TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL,

DIRECT SUPPORT, AND GENERAL SUPPORT

MAINTENANCE MANUAL

FOR

GENERATORS, PULSE, AN/ PPM-1

(NSN 6625-00-503-0661)

AND AN/PPM-1A

(NSN 6625-00-503-3621)

This copy is a reprint which includes current pages from Change 1.

HEADQUARTERS DEPARTMENT OF THE ARMY
OCTOBER 1976

WARNING

Hazardous voltages are used in the operation of this equipment. Be extremely careful not to contact high-voltage, 115-volt, or 230-volt input connections when working on equipment. When working inside the equipment, always disconnect primary power and ground the high-voltage capacitors. Failure to comply may result in death or serious injury to personnel.

DON'T TAKE CHANCES!

CHANGE No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, 20 October 1982

Operator's, Organizational, Direct Support, And General Support Maintenance Manual
GENERATORS, PULSE,
AN/PPM-1 (NSN 6625-00-503-0661)
AND
AN/PPM-1A (NSN 6625-00-503-3621)

TM 11-6625-237-14, 1 October 1976, is changed as follows:

1. New or changed material is indicated by a vertical bar in the margin of the page.
2. Added or revised illustrations are indicated by a vertical bar in front of the figure caption.
3. Remove and insert pages as indicated in the page list below:

Remove	*Insert*
i and ii	i and ii
1-1 and	1-2 and 1-2
4-1 and 4-2	4-1 and4-2
6-1 and 6-2	6-1and 6-2
7-1 and 7-2	7-1and 7-2
7-5 through 7-10	7-5 through 7-10
A-1	A-1
C-3 and C-4	C-3 and C-4

4. File this change sheet in front of the publication for reference purposes.

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HEADQUARTERS
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OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL
GENERATORS, PULSE, AN/PPM-1 (NSN 6625-00-503-0661) AND AN/PPM-1A (NSN 6625-00-503-3621)

REPORTING; ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DRSEL-ME-MP, Fort Monmouth, NJ 07703.

In either case, a reply will be furnished direct to you.

LIST OF ILLUSTRATIONS

LIST OF TABLES

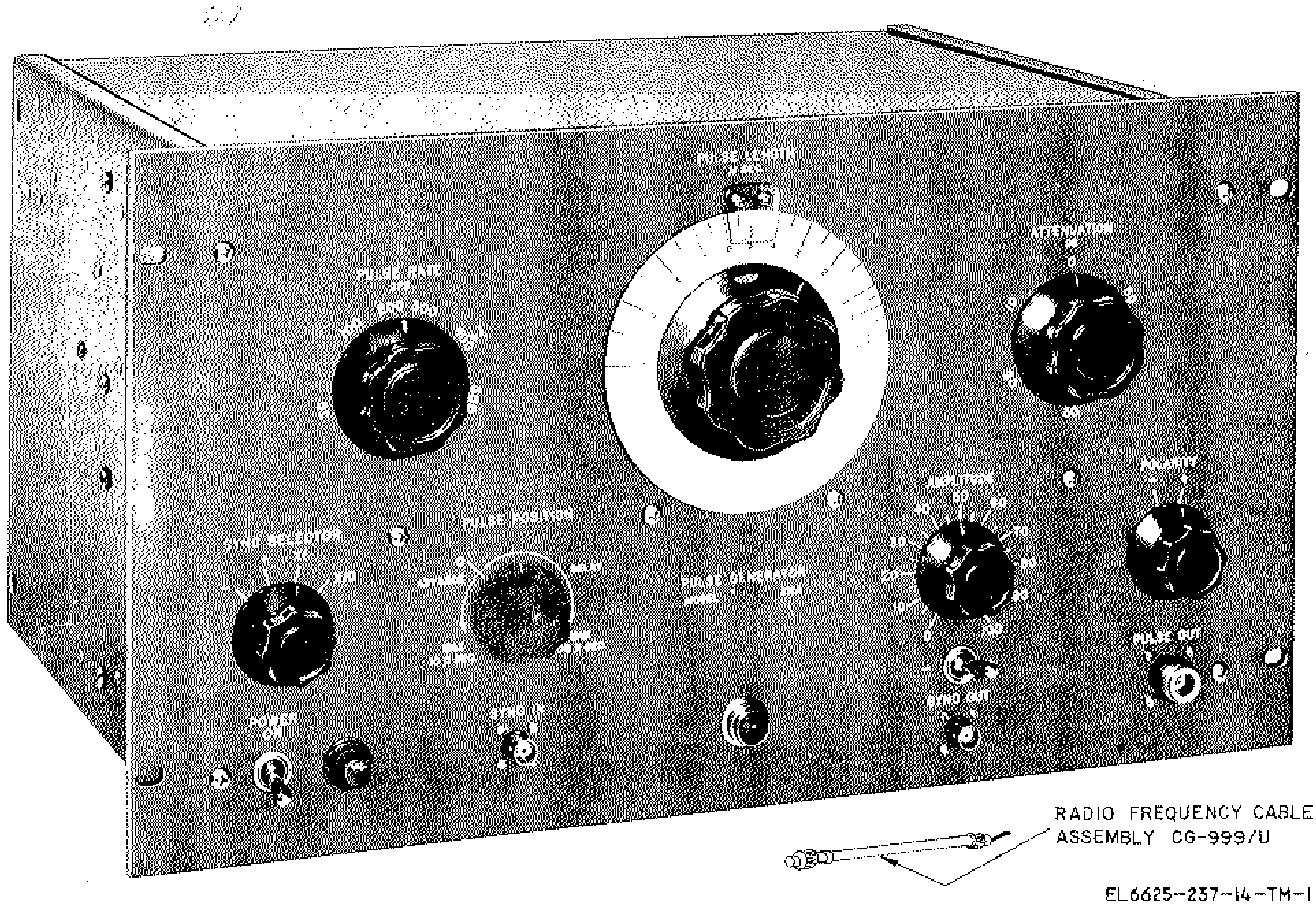

Figure 1-1. Generator, Pulse AN/PPM-1.

CHAPTER 1
INTRODUCTION

Section 1. General

1-1. Scope

a. This manual describes Generators, Pulse AN/PPM-I and AN/PPM-IA and covers their installation, operation, and operator, organizational, direct support, and general support maintenance. Generator, Pulse AN/PPM-I (fig. 1-1) is an operating set consisting of Generator, Pulse SG-69/PPM-1, Cable Assembly, Radio Frequency CG-999/U, and running spares. Generator, Pulse AN/PPM-IA consists of Generator, Pulse SG-69B/PPM-1 (fig. 1-2), Cable Assembly, Radio Frequency CG-2120 and running spares. Since Generators, Pulse AN/PPM-1 and AN/PPM-IA are similar, information contained in this manual applies to both pulse generators, unless otherwise specified.

b. A list of references is contained in appendix A.

c. The maintenance allocation chart (MAC) appears in appendix C.

1-2. Index of Technical Publications

Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

1-3. Maintenance Forms, Records and Reports

a. Reports of Maintenance and Unsatisfactory Equipment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by TM 38-750, The Army Maintenance Management System (TAMMS).

b. Report of Packaging and Handling Deficiencies. Fill cut and forward SF 364 (Report of Discrepancy (ROD)) as prescribed in AR 735-11-2/DLAR 4140.55/ NAVMATINST 4355.73/AFR 400-54/MCO 4430.3E.

c. Discrepancy in Shipment Report (DISREP) (SF 361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 5538/NAVSUPINST 4610.33B/AFR 75-18/MCO 4610.19C/DLAR 4500.15.

1-4. Administrative Storage

Administrative storage of equipment issued to and used by Army activities shall be in accordance with TM 74090-1.

1-5. Destruction of Army Electronics Materiel

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with I'M 750244-2.

1-5.1 Reporting Equipment Improvement Recommendations (EIR)

If your Generators, Pulse AN/PPM-1 and AN/PPMIA need improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Tell us why a procedure is hard to perform. Put it on an SF 368 (Quality Deficiency Report). Mail it to Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DRSEL-ME-MP, Fort Monmouth, NJ 07703. We'll send you a reply.

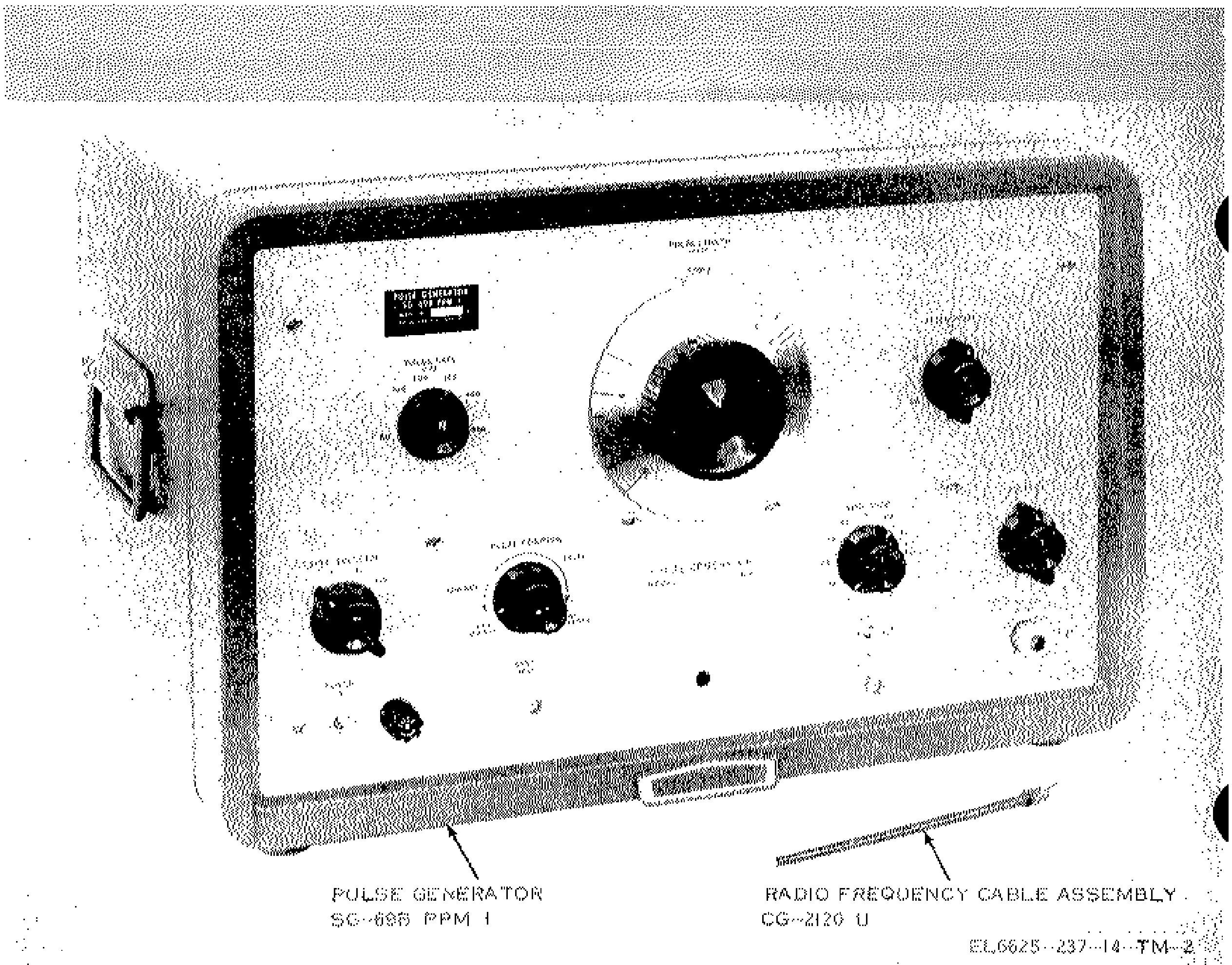

Figure 1-2. Pulse Generator AN/PPM-1A.

Section II. DESCRIPTION AND DATA

1-6. Purpose and Use

Generators, Pulse AN/PPM-1 and AN/PPM-1A are test sets used to determine the response of electronic circuits to rapidly changing signals. The test sets provide variable length positive or negative pulses that are synchronized to equipment under test through built-in delay and sync output circuits. The test sets can be used to test response of radar and television systems, oscilloscopes, nuclear counting circuits, video amplifiers, rf amplifiers, filters, and band pass circuits, The test sets can also be used to check peak measuring equipment to modulate rf carriers, and to pulse modulate uhf signal generators.

1-7. Description

a. Generator, Pulse SG-69/PPM-1 (fig. 1-1) is the only major unit supplied with Generator, Pulse AN/PPM-1A. The unit is housed in a single metal cabinet designed for rack mounting and is intended for use in fixed field installations. Although not designed for mobile use, it can be operated resting on a bench top. All operating controls are mounted on the unit front panel.

b. Generator, Pulse SG-69B/PPM-1 (fig. 1-2) is the only major unit supplied with Generator, Pulse AN/PPM-1A. The unit is housed in a two-part metal cabinet designed for mobile operation and is intended for use on a bench top. The outer metal cabinet is equipped with handles on two sides for easy handling.

The inner metal cabinet (chassis assembly) can be removed from the outer cabinet and mounted in a rack for fixed installation operation. All operating controls are mounted on the unit front panel.

1-8. Description of Minor Components

a. Cable Assembly, Radio Frequency CG-999/U. Cable Assembly, Radio Frequency CG-999/U is the only minor component supplied with Generator, Pulse AN/PPM-1. The cable assembly is identical with Cable Assembly, Radio Frequency CG-2120/U, except that the coaxial cable length is 8-3/4 inches.

b. Cable Assembly, Radio Frequency CG2120/U. Cable Assembly, Radio Frequency CG2120/U (fig. 1-2) is the only minor component supplied with Generator, Pulse AN/PPM-1A. The cable assembly consists of an 8-1/4-inch coaxial cable terminated at one end with a connector that connects with the pulse generator SYNC OUTPUT or PULSE OUTPUT connector.

1-9. Additional Equipment Required

In addition to supplied cable assemblies (para 1-6), 50-ohm coaxial cables and connectors are required but not supplied. The additional cables and connectors are required to connect the pulse generator to other test equipment and to equipment under test.

1-10. Differences Between Models

Generators, Pulse SG-69/PPM-1 and SG-69B/1A are similar in purpose, operation, and appearance. Some later SG-69/PPM-1 models, however, have been modified to improve operational features. These differences are contained in *a* through *f* below. In addition, differences between Generators, Pulse SG69/PPM-1 and SG-69B/PPM-1A are contained in chart 1-1.

a. On equipment starting with serial No. 1039, the method of coupling the pulse from the pulse rate multivibrator to the SYNC OUT circuits is changed. Coupling capacitor C103 was reduced from 50 micromicrofarads (pf) to 30 pf. The difference in wiring is noted in figure 6-8.

b. On equipment starting with serial No. 1239, three resistors and one capacitor have been added to the rear deck to compensate for production tolerances in transformer T1. Also, the value of another resistor has been increased. The difference in wiring is shown in figures FO-2 and FO-3. The added capacitor and resistors are as follows:

(1) Resistor R71, a 600-ohm, 20-watt resistor, has been added from the junction of chokes L4 and L5 to the plate of V17B (pin 5).

(2) Resistors R72 and R73, 220,000-ohm, 2watt resistors, have been added in parallel from the plate of pulse-terminating thyratron V16 to ground.

(3) Capacitor C32, a 0.05 microfarad (µf), 600volt direct current (dc) capacitor, has been added in parallel with R71.

(4) Resistor R19, plate load resistor for V15, has been increased from 1 to 1.5 megohm.

c. In equipment's starting with serial No. 1439, the design of pulse transformers T101 to T103 has been changed because of unavailability of former core materials. Use of these newer pulse transformers requires different circuitry in the blocking oscillator circuits on the front deck. The modifications are as follows:

(1) Capacitor C106 is not used.

(2) Capacitor C140, a 2000-pf mica capacitor, has been added in the grid return path for V102B.

(3) Capacitor C141, a 1000-pf mica capacitor, has been added in the grid return path for V109A.

(4) Capacitor C142, a 1000-pf mica capacitor, has been added in the grid return path for V106B.

(5) Resistor is not used.

(6) Resistor R111 has been replaced by R157, a 220,000-ohm, 1-watt resistor.

(7) Resistor R158, a 27,000-ohm, 1-watt resistor, has been added to the grid return path of V102B.

(8) Resistor R151 and diode CR103 are arranged in the grid circuit of V106B.

(9) Resistor R137 has been replaced by R159, a 27,000-ohm, 1-watt resistor.

(10) Resistor R150 has been replaced by R160, a 27,000-ohm, 1-watt resistor.

(11) Transformer TI01, stock No. 212A-60B, has been replaced by 913-3.

(12) Transformer T102, stock No. 212A-60A, has been replaced by 913-2.

(13) Capacitor C131, a coupling capacitor in the pulse length multivibrator, has been increased from 5,000 to 5,600 pf and now is a low temperature coefficient type. These modifications are included in figures 6-9 and 6-10.

d. Some of the later models will have type HP45/3HP45 tubes instead of type 3C45 (V6 and V16).

e. Pulse generators (model SG-69/PPM-1) procured on Order No. 39131-Phila-53 are identical with the equipment bearing serial numbers 1439 and higher supplied under Order No. 2990-Phila-53 (c above), except for the three circuit modifications described below. These modifications do not affect the specifications or the operation of the equipment.

(1) Resistor RH, a LO-watt, wire-wound resistor, is changed from 500 to 800 ohms. It is located in the circuit of V13.

(2) Resistor R81, a 220 ohm, 1/2 Watt composition resistor, is added in series with the grid of V16.

(3) Resistor R82, a 25,000-ohm, 10-watt, wire-wound resistor, is added in parallel with tubes V12 and V14.

f. Pulse generators furnished on Order No. 19315Phila-58 are identical with equipment furnished on previous order numbers except for the differences listed below. These modifications do not affect the specifications or the operation of the equipment.

(1) Resistor R22 has been changed to 100 ohms.

(2) Resistor R83, a 100-ohm resistor, has been added in parallel with R22.

13) Resistor R84, a 1,250-ohm, 10-watt resistor, has been added in series with pin 3 of V3 and L3.

(4) Resistor R85, a 1,000-ohm, 1-watt resistor, has been inserted, in series, between the plate lead of V3 and ground.

(5) Resistor R86, a 10K, 10-watt resistor, has been added in series with resistor R28.

(6) Resistor R87, a 330-ohm, 10-watt resistor, has been added in series with the place of V17 (pin 2) and resistor R24.

(7) Capacitors C3 and C10 have been changed to 0.22 µf.

(8) Resistor R88, a 100-ohm resistor, has been added in parallel with R21.

(9) Capacitor C9 has been changed to 39 pf.

(10) Capacitor C32 has been changed to 0.047 µf.

(11) Capacitor C103 has been changed to 39 pf.

(12) Capacitor C140 has been changed to 1,800 pf.

(13) Tubes V102, V106, and V109 use type 5963 tubes instead of type 12AU7. Both types are interchangeable.

1-11. External and Internal Differences Between Pulse Generators

The differences between Generators, Pulse SG-69/PPM-1 and SG-69B/PPM-1 are listed in chart 11.

Chart 1-1. Pulse Generators SG-69/PPM-1 and SG-69B/PPM-1 External and Internal Differences

Item	Pulse Generator SG-69/ PPM-1	Pulse Generator SG-69B/ PPM-1 (Order No. 4516-PP-60)
Front panel		New type control knobs; light gray paint.
Rf adapter cable	Alligator clips and type -N connector	Wire lead terminals and modified BNC connector.
Capacitors:		
C17	0.25 µf	0.22 µf
C18	0.25 µf	0.22 µf
C19	0.25 µf	0.22 µf
C27	0.25 µf	0.22 µf
C107	0.25 µf	0.22 µf
C111	0.25 µf	0.22 µf
C119	0.25 µf	0.22 µf
C134	0.25 µf	0.22 µf
C20	2,000 pf	1,800 pf
C24	2,000 pf	1,800 pf
C106	250 pf	220 pf
C115	250 pf	220 pf
C123	250 pf	220 pf
C132	250 pf	220 pf
C108	.05 µf	0.047 µf
C9	40 pf	39 pf
C113	40 pf	39 pf
C118	50 pf	47 pf
C120	50 pf	47 pf
C122	0.01 µf	0.001 µf
C124	0.01 µf	0.001 µf
C116	0.02 µf	0.022 µf
C126	20 pf	22 pf
C133	20 pf	22 pf
C127	25 pf	27 pf
C135	250 pf	270 pf
C138	250 pf	270 pf

Chart 1-1. Pulse Generators SG-69/PPM-1 and SG-69B/PPM-1 External and Internal Differences-Continued

Item	Pulse Generator SG-69/ PPM-1	Pulse Generator SG-69B/ PPM-1 (Order No. 4516-PP-60)
Semiconductor diodes:		
CR102	JAN type 1N34	JAN type 1N34A
CR106	JAN type 1N34	JAN type 1N34A
Resistors:		
R30	100 ohms	Changed to a 500 ohm potentiometer
R32	270K ohms	330K ohms
R102	18K ohms	15K ohms
R114	330 ohms	4,700 ohms
R120	270K ohms	180K ohms
R134	15K ohms	25K ohms
R138	10K ohms	2,700 ohms
R141	33K ohms	3,300 ohms
		A 2,700 ohm resistor, R162, has been added across the secondary winding of transformer T103 to dampen oscillations.
		A 39K ohm resistor, R163, has been added across the primary winding of transformer T102 to dampen oscillations.
		A 15K ohm resistor, R165, has been added across the primary winding of transformer T101 to dampen oscillations.
		A 33 ohm resistor, R89, has been added in series with the cathode of V6 and remaining cathode circuitry.
V10	12AX7	6U8A
V13	5R4GYA	5U4GB
V102, V106, V109	12AU7	5963

12. Tabulated Data

Pulse length .... Continuously variable from 0.07 to 10.0 µsec.

Pulse amplitude .... 50v into 50-ohm load (max), with a 50 db, 6-position step (10 db/step) ATTENUATION control and an AMPLITUDE control providing 10 db of continuous variation.

Pulse shape .... Rise and decay time 0.02 µsec (approx) (10 to 90 percent of maximum amplitude); variation of crest voltage less than 5.0 percent at 50v output; AMPLITUDE control attenuation causes some increase in crest variation; ATTENUATION control causes no increase in crest variation.

Pulse polarity .... Positive or negative.

Internal impedance.... 50 ohms or less, either polarity.

Repetition rate .... 50 to 5,000 pps.

Synchronization .... Can be triggered from an external positive or negative pulse source having an amplitude of 5v at rates up to 5,000 pps.

Output (SG-69/PPM-1) ±40v or -25v trigger pulses into a 200 ohm or greater load; pulse duration of 1.0 µsec (approx) at half voltage points with less than 0.25 µsec risetime.

Output (SG-69B/PPM-1) +25v (min) or -15v (min) trigger pulses into a 2000 ohm load: pulse duration of 1.0 µsec (approx) at half voltage points with less than 0.25 µsec risetime.

Main pulse position ...... Adjustable, with respect to output trigger pulse, from 10 µsec advance to 100 µsec delay for pulse rates to 2500 pps, adjustable from 10 µsec advance to 50 µusec delay for pulse rates to 5000 pps.

Power requirements..... 115 or 230v, 50 to 60 Hz, 380 watts (max.).

Weight (SG-69/PPM-1) 48 lb.

Weight (SG-69B/PPM-1) 56 lb.

1-13. Items Comprising an Operable Equipment

Items comprising an operable AN/PPM-1 or AN/PPM-1A are listed in tables 1-1 and 1-2.

Table 1-1. Items Comprising an Operable Generator, Pulse AN/PPM-1

NSN	Item	Qty (ea)	Dimensions (in)			Unit Weight (lb)
			Height	Depth	Width	
6625-00-545-7953	Generator, Pulse SG-69/PPM-1	1	10 ½	14 ½	19	48
6625-00-519-20P	Cable Assembly, Radio Frequency CG-999/U	1	8 ¾ in. length			

Table 1-2. Items Comprising an Operable Generator, Pulse AN/PPM-1A

NSN	Item	Qty (ea)	Dimensions (in)			Unit Weight (lb)
			Height	Depth	Width	
6625-00-682-2581	Generator, Pulse SG-69B/PPM-1	1	12 ¾	14-3/16	20 ¾	56
5995-00-753-1169	Cable Assembly, Radio Frequency CG-2120/U	1	8 ¼ in. length			

CHAPTER 2

SERVICE UPON RECEIPT OF EQUIPMENT AND INSTALLATION

2-1. Unpacking

a. Packaging Data. When packed for shipment, the pulse generator, cable assembly, and running spares are placed in a single carton and packed in a wire-bound crate. A typical packing crate and its contents are shown in figure 2-1.

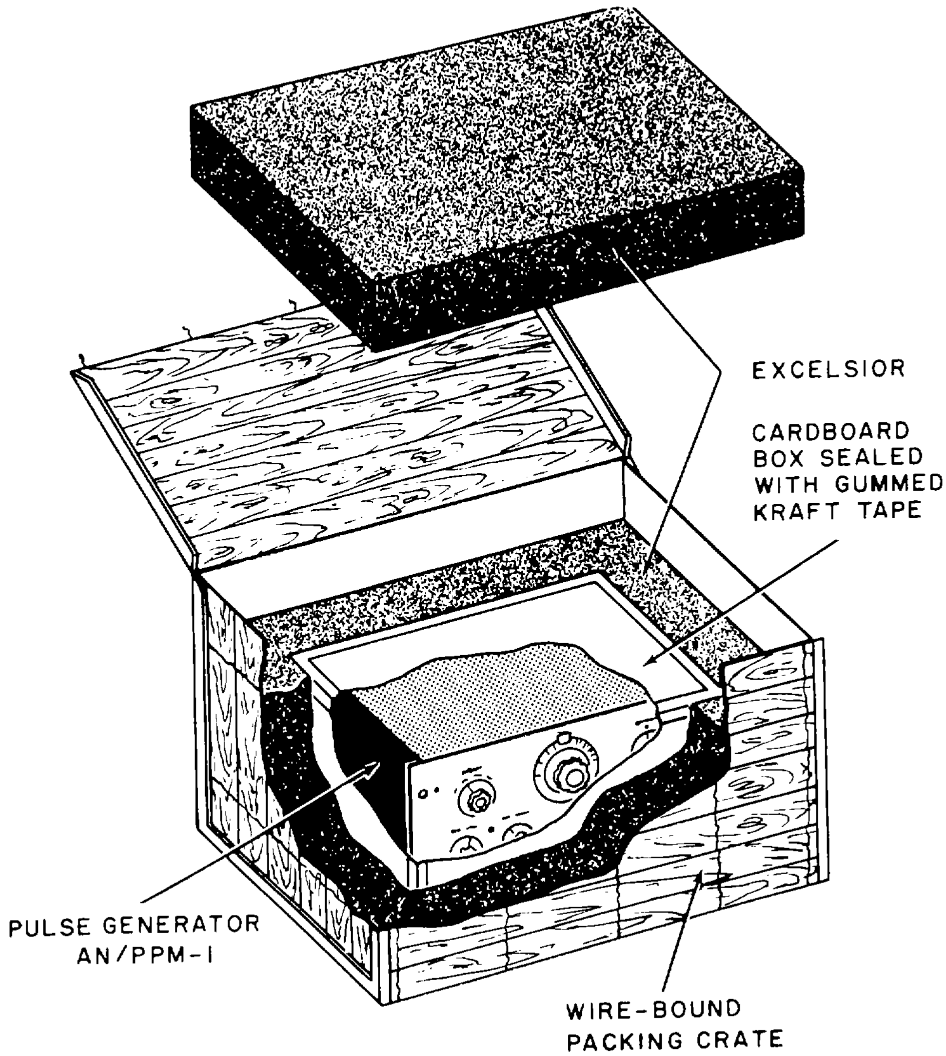

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Figure 2-1. Typical packaging diagram.

b. Unpacking Procedure. Remove contents of packing crate as follows:

(1) Cut wire binding.

CAUTION

Do not attempt to pry off crate sides or top. Failure to comply may result in damage to equipment.

(2) Fold back top of packing crate.

(3) Remove excelsior or corrugated paper covering equipment inside crate.

(4) Remove running spares and cable assembly from crate.

(5) Remove equipment from inner carton or wrapping and place on workbench.

2-2. Checking Unpacked Equipment

a. Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, report the damage on DD Form 6 (para 13b).

b. See that the equipment is complete as listed on the packing slip. If a packing slip is not available, check the equipment against the component data given in tables 1-1 and 1-2. Report all discrepancies in accordance with TM 38-760. The equipment should be placed in service even though a minor assembly or part that does not affect power function is missing.

c. Check to see whether the equipment has been modified. (Equipment which has been modified will have the MWO number on the front panel near the nomenclature plate.) Check also to see whether all currently applicable MWO's have been applied. (Current MWO's applicable to the equipment are listed in DA Pam 310-7.)

2-3. Seating of Tubes and Fuses.

a. Inspection of Tubes and Fuses. The pulse generator is shipped with all tubes and fuses installed. Check to see that line fuse of correct rating (para 2-4b) is installed in front panel fuseholder. Check for breakage and proper seating of tubes (fig. 2-2). To check Generator, Pulse SG-69/PPM-1 tubes, remove chassis cover in accordance with paragraph 2-3b. To check Generator, Pulse SG69B/PPM-1 tubes, remove chassis from equipment case in accordance with paragraph 2-3c.

b. Cover Removal (SG-69/PPM-1). Remove pulse generator cover as follows:

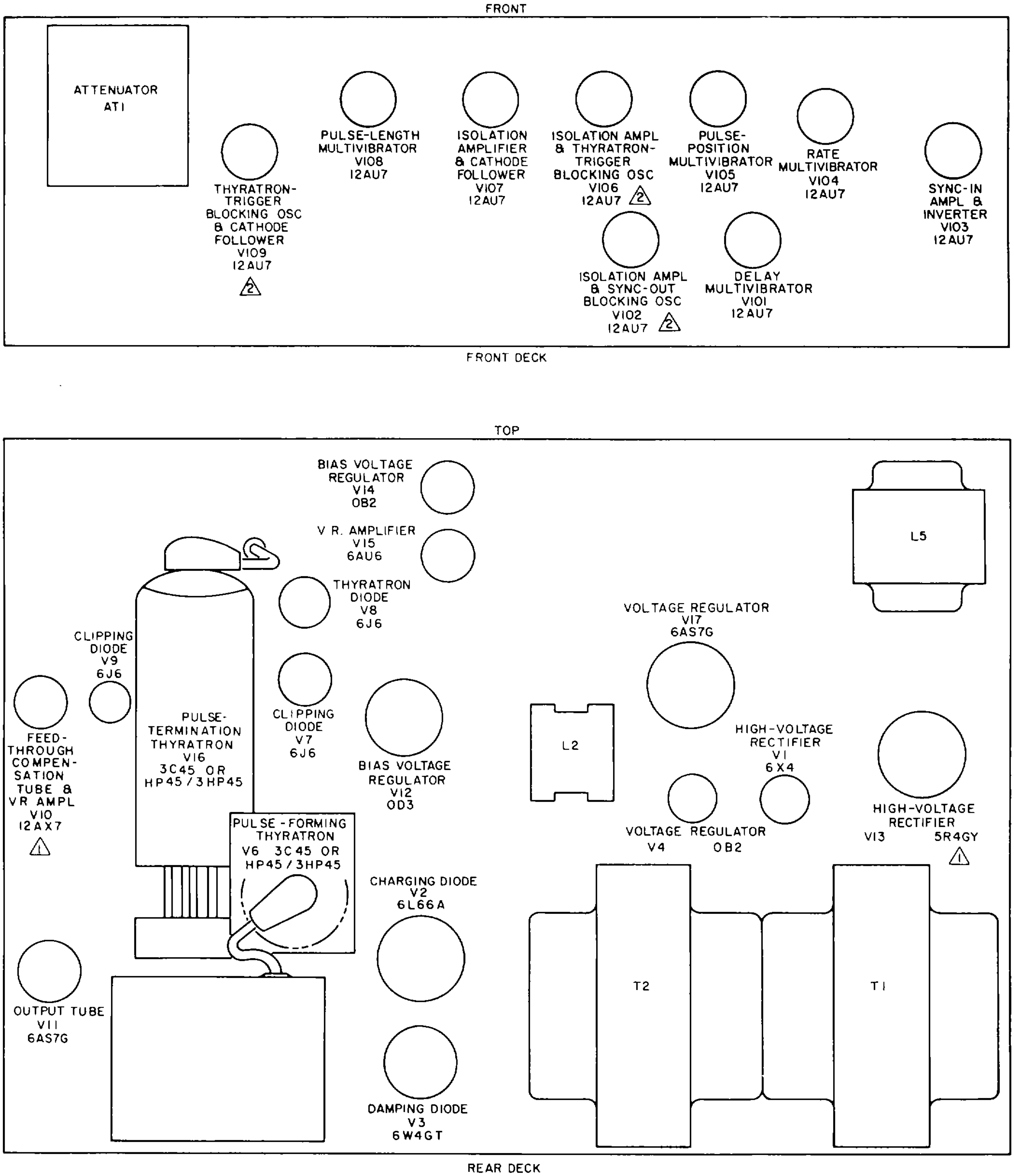
(1) Remove four screws securing cover to rear of equipment chassis.

(2) Slide cover off rear of chassis.

c. Case Removal (SG-69B/PPM-1). Remove pulse generator equipment case as follows: (1) Remove four screws securing rear cover to equipment case and remove rear cover.

(2) Remove two setscrews from bottom of equipment case securing chassis front panel to case.

(3) Slide chassis out of equipment case.



NOTES

1. FOR PULSE GENERATOR SG-69B/PPM-1, TUBE V10 IS TYPE 6U8A AND TUBE V13 IS TYPE 5U4GB

2. FOR PULSE GENERATOR SG-69B/PPM-1, TUBES V102, V106, AND V109 ARE TYPE 5963.

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Figure 2-2. Pulse generator, tube location diagram.

24. Equipment Installation and Connections

a. Installation. All components required to install the pulse generator are contained in the equipment packing crate. If the pulse generator is to be rack-mounted, access to the top, bottom, and rear of the chassis must be provided for servicing. A distance slightly greater than twice the depth of the cover should be provided so that the cover can be removed without removing the pulse generator from the rack. If Generator, Pulse SG-69B/PPM-1 is removed from its case and rack-mounted, a chassis cover should be fabricated to protect electronic components from excessive dust. To rack-mount the pulse generator, position unit in rack as desired and secure in place with four front panel bolts.

b. Connections. The pulse generator can be powered from either a 115or 230-volt, 50to 60-Hz power source. For 115-volt operation, pulse generator transformer T1 and T2 primary windings are connected in parallel (fig. FO-2), and a 4-ampere slow-blow line fuse is installed in the front panel fuseholder (fig. 3-1). For 230-volt operation, transformer T1 and T2 primary windings must be reconnected in series (fig. FO-2) and a 2-ampere slow-blow fuse installed in the front panel fuseholder. Be sure that transformer windings are connected properly, line fuse is of correct value installed, and connect pulse generator power cord into selected power source.

CHAPTER 3

OPERATING INSTRUCTIONS

Section I. CONTROLS AND INSTRUMENTS

3-1. General

Before operating the SG-69/PPM-1 or SG69B/PPM-1A, the operator must become thoroughly familiar with the controls and indicators. Do not operate the pulse generator until the location, function, and use of each control and indicator are understood.

3-2. Operator Controls

Locations of the operator controls and indicators are shown in figure 3-1. Table 3-1 provides information on the function of each of the controls and indicators.

Table 3-1. Operator Controls and Indicators

NOTE

This table covers only items used by the operator; items used by higher category maintenance personnel are covered in instructions for the appropriate maintenance categories.

Control, indicator or connector	*Function*
POWER switch	In ON position, connects pulse generator to ac power source and lights indicator lamp I1.
Power on indicator lamp	When lighted, indicates that pulse generator is energized.
PULSE LENGTH control	Controls width of main output pulse.
PULSE RATE control	In conjunction with the SYNC SELECTOR switch, controls repetition rate of synchronizing pulses from 50 to 5,000 pulses per second.
SYNC SELECTOR switch	Selects two ranges (X1 and X10) of internally generated pulse rates or required circuits for external synchronization from either positive or negative externally generated synchronizing pulses.
PULSE POSITION control	Controls timing between main pulse output and synchronizing pulse output. Outer control provides coarse adjustment and inner control provides fine adjustment. Control is normally used to position main pulse on an oscilloscope screen when the oscilloscope is synchronized by the pulse generator (SYNC OUT).
AMPLITUDE control	Controls main output pulse amplitude over 10-db range.
ATTENUATION switch	Selects main output pulse attenuation in 10-db steps up to 50 db.
POLARITY switch	Selects main output pulse polarity applied to PULSE OUT connector.
SYNC OUT switch	Selects sync output voltage polarity applied to SYNC OUT connector.
Fuseholder and fuse	Protect pulse generator from circuit overloads.
PULSE OUT connector	Provides output connection for main output pulse.
SYNC OUT connector	Provides output connection for sync voltage.
SYNC IN connector	Provides input connection for trigger voltages to be applied to pulse generating circuits.

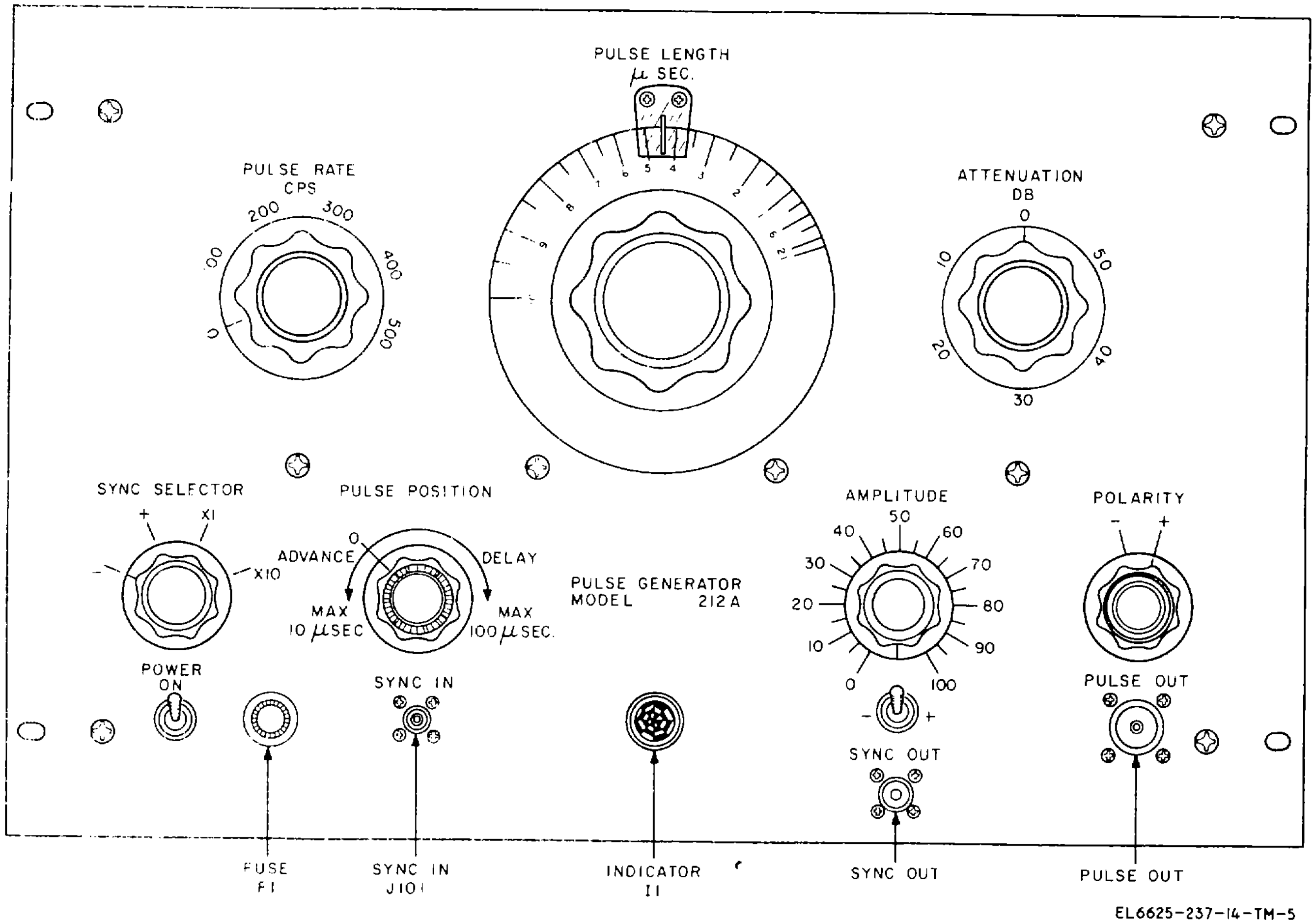


Figure 3-1. Pulse generator, controls and indicator.

Section II. OPERATION UNDER USUAL CONDITIONS

3-3. Types of Operation

There are two basic modes of operation of the set. The choice of operation to be used depends on the availability of, and the need for, external synchronization.

a. If external synchronization is not required, the pulse generator will serve as a source of controlled width pulses at any repetition rate between 50 and 5,000 pps. The starting and operating procedures in paragraphs 3-4 and 3-5 are applicable. The SYNC SELECTOR switch must be set at either the X1 or X10 position, depending on the desired repetition rate. If this switch is set on either the + or - position, and external synchronization is not provided, there will be no output signal from the pulse generator.

b. If external synchronization is desired, the trigger pulse can be either a negative or positive 5volt signal with a repetition rate less than 5,000 pps. This signal is applied to the appropriate circuits through the SYNC IN connector on the front panel of the pulse generator. In this mode of operation, the SYNC SELECTOR switch must be set at either + or - position, depending on the polarity of the input trigger pulse. If this switch is set on either the X1 or X10 position, the external synchronization will have no effect, and the repetition rate of the output pulse will be determined by the setting of the PULSE RATE control.

3-4. Preliminary Starting Procedure.

a. Set POWER ON switch to the off position.

b. Set PULSE POSITION control to midrange.

c. Set SYNC SELECTOR switch to X1 or X10 for internal pulsing; + or - for external synchronized pulsing.

d. Set AMPLITUDE control to 90.

e. Connect rear panel power cord to external power source.

f. Set front panel switch to POWER ON.

3-5. Operating Procedure.

a. Allow pulse generator to warm up at least from 3 to 5 minutes. A 10-minute warmup is recommended when possible. Premature operation will cause the automatic overload relay to buzz or chatter. The relay can be stopped from buzzing or chattering during warmup by setting SYNC SELECTOR switch to either + or -.

CAUTION

Do not set PULSE POSITION control greater than 50 msec when a repetition rate of more than 2,500 pps is used. The 2 o'clock position of the PULSE POSITION control corresponds to approximately 50 msec delay. Maximum delay of 100 msec can be used for repetition rates up to 2,500 pps. Above 2,500 pps, delay must be decreased as the repetition rate in increased to prevent overloading tube in the pulse position circuit.

b. For internal pulsing operation, set SYNC SELECTOR switch to either X1 or X10 and set PULSE RATE switch to desired pulse rate.

CAUTION

Do not drive the pulse generator at a repetition rate in excess of 5,000 pps. Failure to comply may result in damage to thyratron tubes.

c. For external synchronization, set SYNC SELECTOR switch to either + or - (depending on polarity of external synchronizing pulses) and apply synchronizing pulses of desired rate to SYNC IN connector.

d. Using 50-ohm coaxial cable, connect PULSE OUT connector to input connector of equipment under test, SYNC OUT connector to external sync input connector of an associated test oscilloscope, and output connector of equipment under test to oscilloscope signal input connector. Typical connections are shown in figure 3-2.

NOTE

Cables should be terminated with 50-ohm resistive loads if more than 6 feet long.

e. Set SYNC OUT switch to either + or -, whichever provides best synchronization and select main pulse polarity (+ or -) with POLARITY switch.

f. Adjust PULSE POSITION control to position waveform on oscilloscope screen and adjust PULSE LENGTH control until oscilloscope indicates waveform with desired pulse width. The pulse width can be adjusted from less than 0.7 µsec to 10.0 µsec. This pulse width is correct within plus or minus 10 percent, except in the case of very short pulses where considerably more variation in accuracy will be noticed.

g. Using ATTENUATION switch and AMPLITUDE control, adjust amplitude of waveform displayed on oscilloscope. The best output waveshape is obtained with the AMPLITUDE control set as close as possible to 100. As the amplitude is reduced by the AMPLITUDE control, the waveshape deteriorates slightly. To avoid this deterioration, perform major amplitude adjustments with ATTENUATION switch and fine amplitude adjustments with AMPLITUDE control. As a general rule, the AMPLITUDE control should be set to a position slightly less than 100 for best waveshape presentation.

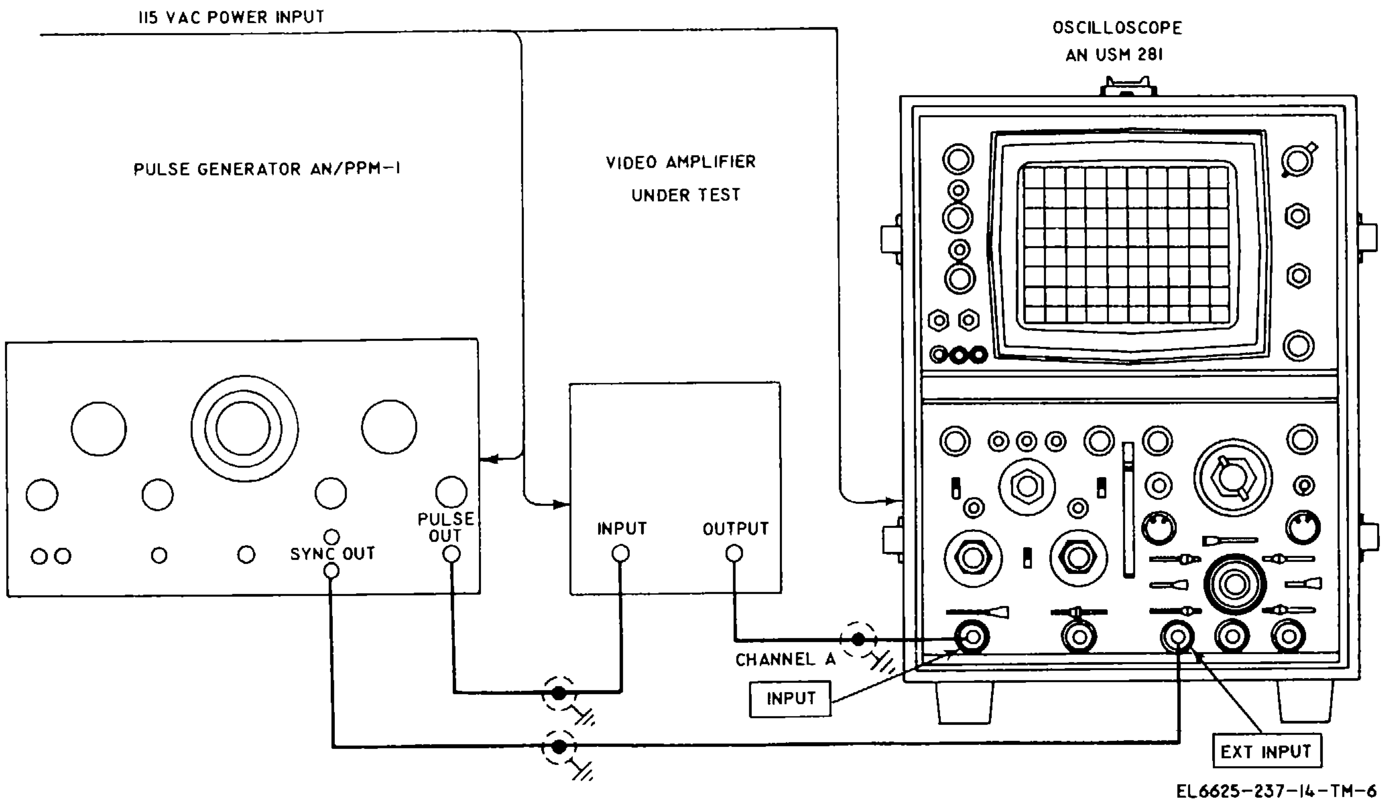


Figure 3-2. Typical connection diagram.

3-6. Procedure for Shutdown

To deenergize the pulse generator, set POWER ON switch to off (down) position. Unless the equipment is to be used again immediately, disconnect coaxial cables from all front panel connectors.

Section III. OPERATION UNDER UNUSUAL CONDITIONS

3-7. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather affect the efficient operation of electronic equipment. Instructions and precautions for operation under such adverse conditions follow:

a. Handle the equipment carefully.

b. Keep the equipment warm and dry. If the pulse generator is not kept in a heated inclosure, construct an insulated box for the equipment.

c. Make certain the equipment is warmed up sufficiently before attempting to use it. This may take 10 to 15 minutes, depending on the temperature of the surrounding air.

d. When equipment which has been exposed to the cold is brought into a warm room, it will sweat until it reaches room temperature. When the pulse generator has reached room temperature, dry it thoroughly.

3-8. Operation in Tropical Climates.

When operated in tropical climates, electronic equipment may be installed in tents, huts or, where necessary, in underground dugouts. When equipment is installed below ground, and when it is set up in swamp areas, moisture conditions are more acute than normal in the tropics. Ventilation usually is very poor, and the high relative humidity cause: ; condensation of moisture on the equipment whenever the temperature of the equipment becomes lower than the ambient air. To minimize this condition, place lighted electric bulbs under the equipment.

3-9. Operation in Desert Climates.

The main problem with equipment operation in desert areas is the large amount of sand and dust that enters the moving parts of the equipment, such as tuning shafts and switch contacts. Therefore, cleaning and servicing intervals shall be shortened according to local conditions.

CHAPTER 4

ORGANIZATIONAL MAINTENANCE

NOTE

The operator will perform organizational maintenance. All test set repairs will be referred to general support category.

4-1. Scope of Organizational Maintenance.

This chapter provides instructions for organizational maintenance of the pulse generator set. The following instructions list the actions to be taken at the organizational maintenance category and the tools, materials, and test equipment required.

a. Daily preventive maintenance checks and services (para 4-4).

b. Weekly preventive maintenance checks and services (para 4-5).

c. Quarterly preventive maintenance checks and services (para 4-6).

d. Cleaning (para 4-7).

e. Touchup painting (para 4-8).

f. Troubleshooting (para 4-9).

g. Replacement of fuse and indicator lamp (para 4-10).

4-2. Special Tools and Equipment.

No special tools or equipment is required for organizational maintenance.

4-3. Preventive Maintenance.

Preventive maintenance is the systematic care, servicing, and inspection of equipment to prevent the occurrence of trouble, to reduce downtime, and to assure that the equipment is serviceable.

a. Systematic Care. The procedures given in paragraphs 4-4 through 4-7 cover routine systematic care and cleaning essential to proper upkeep and operation of the equipment.

b. Preventive Maintenance Checks and Services. The preventive maintenance checks and services charts (para 4-4 through 4-6) outline functions 1;o be performed at specific intervals. These checks and services are to maintain Army electronics equipment in a combat-serviceable condition; that is, in good general (physical) condition and in good operating condition. To assist operators in maintaining combat serviceability, the chart indicates what to check, how to check, the normal conditions, and the minimum time required for inspection. If a defect cannot be remedied by the corrective actions listed, higher category of maintenance or repair is required. Records and reports of these checks and services must be made in accordance with the requirements set forth in TM 38-750.

c. Preventive Maintenance Checks and Services Periods. Preventive maintenance checks and services of the equipment are required daily, weekly, and quarterly.

(1) Paragraph 4-4 specifies the checks and services that must be accomplished daily (or at least once each week if the equipment is maintained in standby condition).

(2) Paragraphs 4-5 and 4-6 specify additional checks and services that must be performed o: n a weekly and quarterly basis, respectively.

4-4. Daily Preventive Maintenance Checks and Services

Time required: 0.6

Sequence No.	Item to be inspected	Procedure	Work time (M/ H)
1	Completeness..................	See that the equipment is complete (para 1-13).	0.1
2	Exterior surfaces..............	Clean the exterior surfaces, including the panel and meter glasses. Check 0.1 both meter glasses and indicator lens for cracks (para 4-7).	0.1
3	Connectors......................	Check the tightness of all connectors.	0.1
4	Controls and indicators.....	While making the operating checks (items 5 and 6), observe that the mechanical action of each control is smooth, and free of external or internal binding, end that there is no excessive looseness. Replace fuses, knobs, and lamps as required	0.1
5	Operation..........................	Operate the equipment (ch 3). The power on indicator lamp should glow	0.1
6	POWER ON switch...........	Set to OFF. Note that the power on indicator lamp extinguishes	0.1

4-5. Weekly Preventive Maintenance Checks and Services

Time required: 0.2

Sequence No.	Item to be inspected	Procedure	Work time (M/ H)
1	Cables.............................	Inspect cables for chafed, cracked, or frayed insulation. Inspect for loose terminals.	0.1
2	Metal surfaces.................	Inspect exposed metal surfaces for rust and corrosion.	0.1

4-6. Quarterly Preventive Maintenance Checks and Services

Time required: 0.2

1	Publications.....................	See that all publications are complete, serviceable, and current (DA Pam 310-4).	0.1
2	Modifications...................	Check DA Pam 310.4 to determine whether new applicable MWO's have been published. All URGENT MWO's must be applied immediately. All NORMAL MWO's must be scheduled.	0.1

4-7. Cleaning

Inspect the exterior of the equipment. The exterior surfaces should be free of dust, dirt, grease, and fungus.

a. Remove dust and loose dirt with a clean, soft cloth.

b. Remove grease, fungus, and ground-in dirt from the case; use a cloth dampened (not wet).

c. Remove dust or dirt from plugs and jacks with a brush.

d. Clean the front panel, controls and switches; use a soft, clean cloth. If necessary, dampen the cloth with water; mild soap may be used for more effective cleaning.

4-8. Touchup Painting Instructions

Remove rust and corrosion from metal surfaces by lightly sanding them with fine sandpaper. Brush two thin coats of paint on the bare metal to protect it from further corrosion. Refer to the applicable cleaning and refinishing practices specified in TB 43-0118.

4-9. Organizational Troubleshooting

a. General. The troubleshooting chart (b below) will help locate trouble in the pulse generator. Only those corrective measures are given which the unit repairmen can accomplish. If the corrective measure does not restore normal equipment performance, higher category of maintenance is required.

b. Troubleshooting Chart.

Sequence No.	Item to be inspected	Probable trouble	Corrective measures
1	Power on indicator lamp does not illuminate	Defective indicator lamp, fuse, or no power input	Check power input, fuse, and indicator lamp. If correct, higher category of maintenance is required.
2	With POWER ON switch set to OFF, indicator lamp does not extinguish	Defective switch	Higher category maintenance is required

4-10. Repairs

a. Replacement of Power On Indicator Lamp- Replace indicator lamp I1 as follows:

(1) Remove equipment cover or case in accordance with paragraph 2-3b or c.

(2) Pull defective indicator lamp out of socket located behind glass indicator jewel.

(3) Install new indicator lamp in socket and replace equipment cover or case.

b. Replacement of Power Fuse. Replace power fuse Fl as follows: (1) Rotate front panel fuseholder cover counterclockwise and remove fuseholder cover and fuse.

(2) Remove fuse from fuseholder cover.

(3) Insert new fuse in fuseholder cover.

(4) Install new fuse and fuseholder cover in fuseholder and secure in place by rotating cover clockwise.

CHAPTER 5
FUNCTIONING OF EQUIPMENT

5-1. General

This chapter contains an overall functional description of Generators, Pulse AN/PPM-1 and AN/PPM-1A. A block diagram of the pulse generators is shown in figure 5-1. Functional analysis of the equipment is covered in this chapter.

5-2. Overall Functional Description.

a. General. The set is used for determining the action of circuits which are subject to rapid variations. This equipment generates pulses; pulse duration is continuously variable from 0.07 to 10 μsec at repetition rates of 50 to 5,000 pulses per second. Fifty-volt pulse amplitudes, either positive or negative in polarity, are obtained easily when working into 50-ohm loads. The pulse generator may be triggered externally by applying 5-volt, positive or negative pulses, at rates up to 5,000 pulses per second to SYNC IN connector J101. Output sync pulses for triggering external equipment are available at SYNC OUT connector J102 in advance of, or following, the output pulse. The amplitude of the main output pulse may be controlled in five 10db steps by the ATTENUATION control in the step attenuator circuit. The AMPLITUDE control serves as a vernier to the step attenuator circuit, giving continuous control of the amplitude of the output pulse.

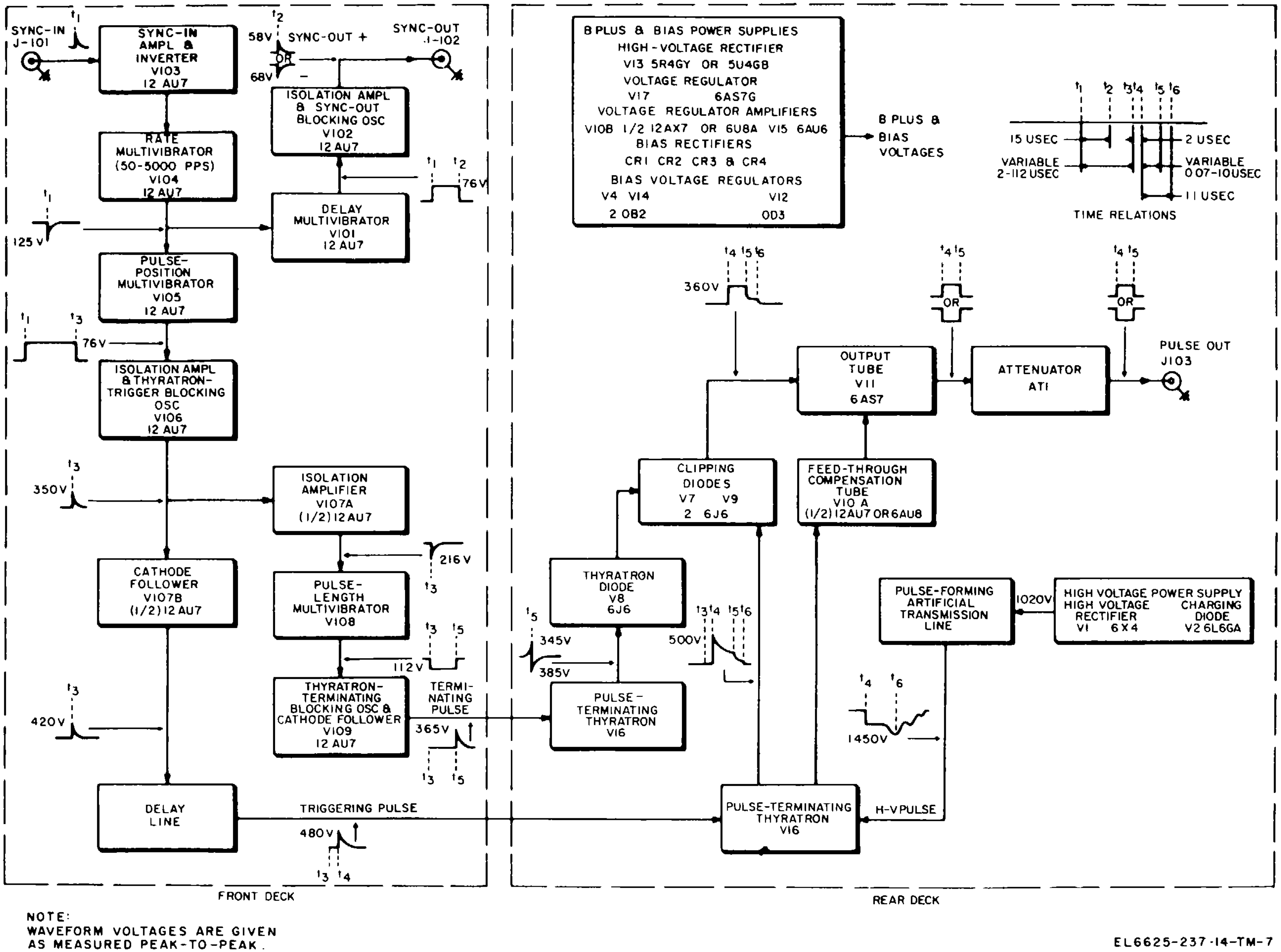


Figure 5-1. Pulse generators, block diagram.

b. Functional Sections. A simplified functional block diagram of the pulse generator is shown in figure 5-2. The pulse generator consists of three basic functional circuit sections. They are the triggering and synchronizing section, pulse generating section, and B + and bias power supply section. Each of these three sections is described in (1), (2), and (3) below.

(1) *Triggering and synchronizing section*. This section consists of nine 12AU7 vacuum tubes (V101 through V109) and their accompanying circuits. Physically, the triggering and synchronizing section occupies the front deck (fig. 2-2). This section has several functions. The rate, position, and length of the output pulse are controlled from the front panel by potentiometers and switches electrically located in this section. A triggering pulse, which initiates, and a terminating pulse, which shuts off the output pulse, are developed in this section. Thus, the triggering and synchronizing circuits provide stable, yet adjustable, control of the output pulse. The pulse generator may be synchronized by injecting external sync pulses to SYNC IN connector J101. However, rate multivibrator V104 is also capable of performing as a free-running multivibrator, functioning independently of external sync pulses. In either case, sync pulses for triggering external equipment may be obtained at SYNC OUT connector J102.

(2) *Pulse-generating section*. The pulse-generating section uses the triggering and terminating pulses from the triggering and synchronizing section to control the main output pulse. This section produces high-voltage pulses by means of a self-contained high-voltage power supply which charges a pulse-forming artifical transmission line. Control of the high-voltage pulse is maintained by a pair of thyratron switch tubes. The thyratrons are controlled by the triggering and terminating pulses generated by the triggering and synchronizing circuits. The output pulse is clipped, and its amplitude is controlled by an attenuator which feeds the output to PULSE OUT connector J103.

(3) B + and bias power supply section. To maintain maximum stability in the output pulse, B+ and bias voltages must be controlled by regulated power supplies. Conventional power supplies are used, furnishing dc supply voltages regulated by glow discharge type regulator tubes V4, V12, and V14, or by electronic regulators and amplifiers V15, V1OB, and V17.

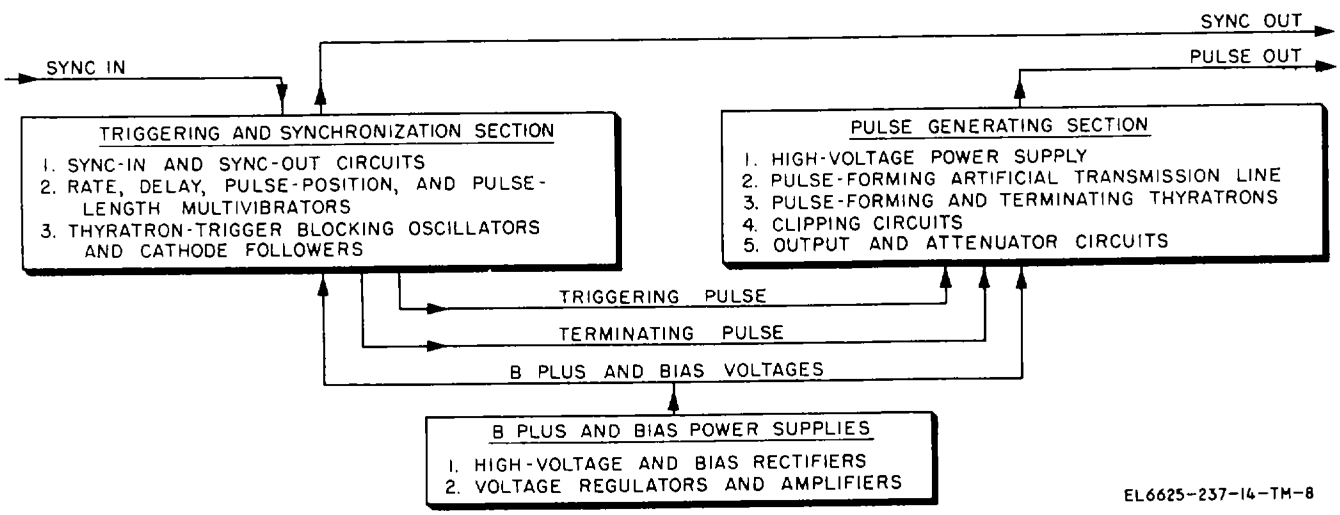


Figure 5-2. Pulse generators, functional block diagram.

5-3. Stage Analysis

a. The general operation and purpose of each of the three basic functional sections of the pulse generator have been explained in paragraph 5-2. Paragraphs 5-4 through 5-14 provide a detailed analysis of each stage in the pulse generator. To understand the function of all circuits in this equipment, while reading the remainder of this section, constant reference should be made to the system block diagram (fig. 5-1) and the circuit diagrams that apply to the various stages. The circuit diagrams reflect only typical pulse generator stage circuits.

b. Minor circuit configuration and component value differences exist between pulse generator models. For exact circuit configurations and component values, refer to schematic diagrams (fig. 6-8, 6-9, and 6-10) associated with each equipment model.

For complete discussion of differences in models, refer to paragraphs 1-8 and 1-9.

5-4. Sync-In Amplifier and Inverter Circuits.
(fig. 5-3)

a. When external negative or positive 5-volt sync pulses are supplied through connector J101 to the pulse generator, they are either amplified and inverted, by twin-triode V103. The inverting action is such that, in combination with the SYNC SELECTOR switch, a negative pulse is obtained from V103 to trigger biased-to-cutoff rate multivibrator V104. If the SYNC SELECTOR switch is in the + position, the trigger pulse is obtained from the plate of sync-in amplifier V103A and is opposite in polarity to the input sync pulse. In the --position, the trigger pulse is obtained from the plate of sync-in inverter V103B and is the same in polarity as the input synchronization pulse.

b. No output pulse will be obtained when the SYNC SELECTOR switch is in the + or-position unless an external sync pulse is supplied to connector J101. Input coupling capacitor CII0 prevents any dc voltage present on the input synchronizing signal from reaching the grid (pin 7) of V103A. This grid is biased to -5.4 volts with respect to cathode resistor R116. The grid (pin 2) of sync-in inverter V103B is held at a negative 26 volt bias by a regulated bleeder-bias network.

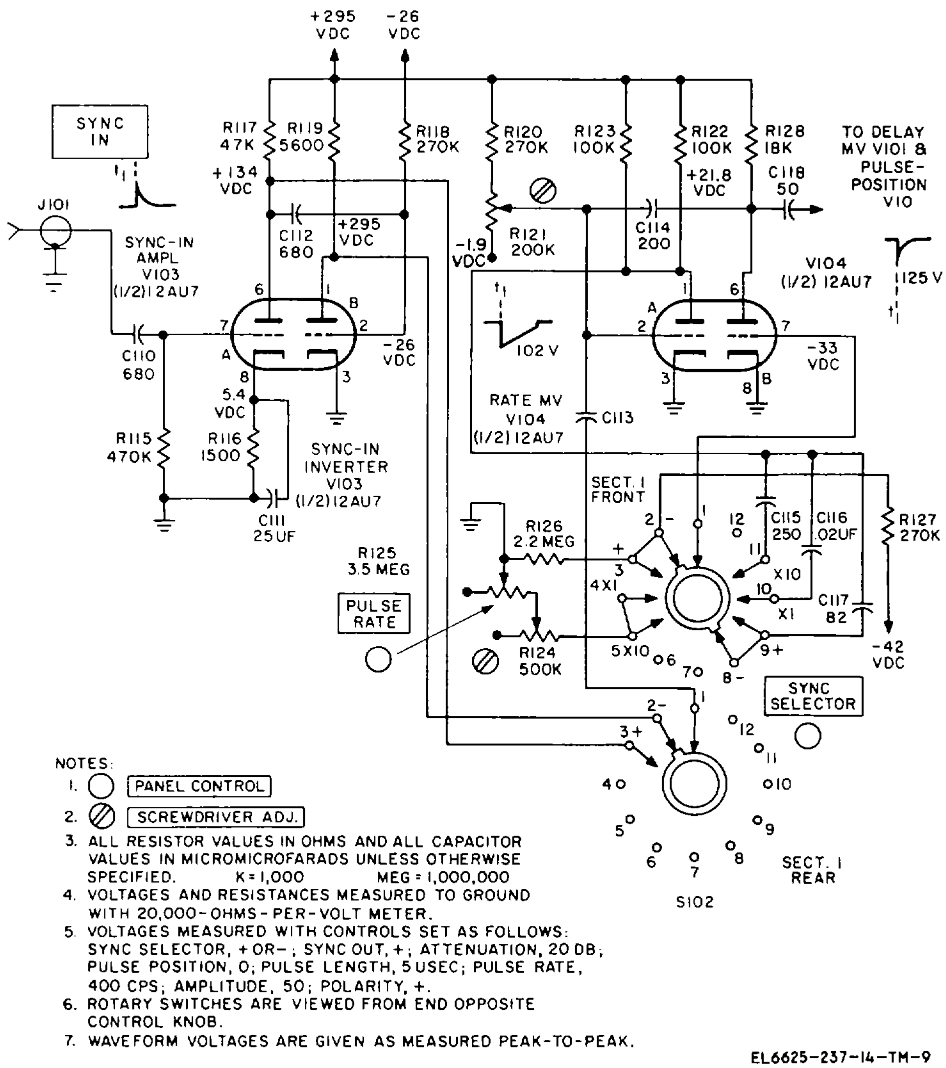


Figure 5-3. Typical sync-in amplifier and inverter, and rate multivibrator circuits.

5-5. Rate Multivibrator Circuits

(fig. 5-3)

a. This stage, V104 with its associated circuitry acts as either a driven or free-running multivibrator; when operated free-running, it determines the repetition rate of the output pulse. During externally synchronized (driven) operation, the multivibrator is biased so that a new cycle can be initiated only by an external trigger pulse and PULSE RATE control R125 is disabled by switch S102 (front). The driving trigger is obtained through switch S102 (rear) from the plate of either V103A or V103B, depending on the polarity of the input trigger pulse.

b. In the free-running condition, multivibrator V104 has ranges from 50 to 500 and 500 to 5,000 pulses per second, depending on the setting (X1 or X10) of the SYNC SELECTOR switch. Switch S102 (front) controls the time constant of the grid circuit of V104B. When the switch is in the X10 position, rate determining capacitor C115 (250 uuf) is placed in the circuit, giving the shortest time constant and the highest repetition frequency. A longer time constant and a frequency one-tenth as great is obtained with switch S102 in the X1 position. Rate adjust potentiometers R121 and R124 are provided for higher category calibration of the repetition rate. The + and - positions of switch S102 are discussed in paragraph 5-4.

5-6. Sync-Out Amplifier Circuits

(fig. 5-4)

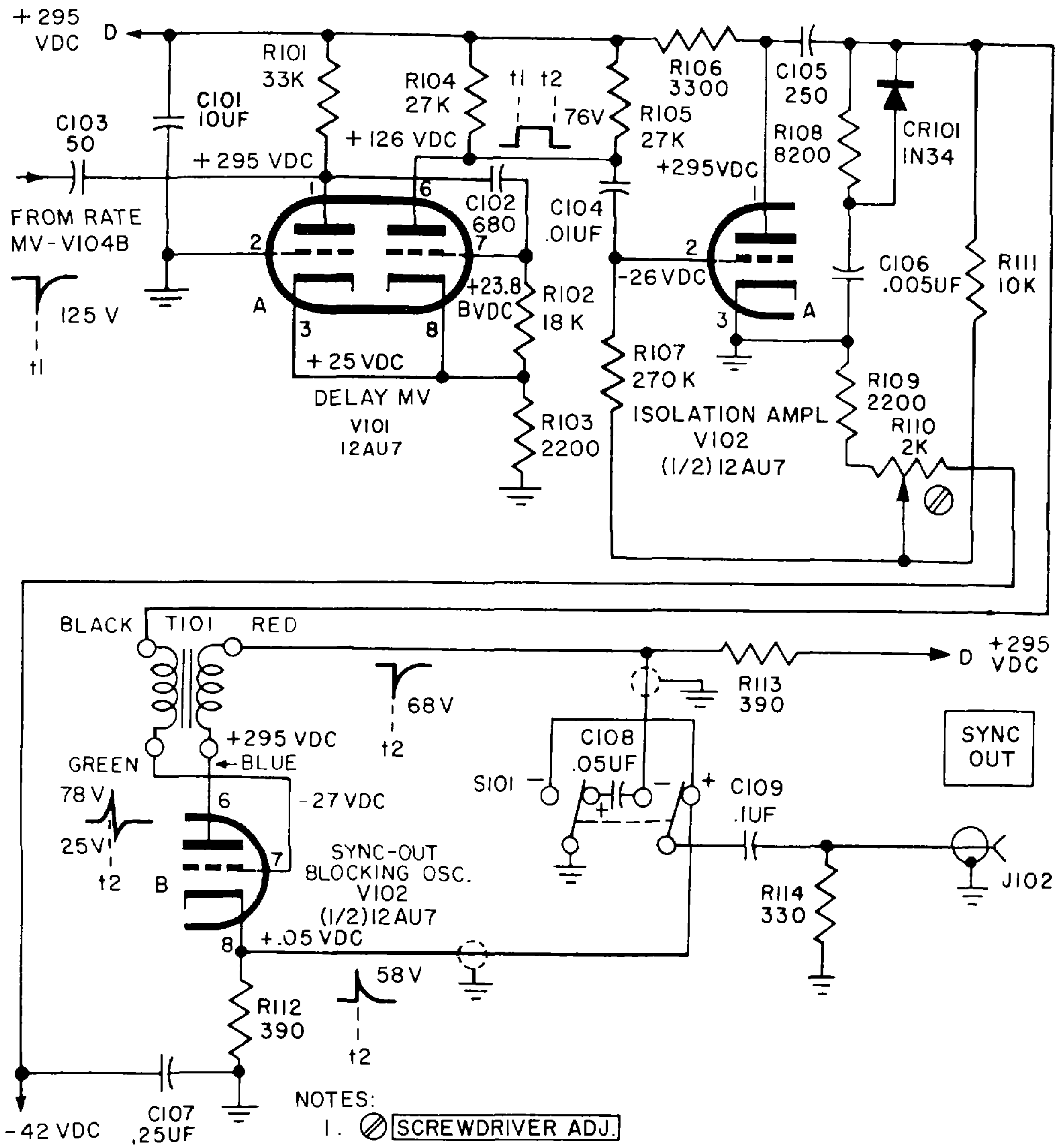
a. Pulses for synchronizing external equipment are generated and shaped by the sync-out circuits which consist of one-shot multivibrator V101, isolation amplifier V102A, blocking oscillator V102B, and associated circuitry. The repetition rate of the sync pulse provided by these circuits is controlled by rate multivibrator V104. Crystal CR102 clips the positive portions of the output signal from V104B. The remaining negative pulse is applied to the plate of V101. In equipment starting with serial number 1039, this pulse is applied to the cathode of V101B. (It also is applied to V105A which is discussed in paragraph 5-7.) This negative pulse triggers one-shot, cathode-coupled multivibrator V101. Multivibrator V101A is biased to cutoff by the cathode current of V101B flowing through resistor R103. The grid of V101B is held effectively at zero bias by resistor R102 which returns to the cathode of V101B.

b. The length of the pulse appearing at the plate of V101B controls the delay of the synchronizing signal with respect to the output pulse. This pulse length, which has a nominal value of 15 µsec, is determined by the time constant of resistor R102 and capacitor C102. The positive pulse at the plate of V101B is coupled to the grid of isolation amplifier V102A by capacitor C104. The grid of isolation amplifier V102A is held at a negative 26 volt bias by a regulated bleeder-bias network. The negative pulse at the plate of V102A is differentiated by capacitor C105 and resistor R108, resulting in a short negative-going pulse followed by a positive-going pulse.

c. These pulses correspond closely in position to the leading and trailing edges of the negative pulse at the plate of V102A. The negative portion of this differentiated signal is clipped by crystal CR101, and the positive portion is applied through the secondary winding of transformer T101 to the grid of blocking oscillator V102B. The grid of blocking oscillator V102B is held at a negative 27 volt bias by a regulated bleeder-bias network. Blocking oscillator V102B forms the actual sync-out pulse and delivers it to SYNC OUT connector J102 through polarity reversing switch S101.

d. In the position, switch S101 selects the negative pulses from the plate winding of transformer T101 and couples them to the SYNC OUT connector while simultaneously shorting out cathode resistor R112. In the + position, this switch selects the positive pulses developed across cathode resistor R112 and provides an ac ground through capacitor C108 for the negative pulses developed in the plate circuit. Resistor R114 serves as a terminating load resistance.

e. In instruments having serial numbers of 1439 and above, the circuitry is modified to accommodate a newer design of pulse transformer. In the newer circuit, crystal CR101 shorts to ground the negative pulse from V102A, but allows the positive-going trailing edge of the pulse to feed to the grid winding of the pulse transformer to trigger blocking oscillator V102B.



NOTES:

1. ⊘ SCREWDRIVER ADJ.
2. ALL RESISTOR VALUES IN OHMS AND ALL CAPACITOR VALUES IN MICROMICROFARADS UNLESS OTHERWISE SPECIFIED. K = 1,000 MEG = 1,000,000
3. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH 20,000-OHMS-PER-VOLT METER.
4. VOLTAGES MEASURED WITH CONTROLS SET AS FOLLOWS: SYNC SELECTOR, + OR −; SYNC OUT, +; ATTENUATION, 20 DB; PULSE POSITION, 0; PULSE LENGTH, 5USEC; PULSE RATE, 400 CPS; AMPLITUDE, 50; POLARITY, +.
5. WAVEFORM VOLTAGES ARE GIVEN AS MEASURED PEAK-TO-PEAK.

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Figure 5-4. Sync-out amplifier circuits.

5-7. Pulse Positioning Circuits
(fig. 5-5)

a. The negative pulse developed by rate multivibrator V104 is used to trigger one-shot, cathode-coupled multivibrator V105. Multivibrator V105A is biased to cut off by the cathode current of V105B flowing through resistor R131. The grid of V105B is held effectively at zero bias by resistor R133 and the two-section potentiometer (R132 and R132A) which return to the cathode. The grid voltage with respect to ground of V105B is 23.8 volts.

b. The PULSE POSITION potentiometer sections are connected in series, and R132A acts as a vernier on R132. Resistor R133 maintains a minimum resistance of 680 ohms from grid to cathode. At this setting, the pulse from V105B is 2 µsec long. At maximum setting of the PULSE POSITION control, the pulse is 112 µsec in length. This positive, variable length is applied to the grid of isolation amplifier V106A, where it is inverted. The negative variable-length pulse at the plate of V106A is differentiated by capacitor C123 and resistor R137; this action results in a short negative-going pulse followed by a short positive-going pulse. The trailing pulse edge is applied, through crystal rectifier CR103 and the grid winding of transformer T102, to the grid of thyratron trigger-blocking oscillator V106B. The output from V106B triggers TM 11-6625-237-14 the pulse-forming and pulse-terminating circuits simultaneously.

c. In instruments having serial numbers of 1439 and above, circuitry is modified to accommodate a newer design of pulse transformer. In the newer circuit, crystal CR103 shorts to ground the negative pulse from V106A, but allows the positive-going trailing edge of the pulse to feed to the grid winding of the pulse transformer to trigger blocking oscillator V106B.

d. The pulse from V106B is applied to cathode follower V107B and delay line DL101 which are used for impedance-matching and fixed delay insertions, respectively.

e. The fixed delay introduced by delay line DL101 is 2 µsec. This additional delay is required because of the design characteristics of pulse length multivibrator V108 which has a minimum pulse length of 2 µsec. In series with the grid of cathodefollower V107B is crystal rectifier CR104. This crystal rectifier prevents positive transients from the grid of pulse-forming thyratron V6 from feeding back to blocking oscillator V106B through the delay line and the cathode-grid capacitance of cathodefollower V107B. Crystal rectifier CR103 is used in the grid circuit of blocking oscillator V106B to reduce further the possibility of interaction because of feedback coupling from pulse-forming thyratron V6.

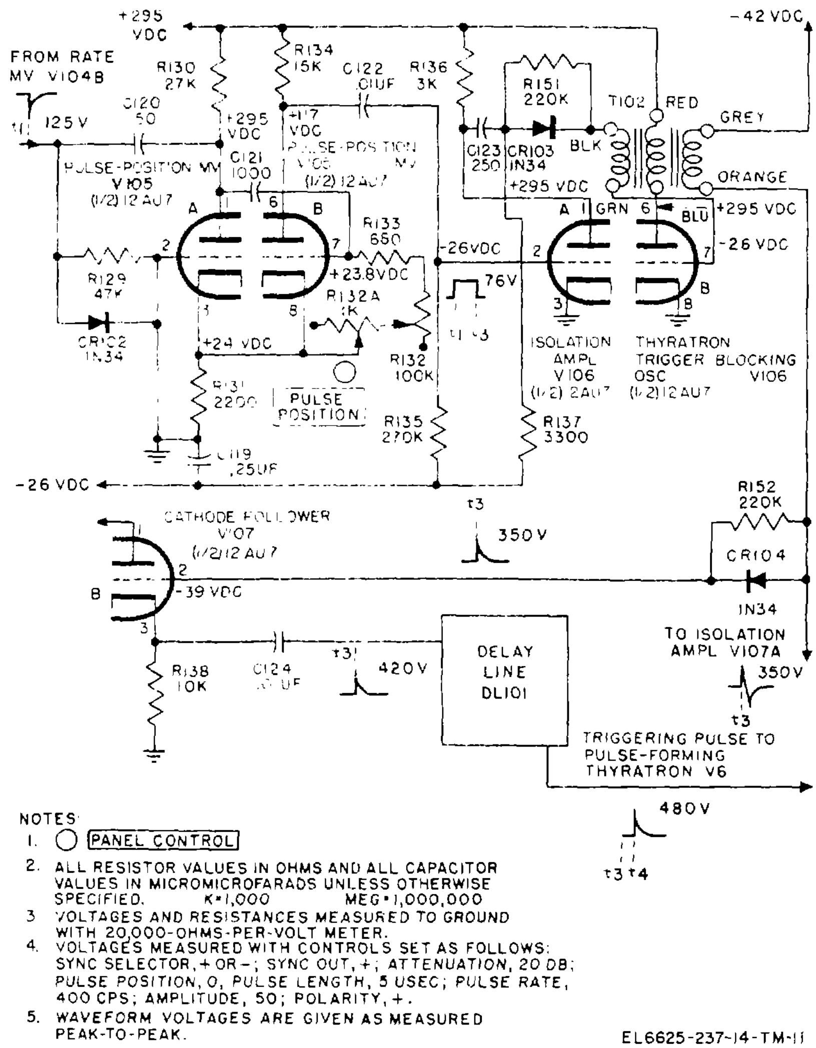


Figure 5-5. Pulse position circuits.

5-8. Pulse Length Circuits

(fig. 5-6)

a. The pulse generated by V107B serves as the triggering pulse for the main output signal. The pulse length circuits consisting of V107B, V108. and V109 develop a pulse which is used to terminate the main output pulse. The positive output pulse at the tertiary winding of transformer T102 is coupled through capacitor C127 (fig. 6-9) to the grid of isolation amplifier V107A.

b. The inverted pulse at the plate is coupled to the grid of positive grid-return, one-shot multivibrator V108. This multivibrator differs from V101, V104, and V105 in the method of biasing the grid of the first, or conducting, section of V108. With the grid returned to B +, a negative trigger may be used, a negative output pulse may be obtained, and more accurate control of the pulse length is available. Actual control of the pulse length is accomplished by potentiometer R142, PULSE LENGTH control on the front panel. The minimum pulse length may be adjusted by setting potentiometer R143 (a front deck screwdriver adjustment). The maximum length may be adjusted by varying C128 (also a screwdriver front deck adjustment).

c. The negative pulse at the plate of V108B is differentiated by capacitor C132 and resistor R150, resulting in a negative-going pulse closely followed by a positive-going pulse. The negative-and positive going pulses correspond in time position to the leading and trailing edges of the adjustment length pulse developed by multivibrator V108. This signal is applied through the grid winding of transformer T103 to the grid of V109A.

d. The positive pulse serves as a trigger for thyratron terminating blocking oscillator V109A. Crystal rectifier CR106 clamps the grid of V108B to the fixed bias supply to minimize changes in grid bias with changes in pulse rate. This action minimizes variations in pulse length with changes in pulse rate.

Crystal rectifier CR105 minimizes coupling of the positive trigger pulse to the grid bias supply. At the same time, CR105 provides a low impedance discharge path for the grid of V109A. In instruments having serial numbers of 1439 and above, the circuitry is modified to accommodate a newer design of pulse transformer. In the newer circuit, crystal CR105 shorts to ground the negative pulse from V108B, but allows the positive-going trailing edge of the pulse to feed to the grid winding of the pulse transformer in order to trigger blocking oscillator V108A.

e. The positive pulse developed across the tertiary winding of transformer T103 is fed to the grid of cathode-follower V109B, and the resulting positive pulse at the cathode (developed across cathode resistor R139) is fed to the grid of pulse terminating thyratron V16.

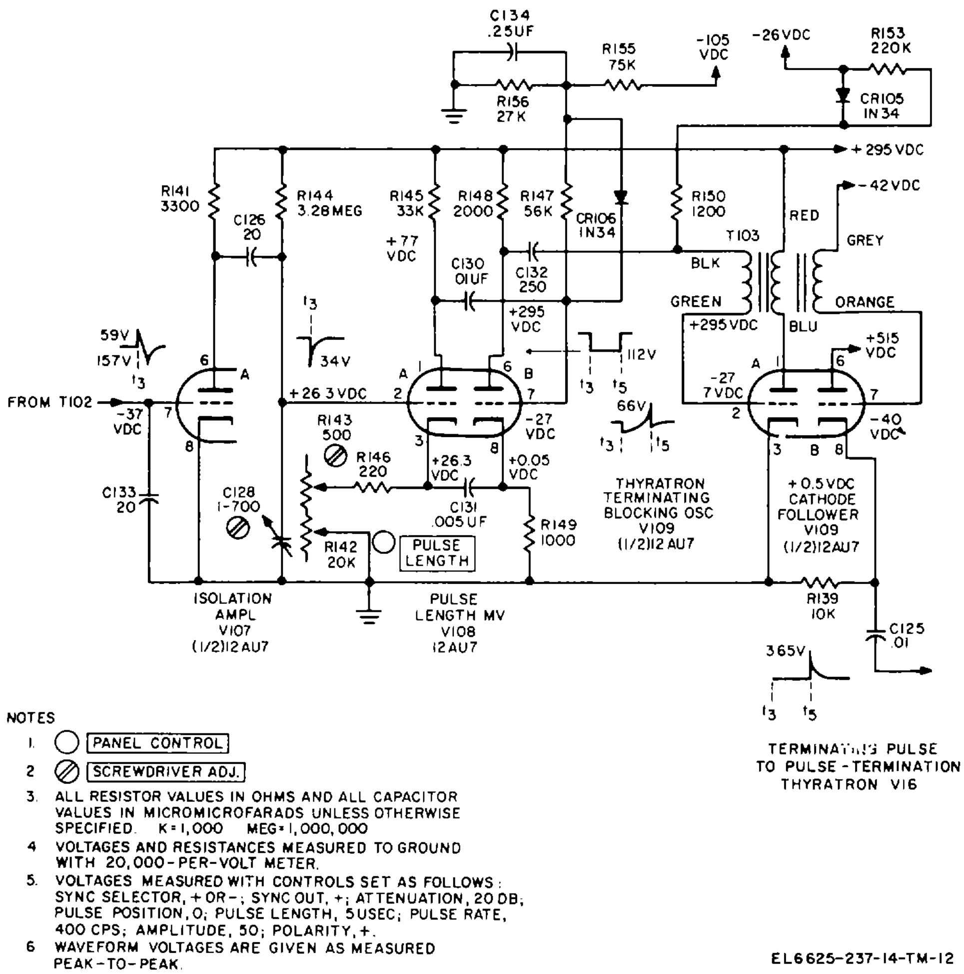


Figure 5-6. Typical pulse length circuits.

5-9. Pulse Generating Circuits
(fig. 5-7)

a. The circuits of the triggering and synchronizing section, which are described in paragraphs 5-4 through 5-8, develop critically timed pulses which control the generation and length of the output pulse. Actual control is accomplished in the grid circuits of pulse-forming thyratron V6 and pulse-termination thyratron V16, which turn the output pulse on and off, respectively. The high voltage required by pulse-forming thyratron V6 is supplied by high-voltage rectifier V1.

b. The effective dc voltage from this rectifier is raised by connecting the center tap of the high-voltage secondary winding to the 590-volt dc output of rectifier V13 instead of to ground. The center tap of the low-voltage secondary winding of transformer T2 is grounded. The resulting 1,100 volts (approximately) which are available at the cathode of high-voltage rectifier V1 is supplied to charging choke L2, through filter choke L1 (fig. FO-2) and then to the plate and screen of charging diode V2. The cathode of charging diode V2 at approximately 1,020 volts, is connected to the plate of pulse forming thyratron V6 and pulse-forming line X101.

c. The solenoid of relay REL1 which is in series with the center tap of the high-voltage secondary winding of transformer T1 serves as an overload protector. If V6 draws an excessive current, relay RELI energizes and applies a large negative voltage to the grid of charging diode V2. This action drives V2 to cutoff and removes plate voltage from thyratron V6. With thyratron V6 no longer drawing current, relay REL1 is no longer energized, returns to its original position, and applies dc to the plate of V6. This action is repetitive as long as excessive current is drawn through the center tap of the high-voltage secondary winding of transformer T1.

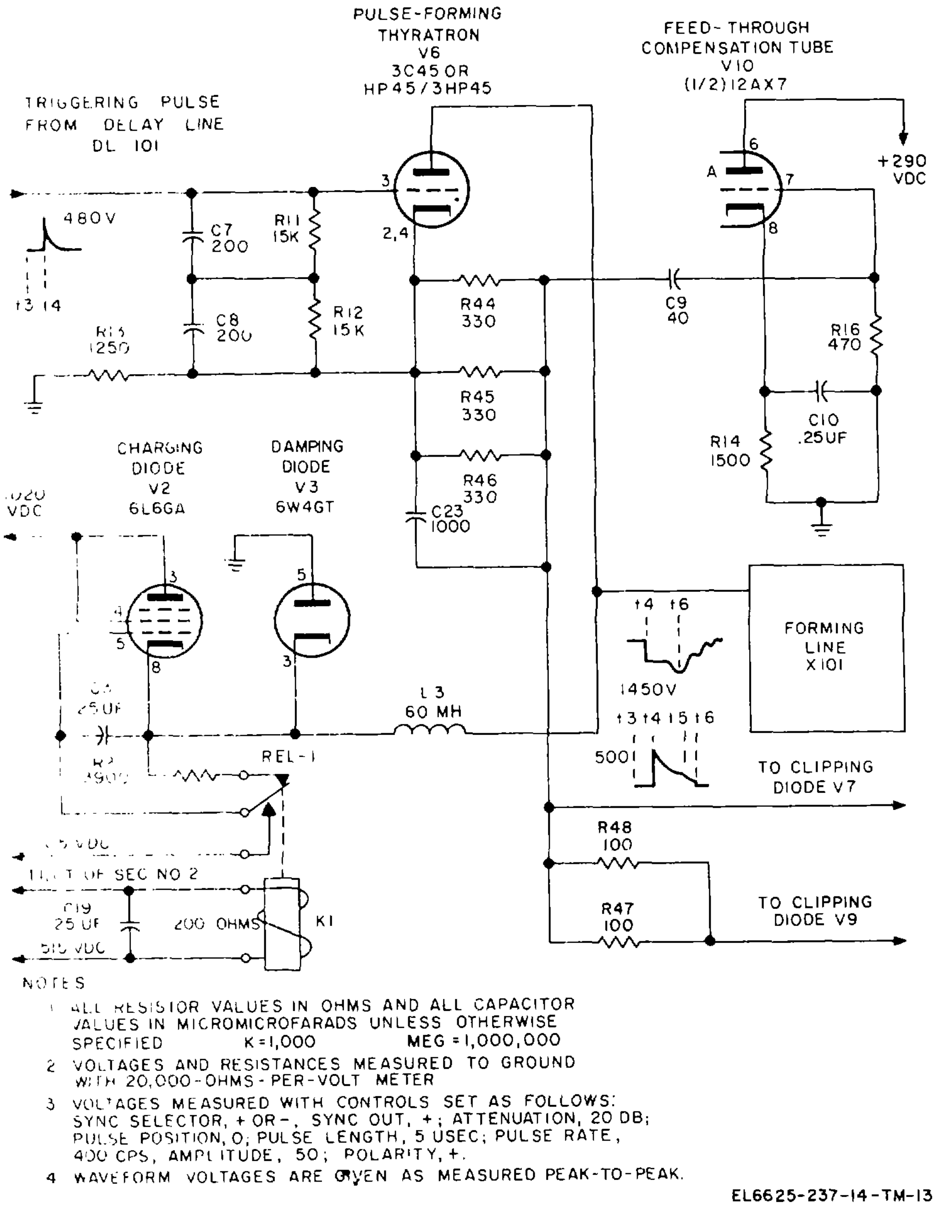


Figure 5-7. Pulse-generating circuits.

5-10. Pulse-Forming Thyratron Circuit
(fig. 5-7)

a. Application of dc voltage to pulse-forming line X101 through charging choke L2 causes the voltage across X101 to rise considerable above the dc supply voltage because of the initial charging transient. The voltage across X101 acts as the plate voltage for thyratron V6. The voltage reaches approximately 1,600 volts and is prevented from discharging back to the power supply voltage of 1,100 volts by charging diode V2. Thyratron V6 does not conduct until a trigger pulse is applied to the grid. This trigger pulse is obtained from cathode follower V107B through delay line DL101 and represents the leading edge of the main output pulse.

This trigger pulse when applied to the grid of thyratron V6 causes V6 to conduct heavily. This current flow discharges pulse-forming line X101, and the plate voltage of V6 falls.

b. Pulse-forming line X101 has been designed so that this fall in plate voltage results in a reflection from the open end of the line that drives the plate of thyratron V6 still further negative and stops conduction in the tube. This reflected negative voltage appears at the plate of V6 approximately 10.5 µsec after the application of the trigger pulse and the start of conduction. Immediately after V6 stops conducting, plate voltage starts to rise and the pulse-forming line recharges in preparation for the application of the next trigger pulse to the grid of V6, at which time the cycle repeats.

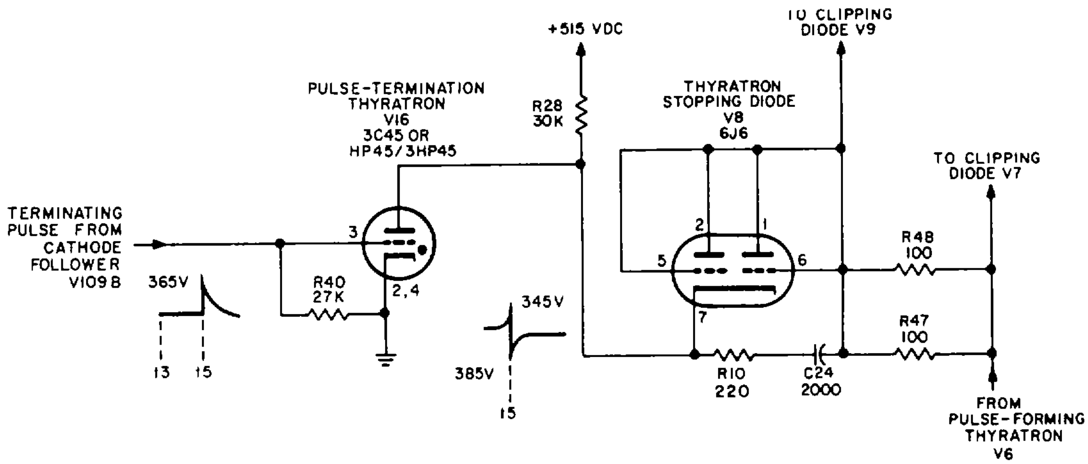
c. Damping diode V3 conducts when the negative reflection from X101 exceeds the voltage required to stop conduction in V6. During periods when V6 is conducting, a positive voltage is developed across cathode resistor R13. Since V6 goes from the non-conducting to the conducting condition in a very short time, the voltage at the cathode of V6 is a pulse having a very short, steep, leading edge and a duration of approximately 10.5 µsec.

5-11. Pulse-Terminating Circuit
(fig. 5-8)

a. Precision control of the length of the main output pulse is maintained by pulse-termination thyratron V16 and thyratron stopping diode V8. Thyratron V16 does not conduct until triggered by a pulse from cathode follower V109B. This pulse-terminating trigger, which follows the trigger applied to the grid of pulse-forming thyratron V6, is applied to the grid and causes conduction. The plate of V6 is connected to the cathode of thyratron stopping diode V8. The positive pulse developed in the cathode circuit of V6, after limiting to approximately 300 volts, is applied to the plate of V16 through diode V8. This pulse voltage, in addition to the dc voltage supplied through R28, causes V16 to conduct when its grid is fired by the pulse-terminating trigger.

b. This conduction accomplishes two things: First, V8 presents a very low impedance to the pulse from pulse-forming thyratron V6, and causes a very rapid fall of the pulse to form the trailing edge: second, in conjunction with resistor R10 and capacitor C24, it allows thyratron V16 to be extinguished.

c. In later equipment, particularly model SG69/FCC, R81 has been added. Resistor R81 is a 220ohm current-limiting resistor in series with the grid of V16, and has been installed to minimize jitter on the trailing edge of the output pulse. The jitter sometimes occurred because of low amplitude parasitic oscillation in the grid circuit of stop thyratron V16.



NOTES:
1. ALL RESISTOR VALUES IN OHMS AND ALL CAPACITOR VALUES IN MICRMICROFARADS UNLESS OTHERWISE SPECIFIED K=1,000 MEG=1,000,000
2. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH 20,000-OHMS-PER-VOLT METER.
3. VOLTAGES MEASURED WITH CONTROLS SET AS FOLLOWS: SYNC SELECTOR, + OR -; SYNC OUT, +; ATTENUATION 20 DB PULSE POSITION, 0; PULSE LENGTH, 5 USEC; PULSE RATE, 400CPS; AMPLITUDE, 50; POLARITY, +.
4. WAVEFORM VOLTAGES ARE GIVEN AS MEASURED PEAK-TO-PEAK.

EL6625-237-14-TM-14

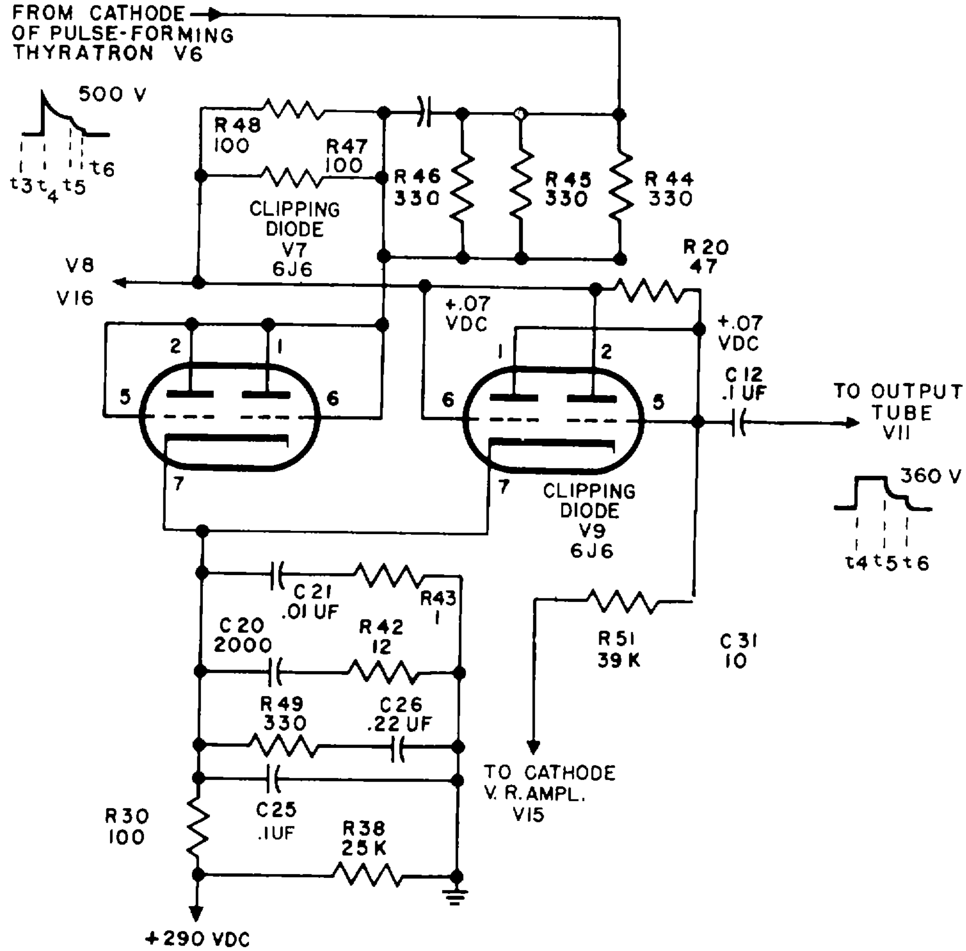
Figure 5-8. Typical pulse-terminating circuits.

5-12. Pulse-Clipping Circuits

(fig. 5-9)

a. The pulse appearing on the cathode of thyratron V6 is applied to the plate of clipping diode V7. The cathode of V7 is supplied with a bias variable from approximately 260 to 320 volts by means of the AMPLITUDE control. Therefore, V7 clips the pulse at approximately the value of the bias. This clipped pulse is passed through a second clipping network, consisting of resistors R47, R48, and diode V9. The pulse is then applied to the plates of thyratron stopping diode V8.

b. The cathode of the second clipping diode V9 is also biased to the 260-320-volt value. The action of V9 is to further smooth the top of the pulse. Diode V9 also reduces the top of the pulse and variations resulting from the action of thyratron stopping diode V8. From V9, the pulse is fed to the grid of output tube V11.



NOTES:

1. ALL RESISTOR VALUES IN OHMS AND ALL CAPACITOR VALUES IN MICROMICROFARADS UNLESS OTHERWISE SPECIFIED. K=1,000 MEG=1,000,000
2. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH 20,000-OHMS-PER-VOLT METER.
3. VOLTAGES MEASURED WITH CONTROLS SET AS FOLLOWS: SYNC SELECTOR, + OR −; SYNC OUT, +; ATTENUATION, 20 DB; PULSE POSITION, 0; PULSE LENGTH, 5 USEC; PULSE RATE, 400 CPS; AMPLITUDE, 50; POLARITY, +.
4. WAVEFORM VOLTAGES ARE GIVEN AS MEASURED PEAK-TO-PEAK.

EL6625-237-14-TM-15

Figure 5-9. Pulse-clipping circuits.

5-13. Feedthrough Compensating Stage.
(fig. 5-7)

a. To compensate for distortion in the output pulse caused by the grid-to-plate capacitance in output tube V11, feedthrough compensation stage V10 has been incorporated. The grid-to-plate capacitance of V11 causes a relatively low amplitude positive spike to appear in the output of V11 at the time of the start of the main output pulse. When a negative output pulse is selected, this spike appears as a short positive pip immediately preceding the leading edge of the negative pulse. When a positive output is selected, this spike appears as a notch in the leading edge of the output pulse. Stage 'V10A minimizes this effect.

b. The grid of V10A is fed from a differentiating network (capacitor C9 and resistor R16) which connects to the cathode circuit of pulse-forming thyratron V6. The resulting short positive and negative pulses correspond in time to the leading and trailing edge of the pulse at the cathode of V6. These pulses are amplified and inverted by V10A and the negative leading pulse is applied to the plate of V11 through adjustable capacitor C11 (fig. 5-10).

Capacitor C11 is used to vary the amplitude of the compensating spike which cancels out the undesired leading edge spike generated in V11.

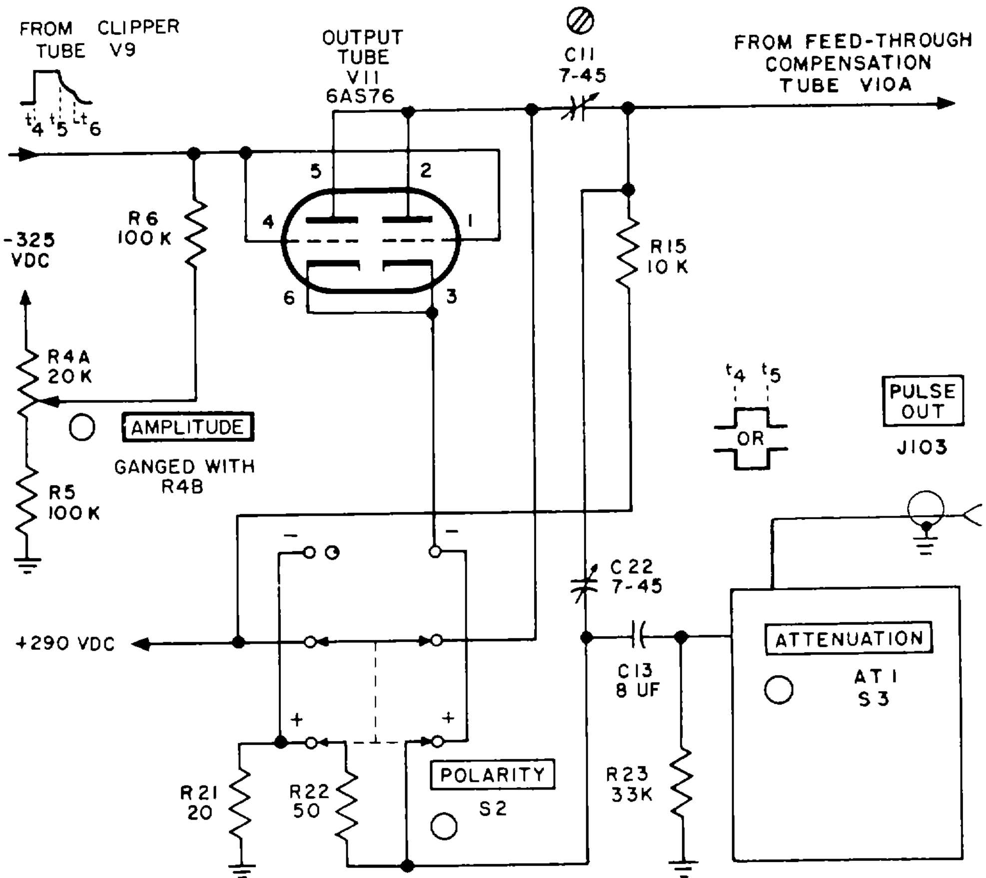
5-14. Output Circuits

(fig. 5-10)

a. After the final shaping and smoothing action of the upper portions of the output pulse by clipping diode V9, it is coupled to the paralleled grids of output stage V11 through capacitor C12. These paralleled grids are connected to a bias supply (-360 volts) through potentiometer R4A. This potentiometer, which is one section of the AMPLITUDE control, permits varying the bias voltage on the grids from -300 to -360 volts. Potentiometer R4B, the second section of the Amplitude control, controls the grid bias on voltage regulator amplifier V15 which, in conjunction with voltage regulator V17A, controls the plate voltage applied to output tube V11 and the cathode bias on clipping diodes V7 and V9.

b. Polarity switch S2 provides facilities for selecting a positive or negative polarity pulse for application to attenuator AT1. When in the position, resistor R21 is the V11 cathode load, and resistor R22 is the plate load across which the output pulse is developed. In the + position, resistor R22 is switched in series with resistor R21 in the cathode circuit and ac ground while capacitors C5 and C27 (fig. FO-2), are connected to the plate.

c. The positive pulse voltage developed across resistors R21 and R22 is coupled to attenuator AT1 through capacitor C13. To provide a more constant pulse amplitude with changes in repetition rate and pulse length, a compensation circuit is incorporated. When either the rate or pulse length is increased, a positive voltage is applied to the cathode of voltage regulator amplifier V15 through resistor R51 (fig. FO-2) which causes the plate voltage of output tube V11 and the cathode bias of clipping diodes V7 and V9 to increase. This compensates for the decrease in amplitude which otherwise would occur when the rate or pulse length was increased. Attenuator AT1 is used to reduce the amplitude of the output pulse in 10-db steps with a maximum attenuation of 60 db available. Intermediate values of attenuation may be obtained by setting the AMPLITUDE control which has a continuous range over 10 db.



NOTES:
1. ◯ PANEL CONTROL
2. ⊘ SCREWDRIVER ADJ.
3. ALL RESISTOR VALUES IN OHMS AND ALL CAPACITOR VALUES IN MICROMICROFARADS UNLESS OTHERWISE SPECIFIED. K=1,000 MEG=1,000,000
4. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH 20,000-OHMS-PER-VOLT METER.
5. VOLTAGES MEASURED WITH CONTROLS SET AS FOLLOWS: SYNC SELECTOR, + OR −; SYNC OUT, +; ATTENUATION, 20 DB; PULSE POSITION, 0; PULSE LENGTH, 5 USEC; PULSE RATE, 400 CPS; AMPLITUDE, 50; POLARITY, +.
6. WAVEFORM VOLTAGES ARE GIVEN AS MEASURED PEAK-TO-PEAK.

EL6625-237-14-TM-16

Figure 5-10. Output circuits.

CHAPTER 6

GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

Section I. GENERAL

6-1. Scope of General Support Maintenance

The procedures for troubleshooting and maintenance of the pulse generator are contained in subsequent sections of this chapter. Where applicable, the procedures include instructions for making voltage and resistance measurements and instructions for replacing components when the procedure is not obvious. When making voltage and resistance measurements, observe the instructions in paragraph 6-2.

6-2. Voltage and Resistance Measurements

WARNING

When servicing the pulse generator, be extremely careful of exposed high voltages. With the equipment deenergized, potentials as great as 500 volts may be retained in charged capacitors. Prior to touching any part, short the part to ground. Use only one hand when measuring tube socket voltages.

Make all voltage and resistance measurements using Multimeter AN/USM-223, or equivalent, at the points specified in the troubleshooting chart. To make additional voltage, resistance, or continuity measurements that are not specified in table 6-1, refer to the appropriate schematic and wiring diagrams to determine the test point desired.

Section II. TOOLS AND EQUIPMENT

6-3. Common Tools and Test Equipment

Tools and test equipment required for troubleshooting the pulse generators are listed below.

a. Oscilloscope AN/USM-281 A (NSN 6625-00228-2201).

b. Generator, Signal AN/USM-358 (NSN 662500-455-7302.

c. Multimeter AN/USM-223 (NSN 6625-00-9997465).

d. Tool Kit, Electronic Equipment TK-100/G (NSN 5180-00-605-0079).

e. Test Set, Electron Tube TV-7/U (NSN 662500-820-0064).

f. Counter, Electronic, Digital Readout AN/USM-459 (NSN 6625-01-061-8928).

6-4. Special Tools and Equipment

No special tools and equipment are required for general support maintenance.

Section III. TROUBLESHOOTING

6-5. General

Troubleshooting at general support maintenance includes all techniques outlined for organizational maintenance (ch 4) and any special or additional techniques required to isolate a defective part. Paragraphs 6-7 through 6-11 describe localizing and isolating techniques to be used within the unit.

6-6. Organization of Troubleshooting Procedures

a. *General.* The first step in servicing any defective electronic component is to sectionalize the fault. Sectionalization means tracing the fault to the major circuit responsible for the abnormal operation of the equipment. The second step is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition. Some faults, such as burned-out resistors and shorted transformers, can often be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltage and resistance.

b. *Component Sectionalization and Localization*. The tests listed below aid in isolating the source of trouble. To be effective, the procedure should be followed in the order given.

Remember that servicing procedure should cause no further damage to the pulse generator. First, trouble should be localized to a single stage or circuit. Then the trouble may be isolated within that stage or circuit by appropriate voltage, resistance, and continuity measurements. The service procedure is summarized as follows:

(1) *Visual inspection*. The purpose of visual inspection (para 6-7) is to locate any visible trouble. Through this inspection alone, the repairman frequently may discover the trouble or determine the stage in which the trouble exists. This inspection is valuable in avoiding additional damage to the pulse generator which might occur through improper servicing methods and in forstalling future failures.

(2) *Input resistance measurements*. These measurements (para 6-8) prevent further damage to the pulse generator from possible short circuits. Since this test gives an indication of the condition of the filter circuits, its function is more than preventive.

(3) *Troubleshooting table*. The trouble symptoms listed in table 6-2 will aid greatly in localizing trouble.

(4) *Intermittents.* In all these tests the possibility of intermittents must not be overlooked. If present, this type of trouble often may be induced by tapping or jarring the set. It is possible that the trouble may not be in the pulse generator itself, but in the installation or other external conditions.

CAUTION

Do not attempt removal or replacement of parts before reading the instructions in paragraph 6-12.

6-7. Visual Inspection

a. Failure of the pulse generator to operate properly usually will be caused by one or more of the following faults:

(1) Improperly connected power cable, or no voltage at the outlet into which the power cable is connected.

(2) Burned-out fuse.

(3) Broken wires.

(4) Defective tubes.

(5) Improperly connected output or input cables.

(6) Worn, broken, or disconnected cords or connectors.

b. When failure is encountered and the cause is not immediately apparent, check as many of the items in a above as is practicable before starting a detailed examination of the individual parts of the circuit. If possible, obtain information from the person who normally uses the equipment regarding performance at the time trouble occurred.

6-8. Checking Filament and B+ Circuits for Shorts

a. *When to Check*. Trouble within the pulse generator often may be detected by checking the resistance of the filament and high-voltage circuits before applying power to the equipment, thereby preventing damage to the power supply. Perform the checks whenever abnormal conditions occur during operation or operational tests that indicate possible power supply troubles.

b. *Conditions for Tests*. To prepare for short circuit tests, perform the following steps:

(1) Disconnect power cord from power source.

(2) Set POWER ON switch to off position.

(3) Remove all tubes from tube sockets.

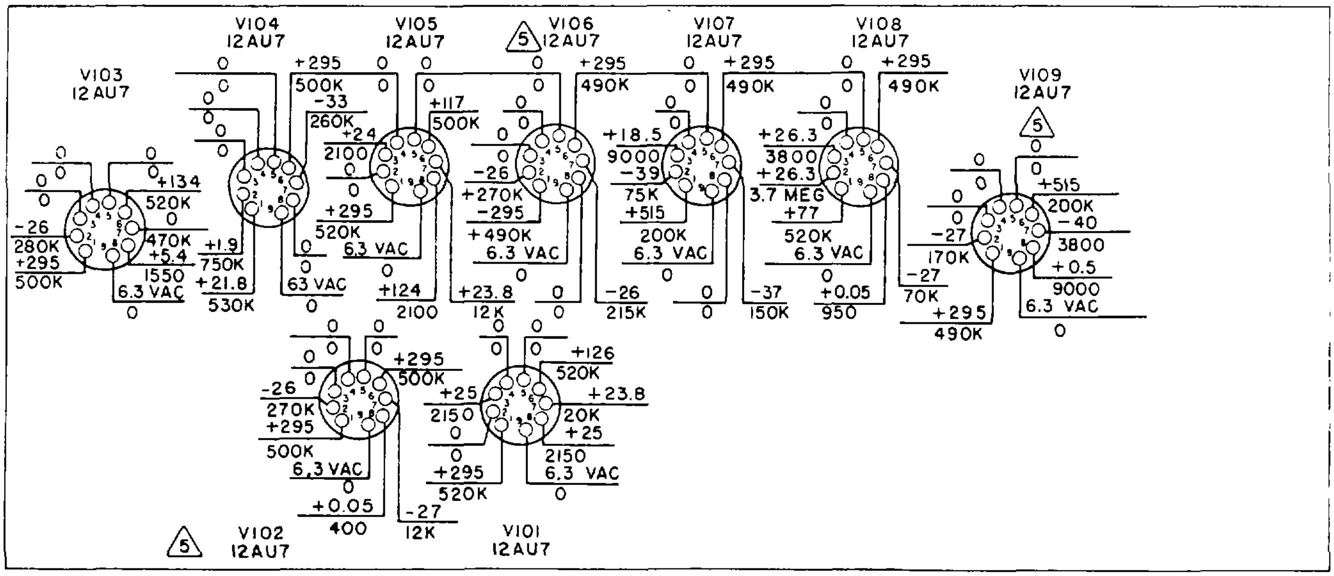
c. *Measurements*. Perform the resistance measurements indicated in table 6-1. If abnormal indications are obtained, perform the additional isolating procedures outlined. When the faulty part is located, repair the trouble before applying power to the equipment.

Table 6-1. Short Circuit Tests

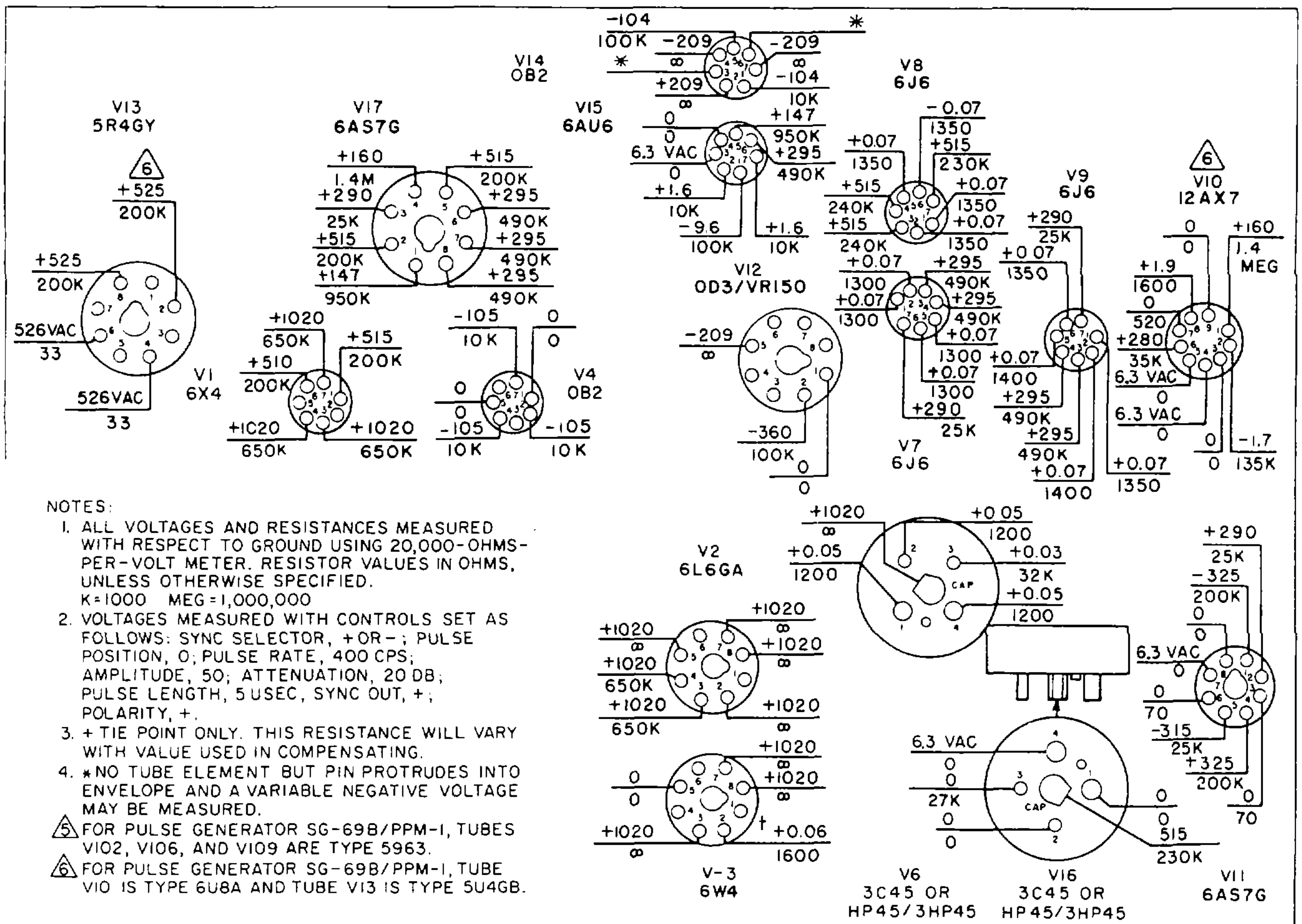
Point of measurement	*Normal indication*	*Isolating procedure*
From tube socket V1, pin 7 (fig. 6-1) to ground	Resistance indication of approximately 650K ohms. For equipment with serial numbers of 1239 and above, indication should be approximately 550K ohms.	If resistance indication is less than normal, check capacitors C1 and C2 for shorts.
From tube socket V13, pin 8 (fig. 6-1) to ground	Resistance indication of approximately 200K ohms. For equipment with serial numbers of 1239 and above, indication should be approximately 83K ohms.	If resistance indication is less than normal, check capacitors C14, C16, and C16 for shorts.
From tube socket V16, pin 1 (fig. 6-1) to ground	Zero resistance indication	If any resistance indication is noted, check for shorts to ground in wiring between tube socket V16 and secondary winding of transformer T2.

Table 6-1. Short Circuit Tests-Continued

Point of measurement	Normal indication	Isolating procedure
From tube socket V15, pin 4 (fig. 6-1) to ground	Zero resistance indication	If any resistance indication is noted, check for shorts to ground in wiring between tube socket V15 and secondary winding of transformer T2.
From tube socket V10, pin 9 (fig. 6-1) to ground	Zero resistance indication	If any resistance indication is noted, check for shorts to ground in wiring between tube socket V10 and secondary winding of transformer T2.
From tube socket V11, pin 8 (fig. 6-1) to ground	Zero resistance indication	If any resistance indication is noted, check for shorts to ground in wiring between tube socket V11 and secondary winding of transformer T2.
From tube socket V3, pin 8 (fig. 6-1) to ground	Infinite resistance indication	If resistance indication is less than normal, check for short to ground in wire between pin 8 and secondary winding of transformer T2. Also check continuity of T2 secondary windings.
From tube socket V8, pin 4 (fig. 6-1) to ground	Resistance indication of approximately 240K	If resistance indication is less than normal, check for shorts to ground in wiring between tube socket V8 and secondary winding of transformer T2.
From tube socket V6, pin 1 (fig. 6-1) to ground	Infinite resistance indication	If resistance indication is less than normal check capacitor C28, resistors R27 and R50, inductors L6 and L7, and associated wiring to secondary winding of transformer T2 for shorts.



FRONT DECK



NOTES:

1. ALL VOLTAGES AND RESISTANCES MEASURED WITH RESPECT TO GROUND USING 20,000-OHMS-PER-VOLT METER. RESISTOR VALUES IN OHMS, UNLESS OTHERWISE SPECIFIED. K=1000 MEG=1,000,000
2. VOLTAGES MEASURED WITH CONTROLS SET AS FOLLOWS: SYNC SELECTOR, + OR −; PULSE POSITION, 0; PULSE RATE, 400 CPS; AMPLITUDE, 50; ATTENUATION, 20 DB; PULSE LENGTH, 5 USEC, SYNC OUT, +; POLARITY, +.
3. + TIE POINT ONLY. THIS RESISTANCE WILL VARY WITH VALUE USED IN COMPENSATING.
4. * NO TUBE ELEMENT BUT PIN PROTRUDES INTO ENVELOPE AND A VARIABLE NEGATIVE VOLTAGE MAY BE MEASURED.

5 (in triangle) FOR PULSE GENERATOR SG-698/PPM-1, TUBES V102, V106, AND V109 ARE TYPE 5963.

6 (in triangle) FOR PULSE GENERATOR SG-698/PPM-1, TUBE V10 IS TYPE 6U8A AND TUBE V13 IS TYPE 5U4GB.

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Figure 6-1. Tube socket voltage and resistance diagram.

6-9. Localizing Troubles.
Troubleshooting table 6-2 outlines procedures for sectionalizing troubles in the pulse generator. Tube locations are shown in figure 2-2. Component locations are identified in figures 6-2 through 6-7.

6-10. Voltage and Resistance Checks.

a. *Measurements*. Voltage and resistance measurements are shown in figures 6-1 and 6-5, 6-6, and 6-7. When a trouble has been localized to a particular stage or circuit, use voltage and resistance measurements to isolate the trouble to a particular part.

b. *Use of Troubleshooting Table.* When an abnormal symptom has been observed in the equipment, look for a description of this symptom in the Malfunction column, and perform the corrective measures listed in the Corrective action column.

CAUTION

If operational symptoms are not known, or if they indicate the possibility of short circuits within the equipment, perform the short circuit checks described in paragraph 6-8 before applying power to the equipment.

c. *Conditions for Tests.* All checks outlined in the table are to be conducted with the equipment connected to a power source and to a test oscilloscope as indicated in table 4-1.

Table 6-2. Troubleshooting

Malfunction	Probable cause	Corrective action
1. Overload relay REL-1 chatters when equipment is energized	Tube V6 defective	Replace V6 or interchange V6 and V16. Check pulse length adjustment (para 6-13c).
	Tube V104 defective	Replace V104 and check pulse rate adjustment (para 6-13e).
	Tube V105 or V106 defective	Replace V105 or V106.
	Relay REL-1 defective	Clean relay contacts, adjust relay spring tension (para 6-13g) or replace relay.
2. Oscilloscope indicates jitter on leading edge of output pulse.	Tube V6 defective	Replace V6 and check pulse length adjustment (para 6-13c).
3. No sync output pulse available.	Tube V6 defective.	Replace V6 and check pulse length adjustment (para 6-13c).
	Tube V1 or V2 defective Inductor L3 defective	Replace V1 or V2.
	Tube V105 or V106 defective.	Replace L3.
	Capacitor C135 or C138 defective.	Replace V105 or V106.
	Tube V3 or V9 Defective.	Replace C135 of C138.
4. Oscilloscope indicates overshoot on leading edge of output pulse	Capacitor C31 defective.	Replace V3 or V9.
	Tube V1, V2, or V6 defective.	Replace C31.
5. Oscilloscope indicates deterioration on top of output pulse.	Tube V104 defective.	Replace V1, V2, or V6.
	Relay REL-1 defective.	Replace V104 and check pulse rate adjustment (para 6-13e).
	Inductor L2 or L3 defective.	Clean relay contacts, adjust relay spring tension (para 6-13g), or replace relay.
	Tube V7 or V9 defective.	Replace L2 or L3.
6. Oscilloscope indicates an unclipped output pulse with high amplitude peaks		Replace V7 or V9. If either V7 or V9 has shorted, resistor R30 will also be defective and must be replaced.
7. Oscilloscope indicates an enlarged trace at top of output pulse.	Tube V17 defective.	Replace V17 and check regulated voltage adjustment (para 6-13a).
	Tube V15 defective.	Replace V15 and check regulated voltage adjustment (para 6-13a).
	Tube V11 defective.	Replace V11.
8. Oscilloscope indicates that top of Output pulse rolls off prematurely between 1.0 and 6.0 sec.	Capacitor C135, C136, C137, or C138 defective.	Replace defective capacitor.
9. Oscilloscope indicates jitter on trailing edge of output pulse.	Tube V16 or V18 defective.	Replace V16 or V18 and check pulse length adjustment (para 6-13c).
	Tube V8 defective.	Replace V8.
	Crystal CR105 defective.	Replace CR105.
10. Oscilloscope indicates jitter on both edges of output pulse.	Tube V101, V105, or V106 defective.	Replace defective tube.
	Tube V104 defective.	Replace V104 and check pulse rate adjustment (para 6-13e).
	Crystal CR102 or CR103 defective.	Replace CR102 or CR103.

Table 6-2. Troubleshooting- Continued

Malfunction	Probable cause	Corrective action
11. Oscilloscope indicates trigger pulse but no output pulse.	Tube V11 defective.	Replace V11.
	Resistor R21 or R22 defective.	Replace R21 or R22.
12. Oscilloscope does not indicate sync output pulse.	Tube V101 or V102 defective.	Replace V101 or V102.
	Crystal CR101 defective.	Replace CR101.
	Transformer T101 defective.	Replace T101
13. Oscilloscope indicates insufficient output pulse amplitude.	Resistor R35 out of adjustment.	Adjust R35 (para 6-13d)

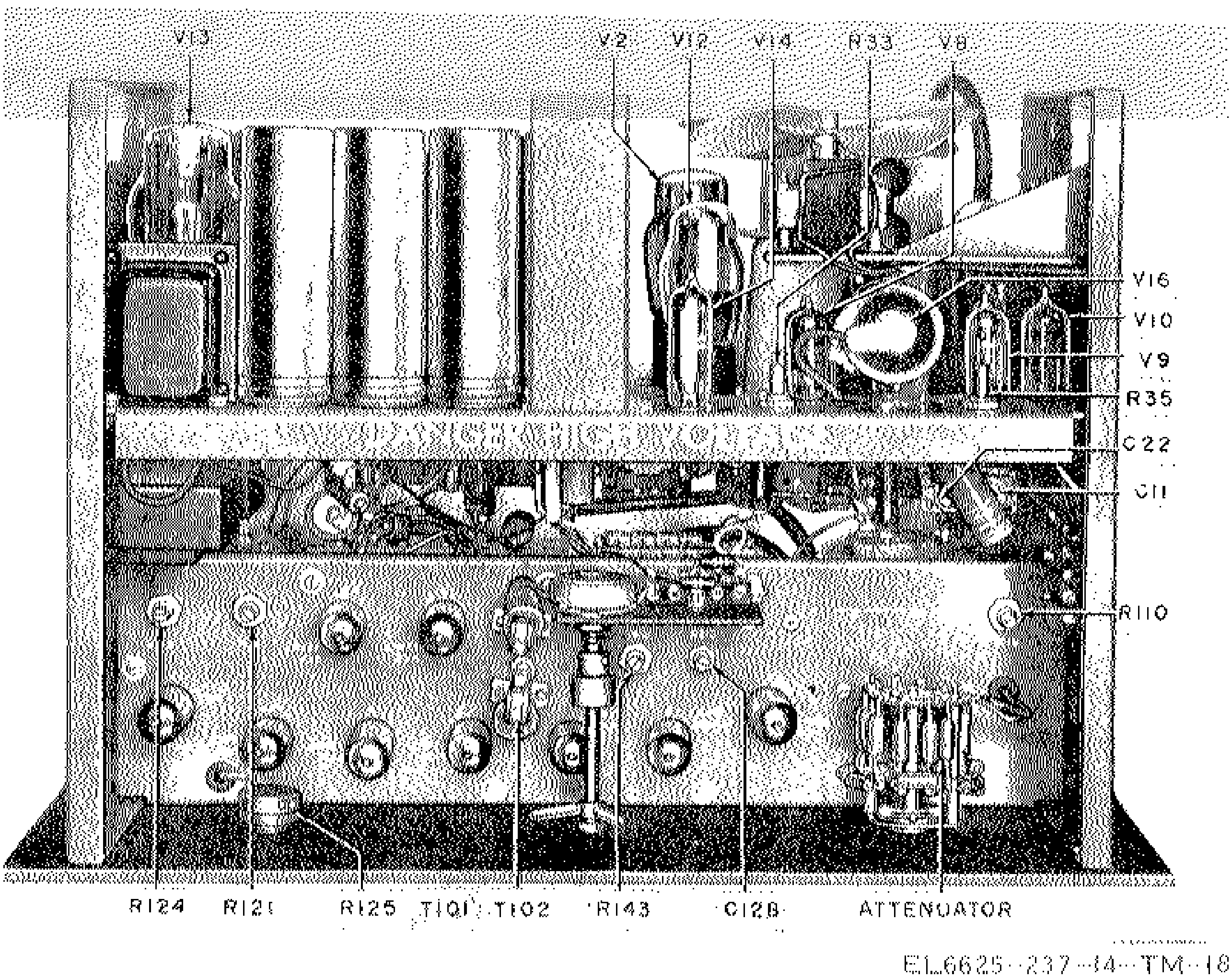


Figure 6-2. Pulse generator, component locations (top view).

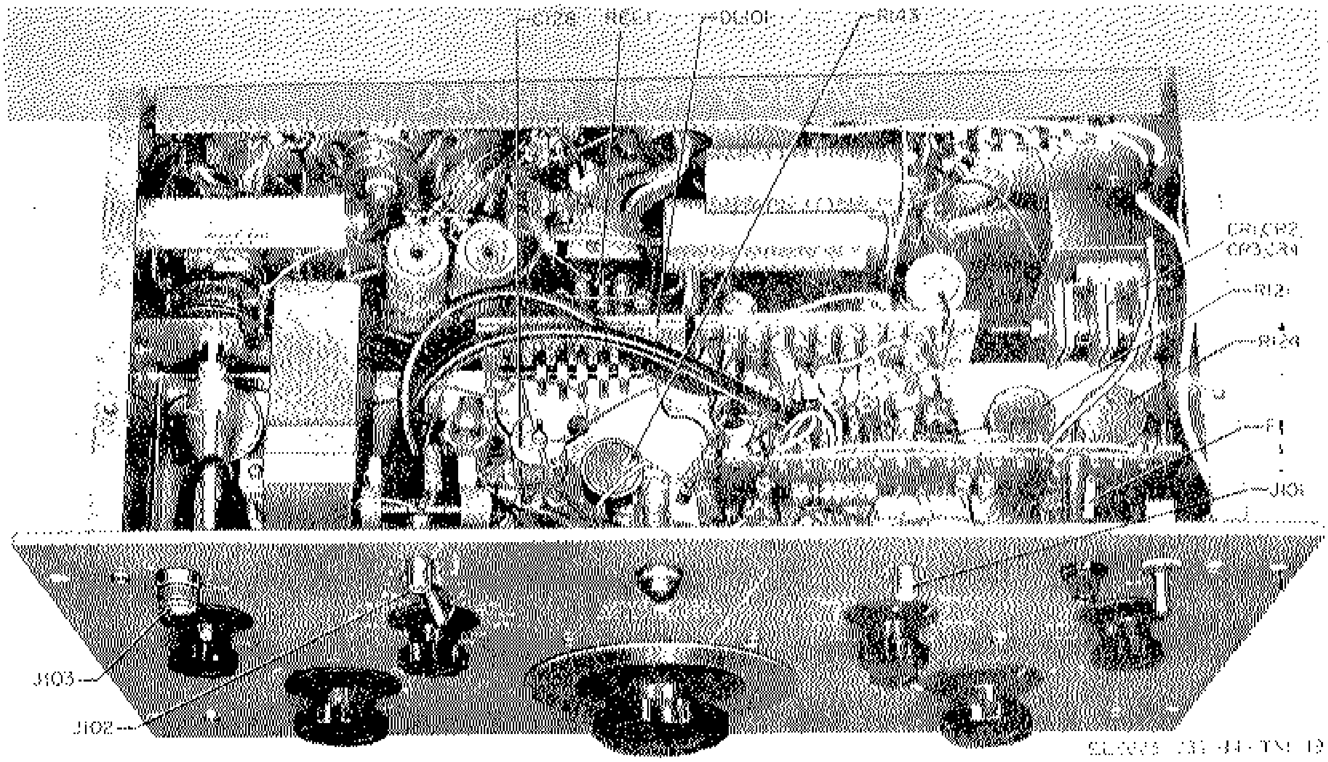
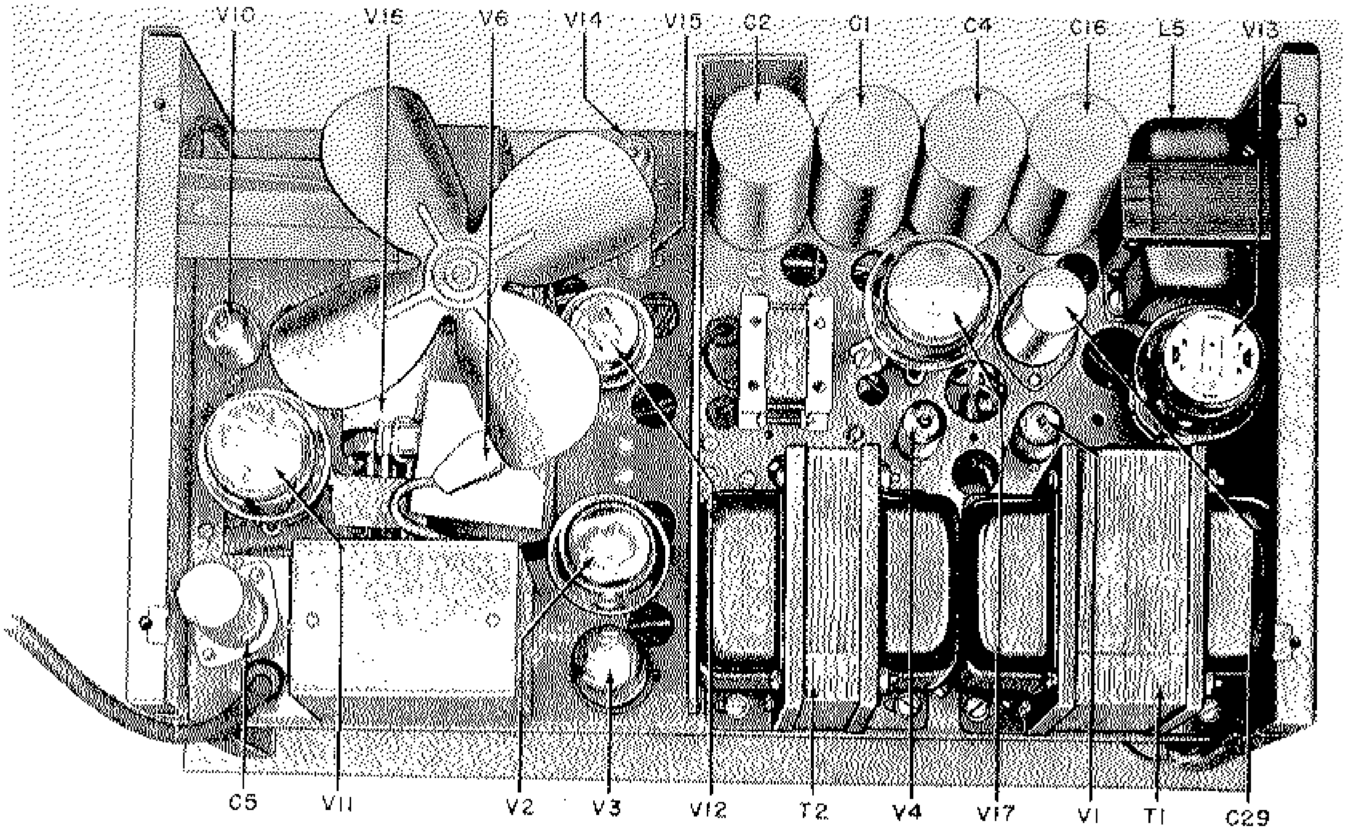


Figure 6-3. Pulse generator, component locations (bottom view).


V10
V16
V6
V14
V15
C2
C1
C4
C16
L5
V13
C5
V11
V2
V3
V12
T2
V4
V17
V1
T1
C29
EL6625-237-14-TM-20

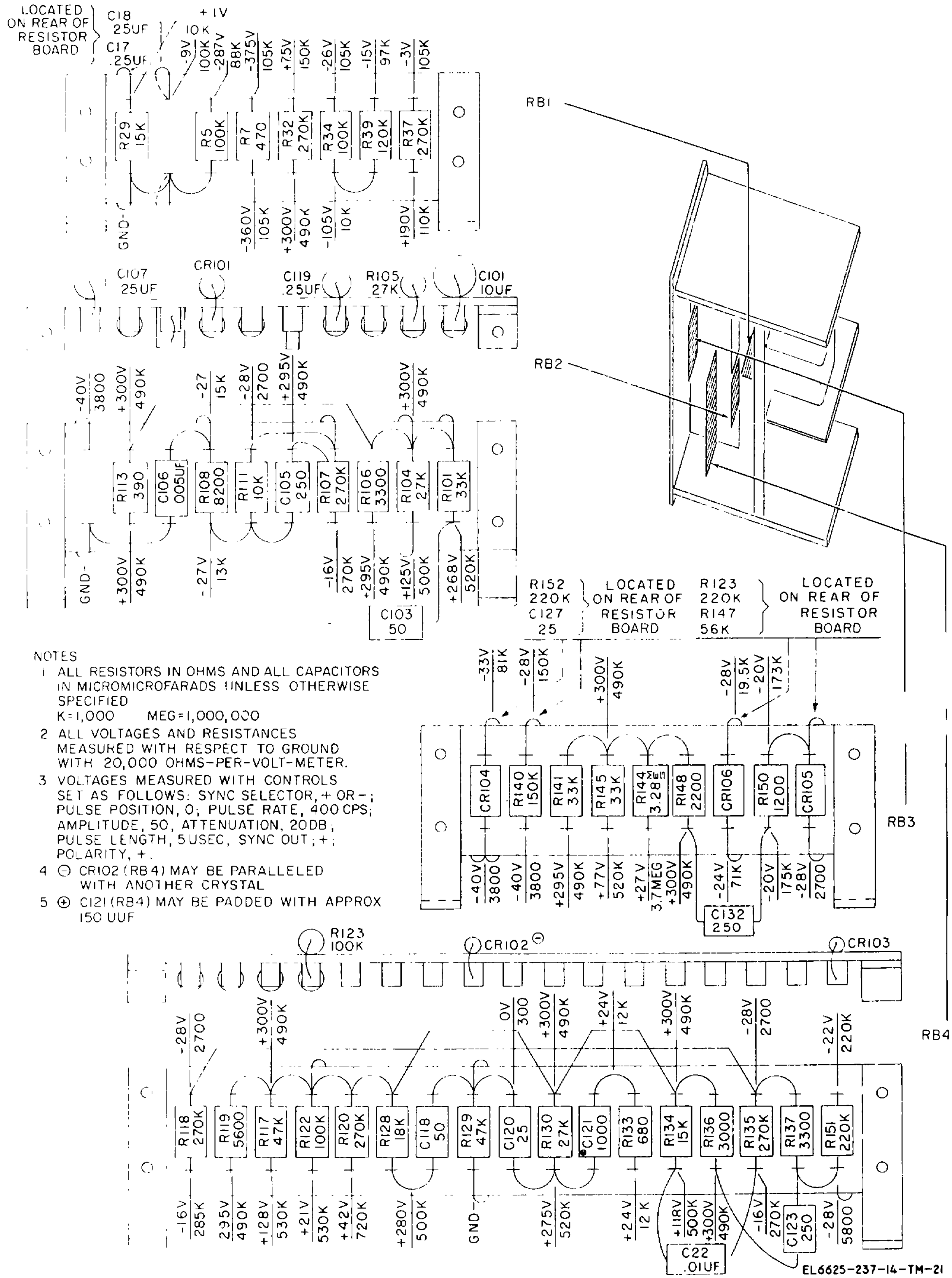


Figure 6-5. Generator, Pulse SG-69/PPM-1 terminal board, component locations,voltage and resistance diagram.

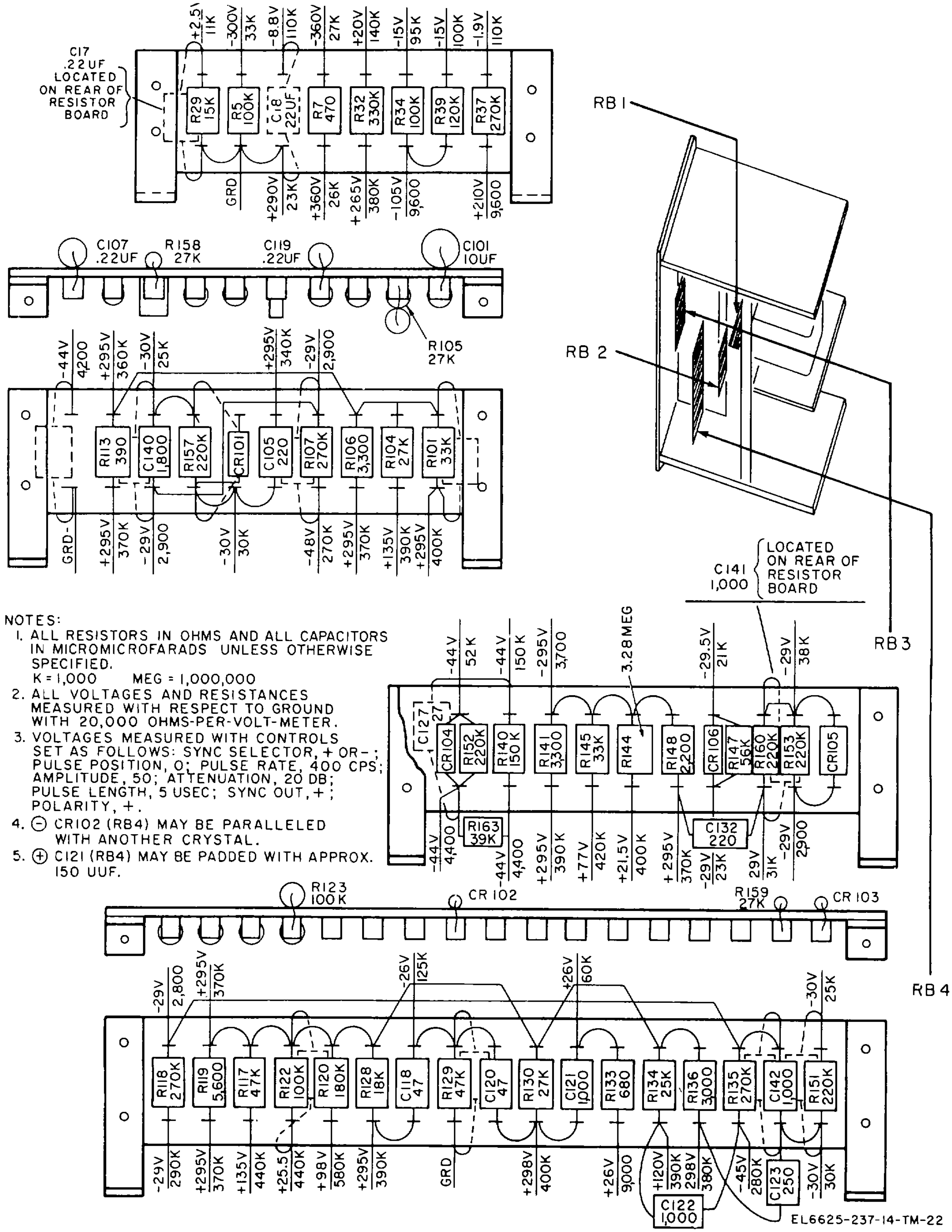
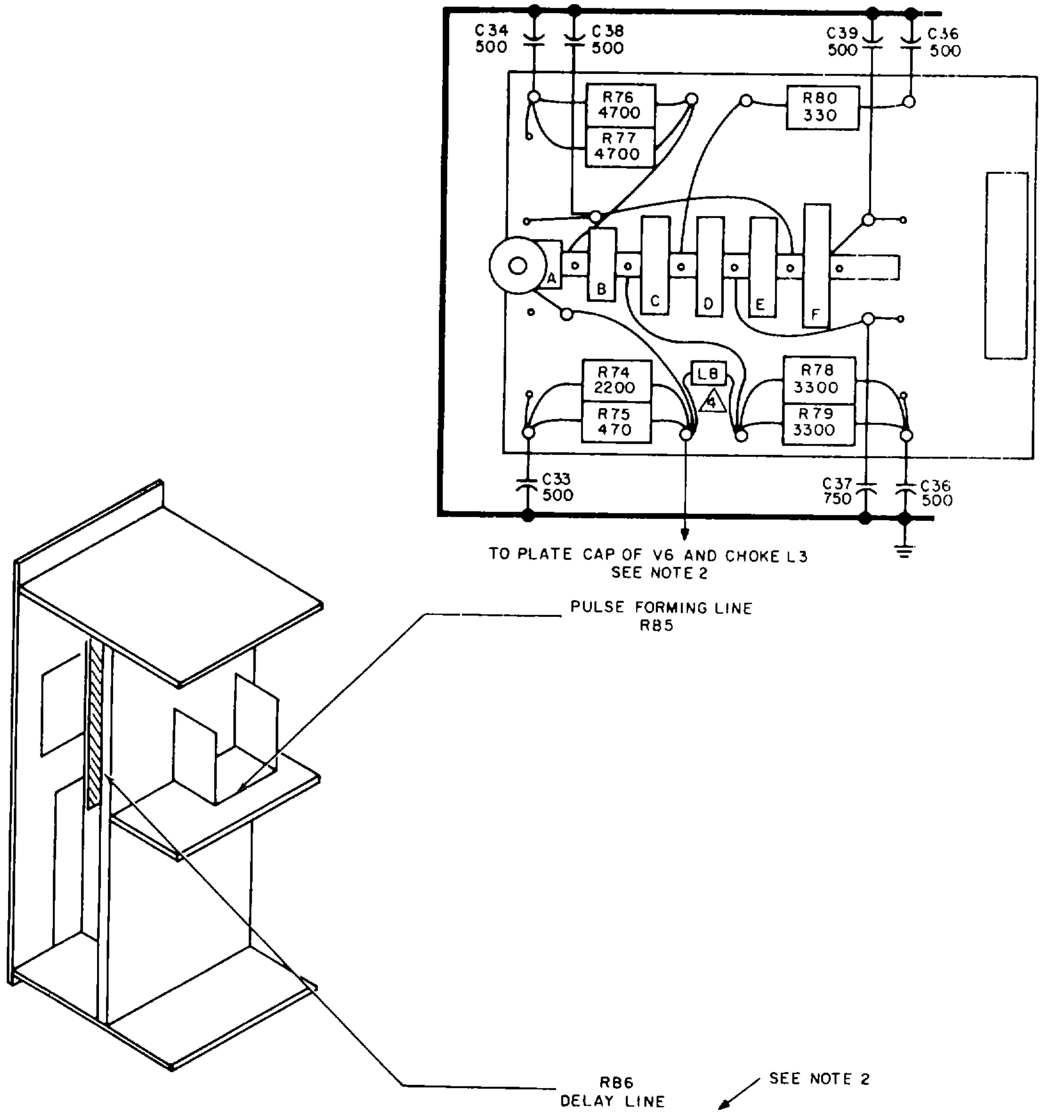
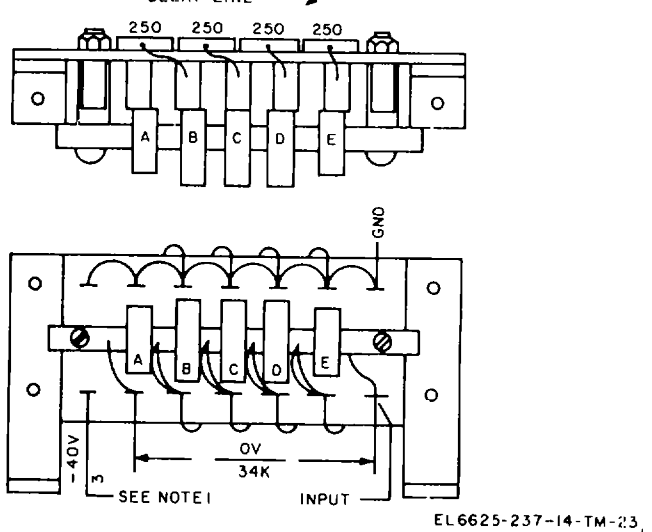


Figure 6-6. Generator, Pulse SG-69B/PPM-1 terminal board, component locations, voltage and resistance diagram.





NOTE:
1. APPROXIMATELY 1020 V AND INFINITE RESISTANCE ON ALL COILS TO GROUND.
2. V6 THYRATRON PLATE GAP MEASURES 1020 V, INFINITE RESISTANCE.
3. WINDING CONSISTS OF SIX PI'S, VALUES OF WHICH ARE AS FOLLOWS:
   A. 8.5,0.5 OHMS
   B. 200 UH,7.0 OHMS
   C. 2 MH,15 OHMS
   D. 2 MH,15 OHMS
   E. 2MH,15 OHMS
   F. 3.6 MH,20 OHMS
4. LB USED ON SG-69B/PPM-1 ONLY
5. THIS TERMINAL IS NOT PART OF DELAY LINE. IT IS A SURPLUS TERMINAL USED AS CONVENIENT TIEPOINT FOR -40V BIAS LEADS
6. C135 THROUGH C138
   WINDING CONSISTS OF FIVE PI'S, VALUES OF WHICH ARE AS FOLLOWS:
   A AND E: 620 MH, 7.5 OHMS
   B, C, AND D: 1.15 MH, 10 OHMS

Figure 6-7. Delay pulse-forming line, component locations, voltage and resistance diagram.

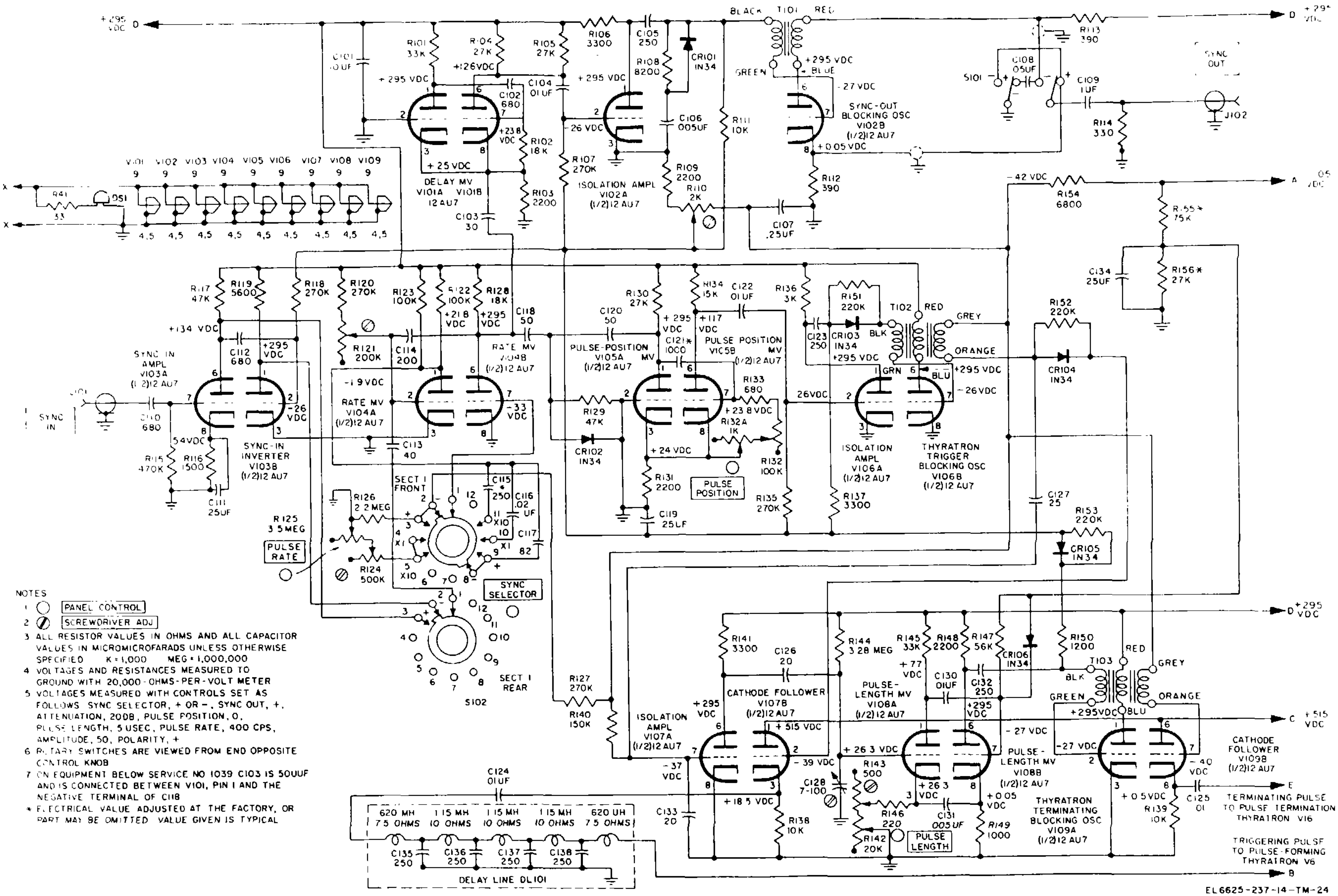


Figure 6-8. Schematic diagram, SG-69/PPM- 1 front deck, serial numbers to 1438.

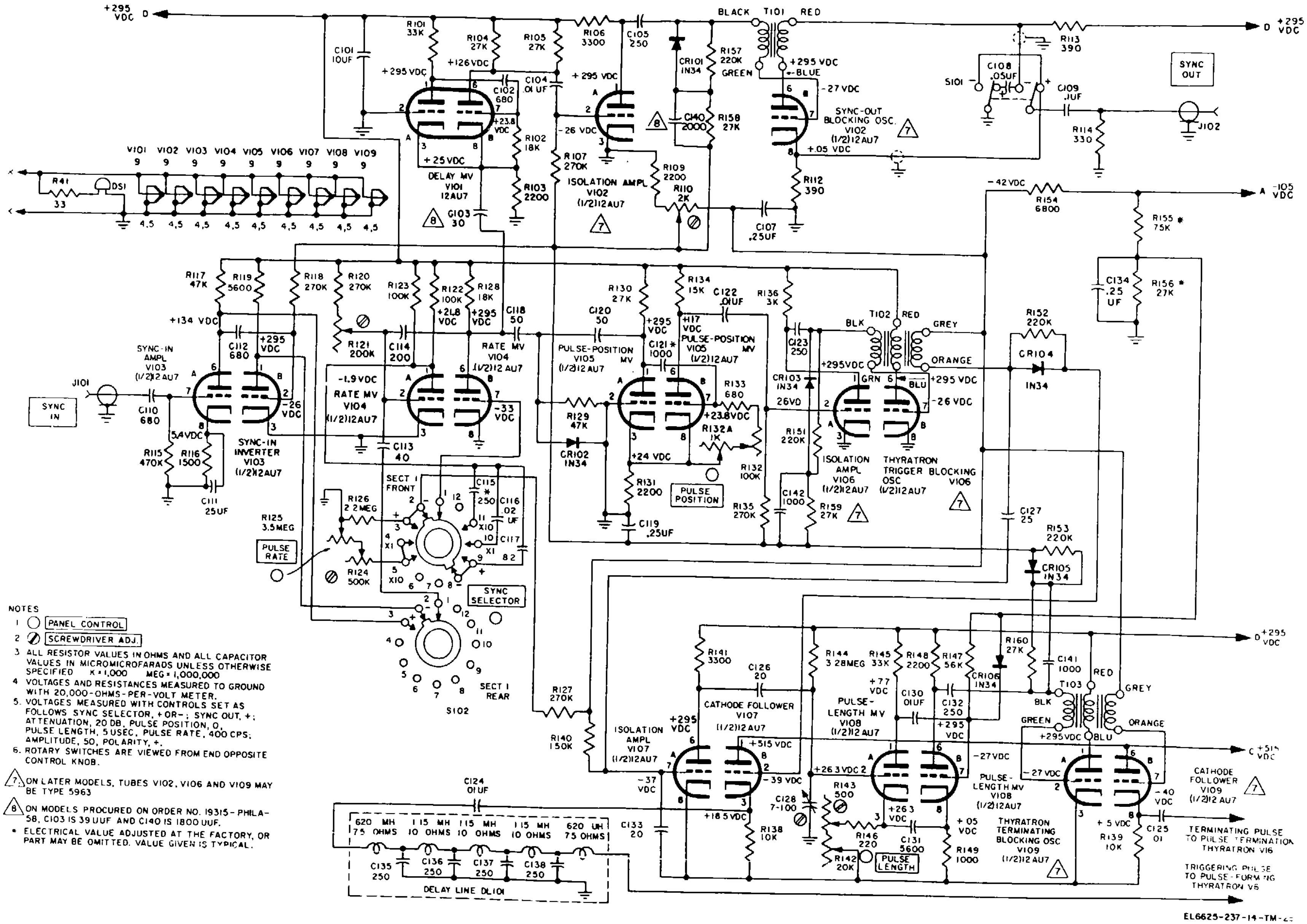


Figure 6-9. Schematic diagram, SG-69/PPM-1 front deck, serial numbers from 1439.

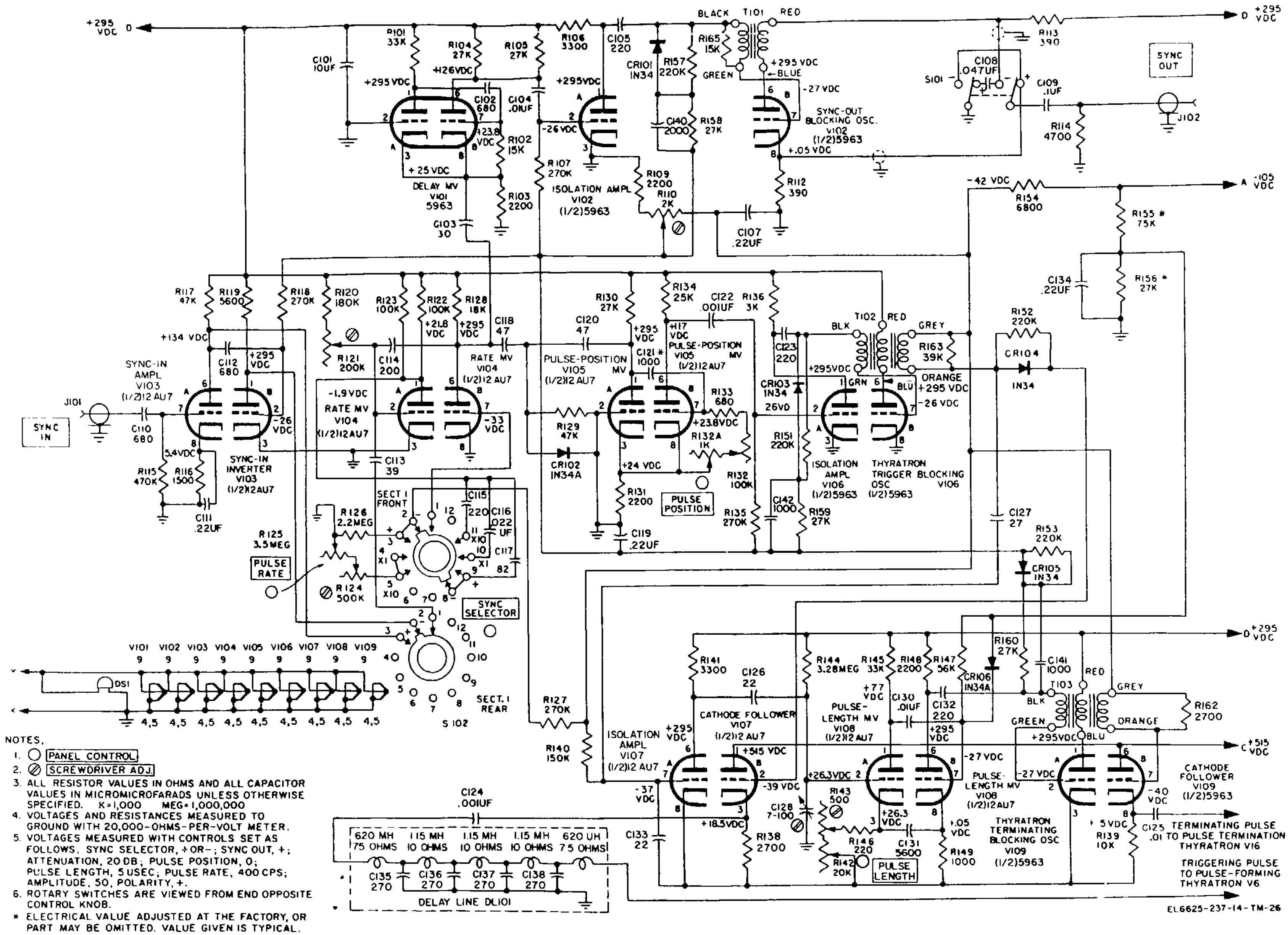


Figure 6-10. Schematic diagram, SG-69B/PPM-1 front deck, order number 4516-PP-60.

6-11. Additional Troubleshooting Data.

a. *Aging of Thyratrons*. Newly installed thyratrons will require aging. If the overload relay buzzes when the equipment is turned on after a thyratron has been replaced, turn the SYNC SELECTOR switch to either of the external settings (- or +), and with the external sync disconnected. If the relay stops buzzing, the thyratron was insufficiently aged. To age the thyratron, turn the SYNC SELECTOR switch to X1 and the PULSE RATE dial to its lowest setting, and allow the unit to operate for a short time, increasing the rate as much as possible without causing the overload relay to buzz. Thyratrons may require ass much as 90 hours of aging for stable operation. During the time the thyratrons are aging, there may occur a noticeable change in ionization time. The time required for ionization will increase as the aging progresses. During the aging period, however, stability usually will improve, and jitter of the main pulse will become less and less.

b. *Sources of Jitter*. Jitter of the output pulse usually is traceable to three sources; tubes, crystals, and ripple in the power supply. Jitter usually appears as a thick or multiple trace of the leading edge, the trailing edge, or both edges of the pulse. Tube V6 will affect jitter on the leading edge. Tube V16, crystals CR105 and CR106, and width multivibrator V108 will affect trailing edge jitter. Delay multivibrators V101 and V105 and crystal CR102, if defective, may cause jitter on both the leading and trailing edges. Similarly, power-supply ripple may cause jitter, and such ripple may affect V101 and V105 in varying degrees.

NOTE

When replacing tubes or crystal rectifiers to clear jitter symptoms, remember that it may be necessary to try several tubes or crystals known to be good before finding one that provides proper operation. Therefore, replace a tube or crystal at least twice before looking elsewhere for trouble. Tubes or crystals which do not prove satisfactory in this equipment may be suitable for most other applications and should not be considered defective without test.

Section IV. MAINTENANCE OF PULSE GENERATOR

6-12. General Parts Replacement Techniques

a. General. Most of the parts in the set are accessible readily and are replaced easily if found to be faulty. In all instances involving multiple connections, however, tag each wire as it is removed so that it may be replaced correctly.

b. Resistors and Capacitors. Certain resistors and capacitors in the set are factory-adjusted to provide certain conditions of operation. The actual value may not be exactly the same as that shown on the schematic diagram. If it becomes necessary to replace any of these parts, the replacement should be made on a cut and try basis. That is, vary the value of the part until the desired operation is obtained. The following subparagraphs list these critical resistors and capacitors and detail the effect of changes in their values.

(1) *Resistor R3*. The original design value of this resistor was 4,000 ohms; however, tolerance variations in transformer T1 have made minor changes necessary. The criterion for the value of R3 should allow the series of voltage regulator tubes V4, V12, and V14 to draw approximately 8 m (milliamperes) when the applied line voltage is 105 volts. Under these conditions the voltage regulator will operate properly. Resistor R3 is factory-set and should not require adjustment or change during normal operation. If transformer T1 is changed, resistor R3 should be checked to make sure that the combination of T1, R3, and the voltage regulator tubes produces the required 8 ma current.

(2) *Resistor R10*. The usual value for this resistor is 200 ohms. Increasing the value of R10 slightly increases the slope of the trailing edge of the main output pulse and reduces overshoot. The value selected should not exceed 330 ohms. Only occasionally does R10 differ from its 200-ohm nominal value.

(3) *Resistor R30*. The usual value for this resistor is 100 ohms. Changing the value of R30 affects the final 30 percent of the top of the main output pulse when the main output pulse is of 10 μ sec duration. That is, the value of R30 affects the top of the main output pulse in the region corresponding to from 7 to 10 μsec. Decreasing R30 reduces the voltage of this portion of the pulse, while increasing R30 raises the voltage during this portion. This resistor is factory-adjusted for maximum flatness for the top of the pulse.

(4) *Resistor R50*. (See also capacitor C28.) Resistor R50 may vary from 330 to 560 ohms. The actual value is selected, in combination with capacitor C28, for minimum hump during the first tenth sec of the top of the main positive output pulse.

(5) *Resistor R162*. The nominal value for this resistor is 2700 ohms. Actual value is selected to reduce pulse width variations.

(6) *Capacitors C28*. The value of this capacitor may vary from 200 to 600 μ μf. In combination with resistor R50, C28 aids in reducing the hump described in (4) above.

(7) *Resistors R155 and R156*. The nominal values of these resistors are 75,000 and 27,000, respectively. Either one may be adjusted by a few percent in order to obtain the proper bias at tile junction of these two resistors. This proper value is between -28 and -30 volts. Usually the adjustment is in the form of a shunt resistor across either R155 or R156.

(8) *Capacitor C121*. The nominal value of C121 is 1,000 μμf. It is part of the pulse length determining network for pulse position multivibrator V105B. Capacitor C121 occasionally is shunted with another capacitor of up to 250 μμf. This is done to obtain a full 100 μsec delay at a repetition rate of 2,500 pps.

(9) Capacitor C31. This capacitor is used only occasionally and, when used, its value is between 5 and 15 μμf. The purpose of C31 is to bypass excessive ringing (overshoot oscillations) in the main output pulse. This ringing may occur when the rise and decay of the main output pulse are exceptionally fast. Capacitor C31 is used only when ringing is not sufficiently reduced by capacitors C11 and C22.

c. *Differences*. The pulse generators previously supplied with type 3C45 thyratrons should use type HP45/3HP45 thyratrons when the spare tubes have been expended. If the type HP45/3HP45 tubes are not available, a type 3C45 may be selected from supply sources, using a trial and error process at finding one that will function properly in the circuit.

6-13. Adjustments

NOTE

Power supply voltages and regulation should be checked and, if necessary, adjusted prior to performing any other internal adjustments.

a. *Regulated Voltage Check and Adjustment*. The +300-volt supply normally maintains essentially constant output voltage with 105 to 125 ac volts line power. Ripple content is approximately 100 millivolts. To check and adjust the regulated voltage, proceed as follows:

(1) Connect multimeter between tube V17, pin 6 (fig. 6-1) and ground.

(2) Set POWER switch to ON and insure that multimeter indicates +300 volts.

(3) If necessary, adjust R33 (fig. 6-2) until multimeter indicates +300 volts.

b. Bias Voltage Check and Adjustment. The bias 6-16 voltage is applied to the grids of tubes V102, V103, V106, and V109. To check and adjust the bias voltage, Proceed as follows:

(1) Connect multimeter between tube V103, pin 2 (fig. 6-1) and ground.

(2) Remove tube V103, set SYNC SELECTOR switch to either + or -, and set POWER ON switch to ON.

(3) If necessary, adjust R110 (fig. 6-2) until multimeter indicates -28 volts.

c. *Output Pulse Length Adjustment*. The PULSE LENGTH dial is hand calibrated to PULSE LENGTH control R142. A worn or replaced control will therefore require readjustment of output pulse length. Capacitor C128 and resistor R143 (fig. 6-2) are provided for adjustment. Capacitor C128 sets the pulse length to 10.0 microseconds, and resistor R143 sets the 0.1 microsecond length. To adjust the pulse length, proceed as follows:

(1) Connect oscilloscope SWEEP MODE TRIGGER SOURCE INPUT connector to pulse generator SYNC OUT connector (fig. 6-3), and oscilloscope CHANNEL A or CHANNEL B INPUT connector to pulse generator PULSE OUT connector J103 (fig. 6-3).

(2) Set PULSE RATE control to 100 and SYNC SELECTOR switch to X10.

(3) Set PULSE LENGTH control to 5.

(4) Set POWER ON switch to ON, and check to see that oscilloscope indicates a 5.0- μsec pulse. If necessary, adjust PULSE LENGTH control until a 5.0- μsec pulse is obtained on oscilloscope and slip PULSE LENGTH dial on PULSE LENGTH control shaft so that it indicates 5.

(5) Set PULSE LENGTH control to 10 and, after a short interval, adjust capacitor C128 (fig. 6-2) until oscilloscope indicates a 10.0- sec pulse.

(6) Set PULSE LENGTH control to .2 and adjust resistor R143 (fig. 6-2) until oscilloscope indicates a 0.2- sec pulse.

(7) Repeat (4), (5), and (6) above as required to obtain best accuracy.

d. Maximum Pulse Amplitude Adjustment. This adjustment should be made whenever the amplitude falls below 50 volts. When correcting this condition, set up the instrument for normal operation with zero attenuation and the AMPLITUDE control set in its maximum position. Connect a 50-ohm load from the PULSE OUT connector to ground in parallel with the calibrated oscilloscope. Adjust variable resistor R35 (fig. 6-2) until a maximum of 60 volts is indicated by the oscilloscope.

e. Pulse Rate Adjustment. The pulse rate is adjusted with resistors R121 and R124. The resistors are interdependent and must be adjusted together. The adjustment is not intended to be made with great accuracy. However, if pulse rate error becomes greater then 10 percent, perform the adjustment as follows:

(1) Connect the AN/USM-207 INPUT connector to pulse generator PULSE OUT connector J103 (fig. 6-3).

(2) Set PULSE RATE control fully clockwise and SYNC SELECTOR switch to X10.

(3) Set POWER ON switch to ON and check to see that the AN/USM-207 indicates 5,100 pps. If the AN/USM-207 indication is incorrect, adjust resistor R124 (fig. 6-2) until the AN/USM-207 indication is 5,100 pps.

(4) Adjust PULSE RATE control until the AN/USM-207 indicates 1,000 pps.

(5) Set SYNC SELECTOR switch X1 and check to see that the AN/USM-207 indicates 100 pps. If meter indication is incorrect, adjust resistor R121 (fig. 6-2) until meter indicates 100 pps.

(6) Loosen PULSE RATE control setscrew, slip control until it is set to 100, and retighten setscrew.

(7) Set SYNC SELECTOR switch to X10 and adjust PULSE RATE control fully clockwise. The AN/USM-207 should indicate 5,100 pps. If necessary, readjust resistor R124 until the AN/USM-207 indication is correct.

(8) Check other points on the PULSE RATE control for calibration accuracy. If errors are found, it may be necessary to displace the 1,000 pps points to either side of the pulse RATE control 100 point by loosening the control setscrew and resetting the control. This compromise is necessary because of differences in tapers of the pulse rate adjustment resistors (R121 and R124).

f. *Output Amplifier Adjustment*. Capacitors C11 and C22 (fig. 6-2) are provided in the output circuit to refine pulse shape or risetime the capacitors are interdependent and must be adjusted together. To perform the adjustment, proceed as follows:

(1) Connect oscilloscope CHANNEL A or CHANNEL B input connector to pulse generator PULSE OUT connector J103 (fig. 6-3).

(2) Set up pulse generator for normal operation and observe both positive and negative pulses on oscilloscope.

(3) If required, adjust capacitors C11 and C22 for optimum pulse shape. Capacitor C11 normally is set to near minimum capacity and capacitor C22 is used for the greater portion of the adjustment.

g. *Overload Relay Adjustment*. The overload relay adjustment is normally not required for the life of the relay. However, if the relay spring tensions have been altered, the relay can be adjusted as follows:

(1) Open circuit between relay REL-1 (fig. 6-3) and resistor R28 and connect multimeter between relay winding and tube V17, pin 5.

(2) Set multimeter range switch to 100MA and FUNCTION switch to DC CURRENT.

(3) Set pulse generator POWER ON switch to ON.

(4) Set PULSE RATE control fully clockwise and set SYNC SELECTOR switch to X10.

(5) Adjust relay armature spring tension until relay operates at 50 ma. Test current can be controlled by varying resistor R124 (fig. 6-2).

(6) Set POWER ON switch to off position, disconnect multimeter from pulse generator, and reconnect resistor R28 to relay REL-1.

(7) Reset resistor R124 in accordance with *e* above.

6-14. Refinishing

Badly marred panels or other portions of the pulse generator which show evidence of wear should be refinished before the equipment is returned to service by field and other personnel. Refer to TB43-0118, Field Instructions for Painting and Preserving Electronics Command Equipment.

CHAPTER 7

GENERAL SUPPORT TESTING PROCEDURES

7-1. General

a. Testing procedures in this chapter are prepared for use by general support category maintenance. The purpose of these procedures is to insure that repaired equipment will meet mandatory specifications before it is returned to the using organization. These procedures can also be employed as guides for testing equipment that has been repaired by direct category maintenance when appropriate tools and test instruments are available.

b. Before consulting a table, comply with all instructions preceding it. At each step, follow the procedures indicated in the *Test equipment* and *Equipment under test* columns. Perform each test procedure and verify the result against the information in the *Performance standard* column.

7-2. Tools and Test Equipment.

All tools, test equipment, and additional equipment required for the testing procedures are listed in tables 7-1 and 7-2. No special tools are required to perform testing procedures in this chapter. For performance tests, see tables 7-3 through 7-8.

Table 7-1. Tools and Test Equipment

Nomenclature	National stock No.	Technical Manual
Oscilloscope AN/USM-281A	6625-00-228-2201	TM 11-6625-1703-15
Generator, Signal AN/USM-358	6625-00-455-7302	TM 11-6625-2509-14

Table 7-2. Additional Equipment Required

Equipment	National stock No.
UG-274A/U BNC T, connector	5935-00-201-2411
Coaxial Cable RG-58A/U	6625-00-230-5505
50-ohm, 4-watt, noninductive resistor	
2K ohm, 1-watt resistor	

7-3. Physical Tests and Inspections
(table 7-3)

a. Test Equipment and Materials. None required.

b. Test Connections and Conditions.

(1) No connections are required.

(2) Remove pulse generator chassis from its case (para 2-1c and d).

Table 7-3. Performance Tests (Physical Tests and Inspections*)*

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedures	Performance standard
1	None	Controls may be in any position	a. Inspect case and chassis for damage, missing parts, and condition of paint. **NOTE** **Touchup painting is recommended instead of refinishing whenever practical; screw heads, binding posts, receptacles, and other plated parts will not be painted or polished with abrasives.** b. Inspect all controls and mechanical assemblies for loose nor missing screws, bolts, and nuts.	a. No damage evident or parts missing. External surfaces intended to be painted will not show bare metal. Panel lettering will be legible. b. Screws, bolts, and nuts will be tight. None missing.

Table 7-3. Performance Tests (Physical Tests and Inspections)--Continued

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedures	Performance standard
			c. Inspect all connectors and fuseholders for looseness, damage, or missing parts.	c. No loose parts or damage. No missing parts.
2	None	Controls may be in any position	a. Rotate all panel controls throughout their limits of travel.	a. Controls will rotate freely without binding or excessive looseness.
			b. Inspect dial stops for damage or bending, and for proper operation.	b. Stops will operate properly without evidence of damage.
			c. Operate all switches.	c. Switches will operate properly.

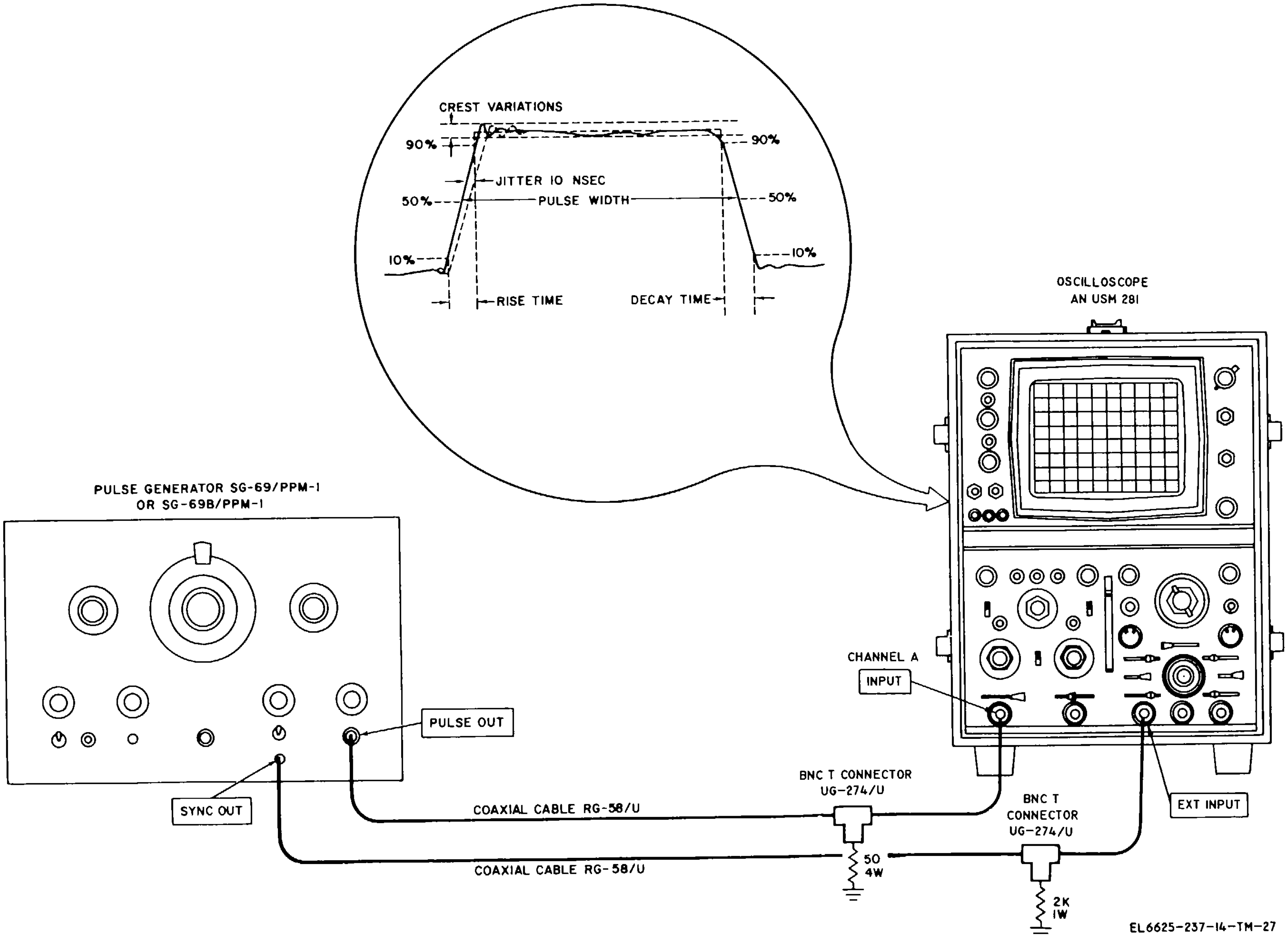


Figure 7-1. Pulse generator output pulse test connections.

7-4. Output Pulse Checks

(table 7-4)

a. Test Equipment and Material.

(1) Oscilloscope AN/USM-281A.

(2) UG-274/U BNC T connectors (2 ea).

(3) RG-58/U 50-ohm coaxial cable.

(4) 2K ohm, 1-watt resistor.

(5) 50-ohm, 4-watt, non inductive resistor.

b. Test Connections and Conditions. Connect the equipment as shown in figure 7-1.

Table 7-4. Performance Tests(Output Pulse Checks)

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
1	AN/USM-281A a. Vertical position control: CHANNEL A b. TRIGGER SLOPE: + c. TRIGGER SOURCE: EXT DC d. CHANNEL A POLARITY: +UP e. CHANNEL A AC-DC: DC f. POWER: ON	a. PULSE POSITION: Midrange b. PULSE RATE: 500 c. SYNCSELECTOR: X10 d. ATTENUATION: 10 e. AMPLITUDE: 100 f. POLARITY: + g. SYNC OUT: + h. PULSE LENGTH: Fully ccw i. POWER: ON	Energize test equipment and pulse-generator and allow 20 minutes warmup period before proceeding.	None.
2	AN/USM-281A a. INTENSITY: As required	None.	a. Adjust pulse generator PULSE. POSITION control and oscilloscope SENSITIVITY, TIME/DIV and HORIZONTAL DISPLAY controls as required until oscilloscope indicates an output pulse (fig. 7-1) with 6.0 cm vertical deflection.	a. None.
	b. FOCUS: As required c. ASTIGMATISM: As required d. VERTICAL POSITION: As required e. HORIZONTAL POSITION: As required		b. Set oscilloscope SWEEP TIME switch to .1 usec/cm and observe output pulse width indicated on oscilloscope.	b. Output pulse should be less than 7.0 mm wide at half amplitude point as shown in figure 7-1.
3	AN/USM-281A Set TIME/DIV 2 μsec/cm	PULSE LENGTH: fully cw	a. Observe output pulse width indicated on oscilloscope. b. Observe top of output pulse indicated on oscilloscope.	a. Output pulse should be more than 5.0 cm wide at half amplitude point as shown in figure 7-1. b. Output pulse crest variations (overshoot and ringing) should not exceed ±3.0 mm from average peak amplitude as shown in figure 7-1.
4	AN/USM-281A a. Set TIME/DIV 0.1 μsec/cm b. HORIZONTAL DISPLAY: As required	PULSE LENGTH: 1	a. Using oscilloscope HORIZONTAL POSITION control, set output pulse leading edge 10 percent amplitude point (fig. 7-1) on graticule centerline. Observe output pulse risetime indicated on oscilloscope.	a. Output pulse risetime between leading edge 10 and 90 percent amplitude points should be less than 2.1 cm as shown in figure 7-1.

Table 7-4. Performance Tests (Output Pulse Checks)-Continued

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
				NOTE **Oscilloscope vertical amplifier accounts for approximately 1.0 mm of total displayed risetime**.
			b. Observe output pulse leading edge jitter displayed on oscilloscope.	b. Output pulse leading edge should be less than 1.0 cm as shown in figure 7-1.
			c. Using oscilloscope HORIZONTAL POSITION control, set output pulse trailing edge 90 percent amplitude point (fig 7-1) on graticule centerline. Observe output pulse decay time indicated on oscilloscope.	c. Output pulse decay time between trailing edge 10 and 90 percent amplitude points should be less than 2.1 cm.
5	AN/USM-281A a. Set TIME/DIV 1 µsec/cm	ATTENUATION: 0	a. Adjust pulse generator PULSE POSITION control and oscilloscope HORIZONTAL POSITION control as required to display output pulse on oscilloscope.	a. Output pulse amplitude should be at least 5.0 cm.
	b. HORIZONTAL DISPLAY: As required		b. Set POLARITY switch to - and observe output pulse amplitude indicated on oscilloscope.	b. Oscilloscope should indicate a negative output pulse with at least 5.0 cm vertical deflection.
	c. CHANNELA SENSITIVITY: 10 V/cm		c. Set pulse generator POLARITY switch to + and observe output pulse on oscilloscope.	c. Oscilloscope should indicate a positive output pulse with at least 5.0 cm deflection.
6	AN/USM-281A Set TIME/DIV 10 µsec/cm	PULSE POSITION: fully ccw	Observe position of output pulse in- indicated on oscilloscope and adjust PULSE POSITION control fully cw.	Leading edge of output pulse should move right at least 5.0 cm from beginning of oscilloscope trace.
7	AN/USM-281A Set TIME/DIV .2 msec/cm	PULSE POSITION: As required to move output pulse leading edge to beginning of oscilloscope trace.	a. Adjust PULSE RATE control ccw until oscilloscope indicates output pulses every 2.0 cm.	a. PULSE RATE control should be set between 200 and 300 indicating a pulse repetition frequency of 2500 cps.
			b. Set oscilloscope TIME/DIV control to 20 usec/cm and, while observing output pulse on oscilloscope, adjust PULSE POSITION control fully cw.	b. Leading edge of output pulse should move right at least 5.0 cm from beginning of oscilloscope trace.
8	AN/USM-281A Set TIME/DIV 2 µsec/cm	ATTENUATION: 20	Reverse input connections to oscilloscope (T-connector with 50-. ohm load to trigger INPUT and T connector with 2K ohm load to CHANNEL A vertical INPUT). Observe position of sync out pulse indicated on oscilloscope and adjust PULSE POSITION control fully ccw.	Leading edge of sync out pulse should move right at least 5.0 cm from beginning of oscillo. scope trace.

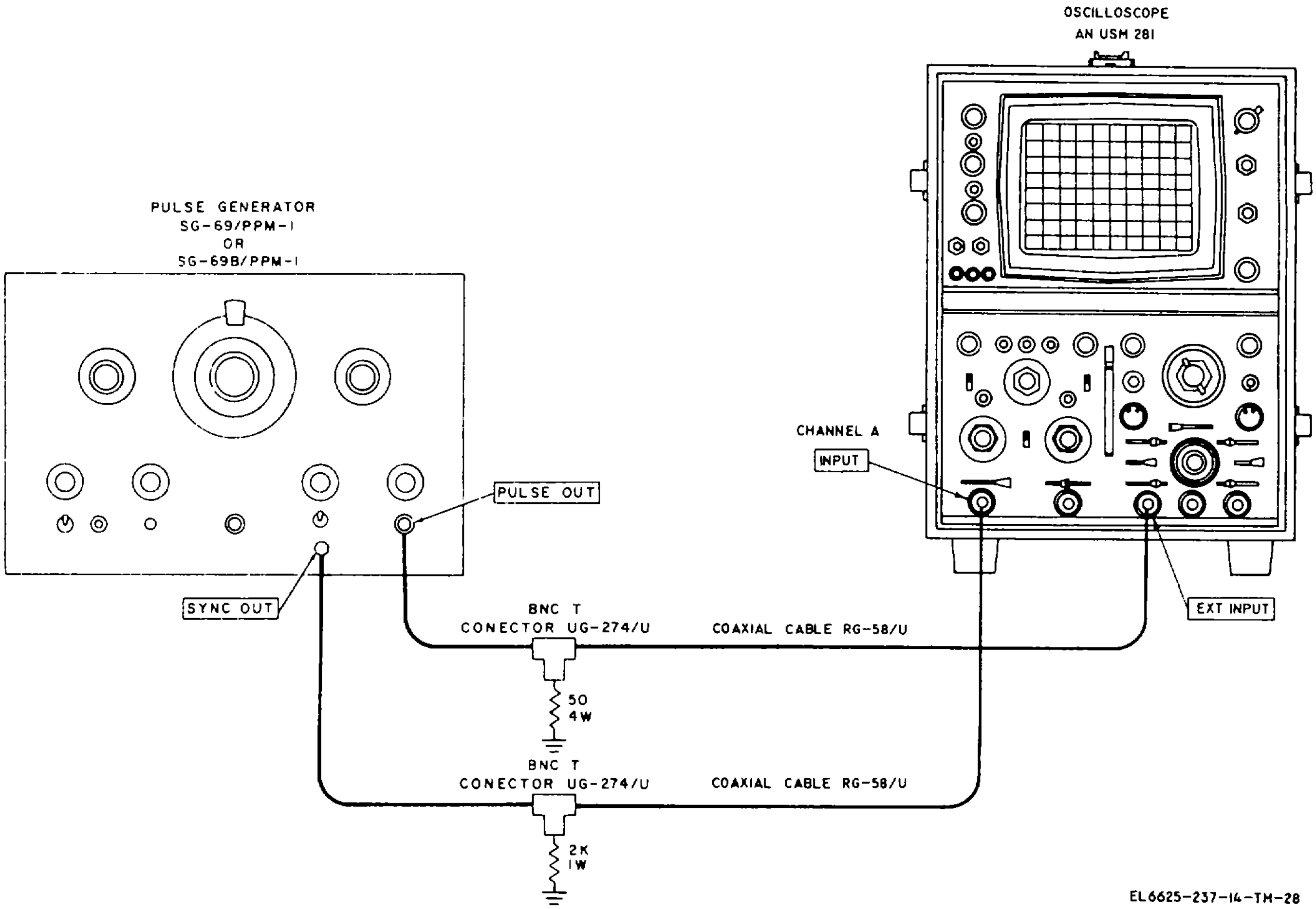


Figure 7-2. Pulse generator repetition rate test connections.

7-5. Repetition Rate Checks

(table 7-5)

a. Test Equipment and Material.

(1) Oscilloscope AN/USM-281A.

(2) UG-274/U BNC T connectors (2 ea).

(3) RG-58/U 50-ohm coaxial cable.

(4) 2K ohm, 1-watt resistor.

(5) 50-ohm, 4-watt, non inductive resistor.

b. Test Connections and Conditions. Connect the equipment as shown in figure 7-2.

Table 7-5. Performance Tests (Repetition Rate Checks)

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
1	AN/USM-281A a. Vertical position control: CHANNEL A b. TRIGGER SLOPE: + c. TRIGGER SOURCE: EXT DC d. CHANNEL A POLARITY: +UP e. CHANNELA AC-DC: DC	a. PULSE POSITION: Midrange b. PULSE RATE: Fully CW c. SYNC SELECTOR: X10 d. ATTENUATION: 20 e. POLARITY +	Energize pulse generator and test equipment and allow 20 minutes warm-up period before proceeding.	None.

Table 7-5. Performance Tests (Repetition Rate Checks)-Continued

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
	f. POWER: ON	f. SYNC OUT: + g. AMPLITUDE: 100 h. PULSE LENGTH: Fully ccw i. POWER: ON		
2	AN/USM-281A a. Set TIME/DIV 50 µsec/cm	j. Set pulse rate to 500	a. Adjust pulse generator PULSE POSITION control and oscilloscope SENSITIVITY and HORIZONTAL DISPLAY controls as required until oscilloscope indicates a stable train of sync out pulses.	a. Space between pulses should be lees than 4 cm (prf greater than 500 pps).
	b. INTENSITY: As required		b. Set oscilloscope TIME/DIV control to 0.5 msec/cm and observe sync out pulses displayed on oscilloscope.	b. Space between pulses should be greater than 4 cm (prf less than 5000 pps).
	c. FOCUS: As required d. ASTIGMATISM: As required e. VERTICAL POSITION: As required f. HORIZONTAL POSITION: As required		c. Set SYNC SELECTOR switch to X1 and observe sync out pulses displayed on oscilloscope.	c. Space between pulses should be greater than 4 cm (prf less than 50 pps).

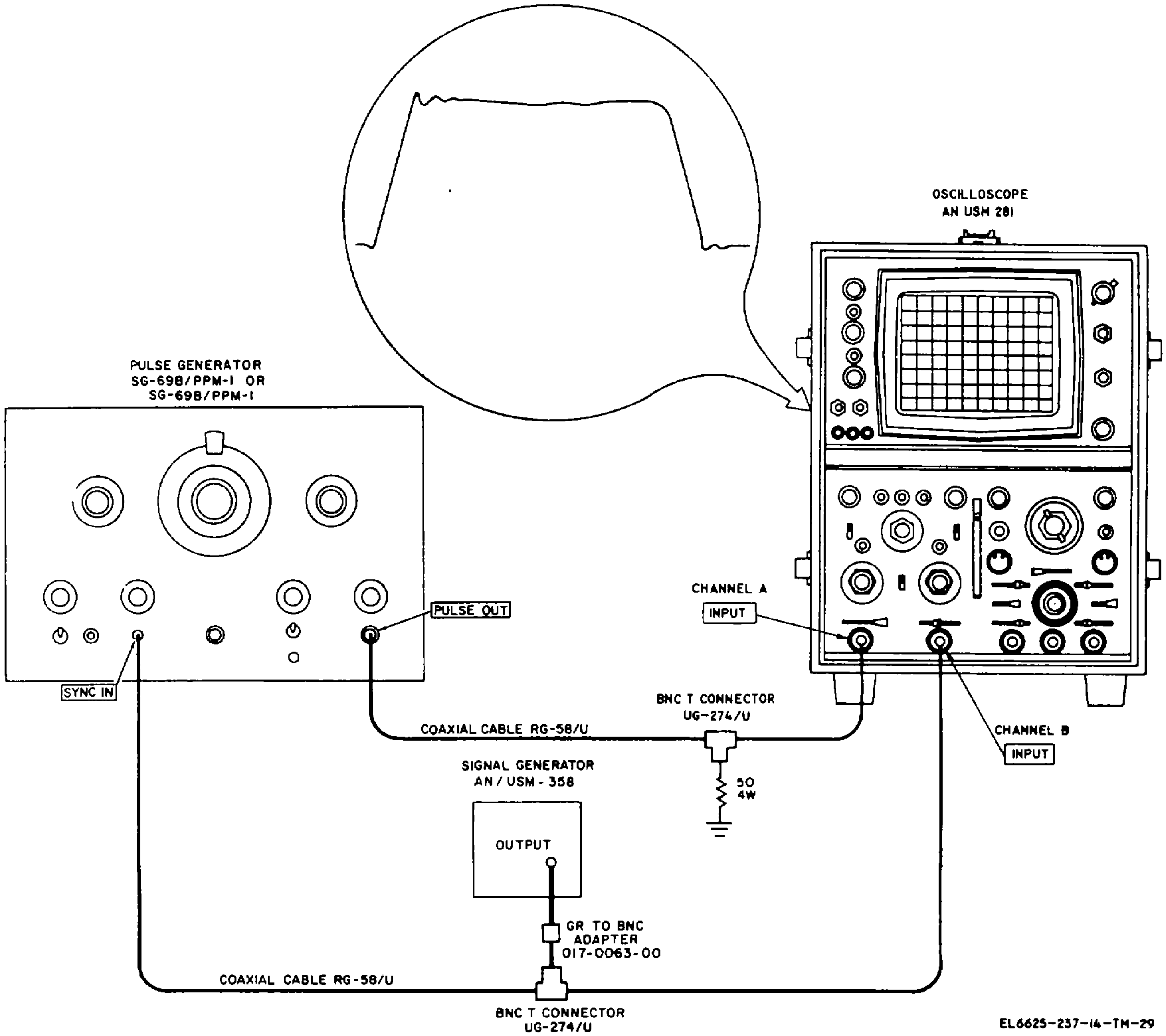


Figure 7-3. Pulse generator sync-in test connections.

7-6. Sync In Checks (table 7-6)

a. Test Equipment and Material.

(1) Oscilloscope AN/ USM-281A.

(2) UG-274/ U BNC T connectors (2 ea).

(3) RG-58/ U 50-ohm coaxial cable.

(4) Signal Generator A N / U S M - 3 5 E.

(5) 50-ohm, 4-watt, non inductive resistor.

b. Test Connections and Conditions. Connected the equipment as shown in figure 7-3.

Table 7-6. Performance Tests

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
1	AN/USM-281A a. Vertical Position Control: CHANNEL B b. TRIGGER SLOPE: + c. TRIGGER SOURCE: INT d. CHANNEL B POLARITY: +UP e. CHANNEL B AC-DC: f. POWER: ON AN/USM-358 a. RANGE: X1K b. FREQUENCY: Midscale between 2 and 3 (2.5) c. Power switch: ON	POWER: ON	a. Energize pulse generator and test equipment and allow 20 minutes warmup period before proceeding. b. Adjust oscilloscope SENSITIVITY TIME/DIV, and HORIZONTAL DISPLAY controls and signal generator OUTPUT AMPLITUDE, ATTEN, FREQUENCY (if required), and SYMMETRY controls until oscilloscope indicates that signal DC generator output is a 5-volt square wave at 2500 pps. Once correct output signal is obtained, proceed to step 2.	a. None. b. None.
2	AN/USM-281A a. Vertical Position control: CHANNEL A	a. PULSE POSITION: Midrange	a. Disconnect signal generator output signal from oscilloscope CHANNEL B INPUT connector and connect output signal to trigger INPUT connector. Adjust pulse generator PULSE POSITION control and oscilloscope SENSITIVITY and HORIZONTAL DISPLAY controls as required until oscilloscope indicates an output pulse (fig. 7-3) with 6.0 cm vertical deflection.	a. Displayed output pulse should be stable without drift.
	b. TRIGGER SOURCE: EXT DC c. CHANNEL A POLARITY: +UP d. CHANNEL A AC-DC: DC e. Set TIME/DIV 1 µsec/cm	b. SYNC SELECTOR: + c. ATTENUATION: 10 d. AMPLITUDE: 100 e. POLARITY:	+	
	AN/USM-359 a. All controls set exactly as adjusted in step 1.	f. PULSE LENGTH: Fully ccw	b. Set SYNC SELECTOR switch to - and observe output pulse indicated on oscilloscope. c. Adjust signal generator FREQUENCY control to midscale between 5 and 6 (5500 pps) and observe output pulse indicated on oscilloscope.	b. Displayed output pulse should be stable without drift. c. Displayed output pulse should be stable without drift.

Table 7-6. Performance Tests--.Continued

Step No.	Control settings Test equipment	 Equipment under test	Test procedure	Performance standard
			d. Set SYNC SELECTOR switch to +and observe output pulse indicated on oscilloscope	d. Displayed output pulse should be stable without drift.

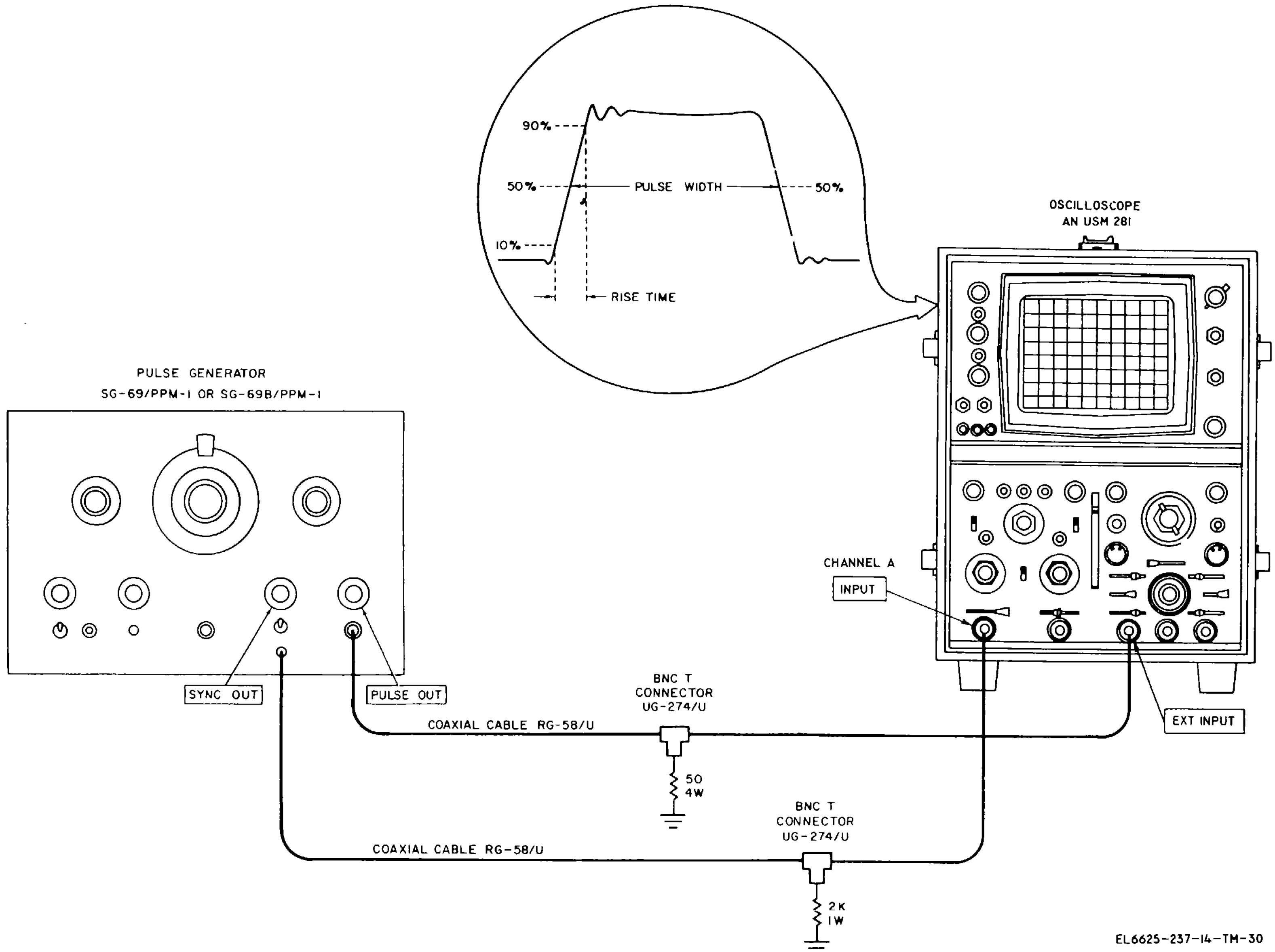


Figure 7-4. Pulse generator sync-out test connections.

7-7. Sync-Out Checks
(table 7-7)

a. Test Equipment and Materials.

(1) Oscilloscope AN/USM-281A.

(2) UG-274/U BNC T connectors (2 ea).

(3) RG-58/U 50-ohm coaxial cable.

(4) 2K ohm, 1-watt resistor.

(5) 50-ohm, 4-watt, non inductive resistor.

b. Test Connections and Conditions. Connect the equipment as shown in figure 7-4.

Table 7-7. Performance Tests

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
1	AN/USM-281A a. Vertical position control: CHANNEL A b. TRIGGER SLOPE: + c. TRIGGER SOURCE: EXT DC d. CHANNEL A POLARITY: +UP e. CHANNEL A AC-DC: DC f. Set TIME/DIV 2 µsec/cm g. SENSITIVITY: 5 V/cm h. POWER: ON	a. PULSE POSITION: Midrange b. PULSE RATE: 500 c. SYNC SELECTOR: X10 d. ATTENUATION: 20 e. AMPLITUDE: 100 f. POLARITY: + f. SYNC OUT: h. PULSE LENGTH: Fully ccw i. POWER: ON	Energize pulse generator and test equipment and allow 20 minutes warmup period before proceeding. -	None.
2	AN/USM.281A a. INTENSITY: As required b. FOCUS: As required c. ASTIGMATISM: As required d. VERTICAL POSITION: As required e. HORIZONTAL POSITION: As required	None.	a. Adjust pulse generator PULSE POSITION control and oscilloscope HORIZONTAL DISPLAY control as required until oscilloscope indicates sync out pulses similar to pulse shown in figure 7-4. b. Set SYNC OUT switch to + and observe sync out pulse indicated on oscilloscope. c. Set oscilloscope TIME/DIV switch to .2 µsec/cm and observe sync out pulse indicated on amplitude oscilloscope. d. Set oscilloscope TIME/DIV switch to .1 µsec/cm and observe sync out pulse indicated on oscilloscope.	a. Sync out pulse vertical deflection should be at least 3.0 cm. b. Sync out pulse vertical deflection should be at least 5.0 cm. c. Sync out pulse should be between 3.0 and 7.0 cm wide at half point as shown in figure 7-4. d. Sync out pulse rise time between leading edge 10 and 90 per cent points (fig. 7-4) should not exceed 3.5 cm.

APPENDIX A
REFERENCES

DA Pam 310-4	Index of Technical Publications.
SB 38-100	Preservation, Packaging, and Packing Materials, Supplies, and Equipment Used by the Army.
SC 5180-91-CL-S21	Tool Kit, Electronic Equipment TK-100/G
TB 43-0118	Field Instructions for Painting and Preserving Electronics Command Equipment Including Camouflage Pattern Painting of Electrical Equipment Shelters.
TM 11-6625-274-12	Operator's and Organizational Maintenance Manual: Test Sets, Electron Tube TV-7/U, TV-7A/U, TV-7B/U, and TV-7D/U.
TM 11-6625-654-14	Operator's Organizational, Direct Support, and General Support Maintenance Repair Parts and Special Tools List (Including Depot Maintenance Repair Parts and Special Tools Lists) for Multimeter AN/USM-223.
TM 11-6625-1703-15	Operator's Organizational, DS, GS, and Depot Maintenance Manual: Oscilloscope AN/USM-281A (NSN 6625-00-228-2201).
TM 11-6625-2509-14&P	Operator's Organizational, Direct Support and General Support Maintenance Manual: Signal Generator AN/USM-358 (NSN 6625-00-228-7842).
TM 11-6625-2941-14&P	Operator's Organizational, Direct Support, and General Support Maintenance Manual: Counter, Electronic, Digital Readout AN/USM-459 (Hewlett-Packard Model 5328A/E42).
TM 38-750	The Army Maintenance Management System (TAMMS).
TM 740-90-1	Administrative Storage of Equipment.
TM 750-244-2	Procedure for Destruction of Electronics Materiel to Prevent Enemy Use (Electronics Command).

APPENDIX C

MAINTENANCE ALLOCATION

Section I. INTRODUCTION

C-1. General

This appendix provides a summary of the maintenance operations for AN/PPM-1 and AN/PPM1A. It authorizes categories of maintenance for specific maintenance functions on reparable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

C-2. Maintenance Function

Maintenance functions will be limited to and defined as follows:

a. Inspect. To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination.

b. Test. To verify serviceability and to detect incipient failure by measuring the mechanical or electrical characteristics of an item and comparing those characteristics with prescribed standards.

c. Service. Operations required periodically to keep an item in proper operating condition, i.e., to clean, preserve, drain, paint, or to replenish fuel/lubricants/hydraulic fluids or compressed air supplies.

d. Adjust. Maintain within prescribed limits by bringing into proper or exact position, or by setting the operating characteristics to the specified parameters.

e. Align. To adjust specified variable elements of an item to about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test measuring and diagnostic equipment used in precision measurement. Consists of the comparison of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g*. Install*. The act of emplacing, seating, or fixing into position an item, part, module (component or assembly) in a manner to allow the proper functioning of the equipment/system.

h. Replace. The act of substituting a serviceable like-type part, subassembly, model (component or assembly) for an unserviceable counterpart.

i. Repair. The application of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining, or resurfacing) to restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module/component/assembly, end item or system. This function does not include the trial and error replacement of running spare type items such as fuses, lamps, or electron tubes.

j. Overhaul. That periodic maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by maintenance standards (e.g., DMWR) in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like-new condition.

k. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like-new condition in accordance with original manufacturing standards. Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (hours, miles, etc) considered in classifying Army equipment/components.

C-3. Column Entries

a. Column 1, Group Number. Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies and modules with the next higher assembly.

b. Column 2, Component/Assembly. Column 2 contains the noun names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. Column 3, Maintenance Functions. Column 3 lists the functions to be performed on the item listed in column 2. When items are listed without maintenance functions, it is solely for purpose of having the group numbers in the MAC and RPSTL coincide.

d. Column 4, Maintenance Category. Column 4 specifies, by the listing of a "worktime" figure in the appropriate subcolumn(s), the lowest level of maintenance authorized to perform the function listed in column 3.

This figure represents the active time required to perform that maintenance function at the indicated category of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance categories, appropriate "worktime" figures will be shown for each category. The number of man-hours specified by the "worktime" figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time, troubleshooting time and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. Subcolumns of column 4 are as follows:

C - Operator/Crew
O - Organizational
F - Direct Support
H - General Support
D - Depot

e. Column 5, Tools and Equipment. Column 5 specifies by code, those common tool sets (not individual tools) and special tools, test, and support equipment required to perform the designated function.

C-4. Tool and Test Equipment Requirements
(Table 1)

a. Tool or Test Equipment Reference Code. The numbers in this column coincide with the numbers used in the tools and equipment column of the MAC. The numbers indicate the applicable tool or test equipment for the maintenance functions.

b. Maintenance Category. The codes in this column indicate the maintenance category allocated the tool or test equipment.

c. Nomenclature. This column lists the noun name and nomenclature of the tools and test equipment required to perform the maintenance functions.

d. National/NATO Stock Number. This column lists the National/NATO stock number of the specific tool or test equipment.

e. Tool Number. This column lists the manufacturer's part number of the tool followed by the Federal Supply Code for manufacturers (5.digit) in parentheses.

SECTION II MAINTENANCE ALLOCATION CHART FOR GENERATORS, PULSE AN/PPM-1 AND AN/PPM-1A

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQPT
			C	O	F	H	D	
00	GENERATORS, PULSE AN/PPM-1 AND AN/PPM-1A	Inspect[1]		0.2				
		Test[2]		0.3				
		Test				0.5		1-6
		Service		0.2				8
		Adjust				0.6		1-6
		Repair				1.0		6
		Rebuild					2.0	1-4,6,7

(1) Visual only.
(2) Simple operational check only.

SECTION III TOOL AND TEST EQUIPMENT REQUIREMENTS FOR GENERATORS, PULSE AN/PPM-1 AND AN/PPM-1A

Tool Or Test Equipment Ref Code	Maintenance Category	Nomenclature	National/NATO Stock Number	Tool Number
1	H,D	OSCILLOSCOPE AN/USM-281A	6625-00-228-2201	
2	H,D	GENERATOR, SIGNAL AN/USM-358	6625-00-455-7302	
3	H,D	MULTIMETER AN/USM-223	6625-00-999-7465	
4	H,D	COUNTER, ELECTRONIC, DIGITAL READOUT AN/USM-459	6625-00-061-8928	
5	H	TEST SET, ELECTRON TUBE TV-7/U	6625-00-820-0064	
6	H,D	TOOL KIT, ELECTRONIC EQUIPMENT TK-100/G	5180-00-605-0079	
7	D	TEST SET, ELECTRON TUBE TV-2/U	6625-00-669-0263	
8	0	TOOLS AND TEST EQUIPMENT AVAIL-ABLE TO THE ORGANIZATIONAL TECHNICIAN BECAUSE OF HIS ASSIGNED MISSION.		

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TRADOC (2)	SAAD (30)
OS Maj Comd (4)	TOAD (14)
LOGCOMDS (3)	SHAD (3)
MICOM (2)	Units org under fol TOE:
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USAERDAA (1)	44-537
USAERDAW(1)	44-545
Instl (2) except	44-547
Fart Gillem (10)	

NG: None

USAR: None

For explanation of abbreviations used, see AR 310-50.

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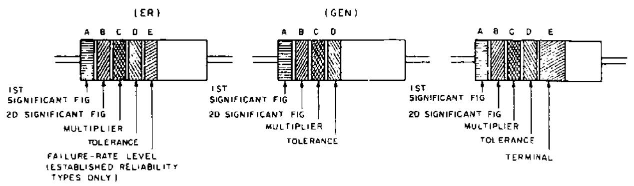


COLOR CODE MARKING FOR COMPOSITION TYPE RESISTORS

COLOR-CODE MARKING FOR FILM-TYPE RESISTORS

TABLE I
COLOR CODE FOR COMPOSITION TYPE AND FILM TYPE RESISTORS

BAND A		BAND B		BAND C		BAND D		BAND E		
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)	COLOR	FAILURE RATE LEVEL	TERM.
BLACK	0	BLACK	0	BLACK	1			BROWN	M=1.0	
BROWN	1	BROWN	1	BROWN	10			RED	P=0.1	
RED	2	RED	2	RED	100			ORANGE	R=0.01	
ORANGE	3	ORANGE	3	ORANGE	1,000			YELLOW	S=0.001	
YELLOW	4	YELLOW	4	YELLOW	10,000	SILVER	±10 (COMP. TYPE ONLY)	WHITE		SOLDERABLE
GREEN	5	GREEN	5	GREEN	100,000	GOLD	±5			
BLUE	6	BLUE	6	BLUE	1,000,000	RED	±2 (NOT APPLICABLE TO ESTABLISHED RELIABILITY).			
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7							
GRAY	8	GRAY	8	SILVER	0.01					
WHITE	9	WHITE	9	GOLD	0.1					

BAND A — THE FIRST SIGNIFICANT FIGURE OF THE RESISTANCE VALUE (BANDS A THRU D SHALL BE OF EQUAL WIDTH.)

BAND B — THE SECOND SIGNIFICANT FIGURE OF THE RESISTANCE VALUE

BAND C — THE MULTIPLIER (THE MULTIPLIER IS THE FACTOR BY WHICH THE TWO SIGNIFICANT FIGURES ARE MULTIPLIED TO YIELD THE NOMINAL RESISTANCE VALUE.)

BAND D — THE RESISTANCE TOLERANCE

BAND E — WHEN USED ON COMPOSITION RESISTORS, BAND E INDICATES ESTABLISHED RELIABILITY FAILURE – RATE LEVEL (PERCENT FAILURE PER 1,000 HOURS) ON FILM RESISTORS, THIS BAND SHALL BE APPROXIMATELY 1-1/2 TIMES THE WIDTH OF OTHER BANDS, AND INDICATES TYPE OF TERMINAL

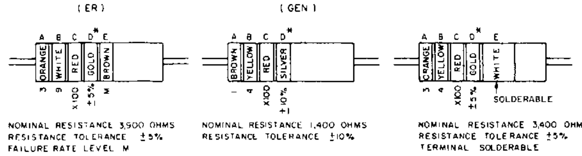
RESISTANCES IDENTIFIED BY NUMBERS AND LETTERS
(THESE ARE NOT COLOR CODED)

SOME RESISTORS ARE IDENTIFIED BY THREE OR FOUR DIGIT ALPHA NUMERIC DESIGNATORS. THE LETTER R IS USED IN PLACE OF A DECIMAL POINT WHEN FRACTIONAL VALUES OF AN OHM ARE EXPRESSED. FOR EXAMPLE:

2R7 = 2.7 OHMS   10R0 = 10.0 OHMS

FOR WIRE-WOUND-TYPE RESISTORS COLOR CODING IS NOT USED, IDENTIFICATION MARKING IS SPECIFIED IN EACH OF THE APPLICABLE SPECIFICATIONS

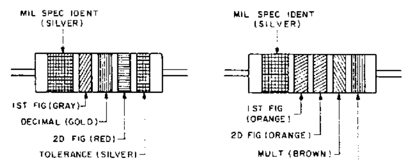
EXAMPLES OF COLOR CODING



COMPOSITION-TYPE RESISTORS   FILM-TYPE RESISTORS

* IF BAND D IS OMITTED, THE RESISTOR TOLERANCE IS ± 20% AND THE RESISTOR IS NOT MIL-STD

A COLOR CODE MARKING FOR MILITARY STANDARD RESISTORS



(A) 8.2UH ± 10%   (B) 330UH ± 5%

COLOR CODING FOR TUBULAR ENCAPSULATED R.F. CHOKES. AT A, AN EXAMPLE OF OF THE CODING FOR AN 8.2UH CHOKE IS GIVEN. AT B, THE COLOR BANDS FOR A 330UH INDUCTOR ARE ILLUSTRATED

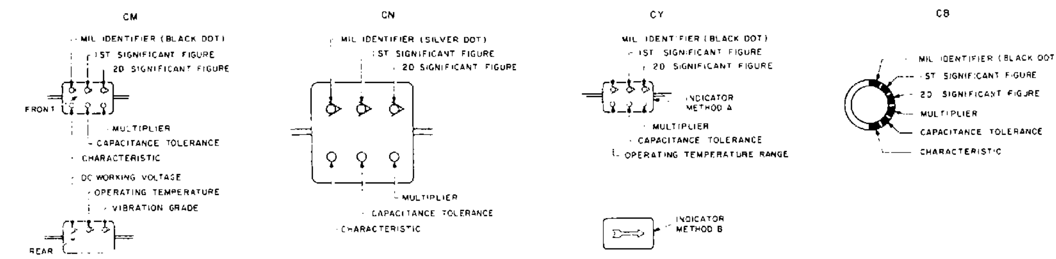
TABLE 2
COLOR CODING FOR TUBULAR ENCAPSULATED R.F. CHOKES

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	INDUCTANCE TOLERANCE (PERCENT)
BLACK	0	1	
BROWN	1	10	1
RED	2	100	2
ORANGE	3	1,000	3
YELLOW	4		
GREEN	5		
BLUE	6		
VIOLET	7		
GRAY	8		
WHITE	9		
NONE			20
SILVER			10
GOLD	DECIMAL POINT		5

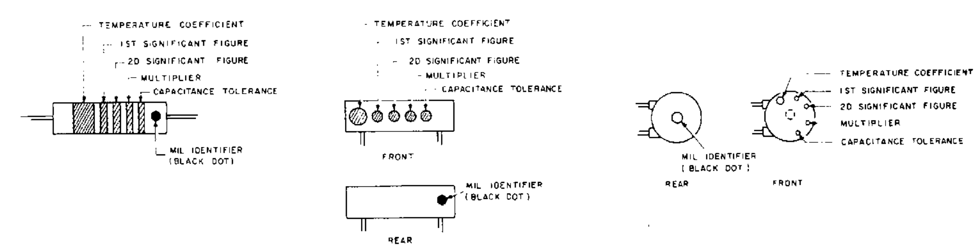
MULTIPLIER IS THE FACTOR BY WHICH THE TWO COLOR FIGURES ARE MULTIPLIED TO OBTAIN THE INDUCTANCE VALUE OF THE CHOKE COIL

B COLOR CODE MARKING FOR MILITARY STANDARD INDUCTORS.

CAPACITORS, FIXED, VARIOUS-DIELECTRICS, STYLES CM, CN, CY, AND CB



MICA-DIELECTRIC   PAPER-DIELECTRIC   GLASS-DIELECTRIC, GLASS CASE   MICA, BUTTON TYPE



AXIAL LEAD   RADIAL LEAD   DISK-TYPE

TABLE 3 — FOR USE WITH STYLES CM, CN, CY AND CB.

COLOR	MIL ID	1ST SIG FIG	2D SIG FIG	MULTIPLIER[1]	CAPACITANCE TOLERANCE				CHARACTERISTIC[2]			DC WORKING VOLTAGE	OPERATING TEMP RANGE	VIBRATION GRADE
					CM	CN	CY	CB	CM	CN	CB	CM	CY, CM	CM
BLACK	CM, CY CB	0	0	1			±20%	±20%		A			-55° TO +70°C	0 55 HZ
BROWN		1	1	10					B	E	B			
RED		2	2	100	±2%		±2%	±2%	C				-55° TO +85°C	
ORANGE		3	3	1,000		±30%			D		D	300		
YELLOW		4	4	10,000					E				-55° TO +125°C	0 2,000 HZ
GREEN		5	5		±5%				F			500		
BLUE		6	6										-55° TO +150°C	
PURPLE (VIOLET)		7	7											
GRAY		8	8											
WHITE		9	9											
GOLD				0.1			±5%	±5%						
SILVER	CN			0.01	±10%	±10%	±10%	±10%						

TABLE 4 — TEMPERATURE COMPENSATING, STYLE CC

COLOR	TEMPERATURE COEFFICIENT[4]	1ST SIG FIG	2D SIG FIG	MULTIPLIER[1]	CAPACITANCE TOLERANCE		MIL ID
					CAPACITANCES OVER 10 UUF	CAPACITANCES 10 UUF OR LESS	
BLACK	0	0	0	1		±2.0 UUF	CC
BROWN	-30	1	1	10	±1%		
RED	-80	2	2	100	±2%	±0.25 UUF	
ORANGE	-150	3	3	1,000			
YELLOW	-220	4	4				
GREEN	-330	5	5		±5%	±0.5 UUF	
BLUE	-470	6	6				
PURPLE (VIOLET)	-750	7	7				
GRAY		8	8	0.01*			
WHITE		9	9	0.1*	±10%		
GOLD	+100			0.1		±1.0 UUF	
SILVER				0.01			

1 THE MULTIPLIER IS THE NUMBER BY WHICH THE TWO SIGNIFICANT (SIG) FIGURES ARE MULTIPLIED TO OBTAIN THE CAPACITANCE IN UUF

2 LETTERS INDICATE THE CHARACTERISTICS DESIGNATED IN APPLICABLE SPECIFICATIONS: MIL-C-5, MIL-C-25D, MIL-C-11272B, AND MIL-C-10950C RESPECTIVELY

3 LETTERS INDICATE THE TEMPERATURE RANGE AND VOLTAGE TEMPERATURE LIMITS DESIGNATED IN MIL-C-11015D

4 TEMPERATURE COEFFICIENT IN PARTS PER MILLION PER DEGREE CENTIGRADE

* OPTIONAL CODING WHERE METALLIC PIGMENTS ARE UNDESIRABLE.

Figure FO-1. Color code markings for MIL-STD resistors, capacitors, and inductors.

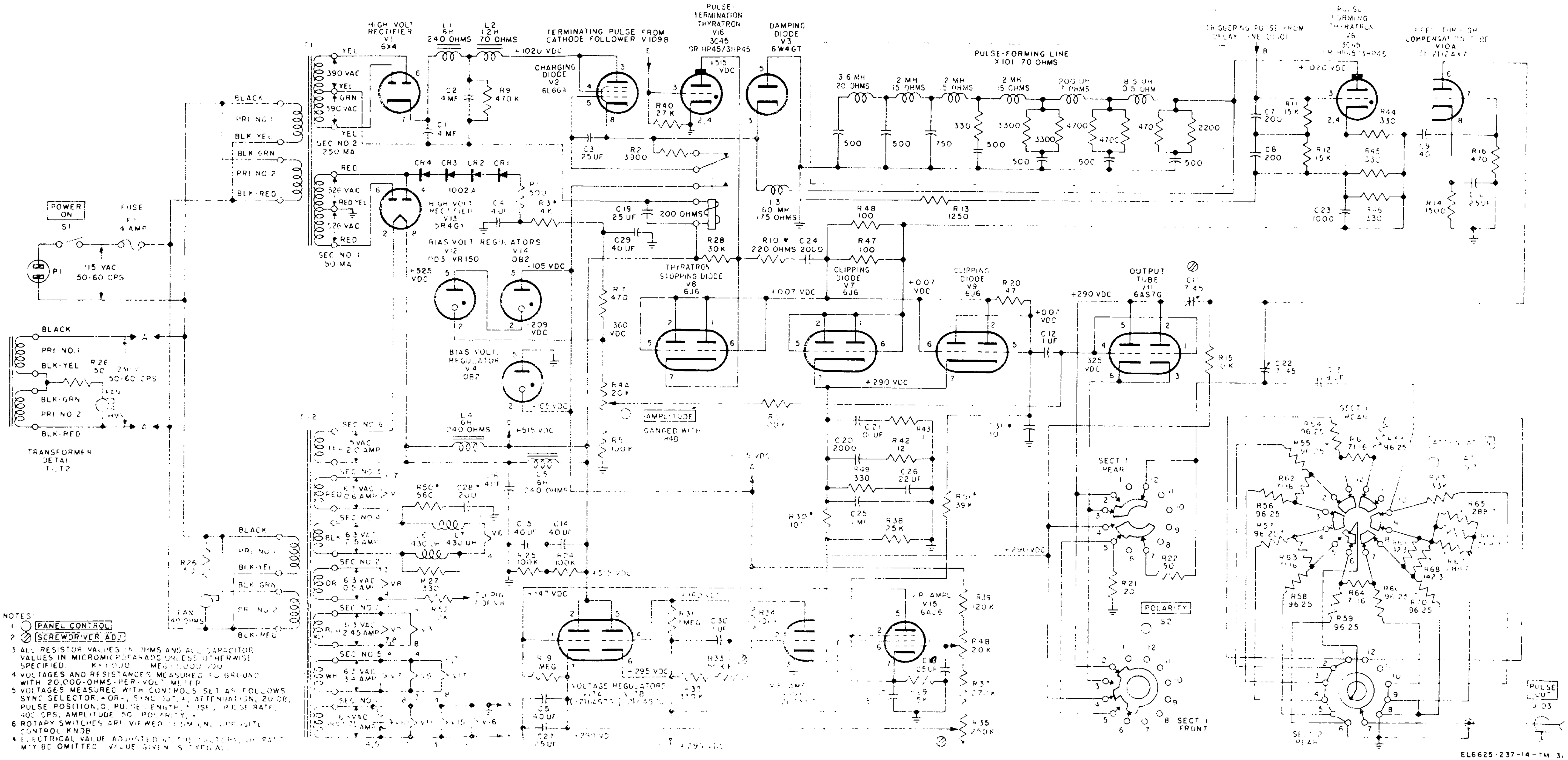


Figure FO-2. Schematic diagram, SG-69/PPM-1 rear deck, serial numbers to 1233.

NOTES.

1. ◯ [PANEL CONTROL]
2. ⊘ [SCREWDRIVER ADJ]
3. ALL RESISTOR VALUES IN OHMS AND ALL CAPACITOR VALUES IN MICROMICROFARADS UNLESS OTHERWISE SPECIFIED K=1,000 MEG=1,000,000
4. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH 20,000-OHMS-PER-VOLT METER
5. VOLTAGES MEASURED WITH CONTROLS SET AS FOLLOWS SYNC SELECTOR, + OR −; SYNC OUT, + ATTENUATION, 20DB; PULSE POSITION, 0, PULSE LENGTH, 5 USEC; PULSE RATE, 400 CPS, AMPLITUDE, 50, POLARITY, +
6. ROTARY SWITCHES ARE VIEWED FROM END OPPOSITE CONTROL KNOB
7. APPLIES TO ALL EQUIPMENTS PROCURED ON ORDER NO 39131-PHILA-58
   - A R1 IS 800 OHMS
   - B R81, 220 OHMS, 1/2-WATT COMPOSITION RESISTOR, IS ADDED IN SERIES WITH GRID OF V16.
   - C R82, 25,000-OHM, 10 WATT, WIRE WOUND RESISTOR, IS ADDED IN PARALLEL WITH TUBES V12 AND V14.
8. APPLIES TO ALL EQUIPMENTS PROCURED ON ORDER NO 19315-PHILA-58
   - A R22 IS 100 OHMS
   - B R83, 100 OHM RESISTOR, IS ADDED IN PARALLEL WITH R22
   - C R84, 1,250-OHM, 10-WATT RESISTOR, IS ADDED IN SERIES WITH PIN 3 OF V3 AND L3.
   - D R85, 1000-OHM, 1-WATT RESISTOR, IS ADDED IN SERIES WITH THE PLATE LEAD OF V3
   - E R86, 10K, 10-WATT RESISTOR, IS ADDED IN SERIES WITH R28
   - F R87, 330-OHM, 10-WATT RESISTOR, IS ADDED IN SERIES WITH V17 PIN 2 AND R24
   - G C3 AND C10 ARE .22UF
   - H R88, 100-OHM RESISTOR, IS ADDED IN PARALLEL WITH R21
   - I C9 IS 39 UUF
   - J C32 IS .047 UF

✕ ELECTRICAL VALUE ADJUSTED AT THE FACTORY, OR PART MAY BE OMITTED. VALUE GIVEN IS TYPICAL.

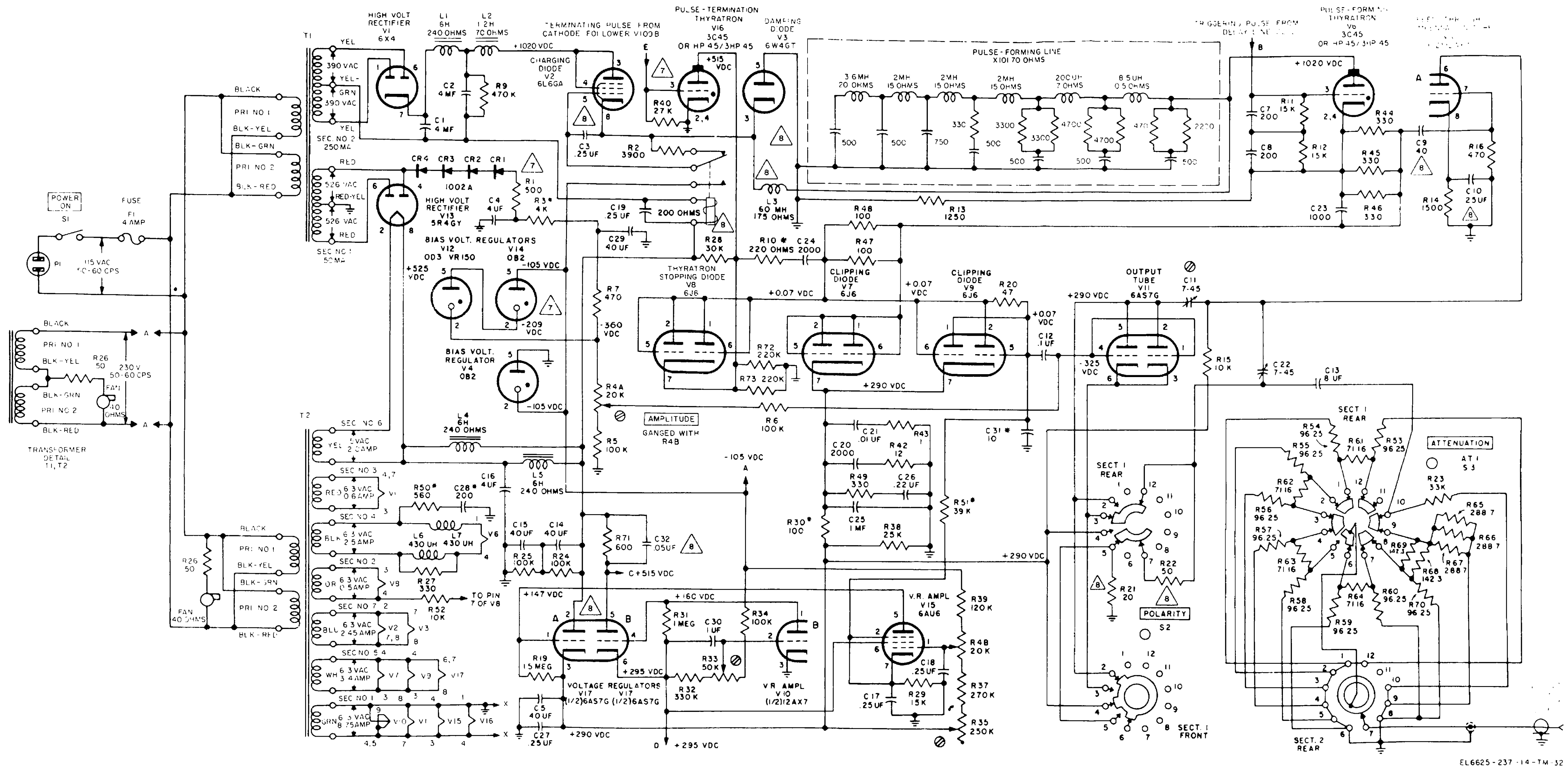


Figure FO-3. Schematic, SG-69/PPM-1 rear deck, serial numbers from 1239.

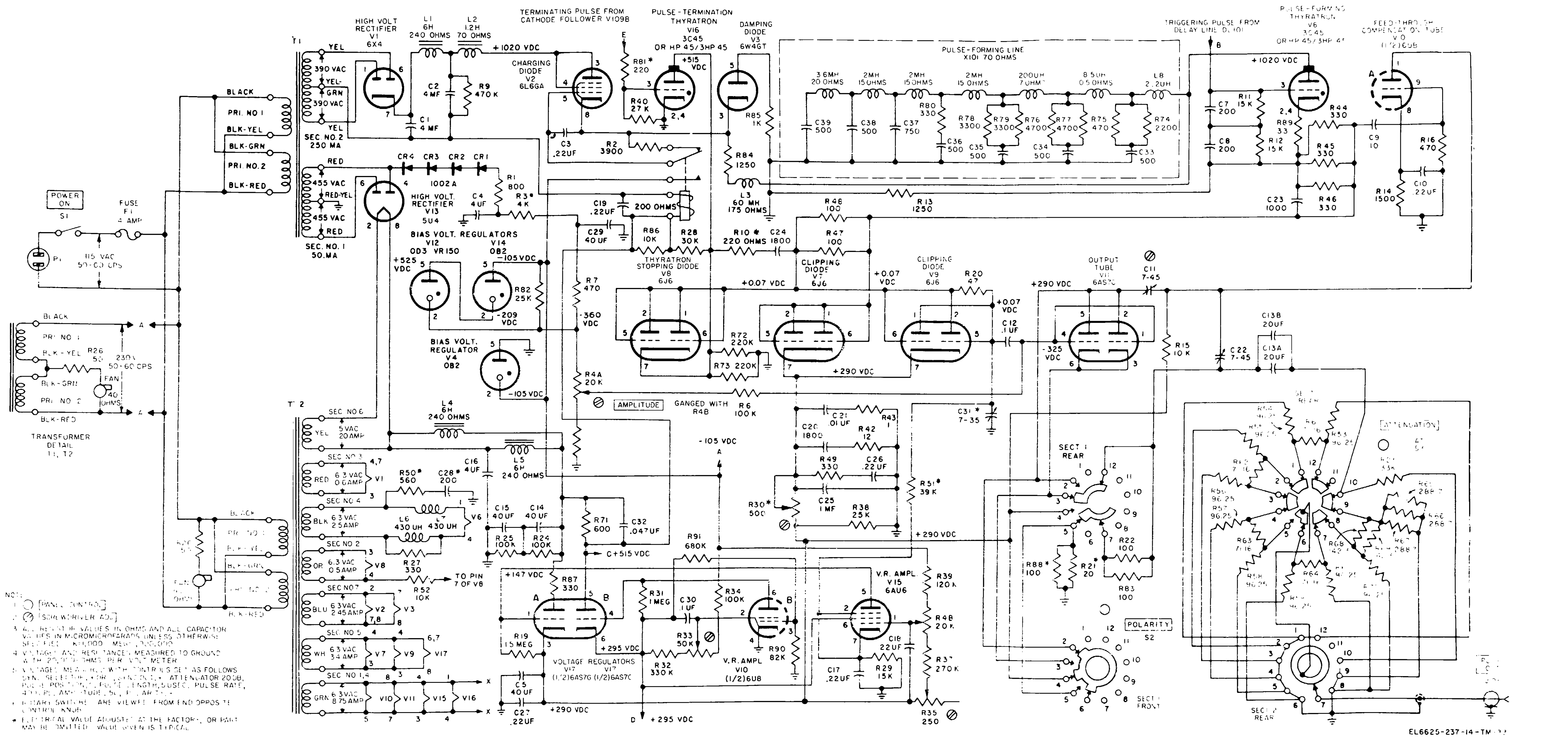
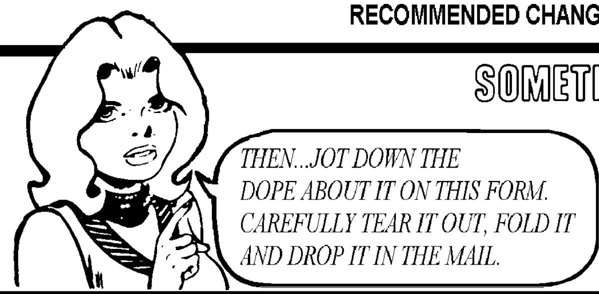


Figure FO-4. Schematic diagram, SG-69B/PPM-1 rear deck, order number 4516-PP-60.

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS



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P.S.--IF YOUR OUTFIT WANTS TO KNOW ABOUT YOUR RECOMMENDATION MAKE A CARBON COPY OF THIS AND GIVE IT TO YOUR HEADQUARTERS.

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*	*To change*	*To*	*Multiply by*
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

PIN: 012170-000