Fig. 7-26. Location of C72 on the Pulse Shape Generator (Series F) card for setting 1 nS **risetime-falltime** range. (Delete the reference to C74 in the illustration and change the C72 reference to read "1 nS range".)

Page 7-28,

TABLE 7-7

Risetime and Falltime Accuracy Check

(Change last 2 columns only)

Risetime or Falltime	
Time	Display
1.1 µs ±10%	5.5 cm ±5.5 mm
110 ns ±10%	5.5 cm ±5.5 mm
100 ns ±10%	5 cm ±5.0 mm
10 ns ±10%	5 cm ±5.0 mm

24 e. If the risetime and/or falltime are out of tolerance in any of the preceding checks, readjust C72 (see step 23) as required to bring the timing within tolerance over the 10 ns to 1.1 µs range.

TEXT CORRECTIONS (cont)

CALIBRATION (cont)

Page 7-27,

TABLE 7-8

Remote Risetime-Falltime Range Check

(Change last 2 columns only)

Risetime and Falltime	
Time	Display
100 ns ±12%	5 cm ±6.0 mm
100 ns ±12%	5 cm ±6.0 mm
1 μs ±7%	5 cm ±3.5 mm
1 μs ±7%	5 cm ±3.5 mm
10 μs ±7%	5 cm ±3.5 mm
10 μs ±7%	5 cm ±3.5 mm

Page 7-29,

25 o. Reconnect the shorting straps between the following points: Terminals 36 and 28; terminal 2 and the 1.74-kΩ resistor connected to terminal 31; terminal 3 and the 1.74-kΩ resistor connected to terminal 32.

25 t. Move the shorting straps connected to the 1.74-kΩ resistors on terminals 31 and 32 to the 3.40-kΩ resistors connected to the same terminals.

Page 7-34,

29 i. Check for--Test oscilloscope display of the double pulse with a delay period of 500 μs, within 3% (+10 ns) of the reference waveform (±1.5 mm over 5 cm).

29 p. Adjust--C32 on the Series C card (see Fig. 7-32) if the delay time interval is not correct.

PARTS LIST CORRECTIONS

INSTRUMENT CHASSIS

REMOVE:

R462	315-0101-00	100 Ω		1/4 W	5%

ADD:

C413	283-0059-00	1.0 µF	Cer	25 V	
C484	283-0000-00	0.001 µF	Cer	500 V	
D413	152-0055-00	1N962B	Zener	11 V	5%
L485	108-0417-00	110 µH			20%
Q413	151-0195-00	6515			
Q423	151-0149-00	2N3441	Silicon		
Q434	151-0190-00	2N3904	Silicon		
Q484	151-0190-00	2N3904	Silicon		
R413	302-0152-00	1.5 kΩ		1/2 W	10%
R485	315-0682-00	6.8 kΩ		1/4 W	5%
R486	301-0153-00	15 kΩ		1/2 W	5%
[1] R536	315-0122-00	1.2 kΩ		1/4 W	5%

CHANGE TO:

C405	290-0310-00	2,000 µF		75 V	
C410	290-0086-00	2,000 µF	EMC	35 V	
C420	290-0310-00	2,000 µF		75 V	
D460	152-0166-00	1N753A	Zener	6.2 V	5%
R460	302-0103-00	10 kΩ	Var	1/2 W	10%
R488	315-0182-00	1.8 kΩ		1/4 W	5%
R504	311-0537-01	20 kΩ	Var	WW	1%
R514	311-0536-01	10 kΩ	Var	WW	1%
R524	311-0536-01	10 kΩ	Var	WW	1%
R530	321-0193-00	1 kΩ(Nominal)		1/8 W	1%
R534	311-0536-01	10 kΩ	Var	WW	1%
R542	311-0536-01	10 kΩ	Var	WW	1%
R552	311-0543-01	4 kΩ	Var	WW	1%
R562	311-0543-01	4 kΩ	Var	WW	1%
T401	120-0457-00	Transformer, Power			

[1] Added between SW10 (TRIG) and pin F of J4.

PARTS LIST CORRECTION

DELAY GENERATOR CARD-SERIES C, MODEL 2

CHANGE TO:

D26	152-0304-00	1N968B	Zener	20 V	5%
[2]L68 (1)	276-0541-00	Core, Ferrite			
R14	301-0391-00	390 Ω		1/2 W	5%

FUNCTION PROGRAM# 1 CARD

SERIES--- Changed from Series D to Series J, Model 1.

Complete Card--- Changed to 670-0216-01

ADD:

C5	283-0128-00	100 pF	Cer	500 V	5%
C14	283-0128-00	100 pF	Cer	500 V	5%
D1	152-0185-00	6185			

CHANGE TO:

C1	283-0115-00	47 pF	Cer	200 V	5%
R15	315-0301-00	300 Ω		1/4 W	5%

WIDTH GENERATOR CARD - Series E, Model 2

CHANGE TO:

D26	152-0304-00	1N968B	Zener	20 V	5%
R12	301-0391-00	390 Ω		1/2 W	5%

PULSE SHAPE GENERATOR CARD-SERIES F, Model 2

ADD:

[3]L14	276-0528-00	Core, Ferrite
[3]L24	276-0528-00	Core, Ferrite
[3]L58	276-0528-00	Core, Ferrite
[3]L68	275-0528-00	Core, Ferrite

CHANGE TO:

C120	290-0121-00	2 μF	EMT	25 V

REMOVE:

C74	281-0097-00	9-35 pF	Cer	Var

[2] Located on the anode lead of D68.

[3] Added to the collector leads of Q14, Q24, Q58 and Q68 respectively.

PARTS LIST CORRECTION

OUTPUT AMPLIFIER CARD - Series G, Model 2

*670-0219-00 Complete Card

ADD:

R43	315-0103-00	10 kΩ	1/4 W	5%

CHANGE TO:

C40	281-0564-00	24 pF(Nominal) Cer		
C44	283-0026-00	0.2 µF Cer	25 V	
R44	315-0103-00	10 kΩ	1/4 W	5%

ATTENUATOR CARD - Series H, Model 2

REMOVE:

B1	151-0046-00	Bulb, Incandescent
B4	151-0046-00	Bulb, Incandescent

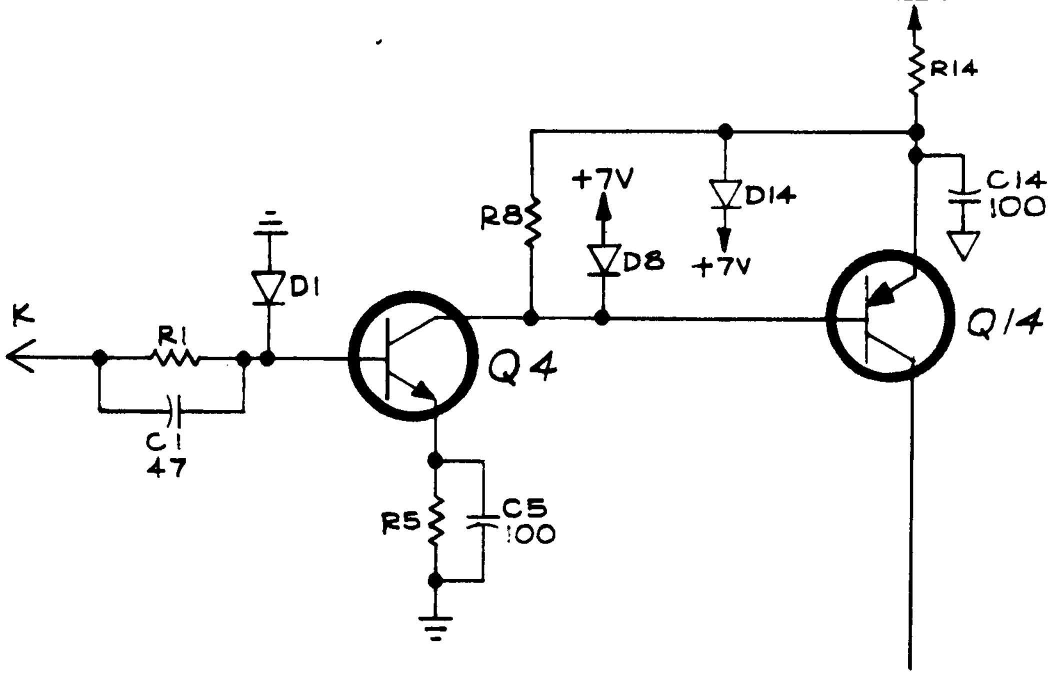
CHANGE TO:

R1	303-0680-00	68 Ω	1 W	5%
R4	303-0680-00	68 Ω	1 W	5%

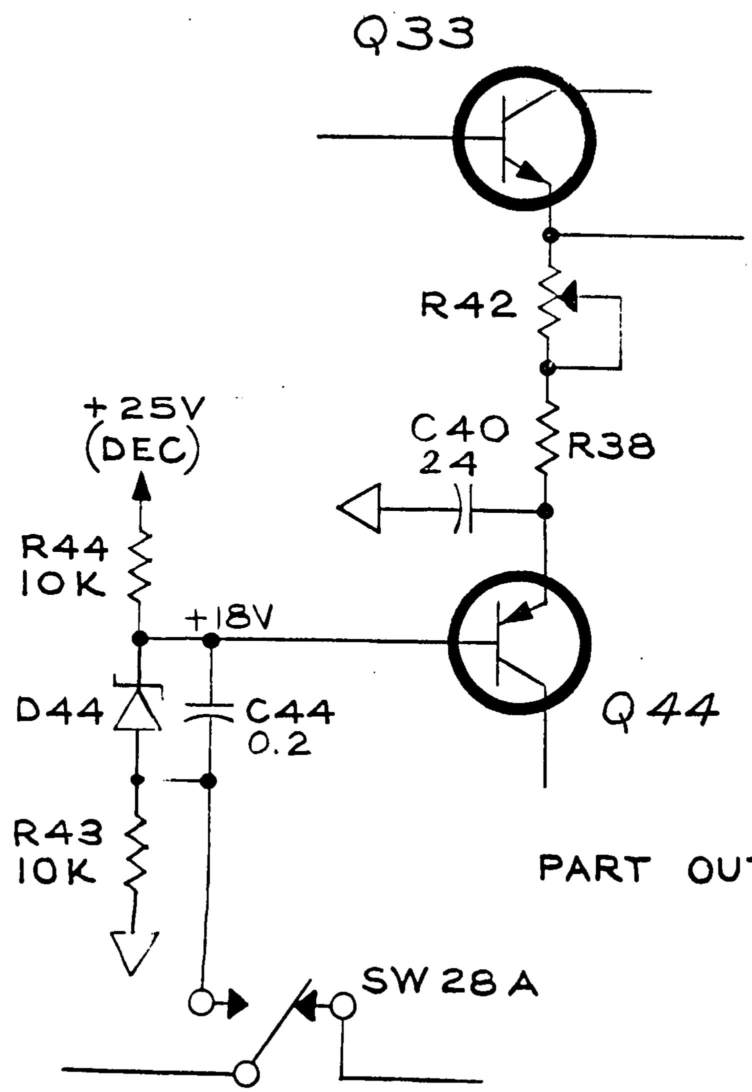
POWER SUPPLY CARD-Series I, Model 2

ADD:

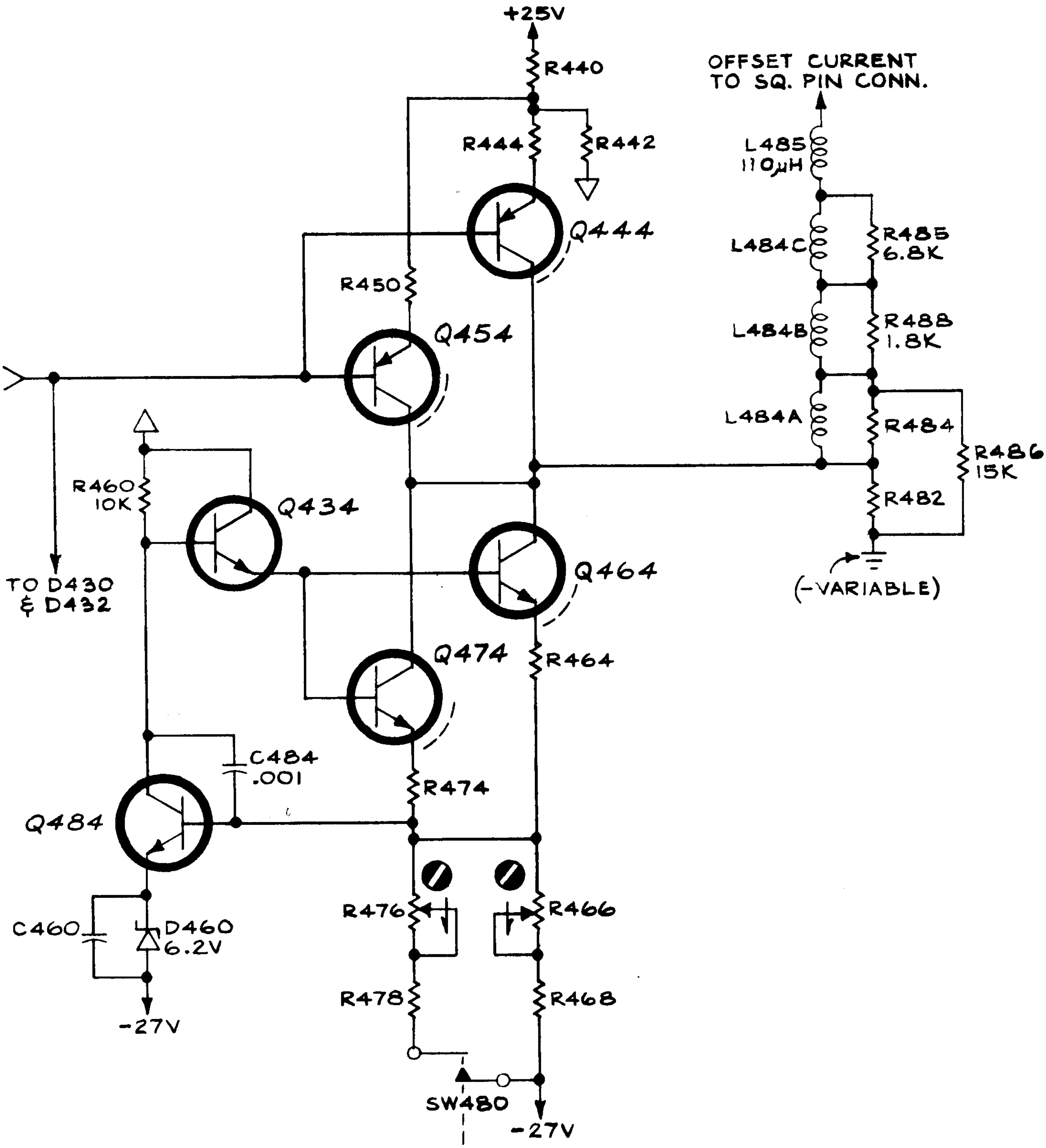
D103	152-0185-00	6185		
D108	152-0185-00	6185		
R92	315-0511-00	510 Ω	1/4 W	5%
R102	315-0511-00	510 Ω	1/4 W	5%
R104	315-0510-00	51 Ω	1/4 W	5%
R105	315-0511-00	510 Ω	1/4 W	5%
R108	315-0510-00	51 Ω	1/4 W	5%



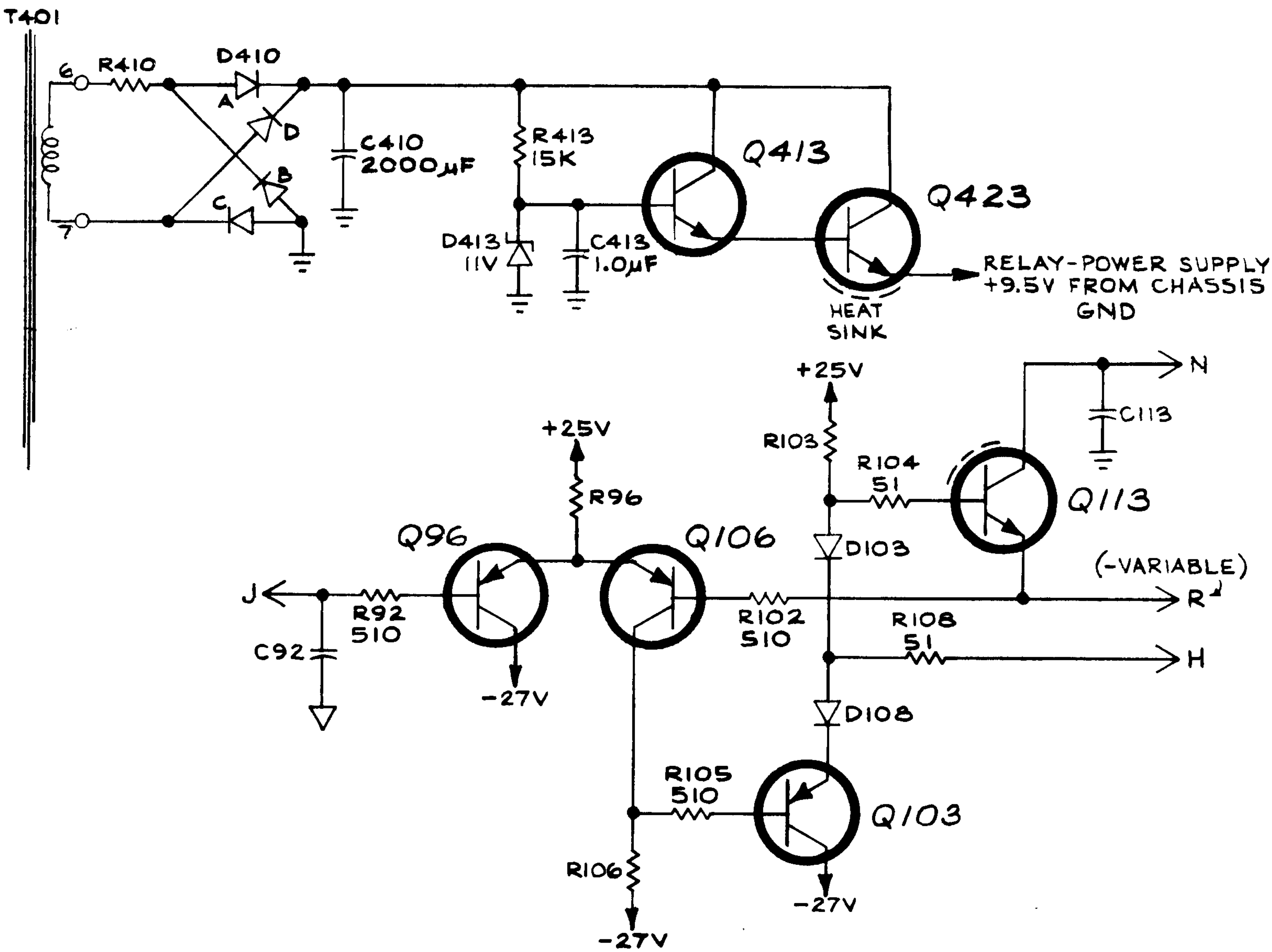
PARTIAL FUNCTION PROGRAM #1 ④



PART OUTPUT AMP. ⑦



PARTIAL OFFSET CURRENT GENERATOR ⟨8⟩



PARTIAL POWER SUPPLY ⑨