TM 11-1535

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

RADAR SETS

AN/SPN-11X, AN/SPN-11Y, AN/SPN-11Z

FIELD MAINTENANCE

DEPARTMENT OF THE ARMY • DECEMBER 1954

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on all components of the radar set.
Up to 900 volts exist in these components.

DON'T TAKE CHANCES!

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNITS:

Radar Receiver-Transmitter RT-268/SPN-11	In Modulator power supply and transmitter circuits (3,000 volts).
Azimuth and Range Indicator IP-193/SPN-11	In PPI circuits (5,000 volts).

Changes in force: C 1 and C 2

CHANGE No. 2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *27 May 1977*

RADAR SETS AN/SPN-11X (NSN 5840-00-503-3532) AN/SPN-11Y (NSN 5840-00-503-3531) and AN/SPN-11Z (NSN 5840-00-503-3529) FIELD MAINTENANCE

TM 11-1535, 30 December 1954, is changed as follows:

The title is changed as shown above.

Page 5. Paragraph 2 is superseded as follows:

2. Reporting of Errors

The Reporting of errors, omissions and recommendations for improving this manual by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forwarded direct to Commander, US Army Electronics Command, ATTN: DRSEL-MA-Q, Fort Monmouth, NJ 07703.

NOTE

Refer to TM 11-1335 for applicable forms and records.

Paragraph 2.1 is added after paragraph 2.

2.1 Reporting Equipment Improvement Recommendations (EIR)

EIR's will be prepared using DA Form 2407, Maintenance Request. Instructions for preparing EIR's are provided in TM 38-750, The Army Maintenance Management System. EIR's should be mailed directly to Commander, US Army Electronics Command, ATTN: DRSEL-MA-Q, Fort Monmouth, NJ 07703. A reply will be furnished direct to you.

Page 177, figure 148. At pin 1 of V107 change "550K" to read "1 Meg."

Figure 222. Add the following under "2. RF SYSTEM."

C. TEST WAVEGUIDE RUN (THE POWER OUTPUT WITH WAVEGUIDE RUN CONNECTED SHOULD NOT BE MUCH LESS THAN WITH THE DUMMY LOAD CONNECTED).

By Order of the Secretary of the Army:

BERNARD W. ROGERS
General, United States Army
Chief of Staff

Official:

PAUL T. SMITH
Major General, United States Army
The Adjutant General

Distribution:

To be distributed in accordance with DA Form 12-51, Direct and General Support maintenance requirements for AN/SPN-11.

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TECHNICAL MANUAL

RADAR SETS AN/SPN-11X, AN/SPN-11Y, AN/SPN-11Z FIELD MAINTENANCE

TM 11-1535
CHANGES No. 1

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *30 August 1955*

TM 11-1535, 30 December 1954, is changed as follows:

Page 6, paragraph 4b. Change the fifth entry from the top of the page to read:

Blower motor input.	115, 32, or 24 vdc, from shipboard supply; **or 115 v, 400 cycle ac from motor generator (on receiver-transmitters bearing Order No. 28468-Phila-55).**

Page 7, paragraph 6. Make the following changes in the "Component" column in paragraph 6:

In *a*, change "Blower motor (115 vdc)" to read: Blower motor **115 v dc (115 v, 400 cycles ac for blower motors mounted in receiver-transmitters bearing Order No. 28468-Phila-55).**

In *b*, change "Blower motor (32 vdc)" to read: Blower motor **32 v dc (115 v, 400 cycles ac for blower motors mounted in receiver-transmitters bearing Order No. 28468-Phila-55).**

In *c*, change "Blower motor (24 vdc)" to read: Blower motor **24 v dc (115 v, 400 cycles ac for blower motors mounted in receiver-transmitters bearing Order No. 28468-Phila-55).**

Page 8, paragraph 7. Change the figure references at the end of the paragraph title to read: (figs. 2, 3, and **3.1**).

Page 9. Add figure 3.1 after figure 3.

Page 13, paragraph 12. Make the following changes:

In the chart in *b*, change the fifth line in the "AN/SPN-11X" column to read: 115 v dc **(115 v, 400 cycles ac in receiver-transmitters bearing Order No. 28468-Phila-55).**

Change the fifth line in the "AN/SPN-11Y" column to read: 32 v dc **(115 v, 400 cycles ac in receiver-transmitters bearing Order No. 28468-Phila-55).**

Change the fifth line in the "AN/SPN-11Z" column to read: 24 v dc **(115 v, 400 cycles ac in receiver-transmitters bearing Order No. 28468-Phila-55).**

Add *c* after *b*.

c. Changes and Additions (Order No. 28468-Phila-55). The following changes or additions have been made in Radar Set AN/SPN-11X, procured on Order No. 28468-Phila-55:

(1) Blower motor B801 operates from the 115-volt, 400-cycle, motor-generator output.

(2) Terminal board TB805, fuse F805, and starting capacitors C802 and C803 have been added for the connections and operation of the blower motor (fig. 204.1).

(3) The convenience panel has been changed so that a larger air filter can be installed.

(4) Spare brushes for the motor generator, the antenna drive motor, and the deflection coil are supplied.

(5) Fuse F301 in the modulator power supply has been changed from 2 amperes to a 1-ampere, slow blow type.

Page 15, Paragraph 18. In *c*, add the following to the last sentence: except, on receiver-transmitters bearing Order No. 28468-Phila-55, the blower motor operates from the motor generator 115-volt, 400-cycle output.

Page 74, paragraph 83. In *b*, change the first sentence to read: The 115-volt 400 cps **ac is** fed through fuses to the low-voltage power supplies, the modulator power supply, the ppi power supply, **and the blower motor (on receiver-transmitters bearing Order No. 28468-Phila-55 only).**

Page 74, paragraph 84. Change the figure references after the paragraph heading to read: (figs. 73, **73.1**, and 74).

Page 75. Add figure 73.1 after figure 73.

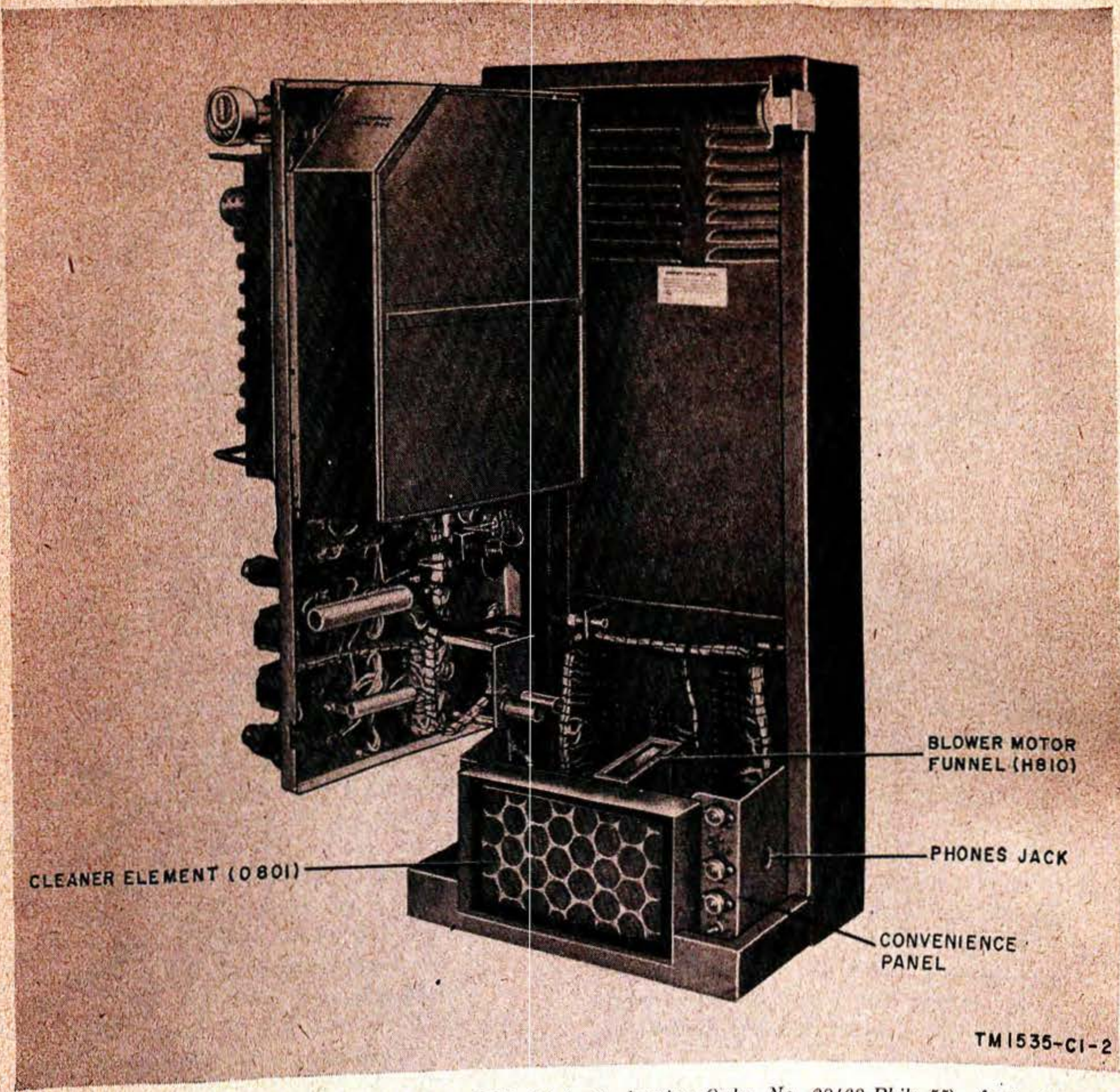

Figure 3.1. Radar Receiver-Transmitter RT-268/SPN-11 (units bearing Order No. 28468-Phila-55), front view, with hinged panel open.

Page 76, paragraph 85. In *e*, change the last sentence to read: The ship's supply voltage **(or, in the case of receiver-transmitters bearing Order No. 28468-Phila-55, the 115 volts, 400 cps)** is fed to the blower motor on the bottom of the receiver-transmitter.

Page 77, figure 75. Add the following note:

NOTE

THE BLOWER MOTORS OF RADAR RECEIVER-TRANSMITTERS RT-268/SPN-11 BEARING ORDER NO. 28468-PHILA-55 ARE ENERGIZED BY THE 115-VOLT, 400-CPS, MOTOR-GENERATOR OUTPUT.

Page 80. Add figure 81.1 after figure 81.

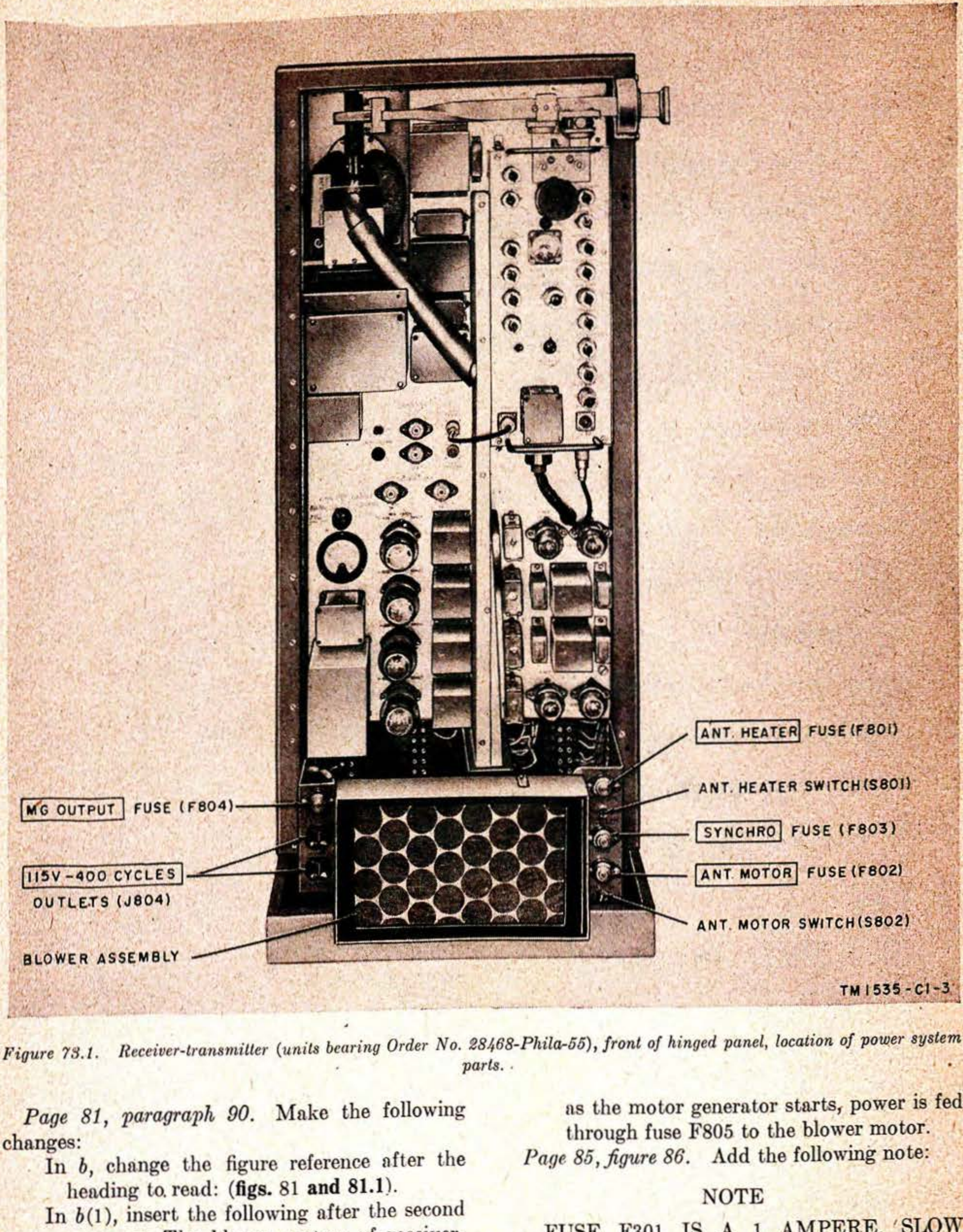

Figure 73.1. Receiver-transmitter (units bearing Order No. 28468-Phila-55), front of hinged panel, location of power system parts.

Page 81, paragraph 90. Make the following changes:

In *b*, change the figure reference after the heading to read: (**figs.** 81 **and 81.1**).

In *b*(1), insert the following after the second sentence: The blower motors of receiver-transmitters bearing Order No. 28468-Phila-55 are energized by the 115-volt, 400-cps, motor-generator output. As soon as the motor generator starts, power is fed through fuse F805 to the blower motor.

Page 85, figure 86. Add the following note:

NOTE

FUSE F301 IS A 1 AMPERE, SLOW BLOW, IN RECEIVER-TRANSMITTERS BEARING ORDER NO. 28468-PHILA-55.

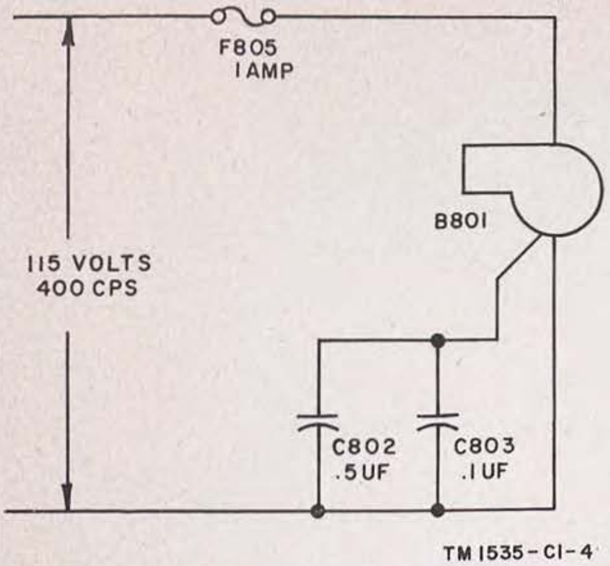

Figure 81.1. Power for blower motor of receiver-transmitters bearing Order No. 28468-Phila-55.

Page 92, paragraph 99e. Change the period after the first word on the page to a comma and add the following: except, on receiver-transmitters bearing Order No. 28468-Phila-55, the blower motor operates from the 115-volt, 400-cps, motor-generator output.

Page 115. Add figure 113.1 after figure 113.

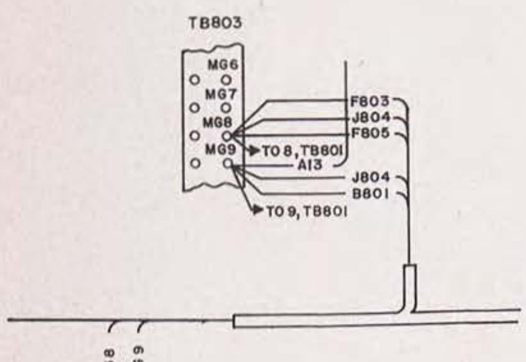

Figure 113.1. Receiver-transmitter (units bearing Order No. 28468-Phila-55), blower circuit, schematic diagram.

Page 116. Paragraph 108. Make the following changes:

Change the figure references after the paragraph heading to read: (figs. 113, **113.1**, 114, and **204.1**).

In *a*, insert the following after the first sentence: On receiver-transmitters bearing Order No. 28468-Phila-55, a fifth terminal board (TB805) is provided for connections of the blower motor circuit.

Page 125, paragraph 116. Make the following changes: Opposite F301 in the chart, change 1 amp, 250V in the Rating column to read: **2** amp, 250V **(or 1 ampere, slow blow type, in receiver-transmitters bearing Order No. 28468-Phila-55).**

Add the following to the fuse table.

Fuse	Protects	Rating	Location
F805	Blower circuit	1 amp, 250 v.	Back of blower mounting panel.

Page 199, paragraph 203. After the tenth line of paragraph 203, add the following: On receiver-transmitters bearing Order No. 28468-Phila-55, another terminal board (TB805) is provided for connections of the blower motor circuit.

Page 211. Add figure 173.1 after figure 173.

Page 247, paragraph 246. Change the figure references at the end of paragraph 246 to read: (figs. 204, **204.1**, 205, and **205.1**).

Page 247. Add figure 204.1 after figure 204.

Page 248. Add figure 205.1 after figure 205.

Page 248, paragraph 247. Change the figure reference in the first line to read: (**figs.** 204 **and 204.1**).

Page 249. Add paragraph 248.1 after paragraph 248.

248.1. Disassembly and Reassembly of Blower Motor of Receiver-Transmitters Bearing Order No. 28468-Phila-55.

(fig. 205.1)

a. Loosen the two setscrews by using a 3/32-inch (across flats) Allen wrench and remove the centrifugal impeller.

b. Remove the four motor mounting screws and lockwashers and separate the impeller housing from the motor.

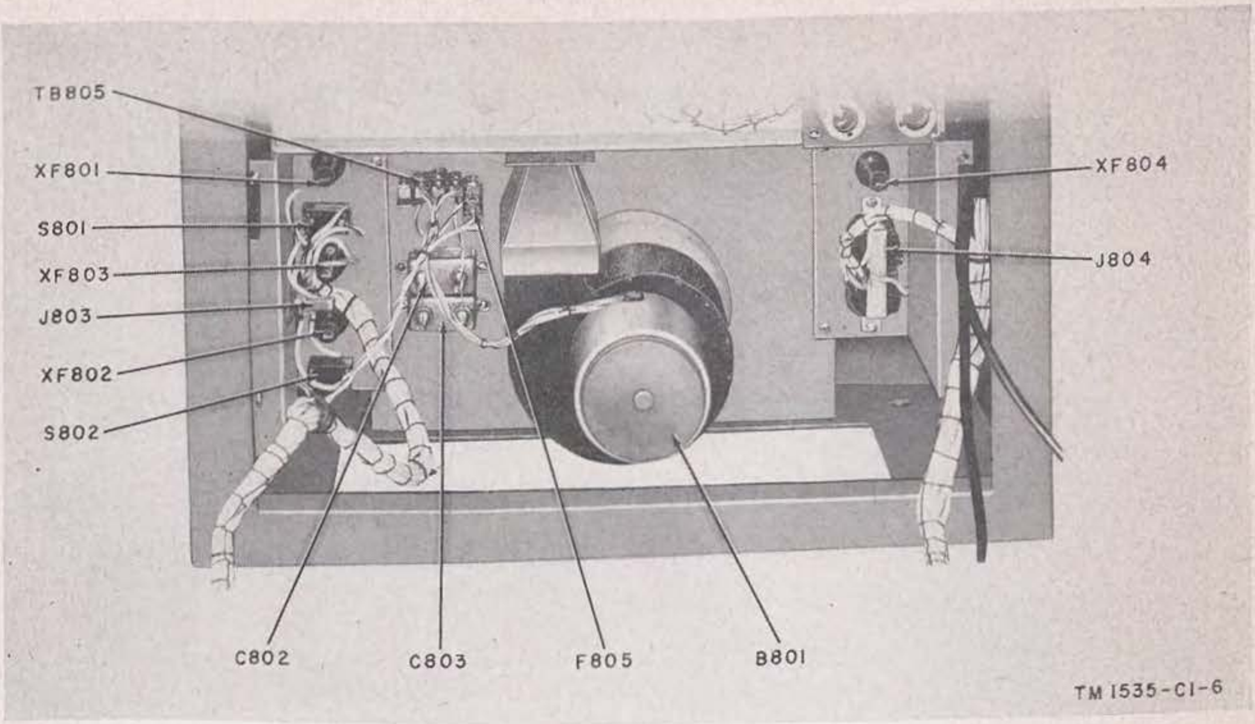

Figure 173.1. Hinged panel, rear view (receiver-transmitters bearing Order No. 28468-Phila-55).

c. Remove the four cap mounting screws and lockwashers by using the 5/32-inch Allen wrench and remove the front cap.

d. Remove the rotor.

e. Remove the bearings by using a bearing puller and exerting pressure against the inner race only. If the rear bearing remains in its housing, place a wooden dowel in the hole at the rear of the motor and tap it with a mallet. The bearing will fall out.

Caution: Always work in a dust-free area when removing or replacing bearings.

f. When reassembling the blower motor, place the rear bearing securely in its housing and push against its inner race with a wooden dowel until the outer race does not extend above its housing.

g. To complete the reassembly, reverse the disassembly procedures in *a* through *e* above.

Figure 212. Add the following note:

NOTE

FUSE F301 IS A 1 AMPERE, SLOW BLOW, IN RECEIVER-TRANSMITTERS BEARING ORDER NO. 28468-PHILA-55.

Figure 220. Add the following notes to figure 220:

5. ON RECEIVER-TRANSMITTERS BEARING ORDER NO. 28468-PHILA-55, BLOWER MOTOR B801 IS CONNECTED (IN SERIES WITH FUSE F805) ACROSS THE MOTOR-GENERATOR AC WINDING (TERMINALS 8 AND 9 OF TB601) AS SHOWN IN FIGURE 113.1. THE REST OF THE CIRCUITRY IS AS SHOWN.
6. FUSE F301 IS A 1 AMPERE, SLOW BLOW, IN RECEIVER-TRANSMITTERS BEARING ORDER NO. 28468-PHILA-55.

[AG 413.44 (25 Aug 55)]

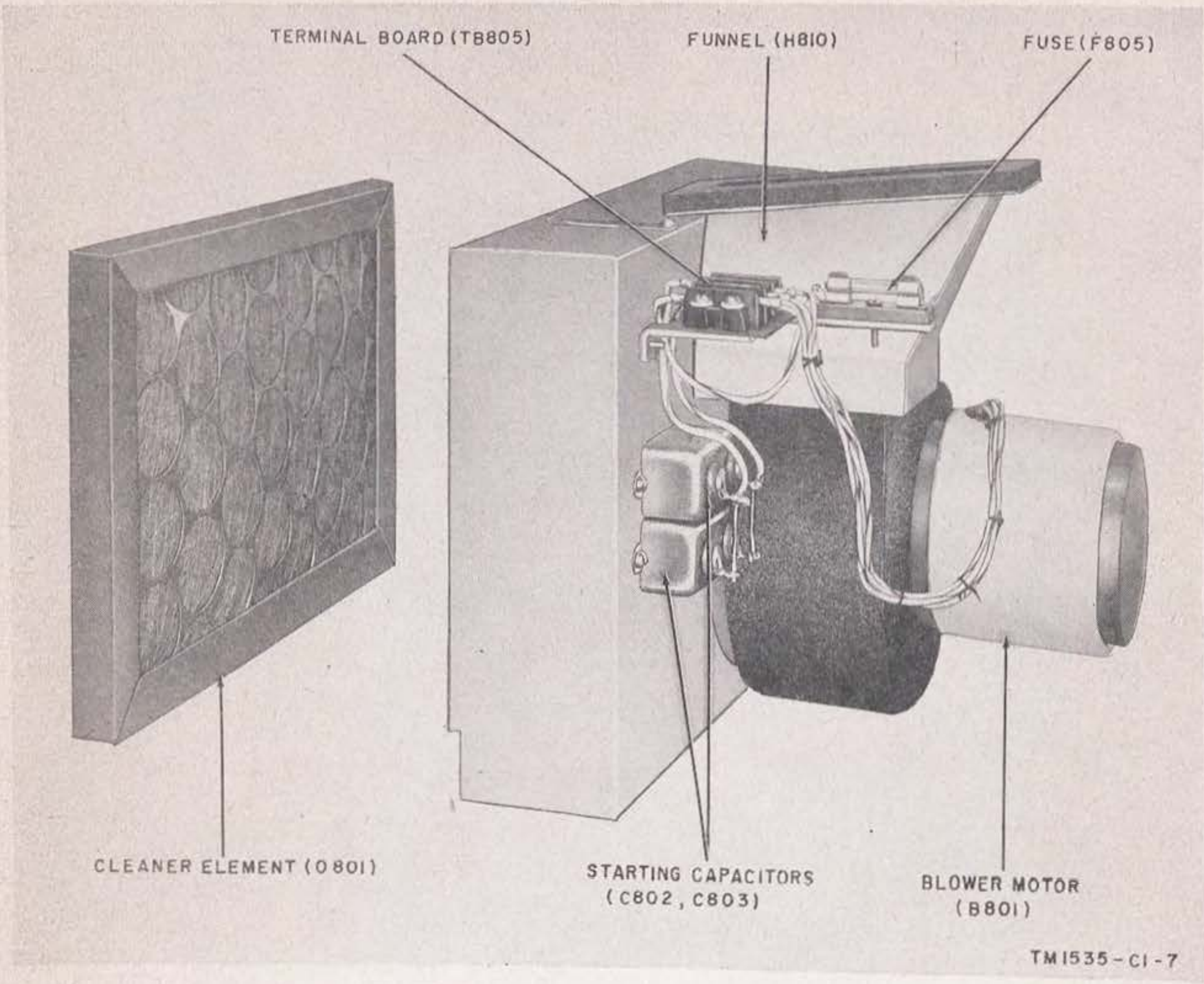

Figure 204.1. Blower assembly supplied on receiver-transmitters bearing Order No. 28468-Phila-55.

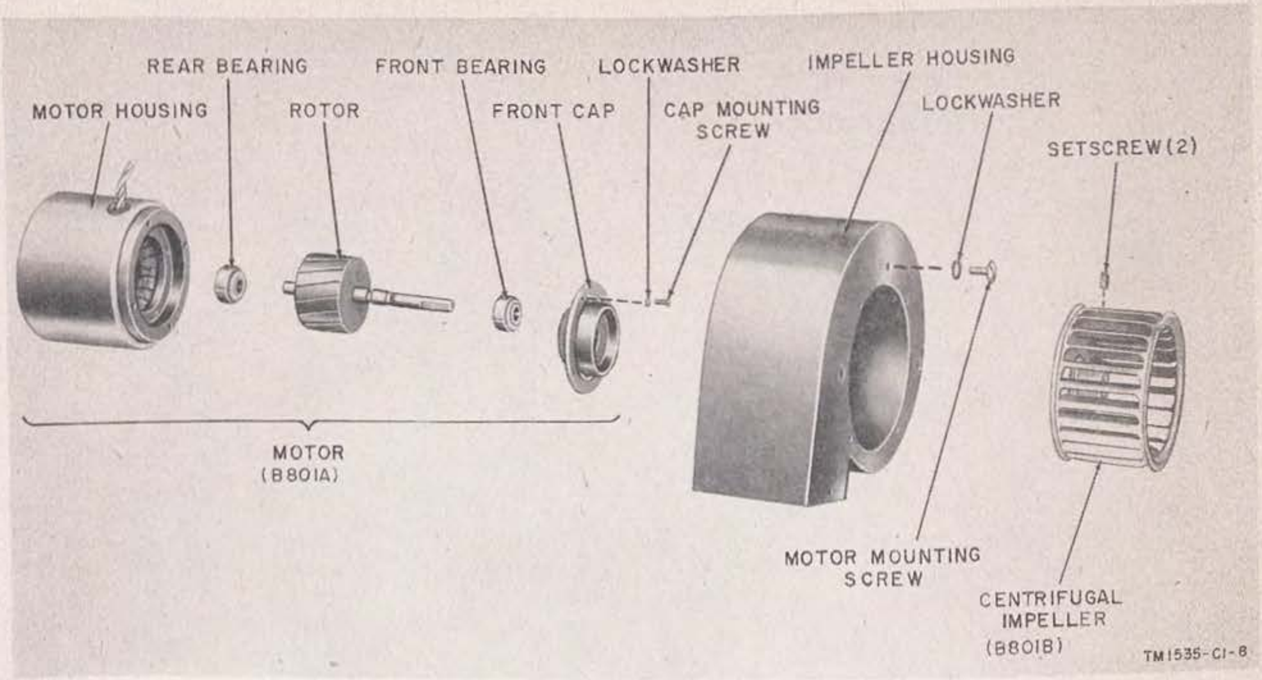

Figure 205.1. Blower assembly of receiver-transmitters bearing Order No. 28468-Phila-55, exploded view.

By order of the Secretary of the Army:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

Official:
JOHN A. KLEIN,
Major General, United States Army,
The Adjutant General.

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11–128R, Sig Depot Co (2)
11–500R (AA–AE), Sig Svc Org (2).
11–557R, Abn Sig Co (2)
11–587R, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2).
11–597R, Sig Base Depot Co (2)

NG: State AG (6); units—same as Active Army except allowance is one copy to each unit.
USAR: None.
For explanation of abbreviations used, see SR 320–50–1.

U. S. GOVERNMENT PRINTING OFFICE: 1955

TECHNICAL MANUAL No. 11-1535

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *30 December 1954*

RADAR SETS AN/SPN-11X, AN/SPN-11Y, AN/SPN-11Z

FIELD MAINTENANCE

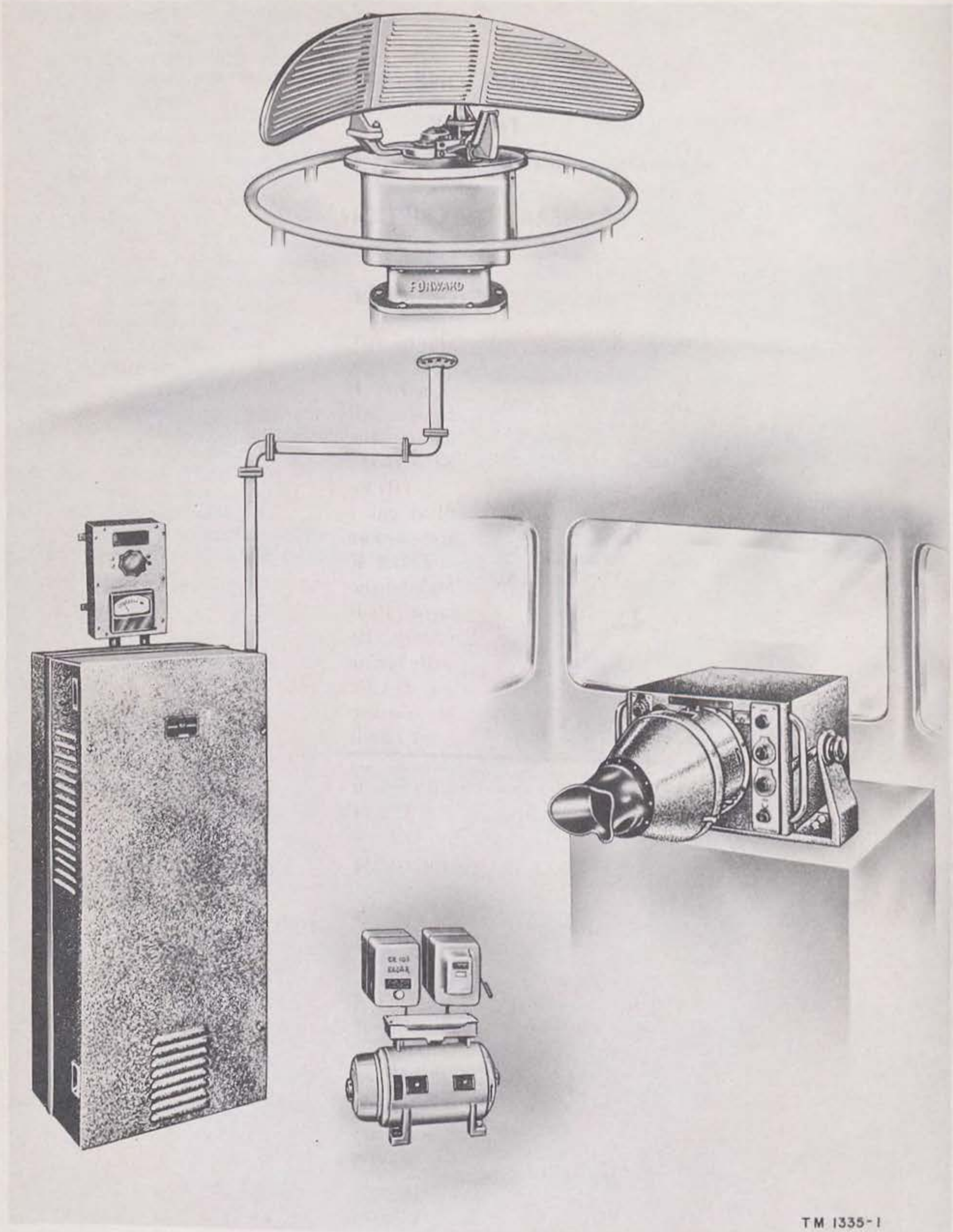


Figure 1. Radar Set AN/SPN-11(*).

PART ONE

THEORY

CHAPTER 1

GENERAL DESCRIPTION

Section I. INTRODUCTION

1. Scope

a. This technical manual contains a discussion of the theory and instructions for the repair of Radar Sets AN/SPN-11X, AN/SPN-11Y, and AN/SPN-11Z. Installation and operation instructions are provided in TM 11-1335.

b. Official nomenclature followed by (*) is used to indicate all models of the equipment item covered in this manual. Thus Radar Set AN/SPN-11(*) represents Radar Sets AN/SPN-11X, AN/SPN-11Y, and AN/SPN-11Z.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army equipment and when performing preventive maintenance.

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745-45-5 (Army); Navy Shipping Guide, Article 1850-4 (Navy); and AFR 71-4 (Air Force).

b. DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the office of the Chief Signal Officer as prescribed in SR 700-45-5.

c. DD Form 535, Unsatisfactory Report, will be filled out and forwarded as prescribed in SR 700-45-5 and TO 00-35D-54.

d. DA Form 11-238, Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar) will be prepared in accordance with instructions on the back of the form.

e. DA Form 11-239, Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar) will be prepared in accordance with instructions on the back of the form.

f. Use other forms and records as authorized.

Section II. DESCRIPTION

3. Purpose and Use

Radar Set AN/SPN (*) (fig. 1) is a shipboard navigational aid which provides position data on vessels and landmarks that are not visible because of fog or darkness. Over a range of 75 yards to 20 nautical miles, the radar set is used to obtain:

a. Anticollision data by observing the positions and courses of vessels on the open sea.

b. Piloting information by observing the position of buoys and other markers in channels and harbors.

c. Bearings and ranges of known landmarks to plot the position of the radar-equipped vessel.

d. Storm warning data by observing and plotting the movements of heavy rain or snow squalls.

4. Technical Characteristics

a. Power Supply Requirements.

Radar Set:	*Shipboard supply*
AN/SPN-11X	115 vdc at 1,000 w.
AN/SPN-11Y	32 vdc at 1,000 w.
AN/SPN-11Z	24 vdc at 1,000 w.

b. Radar Receiver-Transmitter RT-268/SPN-11.

Transmitter:	
Frequency	One preset channel in the 9,320- to 9,430-mc band (3.22—3.18 cm).
Modulation	Pulse.
Pulse width	.4 usec.
Pulse repetition rate	1,000 cps.
Duty cycle	33.8 db.

Transmitter—Continued

Power output (peak)	30 kw (74.6 dbm).
Power output (average)	12 w (40.8 dbm).
Source of rf power	Magnetron, type 725A.
Range (approximate)	75 yd to 20 nautical mi.
Blower motor (input)	115, 32, or 24 vdc, from shipboard supply.
Number of tubes	18.

Radar Receiver R–480/SPN–11:

Frequency	One preset channel in the 9,320- to 9,430-mc band.
Receiver type	Superheterodyne.
Intermediate frequency	30 mc.
Bandwidth	5 mc.
Minimum discernible signal.	—90 dbm.
Type of signal	Pulse.
Number of tubes	16.

Duplexer CU–311/SPN–11:

TR tube	1B24A.
Anti-TR tube	1B35.

Frequency Mixer Stage CV–239/SPN–11:

AFC crystal	1N23B.
Signal crystal	1N23B.
Klystron oscillator	2K25 or 723A/B.

c. Antenna AS–599/SPN–11.

Type of feed	Horn.
Reflector	Parabolic.
Frequency range	9,320 to 9,430 mc.
Input impedance	400 to 500 ohms.
Beam width:	
Horizontal	1.9°.
Vertical	20°.
Bearing resolution	2°.
Attenuation of back and side lobes.	25 db.
Speed of antenna horn rotation.	17 rpm.
Gear ratio, transmitter synchro to antenna horn.	10:1.
Antenna drive motor (input)	115, 32, or 24 vdc, from shipboard supply.

d. Azimuth and Range Indicator IP–193/SPN–11.

Ranges	1, 3, 8, and 20 nautical mi.
Azimuth (relative bearings)	0° to 360°.
Indicator	7-inch cathode ray tube.
Type of presentation	Plan position indicator.
Number of tubes	10.

e. Motor Generator.

Motor:

Input	115, 32, or 24 vdc, from shipboard supply.
Field	Compound wound.
Speed of rotation	1,715 rpm.

Generator:

Input (to field)	115, 32, or 24 vdc, from shipboard supply.
Output	115-volt, 400-cycle single-phase voltage at 6.5 amp, 750 va (for all components, except blower, heaters, and drive motors).

5. Nomenclature Assignments

The letter suffixes X, Y, and Z are used as voltage designators. Thus basic nomenclature followed by X, Y, or Z indicates that the component or radar set operates on a direct current (dc) supply source of 115, 32, or 24 volts, respectively. A list of nomenclature assignments for the components of Radar Set AN/SPN–11(*) is given below. A common usage name is indicated after each component.

Nomenclature	*Common name*
Radar Receiver-Transmitter RT–268/SPN–11.	Receiver-transmitter
Duplexer CU–311/SPN–11	Duplexer
Frequency Mixer Stage CV–239/SPN–11.	Mixer
Radar Receiver R–480/SPN–11.	Receiver
Antenna AS–599/SPN–11	Antenna
Resistance Element HD–124/SPN–11.	Heater (115 volts)
Resistance Element HD–123/SPN–11.	Heater (32- or 24-volt)
Azimuth and Range Indicator IP–193/SPN–11.	Indicator
Junction Box J–497/SPN–11	Junction box
Switch Box SA–284/SPN–11	Switch box (115-volt)
Switch Box SA–283/SPN–11	Switch box (32- or 24-volt)
Motor Starter SA–287/SPN–11.	Starter (115-volt)
Motor Starter SA–286/SPN–11.	Starter (32-volt)
Motor Starter SA–285/SPN–11.	Starter (24-volt)
Motor-Generator PU–243/SPN–11.	Motor generator (115-volt)
Motor-Generator PU–245/SPN–11.	Motor generator (32-volt)
Motor-Generator PU–244/SPN–11.	Motor generator (24-volt)
Voltage Regulator CN–192/SPN–11X.	Voltage regulator (115-volt)
Voltage Regulator CN–193/SPN–11Y.	Voltage regulator (32-volt)
Voltage Regulator CN–194/SPN–11Z.	Voltage regulator (24-volt)

6. Table of Components

a. Radar Set AN/SPN-11X (115 volts Dc).

Component	Required No.	Height (in.)	Depth (in.)	Length (in.)	Volume (cu. ft.)	Unit weight (lb.)
Radar Receiver-Transmitter RT-268/SPN-11	1	43⅝	13¾	20⅝	7. 15	215
Blower motor (115 vdc)	1					
Antenna AS-599/SPN-11	1	33¾	22½	50	21. 97	155
Antenna drive motor (115 vdc)	1					
Resistance Element HD-124/SPN-11	2					
Azimuth and Range Indicator IP-193/SPN-11	1	16⅜	18	19	3. 24	60
Junction Box J-497/SPN-11	1	14⅛	3¾	6¾	. 21	5
Switch Box SA-284/SPN-11	1	7	4	6¾	. 109	4¼
Motor Starter SA-287/SPN-11	1	9½	6 13/16	6 29/32	. 255	13
Motor-Generator PU-243/SPN-11	1	13¾	19½	9¼	1. 433	170
Voltage Regulator CN-192/SPN-11X	1	11½	5½	8⅜	. 30	8
Wave guide sections						
Cables (see cabling diagram)						
Total					34. 67	631

Note. This list is for general information only. See appropriate supply publications for information pertaining to the requisition of spare parts.

b. Radar Set AN/SPN-11Y (32 volts Dc).

Component	Required No.	Height (in.)	Depth (in.)	Length (in.)	Volume (cu. ft.)	Unit weight (lb.)
Radar Receiver-Transmitter RT-268/SPN-11	1	43⅝	13¾	20⅝	7. 15	215
Blower motor (32 vdc)	1					
Antenna AS-599/SPN-11	1	33¾	22½	50	21. 97	155
Antenna drive motor (32 vdc)	1					
Resistance Element HD-123/SPN-11	2					
Azimuth and Range Indicator IP-193/SPN-11	1	16⅜	18	19	3. 24	60
Junction Box J-497/SPN-11	1	14⅛	3¾	6¾	. 21	5
Switch Box SA-283/SPN-11	1	11	5¼	10¼	. 343	8
Motor Starter SA-286/SPN-11	1	11 11/16	7⅛	8¾	. 410	19
Motor-Generator PU-245/SPN-11	1	13¾	19½	9¼	1. 43	170
Voltage Regulator CN-193/SPN-11Y	1	11½	5½	8⅜	. 30	8
Wave guide sections						
Cables (see cabling diagram)						
Total					35. 06	640

Note. This list is for general information only. See appropriate supply publications for information pertaining to the requisition of spare parts.

c. Radar Set AN/SPN-11Z (24 volts Dc).

Component	Required No.	Height (in.)	Depth (in.)	Length (in.)	Volume (cu. ft.)	Unit weight (lb.)
Radar Receiver-Transmitter RT-268/SPN-11	1	43⅝	13¾	20⅝	9. 15	215
Blower motor (24 vdc)	1					
Antenna AS-599/SPN-11	1	33¾	22½	50	21. 97	155
Antenna drive motor (24 vdc)	1					
Resistance Element HD-123/SPN-11	2					
Azimuth and Range Indicator IP-193/SPN-11	1	16⅜	18	19	3. 24	60
Junction Box J-497/SPN-11	1	14⅛	3¾	6¾	. 21	5
Switch Box SA-283/SPN-11	1	11	5¼	10¼	. 343	8
Motor Starter SA-285/SPN-11	1	12	7⅛	8¾	. 432	19
Motor-Generator PU-244/SPN-11	1	13¾	19½	9¼	1. 43	170
Voltage Regulator CN-194/SPN-11Z	1	11½	5½	8⅜	. 30	8
Wave guide sections						
Cables (see cabling diagram)						
Total					37. 08	640

Note. This list is for general information only. See appropriate supply publications for information pertaining to the requisition of spare parts.

7. Radar Receiver-Transmitter RT-268/SPN-11

(fig. 2 and 3)

The receiver-transmitter is an upright rack with a door covering the entire face of it. When the door is opened, the front of a hinged panel, upon which are mounted parts for the transmitting system and low voltage power supplies, is revealed. The duplexer, which funnels the transmitted and received energies to the proper points, is mounted in the upper right-hand corner of the hinged panel. Directly beneath the duplexer is the receiver chassis which is connected to the duplexer through the mixer. On the opposite side of the hinged panel is a shielded compartment that contains other transmitting system and power supply parts. Terminal boards that have interconnecting points between receiver-transmitter parts and all the other components of the radar set are mounted on the lower inside portion of the rack. A convenience panel, upon which are mounted switches, fuses, alternating current (ac) receptacles and a blower, is attached at the bottom of the rack.

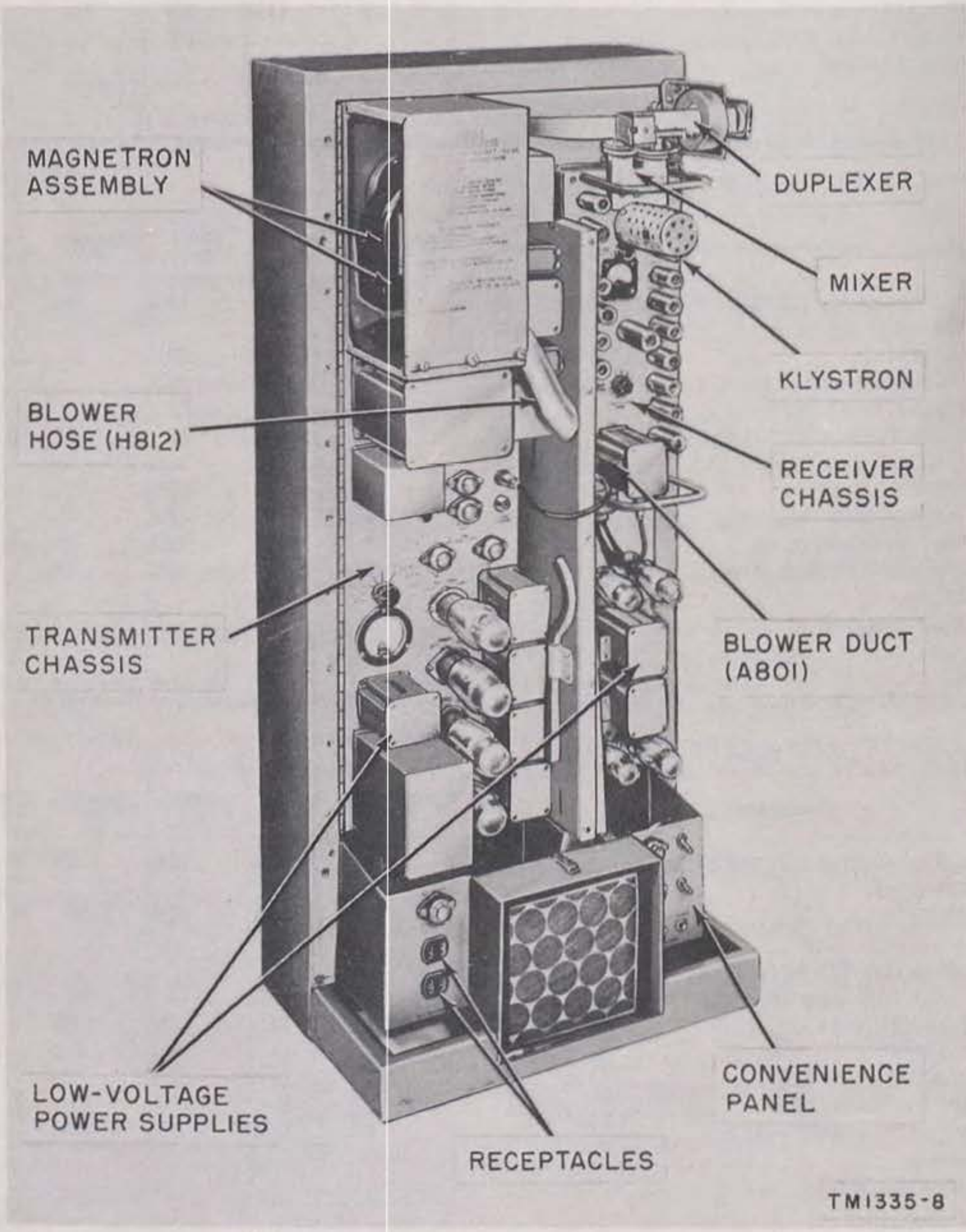


Figure 2. Radar Receiver-Transmitter RT-268/SPN-11, front view.

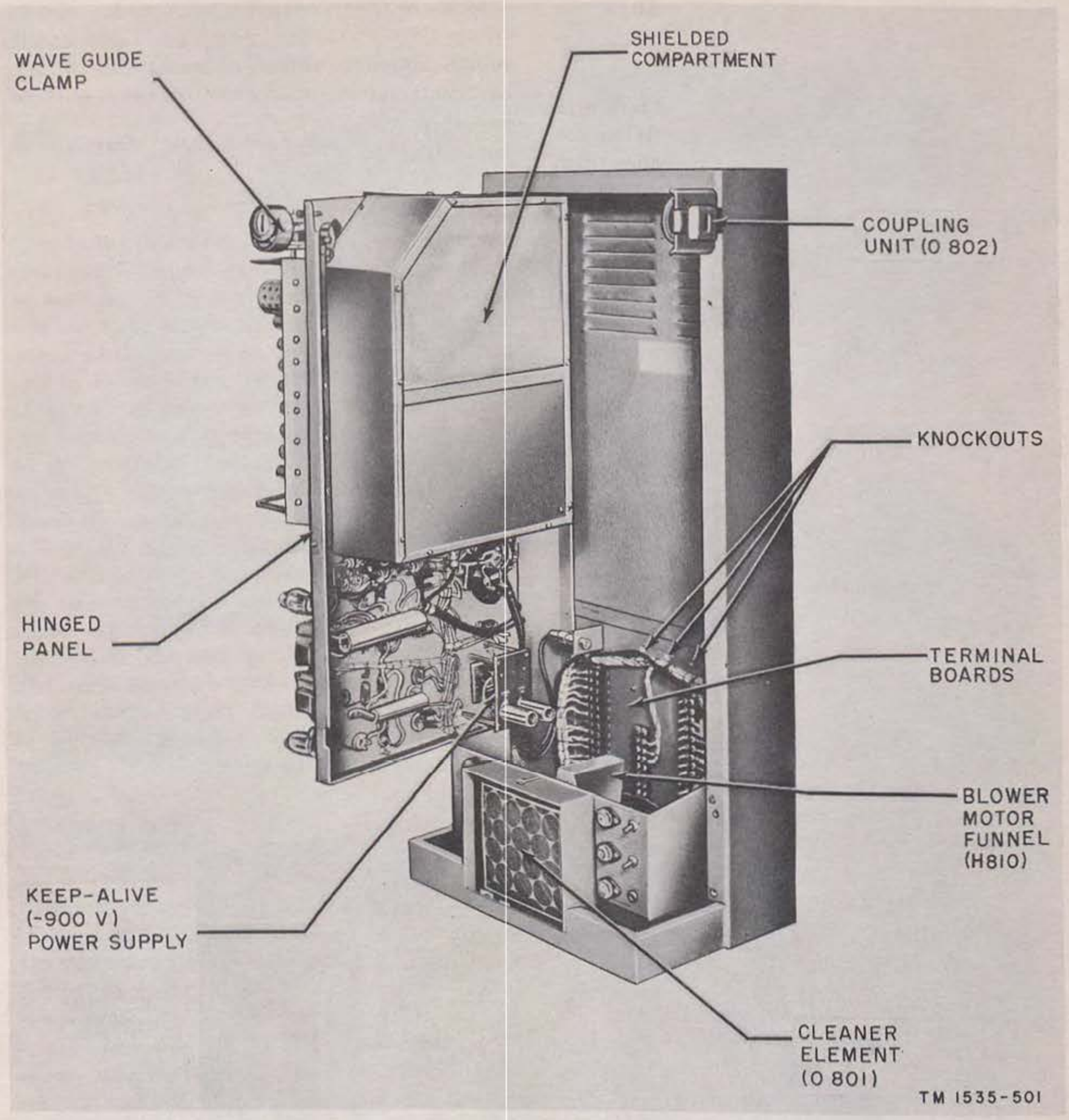


Figure 3. Radar Receiver-Transmitter RT–268/SPN–11, front view, with hinged panel open.

8. Antenna AS–599/SPN–11
(fig. 4)

a. The antenna is composed of two parts: the rotating assembly and the pedestal. The rotating assembly includes the antenna horn and reflector. The pedestal has two compartments: the drive housing which holds the antenna drive motor, and the gear housing which contains all the gear assemblies.

b. The wave guide is connected at the bottom of the gear housing to wave guide assemblies that run up through the pedestal to the antenna horn and reflector.

c. The pedestal also holds the transmitter synchro. This synchro is connected to the antenna drive motor through a gearing system and produces a voltage that is fed to the receiver synchro in the indicator. These synchros cause the sweep

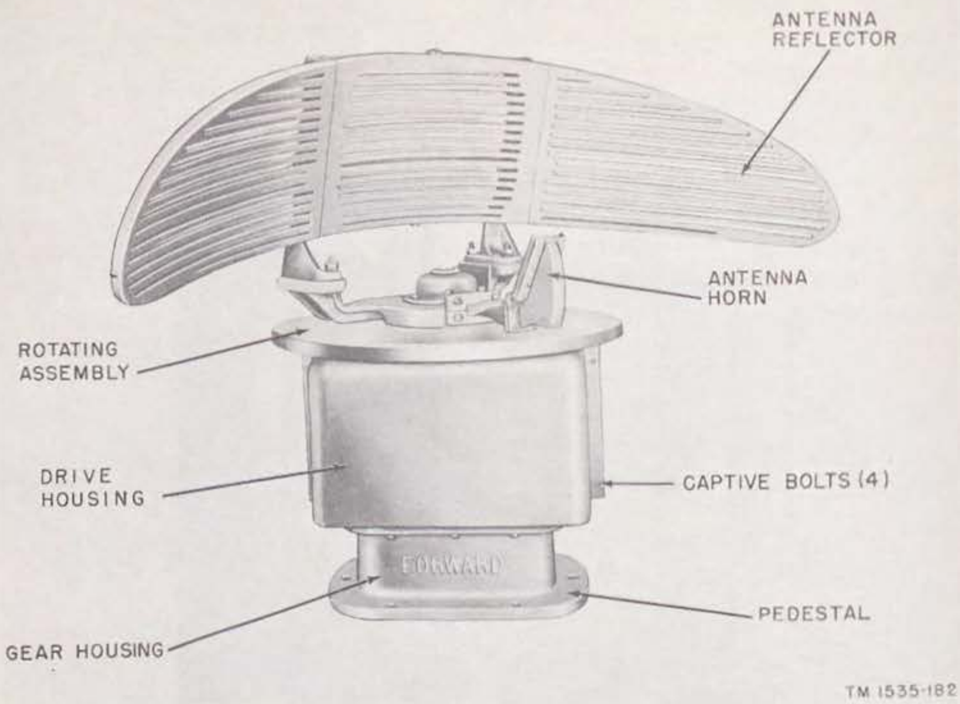


Figure 4. Antenna AS-599/SPN-11.

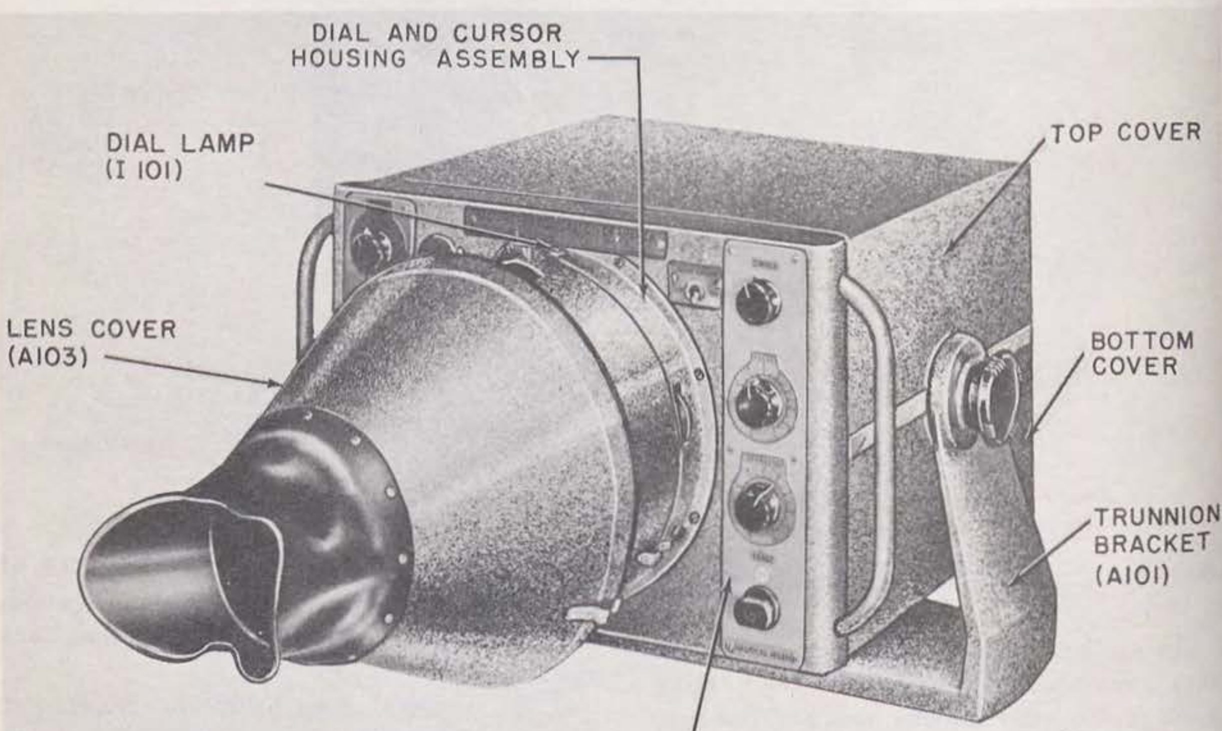


Figure 5. Azimuth and Range Indicator IP-193/SPN-11, front view.

on the plan position indicator (PPI) to rotate in unison with the antenna horn.

d. A can assembly in the pedestal actuates heading flash circuits in the indicator.

9. Azimuth and Range Indicator IP–193/SPN–11
(fig. 5)

a. In the center of the front panel of the indicator is the cathode ray tube which gives a PPI presentation of the surrounding area. The cathode ray tube screen is made more viewable by means of the lens cover which shades the screen and by means of the trunnion bracket which enables the indicator to be titled. Around the tube are the various controls needed for the operation of the radar set. Top and bottom covers are removed by loosening captive screws in the rear of the unit.

b. In the indicator are the range, sweep, video, PPI and synchronizing circuits. The synchronizing circuits work in association with the transmitter synchro in the antenna.

c. Cables are used to connect power, trigger, and video signals between the receiver-transmitter and the indicator. Junction Box J–497/SPN–11 (fig. 156) is used as an interconnection point between the receiver-transmitter and the indicator.

10. Power Group
(fig. 5–9)

The power group consists of four components that are used to convert the ship's line voltage to 115 volts, 400 cycles per second (cps) which are fed to the radar set proper. The power group components are—

a. Switch Box (fig. 6). The switch box contains a lever switch that turns the ship's line voltage on and off. The box also contains fuses. Switch Box SA–284/SPN–11 is used with a supply voltage of 115 volts dc. Switch Box SA–283/SPN–11 is used with a supply voltage of 32 or 24 volts dc.

b. Motor Starter (fig. 7). The motor starter protects the motor generator during the starting period by increasing the power applied to the motor generator in three steps. An overload relay is also included. Motor Starter SA–287/SPN–11 is for use with a supply voltage of 115 volts dc; Motor Starter SA–286/SPN–11 is for use with a supply voltage of 32 volts dc; Motor Starter SA–285/SPN–11 is for use with a supply voltage of 24 volts dc.

c. Motor Generator (fig. 8). The supply voltage is applied through the motor starter to the motor generator. The motor generator converts the input voltage to an output voltage of 115 volts

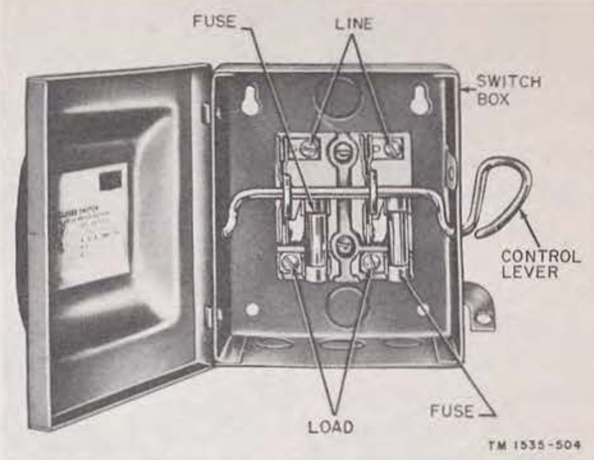


Figure 6. Switch Box SA–284/SPN–11.

Figure 7. Motor starter.

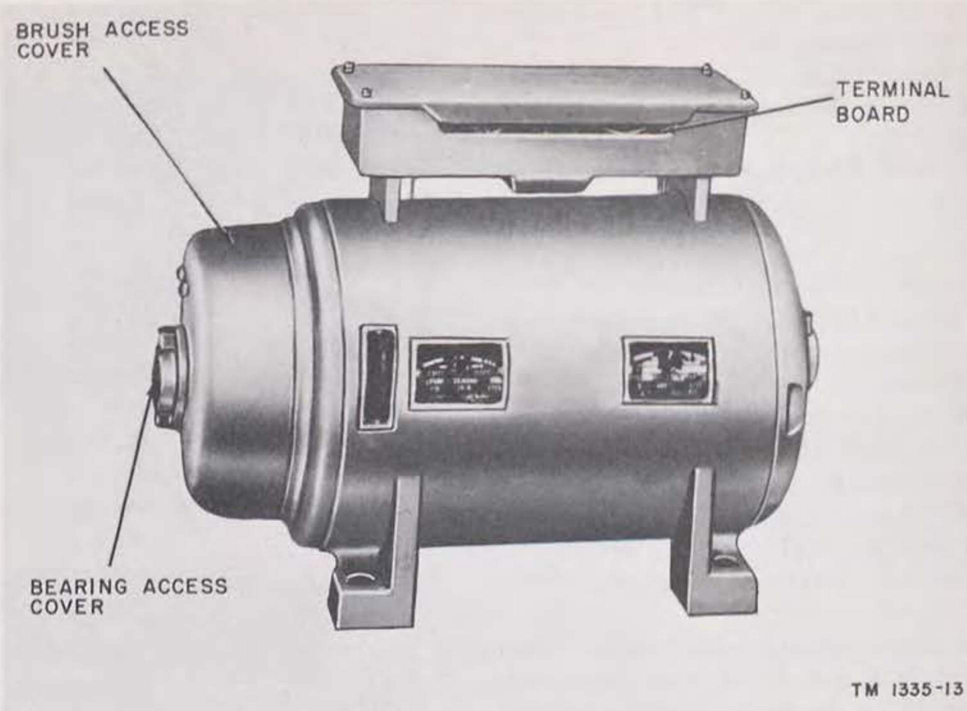


Figure 8. Motor generator.

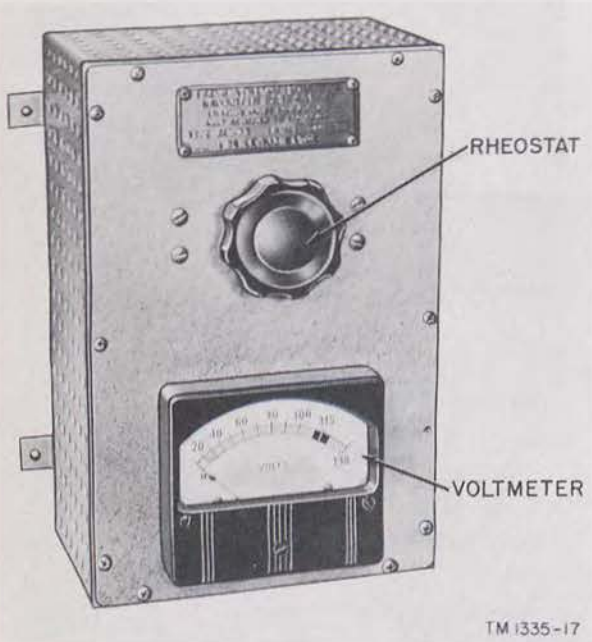


Figure 9. Voltage regulator.

400 cps. Both the input voltage and the output voltage lines are connected to the terminal board mounted on top of the motor generator. Motor-Generator PU-243/SPN-11 is for use with a supply voltage of 115 volts dc; Motor-Generator PU-245/SPN-11 is for use with a supply voltage of 32 volts dc; Motor-Generator PU-244/SPN-11 is for use with a supply voltage of 24 volts dc.

d. Voltage Regulator (fig. 9). This unit contains a rheostat to vary the output voltage of the motor generator and a voltmeter to measure the output voltage. The leads from the voltage regulator are connected to the motor generator through the terminal board on top of the motor generator. Voltage Regulator CN-192/SPN-11X is for use with a supply voltage of 115 volts dc; Voltage Regulator CN-193/SPN-11Y is for use with a supply voltage of 32 volts; Voltage Regulator CN-194/SPN-11Z is for use with a supply voltage of 24 volts.

11. Wave Guides

Wave guide sections for use with Radar Set AN/SPN-11(*) are illustrated in figure 22. One flexible section (not illustrated) and a number of straight, bent, and twist sections are furnished to facilitate installation and to provide the shortest possible wave guide run. Each section is terminated with a plain flange at one end and a choke flange at the other end. When the sections are coupled, the choke flange end of one section is joined to the plain flange end of the next section. The flexible section is 48 inches long, and the straight sections are furnished in ½-, 1-, 2-, 3-, 4-, 8-, and 12-foot lengths. Curved sections are furnished with E or H bends of 45° or 90° respectively. E bends are curved on the wide surface (90° E, fig. 22); H bends are curved on the narrow surface (45° H and 90° H, fig. 22). A wave guide deck fitting, a wave guide ceiling dress plate, and wave guide clamps also are furnished.

12. Differences in Models

a. Common Components. The basic nomenclature Radar Set AN/SPN–11 is used in this manual to refer to the group of components that operate from the 400-cycle, 115-volt output of the motor generator. These common components are listed below.

(1) Radar Receiver-Transmitter RT–268/SPN–11, including Radar Receiver R–480/SPN–11 but less blower motor.

(2) Antenna AS–599/SPN–11, less antenna drive motor and heaters.

(3) Duplexer CU–311/SPN–11.

(4) Azimuth and Range Indicator IP–193/SPN–11.

(5) Junction Box J–497/SPN–11.

(6) Frequency Mixer Stage CV–239/SPN–11.

(7) Cables (except W710 and W712).

(8) Wave guide sections.

b. Additional Components. The letter suffix X, Y, or Z is added to the basic nomenclature to indicate that the particular radar set includes the additional components for operation from a dc supply source of 115 volts, 32 volts, or 24 volts, respectively. The table below indicates the additional components that are required to make up each model of the radar set.

Item	Radar Set		
	AN/SPN-11X	AN/SPN-11Y	AN/SPN-11Z
Supply voltage	115 v dc	32 v dc	24 v dc.
Motor-Generator	PU–243/SPN–11	PU–245/SPN–11	PU–244/SPN–11.
Motor Starter	SA–287/SPN–11	SA–286/SPN–11	SA–285/SPN-11.
Antenna drive motor	115 v dc	32 v dc	24 v dc.
Blower motor	115 v dc	32 v dc	24 v dc.
Resistance Elements (Heaters)	HD–124/SPN–11	HD–123/SPN–11	HD–123/SPN–11.
Switch Box	SA–284/SPN–11	SA–283/SPN–11	SA–283/SPN–11.
Voltage Regulator	CN–192/SPN–11X	CN–193/SPN–11Y	CN–194/SPN–11Z.
Fuse (F601)	250 v 25 amp	250 v 60 amp	250 v 60 amp.
Fuse (F602)	250 v 25 amp	250 v 60 amp	250 v 60 amp.
Fuse (F801)	125 v 10 amp	125 v 15 amp	125 v 15 amp.
Cable W710	DHFA 23	DHFA 23	DHFA 40.

Section III. SIMPLIFIED BLOCK DIAGRAM

13. General

a. To simplify discussion, the radar set has been divided into five systems: the transmitting system, the radio frequency (rf) system, the receiving system, the synchronizing and indicating system, and the power system. In this section, the functions of each system will be given in a general way (fig. 10). In the chapters that follow, each system will be broken down into its individual circuits, and the function of every part in each stage will be explained in detail.

b. The system breakdown is on a functional basis. Not all parts of a system are necessarily contained in one component. The rf system is composed of parts in the receiver-transmitter and in the antenna, as well as of wave guides that connect these two components. Part of the synchronizing and indicating system is in the antenna, and part is in the indicator. The power system is composed of four components: switch box, motor starter, motor generator, and voltage regulator; there are also circuits in the receiver-transmitter and the indicator. For convenience, miscellaneous parts, such as the blower and antenna drive motors, and the heaters, are discussed with the power system.

14. Transmitting System

a. A master blocking oscillator in the transmitting system produces timed triggers that fire the

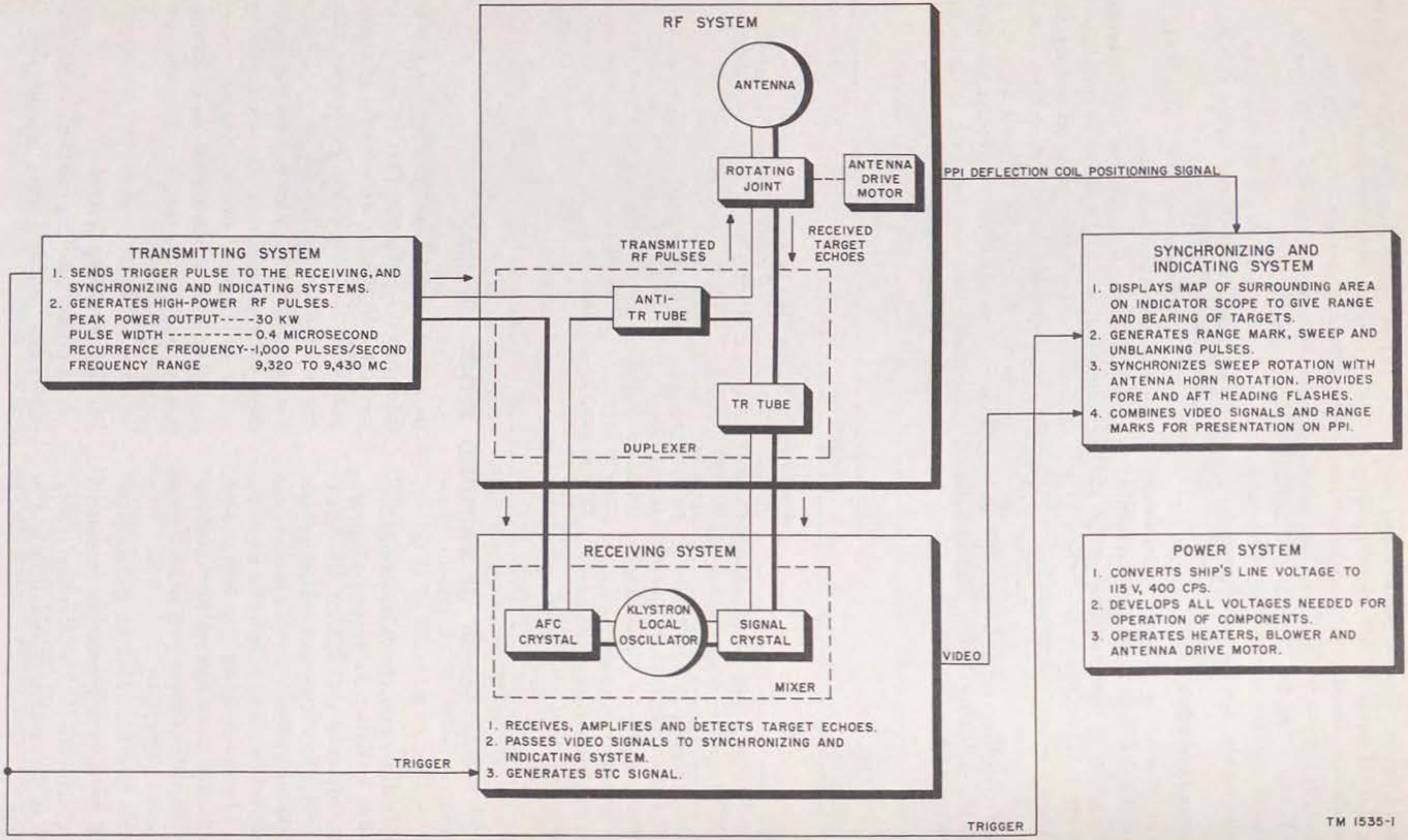


Figure 10. Simplified block diagram.

sensitivity time control circuits in the receiving system and the multivibrator in the synchronizing and indicating system. The pulse repetition frequency (prf) of these triggers is 1,000 pulses per second.

b. The modulator circuits fire the magnetron at the prf. The magnetron generates high power rf (9,320 to 9,430 megacycles (mc)) pulses that have a pulse width of .4 microsecond.

15. Rf System

a. The high power rf pulses pass through the duplexer and the connecting wave guides to the antenna horn. The horn together with the parabolic reflector causes a narrow beam of energy to be radiated into space. Returning echoes are picked up by the reflector and brought to a focus at the horn; from the horn they return along the wave guide sections through the duplexer to the receiving system.

b. The duplexer contains the transmit-receive (TR) and anti-TR tubes. The TR tube prevents the transmitted energy from entering the receiving system; the anti-TR tube prevents the received energy from entering the transmitting system.

c. The antenna drive motor located in the antenna pedestal rotates the antenna horn and reflector when the radar set is scaning.

16. Receiving System

a. The target echoes are fed to the mixer where with the aid of the klystron local oscillator an intermediate frequency (if.) of 30 mc is produced. The signals are then amplified, detected, and passed as video signals to the synchronizing and indicating system.

b. An stc circuit in the receiving system improves the display on the PPI tube in the synchronizing and indicating system.

c. An automatic frequency control (afc) circuit is used to correct the klystron frequency so that the if. will be constant. A small portion of the transmitted signal leaves the transmitting system and goes to the afc crystal in the mixer. When the signal mixes with the klystron output the if. produced is amplified and fed through a charging diode and phantastron circuit. This circuit stabilizes the output of the klystron local oscillator.

17. Synchronizing and Indicating System

The synchronizing and indicating system has a cathode ray tube that gives a PPI presentation of the surrounding area. All the circuits in this system enable the range and bearing of targets to be read from the scope.

a. As mentioned before, the trigger from the master blocking oscillator in the transmitting system fires the one-shot multivibrator in the synchronizing and indicating system. The one-shot multivibrator, in turn, causes the sweep and range mark circuits to operate. The sweep circuits produce a signal that deflects the electron beam in the PPI from the center to the edge of the screen. The range mark circuits produce timed pulses that enable the operator to read the range of targets. The one-shot multivibrator also provides an unblanking signal that prevents the sweep return trace from being visible on the PPI.

b. As the antenna horn rotates, a transmitter synchro in the antenna pedestal sends a signal to the receiver synchro in the indicator. The receiver synchro, in turn, causes the deflection coil on the PPI to rotate, thus making the sweep rotate in synchronism with the antenna horn. The synchronizing circuits also operate cams that produce fore and aft heading flashes. These flashes, which appear as intensified lines on the PPI, enable the operator to read the bearing of targets with reference to the ship's heading.

c. The video signals from the receiving system are fed to the video circuits in the synchronizing and indicating system. Here they are combined with the range marks and amplified before being applied to the PPI.

18. Power System

a. The ship's line voltage is fed through the switch box and the motor starter to the motor generator. The motor starter protects the motor generator by making it accelerate to full speed slowly. The motor generator converts the ship's line voltage to the 115 volts, 400 cps that are needed by the radar set. A voltage regulator is used for adjusting the output voltage of the motor generator.

b. The 115 volts, 400 cps are fed to the low voltage and modulator power supplies in the receiver-transmitter, and to the PPI power supply in the indicator.

c. The ship's line voltage is used to operate the antenna drive motor and the heaters in the antenna, and the blower motor in the receiver-transmitter.

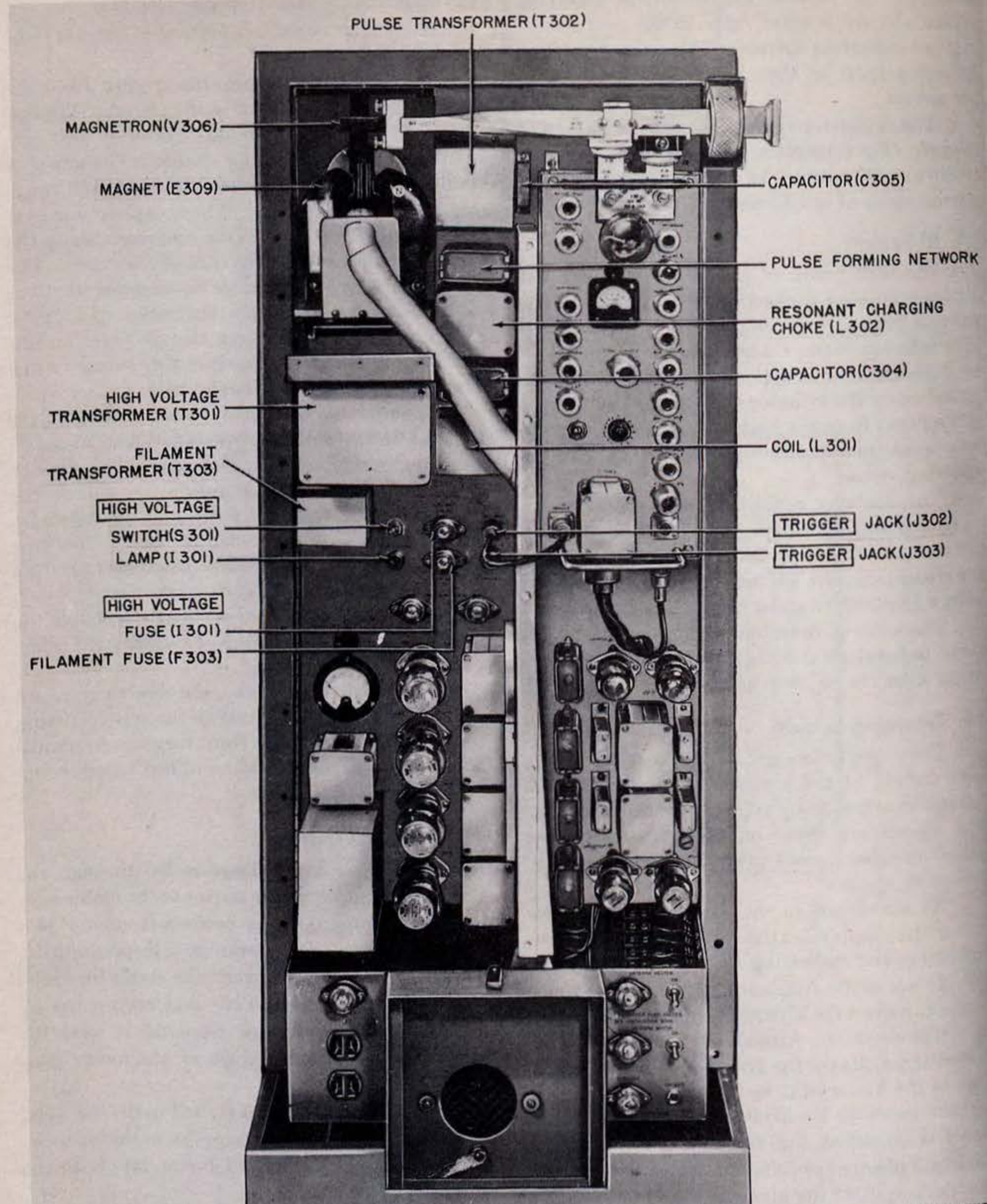


Figure 11. Receiver-transmitter, front view, transmitting system parts.

CHAPTER 2

TRANSMITTING SYSTEM

Section I. INTRODUCTION

19. General

a. The transmitting system generates pulses with a pulse repetition rate of 1,000 cps. These pulses are used to key the magnetron, to trigger the stc circuits in the receiving system, and to synchronize the timing of the sweep, unblanking, and range mark circuits in the synchronizing and indicating system.

b. The transmitter circuits are located within the shielded compartment (fig. 12) and on the front of the receiver-transmitter (fig. 11). Within the shielded compartment attached to the transmitter chassis is the modulator subchassis. The subchassis holds all the transmitting system tubes, except the magnetron.

20. Block Diagram

(fig. 13)

a. Timing Circuits. The signals produced by the timing circuits are used to synchronize the various circuits in the radar set.

(1) Master blocking oscillator stage V307A provides the basic timing for the set. The output pulses are fed to amplifier stage V307B, to the stc circuits in the receiving system, and to the synchronizing and indicating system where they control the range mark circuits and the sweep circuits.

(2) Amplifier stage V307B amplifies and inverts the output of the master blocking

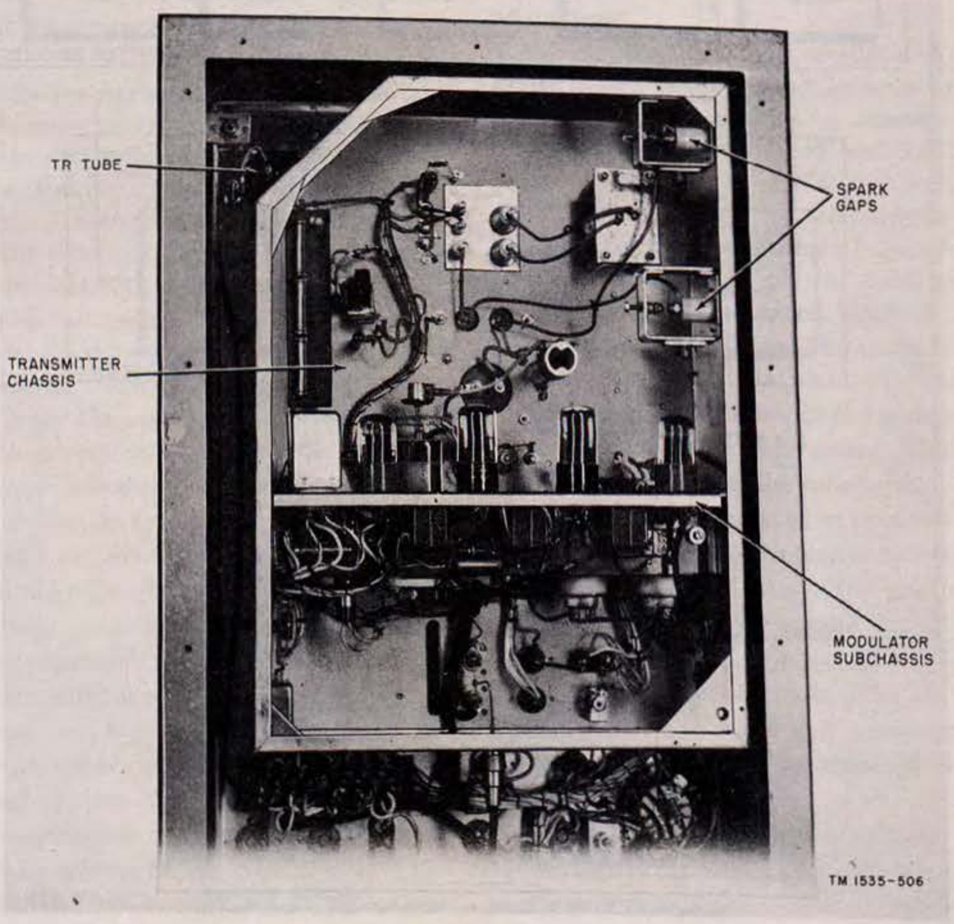


Figure 12. Shielded compartment.

oscillator and isolates stage V307A to prevent feedback from V308.

(3) Triggered blocking oscillator stage V308 generates a relatively wide pulse with a steep leading edge that is used to trigger the modulator.

(4) Cathode follower stage V309 is used to match the output impedance of stage V308 to the input impedance of modulator V305.

b. Transmitter Circuits. Modulator V305 in conjunction with resonant charging inductor L302, pulse forming network Z301, and magnetron pulse transformer T302, controls the operation of the magnetron. Magnetron V306 produces the rf energy.

c. Low Voltage Power Supplies. The low voltage power supplies provide the B+ voltages needed for operation of the stages in the transmitting system. They are described in paragraph 93.

d. Modulator Power Supply. This power supply produces 3,000 volts for operation of the modulator. A time delay circuit prevents the power

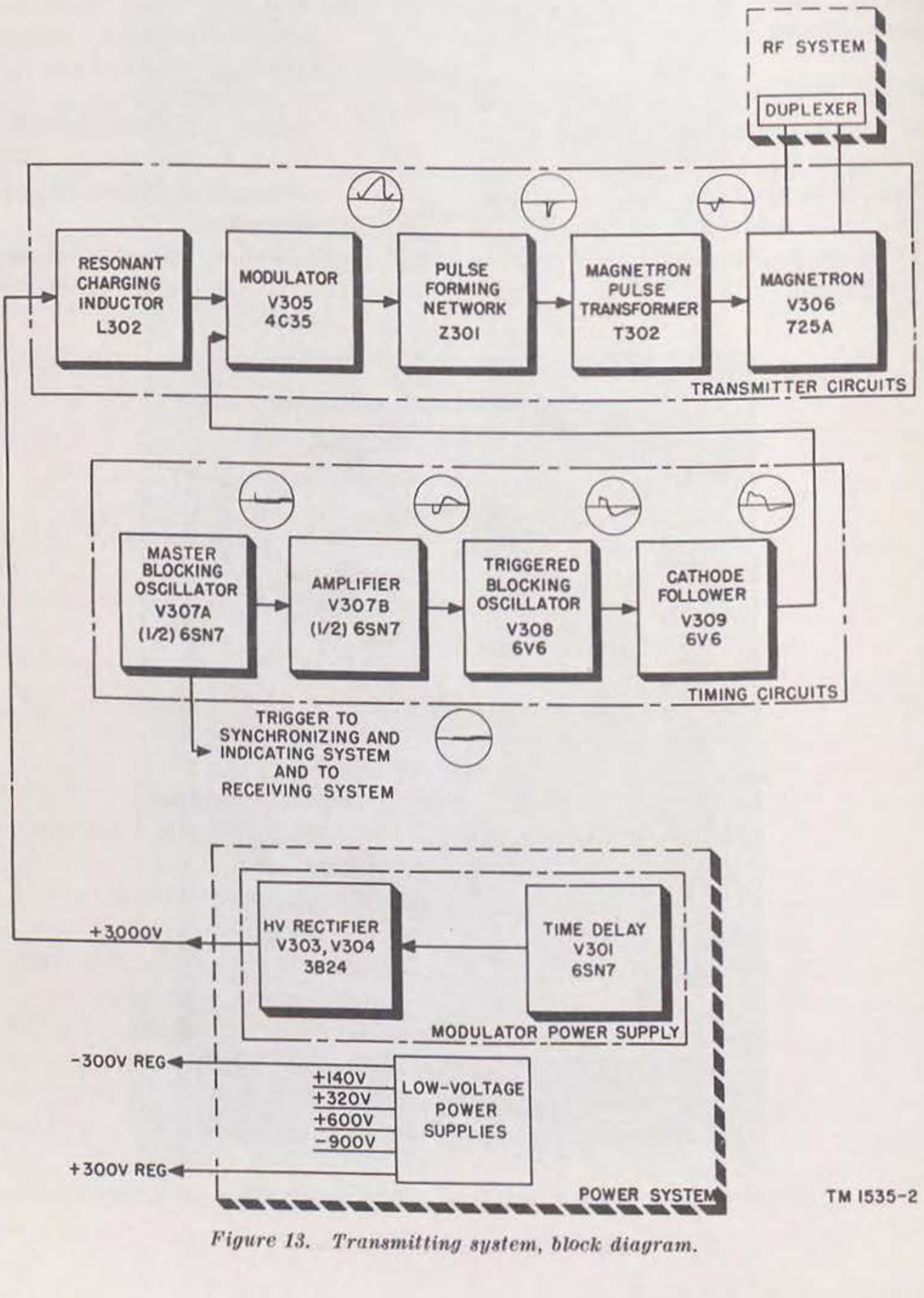


Figure 13. Transmitting system, block diagram.

from being applied to the modulator until the filaments of the transmitter tubes have been adequately heated. The modulator power supply is described in paragraph 94.

Section II. TIMING CIRCUITS

21. Master Blocking Oscillator
(fig. 14)

Master blocking oscillator V307A generates trigger pulses with steep leading and trailing edges. The pulse repetition rate of these triggers is controlled by means of a variable resistor.

a. When plate voltage is applied, plate current increases and produces an expanding field about the plate winding of transformer T304. The voltage induced into the grid winding as a result of this increasing magnetic field drives the grid positive. At the same time, capacitor C306 is charged as shown. The more positive the grid becomes, the greater the plate current flow through the tube; the greater the plate current, the more positive the grid becomes. This regenerative action quickly drives the tube to saturation. The sudden increase in current flowing through cathode resistor R314 produces the steep leading edge of the trigger.

b. As the tube reaches saturation, the plate current becomes almost unvarying with time. As a result, the potential induced across the grid coil decreases, thus making the grid less positive. As the grid potential decreases, the plate current decreases, and the potential induced across the grid coil reverses in polarity. On the grid is the sum of this induced voltage and the negative voltage across C306, which developed during the time the grid was positive. The more negative the grid becomes the lower the plate current flow through the tube; the lower the plate current the more negative the grid becomes. This regenerative action quickly drives the tube to cutoff. Thus, sudden cutting off of current through R314 produces the steep trailing edge of the trigger.

c. After the generation of the trigger pulse, the voltage across capacitor C306 keeps the tube cutoff. As the capacitor discharges through resistors R312 and R313, the grid bias decreases (becomes less negative) until it reaches the cutoff level. At this point, increasing plate current flow generates another cycle and another trigger pulse is produced. Therefore, the pulse repetition frequency is determined by the resistance-capacitance (RC) time constant in the grid circuit. Since the time constant can be varied by means of R313, this resistor controls the pulse repetition frequency.

22. Amplifier
(fig. 14)

The trigger developed across R314 is applied to the grid of V307B, which amplifies and inverts the trigger. It also isolates tube V307A from tube V308 to prevent feedback. Capacitor C307 bypasses cathode bias resistor R315.

23. Triggered Blocking Oscillator
(fig. 14)

When the amplified pulse is applied to the triggered blocking oscillator, the output is a trigger pulse with a sharper leading edge and a flatter top. Since this stage cannot oscillate of its own accord, its output is at exactly the same frequency as its input.

a. Triggered blocking oscillator V308 is normally biased beyond cutoff by keeping its grid at −55 volts. This is done by means of a voltage divider consisting of R316 and R317 connected across the regulated −300-volt supply. When tube V307B is triggered, the change in current through the plate winding of transformer T305 induces a voltage across the grid winding that causes the control grid of V308 to go positive. The more positive the grid becomes, the more current flows through the plate winding; the more the current flowing through the plate winding, the more positive the grid becomes. This cumulative action quickly drives the tube to saturation.

b. As the plate current approaches saturation, the current increases at a slower rate; consequently the voltage induced across the grid winding decreases. As the grid potential decreases, the plate current decreases and the potential induced across the grid winding reverses in polarity. The tube is quickly driven to cutoff and remains cutoff by the bias from the voltage divider until the next pulse arrives.

c. The output of V308 is coupled by separate zwindings of transformer T305 to the grid of cathode follower tube V309. Capacitor C309 filters the −300-volt supply. Capacitor C308 is an

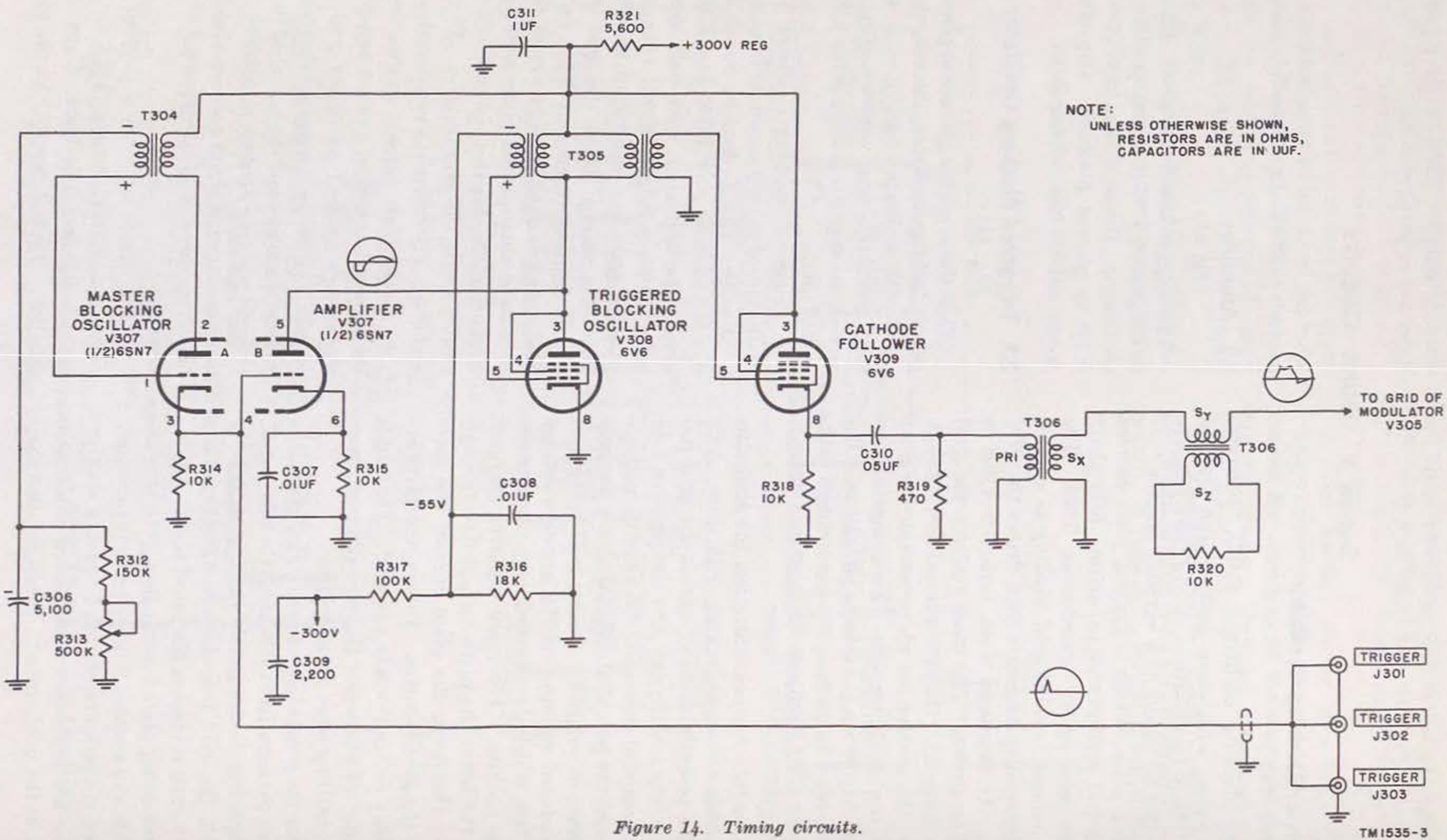


Figure 14. Timing circuits.

ac bypass across R316. Resistor R321 and capacitor C311 form a plate decoupling circuit.

24. Cathode Follower

(fig. 14)

The cathode follower stage plus transformer T306 and its associated circuitry presents an almost perfect impedance match between the triggered blocking oscillator output and the modulator input. At the same time, it prevents the occurrence of any undesirable oscillations that may cause unwanted triggering.

a. The output impedance of V308 is matched to the high input impedance of V309 by transformer T305. The output impedance of V309, which is determined mainly by R318, is matched by means of transformer T306 to the input of modulator V305. Capacitor C310 keeps dc plate current from flowing through the primary (PRI) of the transformer.

b. Two precautions are taken to prevent undesirable oscillations. First, damping resistor R319 is placed across the primary (PRI) of transformer T306. Secondly, the secondary of transformer has two windings S_x and S_y. Energy is coupled from S_y into a third winding S_z and is dissipated by resistor R320.

Section III. TRANSMITTER CIRCUITS

25. Modulator Stage

(fig. 15)

The modulator, by applying high voltage negative pulses to the cathode of the magnetron, controls its operation and permits rf energy to be produced in short powerful pulses. The modulator tube can therefore be compared to a high speed switch. The pulse forming network in its plate controls the exact time the switch is closed.

a. Modulator.

(1) While thyratron V305 is cut off, pulse forming network Z301 charges up to 6,000 volts. The voltage reaches this high value because resonant charging choke L302 keeps up the momentum of charging even after the network has charged up to the supply voltage.

(2) When the sharp positive trigger from T306 is applied to the grid of the 4C35 thyratron, the tube is ionized and plate current flows. Pulse forming network Z301 now discharges through the low impedance path formed by the conducting tube and the primary of pulse transformer T302. Since the impedance of the pulse transformer is the same as that of the pulse forming network, the 6,000 volts are distributed evenly between the two. Three thousand volts immediately appear across the primary of pulse transformer T302.

(3) The pulse forming network acts like an open-ended transmission line. The sudden application of a discharge path to the network produces a wave that travels from A to B. At B the wave sees an infinite impedance, and it therefore is reflected back to A. The time it takes for the wave to travel from A to B and back to A (.4 microsecond in this case) determines the length of time the voltage across the primary of T302 remains at 3,000 volts. In other words, a sharp-edged flat-topped pulse of 3,000 volt-amplitude and .4-microsecond duration is produced across the primary P of T302.

(4) An oversimplified way of explaining why the pulse forming network discharges in such a manner as to obtain a flat-topped output pulse is as follows. Capacitor C_x discharges through coil L_x. At the same time C_y discharges through L_y into C_x, thus replacing the depleted charge. As a result, the voltage across C_x (and therefore the output voltage) remains constant. In the same way, capacitor C_z discharging through L_z into C_y keeps the voltage across C_y constant. Until C_z and then C_y discharge fully, the output voltage is kept constant by the full charge across C_x. When C_x is finally allowed to discharge, the output voltage falls suddenly to zero and produces the steep trailing edge of the output pulse.

b. Magnetron Pulse Transformer.

(1) The function of pulse transformer T302 is to step up the input pulse from 3,000 volts to 10,000 volts and to match the

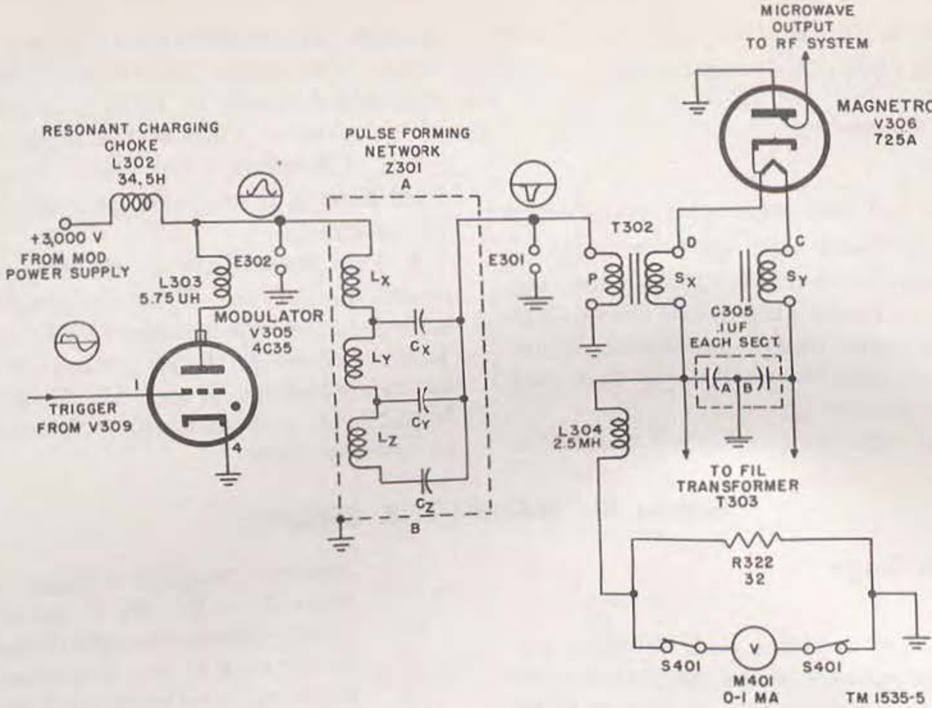


Figure 15. Transmitter circuits.

impedance of Z301 to the input impedance of the magnetron. The transformer has a wide frequency response, so that it passes the pulse without materially altering its shape.

(2) Two secondary windings, S_x and S_y, are wound on pulse transformer T302. When a 3,000-volt pulse is applied to the primary, 10,000 volts are induced across each secondary. Since capacitor C305 keeps the lower ends of both S_x and S_y at ac ground potential, points C and D are at the same potential with reference to ground. Therefore, the pulse does not cause any *difference* of potential between C and D. The voltage across the magnetron filament (between C and D) is determined solely by filament transformer T303. Therefore, by using two secondaries in pulse transformer T302, filament transformer T303 does not have to be insulated for 10,000 volts but may be a conventional transformer.

26. Spark Gaps

(fig. 15)

Two spark gaps, E301 and E302, are connected one across either side of pulse forming network Z301. Their purpose is to protect resonant charging choke L302, pulse forming network Z301, and magnetron pulse transformer T302 from heavy overloads caused by fluctuation of the ship's supply voltage. They also protect modulator high-voltage transformer T301 and filter choke L301 in the modulator power supply (fig. 86). The extra power developed during these overloads is dissipated across the .036-inch gap across E301, and the .072-inch gap across E302, rather than through the foregoing parts.

27. Magnetron

(figs. 16 and 17)

a. Magnetron V306 is a 725A tube. It is essentially a diode mounted between the poles of a powerful permanent magnet. The anode consists of 12 hole-and-slot resonators that are coupled together by double ring straps. During manufacture the magnetron is pre-tuned, an output loop is placed over the hole of one of the resonators, and a matched coaxial-to-wave guide junction is built in. (For a detailed discussion of magnetrons, refer to TM 11-673, Generation and Transmission of Microwave Energy.)

b. The magnetron plate is at ground potential. Application of the 10,000-volt negative pulse from

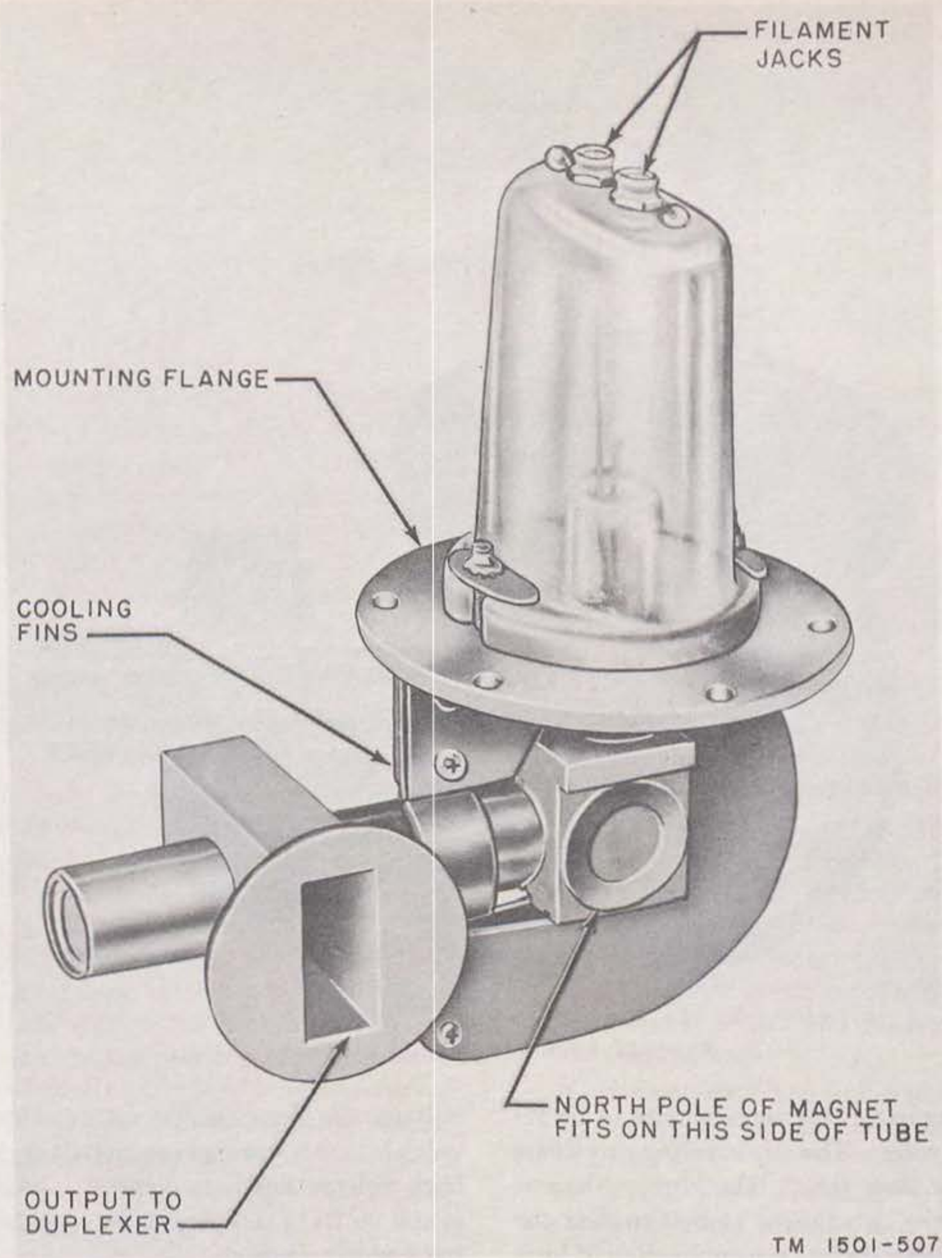


Figure 16. Magnetron 725A.

pulse transformer T302 (fig. 15) to the magnetron cathode produces a strong electric field across the diode. Electrons, emitted by the filament, travel in near-circular paths determined by this electric field as well as the magnetic field, which is perpendicular to the electric field. The number of times per second the electrons travel near-circular paths determines the frequency of the generated electromagnetic waves. The magnetron oscillates for .4 microsecond, as determined by the length of the pulse applied to the cathode.

c. While the magnetron oscillates, cathode current flows through coil L304 and resistor R322. When test meter switch S401 is placed in the MAG. I position, test meter M401 is connected across resistor R322 and indicates the magnetron current. L304 and C305 prevent rf energy from entering the meter.

d. When the POWER switch in the indicator is turned on, full filament voltage of 6.3 volts is applied to the magnetron filament. After a delay of 3 minutes, relay K302 (fig. 86) operates and

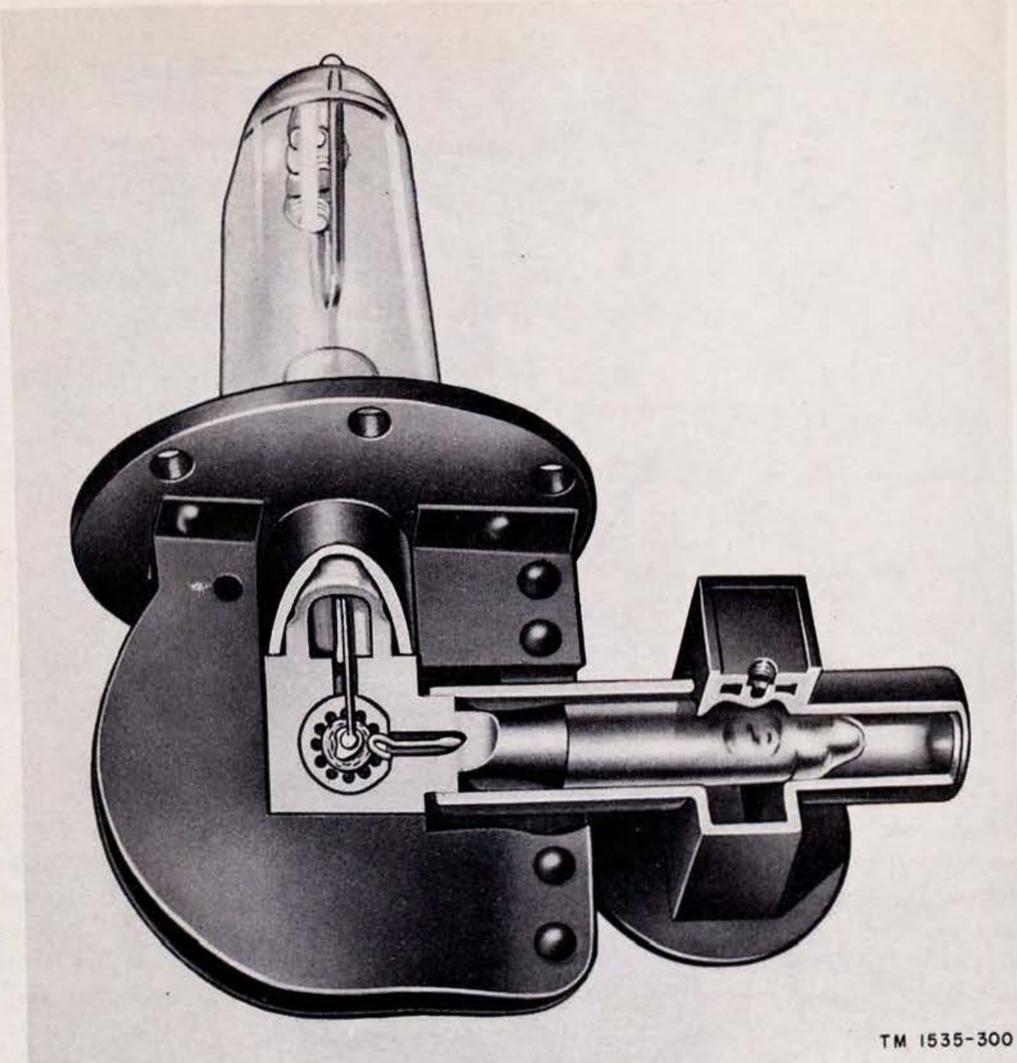


Figure 17. Magnetron 725A, cut-away view.

causes the magnetron filament voltage to be reduced to 4.5 volts. The high voltage rectifiers operate at the same time. The higher filament voltage, 6.3 volts, is required at first to heat the magnetron filament before the application of high voltage; the lower magnetron filament voltage, 4.5 volts, is used for proper magnetron operation after high voltage has been applied. Refer to paragraph 94 for a complete discussion of the modulator power supply.

CHAPTER 3

RF SYSTEM

Section I. INTRODUCTION

28. General

a. The rf system receives pulses of microwave energy from the transmitting system and transmits these pulses to free space via the duplexer, wave guides and the antenna. The antenna radiates into space a highly directional beam of microwave energy that scans through an azimuth range of 360°. When this energy intercepts a target, a small portion is reflected back to the antenna and is conducted via wave guides and the duplexer to the receiving system.

b. The duplexer, which contains the TR and anti-TR tubes, is mounted in the upper right hand corner of the receiver-transmitter (fig. 18). It is directly attached to the magnetron in the transmitting system and to the mixer in the receiving system. The antenna is connected to the duplexer by a wave guide run between the antenna and the flange at the end of the duplexer.

c. The antenna (figs. 19 and 20) includes the rotating mounting base, the antenna drive motor, and the rotating joint. The horn and reflector, which are bolted to the rotating mounting base, radiate the microwave energy. The antenna drive motor and rotating joint cause the rotating mounting base to rotate through an azimuth range of 360°. The transmitter synchro is also mounted inside the antenna pedestal.

d. A PHONES jack for communicating with a man at the indicator location is included in the antenna.

29. Block Diagram

(fig. 21)

The parts of the rf system are the wave guides, Duplexer CU-311/SPN-11, and Antenna AS-590/SPN-11.

a. Wave Guides. The wave guides (fig. 22) connect the duplexer with the antenna.

b. Duplexer CU-311/SPN-11. The duplexer permits the use of a single antenna for both transmission and reception. Its components are listed below.

(1) *TR tube.* The TR tube automatically prevents energy from entering the receiving system when microwave energy is being radiated.

(2) *Anti-Tr tube.* The anti-Tr tube prevents received energy from entering the transmitting system and being dissipated in the magnetron when microwave energy is being received.

(3) *Attenuator.* The attenuator is a hole in the duplexer through which a small amount of the transmitted energy is fed to the afc crystal in the mixer.

c. Antenna AS-599/SPN-11. The antenna is composed of the following.

(1) *Antenna horn.* The antenna horn radiates and receives microwave energy.

(2) *Antenna reflector.* The reflector directs the energy into a narrow beam. It also receives energy and focuses it onto the antenna horn.

(3) *Suppressor.* The suppressor reduces the energy fed by the side lobes of the radiated beam.

(4) *Fixed joint assembly.* This assembly couples the energy from the horizontal wave guide to the vertical wave guide with a minimum loss of energy.

(5) *Rotating joint assembly.* The rotating joint permits the transfer of microwave energy from the fixed joint assembly to the rotating joint assembly; from here it goes to the antenna horn and reflector.

(6) *Antenna drive motor.* The antenna drive motor rotates the rotating joint assembly and the horn and reflector through a complete azimuth scan at the rate of 17 rpm. The antenna drive motor as well as the thermostat and heaters are dis-

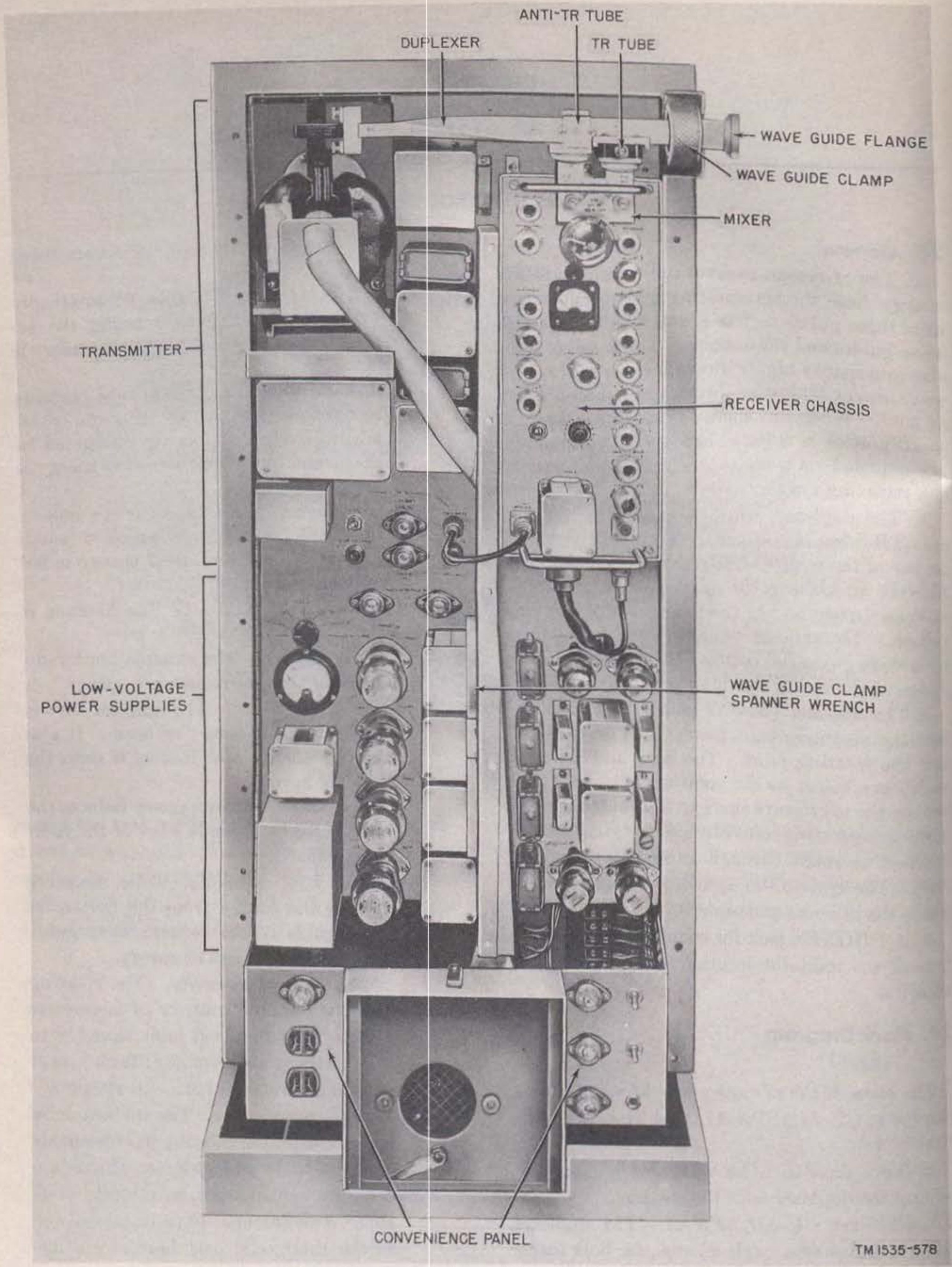


Figure 18. Receiver-transmitter, rf parts called out.

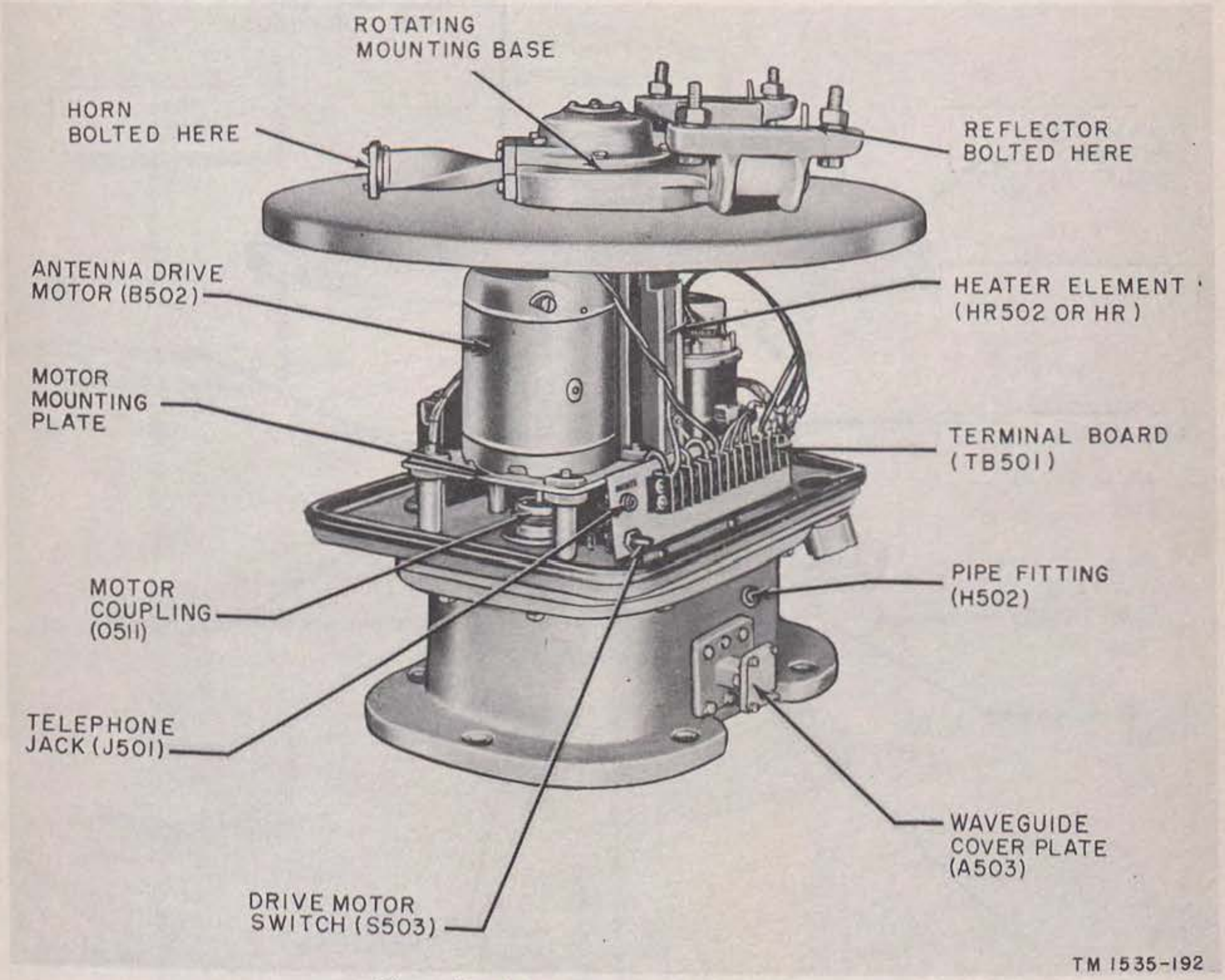


Figure 19. Antenna drive assembly, rear view.

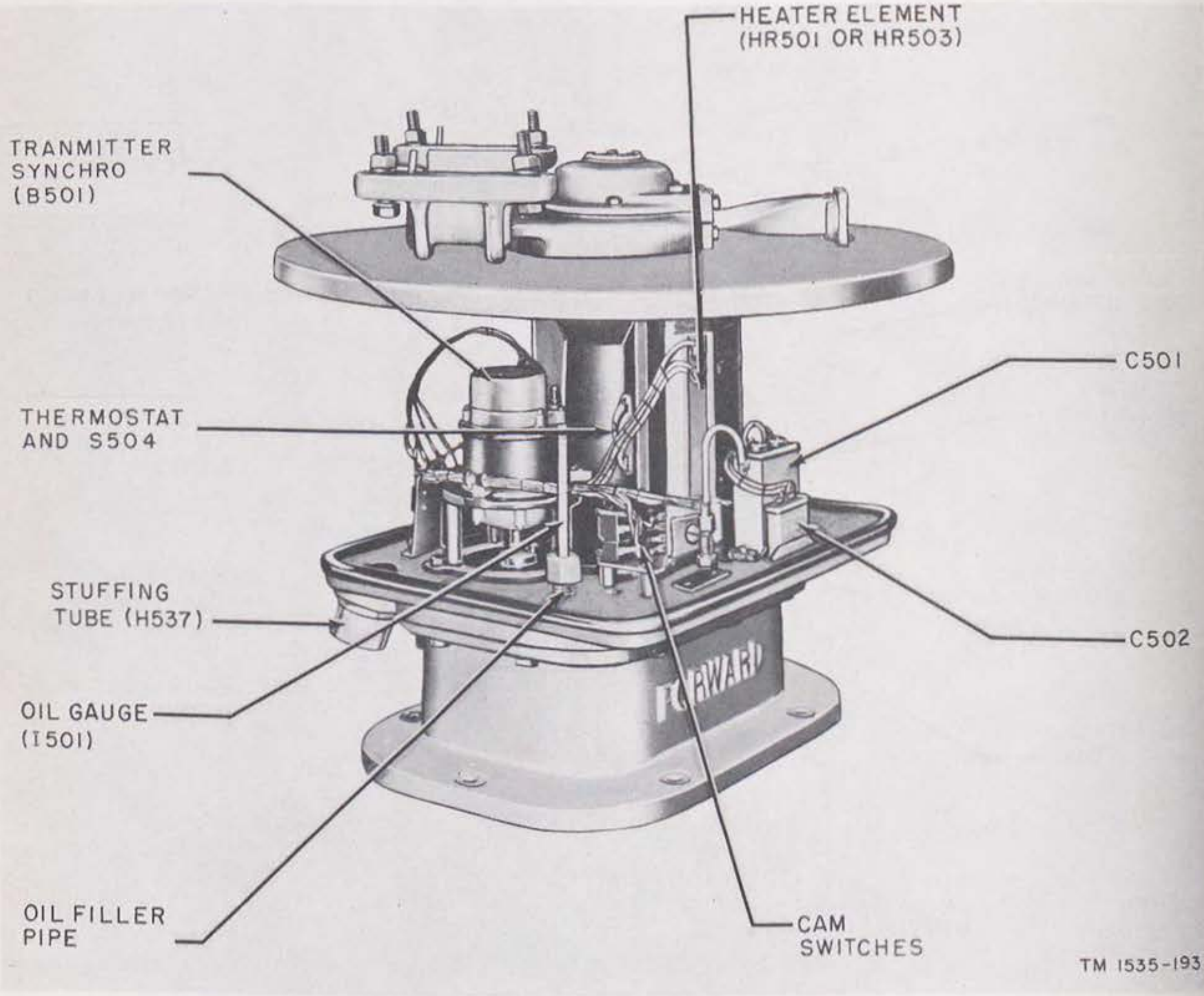


Figure 20. Antenna drive assembly, front view.

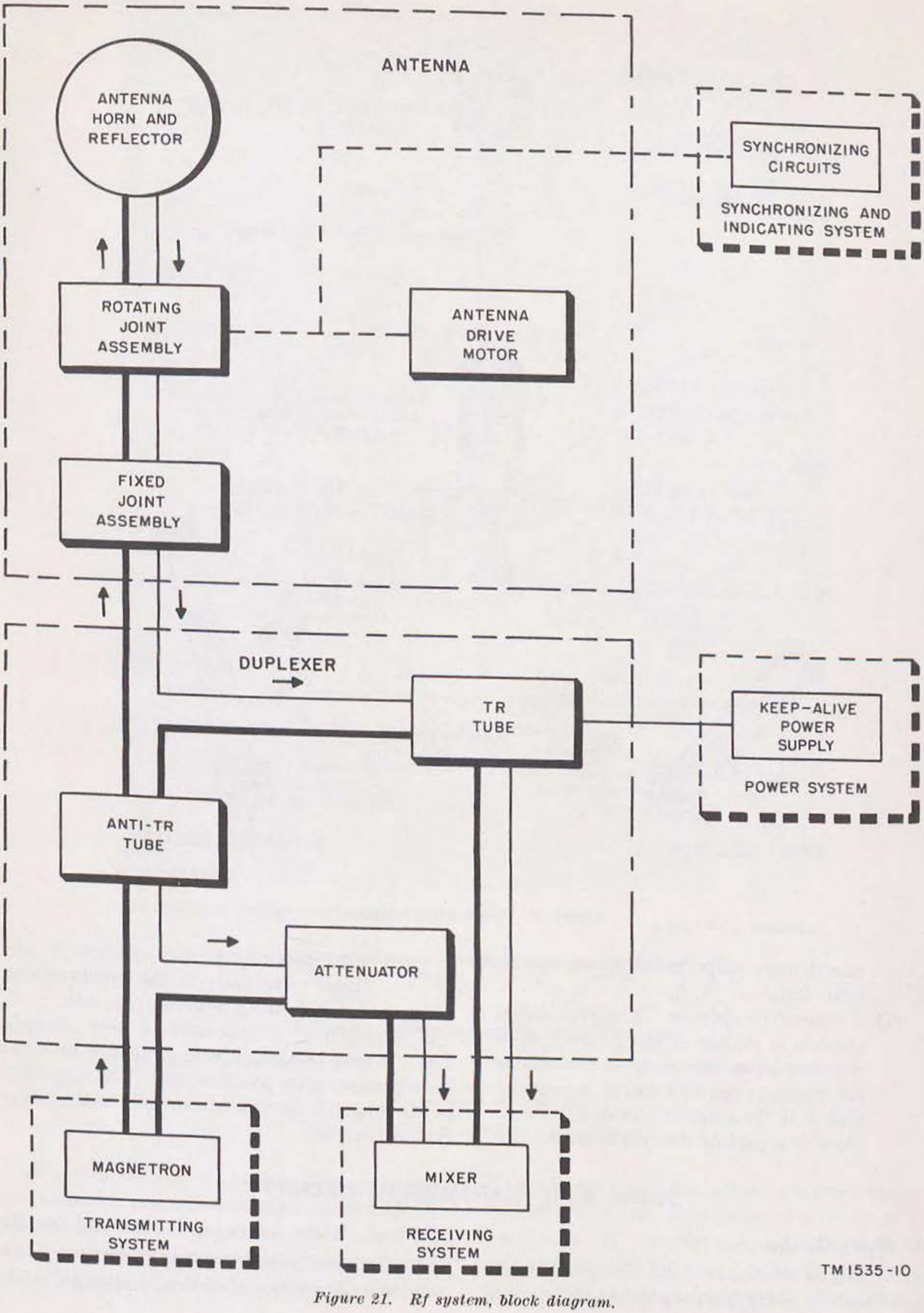


Figure 21. Rf system, block diagram.

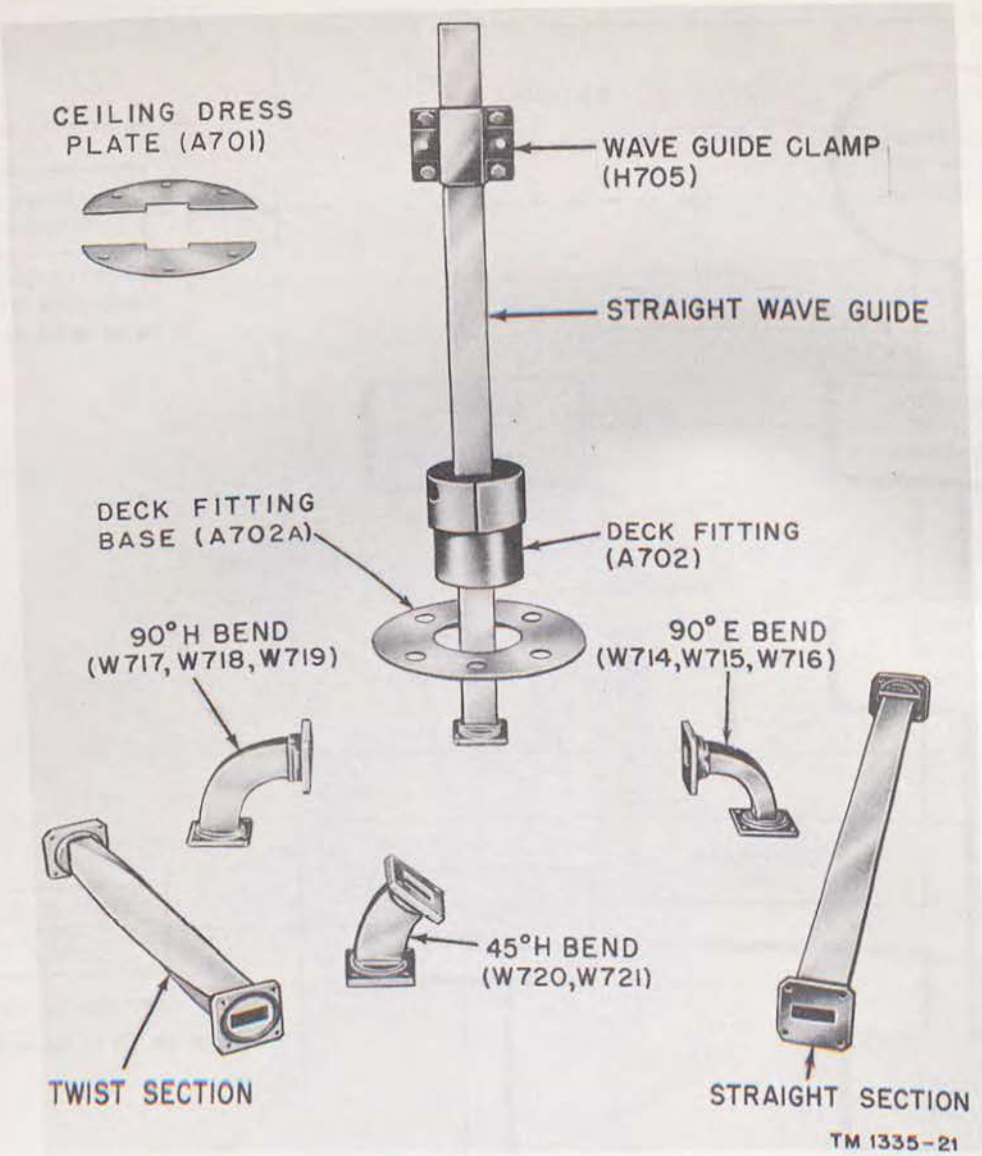


Figure 22. Wave guide sections.

cussed more fully in the power system (par. 90).

(7) *Transmitter synchro.* The transmitter synchro is geared to the antenna drive motor and produces a signal that makes the sweep on the PPI rotate in synchronism with the antenna horn and reflector. Since it is part of the synchronizing circuits, the transmitter synchro is discussed more fully in the synchronizing and indicating system (par. 80).

d. Keep-Alive (−900-volt) Power Supply. The TR tube requires a voltage that is obtained from the keep-alive power supply. The keep-alive power supply is discussed more fully in the power system (par. 93).

Section II. RF TRANSMISSION CIRCUITS

30. Wave Guides

a. Nature of Radiation. Rf energy, like all electromagnetic energy, is propagated in the form of waves. These waves have crests and troughs where the electric field intensity is maximum in a positive and negative direction, respectively (A,

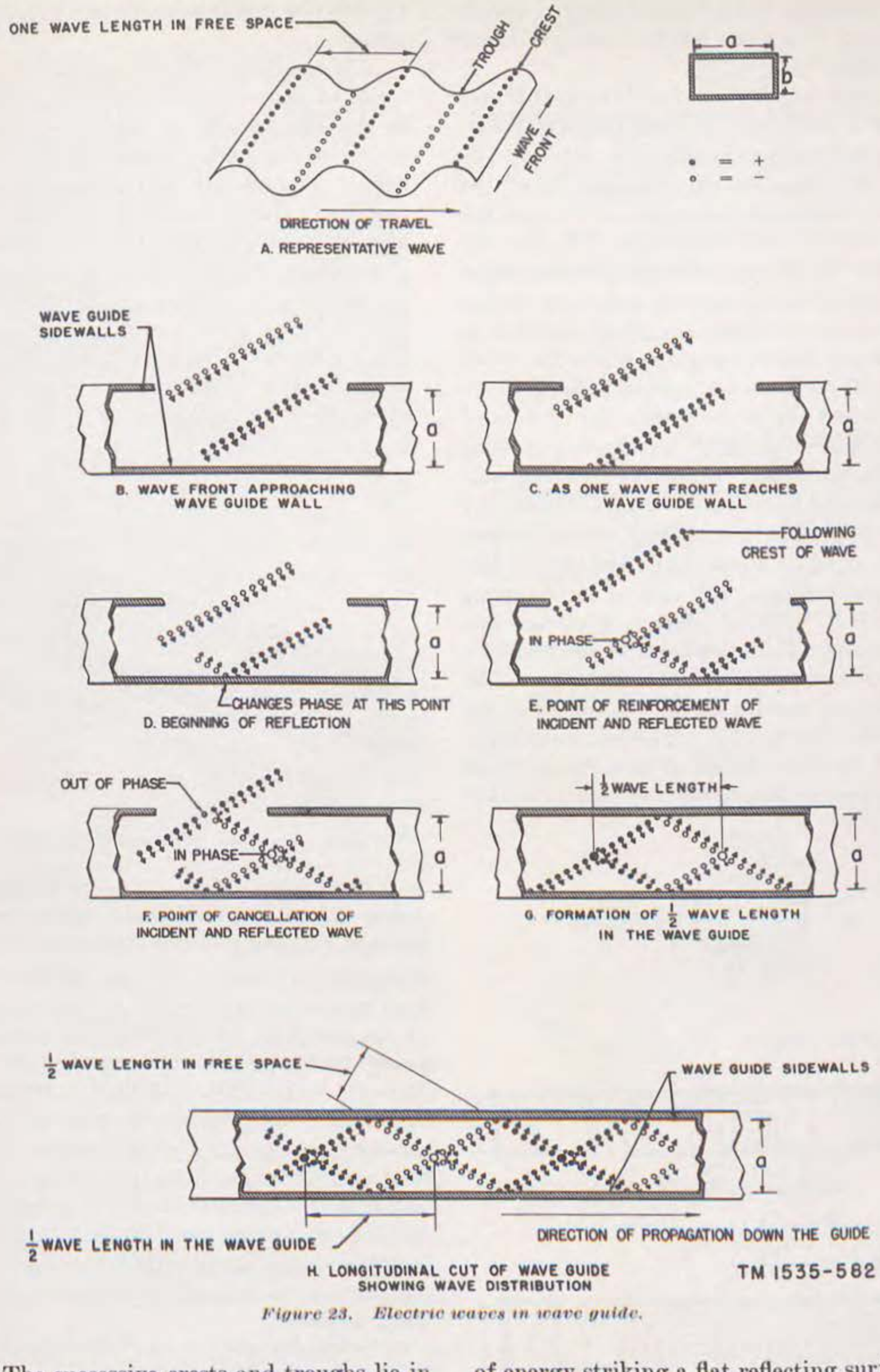


Figure 23. Electric waves in wave guide.

fig. 23). The successive crests and troughs lie in parallel planes that move through space with the speed of light. Wave length is the measure of distance between successive crests or troughs.

b. Reflection. Consider these successive waves of energy striking a flat reflecting surface such as the side of a section of rectangular wave guide (B and C, fig. 23). At the points of reflection, the field intensity of the waves passes through zero, and the reflected waves undergo a phase reversal so that the incident crests become reflected troughs (D and E, fig. 23) and the incident troughs become reflected crests.

c. Intersection of Reflected and Incident Waves. The reflected crests and troughs intersect the incident crests and troughs along lines parallel to the reflecting surface. At the intersection of two troughs, the intensity is twice that of a single incident or reflected crest or trough (F, fig. 23). Where a crest and trough intersect, the intensity is zero. The distance between the reflecting surface and the regions of double amplitude depends on the wave length and the angle at which the waves strike and reflect from the surface. As the incident and reflect waves progress, their points of intersection move parallel to the reflecting surface.

d. Double Reflection. If another reflecting surface were placed parallel to the first, the energy could be confined to a relatively narrow space, dimensions of which would be determined by the points of intersection. The row of intersections nearest the first (original) reflecting surface has double intensity. The second row of intersections of crests with troughs has zero intensity. The second reflecting surface actually is placed along this latter row (G, fig. 23). The resulting wave pattern (H, fig. 23) consists of zero electric field intensity at both reflecting surfaces and of double intensity at points midway between the reflecting planes.

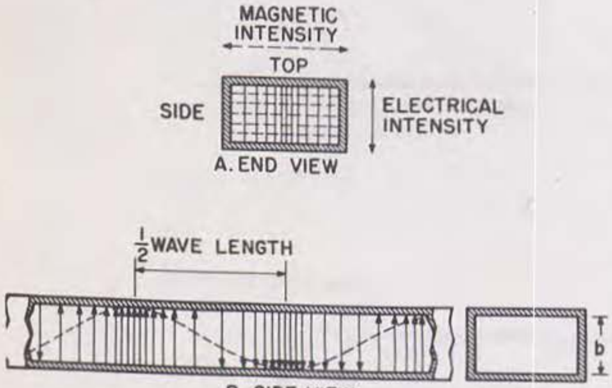


Figure 24. Electric and magnetic field intensity in wave guide.

e. Wave Guide Electromagnetic Fields. The mode of transmission described above is known as the $TE_{1,0}$ mode. A, figure 24 shows a cross-section of the guide and the electric and magnetic fields. The electric field is most intense at the center and diminishes toward the sides. One-half of a wave length down the guide from a region of maximum intensity the field is again maximum but of opposite polarity (B, fig. 24). The magnetic field, at right angles to the electric field, forms closed loops lying in a plane at right angles to the narrow sides of the guide (C, fig. 24). Figure 25 is a cross section of a wave guide showing wave propagation.

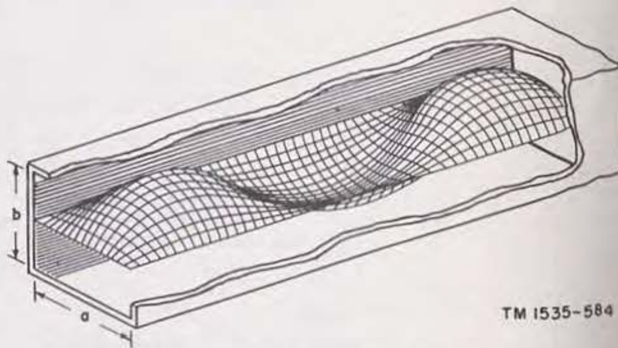


Figure 25. Wave propagation in wave guide.

f. Limits of Distance Between Reflecting Surfaces. The distance between successive intersections of incident and reflected crests is known as the guide wave length (H, fig. 23) and is greater than that of a wave length in free space because of the limits set by the reflecting surfaces. The guide wave length increases as the reflecting surfaces are moved closer together, because the angle of incidence must decrease to maintain the double intensity intersections at the center. When the distance between surfaces is equal to a half wave length in free space, the angle of incidence is zero and the wave guide wave length is infinite. This is the minimum permissible separation of reflecting surfaces to have the wave propagate in the $TE_{1,0}$ mode.

g. Guide Dimensions in Radar Set AN/SPN-11(*). In the hollow rectangular wave guide used with this radar set, the two reflecting surfaces are the narrow sides (b) of the wave guide. The distance (a) between these planes must be, for 3.2-centimeter (cm) operation, greater than 1.6

cm. The actual dimension is 2.29 cm. The distance (b) between the other two sides of the wave guide is made less than one-half wave length in space so that modes other than the $TE_{1,0}$ mode will not be propagated. The actual distance is 1.02 cm.

h. Energy Transmission. If a suitable means of introducing and removing energy from the wage guide is provided, attenuation is small. The metal sides shield the magnetic field from the outside of the wave guide. Current flow caused by the magnetic field is confined to a layer of metal only a few hundred-thousandths of an inch thick on the inner surface of the wave guide. Hence, all of the energy is confined within the wave guide. The only losses are heat due to the resistance of the current-carrying layer and reflections due to mismatch in the wave guide. To reduce the heat loss, the inner surface of the wave guide is made corrosion resistant to decrease the resistance of the current-carrying layer.

i. Cutoff Frequency. A wave guide acts like a high pass filter: it does not pass frequencies below a certain cutoff frequency. The cutoff frequency has a wave length in free space twice the width (a) of the wave guide. In order that a wave guide may transmit energy of a given wave length, its width must be more than one-half the wave length of the energy to be transmitted. The wave fronts in a wave guide when the frequency is well above cutoff is shown in A, figure 26. Note that the width of the wave guide is considerably larger than one-half wave length in free space, and that the angle that the wave fronts make with the wave guide axis is large. In B, figure 26, the same width of the wave guide is only slightly more than one-half wave length when the frequency is near cutoff. The angle that the wave front makes with the axis of the wave guide is small, and therefore the angle of reflection also is small. The wave length within the wave guide then becomes large, and the wave fronts travel down the wave guide nearly parallel to the side walls. Most of the energy in the wave front is absorbed in the side walls and, at the cutoff frequency, all the energy is absorbed.

j. Current Flow. A current, produced by the magnetic field of the wave, flows through the wave guide. This current circulates around the wave guide as shown in A, figure 27. A narrow slit may be cut along the top or bottom of the wave guide without disturbing or causing reflection of the

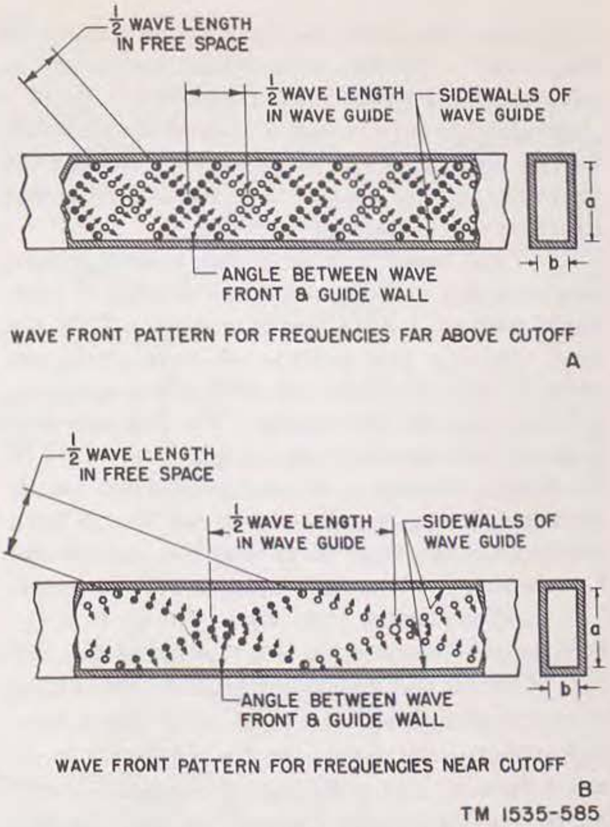


Figure 26. Change in reflection angle with change of frequency.

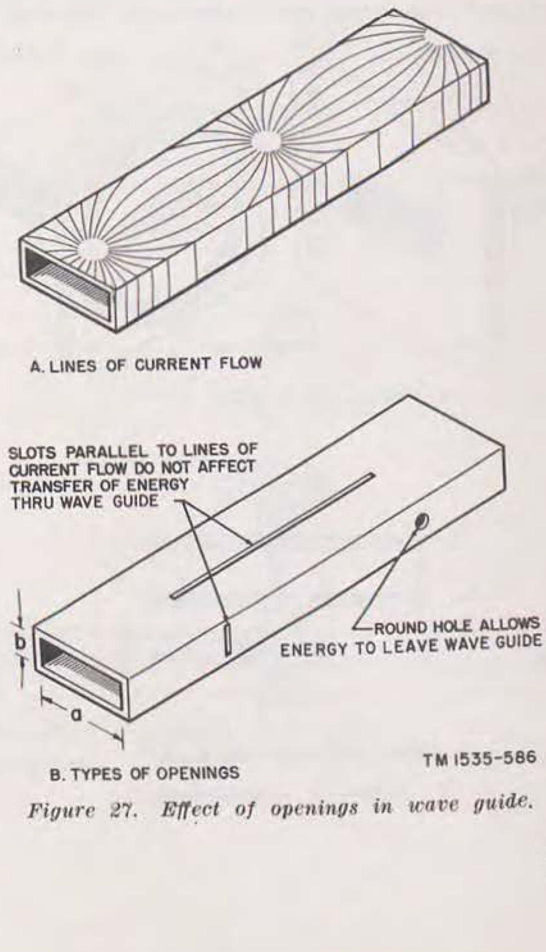


Figure 27. Effect of openings in wave guide.

traveling energy, because the potential across the slot is zero. For the same reason, a slot may be cut along the width of the narrow side (B, fig. 27). Any other type of cut, such as a circular hole on the narrow side, permits energy to be removed from the wave guide, because a potential difference exists across this type of opening.

k. Choke Joints. Choke joints are designed for easy assembly and disassembly of lengths of wave guide without a high loss of energy. They are used wherever two sections of wave guide are coupled, or where some part, such as a magnetron, is mounted to the wave guide. The two halves of a choke joint are shown in A, figure 28. One of the flanges contains a circular groove one-fourth wave length deep at a distance of one-fourth wave length from the inner surface of the wave guide. A cross-section of the joint is shown in B, figure 28. The L-shaped cavity (fig. 29) is similar to a ½-wave length transmission line shorted at the far end. Current and voltage are so distributed along a transmission line that a short looks like a very high impedance at a distance of a one-fourth wave length from it. At a distance of one-fourth wave length, the line appears shorted (fig. 29). At the point where the flange bolts establish contact, the choke joint represents a high impedance that matches the high line impedance. Hence, to

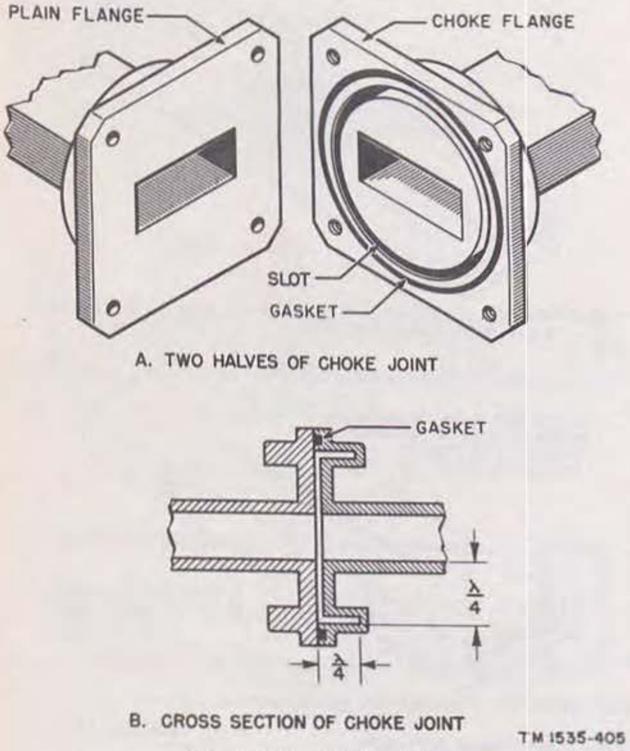


Figure 28. Choke joint.

energy traveling down the guide, no discontinuity is apparent, and no reflections are set up. It is as though the inner surface of the wave guide remained unbroken even though the two sections of the guide are connected together by means of a choke joint.

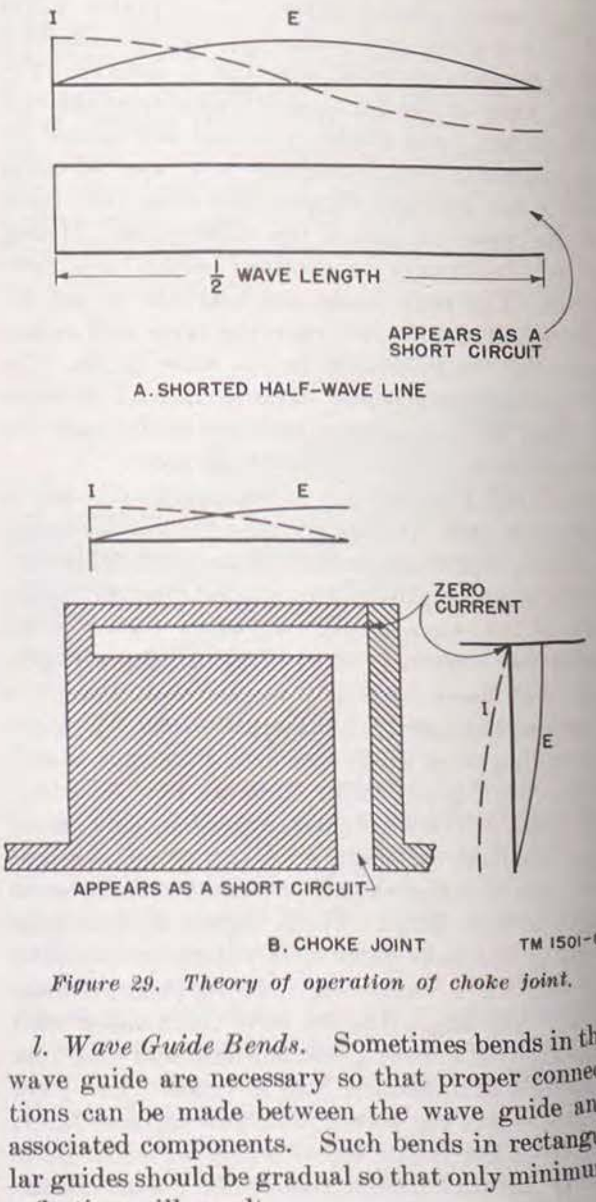


Figure 29. Theory of operation of choke joint.

l. Wave Guide Bends. Sometimes bends in the wave guide are necessary so that proper connections can be made between the wave guide and associated components. Such bends in rectangular guides should be gradual so that only minimum reflection will result.

m. Typical Wave Guide Run. Figure 30 shows a typical wave guide run from the receiver-transmitter to the antenna.

31. Duplexer

The duplexer is a wave guide that is used to connect the transmitting system and the receiving system to the same antenna. To prevent inter-

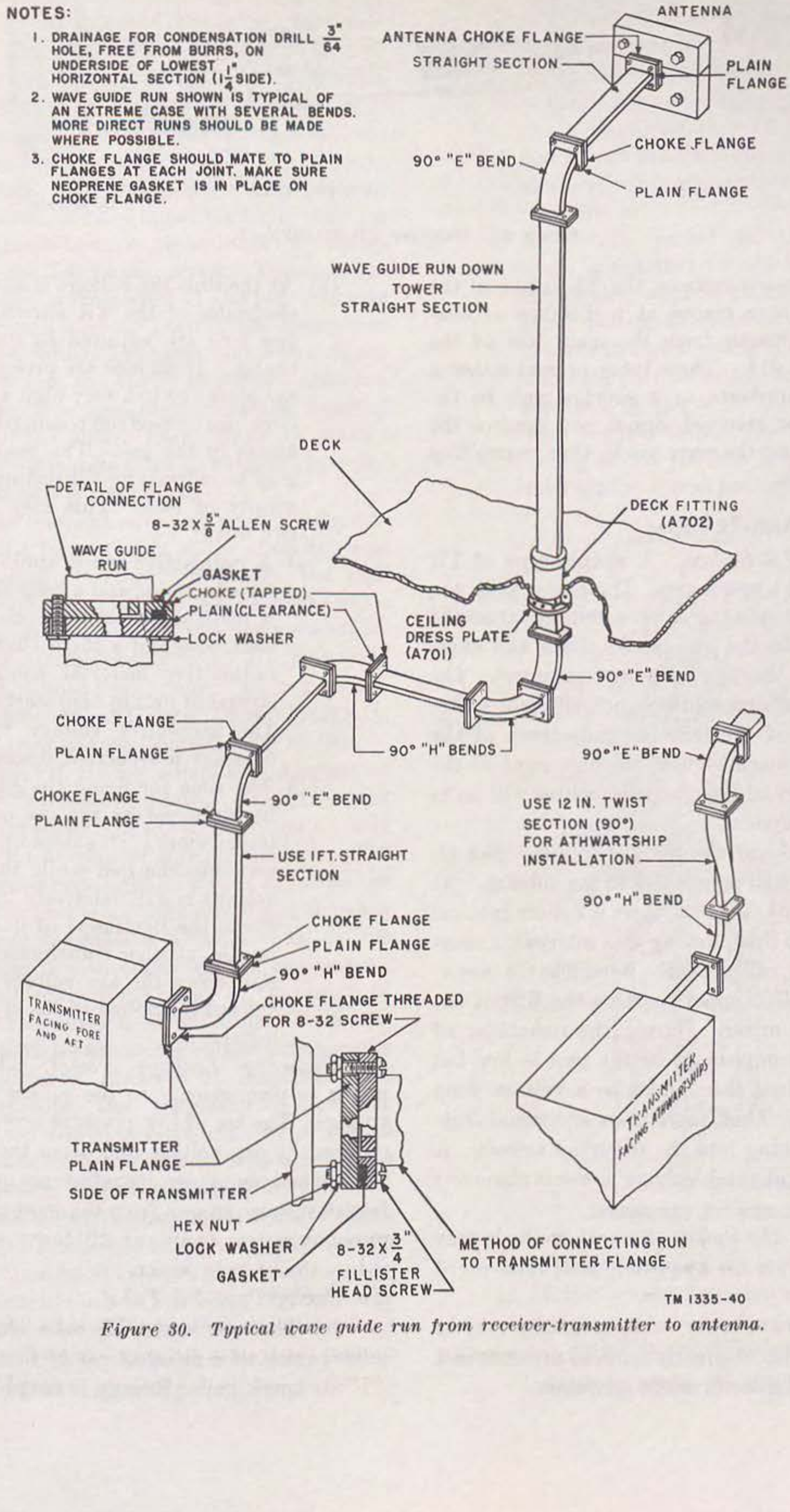


Figure 30. Typical wave guide run from receiver-transmitter to antenna.

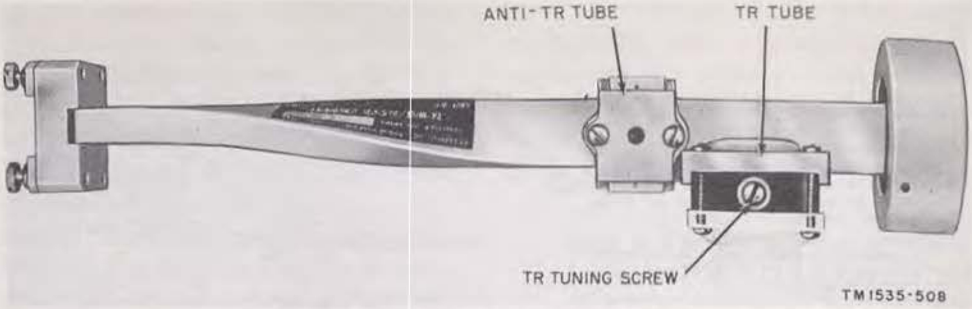


Figure 31. Duplexer CU-311/SPN-11.

action between the systems, the TR tube and the anti-TR tube are placed at a distance of one-fourth wave length from the main line of the duplexer (fig. 31). These tubes present either a very high impedance or a short circuit to the transmitted or received signal and control the impedance along the wave guide, thus controlling the signal path.

32. TR and Anti-TR Tubes

a. Simple TR Switch. A simple type of TR switch may be a spark gap. The power from the transmitter circuits builds up a voltage across the spark gap until the gap breaks down and effectively shorts the receiving system input. The energy of returning echoes is not sufficient to fire the gap and, if the reflected impedance of the magnetron is made high at the gap, most of the received energy of the returning echoes will go to the receiving system.

b. Drawbacks of Simple TR Swith. Not all of the transmitted power goes to the antenna. At the beginning of the pulse, there is a short interval before the gap fires; during this interval, a short burst of power, called a *spike*, flows into the receiving system. This spike shortens the life of the crystal in the mixer. During the remainder of the pulse, the impedance of the gap is low but is not zero, since there must be a voltage drop across the arc. Thus, there is an additional *leakage* power flowing into the receiving system. A minimum of spike and leakage power is obviously desirable.

c. Reducing the Spike. Several methods may be used to reduce the amplitude and duration of the spike.

(1) To fire at lower voltage, the gap may be operated at greatly reduced pressure in a sealed glass or metal container.

(2) At the time the voltage is applied to the electrodes of the TR switch, at least a few ions are required to start the discharge. If no ions are present, the voltage must rise to a very high value to produce ions by electron bombardment of the atoms in the gas. The resulting spike may be reduced by furnishing a constant supply of ions. This may be done in two ways:

(*a*) A radioactive salt is applied to one of the electrodes, and a keep-alive voltage is maintained between one of the gap electrodes and a third electrode. The radioactive material emits a steady stream of ions to help start conduction. The keep-alive voltage maintains a constant low-current discharge.

(*b*) The time for firing the gap may also be shortened by the use of a step-up transformer. This steps up the voltage and fires the gap while the incoming voltage is still relatively low. To decrease the likelihood of damaging the crystal, another transformer is used to step down the arc voltage before the voltage is applied to the crystal in the mixer.

d. Reducing Leakage Power. The leakage power is proportional to the square of the arc voltage. The use of low pressure around the gap reduces the gap voltage and hence the loss. The step-up and step-down transformers cause the effective voltage, as seen from the wave guide or the receiving system, to appear still lower, and further reduce the leakage power.

e. Cavity-Type TR Tube.

(1) The microwave TR tube (fig. 32) consists of a resonant cavity that contains a spark gap. Energy is coupled into and

out of the cavity through openings covered with small disks of glass (windows) in opposite sides of the cavity. The step-up and step-down ratios are related to the size of the openings; the step-up ratio is higher as the size of the openings is reduced. The gap electrodes are inserted into the top and bottom of the resonant cavity. The hollow lower electrode cone is fixed, but the upper electrode cone can be made to move up and down by means of the TR tuning screw. The resonant cavity is connected to the gas reservoir through a small port in the lower cone from which hydrogen and water vapor flow into the cavity to replace absorbed gas. The keep-alive electrode, inserted into the hollow lower electrode, obtains its −900 volts through a cap at the lower end of the reservoir.

(2) The resonant cavity of the TR tube acts like a tuned circuit at the operating frequency. During transmission, the high potential applied to the tube breaks down the gap, effectively placing a short-circuit across the duplexer. At the end of the transmitted pulse, the arc is extinguished and echo signal energy is allowed to enter the receiving system.

(3) The TR tuning adjustment consists of two concentric screws. The inner and outer threads of the screws differ slightly in the number of threads per inch. The thread ratio of the two screws causes the inner screw to move down and the electrode to move a distance equal to the difference in travel of the two screws. The total tuning range of the switch in wave lengths is 3.1 to 3.5 cm. When the electrodes are moved closer together, the equivalent capacity is increased and, therefore, the frequency is lowered. When the electrodes are moved farther apart, the equivalent capacity is decreased and the frequency is raised.

(4) The negative keep-alive voltage maintains a continuous discharge between the keep-alive electrode and the hollow cone. Some of the ions formed by this discharge enter the space between the cones and cause the gap to break down more readily when a microwave pulse is applied. The glass boot around the electrode causes the keep-alive discharge to be concentrated in the region nearest the gap. To protect the signal crystal in the mixer during the warmup period, the keep-alive voltage is applied 3 minutes before the main rf power is turned on. (A complete discussion of the keep-alive power supply can be found in the power system chapter (par. 93).)

(5) A certain period of time—recovery time—is required for the ions to become neutralized after a pulse has fired the gap. During this recovery period, there is a loss in signal strength because a considerable portion of the signal energy is absorbed by the ions. A new TR tube has a recovery time of 1 to 2 microseconds during which the loss is approximately one-half the signal power.

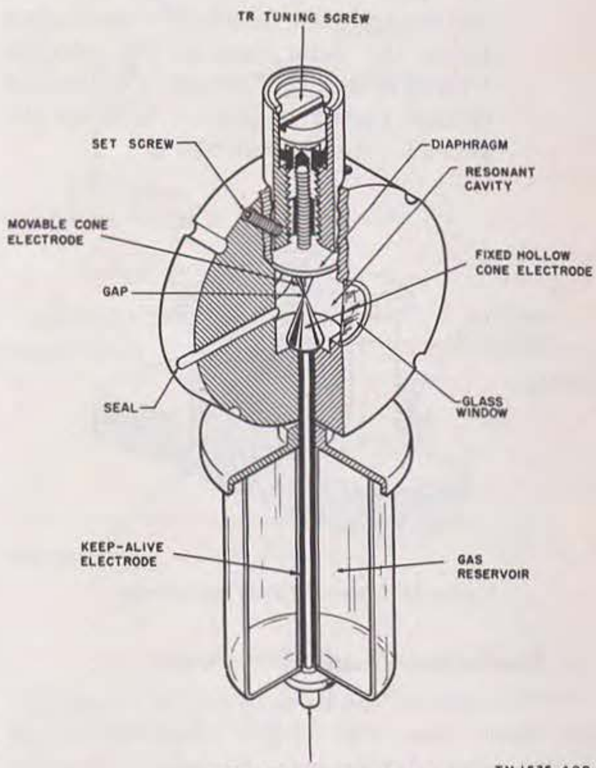


Figure 32. TR tube.

f. Anti-TR Tube.

(1) If the output impedance of the magnetron were always fixed, it would be a relatively simple matter to divert all received signals to the TR tube and from

there to the mixer. The length of the wave guide from the magnetron to the TR tube could be adjusted so that the magnetron would present a high impedance to the signal, and most of the signal energy would flow through the lower resistance path of the receiving system. However, the magnetron impedance varies over a wide range and, therefore, an anti-TR tube (fig. 33) is necessary to establish the proper impedance to control the signal path.

(2) Anti-TR tube V201 is a gas tube that does not use a keep-alive electrode and is untuned. The loaded Q of the cavity is made very low by a large window at one end. The cavity is placed in series with the line from the transmitter circuits by substituting the face of the tube containing the window for a portion of the broad side of the wave guide. During transmission, breakdown takes place across the inner face of the window. During reception of returning echoes, not enough energy is present to cause the anti-TR tube to break down.

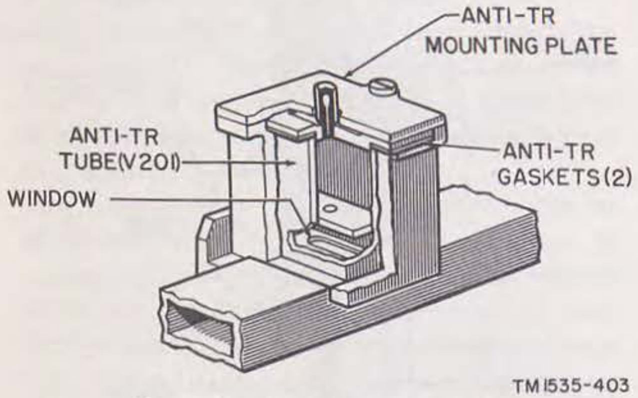


Figure 33. Anti-TR tube and mount.

33. Equivalent Circuit of Duplexer

a. The duplexer can be compared to a transmission line. (See TM 11–673, Generation and Transmission of Microwave Energy.) The TR tube, which is connected to the narrow side of the duplexer, is effectively in parallel with the equivalent transmission line. The anti-TR tube, which is connected to the broad side of the duplexer, is effectively in series with the equivalent transmission line. The complete equivalent circuit of the duplexer is shown in A of figure 34.

b. When the magnetron fires, the high rf energy flowing down the duplexer causes the TR and anti-TR tubes to fire as shown in B of figure 34. The short at the TR tube causes the line between it and the main body of the duplexer to act as a one-fourth wave length, short-circuited stub. No energy is diverted to the receiving system. At the same time, the short across the anti-TR tube effectively makes the transmission line solid at that point. Practically all the energy from the transmitter circuits travels down the line to the antenna.

c. During the time the magnetron is not firing and echoes are being received by the antenna, neither the TR nor the anti-TR tubes receives enough energy to fire. The TR and anti-TR tubes are open as shown in C of figure 34. The open at the anti-TR tube effectively opens up the line at that point. This open is reflected as a similar open three half-wave lengths back. The received energy is thus prevented from going down to the transmitter circuits, but is deflected through the TR tube to the receiving system.

34. Antenna Wave Guide Assemblies

(figs. 35, 36, and 37)

Microwave energy is coupled from the wave guide run to the wave guide flange in the back of the antenna pedestal. Inside the pedestal, the energy is coupled from a fixed joint assembly to a rotating joint assembly to which is attached the antenna horn.

a. Fixed Joint Assembly. The stationary rectangular wave guide is clamped to the gear housing of the antenna pedestal. The round stationary section extends through a vertical hollow shaft (not shown in fig. 35).

b. Rotating Joint Assembly. Attached to the hollow shaft and above it is the rotating mounting base to which are bolted the antenna horn and reflector. The vertical hollow shaft, and thus the whole assembly, is made to rotate by the antenna drive motor through gearing assemblies. (See pars. 231 through 237 for a discussion of the gearing assemblies.)

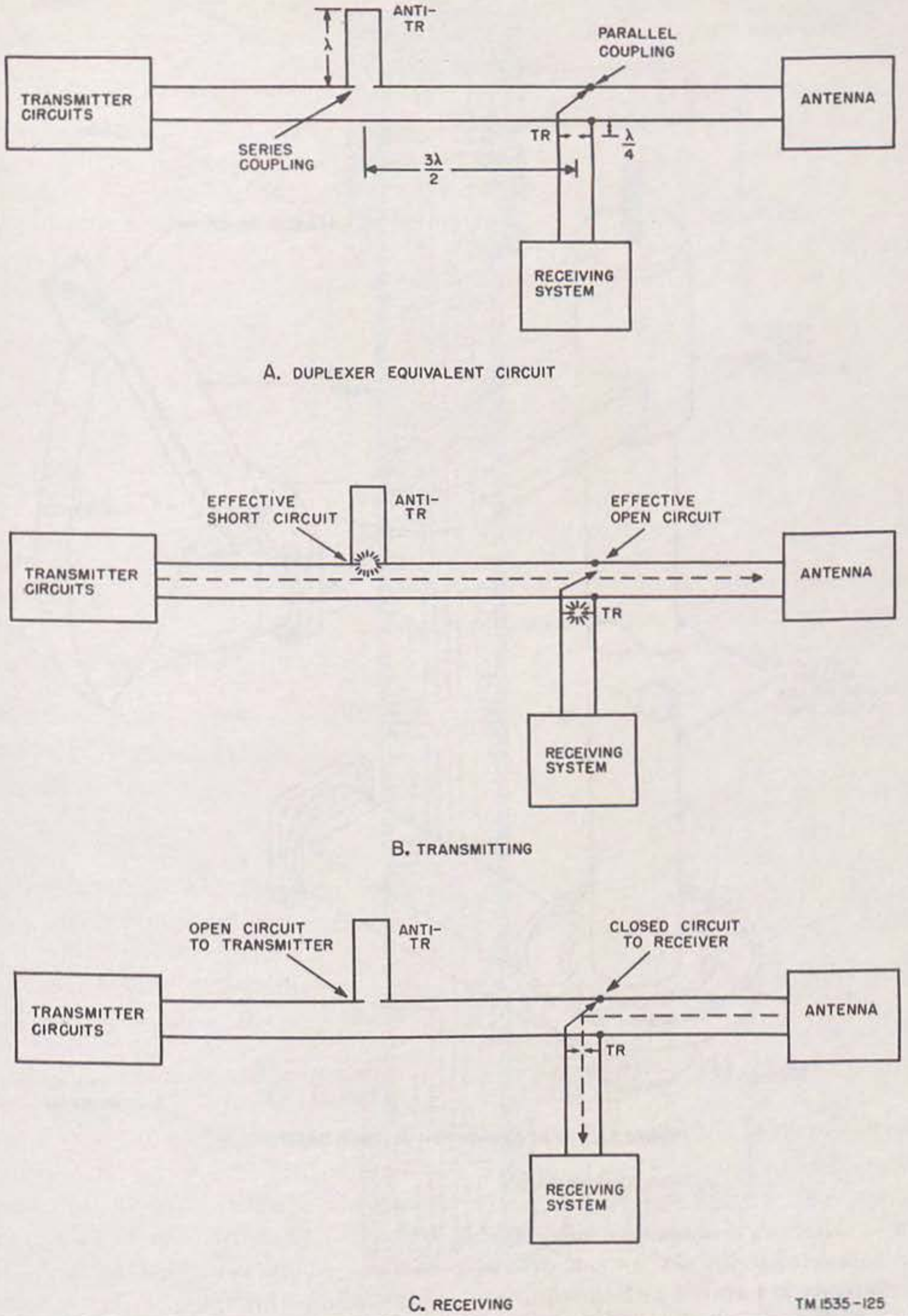


Figure 34. Equivalent circuit for duplexer.

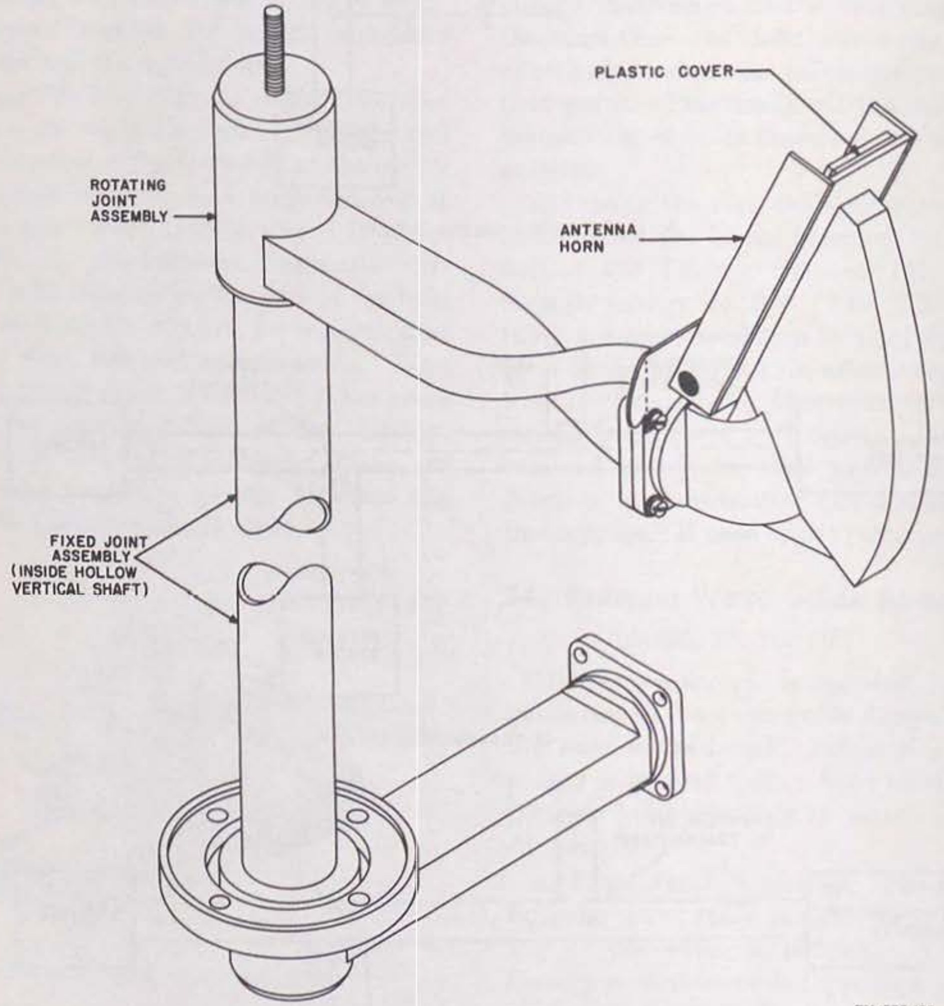


Figure 35. Wave guide run through antenna.

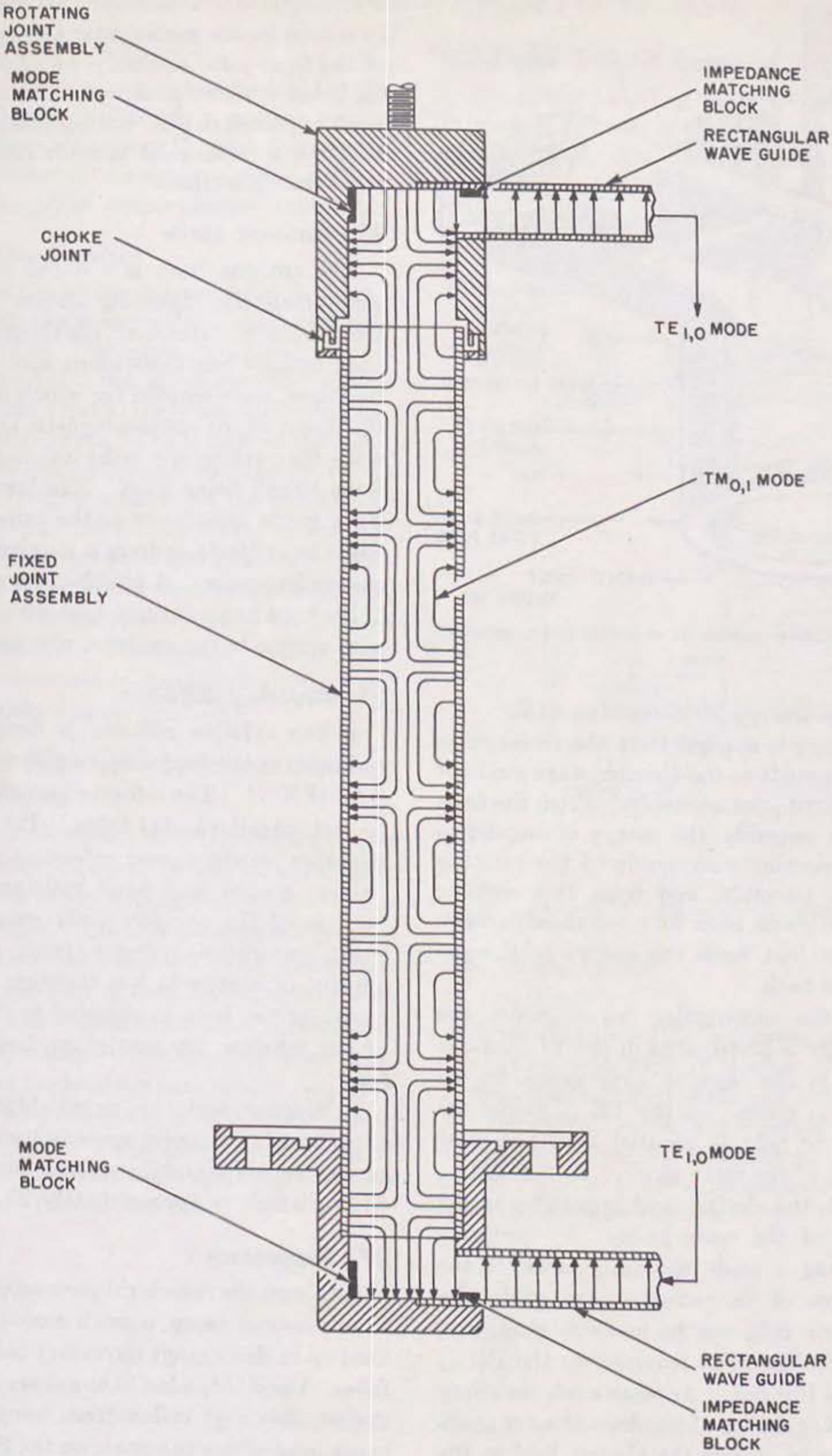


Figure 36. Coupling of energy between fixed and rotating joint assemblies, view of E lines.

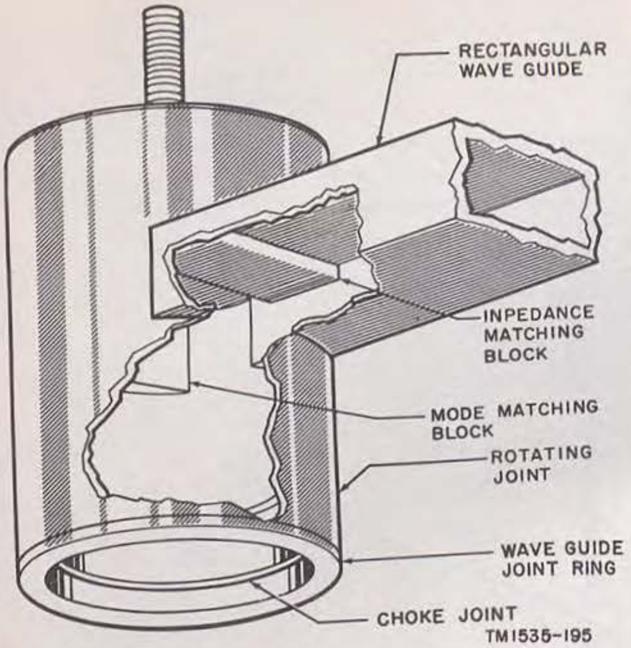


Figure 37. Rotating section of rotating joint, cutaway view.

c. Coupling Energy Between Assemblies.

(1) Energy is applied from the rectangular wave guide to the circular wave guide of the fixed joint assembly. From the fixed joint assembly, the energy is coupled to the circular wave guide of the rotating joint assembly, and from this circular wave guide back to a rectangular wave guide that feeds the energy to the antenna horn.

(2) In the rectangular wave guide, the energy is propagated in the $TE_{1,0}$ mode and in the circular wave guide, in the $TM_{0,1}$ mode. In the $TE_{1,0}$ mode, the electric field is parallel to the narrow sides of the wave guide. In the $TM_{0,1}$ mode, the electric field is parallel to the axis of the wave guide. By properly placing a mode matching block at the bottom of the circular wave guide, the electric field can be made to change to the configuration required for the $TM_{0,1}$ mode (fig. 36). Another mode matching block at the top of the circular wave guide serves to change the electric field to the proper configuration required for the $TE_{1,0}$ mode.

d. Impedance Matching. To match the impedance between the rectangular and circular sections of the fixed joint assembly, an impedance matching block is placed as shown. A similar matching block is placed in the rotating joint assembly. In addition, a choke joint is made between the fixed and rotating sections.

35. Antenna Horn

The antenna horn is a flared wave guide, an electromagnetic directing device similar to an acoustic horn. However, the throat of an acoustic horn usually has dimensions much smaller than the sound wave lengths for which it is used, while the throat of the electromagnetic horn has dimensions that are in the order of magnitude of the wave length being used. The horn matches the wave guide impedance to the impedance of free space in order to radiate a maximum amount of energy into space. A plastic cover over the mouth of the horn keeps out moisture which would otherwise attenuate the radiated energy.

36. Antenna Reflector

a. The antenna reflector is designed to direct radiation at the frequency employed by Radar Set AN/SPN-11. The reflector is made of uniformly spaced, parallel metal tubes. This type of construction provides good reflecting properties and reduces weight and wind resistance. However, because of the comparatively small spacing between successive reflector bars, a very small amount of energy is lost through leakage. The mouth of the horn is adjusted to the focal point of the reflector for maximum directivity of the beam.

b. Bearing resolution, or the ability of the radar to separate two closely spaced targets at the same range, depends mainly on the horizontal beam width, which is approximately 2°.

37. Suppressor

Although the reflector directs most of the energy in one narrow beam, a small amount of energy is used up in short range secondary beams called *side lobes*. These side lobes have a short range. Nevertheless, they may reflect from nearby objects and cause false echoes to appear on the PPI. To minimize the effect of side lobes, a suppressor is mounted in front of the horn window.

38. Antenna Drive Motor

The antenna drive motor is powered by the line voltage of the ship. Through a gearing system, it rotates the antenna horn at 17 rpm. The method of applying power to the antenna drive motor is discussed in the power system chapter (par. 90).

39. Transmitter Synchro

The rotor of the transmitter synchro is coupled mechanically to the antenna drive shaft at a step-up ratio of 1:100. Therefore, when the antenna horn is rotating at its normal speed of 17 revolutions per minute (rpm), the transmitter synchro rotor rotates at 170 rpm. The stators of the transmitter synchro are connected electrically to the stators of the receiver synchro in the synchronizing and indicating system. By means of the 10:1 step-down gearing between the receiver synchro rotor and the PPI deflection coil, the deflection coil is made to rotate at the same speed as the antenna horn and reflector. Transmitter and receiver synchros are discussed in the synchronizing and indicating system chapter (par. 80).

40. Heading Flash and Synchro Alinement Cam Switches

The synchro alinement and the heading flash cam switches are clamped to the antenna drive shaft and rotate at the same speed as the antenna horn and reflector. The alinement cam switch in the antenna is normally closed for 330° of antenna horn rotation and may be used in conjunction with the alinement cam switch located in the indicator, to aline the synchros. The heading flash cam switch actuates the heading flash circuit located in the indicator to give fore and aft heading flash signals on the PPI. These circuits are discussed more fully in the synchronizing and indicating system chapter (par. 81 and 82).

41. Heaters and Thermostat

The antenna gearing system, which is contained in the gear housing of the antenna pedestal, is submerged in oil. The oil is kept at a constant temperature by means of heaters and a thermostat. These circuits are discussed in the power system chapter (par. 90).

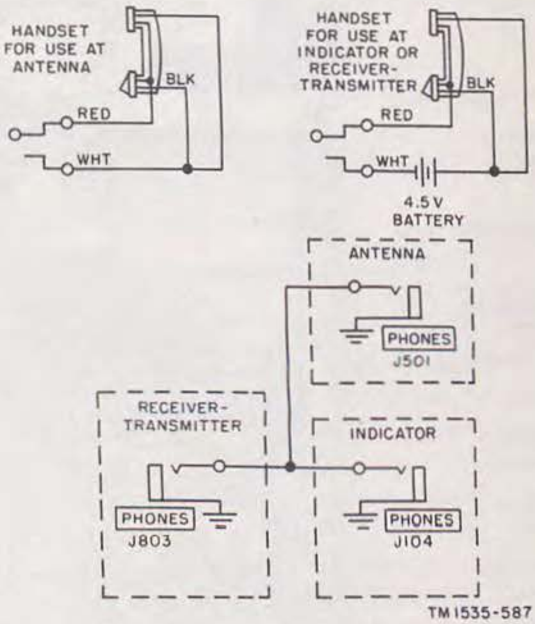


Figure 38. Phone circuit, schematic.

42. Phone Circuit

(fig. 38)

PHONES jack J501 is located in the antenna, PHONES jack J803 is located on the receiver-transmitter, and PHONES jack J104 is located in the indicator. A battery-powered handset may be used at either the indicator or receiver-transmitter location to effect telephone communication with the antenna location.

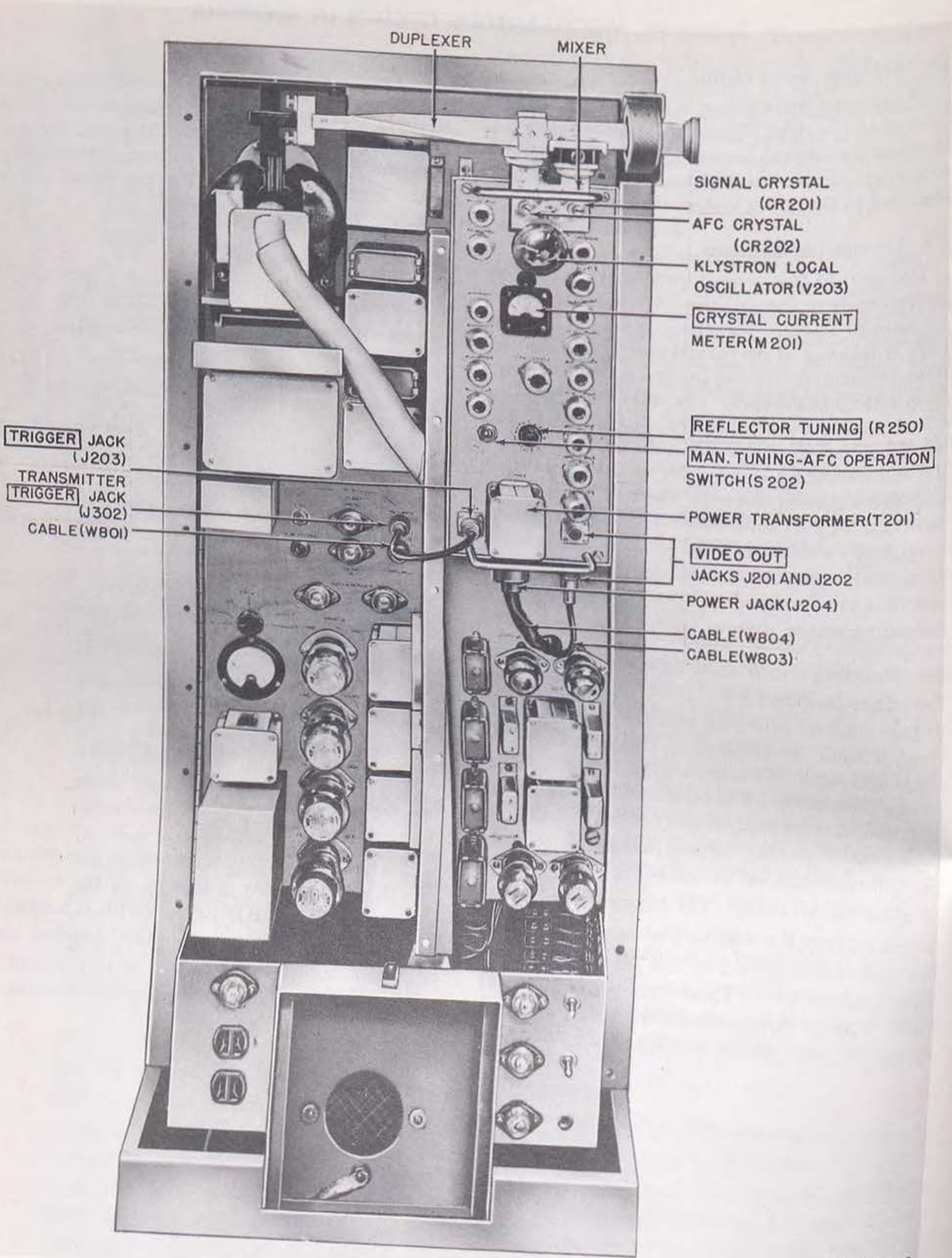
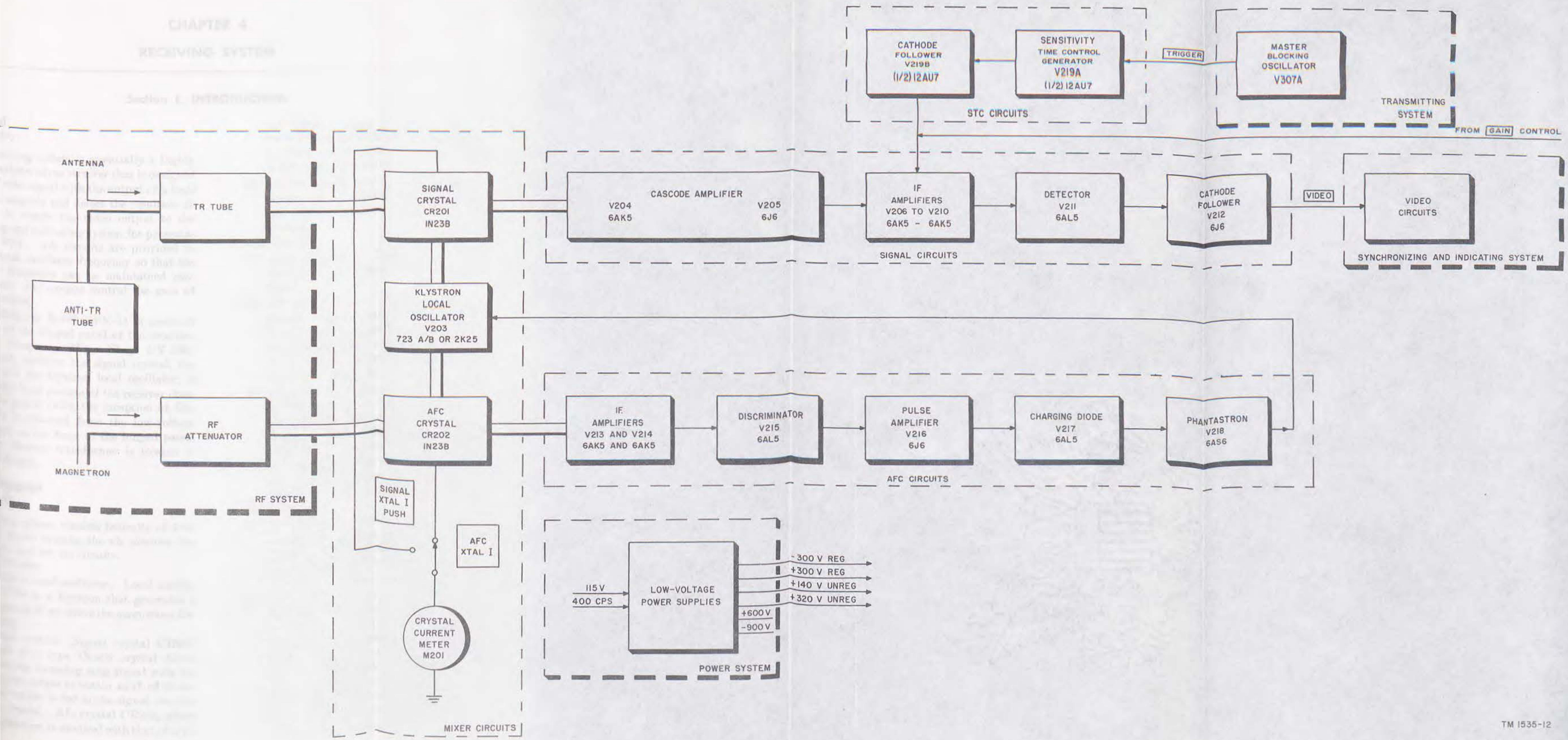


Figure 39. Receiver-transmitter, receiving system parts.



TM 1535-12

Figure 40. Receiving system, block diagram.

CHAPTER 4

RECEIVING SYSTEM

Section I. INTRODUCTION

43. General

(fig. 39)

a. The receiving system is essentially a highly sensitive superheterodyne receiver that is designed to mix the rf echo signal with the output of a local oscillator; to amplify and detect the resultant if. signal; and to couple the video output to the synchronizing and indicating system for presentation on the PPI. Afc circuits are provided to control the local oscillator frequency so that the intermediate frequency can be maintained constant at 30 mc. Stc circuits control the gain of the signal circuits.

b. Radar Receiver R–480/SPN–11 is mounted on the front of the hinged panel of the receiver-transmitter. Frequency Mixer Stage CV–239/SPN–11, which contains the signal crystal, the afc crystal, and the klystron local oscillator, is mounted on the front portion of the receiver chassis. Receiver power (with the exception of filament power) is obtained from the low-voltage power supplies on the front of the hinged panel. The receiver filament transformer is located in the receiver chassis.

44. Block Diagram

(fig. 40)

The receiving system consists basically of four sections: the mixer circuits, the afc circuits, the signal circuits, and the stc circuits.

a. Mixer Circuits.

(1) *Klystron local oscillator.* Local oscillator V203 is a klystron that generates a frequency 30 mc above the magnetron frequency.

(2) *Signal crystal.* Signal crystal CR201, which is a type IN23B crystal diode, mixes the incoming echo signal with the klystron output to obtain an if. of 30 mc. This output is fed to the signal circuits.

(3) *Afc crystal.* Afc crystal CR202, whose construction is identical with that of crystal CR201, mixes a portion of the radiated energy with the klystron output to obtain and if. of 30 mc. This output is fed to the afc circuits.

(4) *Crystal current meter.* Meter M201 indicates the dc current flowing through the signal crystal or through the afc crystal.

b. Afc Circuits.

(1) *Afc if. amplifiers.* Tubes V213 and V214 amplify the intermediate frequency signal.

(2) *Afc discriminator.* Discriminator V215 provides negative output pulses when the if. is above the proper frequency, positive pulses when the if. is below the required point, and no pulses when the if. is at the proper frequency.

(3) *Afc pulse amplifier, charging diode and phantastron.* The discriminator pulses are amplified and inverted in afc pulse amplifier V216. These pulses, when applied to phantastron V218, keep the if. centered about the correct value of 30 mc. Charging diode V217 aids in controlling the action of the phantastron.

c. Signal Circuits.

(1) *If. amplifiers.* There are seven if. stages. The 30 mc if. output of the signal crystal is applied to a cascode amplifier consisting of V204 and V205. The remaining if. stages are V206 through V210.

(2) *Video detector and cathode follower.* The output of the last if. stage is applied to video detector V211. This stage removes the if. component from the echo signal. The resultant video pulse is applied to cathode follower V212. The low output impedance matches the 75 ohms coaxial cable that conducts the video signals to the video circuits in the synchronizing and indicating system.

d. Stc Circuits. Stc generator V219A is triggered at the same time the magnetron is fired. The stc signal is fed through stc cathode follower V219B to if. amplifiers V207 and V208. The feedback pulse reduces the if. gain at the beginning of the PPI sweep, thus suppressing sea return.

Section II. MIXER CIRCUITS

45. Mixer

The mixer consists of the klystron local oscillator, the afc and signal crystals, and the mixer cavities. Both crystal circuits convert signals at the frequency of the transmitted pulse to if. signals at 30 mc.

a. Signal Crystal.

(1) Signal crystal CR201 is a small silicon crystal in contact with a sharply pointed flexible tungsten whisker (fig. 41). The entire unit is sealed and mounted horizontally inside the signal crystal cavity of the mixer. The upper end of the crystal is grounded to the cavity; the lower end plugs into a coaxial connector.

(2) The echo signals enter the signal crystal cavity through the TR tube. The klystron local oscillator output, which is 30 mc above the echo signal frequency, enters the signal crystal cavity through the coupling window between the oscillator cavity and the signal crystal cavity. The degree of coupling between the klystron local oscillator and the signal crystal cavity can be varied by means of adjustment (A, fig. 44). The difference frequency between the echo signal and the klystron local oscillator output is detected by signal crystal CR201 and fed through the coaxial connector to the input of the cascode if. amplified (V204, V205).

b. Afc Crystal.

(1) Afc crystal CR202 is similar to CR201 and is mounted in the afc crystal cavity in the same manner as the signal crystal.

(2) The transmitted signal is coupled through a hole in the duplexer to the afc crystal cavity. The hole attenuates the high powered signal by 70 decibels (db). The klystron local oscillator output, which is 30 mc above the magnetron frequency, enters the afc crystal cavity through the coupling window between the oscillator cavity and the afc crystal cavity. The degree of coupling between the klystron local oscillator and the afc crystal cavity can be varied by means of adjustment (B, fig. 44). The difference frequency between the magnetron output and the klystron local oscillator output is detected by afc crystal CR202 and fed through the coaxial connector to the grid of aft if. amplifier V213.

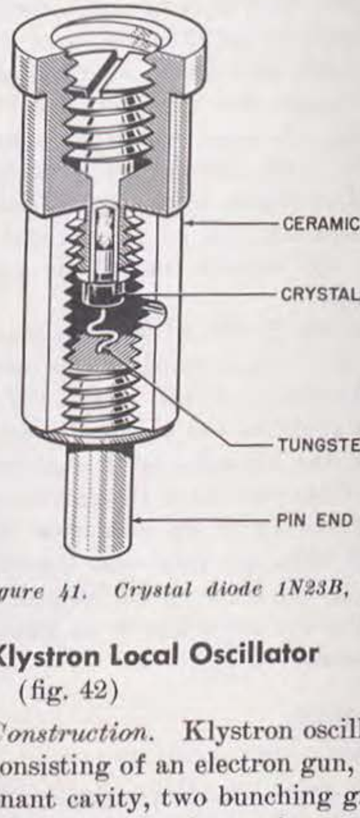


Figure 41. Crystal diode 1N23B, construction.

46. Klystron Local Oscillator
(fig. 42)

a. Construction. Klystron oscillator V203 is a tube consisting of an electron gun, a control grid, a resonant cavity, two bunching grids, and a reflector plate. A cavity tuning strut around the top of the tube deforms the cavity and thus varies the point of resonance. Coupling between the tube and the mixer is made through a coaxial line that extends through the base of the tube. A coupling loop at one end of the inner coaxial line picks up rf energy from the tube; the other end of the coaxial line extends a quarter-wave length into the oscillator cavity in the mixer.

b. General Operation. The control grid, which is maintained at +300 volts, accelerates cathode electrons into the area between the bunching grids. After passing through the cavity grids, the electrons are repelled by the negative reflector voltage to the cavity grids. If the phase of the electron current returning to the bunching grids is such that energy is given to the cavity, cavity oscillations will be reinforced.

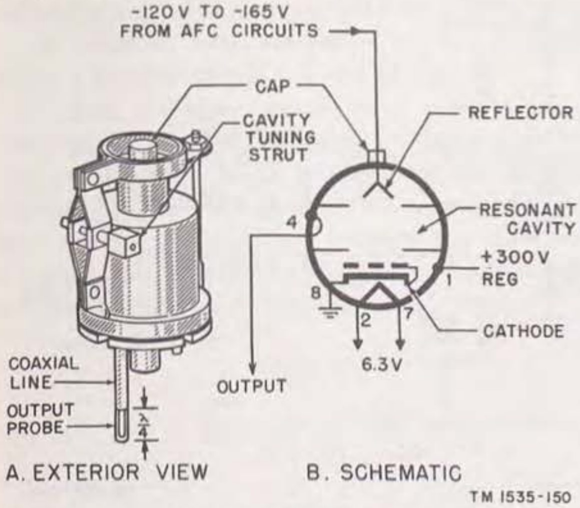


Figure 42. Klystron local oscillator, construction.

c. Bunching. Since the bunching grids are attached to the cavity, the electric field about the grids varies at the same frequency as the cavity (1, fig. 43). The effect upon an electron shot through the bunching grids depends on the arrival time of the electron with reference to the varying field about the bunching grids.

Note. The graph in figure 43 is not drawn in terms of voltage, but in terms of the effect of the field upon an electron: a positive variation on the graph indicates the field is in such a direction as to accelerate an electron upward; a negative variation indicates the field is in such a direction as to accelerate an electron downward.

(1) An electron arriving at the grids when the field is changing from an upward accelerating field to an upward decelerating one (point a) is unaffected by the bunching grids. The electron continues until it is repelled by the negative reflector voltage and returns to the grids when the field about them is as shown at point x.

(2) An electron reaching the grids is retarded when the field is as shown at point b. Consequently, it does not travel as far as the first electron before being repelled by the reflector field. But since it starts out after the previous electron, both reach point x simultaneously.

(3) An electron arriving at the grids is accelerated when the field is as shown at point c. As a result, it travels a greater distance upward before being repelled by the reflector field. But since it starts out after the first electron, both reach point x simultaneously.

(4) Thus electrons are bunched. Optimum performance of the oscillator is maintained when the bunched electrons arrive at the bunching grids at the time the field offers the greatest retarding force (point x). Since decelerating electrons give up energy, the oscillations of the cavity are sustained.

d. Modes of Operation. The relative phase of the bunched current and the voltage across the bunching grids is controlled by the reflector voltage. Changing this voltage varies the time spent by the electrons in the field and therefore the point at which the bunches return to the buncher grids. Instead of being made to return at point x, the reflector voltage can be adjusted so that the bunches return any number of cycles later (point x′, x″, and so forth). Thus the reflector voltage controls the *mode* of operation.

e. Tuning. Tuning may be controlled either by the turning cavity tuning strut, which varies the size of the cavity, or by changing the reflector voltage. The latter can be done manually or automatically.

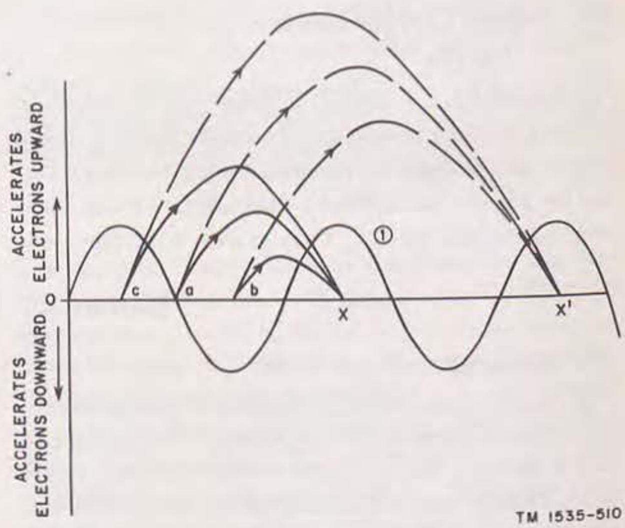


Figure 43. Operating characteristics of klystron oscillator.

(1) Manual tuning is obtained by varying REFLECTOR TUNING control R250 (fig. 48) which is across the minus 300-

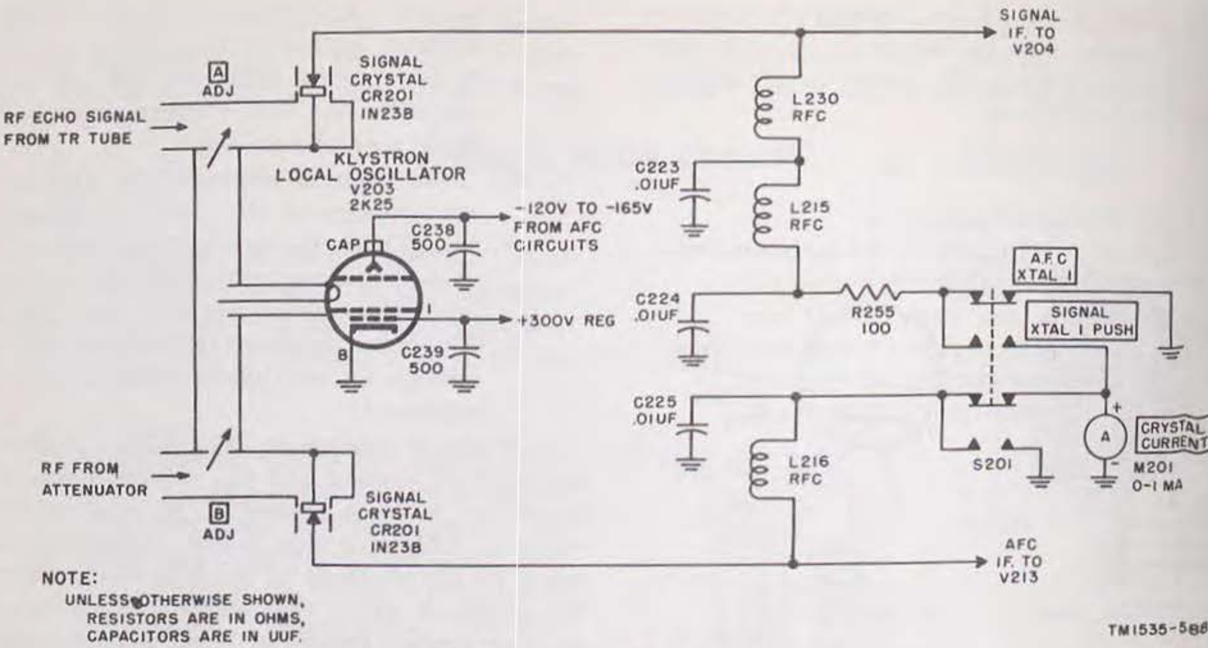


Figure 44. Mixer circuits, schematic

volt supply. Switch S202 should be at the MAN. TUNE position.

(2) With switch S202 at the AFC OPERATION position, the output of the afc phantastron, V218, is coupled to the reflector maintaining the oscillator output frequency at exactly 30 mc.

47. Crystal Current Meter

(fig. 44)

CRYSTAL CURRENT meter M201, which is a 0 to 1 milliampere (ma) dc meter located in the center of the receiver chassis, measures either signal or afc crystal current, depending on the position of switch S201. This meter, therefore, enables the operator to check quickly the condition of the mixer circuits.

a. Signal Crystal Current. With switch S201 in the SIGNAL XTAL I PUSH (depressed) position, the output of signal crystal CR201 is filtered of ac components by L230, L215, C223, and C224 and fed to meter M201. The meter thus reads only dc. Resistor R255 limits the current.

b. Afc Crystal Current. With switch S201 in the AFC XTAL I (normal) position, the output of afc crystal CR202 is filtered of ac components by L216 and C225 and fed to meter M201. The meter thus reads the dc component of the afc crystal current. When the dc current of either crystal is being measured, the dc current of the other crystal is run to ground.

Section III. AFC CIRCUITS

48. General

a. Automatic frequency control is used to obtain a difference between the magnetron frequency and the klystron local oscillator frequency that is approximately constant and equal to the if. of 30 mc. Afc is necessary because variations in the standing-wave ratio arising from an asymmetrical rotating joint or reflections from nearby objects can pull the magnetron off frequency. Also, the magnetron and klystron local oscillator do not hold constant frequency after several hours of operation, nor do they vary together. Variations in voltage and temperature produce frequency changes.

b. A phantastron circuit produces a sweep voltage, which, when applied to the reflector of the klystron local oscillator, makes the output frequency of that tube vary from a low to a high value. In the mixer, this varying frequency is combined with the magnetron frequency to produce an if. That varies from a value below 30 mc to a value above 30 mc.

c. An if. below 30 mc, when applied to the discriminator, produces a positive pulse that is made negative by the dc amplifier. Since negative pulses have no effect on the phantastron, the phantastron continues to increase the output frequency of the klystron local oscillator, which, in turn, causes a further increase in the if.

d. When the if. increases to a value slightly above 30 mc, the discriminator produces negative pulses which are made positive by the dc amplifier. These positive pulses, when applied to the phantastron, momentarily reverses the direction of its sweep. The frequency is thus brought back to 30 mc, where it is locked in.

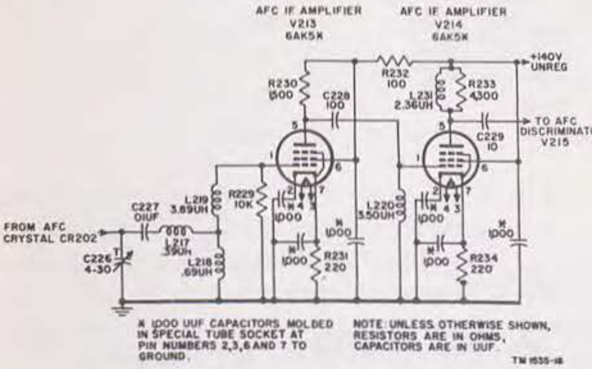


Figure 45. Afc if. amplifiers, schematic.

49. Afc If. Amplifiers V213 and V214
(fig. 45)

a. Two stages of afc if. amplification (V213 and V214) are provided. The input circuit of V213 is tuned to 30 mc by variable capacitor C226 and coils L217, L218 and L219. Capacitor C227 keeps the dc afc crystal current off the grid. R229 is the grid load resistor and R231 is the cathode bias resistor.

b. The amplified signal developed across plate load resistor R230 is coupled through C228 to grid coil L220. The signal developed across L220 is amplified in the plate of V214 and appears across the plate load consisting of L231 and R233. R233 widens the band-pass characteristics of the stage. The cathode and screen bypass capacitors (marked with an asterisk (*) in the figure) are molded into the tube sockets of both stages.

50. Afc Discriminator
(fig. 46)

a. The afc if. pulse from tube V214 is coupled to afc discriminator V215 through capacitor C229 and appears across coil L221. Coil L232 together with its distributed capacitance and C241 resonate at 27.5 mc. Coil L233 together with its distributed capacitance and C242 resonate at 32.5 mc. Resistors R252 and R253 broaden the frequency response of the tuned circuits. L232 is connected to the plate (pin 2) of diode section A of V215, and L233 is connected to the cathode (pin 1) of diode section B. A pulse applied to diode A charges C230 so that point A is positive. A pulse applied to diode B charges C231 so that point B is negative.

b. If a 30 mc if. pulse is applied to the discriminator, the amplitude of this pulse across tuned circuit L232 and C241 is the same as that across tuned circuit L233 and C242. As a result, the positive pulse developed at point A is of equal amplitude to the negative pulse developed at point B. Considering R235 and R236 as a voltage divider, it can be seen that the potential at point C is zero. At the end of the if. pulse, the positive potential on the cathode of the diode A and the negative potential on the plate of diode B cause both sections of tube V215 to stop conducting. Capacitors C230 and C231 discharge through resistors R235 and R236. Since both capacitors are equally charged and they are discharging through the same path, the potential at point C remains zero (fig. 47).

c. An if. pulse whose frequency is below 30 mc has a greater amplitude at diode A than at diode B. As a result, the instantaneous positive potential at point A (e_A) is greater than the instantaneous negative potential at point B (e_B). Since the potential at point C is

$$e_C = \frac{e_A + e_B}{2}$$

it is obvious that point C is positive. At the end of the applied pulse, both diodes stop conducting because the cathode of diode A is positive and the plate of diode B is negative. The capacitors start discharging towards the value of e_C. Because of its smaller charge, C231 discharges first allowing diode B to conduct. As this happens, capacitor C230 discharges through diode B. Therefore, the lower the if. applied to the discriminator, the more positive the pulse at point C. The maximum positive pulse occurs at 27.5 mc (fig. 47).

d. An if. pulse with a frequency above 30 mc produces an instantaneous negative potential at point B that is greater than the instantaneous posi-

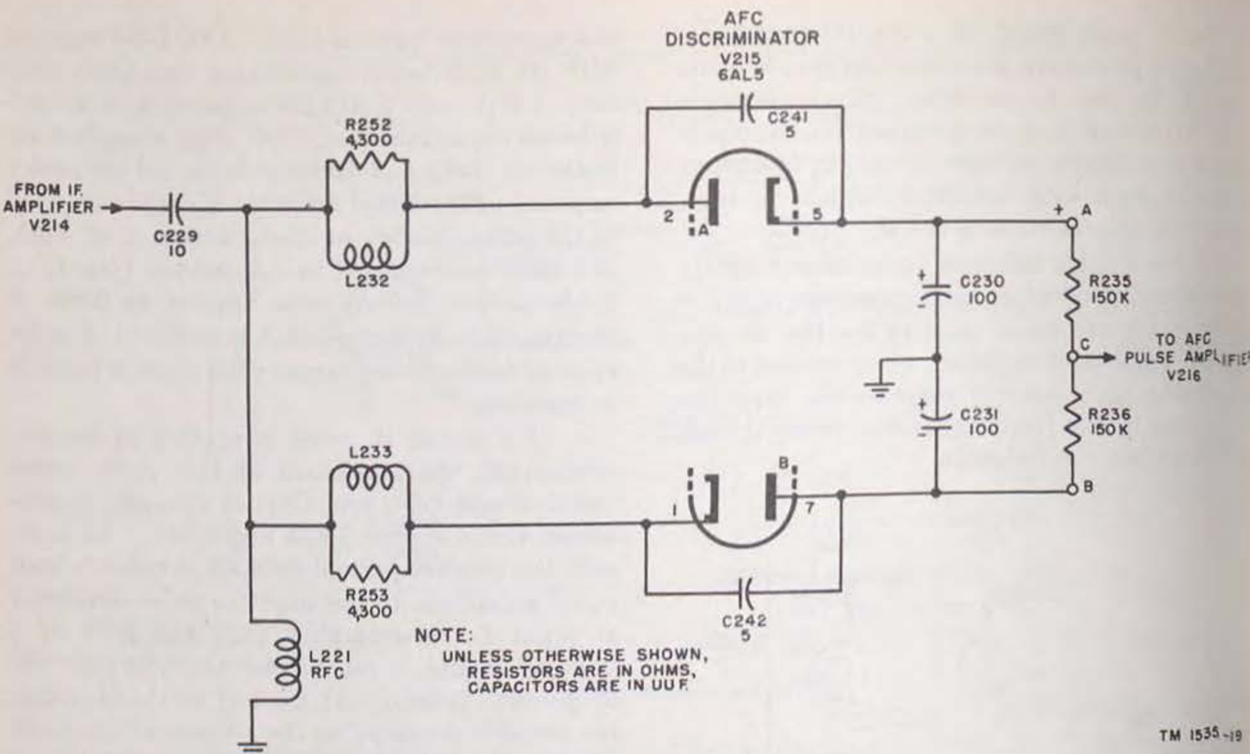


Figure 46. Discriminator schematic.

tive potential at point A, thus making point C negative. Because C230 now has the smaller charge, it discharges first allowing diode A to conduct. C231 now discharges quickly through diode A. Therefore, the higher the if. applied to the discriminator, the more negative the output pulse at point C. The maximum negative pulse occurs at 32.5 mc (fig. 47).

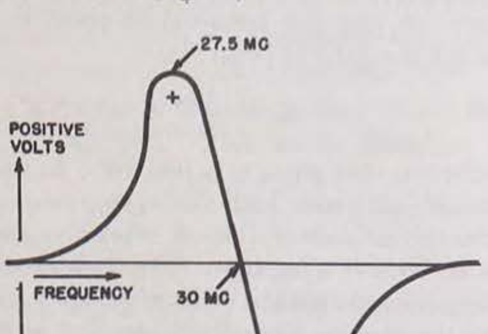


Figure 47. Discriminator output.

51. Afc Pulse Amplifier

The output from point (C, fig. 46) of the discriminator is fed to a conventional amplifier, V216 (fig. 48). To stabilize the circuit, signal degeneration is obtained by leaving cathode bias resistor R239 unbypassed. The output is similar to the discriminator output, except that it is amplified and reversed in phase. The positive pulses from the discriminator, which occur when the if. is below 30 mc, become amplified negative pulses in the dc amplifier output. The negative pulses from the discriminator, which occur when the if. is above 30 mc, become amplified positive pulses. When the if. is at 30 mc, no pulses are applied and therefore none are obtained from the pulse amplifier.

52. Charging Diode and Phantastron (fig. 48)

The output of pulse amplifier V216 is coupled through C232 to charging diode V217 and to the grid of phantastron V218. Wave forms for the phantastron are illustrated in figure 49. The voltage on the plate of V218 is determined by the drop across resistor R243. The screen potential is determined by voltage divider R245 and R244. Both

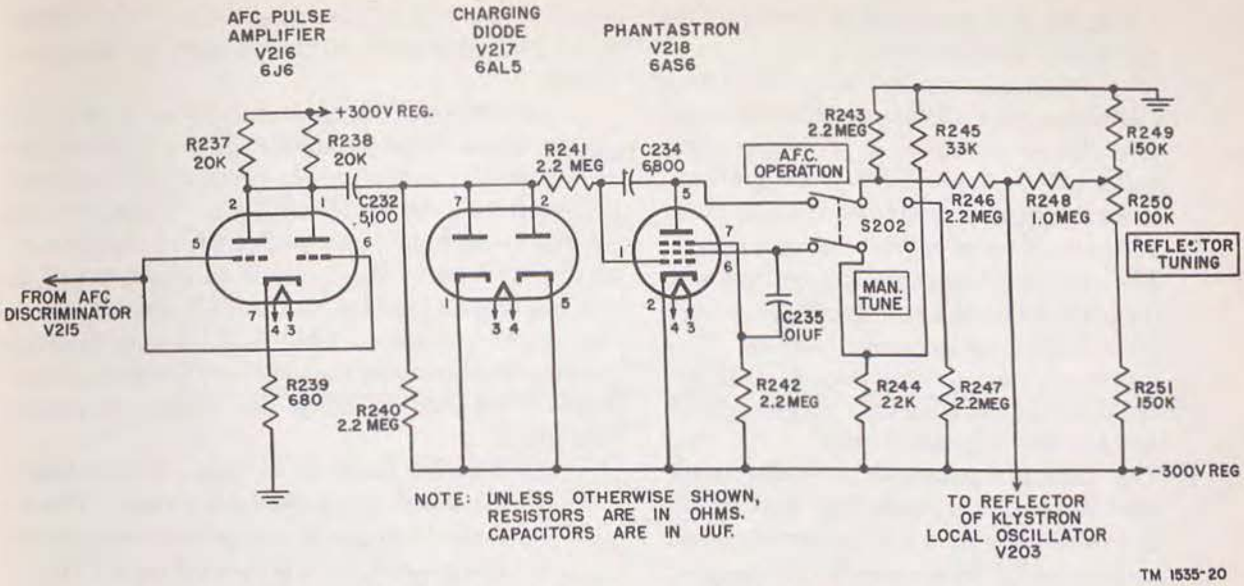


Figure 48. Pulse amplifier, charging diode and phantastron circuit, schematic.

plate and screen potentials are negative with respect to ground, but positive with respect to the cathodes of V217 and V218, which are at minus 300 volts. This arrangement is used to produce a negative voltage for the reflector of the klystron local oscillator. The negative voltage is obtained from across voltage divider R249, R250, and R251. With switch S202 in MAN. TUNE position, REFLECTOR TUNING control R250 is used to determine the reflector voltage and therefore the frequency at which the klystron local oscillator operates. With switch S202 in A. F. C. OPERATION position, the phantastron output voltage combines with the REFLECTOR TUNING voltage to determine the klystron local oscillator frequency.

a. Operation With 30 Mc If. Input. A 30 mc if. pulse produces no discriminator output and, therefore, does not disturb pulse amplifier V216, charging diode V217, or phantastron V218. Tube V218 therefore acts as an ordinary phantastron circuit ((1) through (5) below).

(1) Assume that the grid of tube V218 is becoming more positive (or less negative). As a result, the plate current increases, thus reducing the potential at the plate.

(2) The falling plate potential eventually comes close to the cathode potential. When this happens, tube current is diverted to the screen causing its potential to drop. This voltage drop, when coupled to the suppressor through C235, cuts off plate current; as a result, there is a sudden rise in plate voltage. Since the grid is connected to the plate by means of

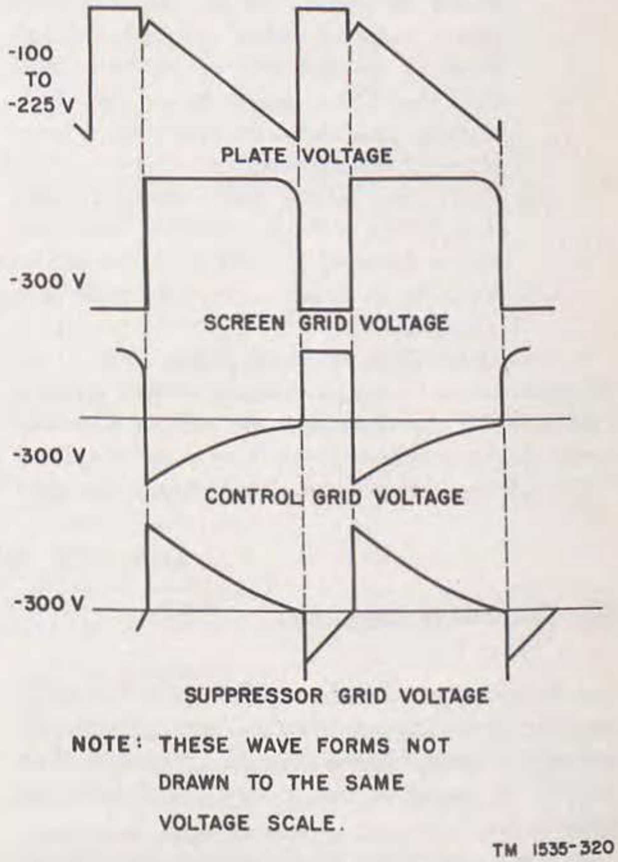


Figure 49. Phantastron wave forms.

C234, the grid potential rises and drives the screen to saturation.

(3) The screen current and the plate potential remain at a maximum while the negative charge on C235, at the suppressor, leaks off through R242. As the suppressor potential rises toward the cathode potential, a pulse of plate current occurs. The resultant negative voltage spike at the plate drives the grid negative through C234, cutting off the screen current. The suppressor now quickly rises to its original positive value and no longer acts to stop the flow of plate current.

(4) The negative potential on the control grid leaks off through R241 and R240. The resultant rise in grid potential causes an increase in plate current that reduces the plate potential. This voltage drop, when coupled back to the grid through C234, retards the rise on the grid, which in turn slows down the plate voltage decrease. This feedback between the grid and the plate produces a straight line decrease in plate voltage. This varying plate potential, when applied through R246 to the reflector of klystron local oscillator V203, causes its output sweep to vary at a constant rate over a large range of frequencies.

(5) When the falling plate voltage comes close to the cathode potential, tube current is diverted to the screen causing its potential to drop. A new cycle is thus initiated.

b. Operation With If. Input Below 30 Mc. An if. pulse below 30 mc produces a 40-volt positive variation in the discriminator output that becomes negative when inverted by pulse amplifier V216. A negative pulse does not change the nonconducting state of charging diode V217. Therefore, the phantastron circuit acts as described above.

c. Operation With If. Input Above 30 Mc. If. pulses above 30 mc produce negative pulses at the discriminator output which become positive when inverted by pulse amplifier V216. These positive pulses, when coupled through C232 to the plate of charging diode V217, cause it to conduct and to place a negative charge on the V217 side of capacitor C232. Resistor R241 is a current limiting resistor that prevents the grid of V218 from drawing current and affecting the charge on capacitor C232.

(1) Because R240 is so large, C232 cannot discharge much between pulses. Therefore, the negative charge becomes greater and greater until it cuts off tube V218.

(2) The sudden cutoff causes the plate potential of tube V218 to rise. This rise in voltage, when fed to the klystron local oscillator, causes its output frequency to decrease, thus decreasing the if. entering the discriminator. This condition continues until the if. is decreased to the value where no positive pulses are applied to the charging diode. This condition occurs at 30 mc.

(3) When no pulses are applied to the charging diode, the phantastron again produces a downward moving sweep that increases the local oscillator frequency and the if.

(4) As soon as the if. increases very slightly, positive pulses are applied to the diode and the cycle is reversed. Figure 50 shows how the cycling described above makes the frequency of the local oscillator lock in at the value that produces an if. of exactly 30 mc.

Section IV. SIGNAL CIRCUITS

53. Cascode If. Amplifier

(fig. 51)

A cascode (grounded-cathode, grounded-grid) amplifier is used to amplify the incoming signal if. before it is applied to the other if. amplifiers. The cascode if. amplifier has a very high signal-to-noise ratio.

a. The input circuit of the cascode amplifier is tuned to approximately 30 mc by variable capacitor C201 and coils L202 and L203. Capacitor C233 keeps dc afc crystal current from the grid of V204.

b. Because triodes are inherently less noisy than pentodes, tube V204 is triode-connected. Resistor R201 and capacitor C205 provide cathode bias. The plate load is provided by L205, which is decoupled by R202 and C202. Coil L204 feeds back from the output a signal that neutralizes the inter-

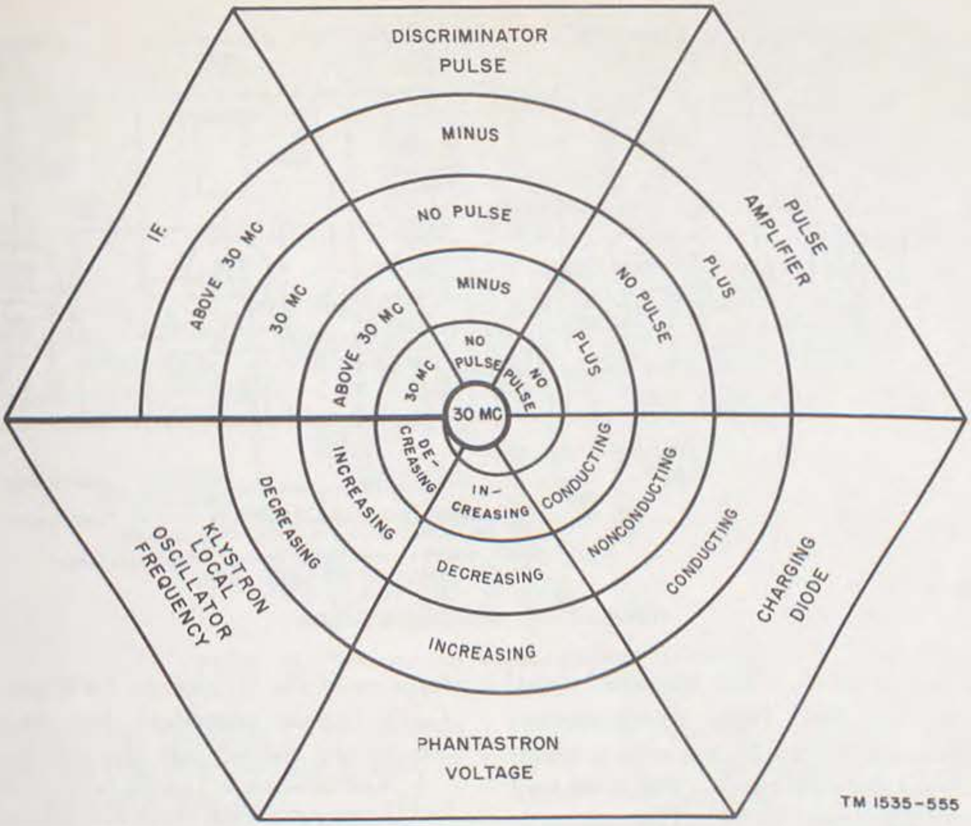


Figure 50. Action of afc circuits.

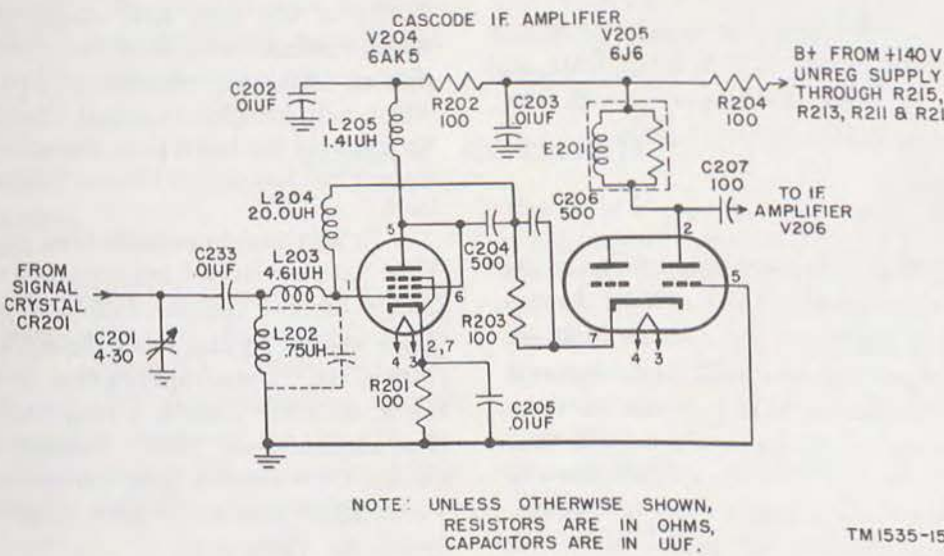


Figure 51. Cascode if. amplifier, schematic.

electrode capacitance of the tube. This further reduces the noise within the stage.

c. The next stage (V205) uses a grounded-grid triode. The grounded grid acts as a shield and reduces the interelectrode capacity; thus, it further reduces the overall noise level. The output of V204 is impressed on the cathode through coupling capacitor C204, cathode bias resistor R203, and cathode bypass capacitor C206. The signal is thus effectively placed between the cath-

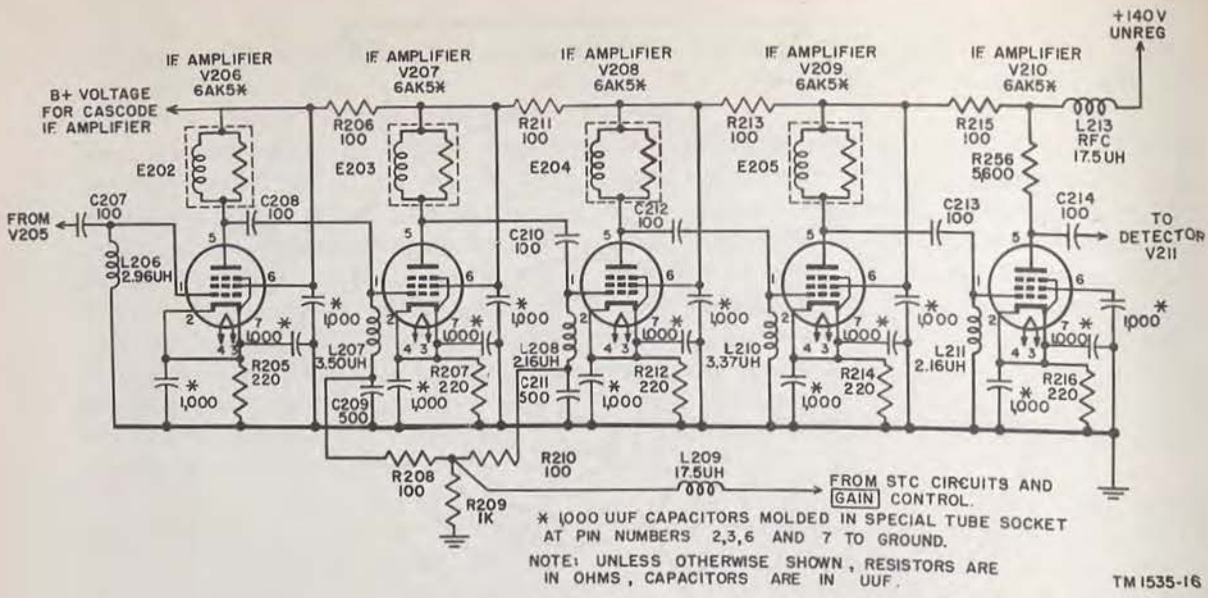


Figure 52. If. amplifiers, schematic.

ode and grid of the stage. The amplified signal appears across plate load E201, which consists of a coil self-resonating at 30 mc with a shunt resistor to broaden the pass band. The plate load is decoupled by R204 and C203. The output is applied to if. amplifier V206 through coupling capacitor C207.

d. B+ is provided from the +140 volt supply through dropping resistors R215, R213, R211, and R206. Note that since R204 is in *series* with R202, V204 can lose its plate voltage if R204 opens up.

54. If. Amplifiers

(fig. 52)

The signal from the cascode amplifier is fed through five stages of amplification (V206 through V210). All the stages are very much alike except for the frequencies to which they are tuned. The plate coils are adjusted to resonate at 30 mc, and the grid coils are adjusted to resonate at various frequencies about 30 mc. As a result, the output of the entire if. section is a band of frequencies 5 mc wide, symmetrically placed about the center frequency of 30 mc.

a. Each stage obtains its bias with a cathode resistor (R205, R207, R212, R214, and R216). Plate and screen voltages are obtained through a decoupling resistor (R206, R211, R213, and R215) in the first four stages, and through a decoupling choke (L213) in V210. To stabilize the characteristics of the if. section, 1,000 micromicrofarad ($\mu\mu$f) bypass capacitors for the cathodes and screens are molded into the tube socket.

b. The grid coils (L206, L207, L208, L210, and L211) resonate with their distributed capacitance plus the interelectrode capacitance of the tube. The plate impedances (E202, E203, E204, and E205) of the first four stages consist of coils which resonate with their distributed capacitance plus any stray capacitances, and parallel resistors which help broaden the band-pass characteristics. To improve the band-pass characteristics further stage V210 has only a resistor (R256) as its plate load.

c. In addition to cathode bias, stages V207 and V208 have a constant negative potential from the GAIN control (on the indicator control panel) and a negative pulse from the stc circuits fed to their grids. These inputs affect the sensitivity of the if. section. L209 is a filter choke. The bias is developed across R209. Resistor R208 and capacitor C209 form a grid decoupling circuit for V207; R210 and C211 form a grid decoupling circuit for V208.

55. Detector

(fig. 53)

The signal from if. amplifier V210 is developed across coil L212, which is resonant at a frequency slightly above the if. Stage V211 rectifies the if. signal and produces a negative video pulse at the

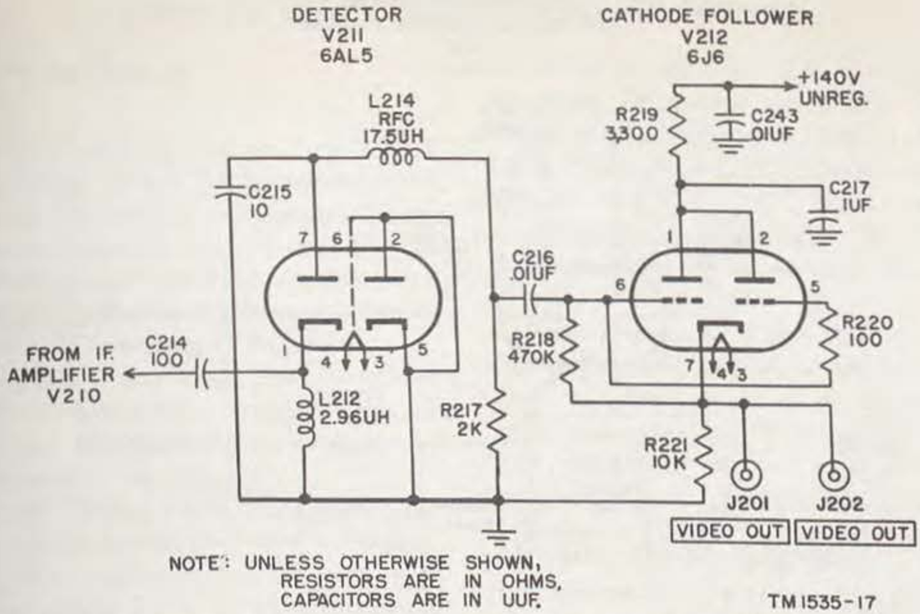


Figure 53. Detector and cathode follower, schematic.

plate. Choke L214 and capacitor C215 filter out the if. component so that only the video portion of the signal is developed across R217.

56. Cathode Follower

Stage V212 limits the video signals to negative 1 volt with a low impedance output that matches the impedance of the output coaxial cable. The video signal is coupled through C216 to the grids of the two parallel-connected sections of the tube. The input signal is developed across grid load R218. The low impedance output is taken from across cathode resistor R221. Capacitor C243 filters the +140-volt supply, R219 is a plate dropping resistor, and C217 keeps ac from flowing through R219.

Section V. STC CIRCUITS

57. Stc Generator

(fig. 54)

Stc generator V219A, also known as the sea suppressor, generates a wave form which is fed to the grids of the second and third signal if. stages immediately after the transmitter circuits are fired. The pulse decreases the gain of the signal if. circuits so that, in the area surrounding the radar, only the stronger echoes appear on the PPI.

a. The positive trigger is applied across R228. Because C221 cannot change its charge instantaneously, the peak positive potential appears instantaneously at the cathode of V219A and tends to cut it off. Immediately afterward, the positive pulse charges capacitor C221 through the low resistance path provided by crystal CR204, as shown. The rapid charging of this capacitor produces the sharp, initial negative downswing of the pulse developed across R227 (fig. 55).

b. With the positive trigger removed, V219A conducts. Capacitor C221 now discharges through the path provided by the tube in series with R225, the power supply, and R228. The slow discharging of capacitor C221 provides the exponential portion of the pulse developed across R227.

c. The SUPPRESSOR control varies the grid bias of V219A. Varying the grid bias changes the effective resistance of the tube. Changing the resistance of the tube varies the discharge time constant of capacitor C221. By varying the discharge time constant, the SUPPRESSOR controls the length of the pulse developed across R227 (fig. 55).

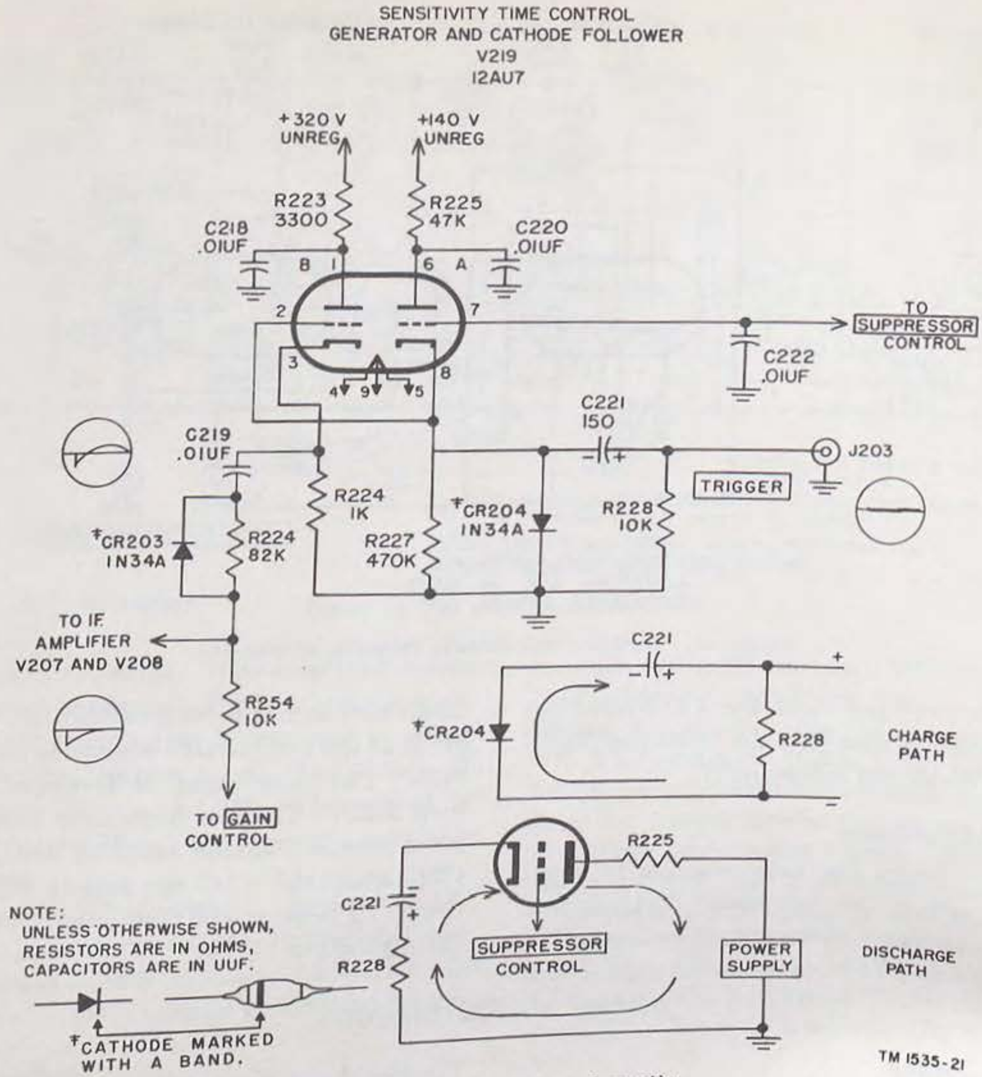


Figure 54. Stc circuits, schematic.

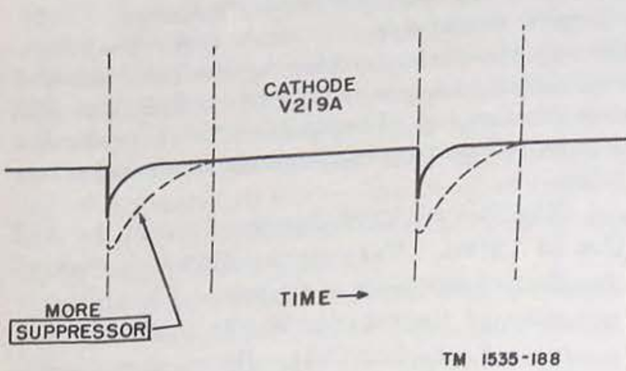


Figure 55. Stc generator, wave forms.

58. Stc Cathode Follower

a. Tube V219B acts as a cathode follower to isolate the stc generator from the signal if. circuits to which the stc pulse is fed. Resistor R224 and crystal CR203 act as a clipper circuit that removes the positive overshoot of the pulse.

b. GAIN control R177 varies the negative bias on the grids of signal if. amplifiers V207 and V208 to vary the signal if. sensitivity. On the 1-mile range, the stc pulse is added to the normal dc bias to reduce the signal if. gain. SUPPRESSOR control R181 determines the length of time the signal if. gain is reduced.

59. Filament Power Supply
(fig. 56)

This supply is located on the receiver chassis and provides filament power for all tubes in the receiving system. The primary of filament transformer T201 is energized by the 115-volt, 400-cps power obtained through POWER connector J204. The two secondaries of the transformer energize the receiving system filaments as follows:

a. Mixer Circuits. Klystron local oscillator V203 has its filament energized directly from one of the secondaries. Capacitor C240 bypasses rf around the filament.

b. Afc Circuits. Tubes V214, V215, and V216 are placed in parallel across the lower secondary. Tube V213 is also in parallel across this secondary, but it has filter choke L229, which separates it from the other filaments to prevent interaction between this and other stages. Charging diode V217 and phantastron V218 are connected across the other secondary. The sockets of afc if. amplifiers V213 and V214 have filament bypass capacitors molded into them.

c. Signal Circuits. All the filaments of the tubes in the signal circuits are connected across the lower secondary. All the if. filaments are separated from each other and from the other stages by means of chokes (L222, L223, L224, L225, L226, L227, and L228). The filaments of the cascode if, amplifier (V204, V205) are bypassed by capacitors C236 and C237. The filaments of the other if. stages are bypassed by capacitors molded directly in the sockets.

d. Stc Circuits. Tube V219 is a 12AU7 and therefore needs 12 volts across its entire filament, or 6 volts across half of it. By applying the ac from the secondary to the center of the filament and connecting the two ends of the filament, 6 volts are placed across each half of the filament.

60. Other Power Supplies

The low-voltage power supplies that provide the B+ for the receiving system are located on the front panel of the receiver-transmitter. The +300 volts, −300 volts, +140 volts and +320 volts from the low voltage power supplies are fed to the receiver chassis through POWER connector J204. For a complete discussion of the low voltage power supplies, refer to the power system chapter (par. 93).

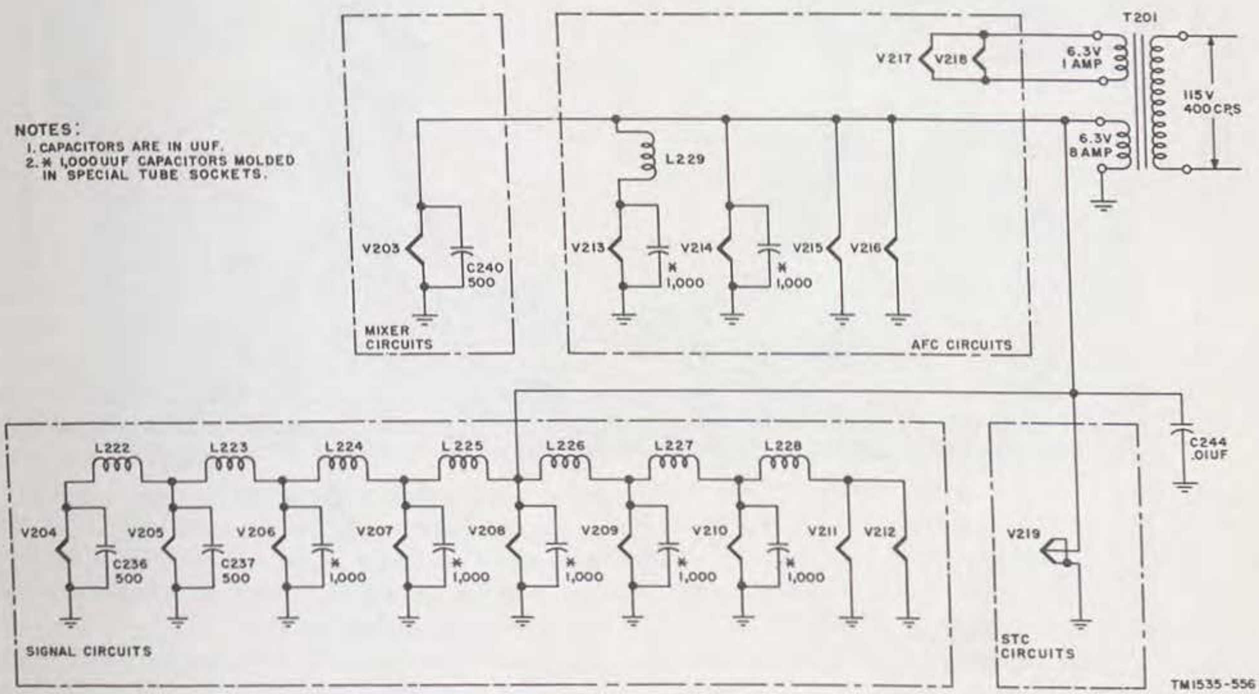


Figure 56. Receiver filament supply, schematic.

CHAPTER 5

SYNCHRONIZING AND INDICATING SYSTEM

Section I. INTRODUCTION

61. General

(figs. 57 and 58)

a. The synchronizing and indicating system has all the operating controls and performs the following major functions:

(1) Generates sweep, range mark, and unblanking signals.

(2) Combines video and range mark signals for presentation on the PPI.

(3) Synchronizes sweep rotation with antenna horn and reflector rotation.

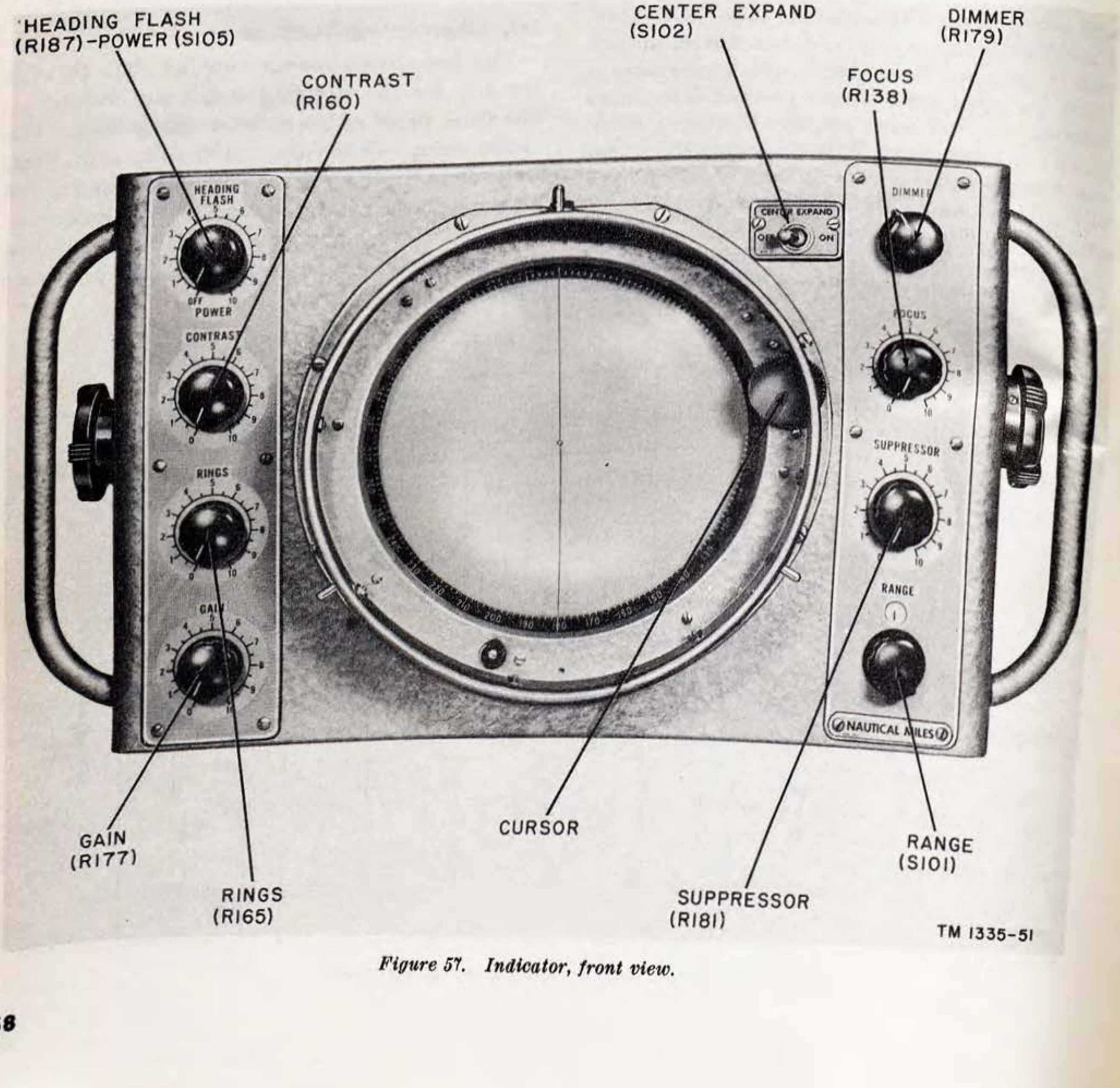


Figure 57. Indicator, front view.

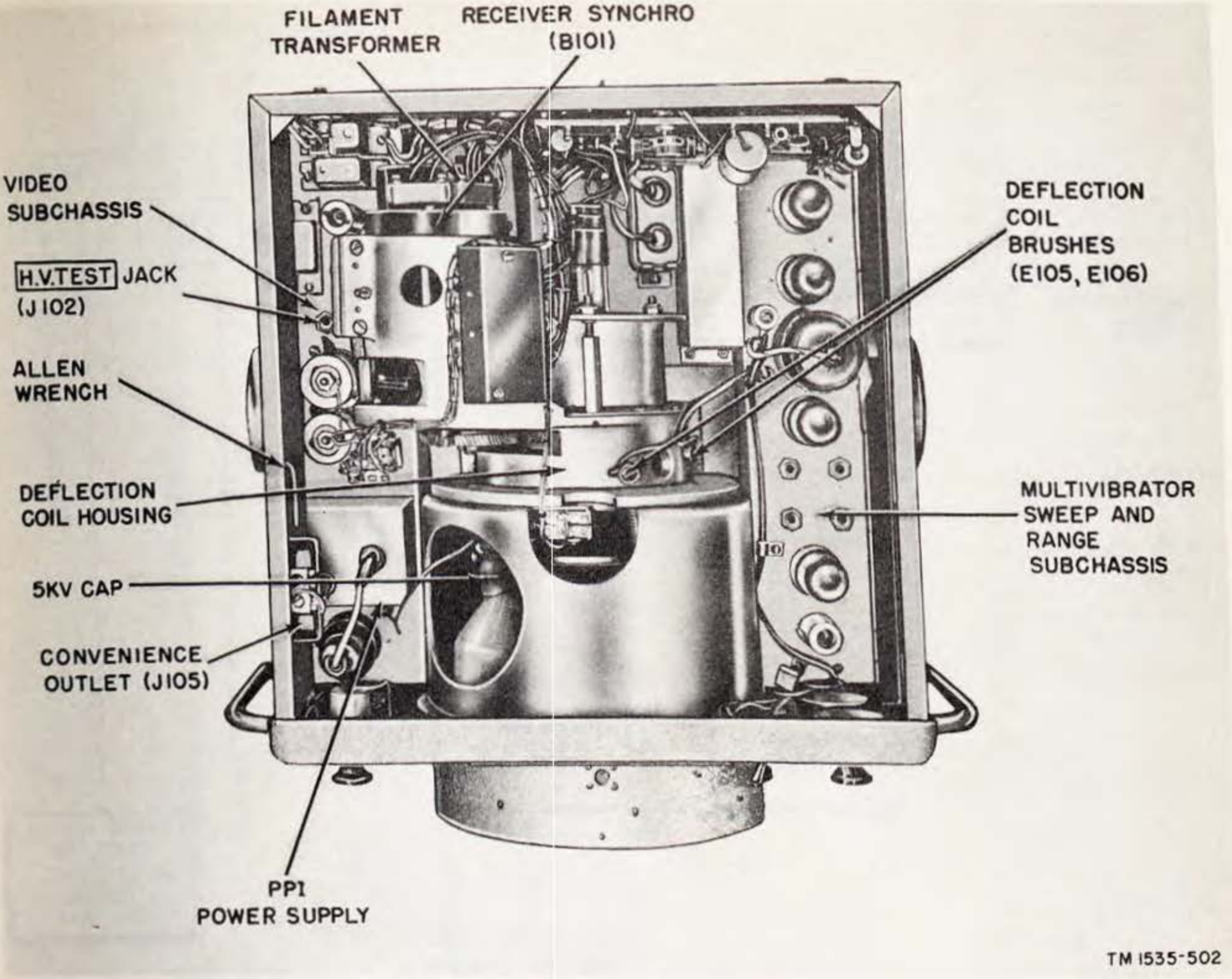


Figure 58. Indicator, top view, cover removed.

(4) Produces fore and aft heading flashes on the face of the PPI.

(5) Presents range and bearing information on the PPI.

b. All the circuits of the synchronizing and indicating system, except the synchronizing circuits, are located in the indicator. The PPI is located in the center of the indicator with a subchassis on either side. The multivibrator, sweep and range subchassis is on the right and the video subchassis is on the left.

c. Some parts of the synchronizing circuits are located in the antenna, some parts are located in the indicator, and the interconnecting points are fed through the terminal boards on the receiver-transmitter. The transmitter synchro and the synchro alinement and heading flash cams are mounted inside the antenna pedestal. The receiver synchro and the heading flash circuit are in the indicator. The SYNCRO fuse is mounted on the receiver-transmitter convenience panel.

d. The PPI power supply parts are mounted on the video subchassis of the indicator. However, since the PPI power supply is considered part of the power system, it is discussed in the power system chapter (par. 95). All the other B+ voltages are obtained from the low voltage power supplies in the receiver-transmitter. All the operating voltages as well as the trigger, video, and synchronizing signals are fed from the terminal boards in the receiver-transmitter, through the junction box, and to the receptacles in the back of the indicator.

e. A PHONES jack for communicating with a man at the antenna location and a convenience outlet to aid in troubleshooting are included in the indicator unit.

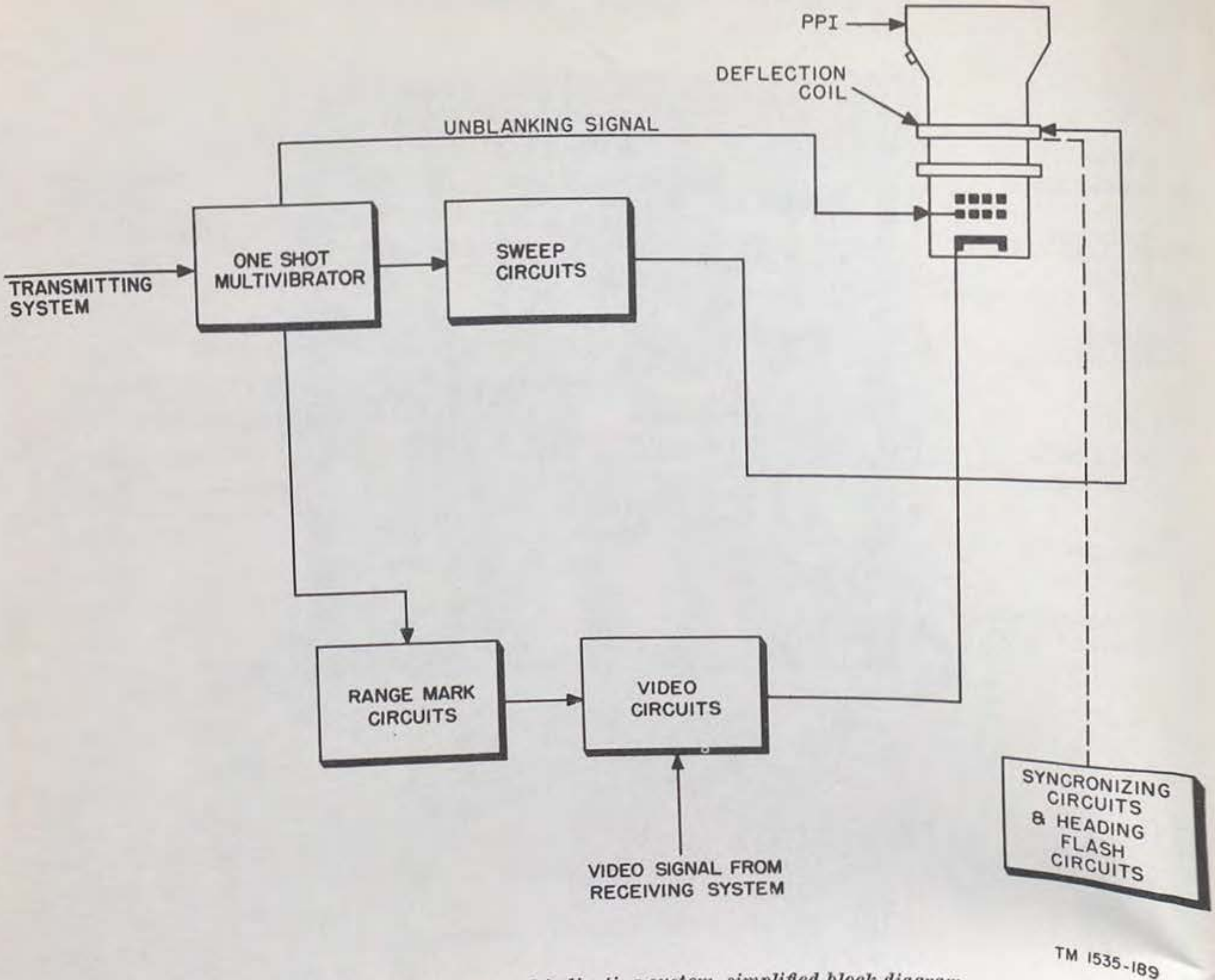


Figure 59. Synchronizing and indicating system, simplified block diagram.

62. Block Diagram

(figs. 59 and 60)

a. One-Shot Multivibrator. At the same time that the transmitter circuits are fired, a positive pulse from the master blocking oscillator in the transmitting system triggers one-shot multivibrator V101 in the synchronizing and indicating system. This one-shot multivibrator produces rectangular pulses which unblank the PPI and trigger the sweep circuits and the range mark circuits.

b. Sweep Circuits. The sweep circuits receive a positive square wave from the one-shot multivibrator and produce a sweep signal that is applied to the deflection coil surrounding the neck of the PPI. The stages are as follows:

(1) *Sweep generator.* Stage V102A generates a saw-tooth wave form; the length of the wave form is determined by the setting of the RANGE switch.

(2) *Sweep voltage amplifier.* Stage V103 amplifies the saw-tooth wave form.

(3) *Dc restorer.* Stage V102B maintains the base line of all input pulses to the sweep current amplifier at the same potential so that the full magnitude of the sweep can be used by the deflection coil of the PPI.

(4) *Sweep current amplifier.* Stage V104 amplifies the sweep current to the degree necessary to drive the deflection coil.

c. Range Mark Circuits. The function of these circuits to produce range marks (rings) on

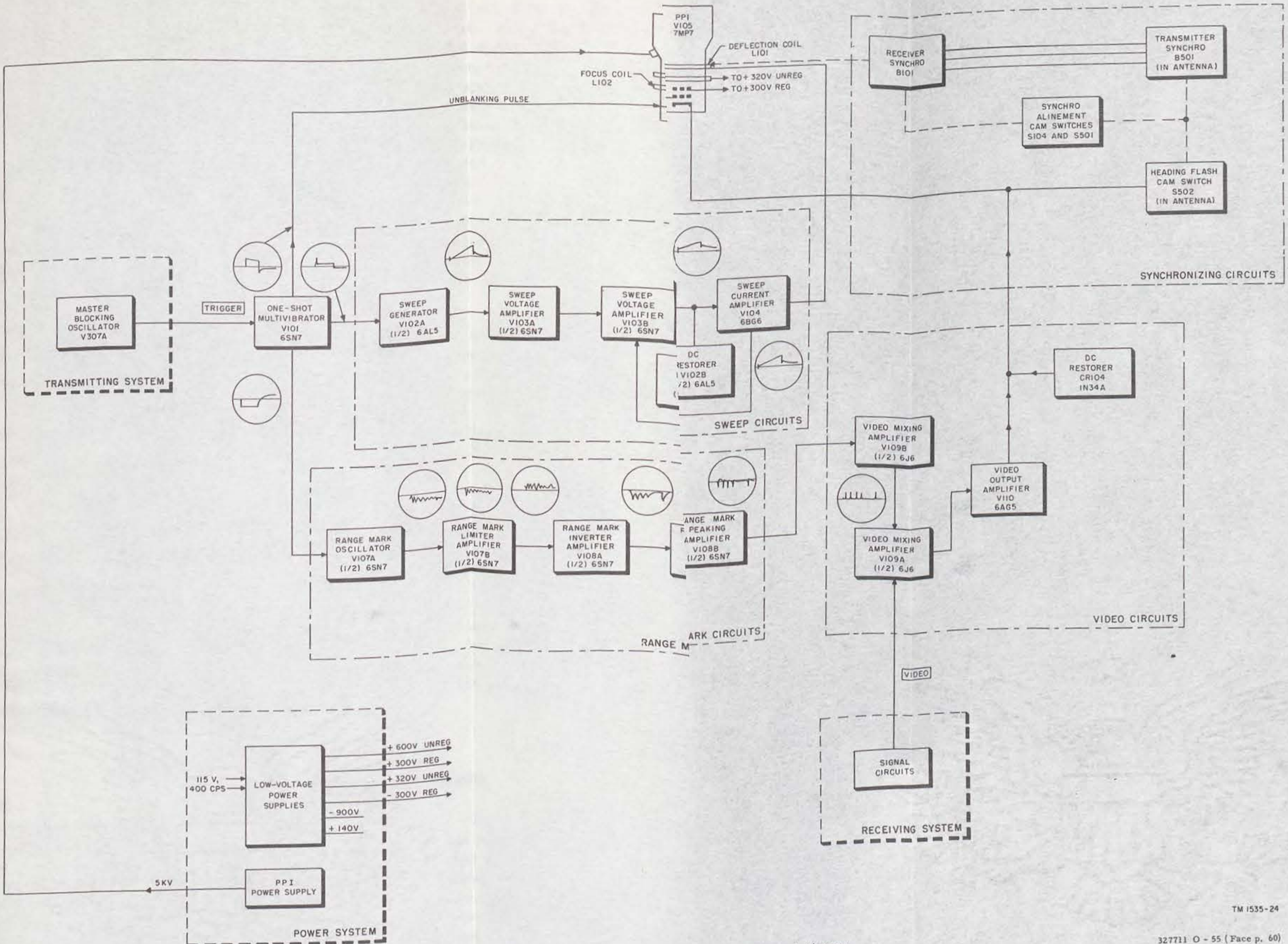


Figure 60. Synchronizing and indicating system, complete block diagram.

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the PPI screen to enable the observer to determine the range of the target. The stages are as follows:

(1) *Range mark oscillator.* Stage V107A receives a negative square wave from the one-shot multivibrator and produces a series of positive pips. The number of pips and the timing between pips is determined by the setting of the RANGE switch.

(2) *Range mark limiter and amplifier.* Stage V107B maintains the amplitude of the pulses at a constant value.

(3) *Range mark inverter amplifier.* Stage V108A amplifies and inverts the range mark signals.

(4) *Range mark peaking amplifier.* Stage V108B sharpens the leading and trailing edges of the pips before apply ing the range marks to the video circuits.

d. Video Circuits. Video signals from the signal circuits in the receiving system and range marks from the range mark circuits are amplified by the video circuits.

(1) *Video mixing amplifiers.* Stage V109 amplifies the range mark and video signals. At the same time, it prevents interaction between the two signals.

(2) *Video output amplifier.* Stage V110 acts as a power amplifier for the video and range mark signals. From this stage, they are applied to the PPI.

(3) *Dc restorer.* Crystal CR104 maintains the base line of all range marks at the same potential.

e. PPI. The PPI is an intensity modulated cathode ray tube that uses electromagnetic deflection. The output from the sweep circuits is applied to the deflection coil and causes a radial sweep to appear on the screen. At the same time, the deflection coil is rotated causing the sweep to rotate upon the screen. Range marks and echoes from the video circuits are applied to the cathode of the tube and cause the sweep to intensify. To make the return trace invisible, the unblanking signal is applied to the grid during the sweep time but not during the retrace time.

f. Synchronizing Circuits.

(1) *Transmitter synchro.* Transmitter synchro B501, located in the antenna (fig. 20), transmits to receiver synchro B101 an error voltage that corresponds to the degree of antenna horn and reflector rotation.

(2) *Receiver synchro.* Receiver synchro B101 (located in the indicator, fig. 58) receives the error voltage and rotates the sweep line by an amount corresponding to the amount of rotation of the antenna horn and reflector. Consequently, the sweep line rotates on the PPI screen in synchronism with the antenna horn and reflector rotation.

(3) *Alinement cam switches.* Alinement cam switches S501 (in the antenna) and S104 (in the indicator) are used to aline the synchronizing circuits when the radar set is first placed in operation.

(4) *Heading flash circuit.* Heading flash cam switch S502 (in the antenna) reduces the cathode bias on the PPI when the antenna horn and reflector pass the fore and aft positions. Sweep intensification is thus produced at the 0° and 180° points.

Section II. ONE-SHOT MULTIVIBRATOR

63. General

The output of master blocking oscillator V307A in the transmitting system triggers one-shot multivibrator V101, which produces the timing for the synchronizing and indicating system. RANGE switch S101 changes the width of the one-shot multivibrator square-wave output so that the synchronizing and indicating system is timed to correspond to the range being used.

64. One-Shot Multivibrator

(fig. 61)

One-shot multivibrator V101 is a two-stage RC coupled amplifier with the output of each stage fed to the input of the other stage.

a. In the balanced condition, tube V101A conducts heavily because of the positive potential on its grid, and V101B is cut off because of the negative potential on its grid. A positive TRIG-

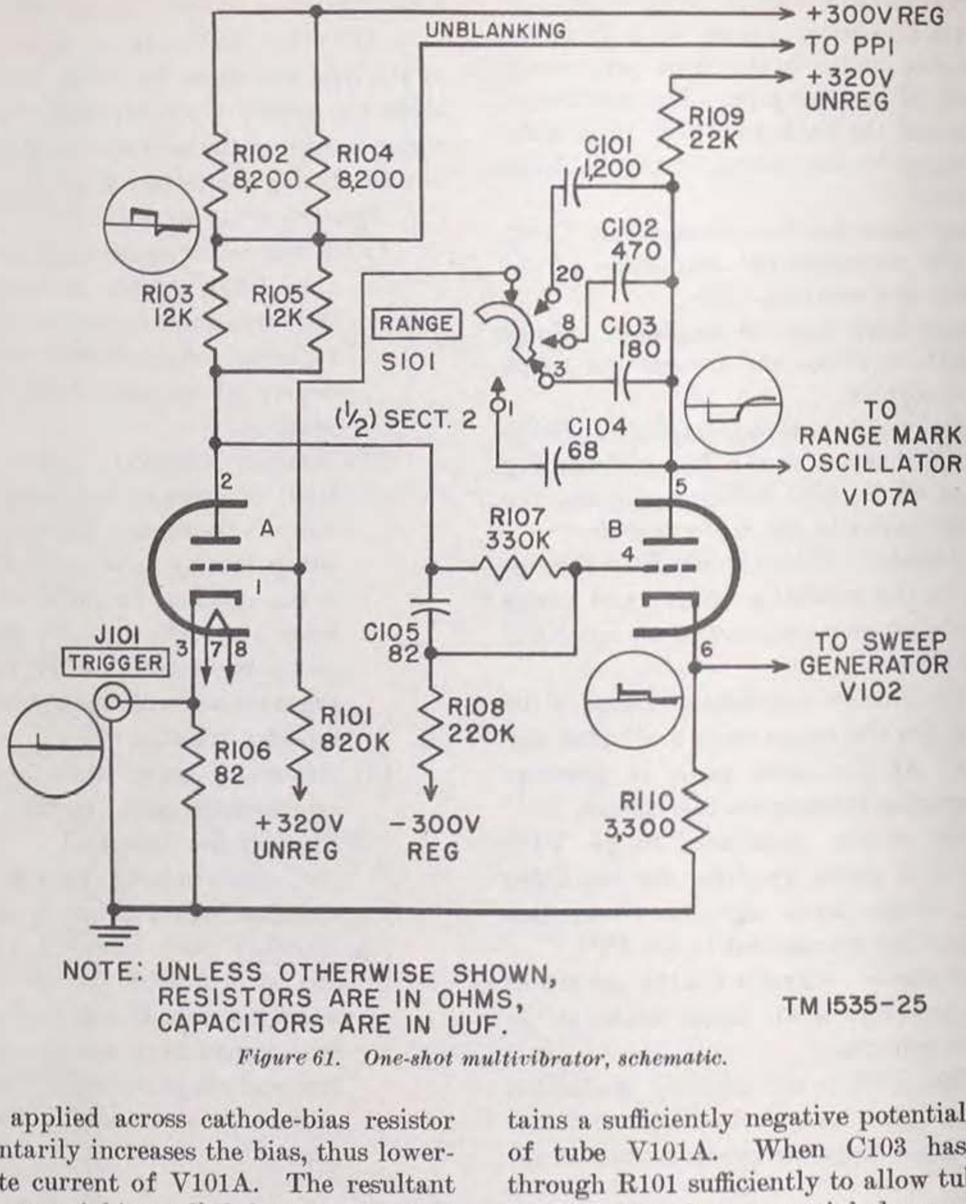

Figure 61. One-shot multivibrator, schematic.

GER pulse applied across cathode-bias resistor R106 momentarily increases the bias, thus lowering the plate current of V101A. The resultant rise in plate potential is applied through capacitor C105 to the grid of the tube V101B causing it to conduct. Increased plate current in tube V101B causes a decline of plate voltage, which is coupled through capacitor C103 to the grid of V101A. This decreasing grid potential causes a further decline in plate current, which in turn causes a further increase in V101A plate potential. This action continues until tube V101A is cut off and tube V101B is saturated.

b. The circuit remains in this condition as long as capacitor C103 (on the 3 mile range) maintains a sufficiently negative potential on the grid of tube V101A. When C103 has discharged through R101 sufficiently to allow tube V101A to conduct, its plate potential decreases. The decrease in plate voltage is coupled through C105 to the grid of V101B. The decrease in grid voltage of V101B causes its plate current to decrease and its plate voltage to increase. This rise is impressed on the grid of V101A, further increasing its plate current. This action takes place almost instantaneously, so that tube V101A is quickly returned to its normal stage of conductivity, and tube V101B is again cut off.

c. The time from t_1 to t_2 (fig. 62), which is the time V101A is cut off, is controlled by the time it

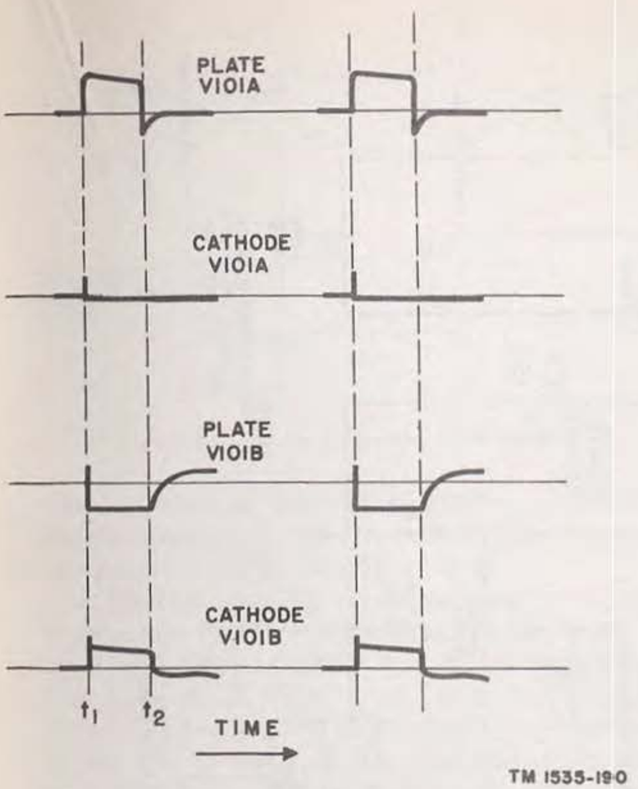

Figure 62. One-shot multivibrator, wave forms.

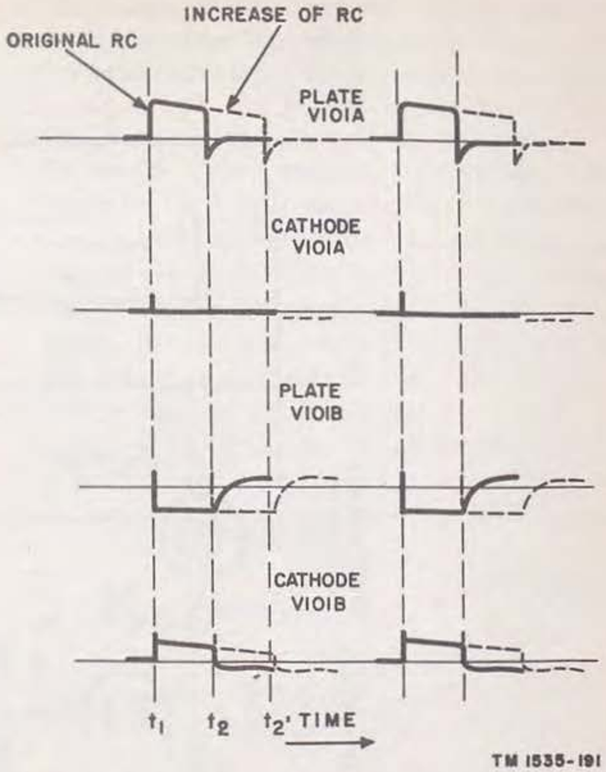

Figure 63. One-shot multivibrator, wave forms with an increase of RC.

takes C103 to discharge through resistor R101. On each range setting, RANGE switch S101 places a different value of capacitance in the circuit thus changing the time constant; this, in turn, changes the length of time it takes V101A to reach conduction and therefore determines the length of the square-wave output. On the 8-mile position, V101A does not reach conduction until time t_2 (fig. 63).

d. Three outputs are taken from the multivibrator. A positive pulse is taken from the voltage divider consisting of R103, R105, R102, and R104, and applied to the grid of the PPI to unblank it during the sweep time. Another positive pulse, taken from the cathode of V101B, is used to trigger sweep generator V102. The negative pulse, developed at the plate of V101B, is used to trigger range mark oscillator V107A.

Section III. SWEEP CIRCUITS

65. General

To cause the spot on the PPI to move linearly with time, a saw-tooth current wave form is applied to the deflection coil of the PPI. In radar, a range of 1 nautical mile is equivalent to approximately 12.2 microseconds (6.1 microsecond to target, 6.1 microsecond to return). Thus, on the 1-mile range, the spot must move from the center to the edge of the PPI in 12.2 microseconds; on the 3-mile range, in 36.6 microseconds; on the 8-mile range, in 97.6 microseconds; and on the 20-mile range, in 144 microseconds. To cause the sweep to rotate about the center of the PPI so that azimuth readings can be made, the deflection coil is rotated in synchronism with the antenna horn at the rate of 17 rpm.

66. Sweep Generator

(fig. 64)

a. Sweep generator stage V102A gives the proper sweep for each range. Tube V102A conducts until the positive square wave from one-shot multivibrator V101 is applied to its cathode. The tube is then cut off and allows capacitor C108 (on the 3-mile range) to charge through resistors R114, R112, R111, and R118. As soon as the square

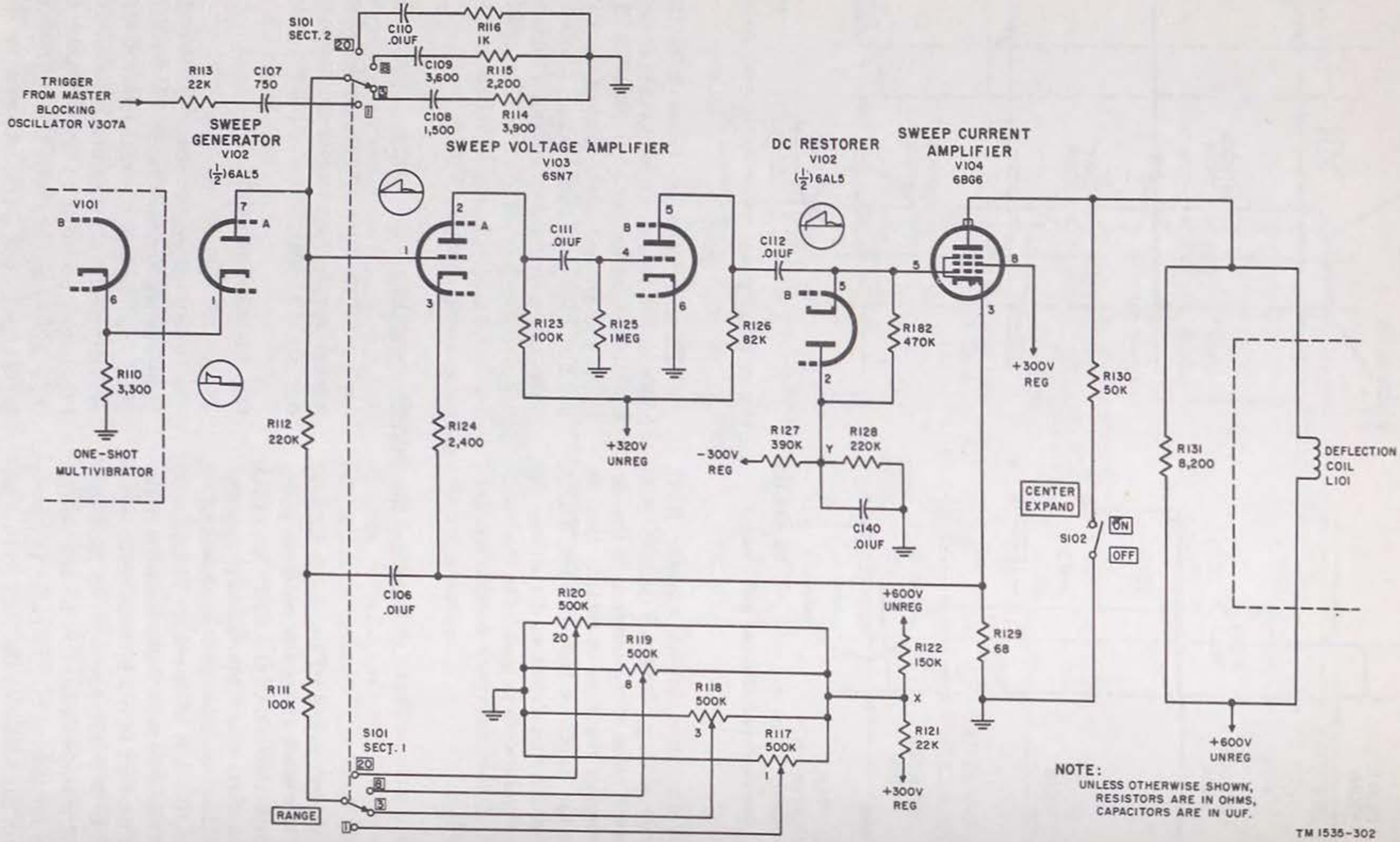

Figure 64. Sweep circuits, schematic.

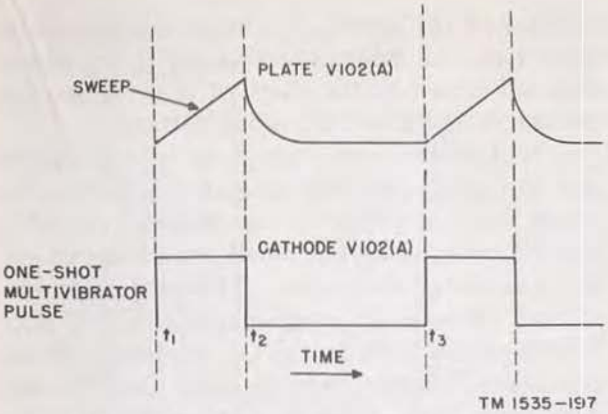

Figure 65. Sweep generator, wave forms.

wave is removed, the tube conducts and immediately discharges the capacitor. The output sweep wave form is shown in figure 65.

b. The time constant can be adjusted by sweep length control R118 (on the 3-mile range) to give the proper slope to the sweep. If the time constant is too small, the sweep moves out to the edge of the PPI too quickly, and the last ring does not appear (B, fig. 66). If the time constant is too long, the sweep may not reach the edge of the PPI, which will make the entire picture too small (C, fig. 66).

c. The circuit theory is the same for the 8- and 20-mile positions of the RANGE switch, except that the sweeps are made longer. For the 1 mile range, the sweep is made shorter. In addition, the trigger pulse from master blocking oscillator V307A is applied to the plate of V102A simultaneously with the opening of the tube. This is done to assure proper linearity at the beginning of the sweep.

67. Sweep Voltage Amplifier

The positive output of sweep generator V102A that appears across resistor R112 is applied between the grid and cathode of sweep voltage amplifier V103A. Capacitor C106 blocks the direct current of tube V103A from the sweep generator stage. Cathode bias resistor R124 is left unbypassed to provide degeneration. The amplified signal developed across R123 is coupled through blocking capacitor C111 to the grid of V103B. The output of this stage, which appears across R126, is a positive sweep pulse.

68. Dc Restorer

The function of this stage is to maintain the base line of all input sweeps at the same potential. The voltage divider, composed of R127 and R128, across the minus 300-volt supply produces a negative potential at point Y. Before a pulse is applied to the circuit, the grid side of capacitor C112 charges up to the same value as point Y. When the positive-rising portion of the sweep pulse is applied to the V102B cathode, the cathode becomes more positive with respect to the plate, thus cutting off the diode. The positive rising sweep is added to the negative potential at the grid of tube V104. When the sweep voltage falls to its base line, the bias is removed from the cathode of V102B, causing the dc restorer to conduct. Capacitor C112 discharges rapidly to the value at point Y. The sweep applied to the grid of sweep current amplifier V104, therefore, varies above the

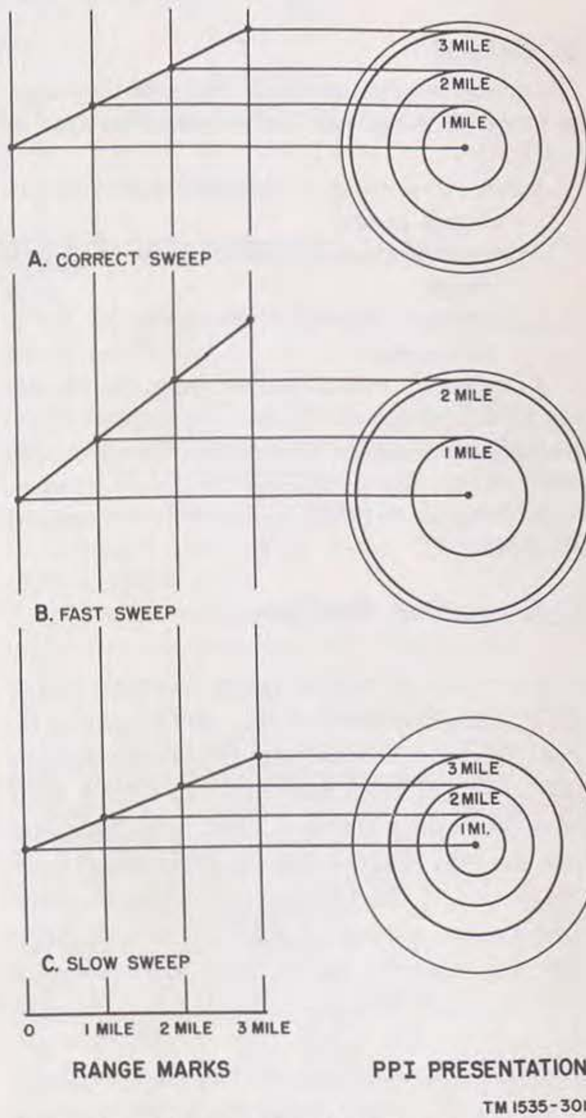

Figure 66. Effect of slow and fast sweeps on PPI picture.

potential at point Y. In other words, V102B acts as a positive clamping circuit.

69. Sweep Current Amplifier

a. Sweep current amplifier stage V104 amplifies the sweep current to the degree necessary to drive deflection coil L101 of the PPI. Resistor R129, in addition to providing bias for this stage, feeds back out-of-phase energy to V103A to increase the linearity of the output of the entire amplifier.

b. At the end of each sweep, sweep current amplifier V104 is cut off because of the high negative potential on its grid. As a result, the current through the deflection coil stops immediately, and the energy in it is dissipated in plate resistor R131. Because of the action of the unblanking circuit (par. 78*c*), the damped oscillations in the deflection coil caused by the shock of interrupting the current do not affect the scope pattern.

c. If deflection coil current is not reduced to zero in the time between sweeps, the spot on the screen does not return to the center of the PPI. The PPI indication is a small circle blacked out in the center of the screen. This may be accomplished deliberately by placing CENTER EXPAND switch S102 in the ON position. When this is done current flows through the deflection coils even when V104 is nonconducting. The current path is from ground, through R130 and the deflection coil, to +600 volts, back to ground.

Section IV. RANGE MARK CIRCUITS

70. General

To accurately determine the range of the target, the following range marks should be displayed on the PPI:

- 2 concentric rings, a half-mile apart, for the 1-mile range.
- 3 concentric rings, 1 mile apart, for the 3-mile range.
- 4 concentric rings, 2 miles apart, for the 8-mile range.
- 4 concentric rings, 5 miles apart, for the 20-mile range.

To obtain more accurate readings of range on the 1-mile sweep, the CENTER EXPAND switch is used to make the first half-mile cover most of the scope.

71. Range Mark Oscillator
(fig. 67)

a. The grid of range mark oscillator stage V107A is slightly positive because the grid is returned to the +320-volt supply through resistor R149. Resistor R148 and capacitor C124A compose a decoupling circuit. Thus, with no signal input, the tube conducts heavily and current flows through one of the LC tanks of Z101, as determined by the setting of RANGE switch S101. When the negative square wave from one-shot multivibrator V101 is applied to the grid through coupling capacitor C119, tube V107A cuts off. However, as the magnetic field around coil L104 (on the 3-mile range) collapses, a voltage is induced in the coil that tends to keep current flowing. Since the tube is cut off, this voltage charges capacitor C121. The capacitor alternately charges and discharges, and produces a damped sine wave (fig. 68). When the pulse is removed, the tube conducts once more and is ready for the next pulse to produce another damped sine wave.

b. The tuned circuits and their frequency of oscillation in terms of equivalent distance in radar miles for each setting of RANGE switch S101 are as follows:

Position	Tuned circuit	Equivalent distance in radar miles
1	L103, C120	½
3	L104, C121	1
8	L105, C122	2
20	L106, C123	5

72. Range Mark Limiter Amplifier
(fig. 67)

The damped oscillations from range mark oscillator V107A are applied to range mark limiter amplifier stage V107B. Grid limiting resistor R151 clips the positive portions of the wave. When the tube is at cutoff, the negative portions of the wave are clipped.

73. Range Mark Inverter Amplifier
(fig. 67)

The purpose of range mark inverter amplifier stage V108A is to amplify and invert the range mark oscillations. The tube is overdriven to fur-

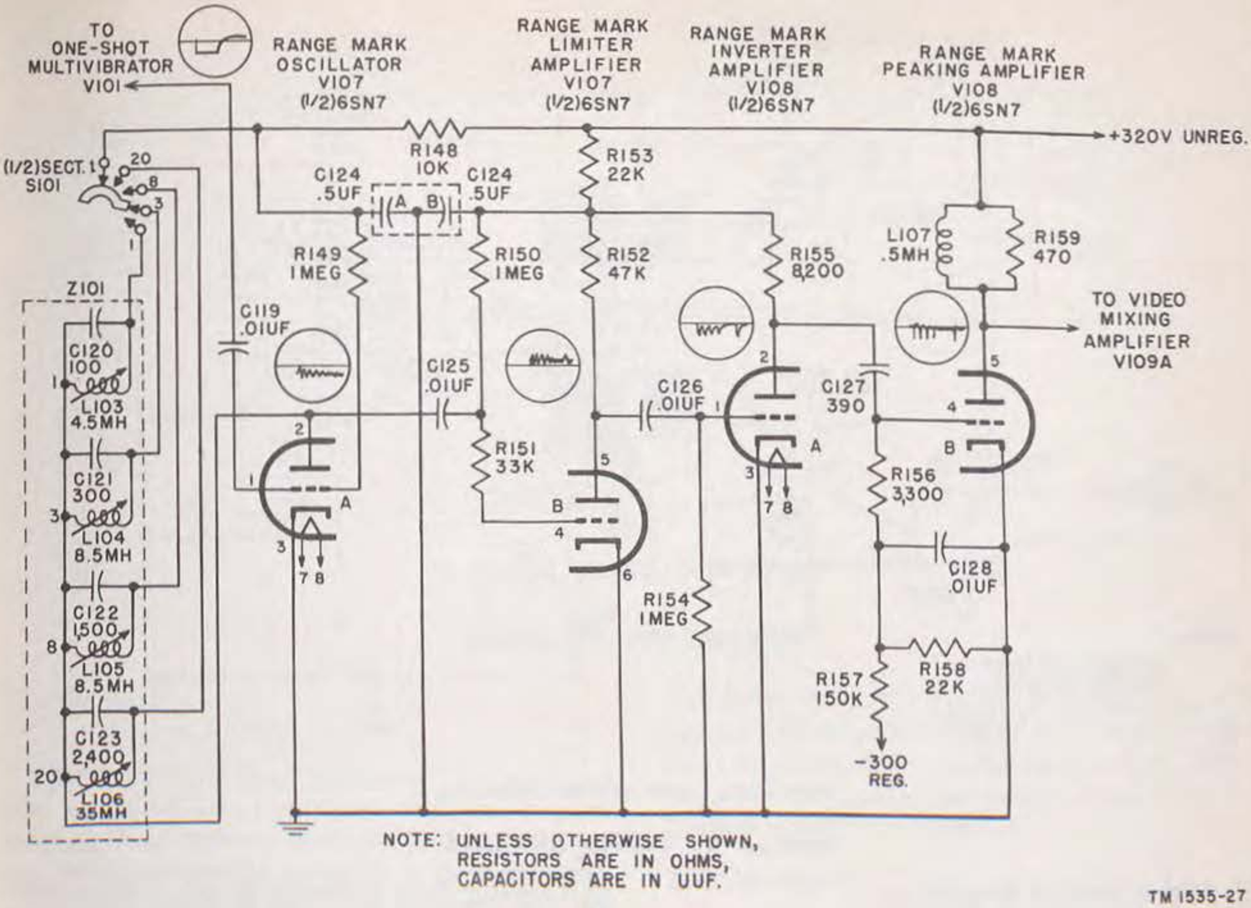

Figure 67. Range mark circuits, schematic.

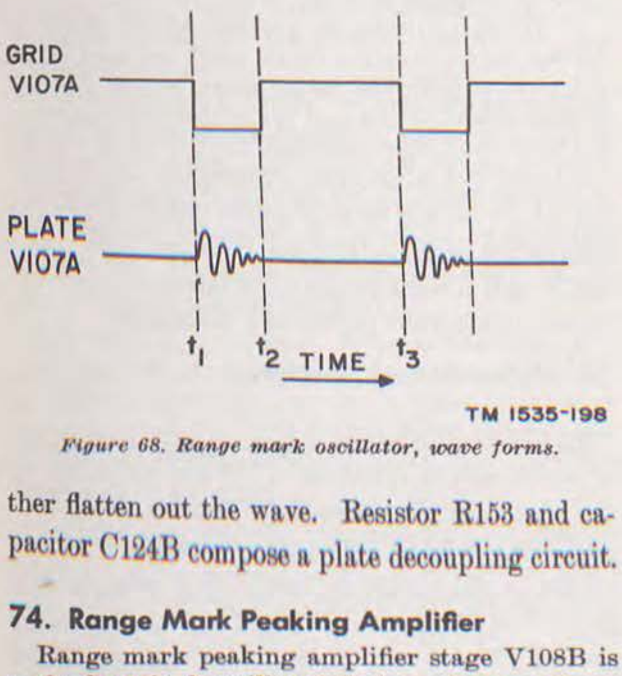

Figure 68. Range mark oscillator, wave forms.

ther flatten out the wave. Resistor R153 and capacitor C124B compose a plate decoupling circuit.

74. Range Mark Peaking Amplifier

Range mark peaking amplifier stage V108B is a shock-excited oscillator that produces a sharp peaked output when triggered by the leading edge of the range mark inverter amplifier V108A output wave. Coil L107 is tuned by means of its distributed capacitance to a frequency of several megacycles. Resistor R159 causes the oscillations to damp out after half a cycle. The result is a narrow output pulse.

a. The tube is biased at cutoff, and the plate normally does not draw current. The positive-going half-cycle input permits the tube to overcome its bias and conduct. With the application of plate current, oscillations are set up in the resonant circuit. A voltage is induced across the coil of such a polarity as to impede the flow of current, thus producing a negative potential at the plate. Resistor R159 damps out the positive swing.

b. When the top portion of the input wave is reached, current through coil L107 does not vary much. Therefore, no potential is induced across it, and the plate returns to its original high potential. The result is a series of sharp negative pulses, spaced an exact distance apart as determined by the setting of RANGE switch S101.

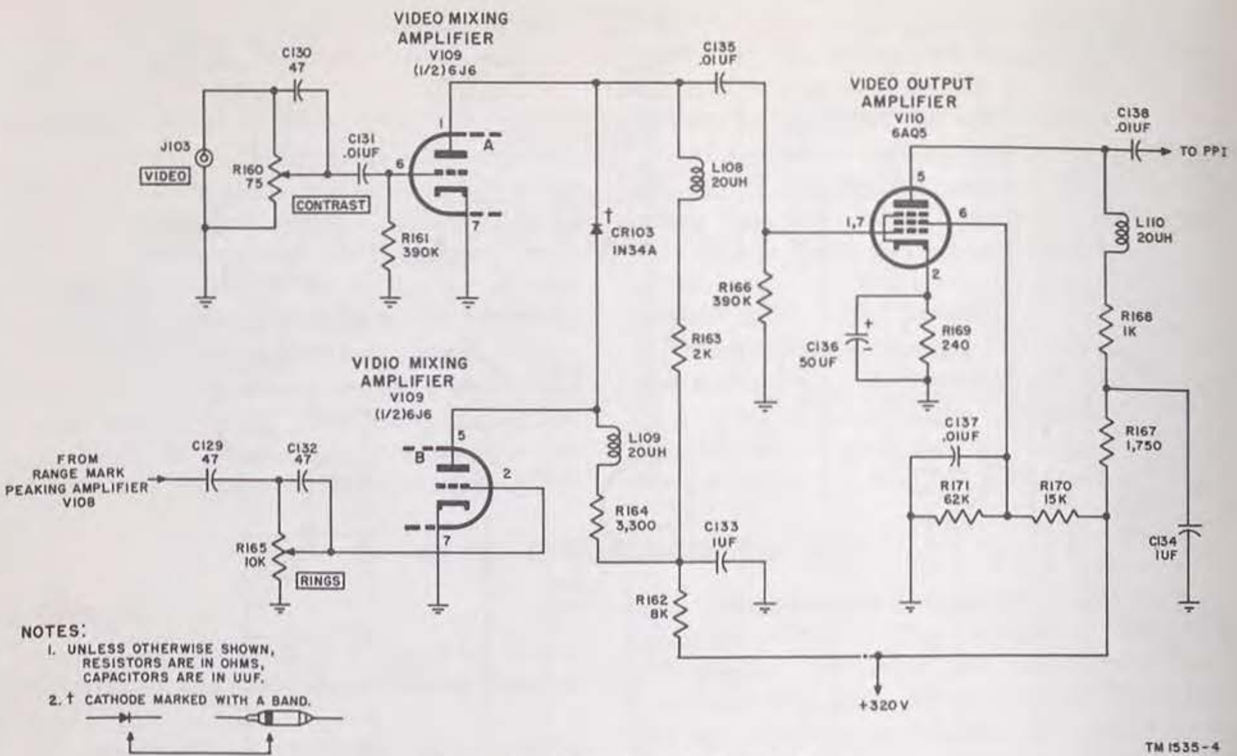

Figure 69. Video circuits, schematic.

Section V. VIDEO CIRCUITS

75. Video Mixing Amplifiers
(fig. 69)

To prevent blooming—an intensification of the PPI trace caused by the simultaneous ocurrence of echo and range mark signals—video mixing amplifier stage V109A amplifies the video signals, and video mixing amplifier stage V109B amplifies the range marks. Adverse interaction between the two signals is prevented by means of a crystal diode.

a. The video output is fed from cathode follower stage V212 in the signal circuits of the receiving system through coaxial cables W706 and W707 to VIDEO jack J103, and is applied across CONTRAST control R160. Resistor R160 is used to control the amplitude of the video signal before it is coupled through C131 to the grid of V109A. The amplified signal appearing across plate load resistor R163 and peaking coil L108 is positive.

b. The range marks are fed from range mark peaking amplifier V108B through blocking capacitor C129 to RINGS control R165. Resistor R165 controls the amplitude of the range marks before they are coupled to the grid of V109B. The amplified signals that appear across plate load resistor R164 and peaking coil L109 are positive. Resistor R162 and capacitor C133 form a plate decoupling circuit.

c. When no video is present at the plate of V109A and a positive range mark appears at the plate of V109B, the range mark passes through crystal diode SD103 and is coupled through C135 to the grid of video output amplifier V110. When the video and range mark signals appear on either side of the crystal diode simultaneously, they buck each other because they are both positive. As a result, only a weak range mark passes through the crystal diode, thus preventing blooming.

76. Video Output Amplifier
(fig. 69)

The video and range marks applied to the grid of video output amplifier V110 are amplified in the plate circuit across load resistor R168 and peaking coil L110. Screen potential is obtained from the voltage divider consisting of R170 and R171. Capacitor C137 keeps the screen at rf ground. The output is fed to the cathode of the PPI through C138. The plate circuit is decoupled by means of R167 and C134.

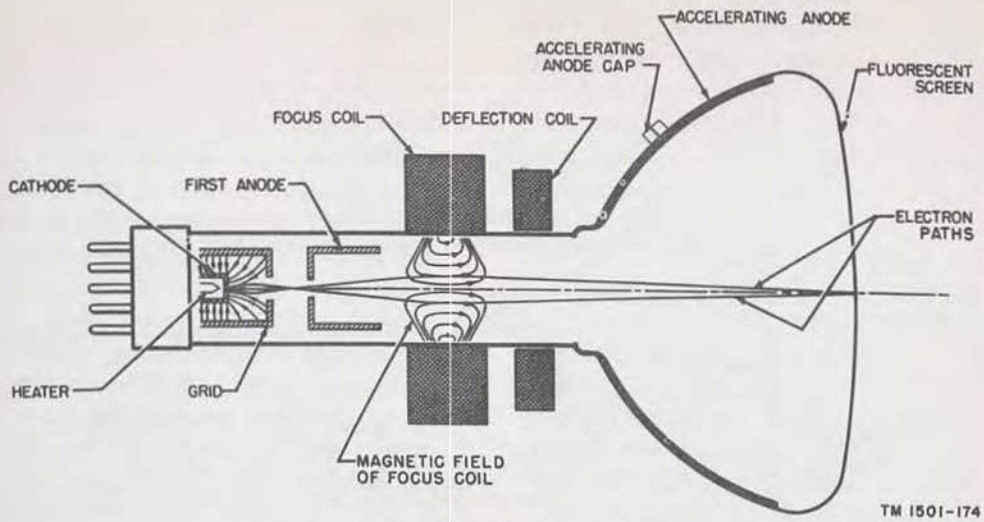

Figure 70. PPI tube, sectional view.

Section VI. PPI CIRCUITS

77. General

(figs. 70 and 71)

The PPI (V105) is a 7MP7 tube. The grid and first anode are small cylinders with small holes through their centers. Both the focus and deflection coils are mounted about the neck of the tube. An Aquadag coating on the inside surface of the tube acts as the accelerating anode. The accelerating potential is fed through the anode cap. On the inner surface of the face of the tube is the fluorescent screen.

a. Formation of Beam. When the cathode is heated, it generates a stream of electrons that is accelerated by the +300 volts on the first anode and the plus 5,000 volts on the accelerating anode. The holes in the center of the negative grid and positive first anode narrow the electron beam so that it forms a spot on the screen.

b. Focusing. Current flowing through coil L102, because of the +320 volts potential, focuses the beam. By varying the parallel resistance across L102 by FOCUS control R138, the amount of current flowing through L102, and thus the focus, can be adjusted.

c. Intensity Control. Resistors R173, R135, and R134 comprise a voltage divider that is placed across the −300-volt supply to tap off a negative potential for the grid of the PPI. By varying INTENSITY control R135, the grid potential is changed, thus changing the number of electrons that strike the screen. The number of electrons that strike the screen per unit time determines the intensity of the spot. Parallel resistor R174 causes R135 to have a finer control of intensity. Filter capacitor C113 keeps the point between R135 and R134 at a steady dc potential.

78. PPI Inputs

Three separate inputs are applied to the PPI: the sweep signal from sweep current amplifier V104; video and range mark signals from video output amplifier V110; and an unblanking pulse from one-shot multivibrator V101.

a. Sweep Input. By applying the output of sweep current amplifier V104 to deflection coil L101, the spot on the screen is made to trace a line from the center to the outer edge of the PPI. At the same time, L101 is rotated about the neck of the tube, thus causing the lines generated on the face of the scope to rotate, effectively covering the entire face of the PPI. When CENTER EXPAND switch S102 is placed in the ON position, a dark circle appears at the center of the screen.

b. Video Input. A voltage divider across the 5-kilovolt (kv) PPI power supply places +10 volts on the PPI cathode. When the video and range mark signals are coupled to the cathode through capacitor C138, they decrease the bias and, therefore, increase the intensity of the trace on the screen. Resistor R172 and crystal CR104 comprise a dc restorer that clamps all signals below the reference level of +10 volts.

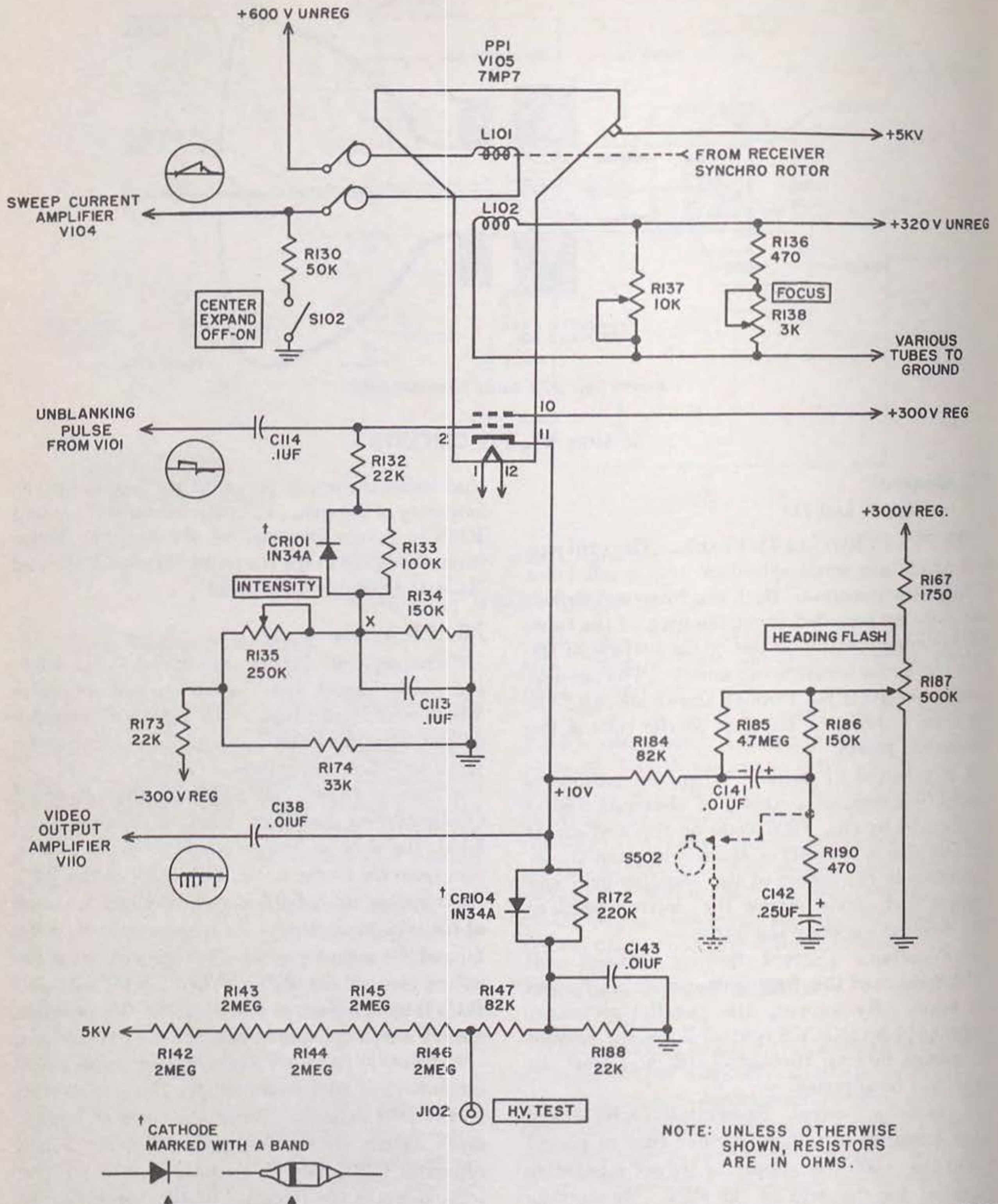

Figure 71. PPI circuits, schematic.

c. Unblanking Input. The unblanking pulse keeps the return trace portion of the sweep invisible. The potentials on the PPI electrodes are arranged so that the tube normally is nonconducting. The positive square wave from one-shot multivibrator V101 is coupled to the grid through C114 only during the time that the linear portion of the sweep is applied to the deflection coil. By making the grid more positive, the tube conducts, enabling the sweep to be traced on the screen and the video and range signals to be seen. At the end of the unblanking pulse, the grid returns to its previous negative potential cutting the tube off. The return trace can not be seen on the PPI. Resistor R133 and crystal CR101 comprise a dc restorer that clamps all unblanking pulses above the reference level of the potential at point X.

79. PPI Picture Compensation
(fig. 64)

The synchronizing and indicating system incorporates two means for maintaining a steady picture on the PPI, despite line voltage variations.

a. Picture Size Compensation. To maintain a steady picture on the PPI, changes in the unregulated 5 kv on the second anode of the PPI are balanced against changes in the unregulated +600 volts that feed sweep generator V102A. If the line voltage increases, the accelerating anode voltage increases and the picture size decreases. To maintain the same picture size, the amplitude of the sweep wave form applied to the deflection coil must increase. To do this, the sweep charging capacitors are charged to the voltage at the junction of R121 and R122 (point X), which is between the +600-volt *unregulated* and the +300-volt *regulated* supplies. The increase in line voltage causes the +600-volt unregulated output to increase, causing the potential at point X to increase. This causes the amplitude of the output sweep wave form to increase automatically to compensate for the change in line voltage. When the line voltage drops, the reverse process occurs.

b. Picture Intensity Compensation. When the line voltage increases, the 5 kv on the accelerating anode increases, thus increasing the intensity of the trace. To compensate for this intensity variation, the cathode is connected to the lower end of the voltage divider across the 5-kv PPI power supply. When the 5-kv increases, the potential at point Y, which is applied to the cathode, also becomes more positive. This reduces the intensity of the trace to compensate for the change in line voltage. When the line voltage drops, the reverse process occurs.

Section VII. SYNCHRONIZING CIRCUITS

80. Transmitter and Receiver Synchros
(fig. 72)

a. General. Transmitter and receiver synchros synchronize the azimuth of the PPI sweep with the azimuth of the antenna horn and reflector. The antenna horn and reflector are geared to the transmitter synchro, which produces an error signal. This signal causes the receiver synchro and the PPI deflection coil, to which it is geared, to rotate with the antenna horn and reflector. As a result, the sweep on the PPI is made to rotate in synchronism with the antenna horn and reflector.

b. Transmitter Synchro. The rotor of transmitter synchro B501 (in the antenna) is a coil of wire that is wound on an iron core. The 115 volts at 400 cps are applied to the rotor through slip rings. The stator has three coils, fixed in position but spaced 120° apart. By transformer action, the magnetic field built up in the rotor, induces across each stator a voltage that depends on the position of each stator with respect to the rotor. The difference in voltage between S1 and S3 is called the error voltage, and is zero only when the rotor is alined so that the voltage induced at S1 is equal to the voltage induced at S3. S2 is connected to reference point R1. As the antenna horn turns, the rotor turns, rotating a magnetic field. The voltages induced in S1 and S3 vary, thus varying the error voltage sinusoidally with the rotation of the rotor. Since the rotor turns continuously, an ever-varying sinusoidal error voltage is produced between S1 and S3.

c. Receiver Synchro. The construction of receiver synchro B101 (in the indicator) is similar to the construction of transmitter synchro B501. The error voltage across S1 and S3 of the transmitter synchro is applied to the stators (S1 and S3) of the receiver synchro. The S2 terminals of B501 and B101 are at the same reference potential because they are connected electrically. Current flowing through the stator coils sets up a resultant

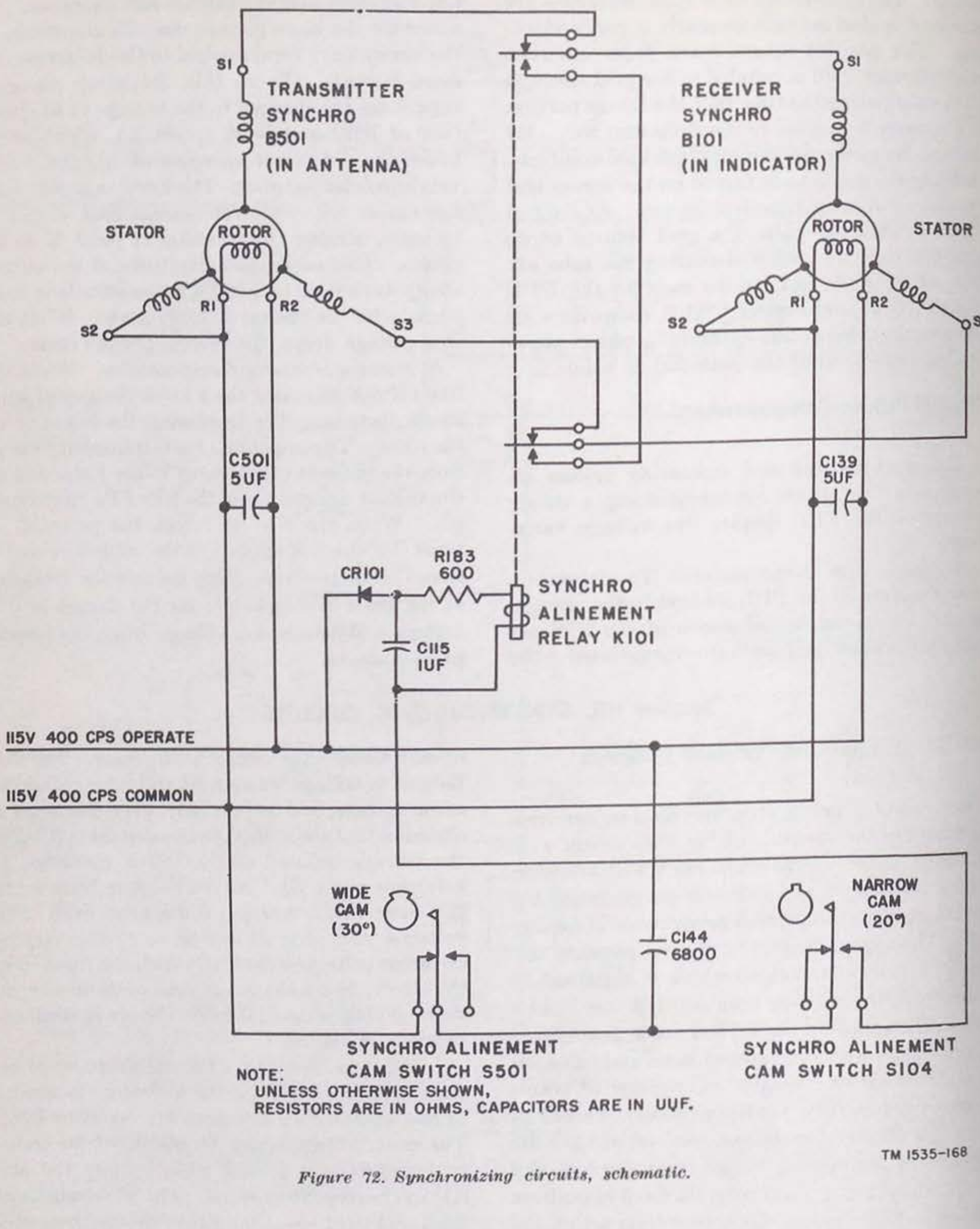

Figure 72. Synchronizing circuits, schematic.

magnetic field that is in the same direction with respect to the stator windings of the receiver synchro as the field in the transmitter synchro is with respect to the stator windings in the transmitter synchro. The rotor acts as an electromagnet and tends to aline itself with the stator field. Because the rotor is geared to deflection coils L101, the deflection coils are moved the same amount and in the same direction as the antenna horn.

d. Gearing Arrangement. The transmitter synchro is diven through a 1-to-10 gear ratio arrangement. Consequently, when the antenna horn rotates at 17 rpm, the rotor of the transmitter synchro rotates at 170 rpm. The rotor of the receiver synchro also rotates at 170 rpm. The gearing between the receiver rotor and the deflection coil is 10-to-1. This causes the sweep to rotate at the speed of the antenna horn, or 17 rpm. This gearing system reduces synchro errors to one-tenth the normal values, and in addition, provides increased torque for turning the deflection coil.

81. Synchro Alinement Cam Switches
(fig. 72)

When the equipment is turned off, the deflection coil L101 coasts to a stop. Since the position at which it stops is independent of the error voltage produced by transmitter synchro B501, the synchronizing circuits must be realined when the radar set is again placed in operation.

a. Both synchro alinement cam switches (S501 in antenna and S104 in indicator) rotate at the same speed as the antenna horn. Synchro alinement cam switch S501 is normally closed, except for a 30° interval. Synchro alinement cam switch S104 is normally open, except for a 20° interval. Because the cam switch contacts are in series, no current flows through the synchro alinement relay K101 when the cam switches are actuated simultaneously. This is the normal mode of operation for properly alined synchronizing circuits.

b. If the synchronizing circuits are out of alinement, the contacts of the synchro alinement cam switches do not close simultaneously. Both transmitter synchro B501 and receiver synchro B101, through a gearing system, turn camshafts until the receiver synchro camshaft causes synchro alinement cam switch S104 (in the indicator) to close its contacts. Since the synchronizing circuits are out of alinement, synchro alinement cam switch S501 (in the antenna) is open. Consequently, a closed circuit is offered synchro alinement relay K101. Relay K101 is energized and a short is placed across S1 and S3 of receiver synchro B101. This effectively removes B101 stator from operation, which results in temporarily locking the rotor in place. When synchro alinement cam switch S501 opens its contacts, relay K101 is de-energized, and the short is removed from the receiver synchro. The receiver synchro now rotates in step with the transmitter synchro.

c. K101 is a 24-volt dc relay. The source voltage is rectified by crystal CR101, filtered by capacitor C115, and then reduced to its proper value by resistor R183.

82. Heading Flash Circuit
(fig. 71)

As the antenna horn rotates past the fore position of the ship, a camshaft, geared to transmitter synchro B501 (in the antenna), closes heading flash cam switch S502. When the antenna horn rotates past the aft position, heading flash cam switch S502 is again closed by a second cam on the camshaft. When cam switch S502 closes, fore and aft heading flashes are produced on the screen of the PPI.

a. When heading flash cam switch S502 is open, C141 and C142 charge with the polarities indicated in figure 71. Capacitor C142 charges through R186 and R190. Capacitor C141 charges through R186, R184, R172, and R188. The potentials across the capacitors have very little effect on the PPI cathode potential because they buck each other in the path between cathode and ground. However, when heading flash cam switch S502 is closed, R190 and C142 are shorted, effectively placing the negative charge of C141 on the cathode. Thus, the bias is reduced and the sweep intensifies momentarily. The action is momentary because C141 discharges quickly through R184, R172, and R188.

b. The amount of charge on C141 and therefore the brightness of the heading flash is controlled by the potential applied across the capacitors. HEADING FLASH control R187 varies this potential.

CHAPTER 6

POWER SYSTEM

Section I. INTRODUCTION

83. General

a. The common components (par. 12) of Radar Set AN/SPN-11 operate from a 115-volt 400-cps power supply. Because most ships do not have this type of supply, each set includes a power group that converts the ship's supply to 115 volts 400 cps. The power group consists of the switch box, the motor starter, the motor generator, and the voltage regulator.

b. The 115 volts, 400 cps are fed through fuses to the low-voltage power supplies, the modulator power supply, and the PPI power supply. The 115 volts are fed also to the receiving system filament transformer and to the transmitter and receiver synchros.

84. Location of Power System Parts
(figs. 73 and 74)

a. The parts for the low-voltage power supplies are mounted on the lower portion of the hinged panel of the receiver-transmitter. The parts for the modulator power supply are mounted on the hinged panel close to the transmitting system. The PPI power supply is mounted on the video subchassis of the indicator. The receiving system filament transformer is mounted on the receiver chassis.

b. The terminal board on top of the motor generator is an interconnection point betwen components of the power group and between the power and the various power supplies. From the motor generator terminal board, power is fed through the receiver-transmitter terminal boards and through switches and fuses on the convenience panel to the power supplies.

Section II. POWER GROUP

85. Block Diagram
(fig. 75)

Figure 75Ⓐ is a block diagram of the power group for Radar Set AN/SPN-11X. This is the nomenclature for the equipment when the power group provided is used with a ship's supply of 115 volts dc. When the power group is used with a ship's supply of 32 volts dc, the nomenclature is Radar Set AN/SPN-11Y (fig. 75Ⓑ). When the power group is used with a ship's supply of 24 volts dc, the nomenclature is Radar Set AN/SPN-11Z (fig. 75Ⓒ). Except for their ratings, all power group parts are similar in operation.

Note. If the ship's supply is 230 volts dc, 115 volts ac, or 230 volts ac, different power group components must be procured.

a. Switch Box. The switch box connects the ship's power to the radar set. Switch Box SA-284/SPN-11 is used for a 115-volt dc power line; Switch Box SA-283/SPN-11 is used for a 32-, or 24-volt dc power line.

b. Motor Starter. The motor starter prevents the full supply voltage from appearing across the motor generator when starting to protect the generator from burning out. Motor Starter SA-287/SPN-11 is used with a ship's supply of 115 volts dc; Motor Starter SA-286/SPN-11 is used with a ship's supply of 32 volts dc; Motor Starter SA-285/SPN-11 is used with a ship's supply of 24 volts dc.

c. Motor Generator. The motor generator converts the ship's supply to 115 volts, 400 cps. Motor-Generator PU-243/SPN-11 is used for a ship's supply of 115 volts dc; Motor-Generator PU-245/SPN-11 is used with 32 volts dc; and Motor-Generator PU-244/SPN-11 is used with 24 volts dc.

d. Voltage Regulator. The voltage regulator controls the output voltage of the motor generator. Voltage Regulator CN-192/SPN-11X is used with a ship's supply of 115 volts; Voltage Regulator CN-193/SPN-11Y is used with 32 volts dc.

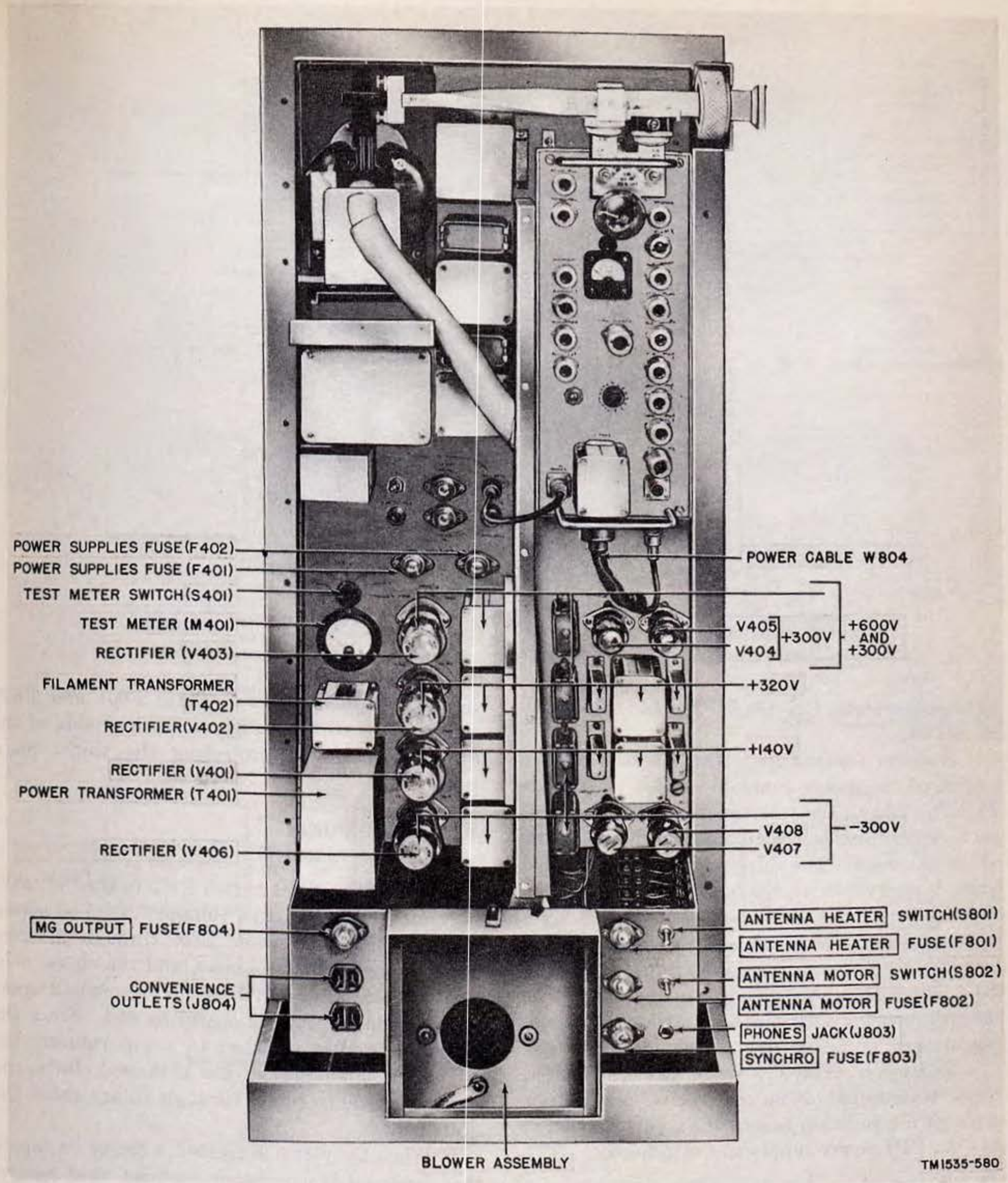

Figure 73. Receiver-transmitter, front of hinged panel, location of power system parts.

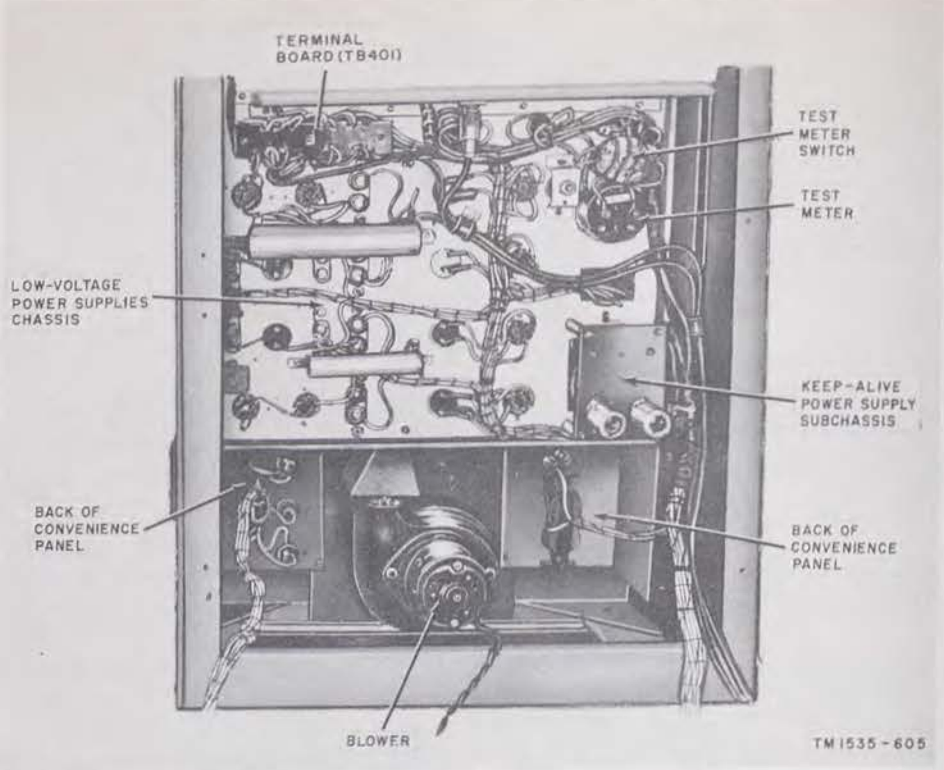

Figure 74. Receiver-transmitter, back of hinged panel, location of power system parts.

Voltage Regulator CN-194/SPN-11Z is used with 24 volts dc.

e. Receiver-transmitter. The 115-volt, 400-cps output of the motor generator is fed to the terminal boards on the receiver-transmitter. From the terminal boards, the voltage is fed to all parts of the radar set. The ship's supply voltage is fed to the blower motor on the bottom of the receiver-transmitter.

f. Antenna. The ship's supply voltage is fed from the receiver-transmitter terminal boards to the antenna drive motor and to the heaters. The 115-volt, 400-cps output is fed to the transmitter synchro.

g. Indicator. The 115 volts, 400 cps are fed from terminal boards on the receiver-transmitter through the junction box to the receiver synchro and the PPI power supply in the indicator.

86. Switch Box

(fig. 76)

Note. On schematics of power group components, power symbols that are slightly different from radio symbols are used.

The switch box controls all the primary power to the equipment. When the operating handle is in the on position, the ship's line voltage is connected to the radar set. Fuses F601 and F602 are in series with each leg on the load side of the switch circuit for protecting the ship's main power line.

87. Motor Starter

(figs. 76 and 77)

a. When POWER switch S105 in the indicator is rotated clockwise, line voltage is applied across the A-section of solenoid L602 through the normally closed cutout contacts, and the closed contact of thermal switch S602. The solenoid operates and pushes out the operating rod. Since the operating rod is attached to a pin running between the open ends of the U-shaped clevis, the clevis is made to rotate through an arc about the clutch shaft.

b. When the clevis is rotated, a finger on top of the clevis opens the cutout contacts, thus removing the short from the B-section of L602. Since the voltage now is applied to the entire solenoid coil L602, the current through the coil is reduced to the value necessary to keep the solenoid core in place. Resistor R602 is connected across the coil to dampen oscillations that may occur upon sudden application of power.

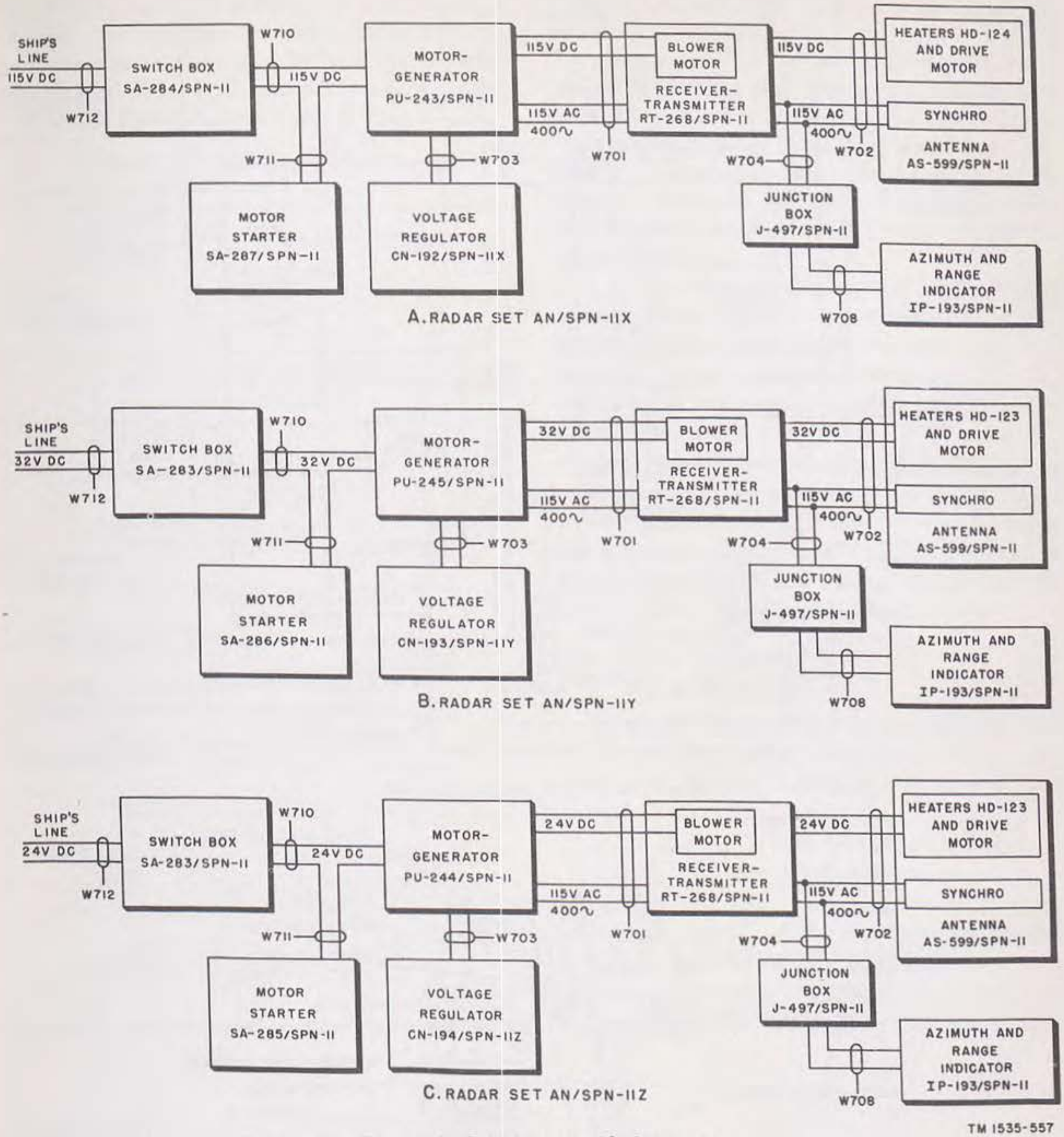

Figure 75. Power groups, block diagram.

c. Rotating with the clevis is the right-hand clutch section to which is attached the movable line contact; the right-hand clutch section rotates until the movable and fixed line contacts close. As soon as this happens, line voltage is applied directly to the motor field for high starting torque; and through resistors R603 and R604 to the armature to limit the current to a safe value while the motor is accelerating. This is condition 1 (fig. 78).

d. The left-hand clutch section is attached to the right-hand clutch section through the torsion spring. As the right-hand clutch section rotates to close the line contacts, the spring winds up and tries to make the left-hand clutch section rotate also. But attached to the left-hand clutch section

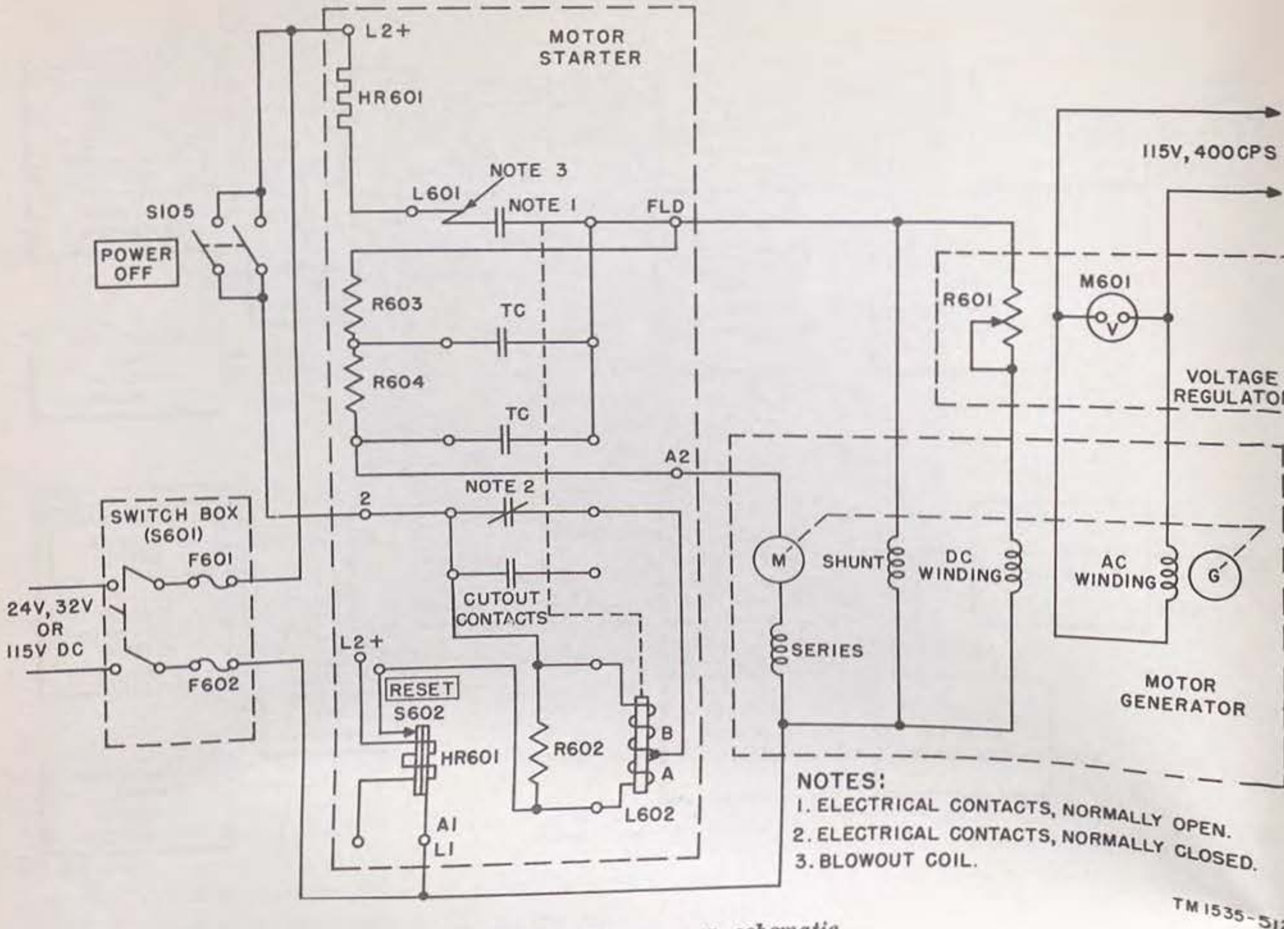

Figure 76. Power group, schematic.

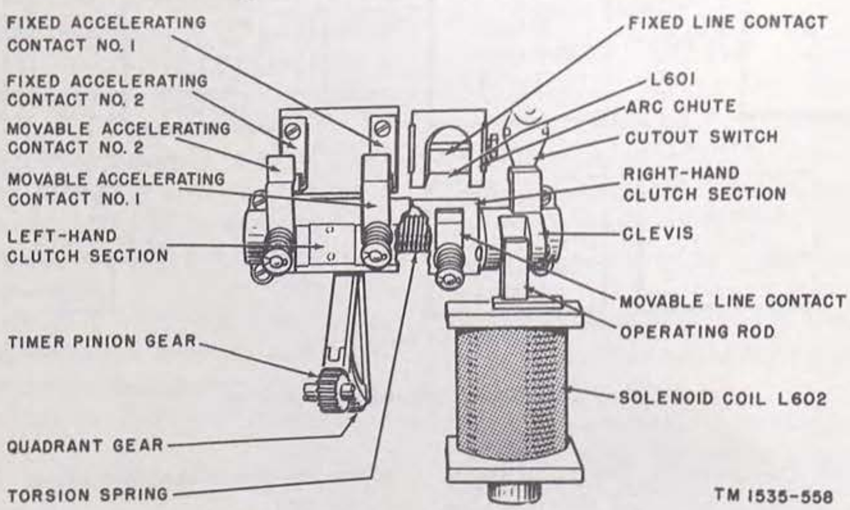

Figure 77. Motor starter, simplified mechanical diagram.

is a quadrant gear coupled to a mechanical timer (fig. 77). The timer slows down the rotation of the left-hand clutch section so that movable accelerating contact No. 1 will not close until 2 seconds after the line contacts have closed. Closing of accelerating contacts No. 1 causes resistor R603 to be shorted out. More current is allowed to flow through the motor. This is condition 2 (fig. 78).

e. By making the arc through which movable accelerating contact No. 2 moves greater than the arc through which movable accelerating contact No. 1 moves, the No. 2 contacts are made to close 1 second after the No. 1 contacts. Closing of the No. 2 contacts causes resistor R604 as well as R603 to be shorted out. Full line voltage now is applied across the motor condition 3 (fig. 78).

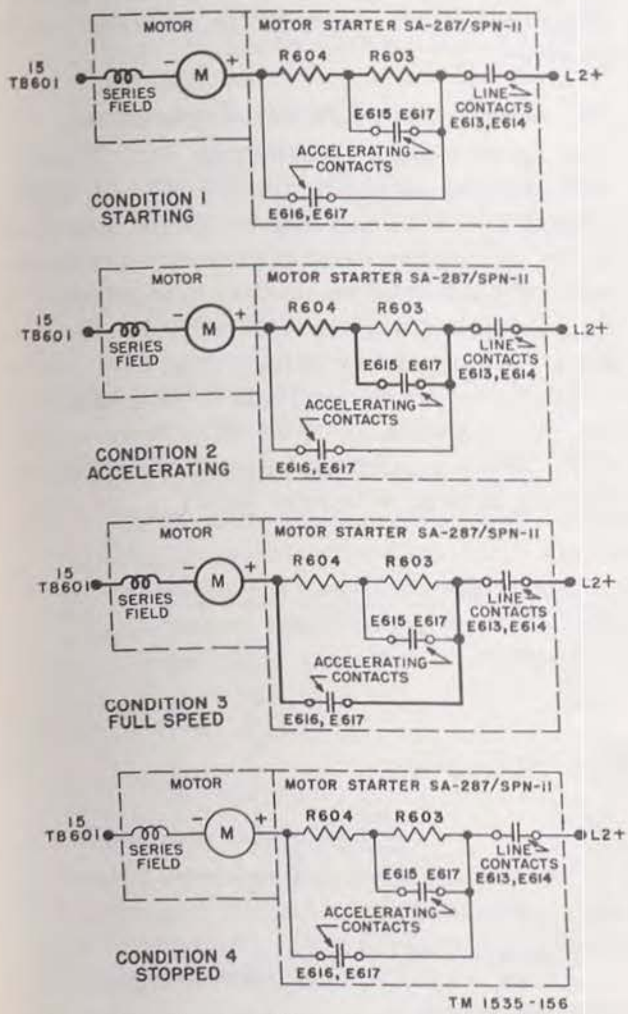

Figure 78. Four conditions of motor starter operation.

f. When POWER switch S105 is turned off, all contacts open up and no current flows through the motor condition 4 (fig. 78).

g. To prevent an arc from forming between the line contacts when they are opened, blowout coil L601 is connected in series with the line contacts. Line current flowing through blowout coil L601 produces a magnetic field whose lines cross the contacts. When the contacts are opened, the magnetic field between them diverts the arc current up the arc chute.

h. All motor generator current flows through heating element HR601. An excessive amount of current flowing through this element causes it to heat and make a bimetallic strip expand. The expansion of the bimetallic strip causes a pair of contacts to which it is linked to open and de-energize the solenoid coil. De-energizing the solenoid opens all the contacts, thus removing the power from the motor. After the bimetallic strip has cooled, the relay contacts may be closed again by pressing the RESET button. If the overload persists, the cycle will be repeated.

88. Motor Generator

(figs. 79 and 202)

Dc applied to the motor turns armature E601, which, in turn, rotates the generator rotor. As a result, the dc input voltage is converted to an ac output that can be used by the radar set.

a. Dc Motor. When voltage is applied to the motor, current flows in the armature and in the field windings. The interaction between the magnetic fields set up by the armature and the field winding currents causes the armature to rotate. The motor is compound-wound: four shunt field windings spaced 90° apart produce constant

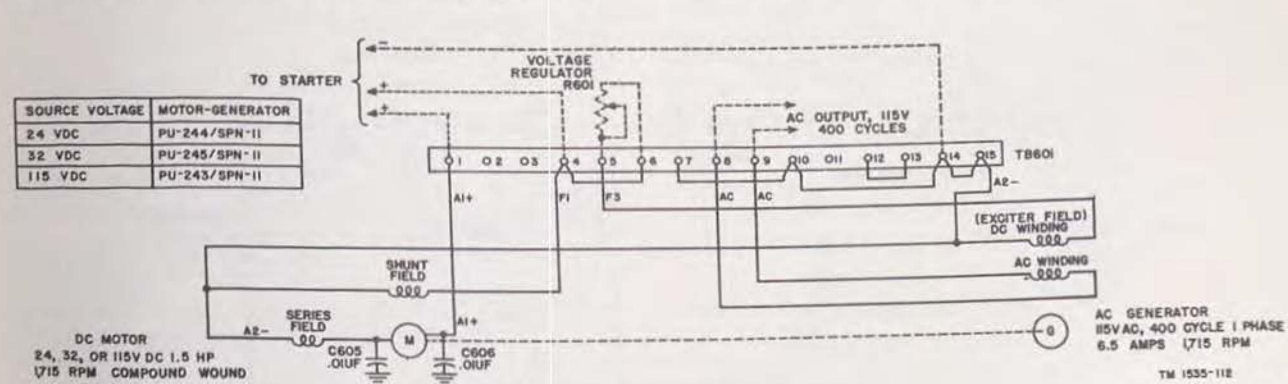

Figure 79. Motor generator, schematic.

speed, and a series field winding increases the starting torque.

b. Ac Generator. The opposite end of the armature holds the generator rotor. On generator stator E606 are a dc winding and an ac winding. The dc winding acts as an exciter. When current from the power source flows in the dc winding, a magnetic field is developed around the circumference of the rotating field poles. This, in turn, develops a rotating magnetic field. As the poles of the rotor sweep past the ac winding in the stator, an ac voltage is induced in the ac winding. The speed of the rotor, the magnitude of the magnetic field, and the number of ac windings are designed to generate an output of 115 volts, single phase at 400 cps.

89. Voltage Regulator
(fig. 76)

a. Rheostat. By varying the resistance in series with the exciter field, rheostat R601 varies the current that flows through the exciter, and thus the magnetic field around it. Because the output of the ac generator is proportional to the exciter magnetic field, varying the rheostat changes the output of the generator.

b. Voltmeter. Voltmeter M601 is connected across the output terminals of the ac generator. Thus the output voltage of the generator can be observed.

90. Miscellaneous Power Connections

a. Synchronizing Circuits (fig. 80). The 115-volt, 400-cps power is applied through SYNCHRO fuse F803 and MG OUTPUT fuse F804 on the convenience panel of the receiver-transmitter to the rotors of transmitter synchro B501 in the antenna and receiver synchro B101 in the indicator. After passing through fuse F101, the ac is rectified by crystal rectifier CR102 to obtain dc for the operation of synchro alinement relay K101. Synchro alinement cam switches S501 and S104 are in series with relay K101.

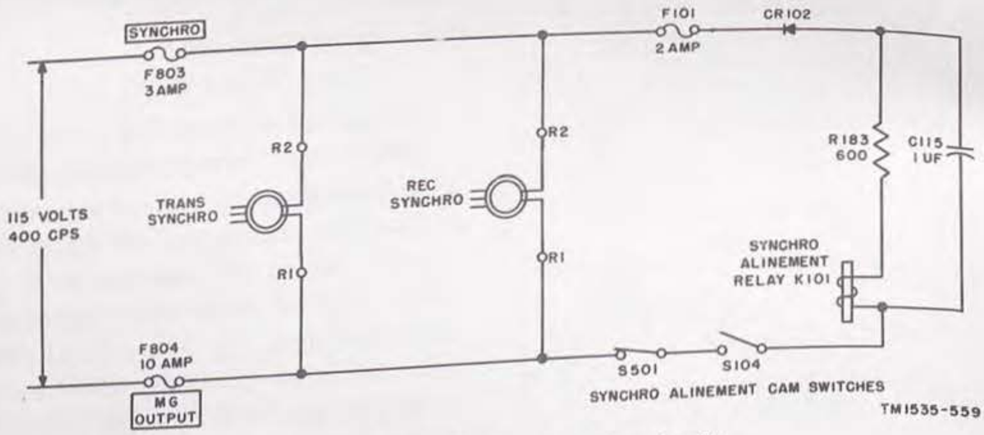

Figure 80. Power for synchronizing circuits.

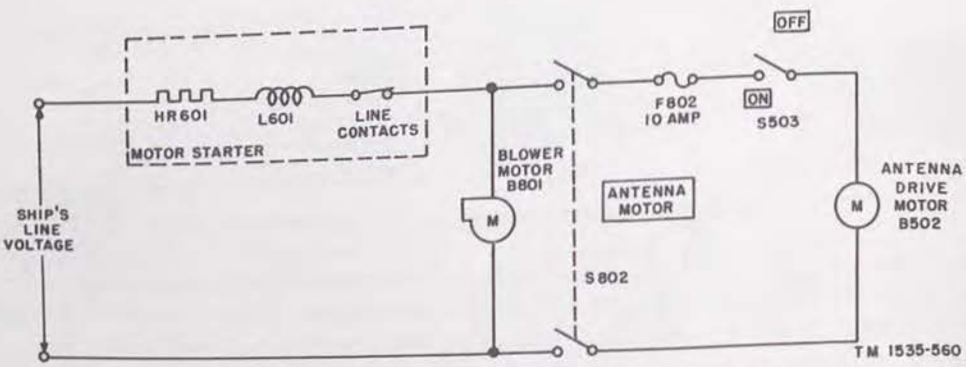

Figure 81. Power for blower motor and antenna drive motor.

b. Blower Motor and Antenna Drive Motor (fig. 81).

(1) The receiver-transmitter blower assembly consists of motor B801, a guarded fan, a replaceable air filter, and duct work. As soon as the switch box lever is placed in the on position, the ship's supply voltage is fed through heater HR601, blowout coil L601, and the line contacts of the motor starter to the blower motor. Air is drawn in through the filter and blown up the duct to the magnetron and to other transmitting system parts. These parts are thus prevented from overheating.

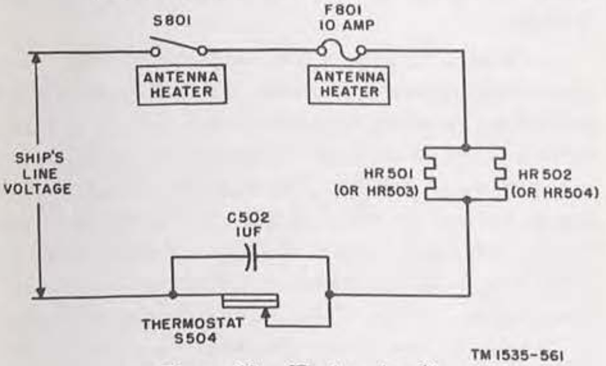

Figure 82. Heater circuit.

(2) The supply line voltage is then fed through the two sets of contacts of ANTENNA MOTOR switch S802, fuse F802, and ON-OFF switch S503 to antenna drive motor B502, which causes the antenna horn and reflector to rotate.

c. Heaters (fig. 82). To keep the oil in the antenna pedestal fluid in the coldest weather, resistors HR501 and HR502 are connected across the ship's supply through ANTENNA HEATER switch S801 and ANTENNA HEATER fuse F801 and thermostat S504. The thermostat keeps the temperature in the pedestal between 40 and 45° by a bimetallic strip. When the temperature reaches 45°, the bimetallic strip bends sufficiently to open a pair of contacts that remove the supply voltage from the heaters. When the temperature cools to 40°, the bimetallic strip returns to its original position and closes the contacts, thus resupplying voltage to the heaters.

d. Convenience Outlets. Two convenience outlets are provided: J804 is located on the convenience panel of the receiver-transmitter and J105 is located in the indicator. These outlets are used to supply 115 volts, 400 cps to soldering irons or other equipment needed for troubleshooting.

Section III. POWER SUPPLY CIRCUITS

91. General

Several dc power supplies are incorporated in the radar set. The table below lists the voltages provided by these power supplies and indicates the systems in which each voltage is used.

System	Power supplies							
	Low voltage						Modulator	PPI
	Regulated		Unregulated					
	+300	−300	+140	+320	+600	−900	Unregulated +3,000	Unregulated 5 kv
Transmitting	X	X					X	
Rf (TR tube)						X		
Receiving	X	X	X	X				
Synchronizing and indicating.	X	X		X	X			X
Power (delay)				X				

92. Block Diagram

(fig. 83)

a. Low-Voltage Power Supplies. The 115 volts, 400 cps are fed to filament transformer T402 and to power transformer T401. These transformers feed all the rectifiers in the low-voltage power supplies.

(1) *Unregulated supplies.* Rectifier V401 produces +140 volts, rectifier V402 produces +320 volts, rectifier V403 produces +600 volts, and the keep-alive rectifier (V409 and V410) produces −900 volts.

(2) *Regulated supplies.* The output of rectifier V403 is fed through voltage regulator tubes V404 and V405 to obtain a regulated output of +300 volts. Rectifier V406, together with voltage regulator tubes V407 and V408, produces a regulated output of −300 volts.

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b. Modulator Power Supply. Filament transformer T303 feeds the transmitting system filaments as soon as the power is turned on and the low-voltage power supplies operate. Plus 320 volts are applied to time-delay circuit (V301 and V302) which causes time-delay relay K301 to operate after a period of approximately 3 minutes. The relay allows power transformer T301 and high voltage rectifier (V303 and V304) to produce +3,000 volts for the modulator. Relay K301 also operates magnetron filament relay K302, which causes the magnetron filament voltage to be reduced from 6.3 volts to 4.5 volts.

c. PPI Power Supply. The 115 volts, 400 cps are applied to power transformer T101. This transformer produces a high ac voltage that is rectified by V106 to obtain +5 kv for the PPI anode. Filament transformer T102, which is in parallel with T101, provides voltage for all the indicator filaments and pilot lamps.

d. Filament Transformer. The 115 volts, 400 cps are applied to transformer T201, which feeds the filament circuit of the receiving system. For a complete discussion of this circuit, refer to paragraph 59.

e. Test Meter M401. The +140-, +320-, +300-, −300-, and +3,000-volt outputs may be read on test meter M401 when test meter switch S401 is placed in the appropriate position. The 115 volts, 400 cps output of the power group is rectified by crystal rectifier CR401 to obtain dc; this dc is read by test meter M401 when test meter switch S401 is on the 115 VAC position.

93. Low-Voltage Power Supplies

(fig 84).

Transformer T401 provides high voltage for all the rectifiers in the low-voltage power supplies. It is protected by fuse F401, which is mounted in the front of the hinged panel. Transformer T402 is connected in parallel with T401 across the 115-volt ac line and is protected by fuse F402. T402 provides voltage for all the rectifier filaments in the low-voltage power supplies, except the keep-alive power supply. The filaments of the keep-alive (−900 v) power supply are fed by two small secondaries on transformer T401. The separate power supplies are discussed below.

a. Power Supply, +140-Volt. The ac voltage developed across the center-tapped winding between taps 9 and 11 of transformer T401 is applied to the plates of full-wave rectifier stage V401. The rectified output is filtered by chokes L404 and L405 and capacitors C405 and C406, and then fed to terminal boards TB401 (fig. 74) and TB801 (fig. 114).

b. Power Supply, +320-Volt. The ac voltage across the center-tapped winding between taps 8 and 12 of transformer T401 is applied to the plates of full-wave rectifier stage V402. The rectified output is filtered by L402, C403, L403, and C404 and then fed to terminal boards TB401 and TB801.

c. Power Supply, +600- and +300-Volt. The ac voltage across the center-tapped, high-voltage secondary winding between pins 7 and 13 of transformer T401 is applied to the plates of full-wave rectifier stage V403. The rectified 600-volt output is filtered by C401, L401, and C402 and then fed to terminal board TB801. Series resistors R401, R402, and R403 act as a bleeder and as voltage divider. The +300 volts, developed across the lower two resistors, are stabilized by the two OD3/VR150 voltage regulator tubes (V404 and V405) that are placed across the resistors. The regulated +300 volts are fed to terminal boards TB401 and TB801.

d. Power Supply, −300-Volt. The potential between tap 13 and tap 10, the grounded tap of transformer T401, is applied to the cathode of V406, which is used as a half-wave rectifier. The output is filtered by C407, L406, and C408 and then applied across the bleeder and voltage divider consisting of R407, R408, and R409. Voltage regulator tubes V407 and V408, across the lower two resistors, keep the output constant at −300 volts. The −300-volt output is fed to TB401 and TB801.

e. Keep-Alive (−900 Volts) Power Supply. The two tubes used are V409 and V410. The 1-volt filaments are fed through dropping resistors R417 and R418. The voltage between tap 12 and the ground of transformer T401 is applied through capacitor C409 to a point connecting the filament of V409 and the plate of V410.

(1) When the polarity of terminal 12 of transformer T401 is positive, tube V410 conducts and capacitor C409 charges through the tube to the polarity shown (fig. 85Ⓐ). The voltage across C409 reaches 450 volts, the peak value of the applied ac.

(2) When the polarity of terminal 12 reverses and becomes negative, V410 stops conducting. The 450 volts across the sec-

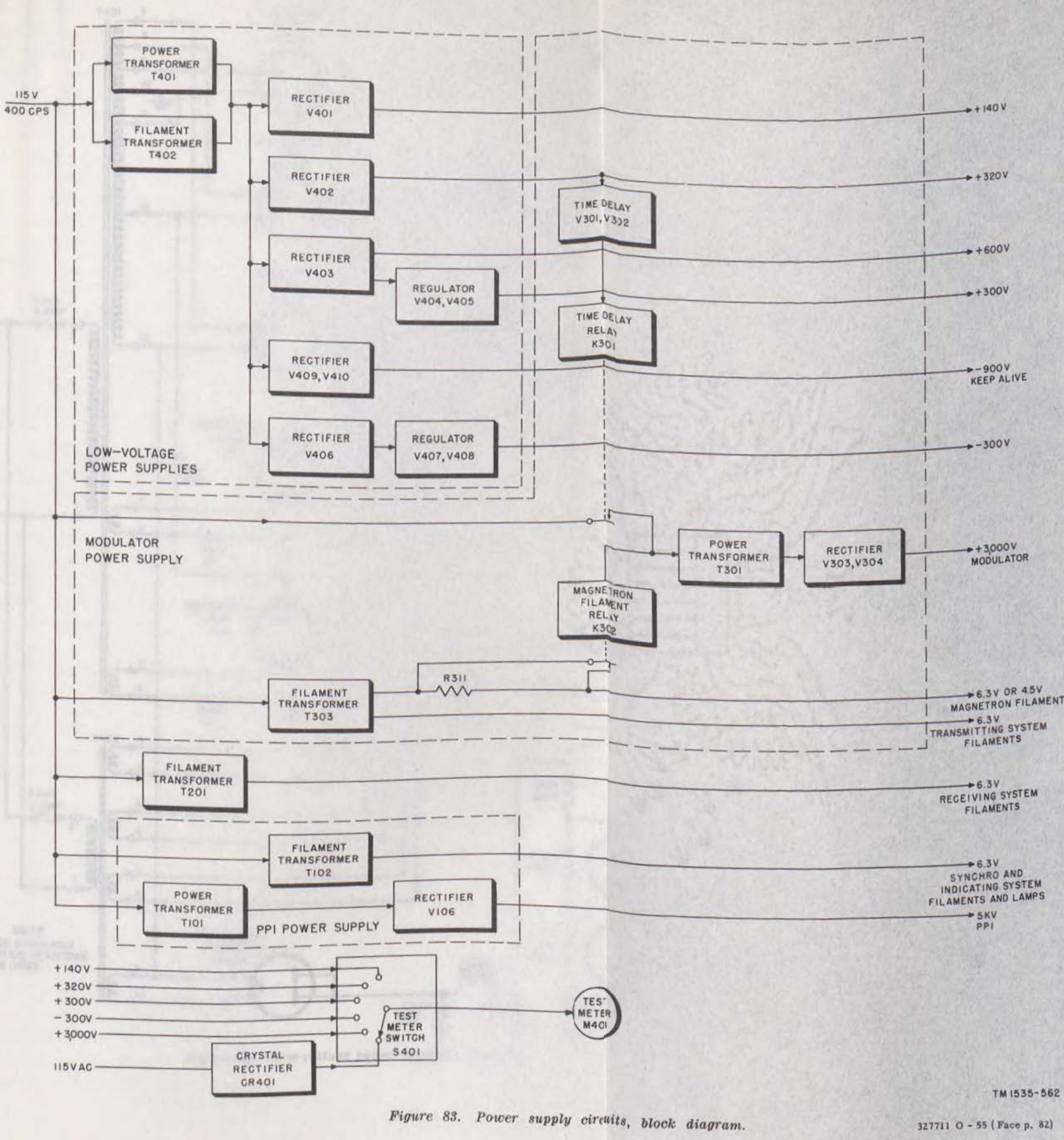


Figure 83. Power supply circuits, block diagram.

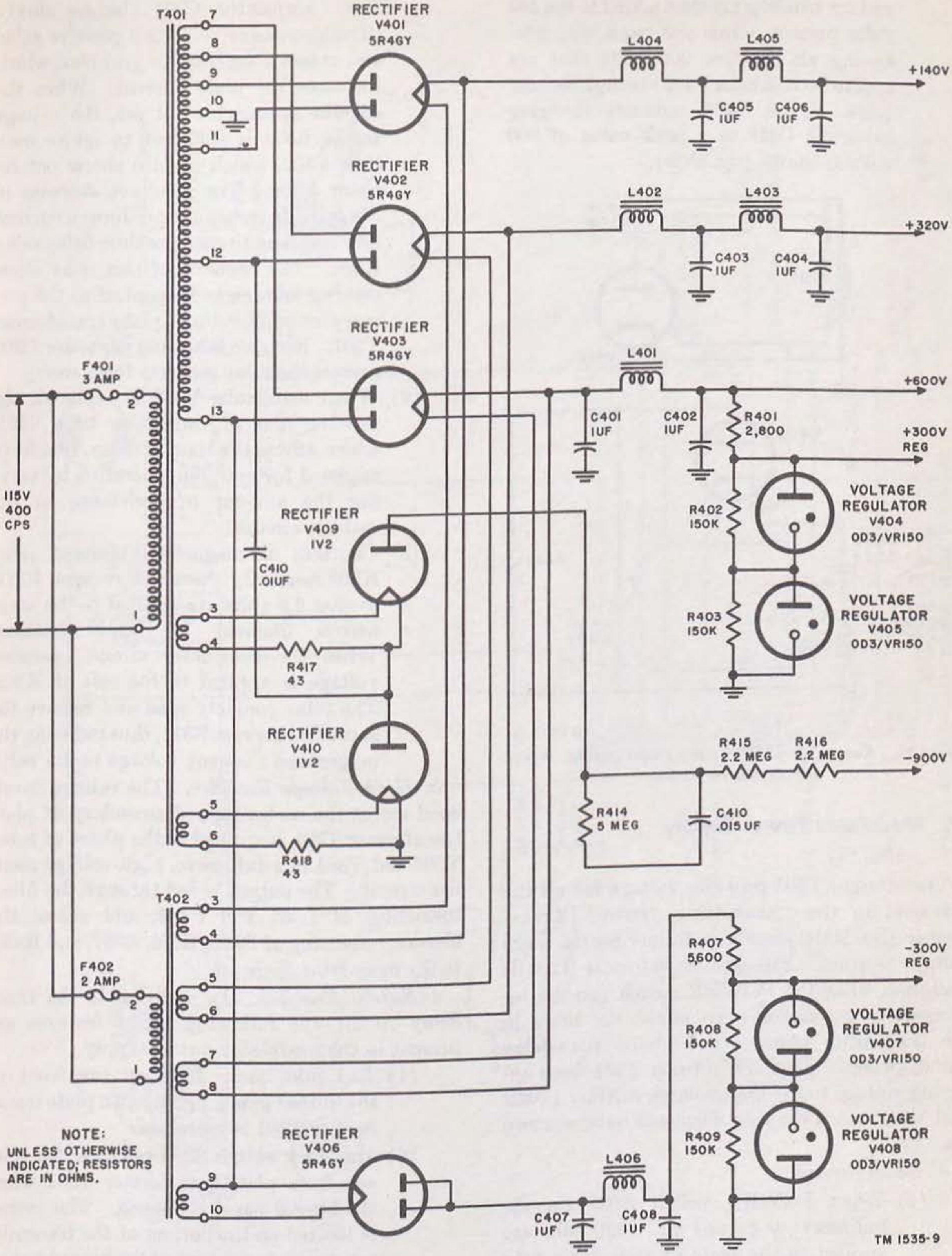


Figure 84. Low-voltage power supplies, schematic.

ondary winding are then added to the 450 volts present across the capacitor, producing an effective 900 volts that are applied across tube V409 through resistor R414. Tube V409 conducts charging capacitor C410 to a peak value of 900 volts as shown (fig. 85Ⓑ).

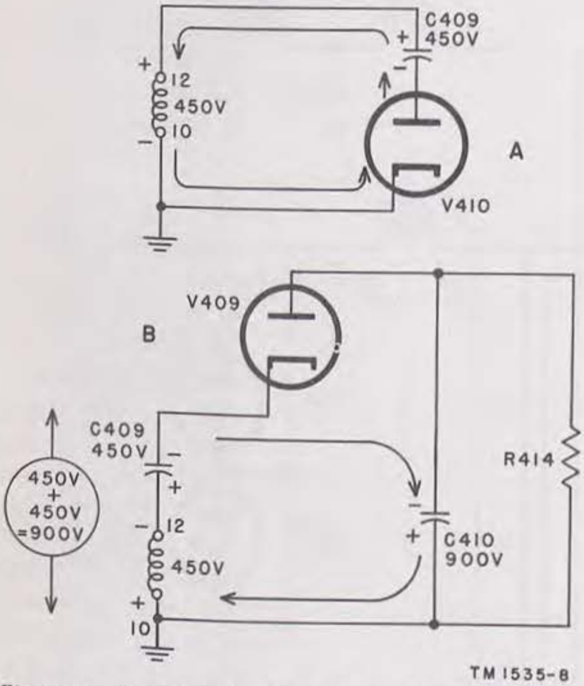


Figure 85. Keep-alive (−900 volts) power supply, charge and discharge paths.

94. Modulator Power Supply

(fig. 86)

Transformer T303 provides voltage for all the filaments in the transmitting system. Transformer T301 is the plate transformer for the high-voltage rectifier. Filament transformer T303 is energized when the POWER switch (on the indicator) is turned on. To guard the tubes in the transmitter circuits, a 3-minute time-delay circuit prevents plate transformer T301 from applying voltage to the high-voltage rectifier (V303 and V304) until the tube filaments have warmed up.

a. Delay Circuit.

(1) When POWER switch S105 (in the indicator) is turned on, +320 volts are applied to the plate of time-delay tube V301, causing it to conduct. Current flowing through the cathode resistors produces bias which limits plate current flow. Capacitor C301 charges slowly through resistor R301 to a positive value and causes a decrease in grid bias, which increases the plate current. When the current approaches 2.4 ma, the voltage across R302 is sufficient to ignite neon tube V302, which in turn shorts out resistor R302. The resultant decrease in the cathode resistance produces a current flow sufficient to energize time-delay relay K301. The contacts of this relay close, causing voltage to be applied to the primary of high-voltage plate transformer T301. Resistor R304 and capacitor C302 protect the relay contacts from arcing.

(2) When neon tube V302 is replaced, the starting bias of time-delay tube V301, which affects the time of delay, should be adjusted for optimum operation by varying the amount of resistance in the cathode circuit.

(3) Contacts of magnetron filament relay K302 normally short out resistor R311, so that 6.3 volts are applied to the magnetron filament for rapid heating. When the time-delay circuit operates, voltage is applied to the coil of K302. The relay contacts open and remove the short from across R311, thus reducing the magnetron filament voltage to 4.5 volts.

b. High-Voltage Rectifier. The voltage developed across the center-tapped secondary of plate transformer T301 is applied to the plates of tubes V303 and V304 in a full-wave, high-voltage rectifier circuit. The output is fed through the filter, consisting of L301 and C304, and across the bleeder, consisting of R305, R306, R307, and R308, to the modulator stage.

c. Safety Features. In addition to the time-delay circuit, the following safety features are present in the modulator power supply.

(1) Red pilot lamp I301, on the front of the hinged panel, lights when plate transformer T301 is energized.

(2) Interlock switch S302 removes the voltage from plate transformer T301 when the hinged panel is opened. The switch is located on the bottom of the transmitter chassis in the rear of the hinged panel.

(3) HIGH VOLTAGE switch S301 can be turned OFF to remove the voltage from transformer T301.

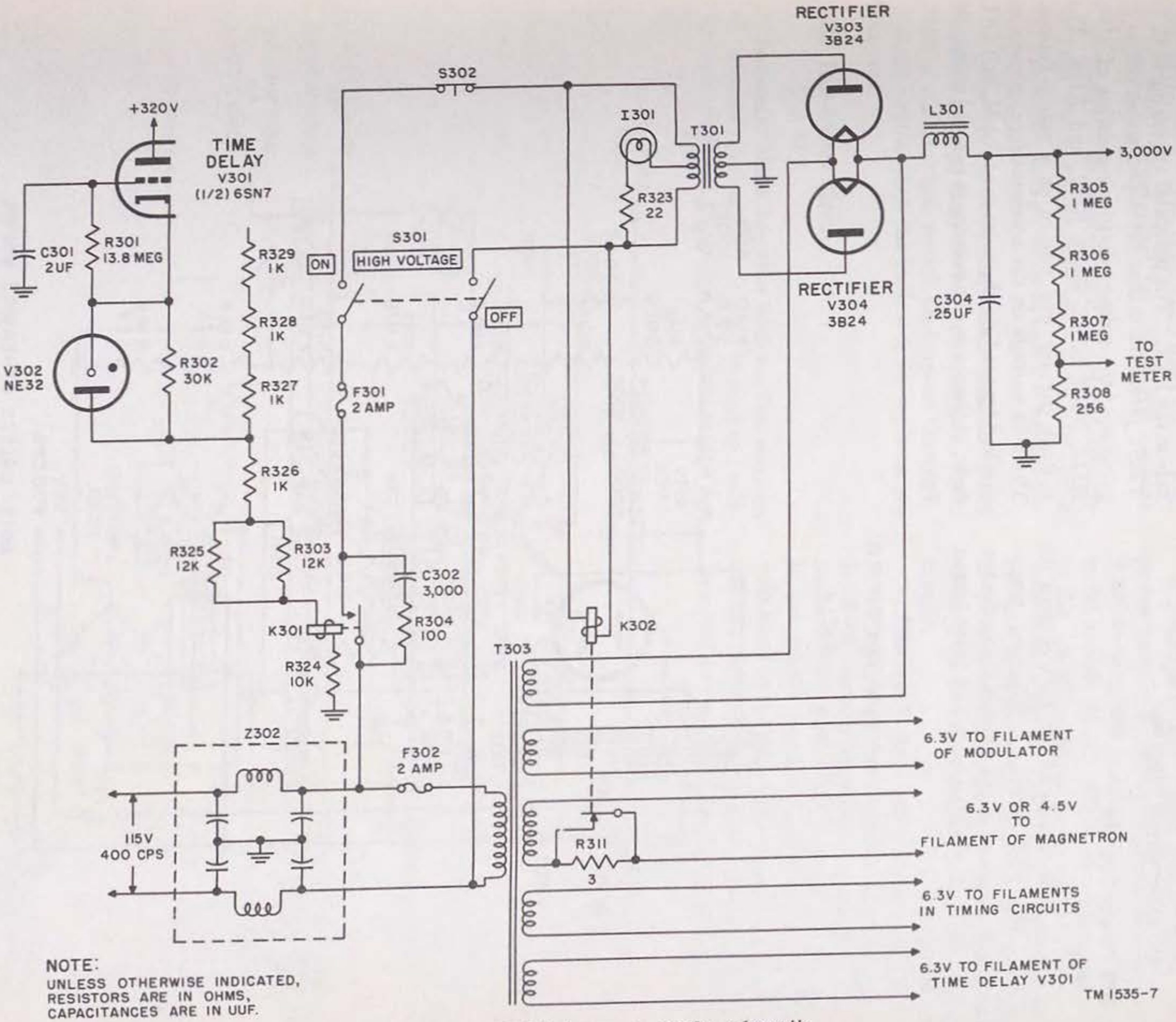


Figure 86. Modulator power supply, schematic.

(4) Fuses F301 and F302 protect transformers T301 and T303, respectively, from overloads.

(5) Filter Z302 prevents the powerful transmitter rf pulses from feeding back to the other power supplies.

95. PPI Power Supply
(fig. 87)

The accelerating anode of the PPI obtains its 5 kv from the PPI rectifier. Filament transformer T102, mounted in the back of the indicator (fig. 58), feeds all the filaments and pilot lamps in the indicator.

a. Power transformer T101 applies a high ac voltage across V102 (2X2–A), which acts as a half-wave rectifier. After the 5-kv output is filtered by C117, R139, and C118, it is fed through resistors R140 and R141 to the accelerating anode cap on the PPI. The potential appearing at H. V. TEST jack J102 is that developed across the lower portion of the voltage divider consisting of R142, R143, R144, R145, R146, R147, and R148. The voltage divider was put in as a safety feature. The 5-kv voltage on the accelerating anode can be checked by reading the voltage at the H. V. TEST jack; at this jack, the voltage is reduced to only 50 volts.

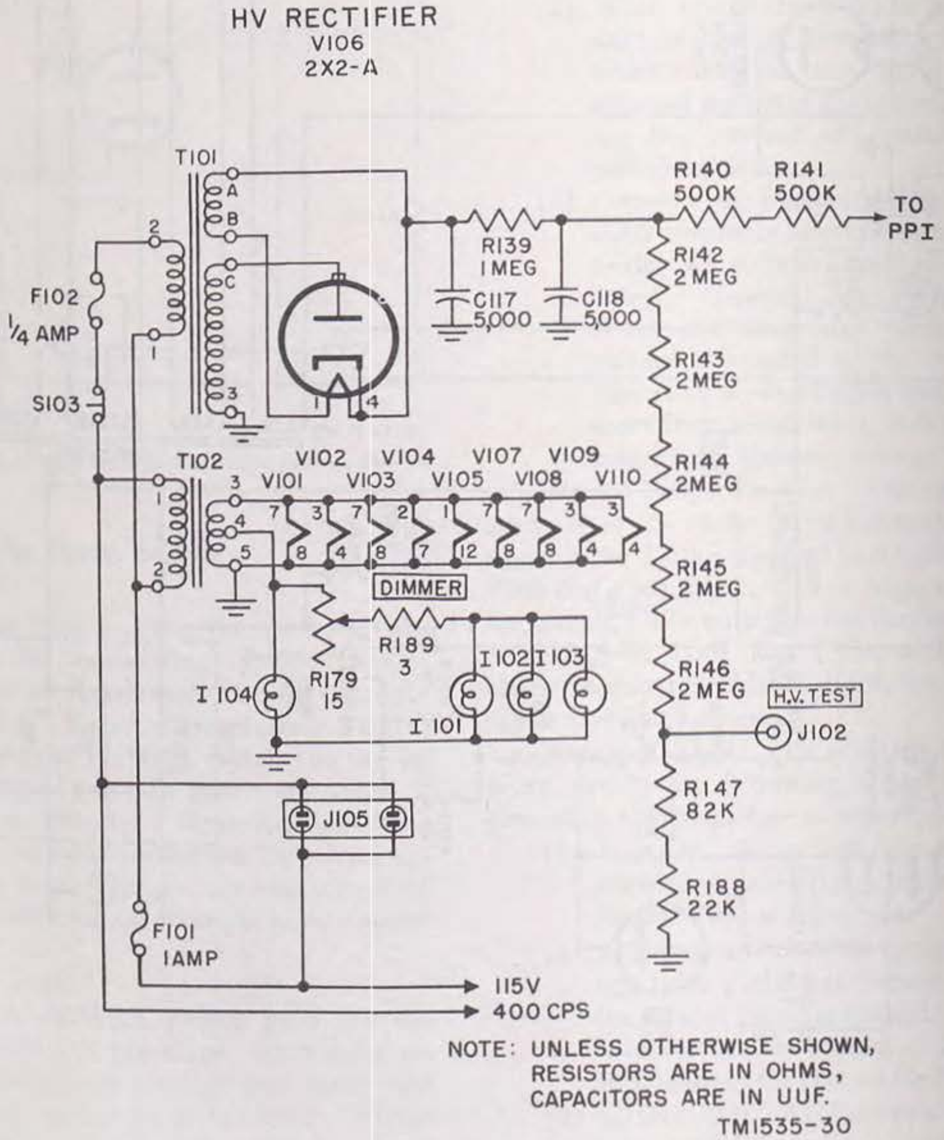


Figure 87. PPI power supply, schematic.

b. Transformer T102 feeds all the filaments in parallel. In addition, a tap on the secondary is used to supply pilot lamp I 104, and the three lamps (I 101, I 102, and I 103) that illuminate the face of the PPI. The amount of light on the face of the PPI is controlled by DIMMER resistor R179.

c. The 115-volt, 400-cps input is applied directly to J105, which can be used as an auxiliary outlet for a soldering iron or other equipment needed for troubleshooting.

d. Fuse F101 protects both transformers. F102 is additional protection for transformer T101. S103 is an interlock switch that opens the high-voltage circuit when the indicator coverplates are removed.

96. Test Meter Circuit
(fig. 88)

Test meter M401, together with the two sections of test meter switch S401, is used to read the voltage outputs of all the power supplies, except for the PPI and the keep-alive power supplies. In addition, the meter reads the 115-volt, ac output of the power group and the current that flows through the magnetron.

a. Plus 140 Volts. The output of the +140-volt power supply is fed through multiplier resistor R406 to terminal number 3 of section 2 of test meter switch S401. When switch S401 is placed in the +140V position, terminal 3 of section 2 is connected to the plus side of test meter M401; the minus side of test meter M401 is connected through terminal 3 of section 1 to ground. The meter and multiplier are thus placed across the +140-volt supply.

b. Plus 320 Volts. The output of the +320-volt power supply is fed through multiplier resistor R405 to terminal number 4 of section 2 of test meter switch S401. When switch S401 is placed in the +320V position, terminal 4 of section 2 is connected to the plus side of test meter M401; the minus side of test meter M401 is connected through terminal 4 of section 1 to ground. The meter and

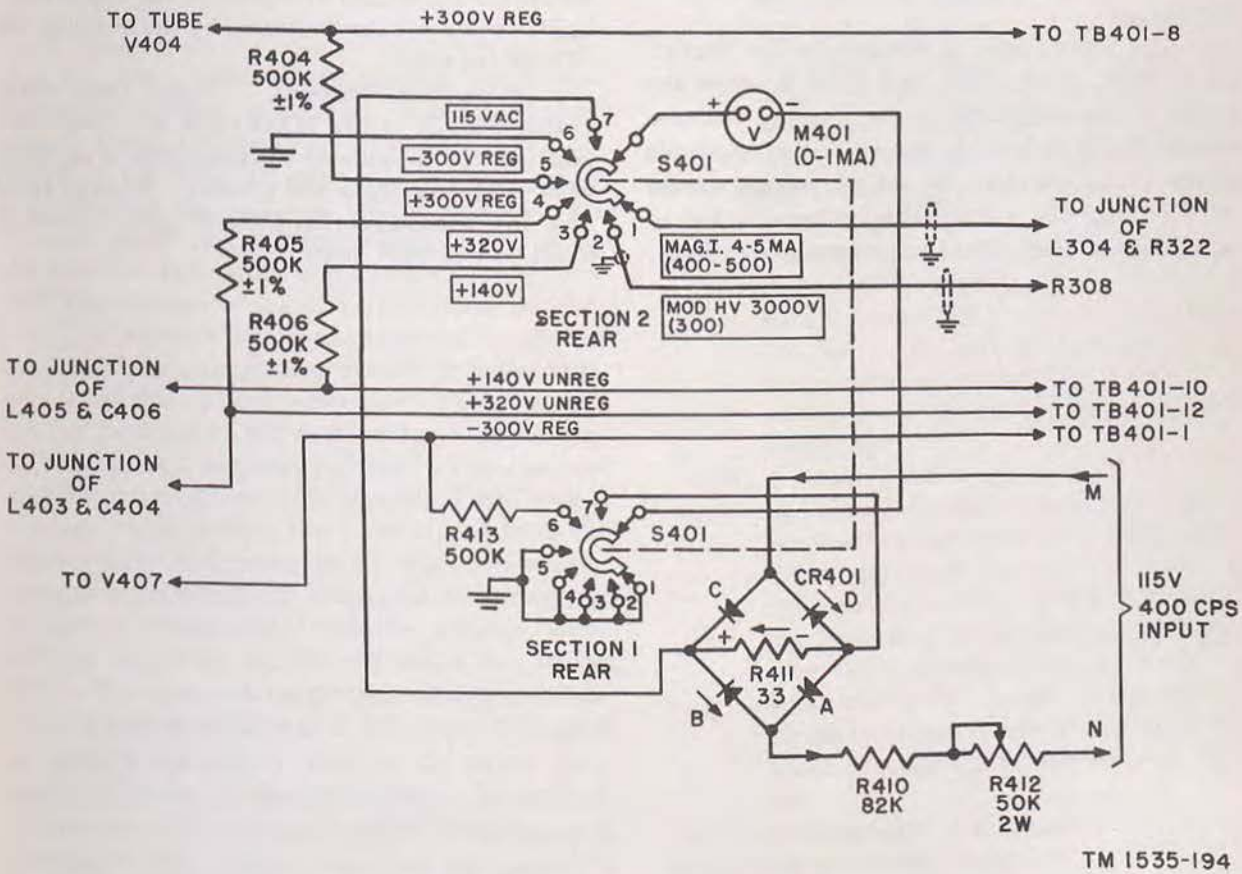


Figure 88. Meter circuit, schematic diagram.

multiplier are thus placed across the +320-volt supply.

c. Plus 300 Volts. The +300-volt output produced by the +600-volt and +300-volt power supply is fed through multiplier resistor R404 to terminal 5 of section 2 of test meter switch S401. When switch S401 is placed in the +300V REG position, terminal 5 of section 2 is connected to the plus side of test meter M401; the minus side of test meter M401 is connected through terminal 5 of section 1 to ground. Although the test meter reads only the +300-volt regulated output, it indicates also the condition of the +600-volt section of the power supply.

d. Minus 300 Volts. The output of the −300-volt supply is fed through multiplier resistor R413 to terminal 6 of section 1 of test meter switch S401. When switch S401 is placed in the −300V REG position, terminal 6 of section 1 is connected to the minus side of test meter M401 and the plus side of test meter M401 is connected through terminal 6 of section 2 to ground. The voltmeter is thus placed with the proper polarity across the −300-volt output.

e. Plus 3,000 Volts. A voltage divider consisting of R305, R306, R307, and R308 is across the output of the modulator power supply. Because the resistance of R308 is one-tenth the resistance of the entire divider, the actual voltage across R308 is only 300 volts. This voltage is fed to terminal 2 of section 2 of test meter switch S401. When switch S401 is placed in the MOD. H. V. 3,000 (300) position, terminal 2 of section 2 is connected to the plus side of test meter M401; the minus side of test meter M401 is connected through terminal 2 of section 1 to ground.

f. 115 VAC. The 115-volt, 400-cps output of the power group is fed through R412 and R410 to crystal rectifier CR401. When line M (fig. 88) is minus and line N is plus, electrons flow down through rectifier D, from right to left across R411, down through rectifier B to line N. When M is plus and N is minus, electrons flow up through rectifier A, from right to left through R411, up through C to M. In both cases, electrons flow from right to left through R411 and produce polarities across it as shown. The plus side of R411 is fed to terminal 7 of section 2 of test meter switch S401. When switch S401 is placed in the 115 VAC position, terminal 7 of section 2 is connected to the plus side of test meter M401; the minus side of test meter M401 is connected through terminal 7 of section 1 to the minus side of R411. The test meter thus reads the rectified dc output. Resistor R412 is used to adjust the test meter reading to the same value indicated by the meter on the voltage regulator.

g. Magnetron Current. When test meter switch S401 is in the MAG.I.4–5 MA (400–500) position, the cathode of the magetron is in series with test meter M401 and ground. Resistor R322 (fig. 15), shunted across the test meter, causes it to act as a current meter.

CHAPTER 7

COMPLETE BLOCK DIAGRAM

97. Purpose of Block Diagram

The complete block diagram of Radar Set AN/SPN-11(*) can be used as a quick review of the theory by a radar repairman who has not worked with this equipment for some time. The block diagram also enables a repairman who is familiar with radar principles but is not acquainted with this particular set to gain a basic understanding of this equipment. In troubleshooting, the block diagram is invaluable because it enables the repairman to narrow the trouble down to a particular circuit before referring to a more detailed schematic.

98. Timing

(fig. 89)

a. Pulling down the lever in the switch box applies the ship's line voltage through the motor starter to the motor generator. When it reaches normal speed, the motor generator produces an output of 115 volts 400 cps. This voltage is applied through the terminal boards and the convenience panel on the receiver-transmitter to all the filament and power transformers, except the plate transformer of the modulator power supply.

b. The master blocking oscillator in the timing circuits of the transmitting system produces triggers at the rate of 1,000 per second. These triggers are fed to the one-shot multivibrator in the synchronizing and indicating system. The one-shot multivibrator places into operation the sweep circuits, which cause a line to be traced from the center of the PPI screen to the edge. When the antenna horn is made to rotate, the deflection coil rotates in synchronism with the antenna horn, causing the sweep to cover the entire face of the PPI. The one-shot multivibrator also develops an unblanking pulse that is fed to the PPI grid to prevent the return trace of the sweep from being visible on the face of the PPI. In addition, the one-shot multivibrator triggers the range mark circuits, which produce pulses that are applied to the cathode of the PPI to form circles on its face. These circles represent distances from the radar set.

c. Three minutes after all the other power supplies have been placed into operation, the modulator power supply goes on. In addition to firing the circuits in the synchronizing and indicating system, the timing circuits now trigger the modulator. All the important pulses are as shown in figure 89.

(1) Operation of the modulator causes the magnetron to produce a .4-microsecond burst of rf energy (not shown to scale in figure 89). The rf energy is fed to the antenna. Some of the energy is fed to the afc, which controls the output of the klystron local oscillator.

(2) The unblanking pulse starts at the very moment the magnetron is fired. The pulse time duration is determined by the setting of the RANGE switch.

(3) The sweep signal starts the same time the unblanking pulse starts. Its length is the same as the unblanking pulse.

(4) On the 3-mile range, the range mark circuits produce three range marks equally spaced across the length of the sweep. On the 1-, 8-, and 20-mile ranges, the range mark circuits produce two, four, and four equally spaced range marks, respectively.

(5) Returning echoes go through the mixer and signal circuits of the receiving system and are converted into video signals. These signals go through the video circuits to the cathode of the PPI in the synchronizing and indicating system. The video signals appear as intensified spots on the PPI screen. Their location on the time base is determined by the distance between the targets and the radar set.

d. One-thousandth of a second after the previous trigger, another trigger sets off the magnetron, the unblanking pulse, the sweep circuits, and the range mark circuits. Again the returning echoes appear as intensified spots on the screen. The fast repetition rate produces a steady picture on the screen.

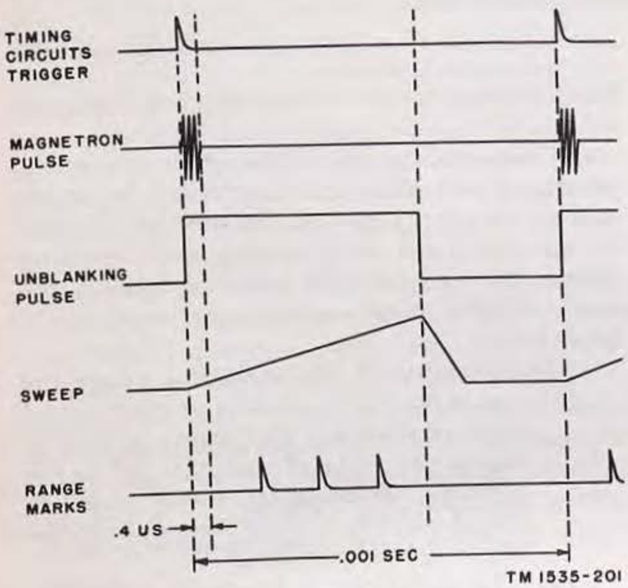


Figure 89. Radar timing chart.

99. Block Diagram

(fig. 211)

Functionally, the radar set is divided into five systems: the transmitting system, the rf system, the receiving system, the synchronizing and indicating system, and the power system. Each system in the block diagram is inclosed by a block made of heavy solid lines. All systems, except the rf system, have groupings of stages that act together and are called circuits. These circuits are inclosed by blocks made of broken lines. Signal paths on the diagram are shown by solid lines with arrow heads, mechanical connections by dashed lines, and wave guides by double lines. The separate systems are described below.

a. Transmitting System.

(1) *Timing circuits.* Master blocking oscillator V307A produces the positive triggers that control the timing of the entire radar set. This timing is adjusted by R313. These pulses are fed directly to the one-shot multivibrator V101 in the synchronizing and indicating system and to the stc circuits in the receiving system. The trigger pulses are run also through the rest of the timing circuits to produce a sharp leading edged pulse that is applied to the modulator.

(2) *Transmitter circuits.* After a delay, power is applied through resonant charging choke L302 to modulator V305. Modulator stage V305, with the aid of pulse forming network Z301, produces a .4-microsecond pulse. Magnetron pulse transformer T302 couples this pulse to magnetron V306, which produces an rf burst of energy of the same length of time.

b. Rf System. The rf energy is fed through the duplexer, the fixed wave-guide joint assembly, and the rotating wave-guide joint assembly to the antenna horn and reflector. The TR tube prevents energy from entering the receiving system and burning out signal crystal CR201. Echoes are picked up by the antenna reflector and horn and are coupled through the same wave guides and duplexer to signal crystal CR201 in the receiving system. The anti-TR tube prevents the echo from entering the transmitting system.

c. Receiving System.

(1) *Mixer circuits.* Echo signals are combined with klystron local oscillator V203 signals in signal crystal CR201 to produce an if. of 30 mc. The frequency of the klystron local oscillator may be adjusted by REFLECTOR TUNING control R250. Part of the rf energy from the magnetron is fed through the attenuator to afc crystal CR202. The magnetron frequency is combined with the klystron local oscillator frequency to produce an if. of 30 mc, which is fed to the afc circuits. CRYSTAL CURRENT meter M201 reads afc crystal current or signal crystal current, depending on the position of AFC XTAL I-SIGNAL XTAL I PUSH switch.

(2) *Afc circuits.* The afc circuits are placed into operation when switch S202 is placed in the AFC OPERATION position. The if. from afc crystal CR202 is amplified by afc if. amplifiers V213 and V214 and is fed to afc discriminator V215. The discriminator produces positive, negative, or no pulses depending on whether the if. is below, above, or at 30 mc. These pulses, when applied to afc

pulse amplifier V216, are inverted. When the inverted pulses are fed to charging diode V217 and phantastron V218, an output is produced that causes the klystron local oscillator to lock at 30 mc.

(3) *Signal circuits.* The signal if. is amplified by V204 to V210, detected by V211, and coupled through cathode follower V212 to the video circuits of the synchronizing and indicating system. The GAIN control varies the sensitivity of the signal circuits.

(4) *Stc circuits.* The trigger pulse from master blocking oscillator V307A sets stc generator V219A into operation at the beginning of each sweep. The generator produces a pulse that is coupled through stc cathode follower V219B to the gain line of the signal circuits. The pulse reduces sea return. The amplitude of the stc pulse is varied by SUPPRESSOR control R181.

d. Synchronizing and Indicating System.

(1) *PPI.* The PPI displays range and bearing information. The 5 kv from the PPI power supply is applied to the second anode to accelerate electrons from the cathode to the screen. The sweep voltage is applied to deflection coil L101. Plus 320 volts are applied to focus coil L102 through FOCUS control R138. The intensity of the trace on the screen is determined by INTENSITY control R135, which varies the potential on the first grid.

(2) *One-shot multivibrator.* One-shot multivibrator V101 sets off the sweep circuits and the range mark circuits. It also produces the unblanking pulse for the grid of the PPI.

(3) *Sweep circuits.* Sweep generator V102A produces a straight line sweep at the same time that the magnetron is fired. The length of the sweep is determined by the setting of RANGE switch S101 and by individual controls R117, R118, R119, and R120. The sweep generator output is amplified by voltage amplifiers V102 and V103 and by current amplifier V104. When CENTER EXPAND switch S102 is placed in the ON position, the deflection coil current does not reach zero in the time between sweeps, and the PPI indication is a dark circle in its center. Dc restorer V102B keeps the PPI trace steady.

(4) *Range mark circuits.* Range mark oscillator V107A produces oscillations whose frequency is determined by the setting of RANGE switch S101 and by individual controls L103, L104, L105, and L106. After the waves are fed through V107B, V108A, and V108B, they become sharp, well-timed pips. These range marks are applied to the video circuits.

(5) *Video circuits.* The amplitude of the range marks is varied by RINGS control R165. The range marks then are applied to video mixing amplifier V109B. The amplitude of the video signals from cathode follower V212, in the receiving system signal circuits, is varied by CONTRAST control R160. The video signals then are applied to video mixing amplifier V109A. A crystal rectifier between the two video mixing amplifiers prevents blooming. The range marks and the video signals are fed through video output amplifier V110 to the PPI cathode.

(6) *Synchronizing circuits.* Geared to the rotating antenna horn is transmitter synchro V501, which sends an error signal to receiver synchro B101 (in the indicator). The receiver synchro, in turn, causes deflection coil L101 to rotate about the neck of the PPI, in synchronism with the antenna horn. Synchro alinement cam switches S501 (in the antenna) and S104 (in the indicator) aline the two synchros when the radar set is first placed in operation. Heading flash cam switch S502 (in the antenna) controls the heading flash circuit (in the indicator) to produce fore and aft heading flashes on the PPI screen. HEADING FLASH control R187 controls the voltage that the heading flash circuit applies to the PPI cathode, and thus controls the intensity of the flashes.

e. Power System.

(1) *Power group.* The ships' line voltage is fed through the switch box to the antenna drive motor, the heaters, and the blower

motor. The motor starter does not operate until POWER switch S105 (in the indicator) is turned on. The motor starter applies power to the motor generator gradually. As soon as the motor generator reaches 115 volts, 400 cps, power is produced. The voltage regulator controls the output of the motor generator.

(2) *Power supply circuits.* The 115-volt, ac power feeds the low-voltage power supplies, the modulator power supply, and the PPI power supply. The low-voltage power supplies produce +300- and −300-volt regulated outputs and +600-, +140-, and +320-volt unregulated outputs for operating the transmitting, receiving, and synchronizing system stages, and −900 volts for application to the TR tube in the rf system. The modulator power supply contains a time-delay circuit that prevents high voltage from being applied to the modulator until the filaments in the transmitter circuits have warmed up. The PPI power supply is located in the indicator, and it provides 5 kv for the second anode. Test meter M401, together with test meter switch S401, is used to determine the condition of the power supply circuits.

PART TWO

TROUBLESHOOTING AND REPAIR

CHAPTER 8

SYSTEM TROUBLESHOOTING

Section I. INTRODUCTION

100. General

Part two of this manual contains all information needed for troubleshooting and repair of the equipment. This chapter contains information that will enable the repairman to determine in what system (transmitting, rf, receiving, synchronizing and indicating, or power) the trouble lies. The chapters that follow contain information and procedures to enable the repairman to pin down the trouble to a definite part, and to repair it.

101. Numbering System

To facilitate part location, a block of numbers has been assigned to each system or component group according to the following table.

System	Component or component group	Number block
Transmitting	Part of receiver-transmitter (includes modulator power supply).	300–399
Rf	Antenna (includes some parts of synchronizing circuits).	500–599
Receiving	Part of receiver-transmitter (includes duplexer).	100–199
Synchronizing and indicating.	Range and azimuth indicator (includes PPI power supply).	100–199
Synchronizing and indicating.[a]	Junction box	700–799
Power	Power group: Motor generator, motor starter, switch box, and voltage regulator.	600–699
Power	Part of receiver-transmitter (low-voltage power supplies).	400–499
Power[b]	Convenience panel and terminal boards on bottom of receiver-transmitter.	800–899

[a] For troubleshooting purposes, the junction box can be considered as being in the synchronizing and indicating system.

[b] Most of the points on the convenience panel and the terminal boards are in the power system.

102. Troubleshooting Data

This paragraph presents a general description of the troubleshooting data and procedures contained in this manual. A specific listing of appropriate charts and figures is presented before each troubleshooting section in the chapters that follow.

a. Block Diagrams. The block diagrams present the electrical and mechanical interrelationships among the systems, circuits, and stages of the radar set. By determining the symptoms and then reasoning back to the causes, it is often possible to trace the trouble to a particular box on the block diagram.

b. Component Schematics. These schematics show all the circuitry present in each of the major components. The range and azimuth indicator schematic (fig. 214) includes the PPI power supply. The antenna schematic (fig. 159) includes the antenna drive motor, the heaters, and the parts of the synchronizing circuits that are mounted on the antenna. The receiver-transmitter circuitry is presented in three separate schematics. Figure 212 shows the transmitting system, together with the duplexer, the low-voltage and modulator power supplies, and the test meter circuit. Figure 213 shows everything that is mounted on the receiver chassis, except the duplexer. Figure 113 shows the terminal board and convenience panel circuitry.

c. Cabling Diagram (fig. 219). This diagram shows how the radar set components are connected. It indicates wiring between terminal boards and plugs of one component and terminal boards and plugs of another component. This diagram is especially useful for tracing trouble between components.

d. Power Distribution Diagram (fig. 220). This diagram indicates the relationships among the power group components and the various power supplies. It shows all the fuses and circuits they protect. Therefore, this diagram is helpful for troubleshooting in the power system.

e. Wiring Diagram. After the trouble has been traced logically to a part on the schematic, the wiring diagram can be used to find the physical location of that part. Wiring diagrams are provided for the following four units or chassis: the indicator (fig. 218), the transmitter (fig. 215), the low-voltage power supplies (fig. 216), and the receiver (fig. 217).

f. Wave-Form Charts. These charts present pictures of wave forms that occur in different parts of the radar set. They are useful for signal tracing. Wave-form charts are given in each of the following troubleshooting chapters.

g. Voltage and Resistance Charts. These charts show the normal voltage and resistance readings at all tube socket pins and other important test points. They are helpful in tracing trouble to a specific part. Voltage and resistance charts are given in each of the following troubleshooting chapters.

h. Color Codes. Resistor (fig. 209), capacitor (fig. 210), and transformer color codes are provided to enable the repairman to identify parts.

i. Component Views. Top, bottom, side, front, back, partial, and exploded views of components are provided. Enough call-outs are included to enable the repairman to find and repair any electrical or mechanical part.

j. Alinement Chart (fig. 221). This chart gives a comprehensive view of the entire alinement procedure. The experienced repairman can use it as a reminder of the alinement parameters.

k. Final Test Chart (fig. 222) This chart gives a comprehensive view of the entire final testing procedure. The experienced repairman can use it as a reminder of the final testing parameters.

103. List of Test Equipment

Name of equipment and nomenclature	Figure	Purpose	TM or USAF No.
Directional Coupler CU-78/UP	-----	-----	
Test Set TS-147/UP	90	Measure magnetron frequency, power level.	TM 11-1247.
Frequency Meter TS-328/U	91	Check 400 cps	
Crystal Rectifier Test Set TS-268/U	92	Test crystal rectifiers	TM 11-1242.
Radio Frequency Indicator TS-446/U	93	Test for rf	
Voltage Divider TS-265/UP	94	Enable high-voltage pulses to be observed on scope.	TM 11-1241.
Signal Generator TS-452A/U	95	If. alinement	
Fluxmeter TS-15B/AP	96	Test magnet	TM 11-2559.
Range Calibrator TS-102A/AP	97	Calibrate range marks	
Square Wave Generator TS-583A/U	98	Test stc and other amplifiers	TM 11-5024.
Radio Frequency Test Load TS-108A/AP	99	-----	
Spectrum Analyzer TS-148/UP	100	Measure magnetron frequency	TM 11-1249.
Electron Tube Test Set TV-7/U	101	Test tubes	TM 11-5083.
Oscilloscope TS-34A/AP	102	View wave forms	TM 11-1067A.
Test Set AN/GPM-1 Oscilloscope TS-239/UP	103	Depot maintenance	TM 11-1080. TM 11-1260.
Audio Oscillator TS-382A/U	104	-----	TM 11-2684A.
Tube Tester TV-2/U	-----	-----	
Multimeter TS-352/U	105	-----	TM 11-5527.
Signal Generator I-222A	106	-----	TM 11-1082.
Electronic Multimeter TS-505/U	107	-----	TM 11-5511.

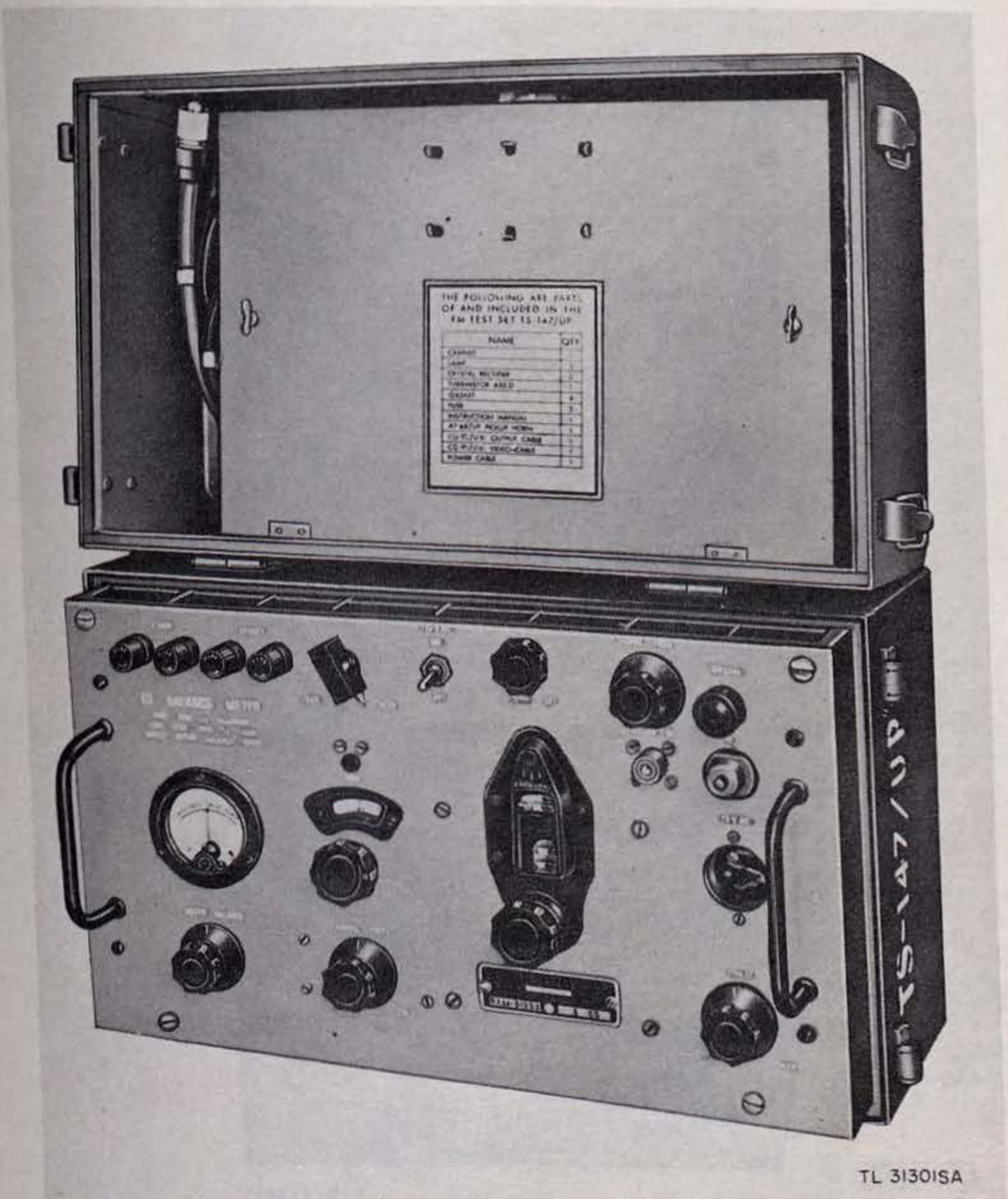


Figure 90. Test Set TS–147/UP.

Figure 91. Frequency Meter TS-328/U.

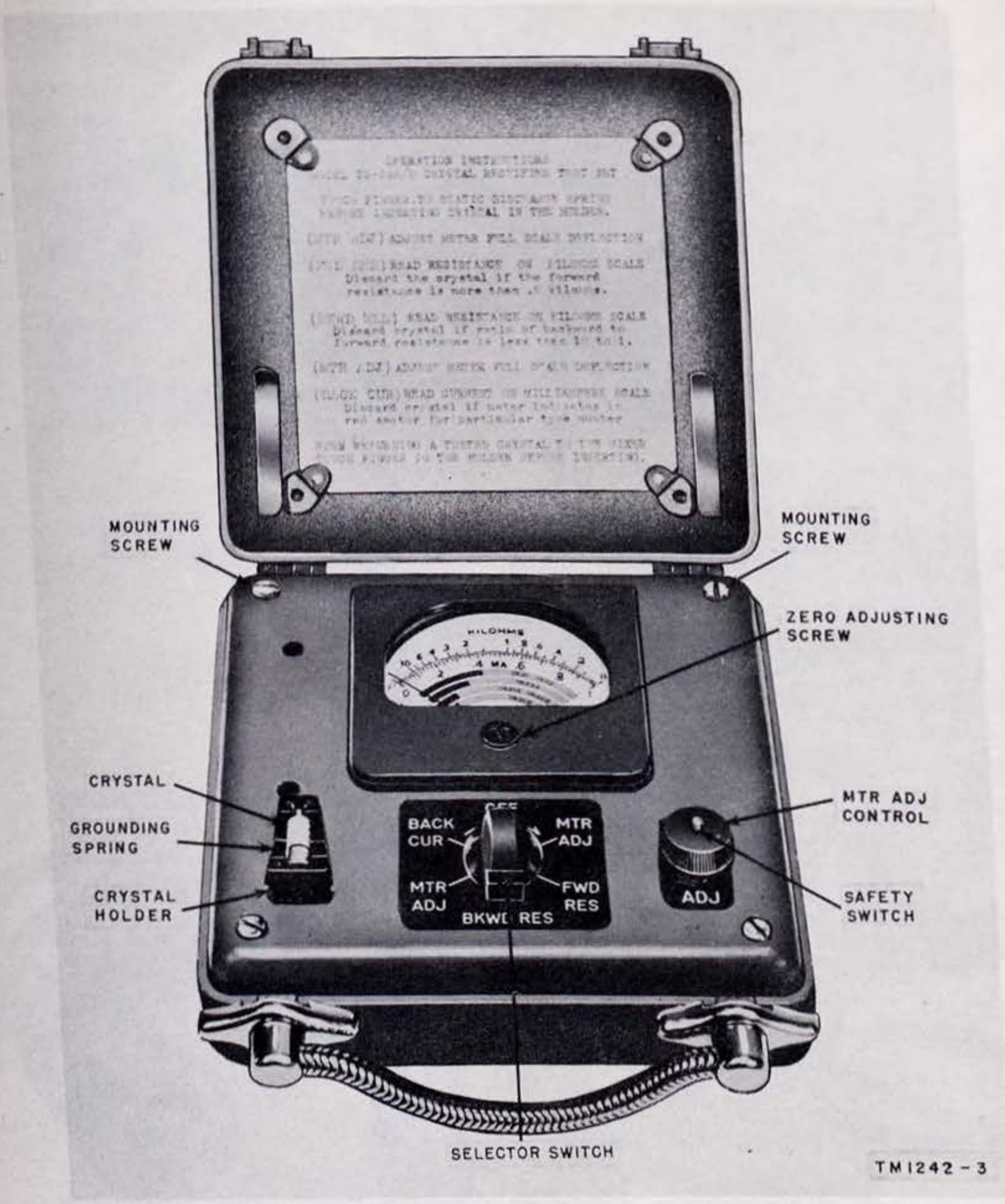


Figure 92. Crystal Rectifier Test Set TS-268/U.

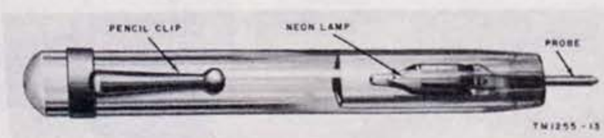


Figure 93. Radio Frequency Indicator TS-446/U.

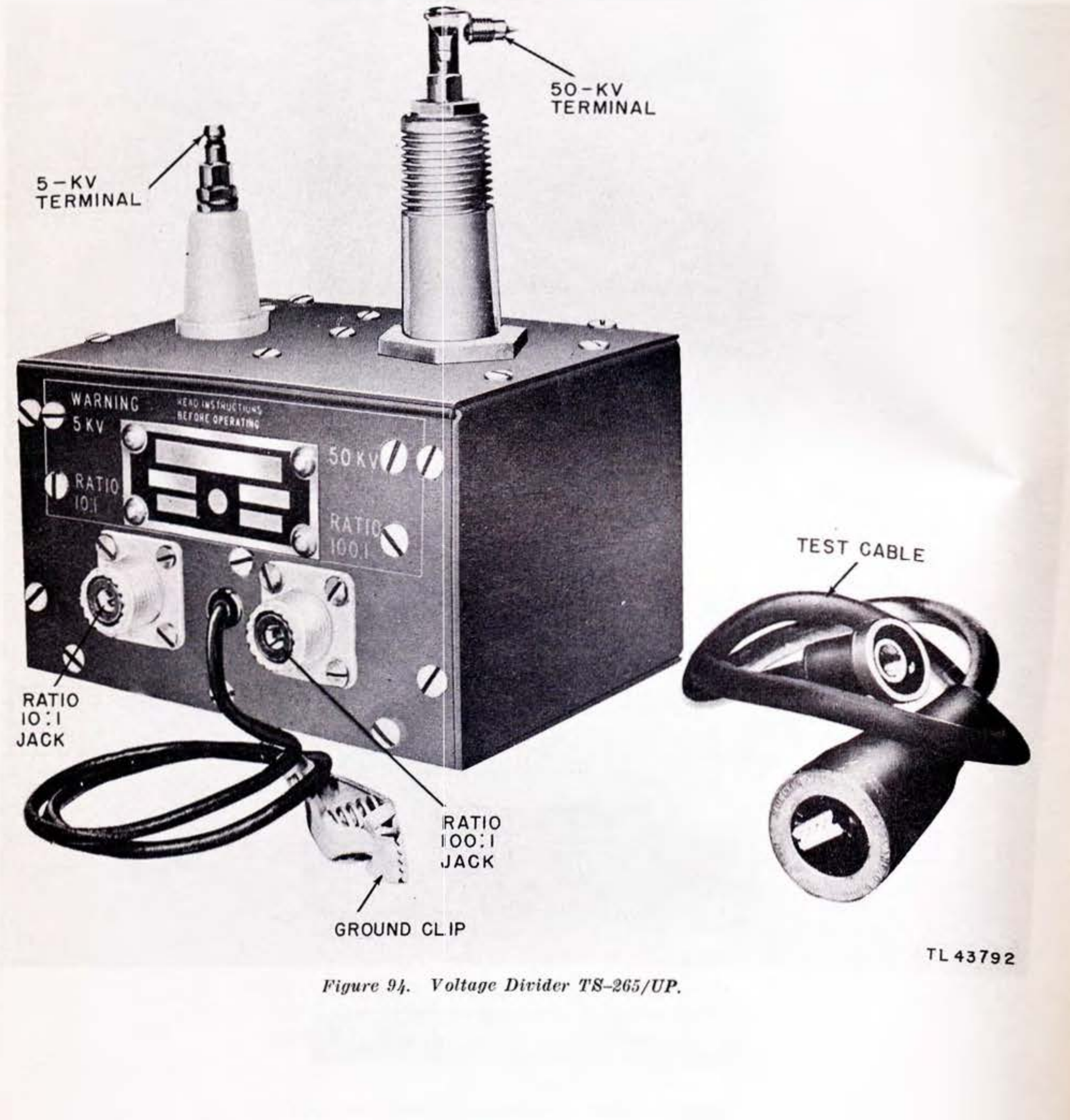


Figure 94. Voltage Divider TS-265/UP.

Figure 95. Signal Generator TS–452A/U.

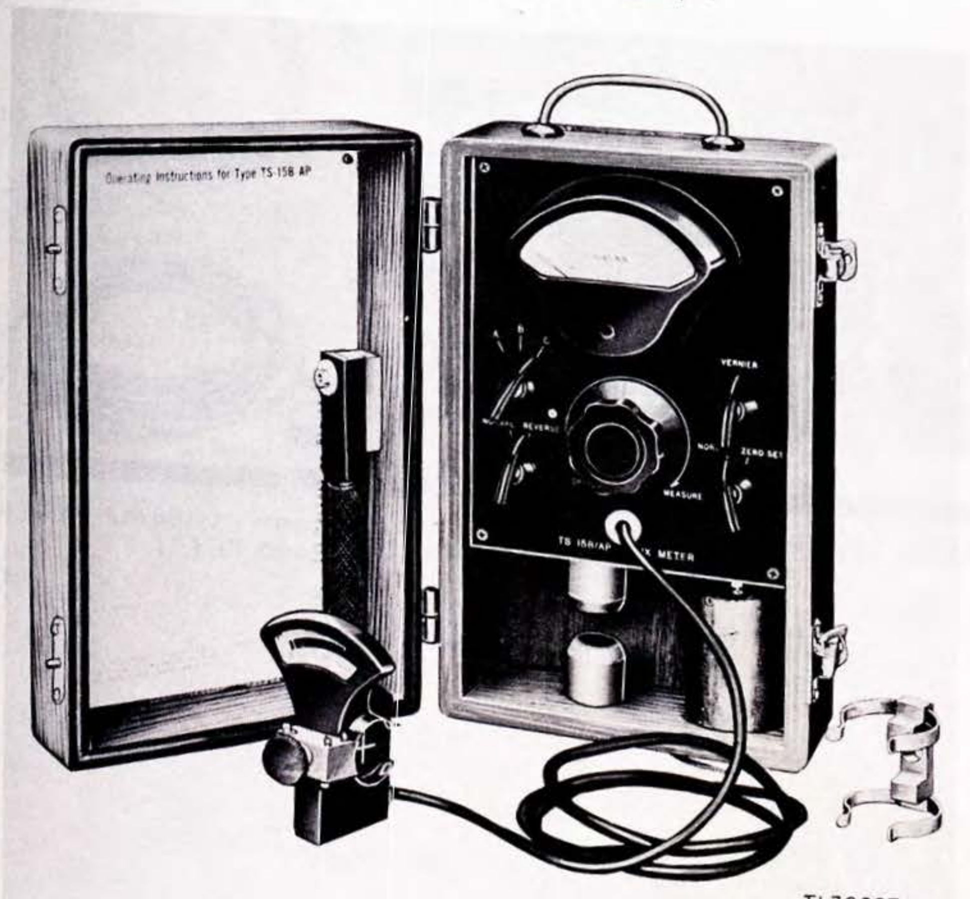


Figure 96. Fluxmeter TS–15B/AP.

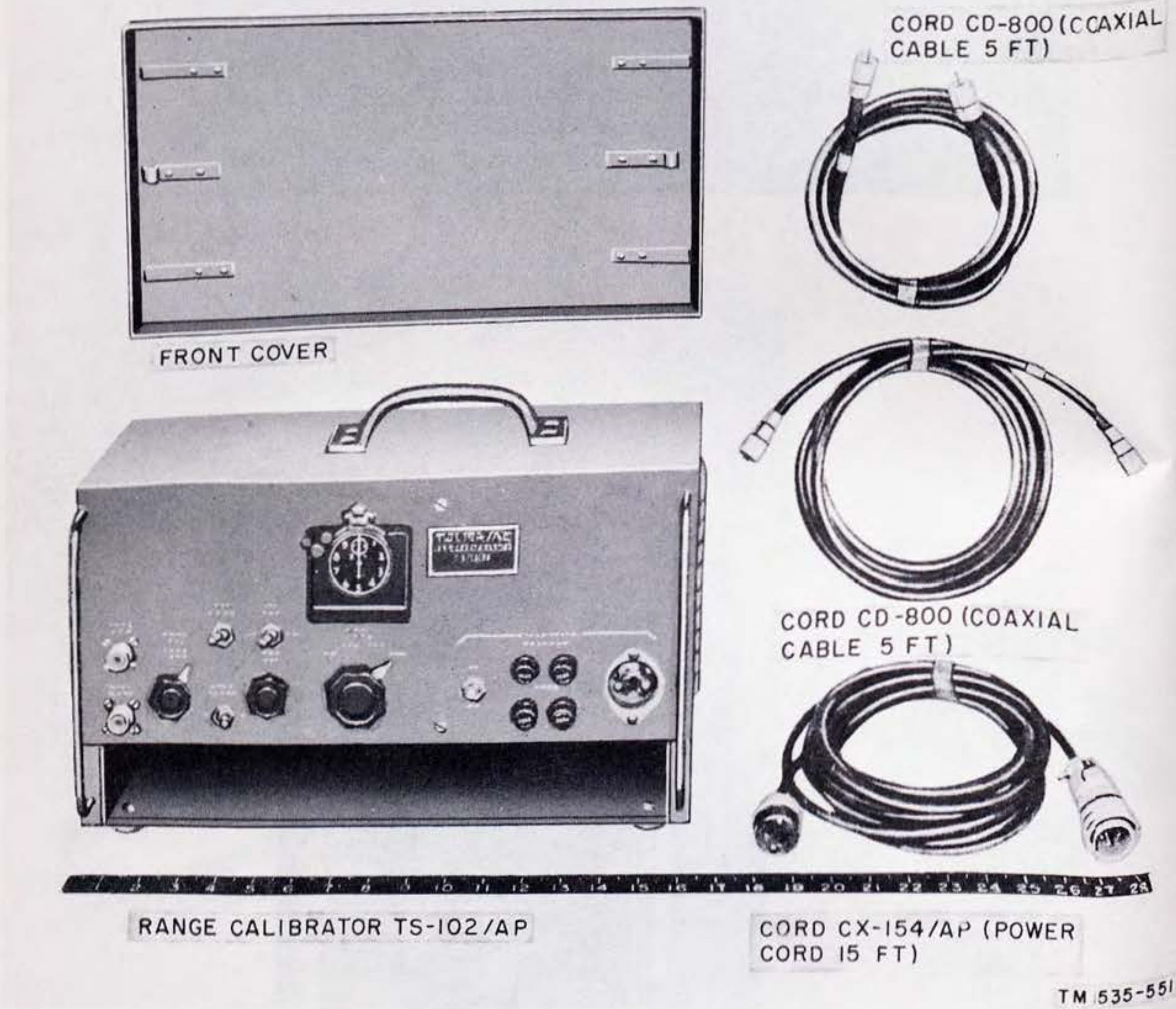


Figure 97. Range Calibrator TS-102/AP.

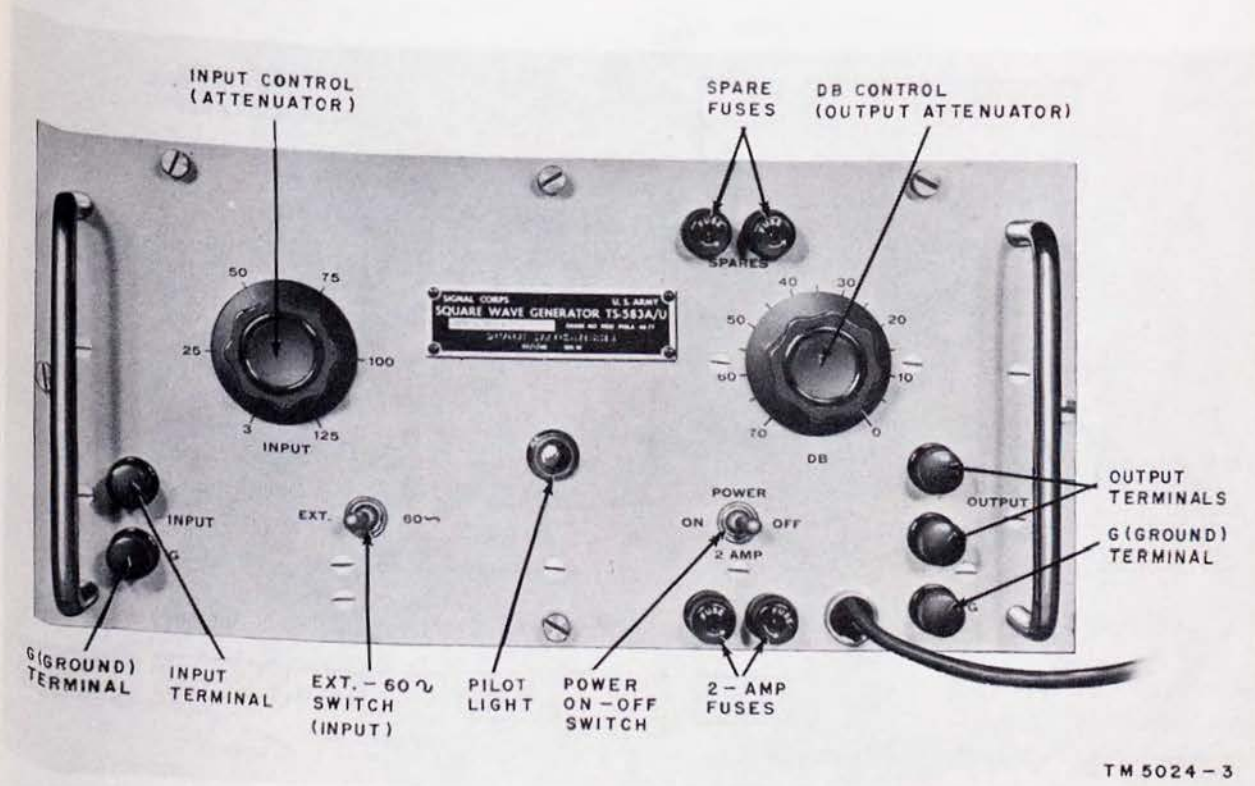


Figure 98. Square Wave Generator TS–583A/U.

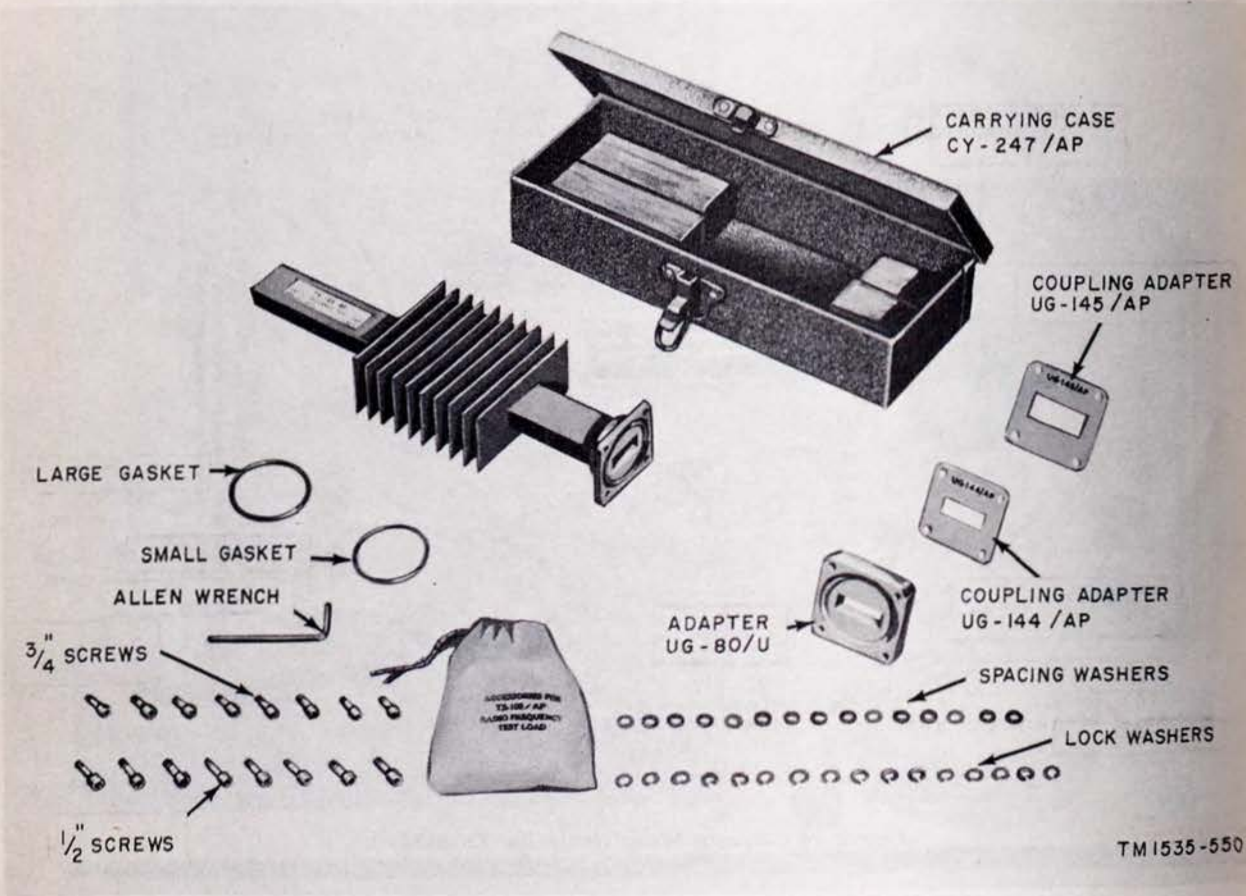


Figure 99. Radio Frequency Test Load TS-108/AP.

Figure 100. Spectrum Analyzer TS–148/UP.

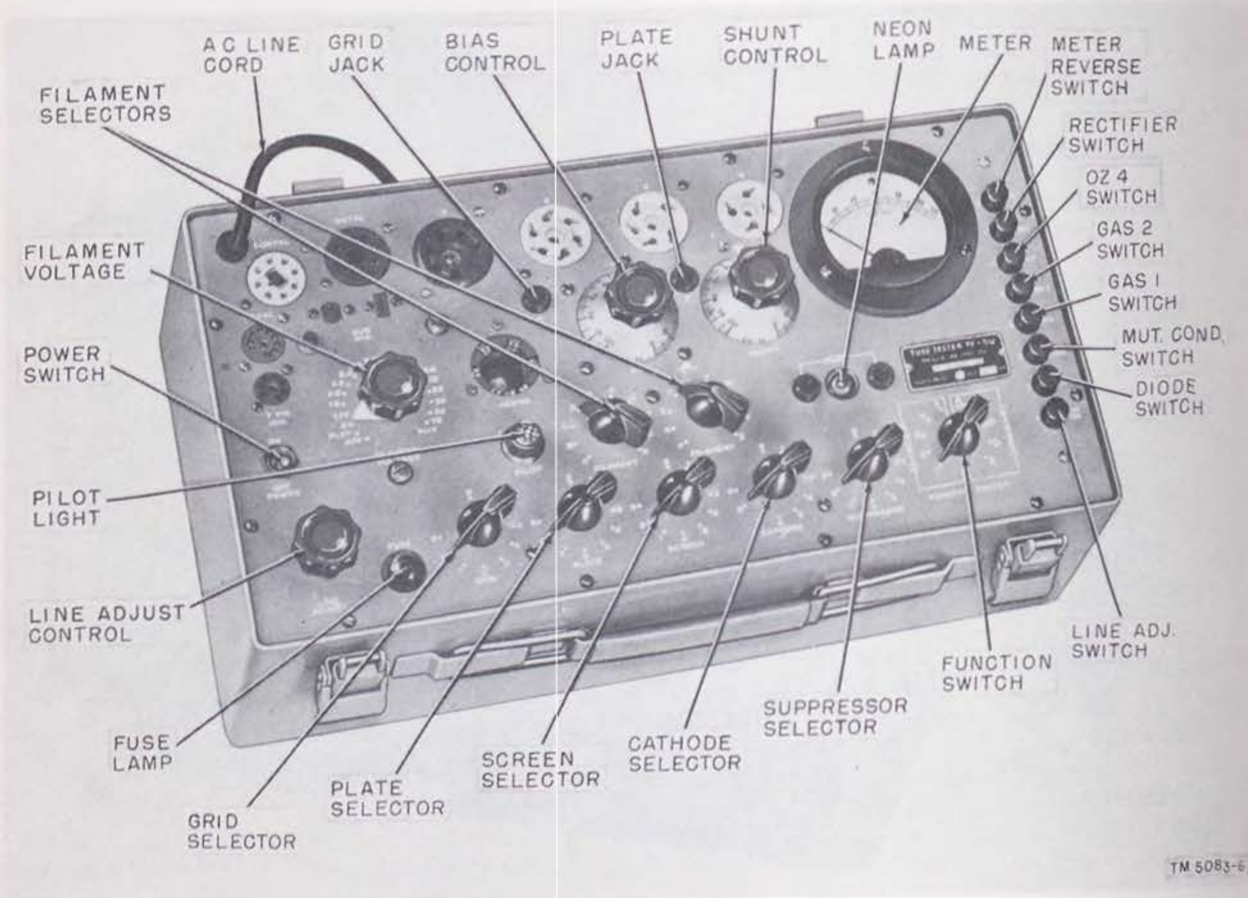


Figure 101. Electron Tube Tester Set TV–7/U.

Figure 102. Oscilloscope TS-34A/AP.

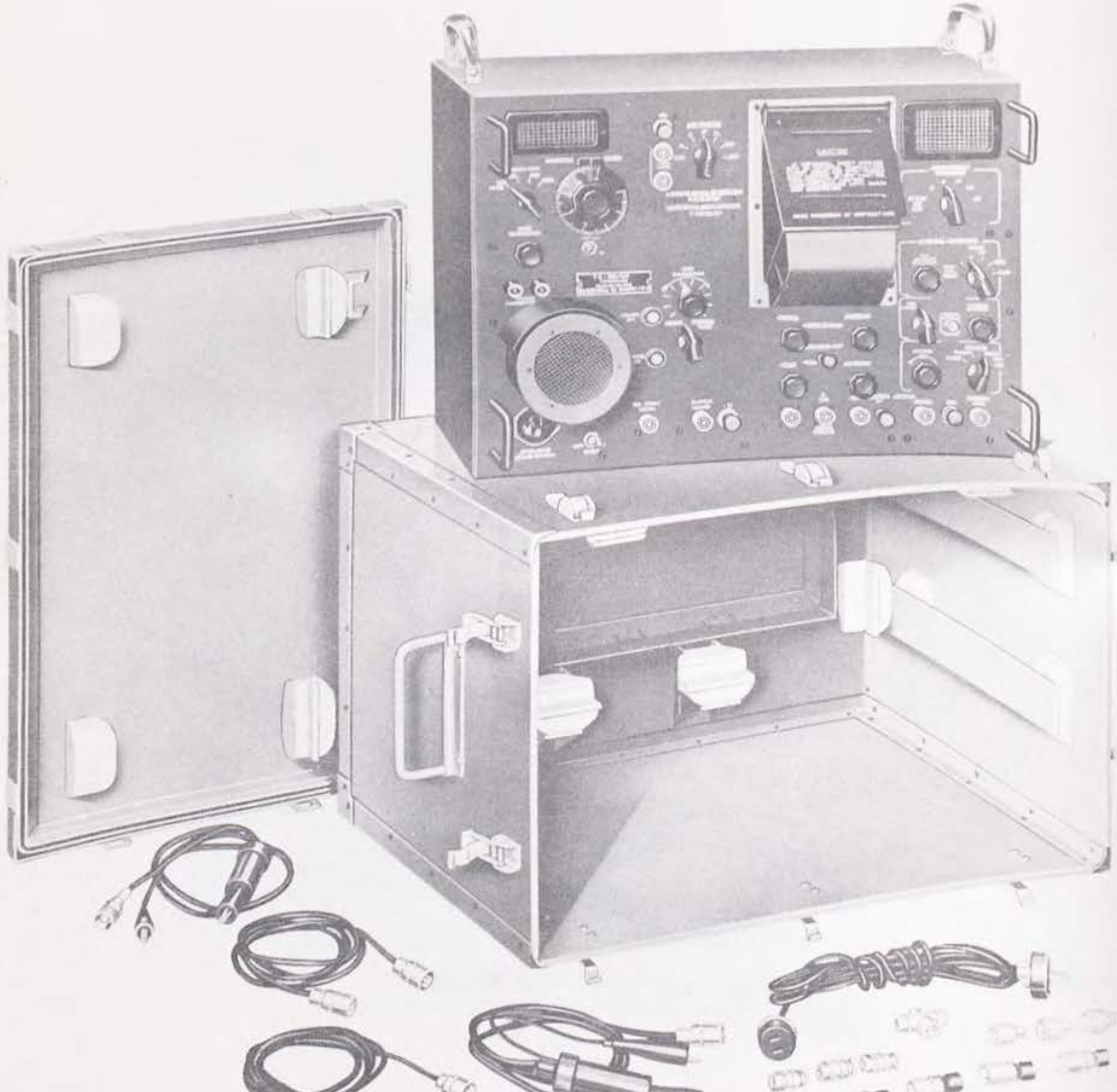


Figure 103. Oscilloscope TS-239/UP.

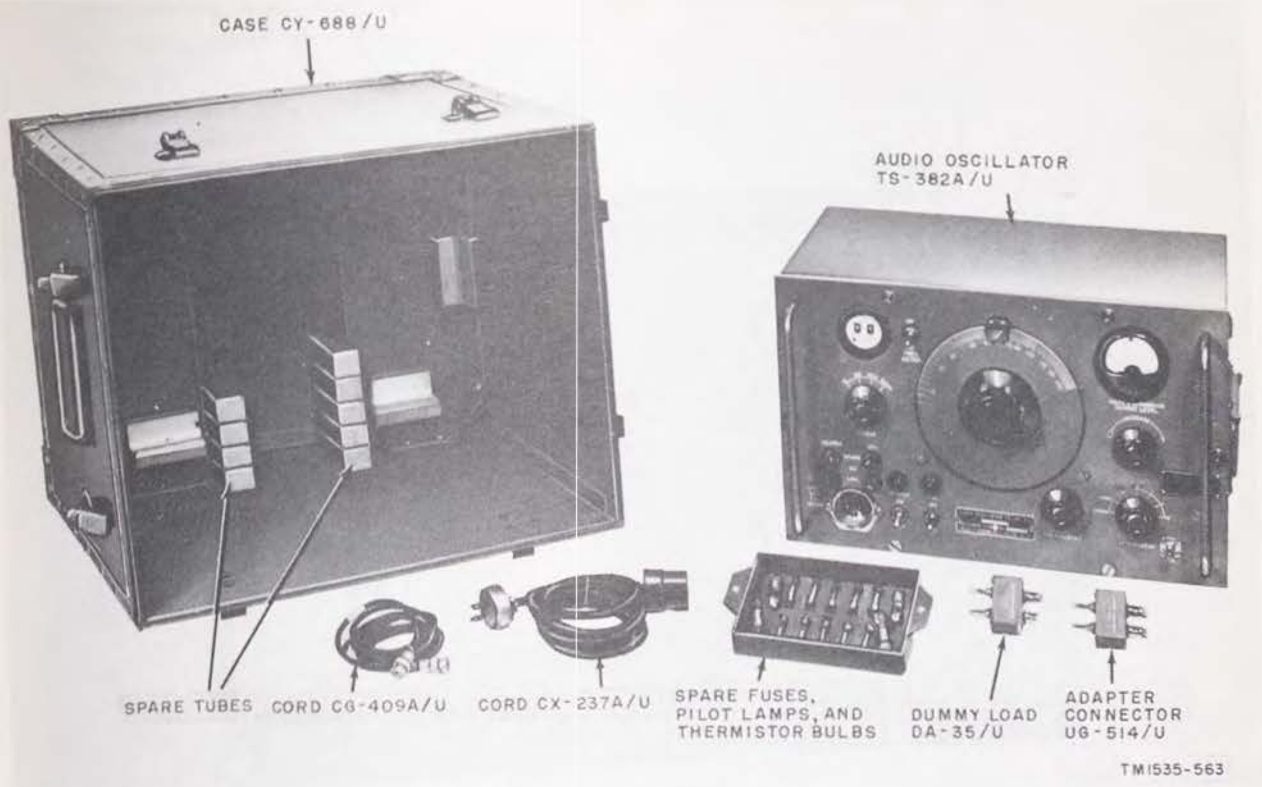


Figure 104. Audio Oscillator TS-382A/U.

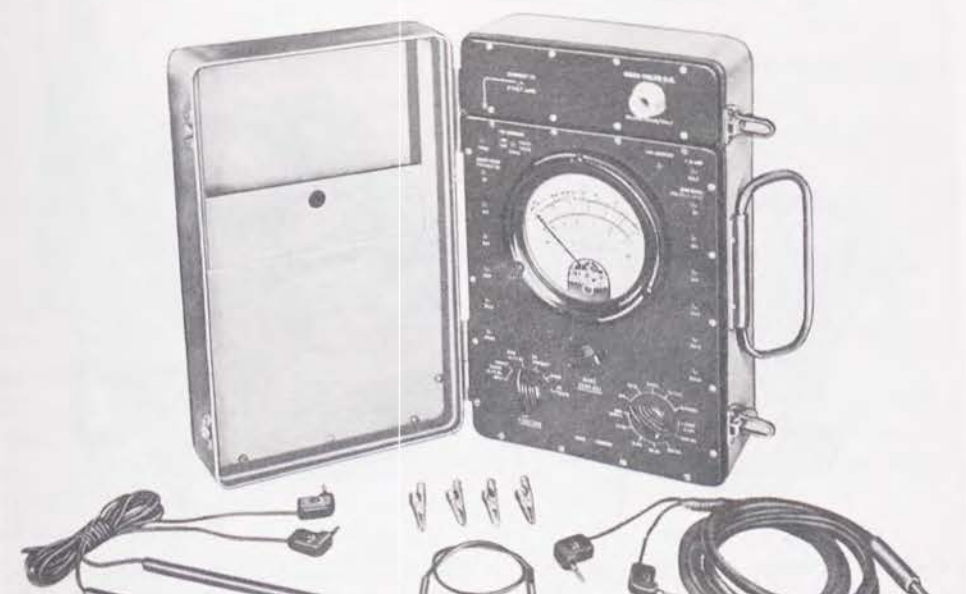


Figure 105. Multimeter TS-352/U.

Figure 106. Signal Generator I–222A.

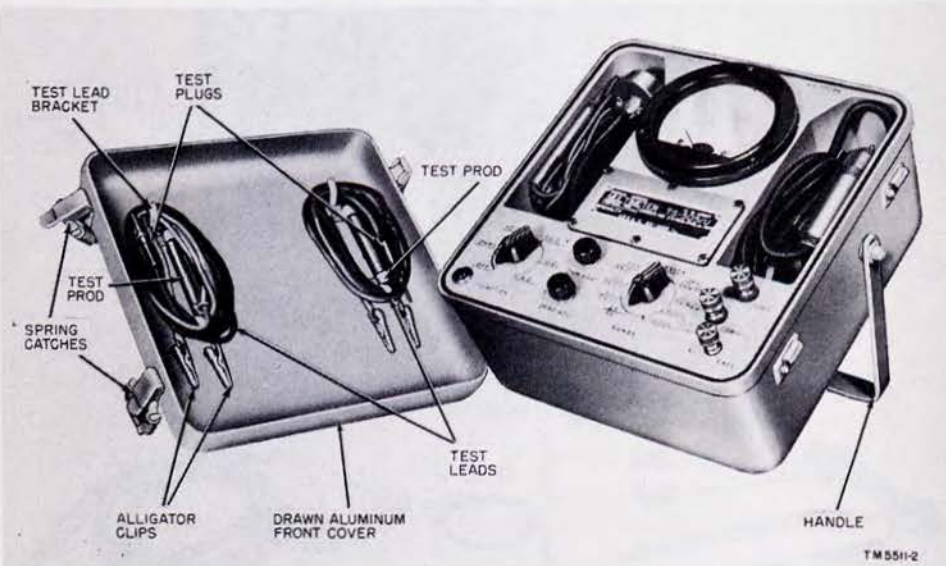


Figure 107. Electronic Multimeter TS–505/U.

104. Tools

a. Tools Supplied With Radar Set.

(1) A wave-guide clamp spanner wrench (fig. 108) (stock No. 6R57534–1) is used to loosen or tighten the wave-guide clamp on the receiver-transmitter. The wrench is attached to the side of the lower duct (fig. 18).

TM 1535-589

Figure 108. Wave-guide clamp wrench.

(2) An Allen wrench (stock No. 6R57400–6) is used to adjust the indicator synchro alinement cam. The wrench is located in the indicator (fig. 58).

(3) A klystron and crystal tool (stock No. 6R38472–1) is used to adjust the tuning strut on the klystron local oscillator and to remove the signal and afc crystals from their holders.

(4) A spark gap gage, which is used to adjust the size of the spark gap, is mounted on each spark gap (fig. 121).

b. Tools Not Supplied. Tools shown in figures 109, 110, and 111 are especially helpful in troubleshooting. The following are not supplied:

(1) Pliers, stock No. 6R4765–5.3
(2) Pliers, stock No. 6R4764–5.7
(3) Pliers, stock No. 6R4764–15.5
(4) Gage, stock No. 6Q45701.15
(5) Tool Equipment TE–113
(6) Moisture and Fungus Proofing Kit MK–2/GSM
(7) Tool Equipment TE–114
(8) Tool Equipment TE–73 (revised)
(9) Flashlight MX–991/U
(10) Lantern MX–290/CV

105. Improvised Tools

Certain improvised tools (fig. 112), necessary for maintenance of the power group, must be constructed by the repairman in the field. Dimensions on tools No. 1 and No. 3 are approximate. The construction of these tools is described in *a* through *d* below.

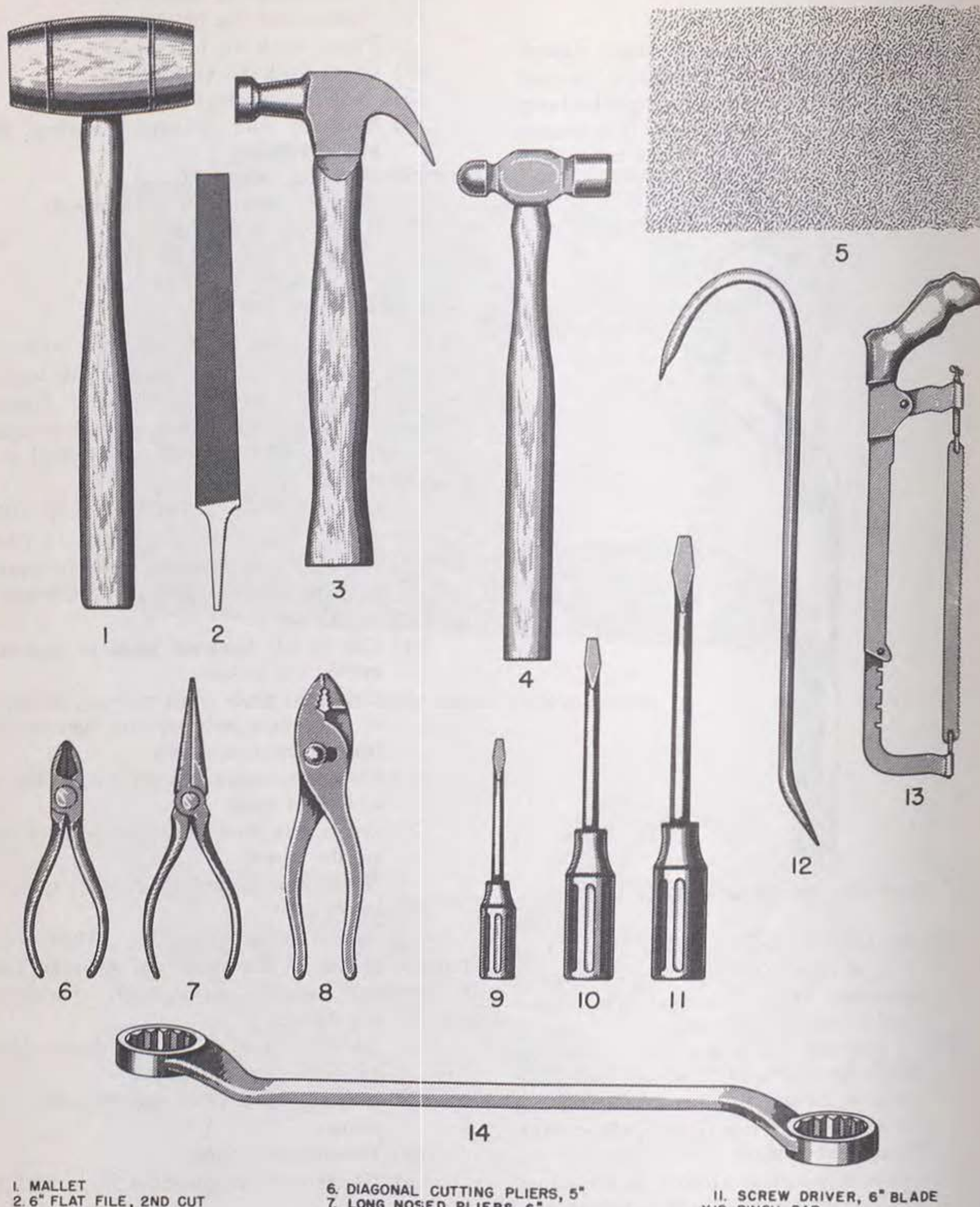
a. Commutator Undercutting Tool (1, fig. 112). The commutator undercutting tool is used for undercutting the mica insulation between the copper bars of the commutators (par. 215). Construct the tool as follows:

(1) Cut an old hacksaw blade to approximately 4½ inches.
(2) Grind the blade down to the exact width of the space between the commutator bars on the commutator.
(3) Cut a slot approximately 1 inch deep in a block of wood.
(4) Insert the blade into the slot of the wooden block.
(5) Wrap the joint with friction tape or heavy cord.

b. Bearing Remover (2, fig. 112). The bearing remover is used in the removal of bearings from the end bell assemblies (par. 244*b*). Construct the tool as follows:

(1) Obtain or make a wooden dowel about 1³⁄₁₆ inches in diameter.
(2) Cut the dowel to approximately 12 inches.
(3) Remove all splinters.
(4) Use the tool as described in paragraph 249.

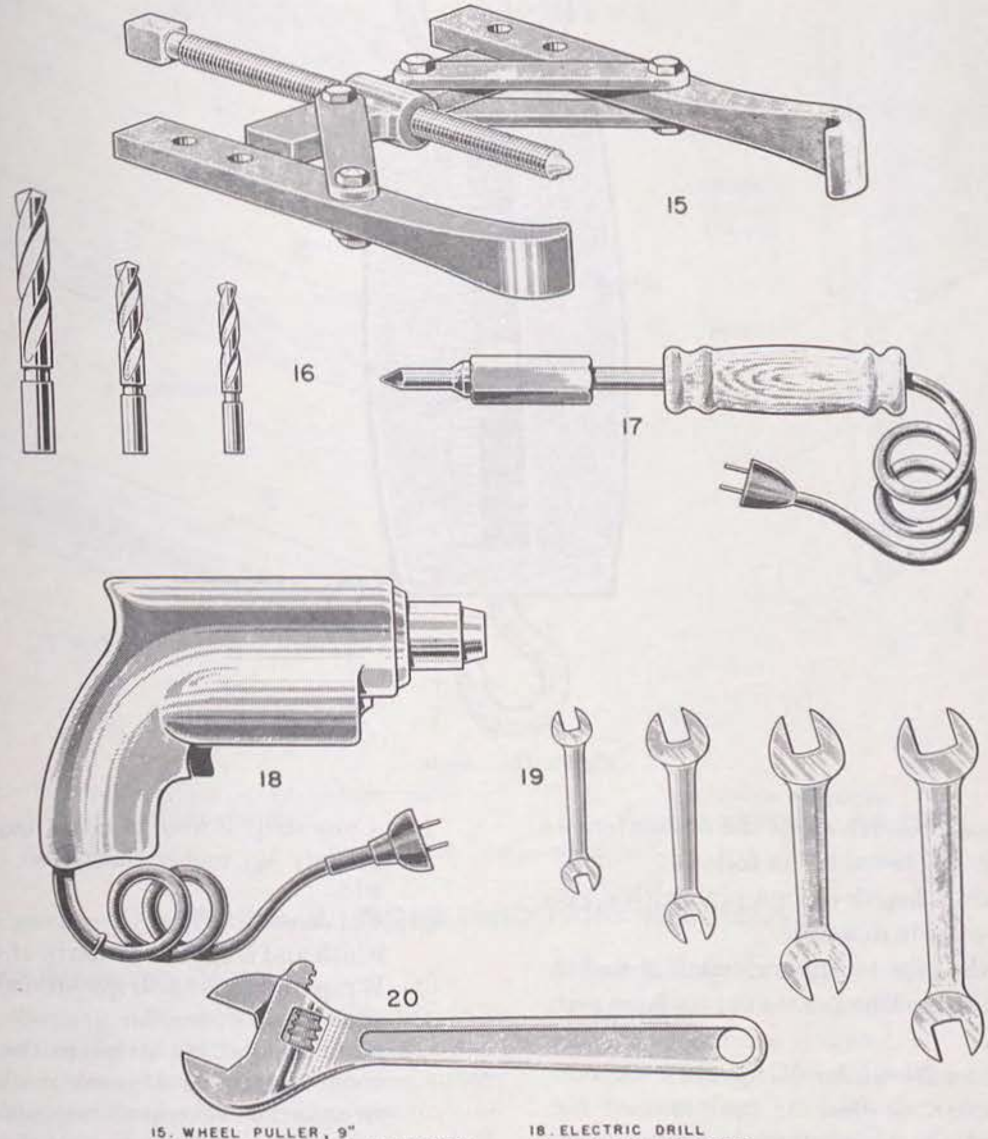
c. Bearing Inserter (3, fig. 112). The bearing inserter is used for inserting a bearing in the end bell bearing housing (par. 245). The tool prevents damage to the bearing or the housing by



1. MALLET
2. 6" FLAT FILE, 2ND CUT
3. CLAW HAMMER
4. BALL PEEN HAMMER
5. SANDPAPER, NO."0000"
6. DIAGONAL CUTTING PLIERS, 5"
7. LONG NOSED PLIERS, 6"
8. SLIP-JOINT PLIERS, 6"
9. SCREW DRIVER, 3" BLADE
10. SCREW DRIVER, 4" BLADE
11. SCREW DRIVER, 6" BLADE
*12. PINCH BAR
*13. HACK SAW
14. OFFSET BOX WRENCH, 1-5/16" X 1-1/2"

TM 5510-94

Figure 109. Representative tools.



15. WHEEL PULLER, 9"
16. TWIST DRILLS, 1/4", 5/16", 17/32"
17. SOLDERING IRON
18. ELECTRIC DRILL
19. OPEN END WRENCHES, SIZES: 5/16", 11/32", 7/16", 1/2", 9/16", 13/16", 7/8"
20. OFFSET ADJUSTABLE WRENCH, 12"

TM 1535-450

Figure 110. More representative tools.

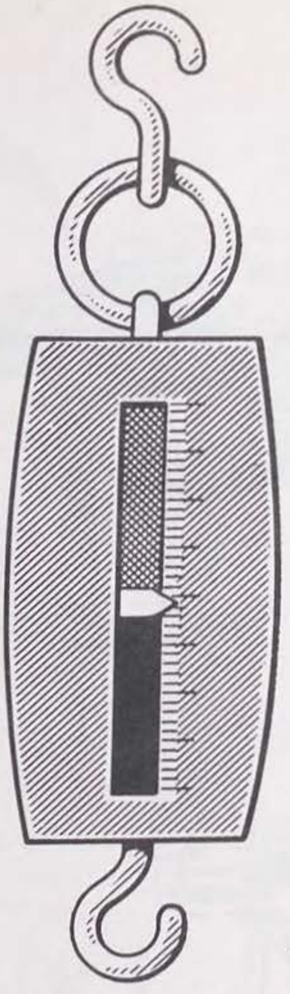


Figure 111. Scale.

providing equal pressure about the circumference of the bearing. Construct it as follows:

(1) Obtain a length of iron pipe with a $1\frac{1}{4}$-inch outside diameter.

(2) Cut the pipe to approximately 9 inches.

(3) Remove the burrs on the cut surfaces with a file.

d. Commutator Burnisher (4, fig. 112). A commutator burnisher, or cleaning tool, is used for maintenance of the commutator surfaces (par. 215). Construct the cleaning tool as follows:

(1) Cut a strip of wood 6 inches long, approximately $\frac{5}{16}$ inches thick, and $1\frac{1}{2}$ inches wide.

(2) Cut several strips of canvas, the same width and length as the strip of wood.

(3) Wrap the canvas strips around the end of the strip of wood.

(4) Rivet the canvas strips to the strip of wood. If rivets are not available, use wire, cord, or several strong rubber bands to hold the canvas strips on the strip of wood.

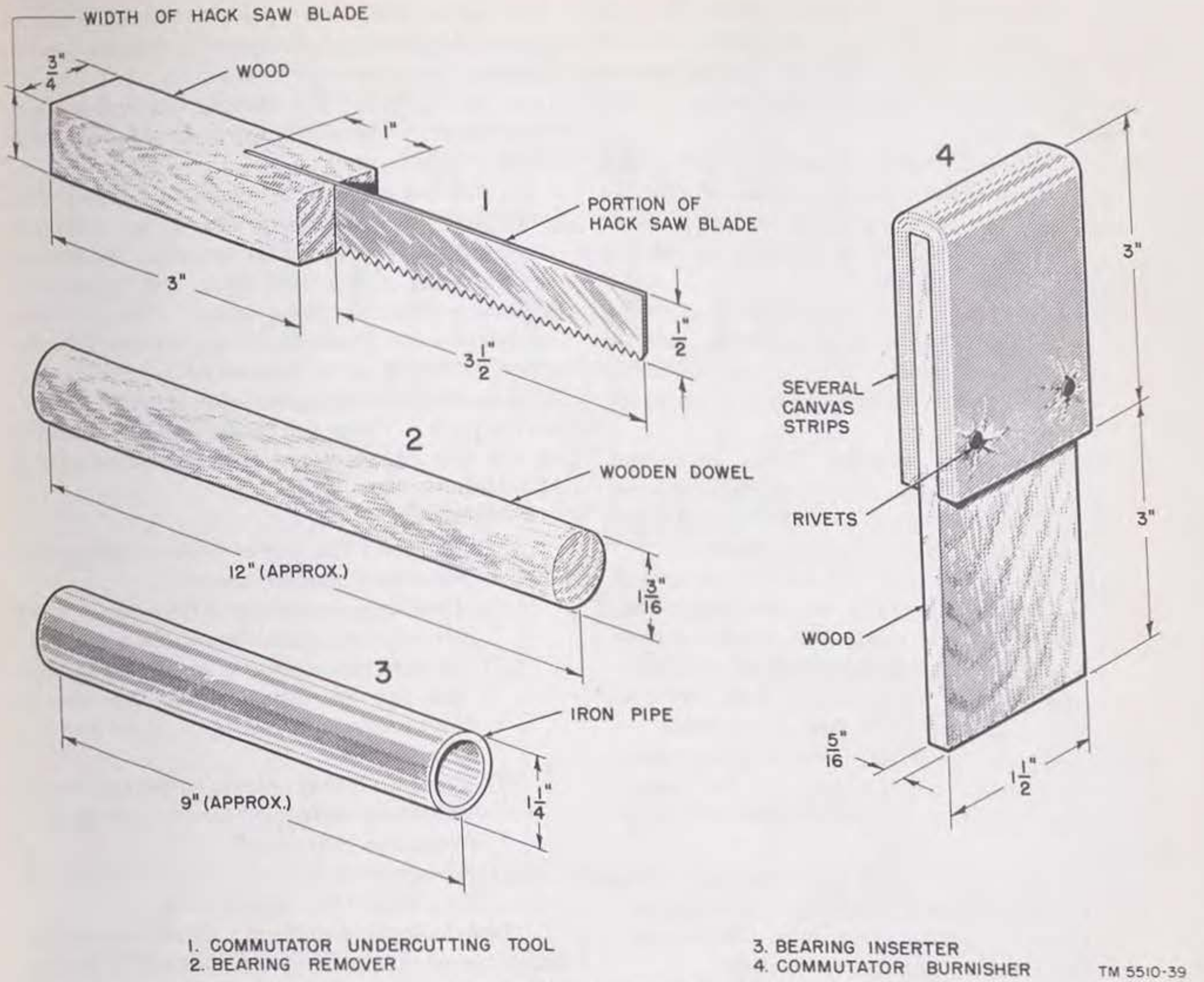


Figure 112. Improvised tools.

Section II. TROUBLESHOOTING PROCEDURES

106. Troubleshooting Steps

Troubleshooting methods, to be effective, depend on the functional organization of the radar set. The radar set is organized as follows: five major systems—transmitting, rf, receiving, synchronizing and indicating, and power—are each composed of two or more circuits; each circuit is broken down into stages; and each stage has many parts. The first step in troubleshooting is to sectionalize the fault to one of the major systems. Then the trouble should be traced to the defective circuits, to the inoperative stage, and finally, to the faulty part.

a. Sectionalizing the Fault to a System. The following methods of troubleshooting are useful in determining in which system the trouble lies. Paragraphs 114 through 116 contain a discussion of these procedures in detail.

(1) *Visual.* Check all fuses. Check meter readings. Watch for smoke that may indicate the location of shorted parts.

(2) *Starting procedure.* By logical reasoning, abnormal indications may be used to trace the breakdown to the system and occasionally to the circuits in the system, responsible for the trouble.

(3) *Cable continuity.* Check continuity of cables with an ohmmeter to determine if trouble lies in a system or in the cables that connect the systems.

b. Tracing Fault to Group of Circuits or to a Stage. After the fault has been traced to a system, refer to the appropriate troubleshooting chapter, where the following information will be found:

(1) *General troubleshooting chart.* This chart gives probable cause of troubles that are often encountered, but it is not foolproof. Further testing is almost always necessary.

(2) *Tube and crystal troubleshooting charts.* These may lead directly to the tube or crystal at fault. Always test the tubes and crystals before assuming they are faulty.

(3) *Wave-form tracing.* This procedure often can lead the troubleshooter, not only to the stage at fault, but to bad parts around a pin on the tube socket.

(4) *Terminal boards.* The terminal boards on the bottom of the receiver-transmitter are useful in tracing faults in the power system. They are also helpful in checking gain, stc, and heading flash circuits. Check the terminals with a voltmeter.

c. Pinning the Fault Down to a Part. The tube, crystal, resistor, capacitor, coil, or transformer at fault can be determined by the following procedures.

(1) *Voltage and resistance reading.* Use the voltage and resistance charts to determine normal readings. Abnormal readings indicate defective parts.

(2) *Tube checking.* Use the tube tester to check any tubes that the tube troubleshooting chart indicates may be defective.

(3) *Crystal checking.* Use the crystal rectifier test set to test any crystals that the crystal troubleshooting chart indicates may be defective.

d. Intermittents. When all the above procedures have proved ineffective, check the equipment for intermittents. Jarring suspected parts, or tapping the chassis, may help in determining the trouble.

107. Voltage and Resistance Readings

Voltage and resistance measurements are an almost indispensable aid to the repairman, because most troubles produce voltages or abnormal resistance readings. Voltage readings are usually taken first since they enable the repairman to isolate the trouble more quickly than resistance readings. However, an incorrect voltage reading across a part does not necessarily mean that that part is at fault. The trouble might lie in a related part. Therefore, the final check should be with an ohmmeter.

a. Normal Values. Normal voltage and resistance readings are given in the voltage and resistance charts. These values are measured between socket pins, plugs, and other test points, and ground, unless otherwise stated. Remember that socket pins are numbered in a clockwise direction when viewed from the bottom of the chassis. On octal sockets, the first pin clockwise from the keyway is pin 1. Plugs and receptacles are numbered on the side to which the associated connector is attached.

b. Cautions.

(1) Turn off the power before making any resistance measurements.

(2) Discharge capacitors with a screwdriver before making resistance measurements.

(3) Be sure the voltmeter used has the same ohm-per-volt rating as that indicated in the voltage and resistance chart you are using.

(4) Be sure all the controls on the equipment are set as instructed in the voltage and resistance chart used.

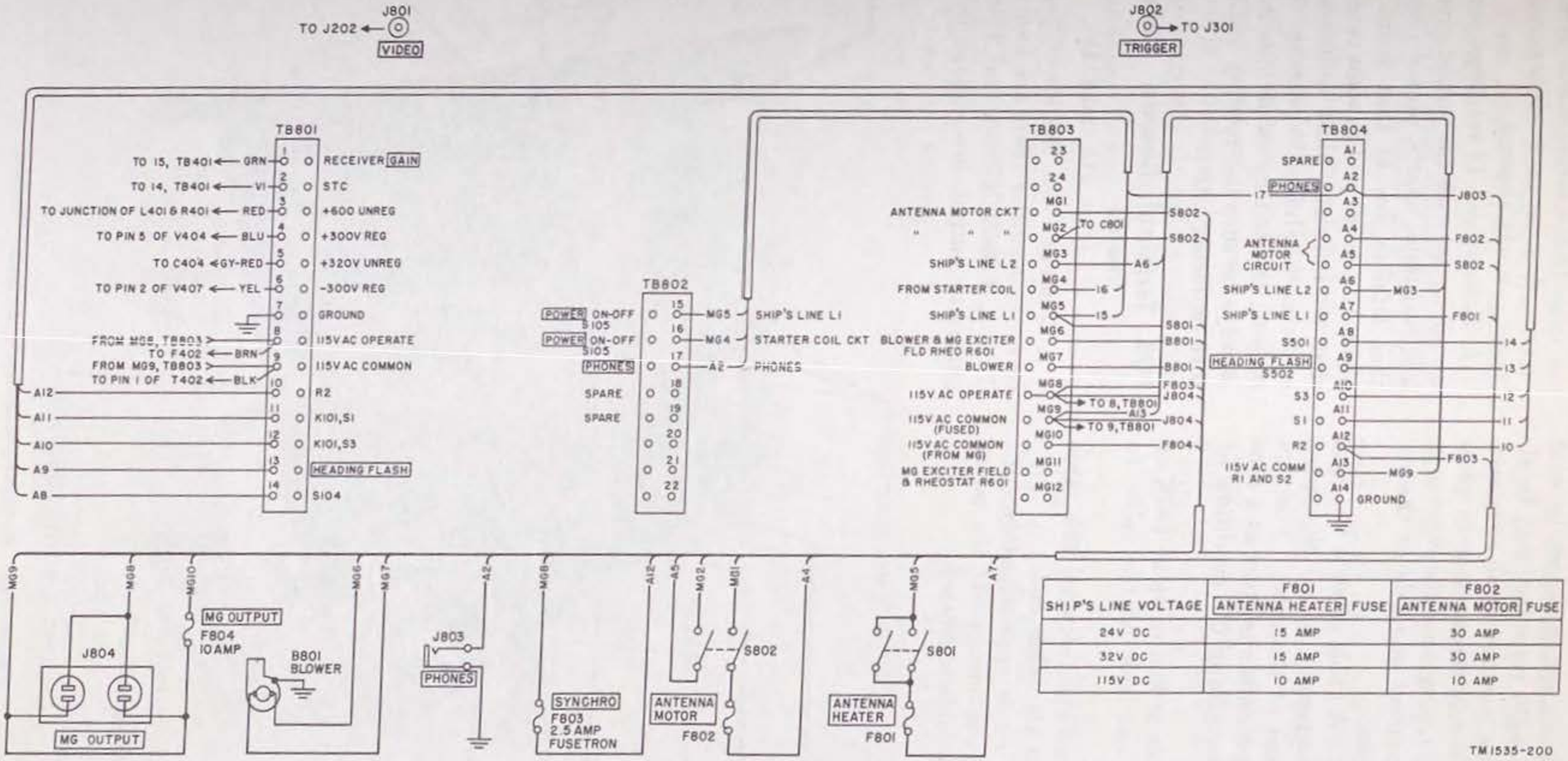
(5) Always turn the voltmeter to the highest scale before taking a reading.

c. High-Voltage Readings. When measuring voltages greater than 300 volts, shut off the power. Then, connect the hot test lead, step away from the voltmeter, turn on the power, and note the reading on the voltmeter. Do not touch any part of the voltmeter, particularly when measuring the voltage between two points that are above ground.

d. Readings Between Points Not in Charts.

(1) To find the voltage between points A and B, subtract the voltage given for point A to ground from the voltage given for point B to ground. If the voltage at pin 2 of the socket is given as 500 volts and that at pin 5 as 300 volts, the voltage between pins 2 and 5 should be 200 volts.

(2) To find the normal resistance between any two points, refer to the schematic. Be careful to include the effect of resistors, or coils, in parallel. For instance, a look resistor might be connected between two points. However, the schematic



SHIP'S LINE VOLTAGE	F801 ANTENNA HEATER FUSE	F802 ANTENNA MOTOR FUSE
24V DC	15 AMP	30 AMP
32V DC	15 AMP	30 AMP
115V DC	10 AMP	10 AMP

Figure 113. Receiver-transmitter, terminal boards and convenience panel, schematic.

might show that a coil is in parallel with it. Since the coil's resistance may be almost negligible, practically no resistance will be read across the resistor in question. To find the value of the resistor in question, disconnect one side of the resistor under test.

e. Cable Continuity. A cable often is too long to be measured for continuity by an ohmmeter with leads at either end of the cable. For this reason, the following procedure is given as a convenient method of determining the condition of the cable.

(1) Place a resistor of known value (50K or more) from one end of the cable to ground.

(2) Place an ohmmeter between the cable and ground at the other end.

(3) If the meter reads approximately 50K, the cable has continuity. If the meter reads zero, the cable is shorted.

(4) If the meter reads much less than 50K, but not necessarily zero, the cable is partially shorted.

f. Tolerances. If readings obtained at a point do not agree with the values given in the voltage and resistance charts, do not immediately assume that trouble lies at that point. Variations of about 10 percent and in some cases even more than that are normal. Most resistors in the set have a tolerance value of 10 percent. Voltage readings may be affected by variations in the power line. Always be sure the reading indicates trouble before replacing parts.

108. Terminal Boards, Voltage Measurements

(figs. 113 and 114)

a. General. On the lower portion of the receiver-transmitter there are four terminal boards, TB801, TB802, TB803, and TB804. The motor generator output, low-voltage power supply out-

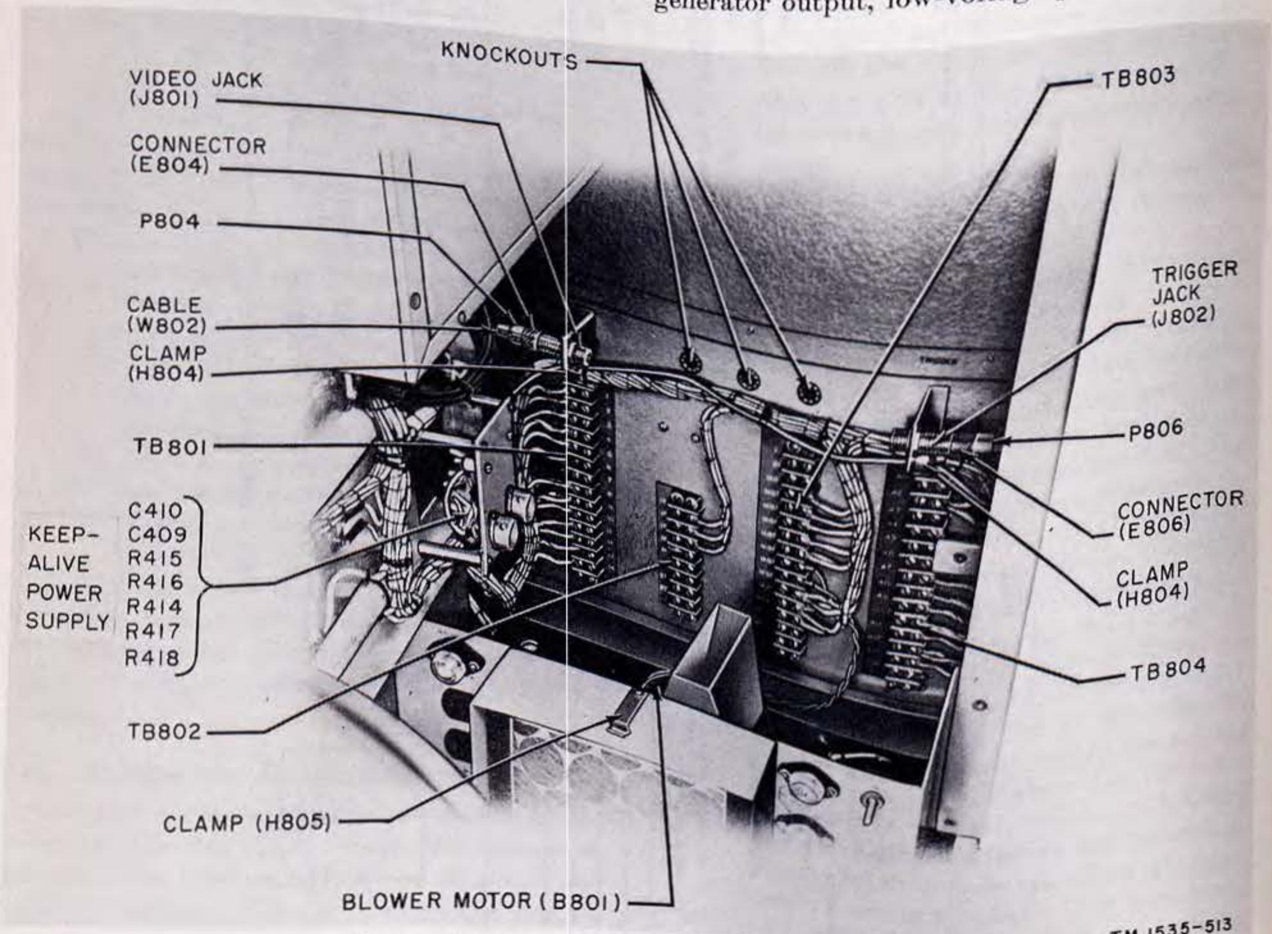


Figure 114. Receiver-transmitter, terminal boards.

puts, and intercircuit voltages are connected at these boards for distribution throughout the radar set. Voltages at these terminals can be checked conveniently.

Warning: Be careful when checking voltages at the terminal boards. Voltages as high as 600 volts are present.

b. Tables. The following tables list the terminals, the voltage measured between the terminals, and a description of the voltage. Refer to figures 113 and 219 for the cable connections between these terminal boards and the components of the radar set. All voltages are dc unless otherwise stated.

(1) *Terminal board TB801.*

Terminals	Voltage	Description
1 and 7	0 to −60 V (depends on setting of R177).	Receiver gain.
2 and 7	0 to −200 V (depends on setting of R181).	Stc bias.
3 and 7	+600 V	Plate supply.
4 and 7	+300 V	Plate supply.
5 and 7	+320 V	Plate supply.
6 and 7	−300 V	Grid bias supply.
9 and 8	115 V, 400 cps	Motor generator output.
10 and 8	0 V	Continuity across SYNCHRO fuse F803.
10 and 9	115 V, 400 cps	Input to synchros.
11 and 12		Output of S1 and S3 of B501.
13 and 9	0 (when S502 closed).	Continuity across heading flash cam switch S502.
14 and 9	0 (when S501 closed).	Continuity across synchro alinement cam switch S501.

(2) *Terminal board TB802.*

Terminals	Voltage	Description
15 and 16	0 V (when S105 closed).	Continuity across POWER switch S105.
17		Continuity to PHONES jacks.
18 to 22		Spares.

(3) *Terminal board TB803.*

Terminals	Voltage	Description
MG1 and MG2.	115 V, 32 V, or 24 V.	Ship's line voltage to antenna drive motor circuit.
MG3 and MG5.	115 V, 32 V, or 24 V.	Ship's line voltage to antenna heaters.
MG5 and MG4.	0 V (with S105 closed).	Continuity across POWER switch S105.
MG4 and MG3.	115 V, 32 V, or 24 V.	Ship's line input to motor starter.
MG6 and MG7.	115 V, 32 V, or 24 V.	Ship's line voltage to blower motor and to motor-generator dc winding through R601.
MG8 and MG9.	115 V, 400 cps	Motor generator output.
MG9 and MG10.	0 V	Continuity across MG OUTPUT fuse F804.
MG11	Slightly less than 115 V, 32 V, or 24 V.	Ship's line voltage from voltage regulator to motor generator dc winding.
MG12		Spare.

(4) *Terminal board TB804.*

Terminals	Voltage	Description
A1		Spare.
A2		Continuity to PHONES jacks.
A3		Spare.
A4 and A5	115 V, 400 cps (with S802 closed).	Ship's line input to antenna drive motor, across ANTENNA MOTOR fuse F802.
A6 and A7	115 V, 32 V or 24 V (with S801 closed).	Ship's line input to antenna heaters fused by ANTENNA HEATER fuse F801.
A8 and A13	0 V (when S501 closed).	Continuity across synchro alinement cam switch.
A9 and A13	0 V (when S502 closed).	Continuity across heading flash cam switch.
A10 and A11		Output of S1 and S3 of B501.
A12 and A13	115 V, 400 cps	Input to B501, fused by SYNCHRO fuse F803.

109. Tube and Crystal Checking

Tube and crystal failures are responsible for a large percentage of the faults that occur in radar sets. Use the tube and crystal troubleshooting charts to determine which tubes may be at fault. Do not resort to indiscriminate tube changing.

a. When putting a new tube in a circuit, note the position of all controls before making any changes. If returning the controls with the new tube in the circuit does not correct the abnormal condition, return the controls to their original positions, and put the old tube back in the circuit, unless a tube test shows that the tube is bad.

Caution: In many radar circuits, the interelectrode capacitance of a tube is a part of a tuned circuit. When tubes are switched, the tuning of the circuits is upset. If too many tube substitutions are made, the set may become seriously misalined.

b. When replacing a tube in a circuit, decide at once whether or not to keep the old tube. Do not change the tubes indiscriminately, or the spares box will become full of tubes the exact age and condition of which are uncertain.

c. Tube Tester TV–7/U is used to check for shorted elements, emission, and mutual conductance of small tubes. The tube tester will not test the performance of high-voltage tubes or rectifiers or of some special tubes in the transmitter circuits. Tube testers are useful, however, for checking receiving tubes that are used in the various components. Results obtained from a tube tester are not always conclusive, because the conditions are not the same as those under which the tube operates in the set. For this reason, the final test of a tube must be its replacement with a tube that is known to be good. In many cases, it is quicker and more reliable to replace a suspected tube with a good one than to check it with the tube tester.

d. Use the crystal rectifier test set to test for front and back resistances and back current of crystals. The front resistance should not be above 500 ohms; the back-to-front ratio should not be less than 10:1. Remember, when replacing crystals, hold the crystal by the body and touch one finger to the radio chassis before placing the crystal in its socket.

110. Wave-Form Checking

a. General.

(1) Wave forms may be observed at the various test jacks and at other points in the equipment by using Oscilloscope TS–34A/AP or TS–239/UP. By comparing the observed wave form with the actual reference wave form shown in the troubleshooting chapters, faults can be localized rapidly.

(2) A departure from the normal wave form indicates a fault located between the point where the wave form was last normal and the point where it is observed to be abnormal. When the wave form at a certain test point is not correct, the fault is not necessarily in the circuit under test. The abnormal wave form may be caused by the absence of a triggering pulse from another circuit. The point at which to start signal tracing a component is at the input trigger plug.

(3) It sometimes is desirable to know whether a signal voltage is reaching the grid of the first tube in a channel. To determine this, when a test jack is not provided, remove the first tube in the channel involved, and insert the test lead of the oscilloscope into the grid connection of the tube socket.

b. Use of Oscilloscope TS–34A/AP. The use of this oscilloscope in viewing wave forms is explained in TM 11–1067A. The essential points of the procedure are given below:

(1) Place SWEEP SELECTOR switch in the STOP-START position if the pulse is more than 280 microseconds long, place the SWEEP SELECTOR switch in the SAWTOOTH position.

(2) Place the SWEEP SPEED COARSE switch in the MED position.

(3) Place the INPUT IMPEDANCE switch in the HIGH 40DB position.

(4) For viewing most signals in the radar set, synchronize the oscilloscope with the radar trigger pulse. Connect TRIGGER jack J302 in the receiver-transmitter to EXT SYNC jack on the oscilloscope with the aid of Coaxial Cord CG–72/U.

(5) Place INT SYNC-EXT SYNC switch in the EXT SYNC position. If radar trigger pulse is not used for synchronization, place INT SYNC-EXT SYNC switch in the INT SYNC position.

(6) Place the POWER switch in the oscilloscope in the ON position.

(7) Connect one end of Probe Assembly MX-50/AP to the SIGNAL INPUT jack on the oscilloscope and the other end of the probe assembly to the point in the radar set under test.

(8) Adjust the FOCUS, BRIGHTNESS, IMAGE SIZE, and POSITION controls on the oscilloscope to obtain a clear, well-centered picture.

(9) Change the spread of the pulse by varying the SWEEP SPEED COARSE and FINE controls.

(10) Adjust the SYNC VOLTAGE switch and INPUT IMPEDANCE switch until a steady picture is obtained.

c. Use of Oscilloscope TS-239A/UP. This oscilloscope is especially useful to determine the amplitude, or duration, of the wave form. Complete instructions for the use of this oscilloscope are given in TM 11-1260. Essential procedures, however, are given in the procedures below.

(1) Place the following controls in the initial positions indicated:

TRIGGER RATE	OFF.
NORMAL-V-PLATE	NORMAL.
SYNC VOLTAGE	Maximum and + or − depending on polarity of signal.
MARKER INTERVALS	OFF.
SWEEP TIME COARSE	10.
SWEEP DELAY	OUT.
SWEEP SELECTOR	SIGNAL.
MULTIPLIER	1.
GAIN	Maximum.
BRIGHTNESS	Fully Counterclockwise.

(2) Place the POWER switch in the oscilloscope to the ON position.

(3) Adjust the FOCUS, VERTICAL POSITIONING, and HORIZONTAL POSITIONING controls until a clear spot is at the left center of the screen.

(4) Connect one end of Probe MX-607/AP to SIGNAL INPUT jack on oscilloscope. Connect the other end of the probe to the point in the radar set under test. Connect the ground lead to the chassis.

(5) Adjust the SYNC VOLTAGE control to make the image on the screen stationary.

(6) Widen or contract the image by the FINE and COARSE SWEEP TIME controls.

(7) Place the left end of the pulse near the left end of the reference scale by adjusting the HORIZONTAL POSITIONING control.

(8) Make the horizontal base line of the pulse coincide with the middle horizontal reference line by adjusting the VERTICAL POSITIONING control.

(9) Adjust the MULTIPLIER and GAIN controls until the top or bottom of the pulse coincides with the upper, or lower, horizontal reference line for positive or negative pulses.

(10) Place MULTIPLIER switch in the CAL position.

(11) Adjust CALIBRATING VOLTAGE control (*not* GAIN), until top or bottom of the pulse coincides with the upper or lower horizontal reference line for positive or negative pulses.

(12) Calculate the signal amplitude by multiplying the CALIBRATING VOLTAGE setting by the MULTIPLIER setting.

(13) Place MARKER INTERVAL switch in the .2 position. For long pulses, use a larger interval.

(14) Read the width of the pulse by counting markers. Use the reference line to interpolate between markers.

111. Replacing Parts

a. General. A replacement part should occupy the same position as the original part and should be an exact duplicate of the old part whenever possible.

(1) A part that has the same electrical value as the original, but differs in physical size, may cause trouble in high-frequency circuits.

(2) In replacing parts, use the same ground point as the original wiring.

(3) Before unsoldering a part, note the position of the leads. If the part, such as a transformer, has a number of connections to it, tag each of the leads.

(4) Be careful not to damage other leads when pulling or pushing them out of the way.

(5) A carelessly soldered connection may create new faults. It is important to make well-soldered joints because a

poorly soldered joint is one of the most difficult faults to find.

b. Replacement of Transformers. In rare instances, it may be necessary to use a power or filament transformer that is not an exact replacement. If the voltage rating of the replacement transformer is not known and the terminals are not marked, the following points will help to determine whether or not the transformer is adequate for replacement purposes:

(1) Usually transformers of similar voltage and current ratings are about the same physical size.

(2) The dc resistance of the primary winding of the average power or filament transformer is approximately 10 ohms.

(3) The dc resistance of the high-voltage secondary winding of the average power transformer (300- to 400-volt output) is approximately 200 ohms. Since this winding usually is center-tapped, the resistance of either half of the winding will be equal to one-half the total secondary resistance.

(4) Although more dangerous, it may be convenient to apply 115 volts ac to the primary and measure the voltage outputs across the secondary leads. Be careful when handling the meter in this procedure, because the secondary leads have unknown voltages.

(5) If the transformer has more than one filament supply winding, the terminals of each winding can be found by resistance checks. The dc resistance of a 5-volt filament winding is quite low (less than 1 ohm) and cannot be distinguished readily from the dc resistance of a 6.3-volt winding. To determine which is the 5-volt and which is the 6.3-volt winding, connect 115 volts to the primary terminals and measure the output of the filament supply windings. The center tap, if any, also can be located by voltage readings.

(6) The transformer may be connected to the load temporarily to check actual voltage output and to see whether the transformer is overheating. If overheating occurs, the transformer may be overloaded and unable to supply the necessary current safely.

c. Tube Sockets and Pins. Be careful when connecting and soldering leads to the pins of vacuum-tube sockets. These pins are fragile, and undue strain may break a pin off at the point where it enters the socket. If one of the pins is broken off, it can be replaced without replacing the entire socket. Proceed as follows:

(1) Use a small screwdriver, or some other pointed object, and push the remaining part of the broken pin through the socket; be careful not to chip the socket.

(2) If extra pins are not available from spare parts, a pin may be obtained from a similar unused socket.

(3) To remove the good pin from the socket, straighten the twisted pin with a pair of pliers and push the pin out of the socket.

(4) The pin may be placed in the socket where it is needed by pushing it into place and then twisting the exposed end slightly to hold it in place.

d. Color Code for Rf Coils. For easy identification and replacement, colored dots have been painted on the rf coils. The chart below lists the symbols, value, and color code for each coil.

Symbol	Color code	Value (in microhenries)
L217	Red-orange	0.39
L218	Red	.69
L202	Red-black	.75
L222 through L229	Red-brown	.85
L205	Brown-white	1.41
L233	Red-grey	1.59
L208	Red-violet	2.16
L231	Brown-grey	2.36
L206	Brown-violet	2.96
L210	Red-green	3.37
L207	Red-blue	3.50
L219	Brown-red	3.89
L203	Brown-blue	4.61
L209, L213, L214, L215, L216, L221, L230.	Yellow	17.5
L204	Orange	20.0

e. Resistor and Capacitor Color Codes. To aid in identification and replacement of resistors and capacitors, a resistor color code chart (fig. 209) and a capacitor color code chart (fig. 210) are included in the manual. In addition to giving the value of the part, these charts also include tolerance, and for capacitors, the voltage rating. Be sure replacements are identical with the original parts.

112. Coaxial Cable Repair

Coaxial cables require great care. They should never be bent, because the insulating material between the inner and outer conductors is easily cracked. The procedure for replacing or repairing the coaxial cable connector is as follows:

a. If the connector is being replaced, cut about 2 inches off the end of the cable to be sure that all cracked insulation is removed.

b. Prepare the cable for connection to the plug body (A, fig. 115).

c. Before inserting the cable into the plug body, tin the center lead and slide the clamping nut and the protective sleeve onto the cable (B, fig. 115).

d. Insert the cable into the plug body and solder the center lead to the conductor tip. Solder the metal braid to the plug body (B, fig. 115).

e. After the plug body has been soldered to the cable, put the clamping nut and the protective sleeve in place and tighten the setscrew in the protective sleeve (C, fig. 115).

113. Cleaning Contacts

Before attempting to clean any of the various contacts in the radar set, identify the type of material to be cleaned. The contacts may be tin, plated copper, plated silver, silver, or tungsten.

Caution: Never use a file or sandpaper on plated contacts.

a. Silver or Silver-Plated Contacts. Clean silver or silver-plated contacts with a cloth or

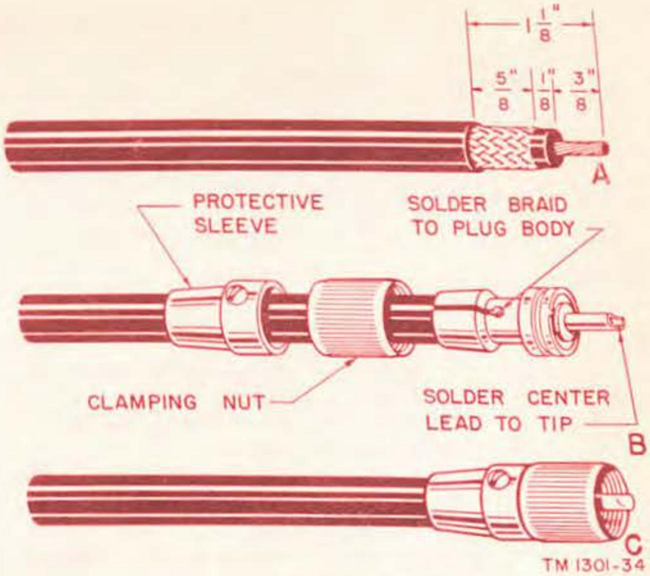


Figure 115. Repair of coaxial cable.

brush that has been dipped in Solvent, Dry Cleaning (SD) and polish the contacts with a clean, dry cloth. If the contacts are corroded, proceed as follows:

(1) Dress the corroded contacts with a piece of crocus cloth or a crocus stick.

(2) Clean the contacts with a clean cloth moistened with carbon tetrachloride.

(3) Polish the contacts with a clean, dry cloth.

Note. The brown discoloration that is found on silver or silver-plated contacts is silver oxide. Since silver oxide is a good conductor, do not remove the discoloration from noncorroded contacts.

b. Tin-Plated Contacts. Clean tin-plated contacts in the same manner as silver or silver-plated contacts (*a* above). When contacts become badly pitted, replace them.

c. Tungsten Contacts. Clean tungsten contacts with a crocus cloth. If the contacts are very dirty, use a burnishing tool or a fine-grit hone. Be sure the face of the contact is flat and the edges of the contact are slightly beveled.

114. Troubleshooting Data

The following data will help in the location of troubles given in the troubleshooting chart based on starting procedure (par. 115).

Fig. No.	Par. No.	Description
	116	Fuse table.
113	------	Receiver-transmitter, terminal boards and convenience panel, schematic.
114	------	Receiver-transmitter terminal boards.
211	------	Complete block diagram.
219	------	Radar Set AN/SPN-11(*), cabling diagram.
212	------	Receiver-Transmitter RT-268/SPN-11 (excluding receiver chassis), schematic.
213	------	Receiver R-480/SPN-11, schematic.
214	------	Range and Azimuth Indicator IP-193/SPN-11, schematic.
220	------	Power distribution diagram.

115. Troubleshooting Based on Starting Procedure

Always start troubleshooting by following the starting procedure given below. Operate the controls as indicated. If normal indications are obtained, proceed to the next step. If at any point in the procedure, the indications are abnormal, make obvious corrections, such as replacing fuses, checking cables, or replacing defective controls. If this does not correct the trouble, refer to the proper system troubleshooting charts, as indicated.

a. Place the following controls in the positions given below before starting.

(1) ANTENNA HEATER switch S801.	OFF
(2) POWER-HEADING FLASH control (S105, R187).	Extreme counterclockwise
(3) INTENSITY control R135.	Extreme counterclockwise
(4) FOCUS control R138	Extreme counterclockwise
(5) ANTENNA MOTOR OFF switch S802.	OFF
(6) Antenna ON-OFF switch S503.	OFF
(7) RINGS control R165	Extreme counterclockwise
(8) CENTEREXPAND switch S102.	OFF
(9) HIGH VOLTAGE switch S301.	OFF
(10) GAIN control R177	Extreme counterclockwise
(11) CONTRAST control R160.	Extreme counterclockwise
(12) SUPPRESSOR control R181.	Extreme counterclockwise

b. Place the switch box handle to the on position. Place ANTENNA HEATER switch S801 on the convenience panel to the ON position.

Normal indications	Probable trouble	Correction
Antenna heaters operate.	Fuse F601 or F602 in switch box open.	Replace. Check for cause of opening.
	Fuse F801 in convenience panel open.	Replace. Check for cause of opening.
	Defective heaters or thermostat S504.	Test resistance. Replace if faulty.
	Open lead in antenna heater line.	Refer to figure 59 to test continuity.

c. Rotate POWER-HEADING FLASH control in a clockwise direction. After a delay, the normal indications will be as indicated in the following chart:

Normal indications	Probable trouble	Correction
Motor generator starts	Motor starter overload switch open	Press RESET button. Check for cause of opening.
	Fuse F601 or F602 in switch box open	Replace. Check for cause of opening.
	In power group of power system	Refer to power group troubleshooting chart (par. 207).
Voltage regulator meter M601 reads	Fuse F804 (fig. 73) in convenience panel open.	Replace. Check for cause of opening.
	In power group of power system	Refer to power group troubleshooting chart (par. 207).
Blower motor B801 on bottom of receiver-transmitter operates	Defective blower motor	Test continuity. If faulty, replace.
	Open lead in blower motor circuit	Refer to figure 113 to test continuity.
Range dial and indicator scale lamps operate. DIMMER control on indicator should affect indicator lamps.	In power supply circuits of power system.	Refer to power supplies troubleshooting chart (par. 206).

d. Rotate voltage regulator rheostat control. Place test meter switch S401 (fig. 73) on receiver-transmitter to the 115 VAC position.

Normal indications	Probable trouble	Correction
Meter M601 on voltage regulator can be made to read 115 volts.	Ship's line voltage low	Check.
	Defective voltage regulator rheostat R601.	Test resistance. Replace if defective.
	In power group of power system	See power group troubleshooting chart.
Test meter M401 on receiver-transmitter reads 115 volts.	Fuse F402 in receiver transmitter open.	Test. Replace if defective.
	R412 on rear of hinged panel not properly adjusted.	Adjust.
	In power system	Refer to power supplies troubleshooting chart (par. 206).

e. Turn INTENSITY control R135 and FOCUS control R138 clockwise.

Normal indications	Probable trouble	Correction
Sweep line visible on PPI	Fuse F101 at rear of indicator open	Test. Replace if faulty. Check for cause of opening.
	Cable or cables between TRIGGER jack on receiver-transmitter and TRIGGER jack on indicator open.	Test for continuity of cables W709 and W705.
	Inoperative PPI power supply power system.	Refer to power supplies troubleshooting chart (par. 206).
	Inoperative one-shot multivibrator V101 or sweep circuits in the synchronizing and indicating system.	Refer to synchronizing and indicating system troubleshooting charts (par. 179–182).
	Defective master blocking oscillator stage in timing circuits of transmitting system.	Refer to transmitting system troubleshooting chart (par. 120–122).

f. Turn on ANTENNA MOTOR switch S802 in convenience panel. Place antenna ON–OFF switch S503 in the ON position. Rotate HEADING FLASH control.

Normal indications	Probable trouble	Correction
Antenna horn and reflector rotate	Fuse F802 on convenience panel open	Test. Replace if faulty. Check for cause of opening.
	Antenna fouled	Remove obstructions.
	Open lead in antenna drive motor circuit.	Refer to figures 113 and 159 to trace continuity.
	Defective antenna drive motor	Test continuity. Replace if faulty.
Sweep on PPI rotates	Fuse F803 on convenience panel open	Test. Replace. Check for cause of opening.
	Inoperative synchronizing circuits in synchronizing and indicating system.	Refer to synchronizing and indicating system troubleshooting charts (par. 179–182).
	Synchronizing circuits not receiving power from power group in power system.	Refer to power group troubleshooting chart (par. 207).
Fore and aft heading flashes appear on PPI. Their intensity varies with rotation of HEADING FLASH control.	Defective HEADING FLASH control R187 in indicator.	Test resistance. Replace if faulty.
	Inoperative synchronizing circuits in synchronizing and indicating system.	Refer to synchronizing and indicating system troubleshooting chart (par. 179–182).

g. Turn RINGS control R165 clockwise. Place RANGE switch S101 successively on positions 1, 3, 8, and 20. On position 1 operate CENTER EXPAND switch S102.

Normal indications	Probable trouble	Correction
Range rings appear on PPI	Defective RINGS control R165	Test resistance. Replace if defective.
	Inoperative video circuits or range mark circuits in synchronizing and indicating system.	Refer to synchronizing and indicating system. Troubleshooting chart (par. 179–182).
Two rings appear on position 1, 3 rings on position 3, and 4 rings on positions 8 and 20.	Inoperative range mark circuits (probably oscillator V107) in synchronizing and indicating system.	Refer to synchronizing and indicating system troubleshooting charts (par. 179–182).
With S101 in the 1 position and S102 in the ON position, the center of the sweep expands into a circle and the ½-mile ring moves out toward the edge.	Defective S102	Test for continuity. Replace if defective.
	Inoperative sweep circuits in synchronizing and indicating system.	Refer to synchronizing and indicating system troubleshooting charts (par. 179–182).

h. Place HIGH VOLTAGE switch S301 on the receiver-transmitter in the ON position. Turn GAIN control R177 and CONTRAST control R160 clockwise.

Normal indications	Probable trouble	Correction
Pilot lamp I 301 lights	Fuse F301	Replace. Check for cause of opening.
	Switches S301 or S302 defective	Test continuity. Replace if defective.
	In power system	Refer to power system troubleshooting chart (par. 205–207).
Echoes appear on PPI	Cable between VIDEO jack J801 on receiver-transmitter and VIDEO jack J103 on indicator open.	Test cables W706 and W707 for continuity.
	Defective transmitting system	Refer to transmitting system troubleshooting charts (par. 120–122).

Normal indications	Probable trouble	Correction
Echoes appear on PPI	Defective rf system	Refer to rf system troubleshooting charts (par. 139–141).
	Inoperative mixer circuits or signal circuits in receiving system.	Refer to receiving system troubleshooting chart (par. 158–161).
GAIN control varies intensity of echoes	Defective GAIN control	Test resistance of R177. Replace if defective.
	Open GAIN line	Refer to figure 113 to test continuity.
CONTRAST control varies intensity of echoes.	Defective CONTRAST control	Test resistance of R160. Replace if defective.
	Inoperative video circuits in synchronizing and indicating system.	Refer to synchronizing and indicating system troubleshooting charts (par. 179–182).

i. Turn SUPPRESSOR control R181 clock-wise.

Normal indications	Probable trouble	Correction
See return at center of scope is reduced	Stc circuits or signal circuits in receiving system inoperative.	See receiving system troubleshooting chart (par. 158–161).
	Open stc line	Refer to figure 113 to check continuity.

116. Fuse Table

Check fuses as one of the first steps in troubleshooting. Learn to associate certain symptoms with certain fuses. After replacing a fuse, be sure to check for the reason the fuse blew. Usually it is caused by a short in the circuit. To determine the location, rating, and the circuit each fuse protects, refer to the table below.

Caution: Never replace a fuse with another fuse of higher rating.

Fuse	Protects	Rating	Location
F301	Plate transformer T301 of the modulator power supply.	1 amp, 250 v	Front of hinged panel.
F302	Filament transformer T303 of the modulator power supply.	2 amp, 250 v	Front of hinged panel.
F401	Power transformer T401 in low-voltage power supplies.	3 amp, 250 v	Front of hinged panel.
F402	Filament transformer T402 in low-voltage power supplies. Also protects T201.	2 amp, 250 v	Front of hinged panel.
F801	ANTENNA HEATER	15 amp, 125 v. (with 24-v and 32-v sources). 10 amp, 250 v (with 115-v source).	Convenience panel.
F802	ANTENNA MOTOR	30 amp, 125 v (with 24-v and 32-v sources). 10 amp, 250 v (with 115-v source).	Convenience panel.
F803	SYNCHRO	2.5 amp, 250 v	Convenience panel.
F804	MG OUTPUT	10 amp, 250 v	Convenience panel.
F601	Power group and blower motor	25 amp	Switch box, inside.
F602	Power group and blower motor	25 amp	Switch box, inside.
F101	Hv transformer T101, filament transformer T102 and synchro alinement relay K101.	2 amp	Back of indicator
F102	PPI power supply	.25 amp	Indicator, inside, upper back left-hand corner.

CHAPTER 9

TROUBLESHOOTING IN TRANSMITTING SYSTEM

Section I. TROUBLESHOOTING PROCEDURES

Cautions: Voltages sufficiently high to cause death are exposed at many points in the receiver-transmitter. Always follow the precautions given below.

1. Do not touch any part in the transmitting system while the HIGH VOLTAGE switch is in the ON position.
2. Do not make any connections that will conduct high voltages to an exposed point.
3. Make all tests with the HIGH VOLTAGE switch in the OFF position.
4. To shut off the power completely, push down the switch box handle.
5. Always ground high-voltage capacitors before touching the capacitors or their associated circuits. Dangerous voltages, present when POWER switch S105 is on, are retained by large capacitors for a considerable time after power has been disconnected from the set.

117. Reference Data

Fig. No.	Par. No.	Description
212	------	Receiver-Transmitter RT-268/SPN-11 (excluding receiver chassis), schematic.
118	------	Transmitting system, tube location chart.
116	------	Transmitting system, wave forms.
121	------	Receiver-transmitter, front view, location of transmitting system parts.
116	------	Fuse Table.
119	------	Transmitter chassis, voltage and resistance chart.
122	------	Modulator subchassis, location of parts.
215	------	Receiver-Transmitter RT-268/SPN-11, transmitting system, wiring diagram.

118. General Information

a. Normal Operation. Power is applied to the transmitting system when indicator POWER switch S105 is rotated clockwise. Before modulator high voltage is applied, the automatic 3-minute time-delay circuit operates to allow proper heating of the modulator and magnetron filaments. Illumination of red warning lamp I 301 on the hinged panel (fig. 11) indicates that time-delay relay K301 has closed and modulator high voltage is on. The correct operation of the modulator power supply is indicated by the proper reading of test meter M401 on the MOD. H. V. position of test meter switch S401. A reading of 4–5 ma on meter M401 when S401 is on the MAG. I. position indicates a properly operating magnetron.

b. Obvious Troubles.

(1) When an incorrect reading is obtained on the +300V. REG. position of test meter switch S401, the timing circuits are affected.

(2) When an incorrect reading is obtained on the +320V unregulated position of test meter switch S401, the time-delay circuit is affected.

(3) When fuse F301 blows, there is trouble in the modulator power supply.

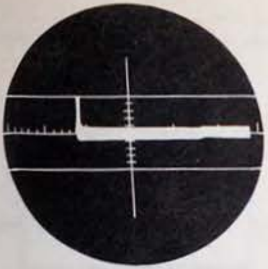
(4) When fuse F302 blows, all transmitter circuit tubes do not light. No sweep appears on the PPI.

(5) When fuse F401 or F402 blows, the timing circuits and the circuits of the receiving, synchronizing, and indicating systems do not operate.

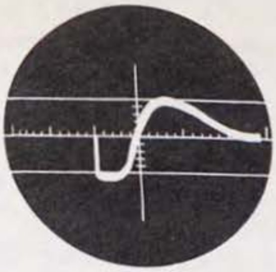
119. Test Points

To determine quickly what circuits or what stages of the transmitting system are at fault, use Oscilloscope TS-34A/AP to observe the wave form at a few test points. The normal wave forms should be as shown in figure 116.

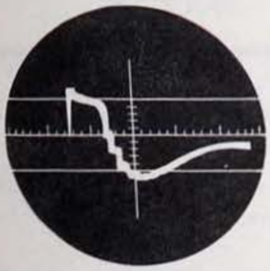
a. Timing Circuits. Proper operation of the timing circuits can be checked by observing the wave form at the grid (pin 1) of modulator V305.



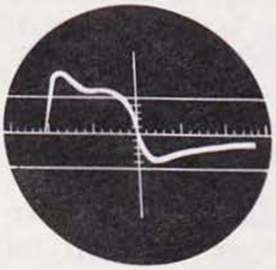
MASTER
BLOCKING OSCILLATOR V307A
TEST POINT: JACK J302
ATTENUATION: 50 db
SWEEP: START-STOP
SPEED: FAST



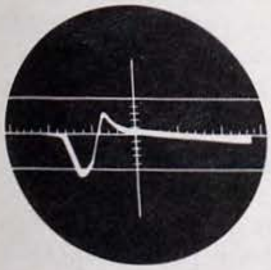
AMPLIFIER V307B
TEST POINT: PLATE, PIN 2
ATTENUATION: 60 db
SWEEP: START-STOP
SPEED: MEDIUM



CATHODE FOLLOWER V309
TEST POINT: GRID, PIN 5
ATTENUATION: 60 db
SWEEP: START-STOP
SPEED: MEDIUM



MODULATOR V305
TEST POINT: GRID, PIN 1 *
ATTENUATION: 60 db
SWEEP: START-STOP
SPEED: FAST



MAGNETRON V306
TEST POINT: CATHODE, THROUGH VOLTAGE DIVIDER
ATTENUATION: 56
SWEEP: START-STOP
SPEED: FAST

NOTES

1. WAVE FORMS TAKEN WITH OSCILLOSCOPE TS-34A/AP.
2. [RANGE] SWITCH ON [3]-MILE RANGE.
3. * INDICATES TUBE REMOVED FROM SOCKET.
4. [EXTERNAL SYNC] INPUT TO [TRIGGER] JACK J303.
5. [H PLATES] SWITCH IN [NORMAL] POSITION.

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Figure 116. Transmitting system, wave forms.

The availability of the proper trigger for operation of the synchronizing and indicating system can be checked by observing the wave form at TRIGGER jack J302 on the receiver-transmitter. If this wave form is incorrect, the trouble is in master blocking oscillator V307A stage. An incorrect wave form at the plate (pin 2) of amplifier V307B indicates trouble in that stage or in blocking oscillator V308. An improper wave form at the grid (pin 5) of cathode follower V309 indicates trouble between that point and the previous test point.

b. Transmitter Circuits. By observing the wave form at the cathode of magnetron V306, trouble can be isolated to either the magnetron or the modulator stages. Since the magnetron is at an extremely high potential, the wave form must be obtained through a voltage divider as described in (1) through (7) below.

Caution: Make sure the set is turned off before making any connections.

(1) Disconnect bleeder resistor R322 and cables W801 and W802 from TRIGGER jacks J301 and J302.

(2) Connect TRIGGER jack J302, in the receiver-transmitter, to the EXT SYNC jack, on Oscilloscope TS-34A/AP, with Coaxial Cord CG-72/U.

(3) Connect a lead between the 5-kv terminal of Voltage Divider TS-265/UP and the magnetron filament marked C. Connect Probe Assembly MX-50/AP between the 100:1 attenuation jack on the voltage divider and the SIGNAL INPUT jack on the oscilloscope.

(4) Place Oscilloscope TS-34A/AP in operation as follows (see TM 11-1067A):

(*a*) Place SWEEP SELECTOR switch in the SAWTOOTH position.

(*b*) Place the SWEEP SPEED COARSE switch in the MED position.

(*c*) Place the INPUT IMPEDANCE switch in the HIGH 40DB position.

(*d*) Place INT SYNC-EXT SYNC switch in the EXT SYNC position.

(*e*) Place the POWER switch in the ON position.

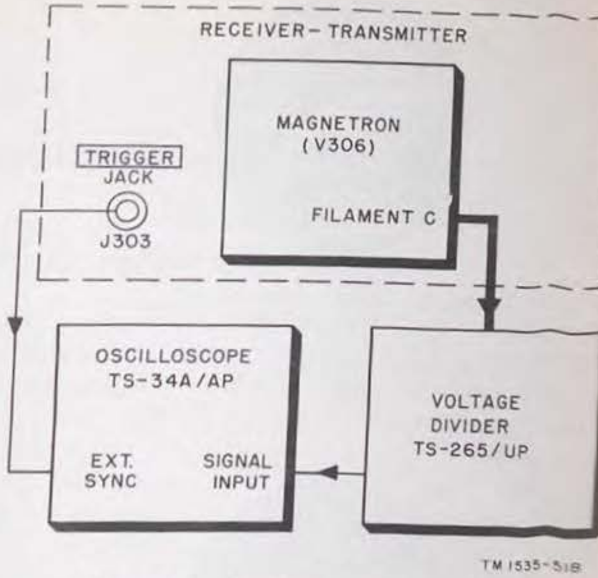

Figure 117. Reading magnetron output.

(5) Place the HIGH VOLTAGE on the receiver-transmitter in the ON position.

(6) Adjust the FOCUS, BRIGHTNESS, IMAGE SIZE, and POSITION controls on the oscilloscope to otain a clear well-centered picture.

(7) Adjust the SYNC VOLTAGE switch, SWEEP SPEED FINE control, and INPUT IMPEDANCE switch until as steady a picture as possible is obtained. The wave form should be as shown in figure 124.

Section II. TRANSMITTING SYSTEM TROUBLESHOOTING CHARTS

120. General

a. Not all the symptoms presented in the following charts are definitely due to trouble in the transmitting system. Some symptons—such as reduced target echoes—may be due to trouble in the rf, receiving, or synchronizing and indicating systems. In any such case, however, it is best to check the transmitting system first.

b. The modulator power supply is part of the power system. Since the modulator power supply plays such an important part in the operation of the transmitting system, symptoms associated with the modulator power supply are incorporated in the following charts.

c. The transmitting system troubleshooting charts do not give all possible symptoms. For the symptoms listed, these charts merely serve as guides to the circuits or stage at fault. To find the exact part at fault, check the tubes and take voltage and resistance readings. Compare these readings with those in the voltage and resistance charts (figs. 119 and 120) and with those in the following transformer chart:

Transformer	Terminals	Resistance reading
T302	1 and ground	Less than 1 ohm.
	2 and 5	Less than 1 ohm.
	3 and 4	Less than 1 ohm.
T304	1 and 2	Less than 1 ohm
	3 and 4	Less than 1 ohm.
T305	1 and 2	15 ohms.
	3 and 4	15 ohms.
	5 and 6	2 ohms.
	7 and 8	15 ohms.
T306	1 and 2	2 ohms.
	3 and 4	2 ohms.
	5 and 6	2 ohms.
	7 and 8	2 ohms.

121. Tube Troubleshooting Chart
(fig. 118)

The chart below indicates which tube may be at fault when certain symptoms are observed on the PPI. Additional indications and test meter M401 readings are included to help decide which tube is at fault. Before deciding definitely that a tube is faulty, always test it by replacement or with a tube tester.

Note. Instructions for replacement of magnetron V306 are given in paragraph 124. After replacing magnetron, retune the set as instructed in paragraphs 169–171. After replacing V307, adjust the prf as instructed in paragraph 126.

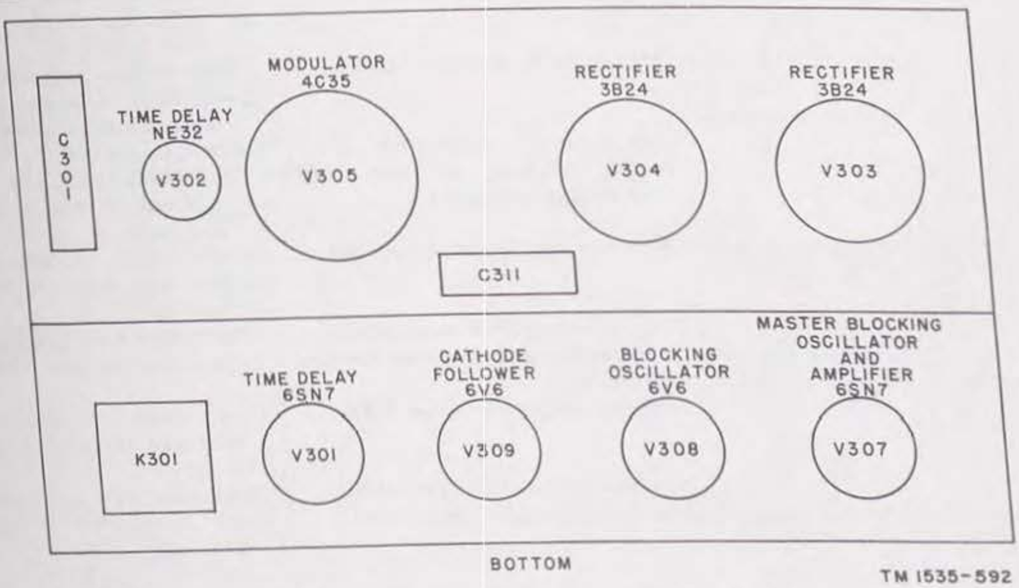

Figure 118. Transmitting system, location of tubes.

Picture symptom	Test meter M401	Additional indication	Tube
Blank PPI	Normal reading on MOD. H. V. position. No reading on MAG. I. position.		V307
Weak echoes; targets appear fuzzy	Low reading on MAG. I. position, or current drops as motor generator output is increased.		V306
Range rings are present on PPI, but no echoes.	Normal reading on MOD. H. V. position. No reading on MAG. I. position.		V305 V306 V30 V30
No echoes on PPI	No reading at MAG. I. and MOD. H. V. positions		V30 V30 V30 V30
No echoes on PPI	No reading at MAG. I. position; low or no reading at MOD. H. V. position.		V3 V3
Normal echoes on PPI	Normal readings on MAG. I. and MOD. H. V. positions.	Time delay more or less than 3 minutes.	V3 V3

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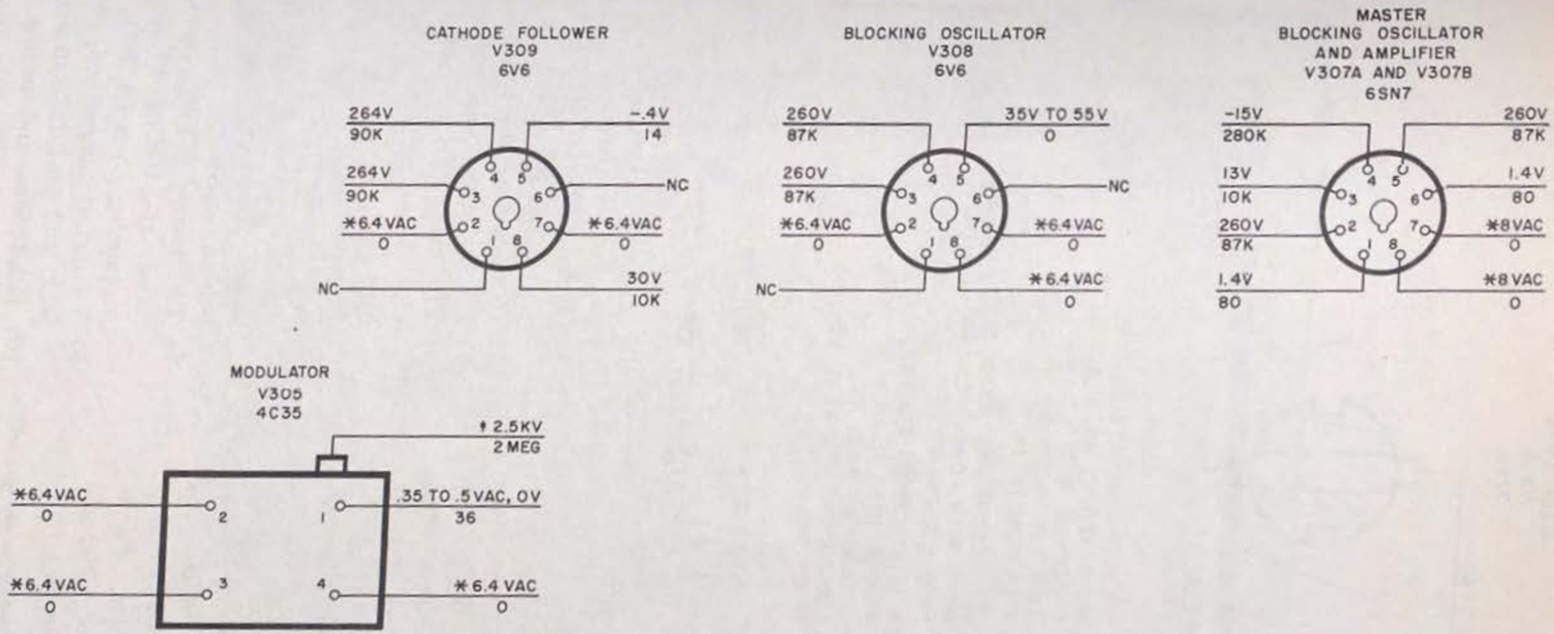
122. General Troubleshooting Chart

Symptom	Probable trouble	Correction
No spot or sweep on PPI. No MAG. I. reading.	Defective master blocking oscillator V307A.	Check wave form at TRIGGER jack J303. If trigger is not present, check V307 and take voltage and resistance readings at V307A.
No sweep on PPI. Normal MAG. I.	Poor connection at TRIGGER jacks J302 or J301.	Check connections.
Sweep, noise, and range rings appear without echoes on PPI. No MAG. I. or MOD. H. V. reading.	HIGH VOLTAGE switch S301 in OFF position.	Place switch S301 in the ON position.
	Interlock switch S302 open	Fasten shielded plate on rear of hinged panel (fig. 121).
	Modulator power supply inoperative.	Check stages V301, V303, and V304, fuses F301 and F302, transformers T301 and T303, relay K301 and filter Z302.
Sweep, noise, and range rings appear without echoes on PPI. No MAG. I. reading. MOD. H. V. reading normal.	Modulator stage inoperative	Take voltage and resistance readings at V305. Check to see if T303 provides filament voltage.
	Timing circuits inoperative	Check stages V307B, V308, and V309.
PPI picture out of sync	Master blocking oscillator V307A producing wrong prf.	Adjust R313 (par. 126). If picture is still out of sync, check stage tube and parts.
Low reading at MAG. I. position on test meter M401 for all positions of RANGE switch (S101).	Defective magnetron stage V306	Check stage. If necessary, replace tube and retune system (par. 168 to 171).
	Defective modulator stage V305	Check stage tube and parts.
Weak echoes on PPI, low reading at MAG. I. position on test meter M401.	Transmitting and receiving systems detuned.	Retune systems (par. 168 to 171).
	Defective megnetron stage V306	Check stage. If necessary, replace tube and retune system (par. 168 to 171).
	Defective modulator stage V305	Check stage tube and parts.
Red warning lamp I 301 does not light, no readings at MAG. I. and MOD. H. V. positions on test meter M401.	Defective time-delay relay K301	Check continuity. If necessary, replace relay.
	Defective time-delay stage V301 and V302.	Check stage tube and parts.
Targets appear fuzzy with dark radial lines (spoking) present on PPI.	Defective magnetron stage V306	Check stage. If necessary, replace tube and retune system (par. 168 to 171).
Red warning lamp I 301 lights. No reading on test meter M401 for MAG. I. or MOD. H. V. positions. Abnormal blue glow in thyratron tube V305.	Defective modulator stage V305	Replace tube V305.
Sweep line, light and dark sectors present on PPI scope; no reading at MAG. I. position and high reading at MOD. H. V. position on test meter M401. No blue glow in tube V305 with HIGH VOLTAGE switch (S301) in OFF position.	No trigger being applied to modulator V305. Trouble in stages of the timing circuits following master blocking oscillator V307A.	Remove tube V305; check for trigger at pin 1 of tube socket. If no trigger is present, check tubes V307, V308, V309, and associated parts.
	Defective modulator stage V305	Check stage tube V305. Check resistance of T305 and T306 windings.
Fuse F301 blows. Pulse transformer T302 breaks down.	Defective spark gap	Adjust (par. 127).

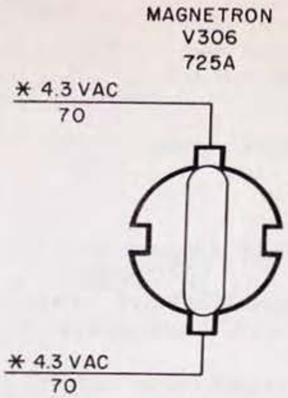


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND UNLESS OTHERWISE NOTED. USE VOLTMETER WITH 20,000 OHMS-PER-VOLT SENSITIVITY.
2. ALL RESISTANCES MEASURED IN OHMS WITH POWER REMOVED FROM EQUIPMENT.
3. * INDICATES AC READINGS TAKEN ACROSS TUBE FILAMENTS.
4. NC INDICATES NO CONNECTION.
5. [CENTER EXPAND] SWITCH S102 IN THE [OFF] POSITION.

TM 1535-162

Figure 119. Transmitting system, voltage and resistance chart.



NOTES

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND UNLESS OTHERWISE NOTED. USE VOLTMETER WITH 20,000 OHMS-PER-VOLT SENSITIVITY.
2. ALL RESISTANCES MEASURED IN OHMS WITH POWER REMOVED FROM EQUIPMENT.
3. * INDICATES AC READINGS TAKEN ACROSS TUBE FILAMENTS. RELAY K302 OPEN. WHEN RELAY IS CLOSED, THE FILAMENT READING IS 6.5 VAC.

TM 1535-158

Figure 120. Magnetron, voltage and resistance chart.

Section III. REPLACEMENT OF PARTS

123. Replacement of Modulator Parts
(fig. 122)

The modulator parts are located on the upper front and rear sections of the receiver-transmitter hinged panel. To reach the parts on the rear of the hinged panel, loosen the four hexagonal-head captive screws on the front of the unit and remove the main cover. Then disconnect the wave guide coupling with the waive guide coupling wrench (fig. 108), loosen the two knurled captive screws, and swing the hinged panel out until it locks. Loosen the 10 machine screws that hold the shielded compartment cover, and remove the cover. Most of the parts can be removed by taking out the machine screws that hold them. Pulse-forming network Z301 and capacitor C302 are secured to the panel by mounting clamps.

124. Replacement of Magnetron and Magnet
(fig. 123)

Warning: Turn off power before removing magnetron.

a. Replacement of magnetron.

(1) Shut off all power.
(2) Remove forward half of magnetic shield (E302, fig. 121).
(3) Remove hose bracket.
(4) Loosen wave guide clamping screws.
(5) Tip magnet down on hinged bracket after loosening the three screws above hinge.
(6) Remove the six screws that hold the magnetron.
(7) Pull magnetron straight forward. (Filament jacks will disengage from P301 behind chassis.)
(8) To remove TB301, remove the four screws and lift off TB301 and the four supporting posts (A 301).
(9) To install magnetron, engage filament jacks and push tube in place.
(10) Reassemble and 'retune klystron local oscillator and TR tube (par. 168 to 171).

Note. **When tightening the screws, keep the magnetic center of the anode block precisely between the poles of the magnet.**

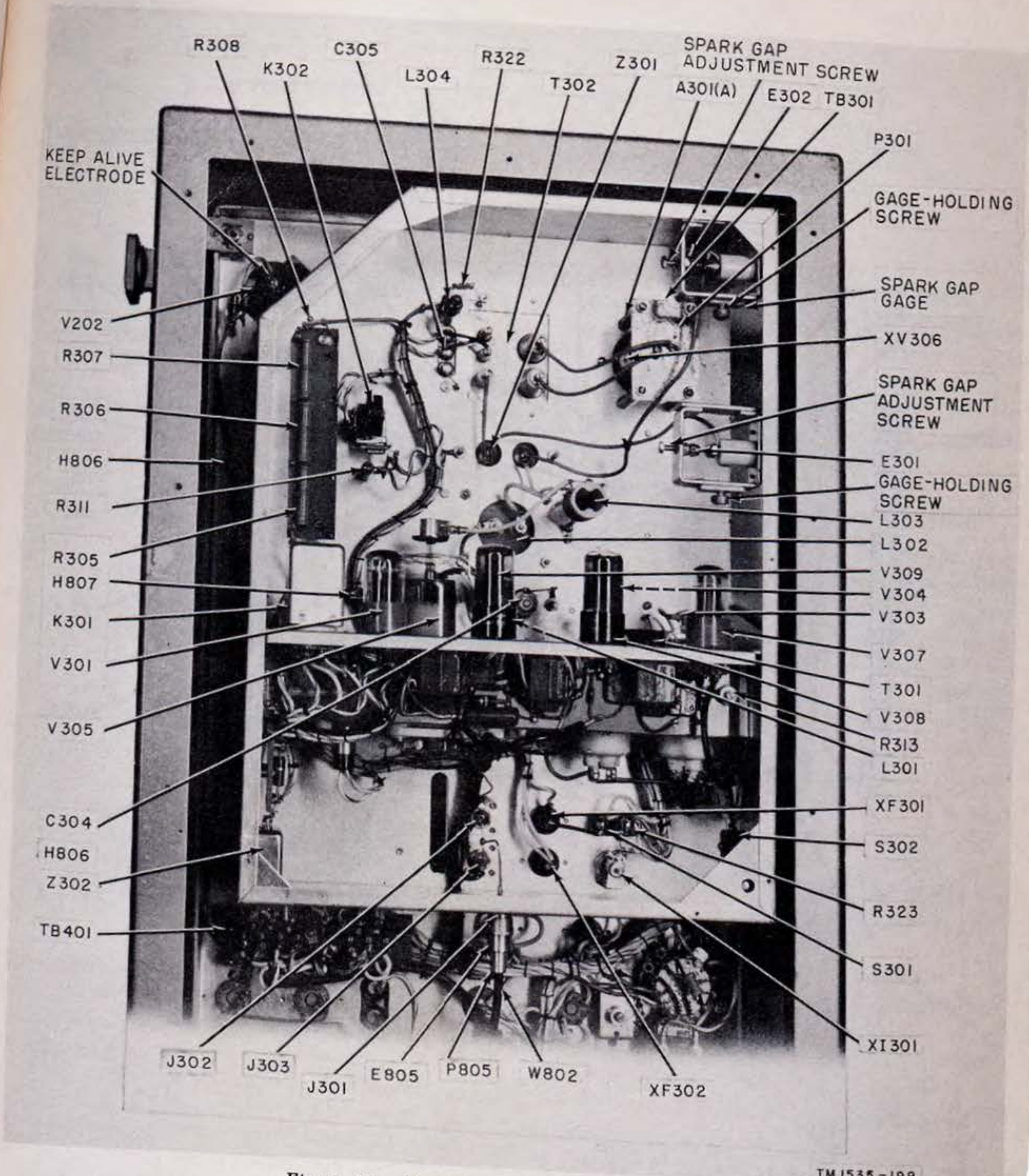


Figure 121. Transmitter chassis, location of parts.

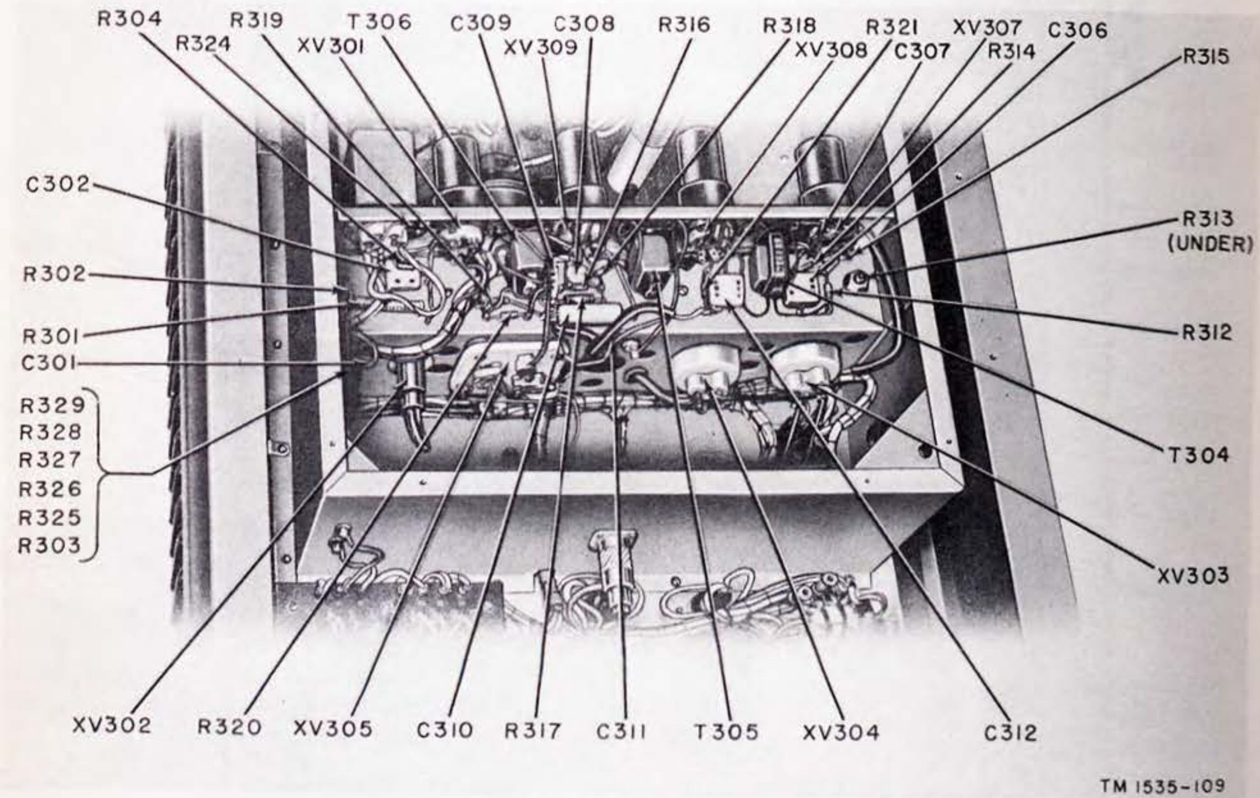


Figure 122. Modulator subchassis, location of parts.

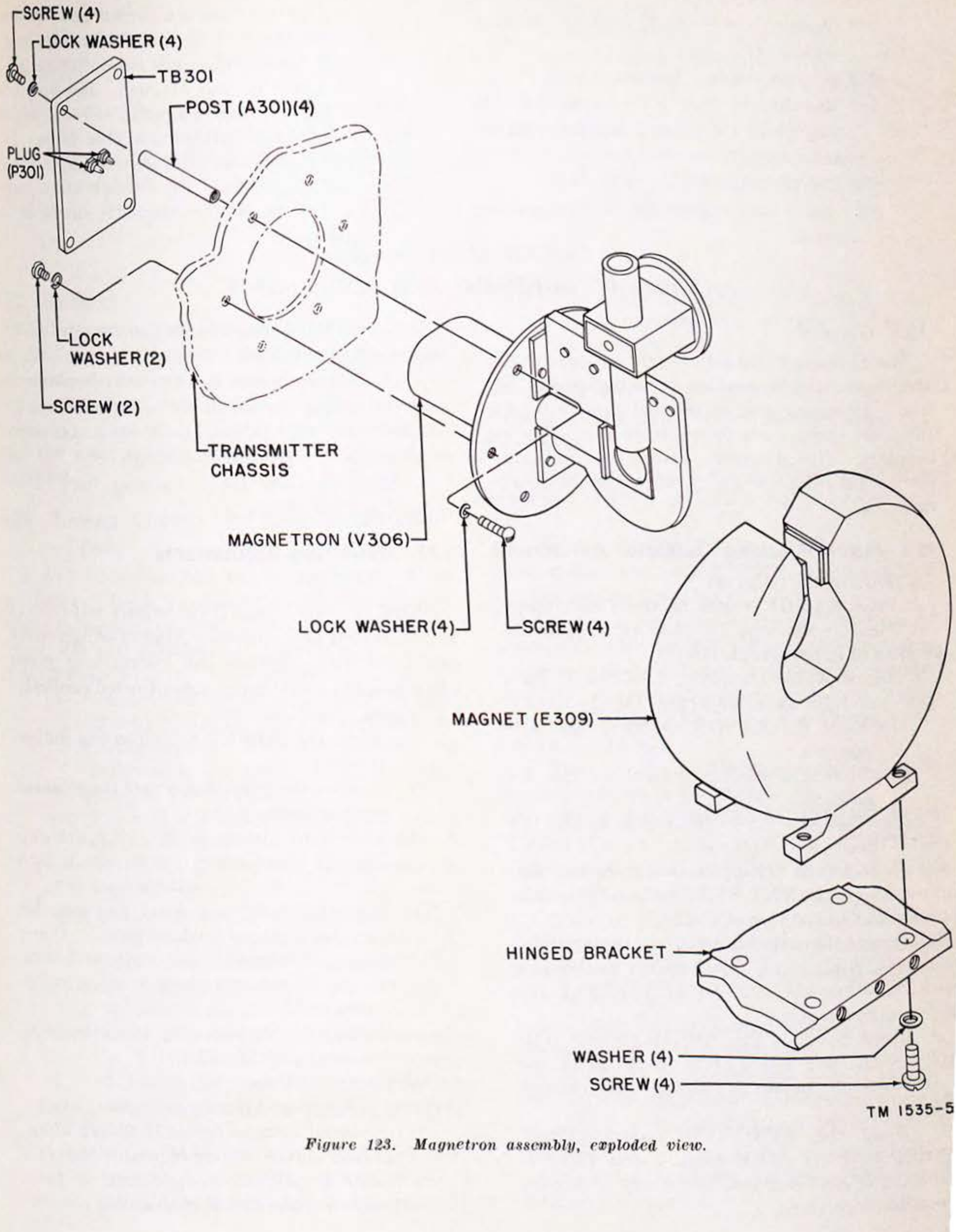


Figure 123. Magnetron assembly, exploded view.

b. Replacement of Magnet (E309).

(1) Shut off all power.

(2) Remove the forward half of the magnetic shield.

(3) Remove the hose bracket.

(4) Remove the four screws that hold the magnet to the hinged bracket, and remove magnet.

(5) Replace magnet.

(6) Center and tighten the four mounting screws.

(7) Do not touch the magnet with a screw driver or any other iron or steel objects.

Caution: Do not permit tools to come in contact with the pole faces of the magnet, because the tools may alter the field strength of the magnet. Remove iron filings or other magnetic material which accumulate around the pole faces. Do not wear a watch while working close to the magnetron. Do not operate a magnetron unless the magnetic shield is in place.

Section IV. ALINEMENT AND ADJUSTMENTS

125. General

The alinement and adjustment procedures for the transmitting system are presented in this section. Alinement and adjustment procedures for the other systems are presented in the following chapters. The alinement chart (fig. 221) summarizes the complete alinement procedure for the radar set.

126. Master Blocking Oscillator Adjustment

a. Turn on the radar set.

b. Place RANGE switch on the 3 mile range.

c. Place Oscilloscope TS-34A/AP in operation as outlined in paragraph 110.

d. Adjust Audio Oscillator TS-382A/U for a 1,000-cps output as follows (See TM 11-2684A):

(1) Place the RANGE switch in the X10 position.

(2) Place the tuning control in the 100 position.

(3) Place the ON-OFF switch in the ON position.

e. Connect TRIGGER jack J302 in the receiver-transmitter to the EXT SYNC jack on the oscilloscope with Coaxial Cord CG-72/U.

f. Connect the output terminals of the oscillator to the SIGNAL INPUT jack on the oscilloscope with Probe Assembly MX-50/AP (SIGNAL INPUT marked on it).

g. Adjust the FOCUS, BRIGHTNESS, IMAGE SIZE, and POSITION controls on the oscilloscope to obtain a clear, well-centered picture.

h. Adjust the SYNC VOLTAGE switch, SWEEP SPEED FINE control, and INPUT IMPEDANCE switch until as steady a picture as possible is obtained.

i. Adjust R313 (fig. 121) until a clear stationary sine wave is obtained.

j. If a stationary sine wave can not be obtained, vary the tuning control on the audio oscillator between 90 and 120. Adjust R313 for a stationary sine wave at any point in this range.

k. Allow the radar set to warm up for 15 minutes. Readjust R313.

127. Spark Gap Adjustments
(fig. 121)

Spark gaps E301 and E302 require adjustment whenever they are replaced. Always adjust spark gap E302 first. Follow the instructions given below to make sure the gaps are adjusted properly.

a. Spark Gap E302.

(1) Turn the POWER switch in the indicator off.

(2) Remove the plate that covers the shielded compartment.

(3) Widen the contact spacing of spark gap E301 to about one-sixteenth of an inch by turning the gap adjustment screw.

(4) Remove the .072-inch spark gap gage by loosening the gap-holding screw. Place the gage between the electrodes and turn the gap-adjustment screw until friction is obtained.

(5) Recheck the gap setting by using the gage in several positions.

(6) Turn on the radar set.

(7) Use the rheostat to vary the motor generator output voltage from 110 to 122 volts (as read on the voltage regulator meter).

(8) Energize interlock switch S302 a few times and make sure that no arcing occurs

at the gap. If arcing occurs, increase the gap setting until no arcing occurs.

b. Spark Gap E301.

(1) Make sure spark gap E302 is adjusted properly before adjusting spark gap E301.

(2) Remove the .036-inch gage by loosening the gage-holding screw. Place the gage between the electrodes and turn the gap-adjustment screw until friction is obtained.

(3) Recheck the gap setting by using the gage in several positions.

(4) Turn on the radar set.

(5) Use the rheostat to vary the motor generator output voltage from 110 to 122 volts (as read on the voltage regulator meter).

(6) Energize interlock switch S302 a few times and make sure that no arcing occurs at the gap. If arcing occurs, increase the gap setting.

Section V. FINAL TESTING

128. General

This final testing section is intended as a guide for determining whether a repaired transmitting system meets the original specifications. Entire test procedures for the transmitting system are given. The final testing chart (fig. 222) summarizes the final testing procedure for the entire radar set.

129. Timing Circuits, Prf and Wave Form Tests

a. Prf. Measure the prf of master blocking oscillator V307A by following the instructions given in paragraph 126. The prf should be between 900 and 1,200 cycles.

b. Master Blocking Oscillator Wave Form.

(1) Connect the output at TRIGGER jack J303 to SIGNAL INPUT terminals on Oscilloscope TS–239A/UP. Adjust the oscilloscope according to instructions given in paragraph 110.

(2) Place MARKER INTERVALS switch on .2. Read the width of the pulse. It should be no less than .5 microsecond long.

(3) By means of CALIBRATING VOLTAGE control, read the amplitude of the pulse. It should be not less than 30 volts.

c. Timing Circuits Output Wave.

(1) Remove modulator tube V305 and connect lead from pin 1 of modulator socket to SIGNAL INPUT on Oscilloscope TS–239A/UP. Adjust the oscilloscope according to instructions in paragraph 110.

(2) Place MARKER INTERVALS switch on .2. Read width of the pulse. It should be no less than .3 microsecond.

(3) Use CALIBRATING VOLTAGE control to calculate the amplitude. It should be no less than 300 v.

130. Magnetron Wave Form Test

Caution: Turn off all power before making any connections.

a. Disconnect bleeder resistor R322 and cables W801 and W802 from TRIGGER jacks J301 and J302.

b. Connect TRIGGER jack J302 on the receiver-transmitter to EXTERNAL SYNC jack of Oscilloscope TS–239A/UP.

c. Connect a lead between the 5KV terminal of Voltage Divider TS–265/UP and the magnetron filament marked C. Connect another lead between the 100:1 attenuation jack on the voltage divider to the SIGNAL INPUT of the oscilloscope with Cord CG–332/U.

d. Turn on the oscilloscope according to instructions given in paragraph 110.

e. Adjust the FOCUS, VERTICAL POSITIONING, and HORIZONTAL POSITIONING controls until a clear spot is seen at the left center of the screen.

f. Turn on the indicator POWER switch.

g. After a delay of 3 minutes, place the HIGH VOLTAGE switch in the receiver-transmitter in the ON position.

h. Adjust the oscilloscope according to the directions given in paragraph 110.

i. Make the horizontal base line of the pulse coincide with the middle horizontal reference line by adjusting the VERTICAL POSITIONING control.

j. Calculate the pulse amplitude by using the following formula:

Pulse Amplitude = 100 × CALIBRATING VOLTAGE setting × MULTIPLIER setting.

The pulse amplitude should be between 8.5 and 10 kv.

k. Calculate the amplitude of the negative overshoot by using the following formula:

Negative overshoot = 100 × CALIBRATING VOLTAGE setting × MULTIPLIER setting.

l. Place the MARKER INTERVAL switch in the .2 position.

m. Measure the rise time (fig. 124) by counting markers. Use the reference line to interpolate between markers. The rise time should be between .1 and .2 microsecond.

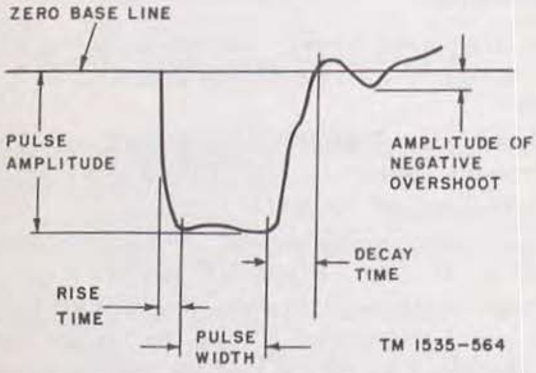


Figure 124. Magnetron output, wave form.

n. Measure the decay time. It should be between .4 and .6 microsecond.

o. Measure the pulse width. It should be between .35 and .45 microsecond.

131. Transmitter Circuits, Power Output (fig. 125)

The power output of the transmitter circuits is obtained with Directional Coupler CU–78/UP, Rf Test Load TS–108A/AP and Test Set TS–147/UP. More details on the use of Test Set TS–147/UP in power measurements may be obtained from TM 11–1247.

a. Disconnect the wave guide run from the duplexer on top of the receiver-transmitter.

b. Connect Directional Coupler CU–78/UP between the duplexer and Rf Test Load TS–108A/AP.

c. Connect Cord CG–92/U to the RF jack on Test Set TS–147/UP. Leave the other end of the cord disconnected temporarily.

d. Set TEST switch on the test set to TRAN.

e. Set the DBM control to its maximum counterclockwise position.

f. Connect the line cord to an ac receptacle. Place the 115 VAC switch in the ON position.

g. Adjust the METER BALANCE control until the meter pointer is at BALANCE.

h. Attach the unconnected end of Cord CG–92/U to the directional coupler, as shown in figure 125.

i. Place the radar set in operation.

j. Turn DBM dial clockwise until the meter pointer is below SET POWER.

k. Detune FREQUENCY meter.

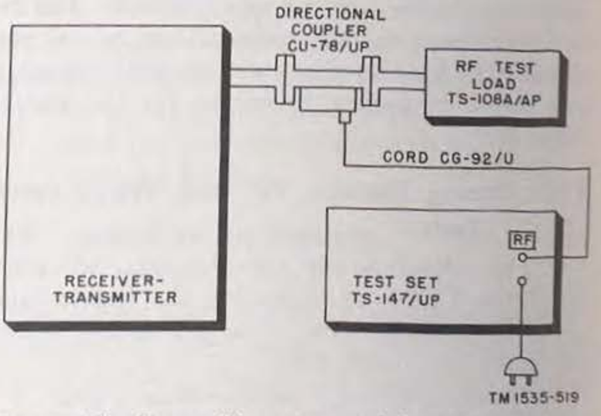


Figure 125. Transmitter power and frequency measurement, test set-up.

l. Turn DBM control counterclockwise to set meter at SET POWER. Read DBM dial and record.

m. Find the total average power in dbm by using the following formula:

Average Power (in dbm) = DBM reading + 30.5.

(The DBM reading is that obtained in *k* above and 30.5 is the total attenuation of the cable and directional coupler.)

n. Use the chart (fig. 10, TM 11–1247) to convert average power in dbm to average power in watts.

o. Find the duty cycle from the following formula:

$$\text{Duty cycle} = \frac{\text{prf} \times (\text{pulse width, in uses})}{1{,}000{,}000}$$

For example, if the prf, as measured in paragraph 126, is 1,000 cycles per second, and the pulse width, as measured in paragraph 130 is .4 microsecond, the duty cycle is

$$\frac{1{,}000 \times .4}{1{,}000{,}000} = \frac{400.}{1{,}000{,}000} = .0004$$

p. Find the peak power from the following formula:

$$\text{Peak power} = \frac{\text{Average power (in watts)}}{\text{Duty cycle}}$$

For example, if the average power as determined from step *n* above is 12 watts, and the duty cycle as determined from step *o* above is .0004, the peak power is

$$\frac{12}{.0004} = 30{,}000 \text{ watts.}$$

The peak power output should be no less than 30,000 watts.

132. Measuring Magnetron Frequency

a. Find transmitter power by performing steps given in paragraph 131.

b. Tune FREQUENCY control on the test set for a dip in the meter reading. Multiply the dial reading by 10 to obtain the frequency in megacycles. The frequency should be between 9,345 and 9,405 mc.

133. Finding Magnetron Spectrum

The frequency spectrum of the magnetron can be found with Spectrum Analyzer TS–148/UP (TM 11–1249) as follows:

a. Place the radar set in operation.

b. Place the ANTENNA MOTOR switch in the receiver-transmitter in OFF position.

c. Place the POWER switch in the spectrum analyzer in the ON position.

d. Adjust INTENSITY control to the desired brilliance.

e. Place SELECTOR switch in the test set to the MIXER position.

f. Turn SPECTRUM WIDTH control to the maximum clockwise position.

g. Adjust SPECTRUM CENTER control for a symmetrical bell-shaped hump on the screen of the spectrum analyzer.

h. Place SELECTOR in the SPECTRUM AMPLIFIER position. If interference occurs, place SELECTOR switch in the SPECTRUM position.

i. Connect Antenna Horn AT–68/UP to Adapter UG–183/U, which is attached to the wave guide at the left side of the spectrum analyzer.

j. Point the antenna horn at the antenna of the radar set.

Caution: Make sure the coupling is not too close.

k. Rotate SPECTRUM WIDTH control until a wave form similar to the one shown in figure 126 is seen.

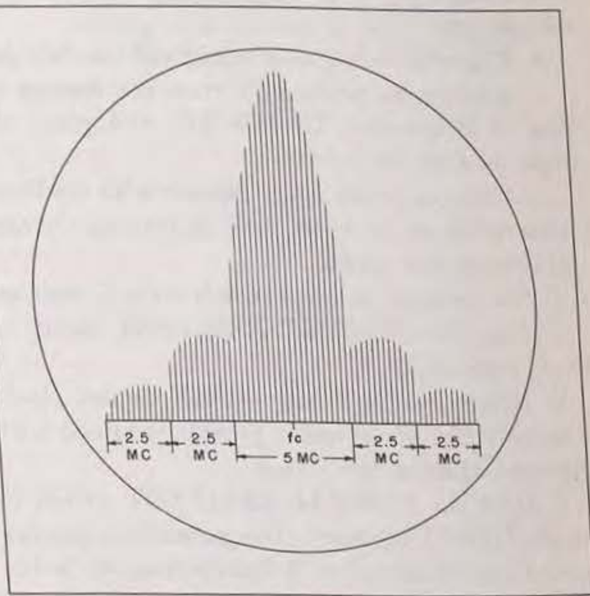


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Figure 126. Magnetron spectrum.

l. Turn FREQUENCY control until the pip coincides with the center point of the wave that is seen on the screen. Record setting of the FREQUENCY dial as f_a.

m. Vary SPECTRUM CENTER control until a duplicate image of that seen in step *k* above is obtained at another point in the frequency spectrum.

n. Turn FREQUENCY control until the pip coincides with the center point of the wave that is seen on the screen. Record setting of the FREQUENCY dial as f_b.

o. Obtain the center frequency (f_c) of the magnetron from the following formula:

$$f_c = \frac{f_a + f_b}{2}$$

The center frequency should be between 9,345 an 9,405 mc.

p. Turn FREQUENCY control until the pi coincides with each minimum point in turn. R cord the setting of the FREQUENCY dial wit the pip at each minimum. The distance betwe the two center minima should be about 5 mc. T distance between all other adjacent minima should be about 2.5 mc.

134. Measuring Flux Density

Caution: Be careful not to strike the magnet with a steel screwdriver or other steel object.

a. Turn POWER switch in the indicator in the off position.

b. Remove the magnetic shield and hose bracket.

c. Remove the probe unit from the storage recess of Fluxmeter TS–15B/AP, and place the probe on a flat surface.

d. Aline the probe meter pointer with the black mark on the probe meter scale by turning the zero adjuster on the probe.

e. Set the range selector switch to the C position.

f. Place the NORMAL-ZERO SET switch in the C position.

g. Rotate the OFF-MEASURE control clockwise until the gauss meter pointer is alined with the mark at 48 on the C scale.

h. Hold the NORMAL-ZERO SET switch in the ZERO SET position. The gauss meter pointer should now be alined with the mark at 96 on the C scale.

i. If the gauss meter pointer is not alined with the mark at 96 on the C scale, note the position of the pointer with respect to the mark at 96. Then turn the zero adjusting screw on the front of the gauss meter to displace the pointer an equal amount on the opposite side of the 96 mark.

j. Release the NORMAL-ZERO SET switch and readjust the OFF-MEASURE control to return the meter pointer to the mark at 48 on the C scale.

k. Repeat procedure in *i* and *j* above until the gauss meter pointer is alined with marks 48 and 96 on the C scale for the two positions of the NORMAL-ZERO SET switch.

l. Place the OFF-MEASURE control in the OFF position.

m. Insert the probe between the poles of the magnet.

n. Place the fluxmeter cabinet as far from the magnet as the probe cable will permit.

o. Turn on the indicator POWER switch.

p. After a delay of about 3 minutes, place HIGH VOLTAGE switch on the receiver-transmitter in the ON position.

q. Set NORMAL-REVERSE switch to the NORMAL position.

r. Turn OFF-MEASURE control slowly clockwise and, at the same time, watch the probe meter.

s. If the point of the probe meter deflects backward, turn the OFF-MEASURE control to the OFF position, set the NORMAL-REVERSE switch to the REVERSE position, and repeat operation described in *r* above.

t. Advance the OFF-MEASURE control until the probe meter pointer is alined with the red mark on its scale, or until the gauss meter pointer reaches full scale. If the latter occurs, return the OFF-MEASURE control to the OFF position, set the range selector switch to the next lower position, and repeat the operation.

u. Use the VERNIER to set the probe meter pointer accurately at the red mark.

v. Read the value of flux density on the A-, B-, or C-scale, as determined by the setting of the range selector switch, and multiply the reading by 100. The flux density should be between 5,050 and 5,150 gausses.

135. Testing Spark Gaps

a. Spark Gap E302.

(1) Set the 400 cps voltage to 108 volts.

(2) Place the HIGH VOLTAGE switch in the OFF position.

Caution: Extremely high voltages are present. Short all high-voltage capacitors to ground with an insulated-handle screwdriver before proceeding.

(3) Short the primary of transformer T302 with a wire lead from terminal 1 to ground.

(4) Place POWER switch in the indicator on.

(5) After 3 minutes, place the HIGH VOLTAGE switch to the ON position and then quickly to the OFF position. Do this once, as quickly as possible. Fuse F301 should blow instantly. If no arc occurs at the gap, the setting is too wide, and should be reset.

b. Spark Gap E301.

(1) Make sure spark gap E302 is properly adjusted before testing E301.

(2) Set the 400-cps voltage to 108 volts. Turn the HIGH VOLTAGE switch to the OFF position.

(3) Place POWER switch in indicator off.

Caution: Extremely high voltages are present. Short all high-voltage capacitors to ground with an insulated-handle screwdriver before proceeding.

(4) Remove the leads from the magnetron terminals.

(5) Place POWER switch in indicator on.

(6) After the delay time, place the HIGH VOLTAGE switch to the ON position and then to the OFF position as quickly as possible. Spark gap E301 should arc, thus causing spark gap E302 to arc. If arcing does not occur reset the gap.

CHAPTER 10

TROUBLESHOOTING IN RF SYSTEM

Section I. TROUBLESHOOTING PROCEDURES

Warning: Voltages sufficiently high to cause death are present in and near the rf parts. Except as specified, make all tests with the indicator POWER switch off.

136. Reference Data

The following chart lists the illustrations which may prove helpful in troubleshooting the rf system.

Fig. No.	Description
127	Duplexer, exploded view.
128	Antenna horn and reflector adjustments.
129	Antenna horn and side lobe suppressor.

137. General Information

a. Normal Operation. If the transmitting system is operating properly, the outgoing signal travels through the duplexer to the wave guide run. The TR tube prevents the transmitted energy from entering and burning out the signal crystal in the receiving system. From the wave guide run, the signal travels through the fixed and rotating joint assemblies in the antenna pedestal to the antenna horn. The antenna horn, with the reflector, radiates the proper pattern. The returning echo is picked up by the antenna horn and reflector. The energy is then fed back through the wave guide run and the duplexer to the signal crystal.

b. Obvious Troubles.

(1) Loose flanges between the duplexer and the wave guide run, or between section of the wave guide run, may cause arcing and produce a rough singing noise.

(2) Wave guides that are dented, misalined, corroded, or otherwise physically altered, may reduce the strength of the target echoes.

(3) If there is no glow present in the anti-TR tube, it is defective.

(4) Dirty or damaged antenna horn window will cause weak echoes.

138. Test Points

If weak echoes are obtained, TR tube V202 may be at fault. The normal life of a TR tube is approximately 2,000 hours. To check the condition of the tube, read the voltage at the keep-alive electrode (fig. 121) as indicated in *a* through *g* below.

Note. Always check the transmitting system before making tests on the rf system.

a. Turn off indicator POWER switch S105.

b. Discharge all high-voltage capacitors.

c. Set up Multimeter TS–352/U (or equal 20,000 ohms-per-volt meter) as a voltmeter.

d. Connect the minus lead from the multimeter to the keep-alive electrode.

e. Connect the multimeter plus lead to ground.

f. Turn on indicator POWER switch.

g. If the voltage reading is not between 325 volts (for new tubes) and 600 volts (for old tubes), replace the TR tube. If no voltage is present, check the keep-alive power supply (par. 202).

Section II. RF SYSTEM TROUBLESHOOTING CHARTS

139. General

a. The rf system troubleshooting charts presented in the paragraphs below serve merely as guides. Not all possible symptoms are listed. When in doubt, the repairman can use these charts to help him get on the right track.

b. Most symptoms indicative of trouble in the rf system are also indicative of trouble in the transmitting or receiving system. Always check the transmitting system first and then the rf system.

c. If arcing occurs between sections of the wave guide run or between the duplexer and the wave guide run, first reduce the modulator plate voltage temporarily by decreasing the motor generator output. If arcing continues, replace magnetron V306 before disassembling the wave guide run.

d. The keep-alive power supply is part of the power system. But since the keep-alive power supply plays such an important part in the operation of the rf system, symptoms associated with the keep-alive power supply are incorporated in the troubleshooting charts (par. 140 and 141).

e. Troubles in the miscellaneous circuits in the antenna are not listed in the charts below. Antenna drive motor and heater troubles are listed in the power system troubleshooting charts (par. 206). Transmitter synchro troubles are listed in the synchronizing and indicating system troubleshooting charts (par. 179–182).

140. Tube Troubleshooting Chart

The following chart lists a summary of picture symptoms and the probable tube in the rf system at fault.

Note. Whenever TR tube V202 or anti-TR tube V201 is replaced, the TR tube tuning screw must be adjusted (par. 149).

Picture symptom	Tube
Weak echoes on PPI	V201 or V202.
Echoes from nearby targets weak; distant targets normal.	*V202, V409 and V410.

*Always replace both tubes V409 and V410 when either one is defective.

141. General Troubleshooting Chart

Symptom	Probable trouble	Correction
External arcing at TR tube V202	Dirt or corrosion between duplexer flange and TR tube.	Clean body of tube with eraser and tighten mounting screws.
External arcing at anti-TR tube V201	Poor contact around V201	Tighten mounting screws and add another gasket under V201, if required.
Arcing heard in wave guide	Damage in wave guide run	Examine wave guide run for loose joints, dents, and corrosion. Replace defective section.
Weak echoes on PPI	Defective anti-TR tube V201	Check for normal blue glow. Replace V201 and retune TR tube (par. 149).
	Defective TR tube V202	Measure keep-alive voltage (par. 138). If it is not between −325 and −600 volts, replace V202 and retune TR tube (par. 149).
	Damage in wave guide run	Examine wave guide run for loose joints, dents, and corrosion. Replace defective section.
Frequent failure of signal crystal (CR201).	Defective TR tube V202	Measure keep-alive voltage (par. 138). If it is not between −325 and −600 volts, replace V202 and retune TR tube (par. 149).
Noise present on PPI, but no echoes	TR tube not tuned	Tune TR tube (par. 149).
	Transmitting system defective	See Transmitting System Troubleshooting Charts (par. 120–122).
	Receiving system detuned or defective.	See Receiving System Troubleshooting Charts (par. 158–161).
Frequent failure of signal crystal (CR201). TR tube V202 has been replaced.	Defective keep-alive power supply	Replace rectifiers V409 and V410. (Always replace both tubes if either is defective.)
Echoes from nearby targets weak; distant targets normal.	Defective TR tube V202	Measure keep-alive voltage (par. 138). If it is not between −325 and −600 volts replace V202 and retune TR tube (par. 149).

Symptom	Probable trouble	Correction
Modulator tube arcing. Transmitting system all right.	High standing wave ratio. Antenna horn window dirty or damaged.	Clean or replace antenna horn window.
	Dented or broken wave guide	Replace defective section. Check tightness of wave guide flanges.
Antenna horn does not rotate	Defective antenna drive motor circuit.	See Power System Troubleshooting Charts (par. 205–207).
Antenna horn rotates, but sweep on PPI does not rotate.	Defective synchronizing circuits	See Synchronizing and Indicating System Troubleshooting Charts (par. 179–182).

Section III. REPLACEMENT OF PARTS

142. TR Tube Replacement
(fig. 127)

To replace TR tube V202, proceed as follows:

a. Turn off indicator POWER switch S105.

b. Loosen the two captive screws and open the hinged panel of the receiver-transmitter.

c. Remove the plate cap clip on the TR tube.

d. Remove the four machine screws (on top of the duplexer) that hold the TR tube.

e. Slowly pull the tube out of the duplexer and turn it approximately 45°, so that it clears the slot in the hinged panel.

f. Insert the new TR tube into the duplexer.

g. Replace the four machine screws and the plate cap clip.

h. Retune the TR tube (par. 149).

143. Anti-TR Tube Replacement
(fig. 127)

To replace anti-TR tube V201, proceed as follows:

a. Turn off indicator POWER switch S105.

b. Remove the two machine screws and the cover plate of the anti-TR box.

c. Remove the anti-TR tube and replace with a new tube.

d. Replace the cover plate and the two machine screws.

144. Duplexer Replacement
(fig. 127)

To replace the duplexer, proceed as follows:

a. Turn off the indicator POWER switch S105.

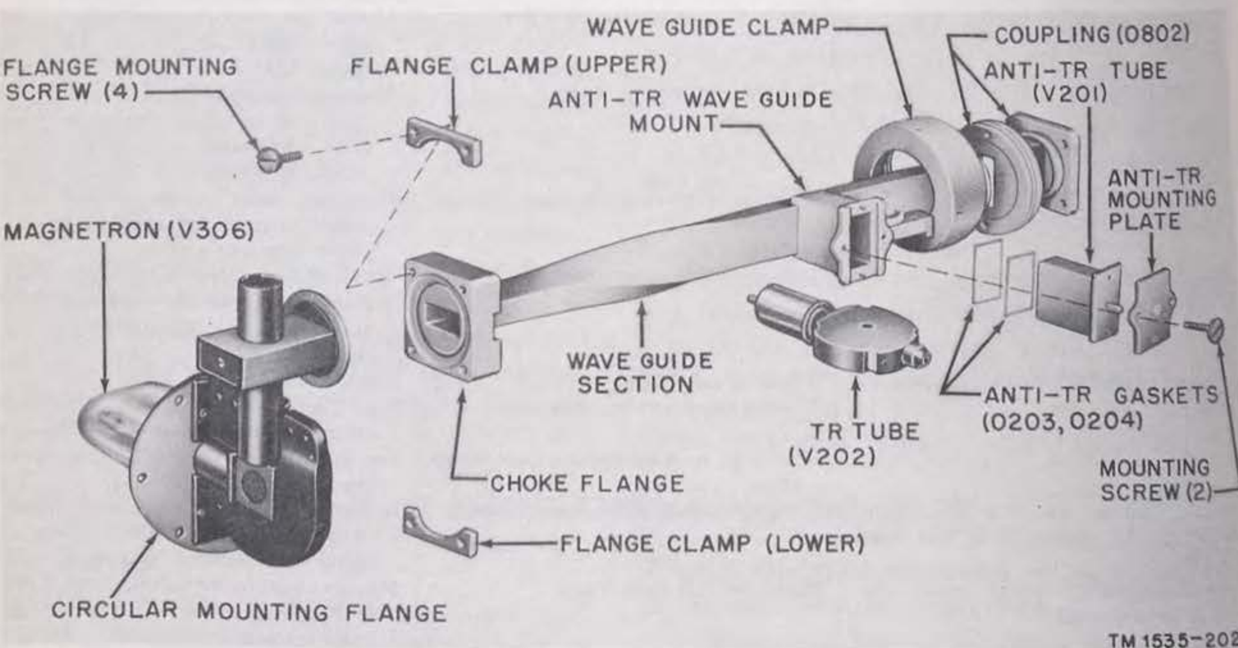

Figure 127. Duplexer, exploded view.

b. Remove the magnetic shield covering the magnet and magnetron.

c. Remove the four flange mounting screws (fig. 127) and the upper and lower flange clamps.

d. Loosen the wave guide clamp.

e. Remove the TR tube as instructed in paragraph 142.

f. Remove the screws at the bottom of the TR box and remove the duplexer.

g. Reverse the procedure in *a* through *f* above to replace the duplexer.

Caution: The TR and anti-TR tubes contain radioactive materials and are a radiation hazard. Handle in accordance with instructions given in TB SIG 225.

145. Wave Guide Replacement

Any wave guide section can be replaced. Remove the four screws from each of the flanges, and replace the section. Refer to TM 11–1335, Radar Sets AN/SPN–11X, AN/SPN–11Y and AN/SPN–11Z, Installation and Operation for instructions on cutting and brazing wave guide sections.

146. Antenna Horn Replacement

a. Remove the four flange screws that secure the horn to the wave guide flange.

b. When replacing the horn, make certain the red paint mark on the horn is alined with the red mark on the suppressor under the two upper flange screws. After mounting, refer to paragraph 150 for antenna horn and reflector adjustment.

147. Antenna Reflector Replacement

a. Remove the two mounting nuts and bolts (fig. 183) that secure the reflector to the rotating mounting base.

b. When mounting a reflector, carefully insert the two dowel pins on the rotating head into the two holes at the base of the reflector mounting brackets. After mounting, refer to paragraph 150 for antenna horn and reflector adjustment.

Section IV. ALINEMENT AND ADJUSTMENTS

148. General

The alinement and adjustment procedures for the rf system are presented in this section. Most of the adjustments in the rf system are mechanical. The alinement chart (fig. 221) gives a summary of the complete alinement procedure for the radar set.

149. TR Tube Tuning

Whenever any part of the rf system is replaced the TR tube must be retuned as follows:

a. Place the radar set in operation.

b. Stop the radar antenna horn on a target that returns a weak echo. If no weak signal is available on the PPI, attenuate the signal by turning GAIN control R177 counterclockwise.

c. Rotate the TR tuning adjustment (fig. 31) to the right or left, as necessary, for maximum amplitude on the PPI.

150. Antenna Horn and Reflector Adjustment

The spacing between the antenna horn and reflector must be checked to assure satisfactory performance. The spacing can be checked with an antenna gage or a 6-foot steel rule. Measurements are made from pips on the top, bottom, and ends of the reflector (fig. 128). The ends of the reflector each have a single pip. The top and the bottom each have two pips. The center of the reflector is located on a line between the two pips on the top and bottom of the reflector.

a. Antenna Gage Check.

(1) Make certain that the antenna horn is fastened securely to the rotating mounting base.

(2) Loosely bolt the reflector to the rotating mounting base so that the reflector may be shifted.

(3) Set the antenna gage between the two pips in the center of the reflector and flush over the horn. *The gage must fit within one-thirty-second inch at all points on the reflector.*

(4) Measure the distance (X, fig. 128) fron the pip on each end of the reflector to eacl edge of the horn flange. Both distance should be the same within one-thirty second inch.

(5) If, because of damage to the antem reflector, the measurement is not sat factory, the reflector position should adjusted as indicated in (6) through (1 below.

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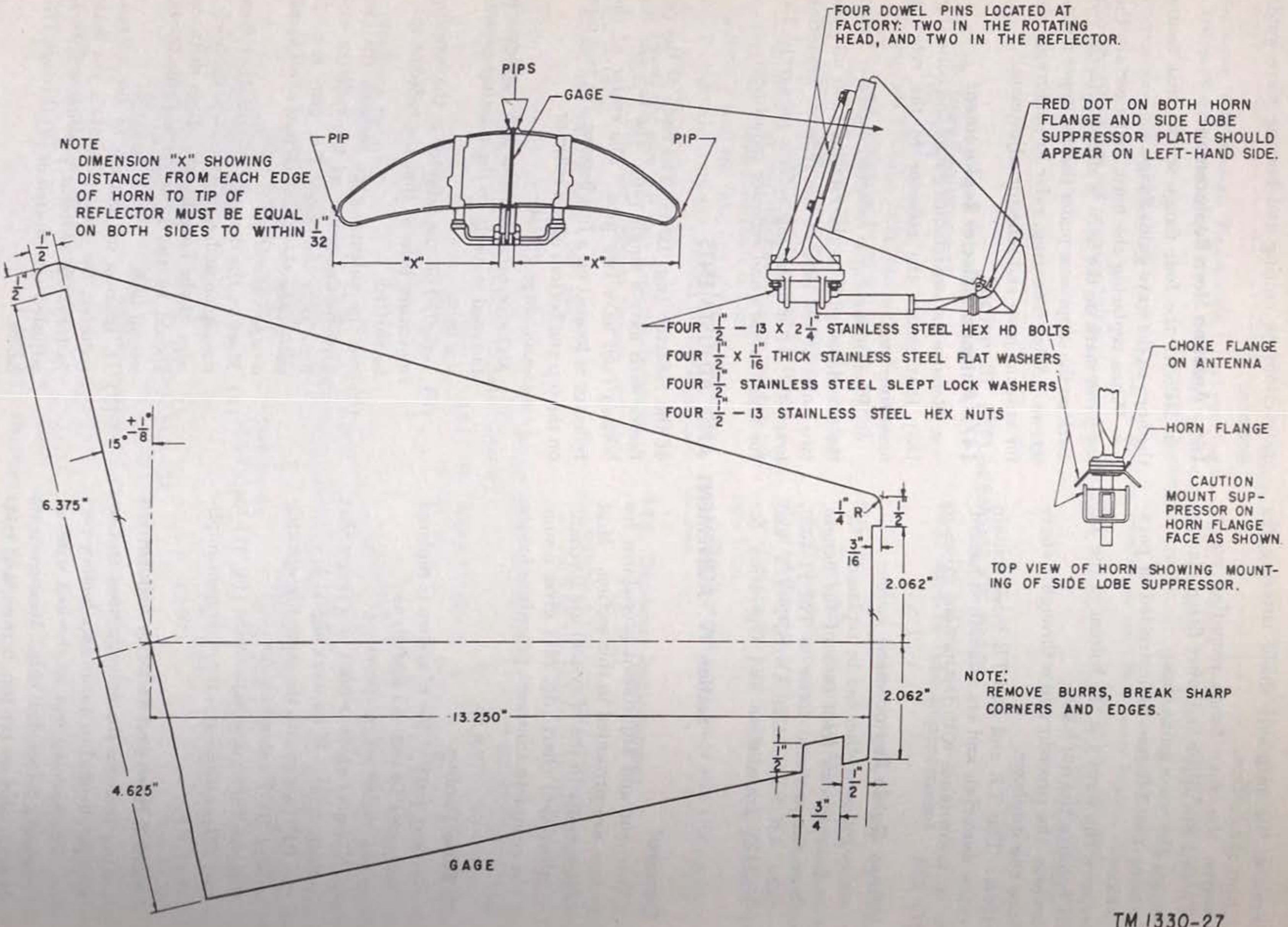


Figure 128. Antenna horn and reflector adjustments.

(6) Determine what damage has been done to the reflector. By visual inspection and with the gage check, note whether the shape of the reflector has been altered.

(7) Use a *rubber* hammer and carefully hit the reflector into proper shape.

(8) Perform the gage check. If the measurements are still unsatisfactory and it is evident that the reflector cannot be hammered into shape, perform the procedures outlined in (9) through (13) below.

(9) Unbolt the reflector and remove the locating pins on the rotating mounting base.

(10) Shift the reflector until the gage fits within one-thirty-second inch at all points on the reflector.

(11) If the adjustment cannot be done merely by shifting the reflector, unbolt the reflector proper from the reflector brackets and remove the dowel pins. Rebolt the reflector loosely to its brackets, and shift the reflector with reference to the rotating mounting base until the spacing conforms to (3) above.

(12) Tighten all bolts.

(13) Relocate the locating pins by drilling new holes for the dowels.

b. Steel Rule Check. When an antenna gage is not available, use a 6-foot steel rule to check the reflector spacing.

(1) Measure $15\frac{7}{16}$ inches, $\pm\frac{1}{32}$ inch, from the top center pips of the reflector to the top center of the flat flange on the horn.

(2) Measure $12\frac{5}{16}$ inches, $\pm\frac{1}{32}$ inch, from the bottom center pips of the reflector to the bottom center of the flat flange of the horn.

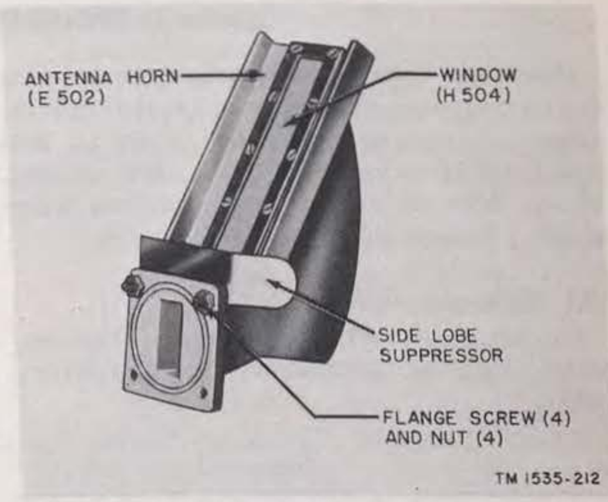


Figure 129. Antenna horn and side lobe suppressor.

(3) Measure the distance from the end pips of the reflector to the corresponding point on each side of the horn flange. Both measurements should be the same within $\frac{1}{32}$ inch.

Section V. FINAL TESTING

151. General

This final testing section is intended as a guide for determining whether a repaired rf system meets the original specifications. Entire test procedures for the rf system are given. The final testing chart (fig. 222) summarizes the final testing procedure for the entire radar set.

152. Testing Wave Guide Run

Test the power output of the transmitter circuits according to instructions given in paragraph 131. Replace RF Test Load TS–108A/AP by wave guide run and antenna; repeat the power output measurement. If the power output with the antenna in place is much less than the power output with the RF test load connected, the trouble may be in the wave guide run. Loosen the wave guide flanges and inspect the insides of the wave guides for corrosion or other damage.

153. Reflector Parabola Curve

Check the curve by holding the antenna parabolic profile gage against the center of the reflector rods. The gap between the reflector and gage should be one thirty-second of an inch or less. The backlash, as measured from the end of the reflector, should be one-fourth inch or less.

CHAPTER 11

TROUBLESHOOTING IN RECEIVING SYSTEM

Section I. TROUBLESHOOTING PROCEDURES

Warning: Voltages sufficiently high to cause death are exposed at certain points in the receiving system. Except where specified, make all tests with POWER switch S105 in the OFF position. Always short out high-voltage capacitors before touching them or their associated circuits.

154. Reference Data

The following chart lists illustrations that may prove helpful in troubleshooting the receiving system.

Fig. No.	Description
130	Receiving system, tube location chart.
132	Klystron local oscillator, voltage and resistance diagram.
131	Receiving system, voltage and resistance diagram.
213	Receiver R–480/SPN–11, schematic.
217	Receiver R–480/SPN–11, wiring diagram.

155. General Information

a. Normal Operation. As soon as high voltage is applied to the transmitting system, rf energy is transmitted by the antenna. Returing echoes are fed through the duplexer to the mixer which produces a 30 mc if. The if. is fed through the signal circuits before being applied through the video circuits to the PPI. The GAIN control varies the if. sensitivity. A second output of the mixer is fed to the afc circuits, which by varying the voltage on the reflector of the klystron local oscillator in the mixer, keeps the if. constant. The proper operation of the mixer is indicated when the reading of CRYSTAL CURRENT meter M201 is correct with AFC XTAL I–SIGNAL XTAL I PUSH switch in either position. The stc circuits are operated by the trigger that is produced by master blocking oscillator V307A of the transmitting system.

b. Obvious Troubles.

(1) Incorrect +140V, +300V REG, or −300V REG outputs, as indicated on test meter M401, will cause the receiving system to operate improperly.

(2) Incorrect +320V output, as indicated on test meter M401, will cause the stc circuits to operate improperly.

(3) If power supplies fuse F402 is open, none of the receiving system filaments will light.

(4) If power supplies fuse F401 is open, supply voltages will not be available.

156. Preliminary Test Procedures

Note. Be sure that the transmitting and rf systems are operating properly before making tests in the receiving system.

a. Mixer.

(1) With switch S201 in the AFC XTAL I (normal) position, read CRYSTAL CURRENT meter M201. If the reading is not between .4 and .75 ma, check afc crystal CR202.

(2) With switch S201 in the SIGNAL XTAL I PUSH (depressed) position, read CRYSTAL CURRENT meter M201. If the reading is not between .4 ma and .75 ma, check signal crystal CR201.

(3) If the CRYSTAL CURRENT meter reads too low on both positions of S201, place A. F. C. OPERATION-MAN. TUNE switch S202 to the MAN. TUNE position. Vary REFLECTOR TUNING control R250. If it has no effect on the CRYSTAL CURRENT meter reading, check the klystron local oscillator.

b. Afc Circuits. Place switch S202 to the MAN. TUNE position and then to the A. F. C.

OPERATION position. If the intensity of the echoes on the PPI decreases as the switch is placed in the A. F. C. OPERATION position, the afc circuits are inoperative.

c. Signal Circuits.

(1) A normal amount of grass on the PPI is a fair indication that the signal circuits are in good order. However, if the noise level is excessive, remove tube V204, and note whether the noise level decreases sharply. If so, the trouble is probably in the mixer or V204. If the noise level does not decrease, the trouble is probably a defective tube in the signal if. circuits.

(2) Vary the GAIN control. If the noise level on the PPI does not change, the fault probably is in the stages following the GAIN control (V207 to V212). If the noise level varies as the GAIN control is turned, the fault is probably in the circuits before the GAIN control (V204 to V206) or in the mixer.

d. Stc Circuits. Trouble in the stc circuits may cause trouble in the signal circuits. To determine if the stc circuits are the cause, position the GAIN control in the extreme clockwise position, and rotate the SUPPRESSOR control counterclockwise. If the fault clears, the fault is in the stc circuits.

157. Test Points

a. Afc Circuits. Perform afc if. alinement procedure given in paragraph 171 below to determine if the afc if. amplifiers and discriminator are operating normally.

b. Phantastron. With the afc crystal removed, use Oscilloscope TS–34A/AP (par. 110) to check the wave form at the plate (pin 5) of V218. It should be as shown in figure 49.

c. Signal Circuits, Cathode Follower.

(1) Connect Oscilloscope TS–34A/AP (par. 110) to VIDEO OUTPUT jack J202.

(2) Connect negative output of Square Wave Generator TS–583/U to the plate (pin 7) of V211.

(3) Increase the output of the square-wave generator until the amplitude of the pulse viewed on the oscilloscope stops increasing.

(4) Determine the amplitude of the pulse. It should be between 1.25 and 2 volts.

d. Signal Circuits, If. Amplifiers. Perform the signal if. alinement procedure given in paragraph 170 below to determine if the signal circuits are operating normally.

e. Stc Circuits. Check the wave form at pin 3 of tube V219. If it is not as indicated in figure 55, check to see if the trigger is arriving at TRIGGER jack J203. If the trigger is not arriving at the jack, check tube V219.

Section II. RECEIVING SYSTEM TROUBLESHOOTING CHARTS

158. General

a. Not all the symptoms presented in the following charts are definitely due to trouble in the receiving system. Some symptoms listed—such as reduced target echoes—may be due to trouble in the transmitting, rf, or synchronizing and indicating systems. In any such case, it is best to check the transmitting and rf systems before troubleshooting the receiving system.

b. The tube troubleshooting chart and crystal troubleshooting chart indicate what tubes or crystals may be at fault. If after replacement of the tube or crystal the fault is not remedied, refer to the general troubleshooting chart.

c. The general troubleshooting chart does not give all possible symptoms. For the symptoms listed, the chart serves merely as a guide to the circuits or stage at fault. To find the exact part at fault, take voltage and resistance readings, and compare them to those given in the voltage and resistance charts (figs. 131 and 132).

159. Tube Troubleshooting Chart

Various symptoms of trouble observed on the PPI may indicate a defective tube. The following chart lists a summary of picture symptoms and additional trouble indications resulting from faulty tubes in the receiving system.

Note. Whenever V203 is replaced, realine mixer (par. 169).

Picture symptom	Test Meter M201	Additional indication	Tube
Weak or no echoes	Normal		V204 through V212. V201 (remote possibility).
Weak or no echoes	Normal	GAIN control varies noise level	V204 through V206.
No echoes	No or low reading		V203.
Normal, targets obscured by sea return.	Normal	SUPPRESSOR control inoperative.	V219.
Alternate sectors of light and dark areas on PPI scope.	Meter M201 sweeps	Symptoms exist for both positions of S202, with R250 properly adjusted.	V203.
		Operation normal when S202 placed in MAN. TUNE position.	V213 through V218.

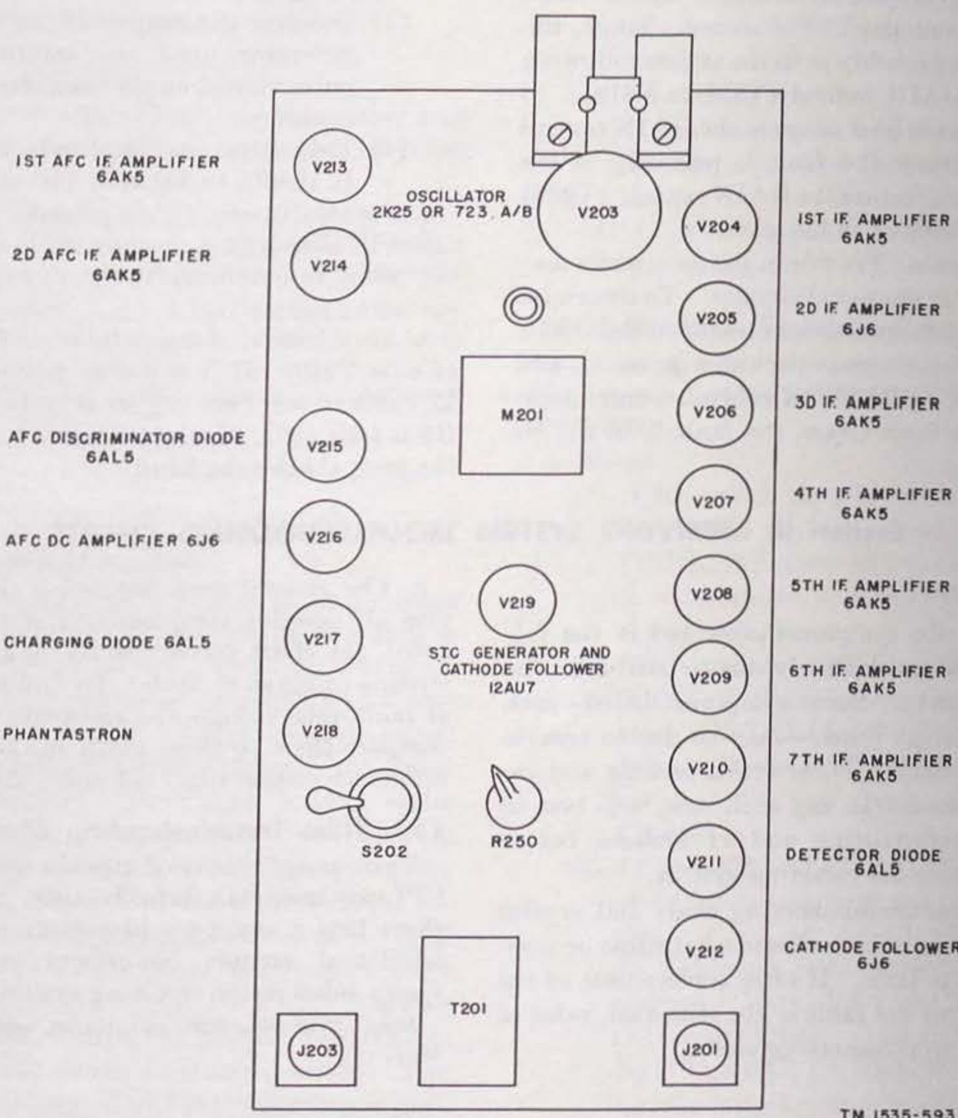


Figure 130. Receiving system, tube location chart.

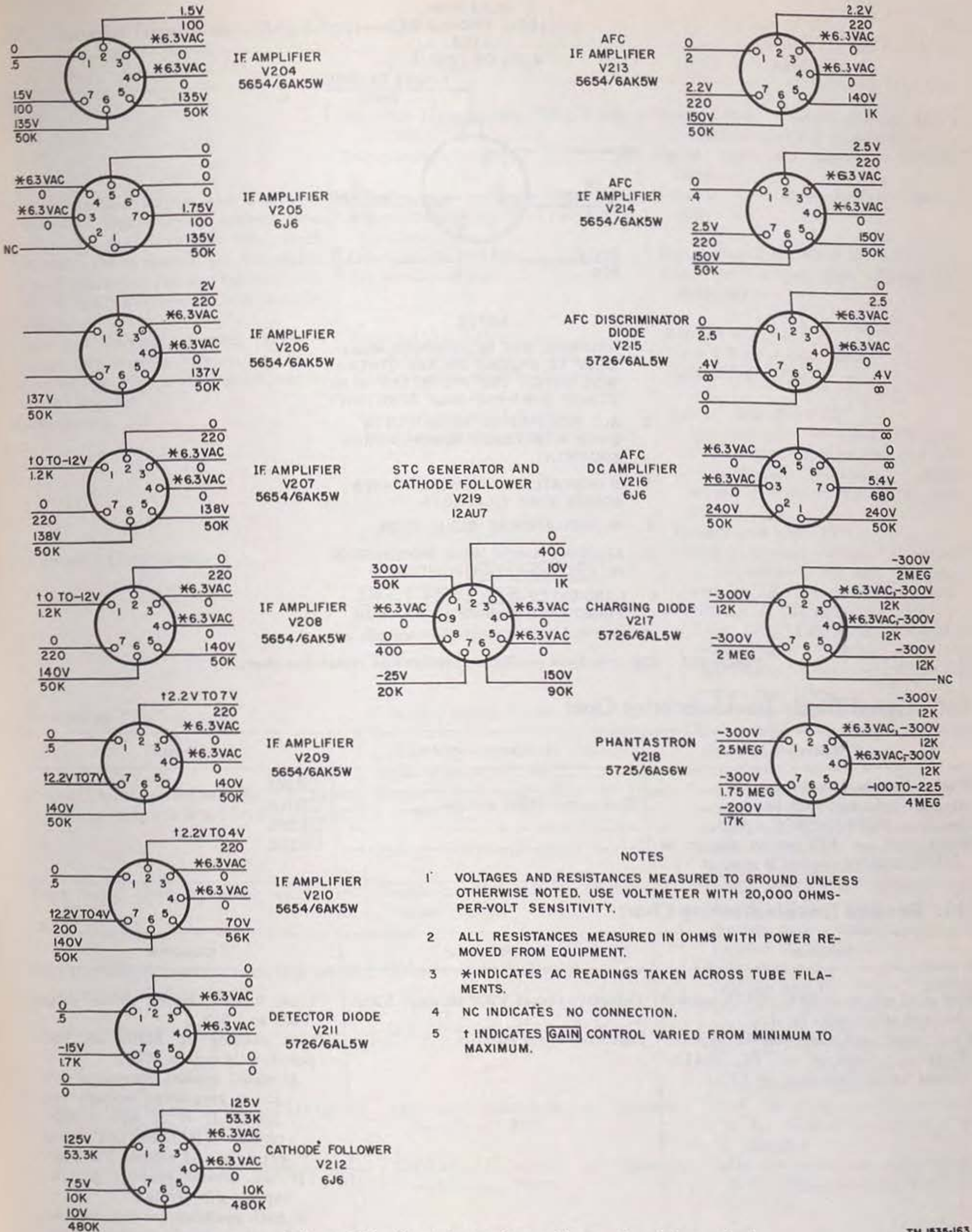
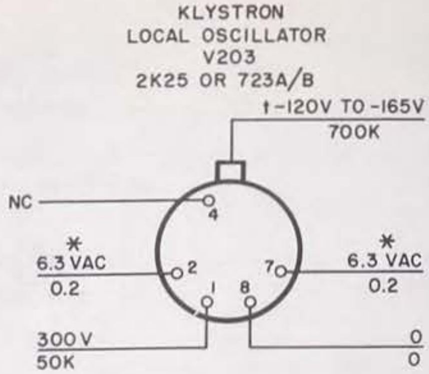


Figure 131. Receiving system, voltage and resistance chart.



NOTES

1 VOLTAGES AND RESISTANCES MEASURED TO GROUND UNLESS OTHERWISE NOTED. USE VOLTMETER WITH 20,000 OHMS-PER-VOLT SENSITIVITY.

2 ALL RESISTANCES MEASURED IN OHMS WITH POWER REMOVED FROM EQUIPMENT.

3 * INDICATES AC READINGS TAKEN ACROSS TUBE FILAMENTS.

4 NC INDICATES NO CONNECTION.

5 READINGS TAKEN WITH SWITCH S202 IN A.F.C. OPERATION POSITION.

6 † INDICATES REFLECTOR TUNING VARIED FROM MINIMUM TO MAXIMUM.

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Figure 132. Klystron local oscillator, voltage and resistance chart.

160. Crystal Diode Traubleshooting Chart

Symptom	Additional indication	Crystal
Weak echoes or no echoes		CR201.
Alternate light and dark bands	Test meter M201 sweeps	CR202.
Poor or no SUPPRESSOR action		CR204.
Bright spot on PPI which moves as SUPPRESSOR control is rotated.		CR203.

161. General Troubleshooting Chart

Symptom	Probable trouble	Correction
Weak or no echoes on PPI. GAIN control does not affect noise level.	Defective stages V207 through V212.	Check tubes. Signal trace stages V207 to V212.
Sweep, noise, and range marks appear. Weak or no echoes on PPI. GAIN control varies noise level on PPI.	Defective mixer circuits	Check reading of M201 on both positions of switch S201. If signal crystal current is low, check keep-alive voltage (fig. 139). If it is not −900v, replace TR tube and signal crystals, and retune TR tube. If afc crystal current is low, replace afc crystal. If both readings are low replace klystron local oscillator and retune mixer (par. 169).

Symptom	Probable trouble	Correction
	Defective signal stages V204, V205, or V206.	Check tubes. Make voltage and resistance checks of these stages.
	Defective afc circuits	Signal trace afc circuits. Check tuning.
Sweep and echoes appear and disappear cyclically. Signal crystal current rises and falls according to the same pattern. (It is normal for the signal crystal current to rise and fall when the HIGH VOLTAGE switch is in the OFF position.)	Klystron local oscillator detuned or tuned to wrong side of magnetron frequency.	Tune klystron local oscillator (par. 169).
	Defective afc circuits	Signal trace from V213 to V218.
	Afc crystal defective	Check crystal (par. 109). Replace if defective.
Noise and crystal current present. Magnetron current correct. All voltages on test meters are correct, but no signals appear.	Tube V218 defective	Replace tube.
	TR tube detuned	Tune TR tube (par. 189).
	Klystron local oscillator detuned	Retune (par. 169).
Weak signals	Receiving system detuned	Retune (par. 168–171).
	Defective signal crystal	Check keep-alive voltage at TR tube. If it is not between 325 and 600 volts, replace TR tube and signal crystal. Retune TR tube (par. 149).
	TR tube detuned	Retune tube (par. 149).
No signal crystal current	Defective signal crystal CR201	Check keep-alive voltage. If voltage is not between 325 and 600 volts, replace TR tube and signal crystal. Tune new TR tube (par. 149).
	Klystron local oscillator not oscillating.	Adjust REFLECTOR TUNING control R250. If this does not clear the trouble, replace the tube, and retune (par. 169).
No noise on PPI	Defective signal circuits	Check tubes V204 to V212.
	Defective video cable between receiving system and indicator.	Check cables W706 and W707 with ohmmeter (par. 107).
	Signal circuits detuned	Retune (par. 170).
Klystron local oscillator difficult to tune. Impossible to get .5 ma crystal current.	Klystron not completely in tube socket.	Push klystron firmly into tube socket. ***Caution:*** The shell of the klystron is at a dangerously high potential.
	Defective klystron tube	Replace klystron. Tune receiving system (par. 168–169).
Dark radial lines (spoking) appear on PPI.	Ripple caused by a faulty tube in the signal circuits.	Remove tubes V204 through V212 one at a time. The faulty tube is the one whose removal causes the spoking to disappear.
SUPPRESSOR control does not affect sea return at close ranges.	Defective stc circuits	Check for proper wave form at cathode (pin 3) of V219. Check for trigger at V203. Check tube V219.
No tube filaments light	Defective filament transformer T201	Check for 115 volts ac at terminals 1 and 2 of T201. If voltage is present, check for open primary. Replace transformer if defective.
Filaments of tubes V217 and V218 do not light; other filaments light.	Defective secondary on filament transformer T201.	Check for open secondary winding (3, 4). Replace transformer T201, if defective.
All filaments out except those of tubes V217 and V218.	Defective secondary on filament transformer T201.	Check for open secondary winding (5, 6). Replace transformer T201 if defective.

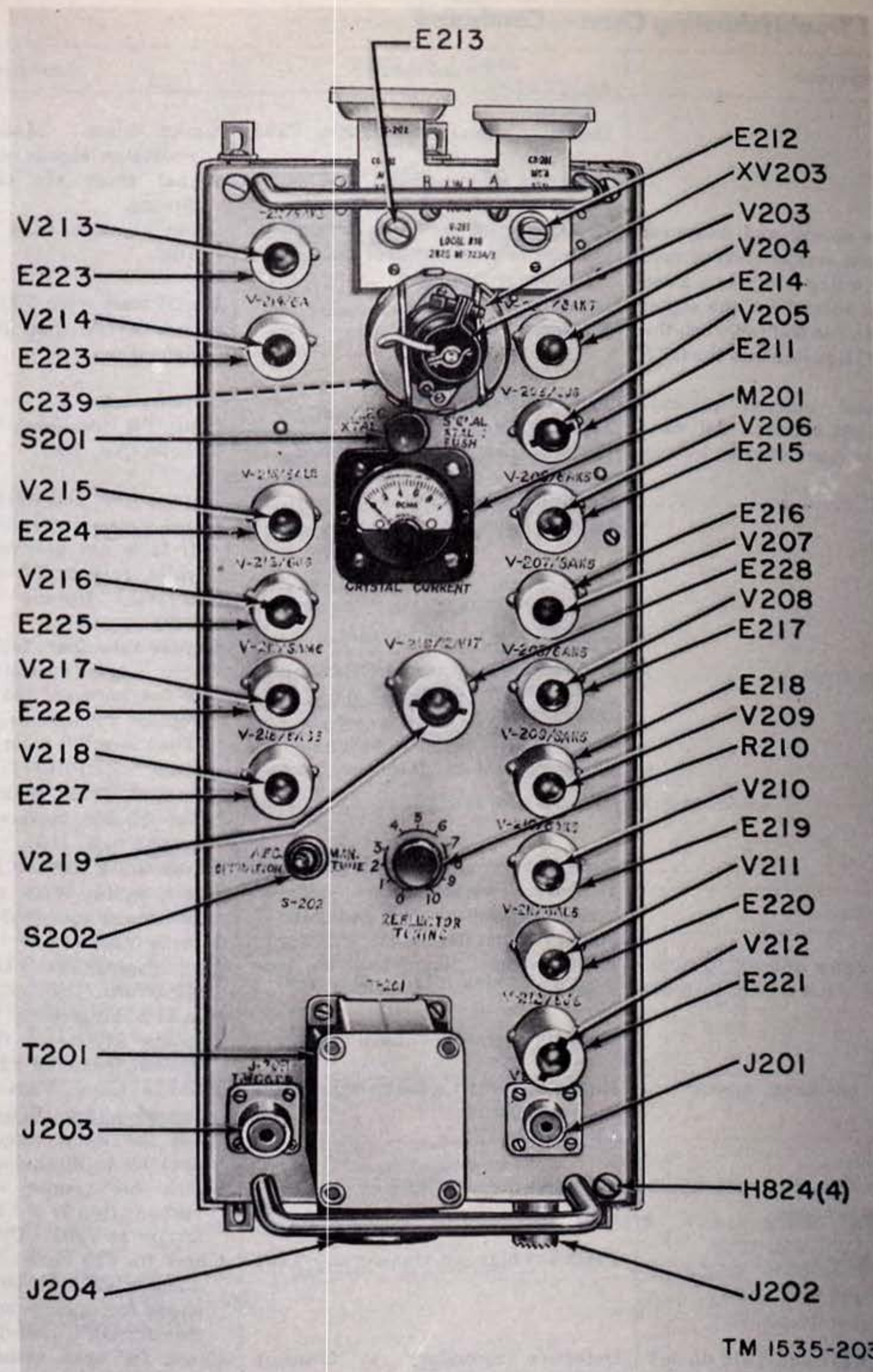


Figure 133. Receiver chassis, top view, location of parts.

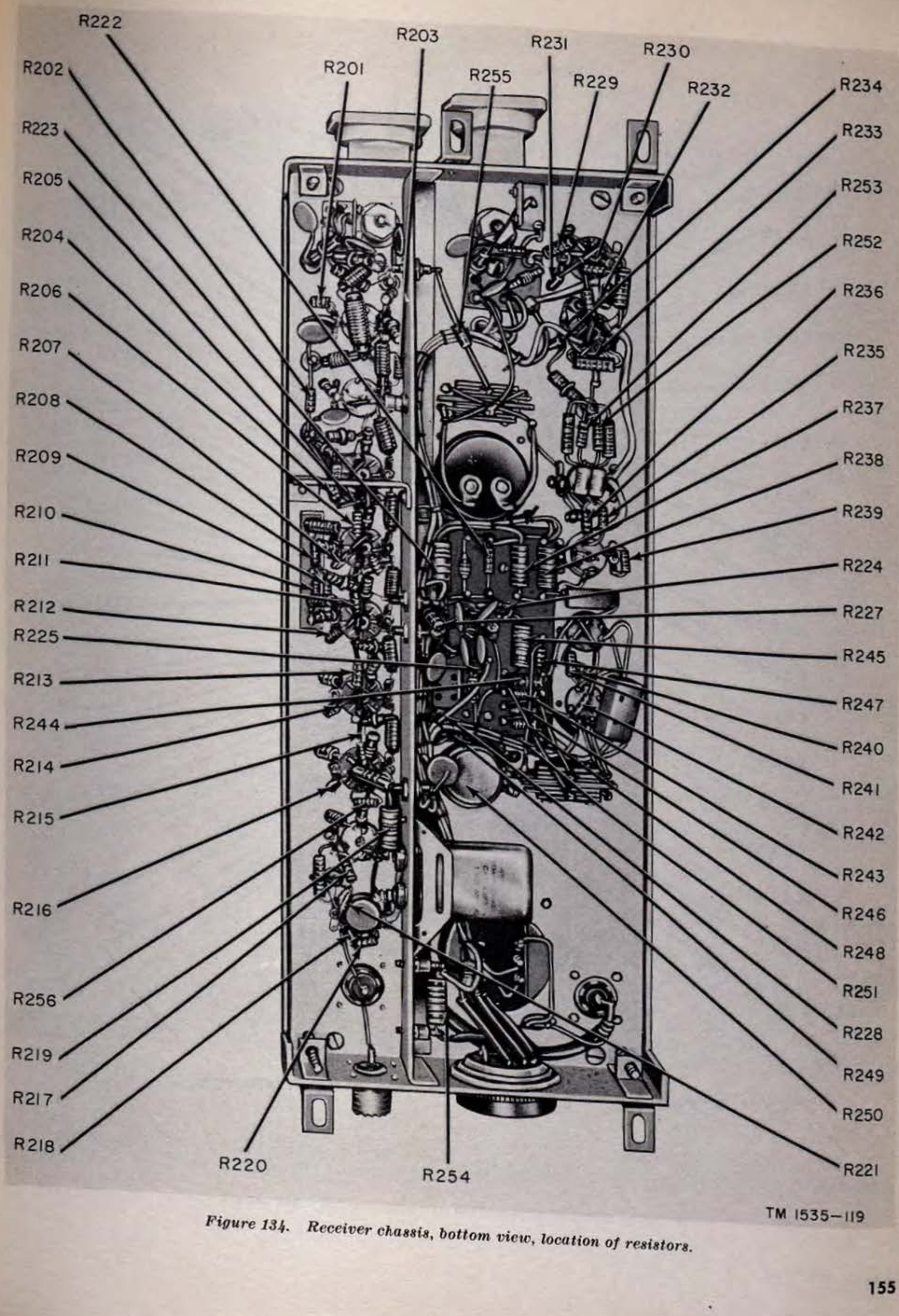


Figure 134. Receiver chassis, bottom view, location of resistors.

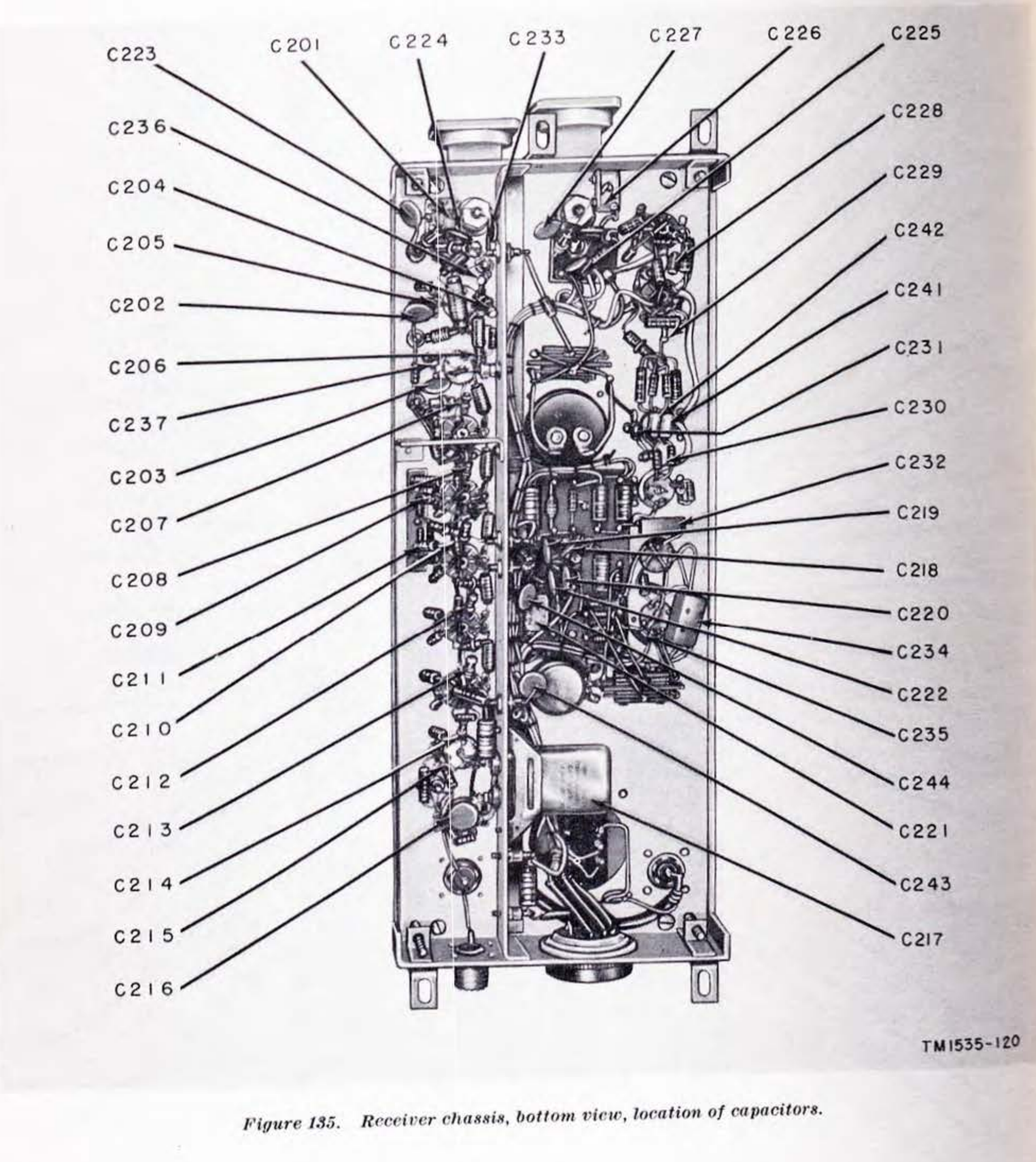


Figure 135. Receiver chassis, bottom view, location of capacitors.

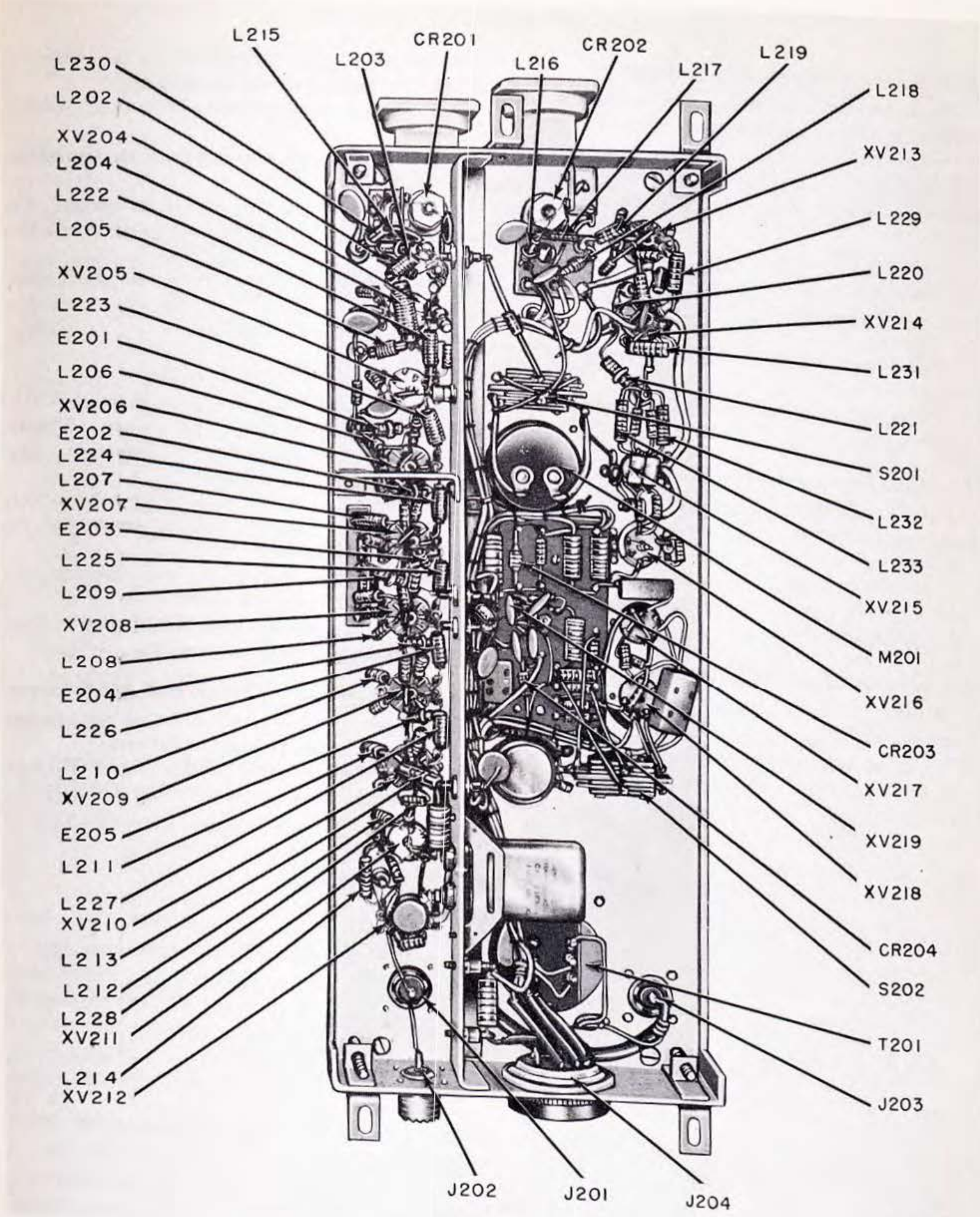


Figure 136. Receiver chassis, bottom view, location of parts.

162. Receiver Chassis Replacement

The receiver chassis is mounted on the upper right side of the receiver-transmitter (fig. 39). To remove the chassis, proceed as follows:

a. Remove the three cables W801, W803, W804 connecting the receiver chassis to the receiver-transmitter.

b. Remove TR tube V202 (par. 142).

c. Remove the four screws that secure the receiver wave guide flange to the duplexer.

d. Remove the four bolts that secure the receiver chassis to the receiver-transmitter unit and remove the chassis.

e. To replace the receiver chassis, reverse the procedure given above.

163. Tube Replacement

Most of the tubes on the receiver chassis are inclosed in tube shields. To remove a shield, press it down, turn it counterclockwise, and release. Pull the tube straight up from its socket. When replacing a tube, do not force it into its socket. This may damage the pins.

164. Klystron Local Oscillator Replacement

Warning: The local oscillator metal tube envelope has 300 volts impressed upon it. Shut off all power before attempting to replace this tube.

To replace local oscillator V203 proceed as follows:

a. Remove the perforated shield covering the tube by pulling the shield straight up.

b. Push aside the two spring clips that hold the tube base.

c. Remove the plate-cap clip from the top of the tube.

d. Slowly pull the tube out of its socket. Do not incline the tube until its long probe clears the socket.

e. To replace the tube, reverse the above procedure.

f. Retune the mixer (par. 169).

165. Tube Socket Replacement

The tube sockets for tubes V206 through V210, V213, and V214 have built-in capacitors. Should one of these capacitors become defective, tube socket replacement is required.

a. Unsolder and tag all leads to the tube socket.

b. Remove the nuts and pull out the screws on either side of the socket.

c. Remove the socket and replace. Reverse the procedure given in *a* and *b* above.

Caution: Run leads to the tube socket so that the leads lie in their original position.

166. Replacement of Signal and Afc Crystals

To replace signal crystal CR201 or afc crystal CR202 in the mixer, proceed as follows:

a. Unscrew the crystal holder (fig. 137) and remove the holder and crystal from the mixer.

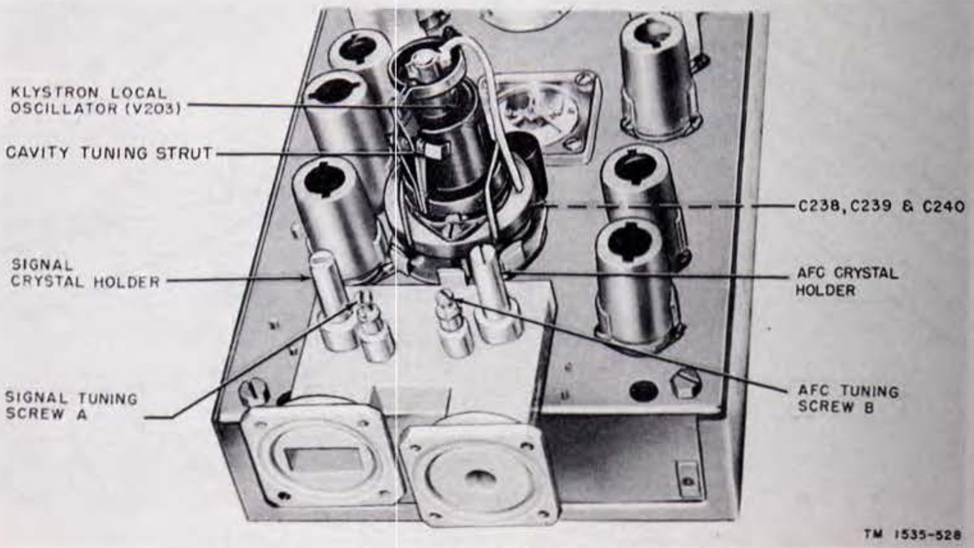


Figure 137. Mixer and klystrom local oscillator.

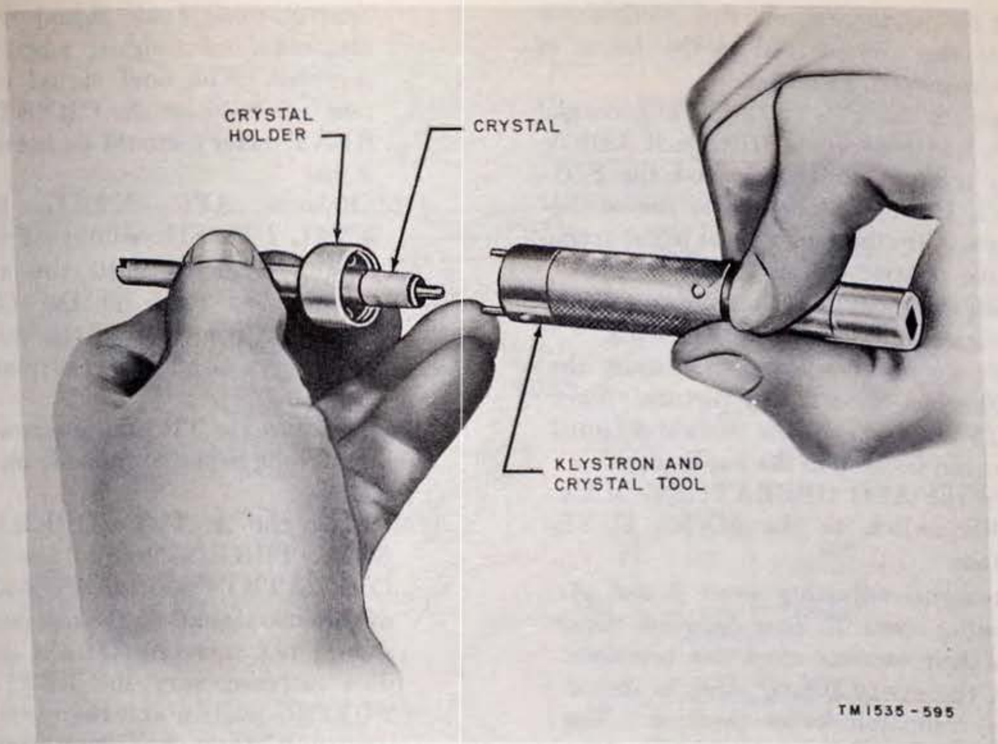


Figure 138. Removing crystals.

b. Place the klystron and crystal tool over the crystal so that its two prongs engage the holes in the crystal holder (fig. 138).

c. Unscrew the crystal cap and remove the crystal.

Caution: Crystals should be handled with care at all times.

d. Replace the crystal in the holder, and tighten with the klystron and crystal tool. Place the crystal holder back in the mixer.

167. Mixer Replacement

a. Remove the receiver chassis (par. 162).

b. Remove the two holding screws that secure the mixer to the chassis.

c. Remove the mixer.

d. Reverse the procedure to replace mixer.

Section IV. ALINEMENT AND ADJUSTMENTS

168. General

The alinement and adjustment procedures for the receiving system are presented in this section. Whenever possible, try to aline the rf system and the receiving system as one unit. The alinement chart (fig. 221) gives a summary of the complete radar alinement procedure.

169. Mixer Alinement
(fig. 139)

a. General. The mixer is alined by means of signal tuning screw A, afc tuning screw B, the klystron cavity tuning strut and the REFLECTOR TUNING control. Signal tuning screw A and afc tuning screw B adjust the coupling between the klystron local oscillator and the signal and afc crystals, respectively. The cavity tuning strut is a coarse adjustment that varies the size of the resonant cavity. The REFLECTOR TUNING control is a fine adjustment that controls the voltage fed to the klystron reflector.

b. Alinement with Oscilloscope. Oscilloscope TS-34A/AP, or any other oscilloscope that can operate from a 400-cps, 115-volt source, should be used. The detailed procedure is as follows (par. 110):

(1) Connect the unmarked oscilloscope test lead between TRIGGER jack J303 on the receiver-transmitter and the EXT

SYNC connector on the oscilloscope. Clip the ground lead to the frame of the receiver-transmitter.

(2) Connect the SIGNAL INPUT coaxial test lead between VIDEO jack J201 on the receiver-transmitter and the SIGNAL INPUT connector on the oscilloscope. Clip the ground lead to the frame of the receiver-transmitter.

(3) Place the radar set in operation. Train the antenna horn on a steady target.

(4) Turn on the oscilloscope. Adjust the oscilloscope for a steady picture. Vary GAIN control on the indicator until *grass* can be seen on the oscilloscope.

(5) Place the AFC OPERATION—MAN. TUNE switch to the MAN. TUNE position.

(6) Turn signal adjusting screw A and afc adjusting screw B, four complete turns from their extreme clockwise positions.

(7) Turn the cavity tuning strut to its extreme counterclockwise position. Use the klystron and crystal tool (fig. 138) for this and all other cavity tuning strut adjustments. Feed the tool through the hole in the klystron insulating shield.

Warning: The cavity tuning strut and the klystron metal envelope have 300 volts impressed on them.

(8) *Slowly* turn the cavity tuning strut clockwise and simultaneously adjust the REFLECTOR TUNING control until echoes appear on the test oscilloscope.

(9) Read the CRYSTAL CURRENT meter in the normal and in the depressed positions of the AFC XTAL I-SIGNAL XTAL I PUSH switch. If the reading on either position exceeds .75 ma., turn signal tuning screw A or afc tuning screw B, as necessary, until the current reading is approximately .70 ma.

(10) Adjust the TR tuning screw for maximum amplitude of the echo signals appearing on the test oscilloscope.

(11) Keep AFC XTAL I-SIGNAL XTAL I PUSH switch depressed. Adjust the REFLECTOR TUNING control for peak signal crystal current. Next adjust the cavity tuning strut for maximum amplitude of echo signals on the oscilloscope. Make slight adjustments in each control until peak signal current and maximum echo signal amplitude occur *together.* The final signal crystal current (as read on the CRYSTAL CURRENT meter) should be between .4 and .5 ma.

(12) Release AFC XTAL I-SIGNAL XTAL I PUSH switch, Turn afc adjusting screw B until the afc crystal current (as read on the CRYSTAL CURRENT meter) is the same as the signal crystal current (as read in (11) above).

(13) Readjust the TR tuning screw for maximum echo signal amplitude on the oscilloscope.

(14) Place the A. F. C. OPERATION—MAN. TUNE switch to the A. F. C. OPERATION position. The amplitude of the echo signals on the test oscilloscope should not increase. If the amplitude does increase, vary the REFLECTOR TUNING control and the cavity tuning strut until the echo signal amplitude is the same on both positions of the A. F. C. OPERATION—MAN. TUNE switch.

c. Alinement Without Oscilloscope. Aline the set with an oscilloscope whenever possible. In an emergency, the set may be alined without an oscilloscope as follows:

(1) Place the radar set in operation. Train the antenna horn on a steady target.

(2) Vary the GAIN control on the indicator until grass is seen on the PPI.

(3) Place the A. F. C. OPERATION—MAN. TUNE switch to the MAN. TUNE position.

(4) Adjust REFLECTOR TUNING control for a peak reading on the CRYSTAL CURRENT meter.

(5) Turn afc adjusting screw B until CRYSTAL CURRENT meter reads .5 ma. Depress A. F. C. XTAL I-SIGNAL XTAL I PUSH switch. Turn signal adjusting screw B until CRYSTAL CURRENT meter again reads .5 ma.

(6) Place the A. F. C. OPERATION—MAN. TUNE switch in the A. F. C. OPERATION position.

(7) Turn the cavity tuning strut to its extreme counterclockwise position. Then *slowly* turn it clockwise. The reading of

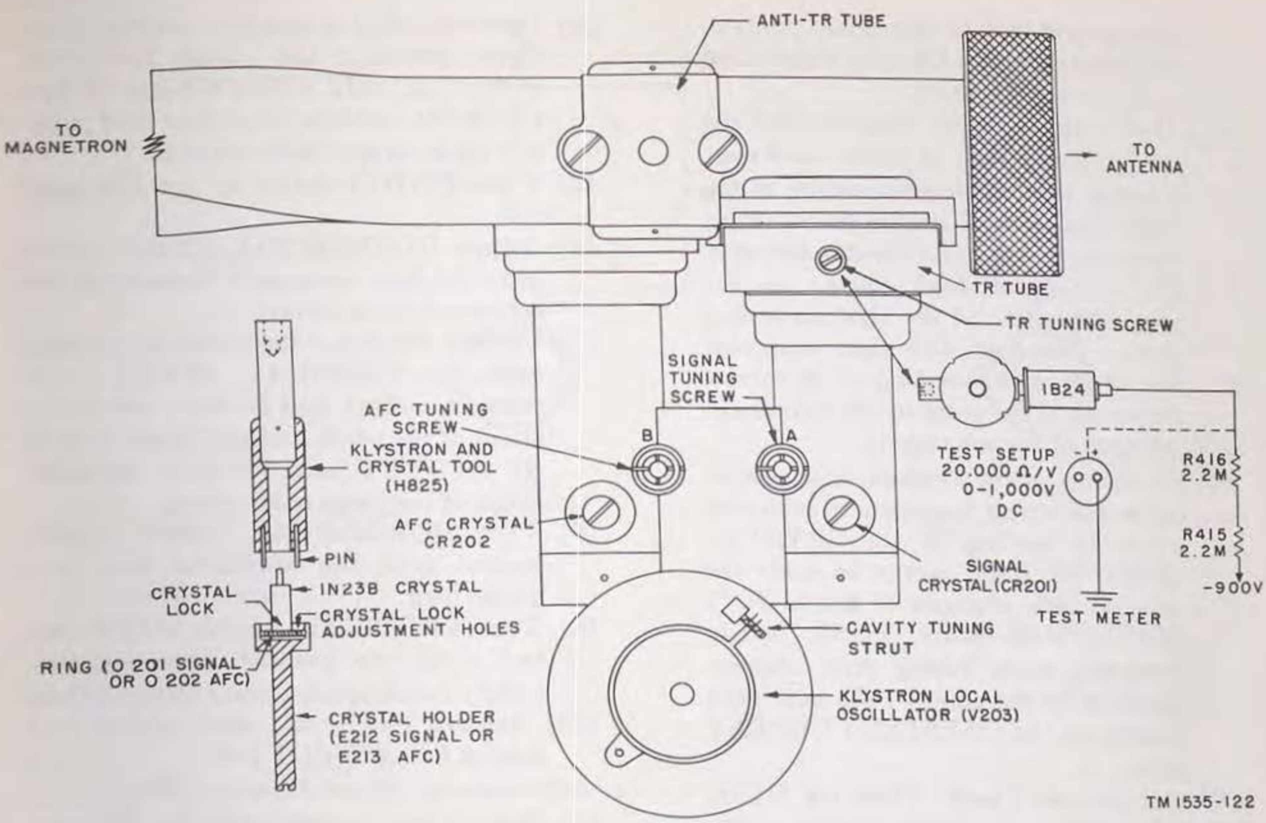


Figure 139. Mixer and duplexer adjustments.

CRYSTAL CURRENT meter will rise and fall periodically.

Warning: The cavity tuning strut and the klystron metal envelope have 300 volts applied.

(8) Turn the cavity tuning strut slowly clockwise and simultaneously rotate the REFLECTOR TUNING control back and forth until the reading of the CRYSTAL CURRENT meter becomes steady.

(9) Place the A. F. C. OPERATION—MAN. TUNE switch in the MAN. TUNE position. Adjust the REFLECTOR TUNING control for peak reading in the CRYSTAL CURRENT meter. Note this reading.

(10) Place the A. F. C. OPERATION—MAN. TUNE switch in the A. F. C. OPERATION position. The reading of the CRYSTAL CURRENT meter should not change. If the reading does change, turn the cavity tuning strut slightly to obtain the same current reading as that obtained from the procedure performed in (9) above.

(11) Repeat procedure indicated in (9) and (10) above until the CRYSTAL CURRENT meter reading is the same in both positions of the A. F. C. OPERATION—MAN. TUNE switch.

(12) Readjust signal adjusting screw A and afc adjusting screw B so that the CRYSTAL CURRENT meter reads between .4 and .5 ma on both positions of AFC XTAL I-SIGNAL XTAL I-PUSH switch.

(13) Readjust the TR tuning screw for maximum intensity of echo signals seen on PPI.

d. Checking Frequency of Klystron Operation. After alining the mixer, make certain the klystron local oscillator is operating at a frequency 30 mc *above* the magnetron frequency. Use the following procedure.

(1) *Slowly* turn the cavity tuning strut clockwise. If echo signals disappear and then reappear, slowly turn the cavity

tuning strut back to its original position. At this position the klystron is operating at its correct frequency.

(2) If echo signals do not reappear when the cavity tuning strut is turned clockwise, it means that the original setting of the cavity tuning strut was incorrect. Turn the cavity tuning strut counterclockwise. The echo signal should appear (in the original position of the klystron tuning strut), disappear and then reappear. The klystron is operating at its correct frequency at the point of the second appearance of the echo signal.

(3) Oscillation of the klystron local oscillator at the wrong frequency is indicated when the reading of the CRYSTAL CURRENT meter cannot be made the same on both positions of the A. F. C. OPERATION—MAN. TUNE switch. Turn the cavity tuning strut counterclockwise to the point of the next peak reading on the CRYSTAL CURRENT meter.

e. Final Alinement Check. Place the HIGH VOLTAGE switch in the OFF position. The reading of the CRYSTAL CURRENT meter should rise and fall periodically. Place the switch in the ON position. The meter reading should be steady.

170. Signal Circuits Alinement

(fig. 140)

Check the alinement of the signal if. whenever a tube or other part in the signal if. is replaced. Usually adjustment of signal trimmer C201 is sufficient. However, if any of the grid coils is replaced, it may be necessary to tune the new grid coil to the proper frequency. Signal Generator TS-452A/U is used for all signal if. alinement.

a. Preparation of Signal Generator TS-452A/U.

(1) Open the large access door on top of the signal generator and place 19-39-mc oscillator plug-in coil L504 in the appropriate socket.

(2) Place wave meter band selector switch in position C (21-46 mc).

(3) Place POWER switch in the ON position. Allow a few minutes for the set to warm up.

(4) Open the small access door on top of the signal generator and adjust INTENS., FOCUS, HORIZ. CENTER and VERT. CENTER controls for a clear and properly centered spot on the screen.

(5) Place MOTOR switch in the ON position.

(6) Adjust HORIZONTAL SYNC control until the spot becomes a horizontal line across the entire screen.

(7) Connect one end of the traveling detector cable to VERTICAL INPUT jack. Connect a short lead between the center chuck of the probe and the center hole of RF OUTPUT jack. Ground the outer chuck of the probe to the panel.

(8) Turn HORIZONTAL AMPL GAIN control until the horizontal line is 2 inches long.

(9) Turn VERTICAL AMPL GAIN control until two parallel lines approximately 1 inch apart appear on the screen.

(10) Remove lead from center chuck and hole of RF OUTPUT jack.

b. Adjustment of Signal Trimmer C201.

(1) Remove signal crystal CR201. Connect the RF OUTPUT jack on the signal generator to the signal crystal jack.

(2) Connect a 220-ohm resistor across E201 and across E202. Remove V207 from its socket.

(3) Connect the traveling detector between the VERTICAL INPUT jack on the signal generator and the cathode (pin 7) of V206.

(4) Place selected RF ATTENUATOR switches on the signal generator (but not the 3 DB switch) at IN.

(5) Throw the 3 DB switch of the RF ATTENUATOR in the signal generator to IN.

(6) Place on the oscilloscope screen a horizontal calibration line corresponding to the amplitude of the attenuated wave form (A, fig. 141). Once this level has been established, do not change the VERTICAL AMPL GAIN or the HORIZONTAL AMPL GAIN controls, or vary any of the RF ATTENUATOR switches, except as specified later.

(7) Adjust the MARKER AMPLITUDE control on the signal generator until the

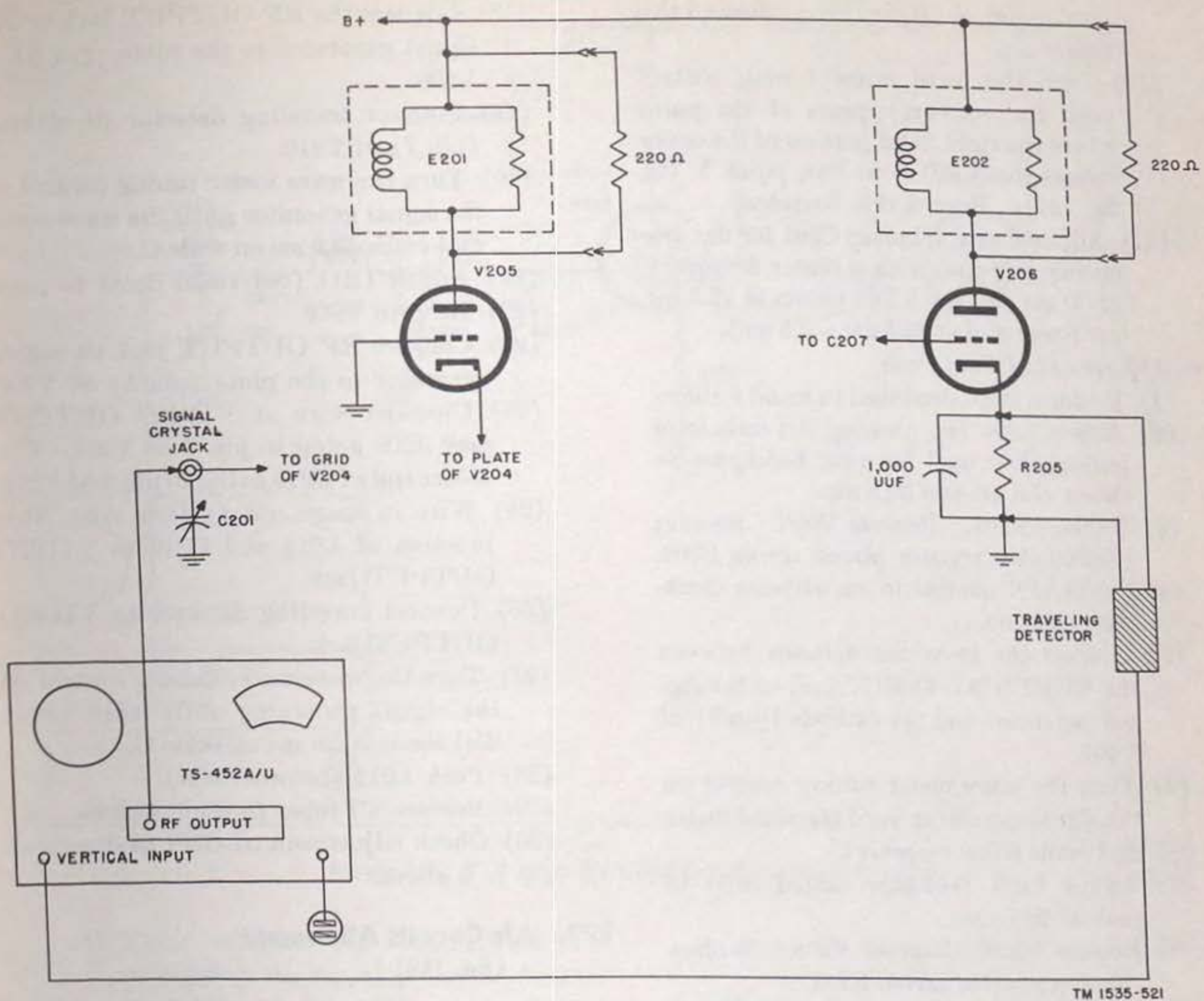


Figure 140. Setup for trimmer C201 adjustment.

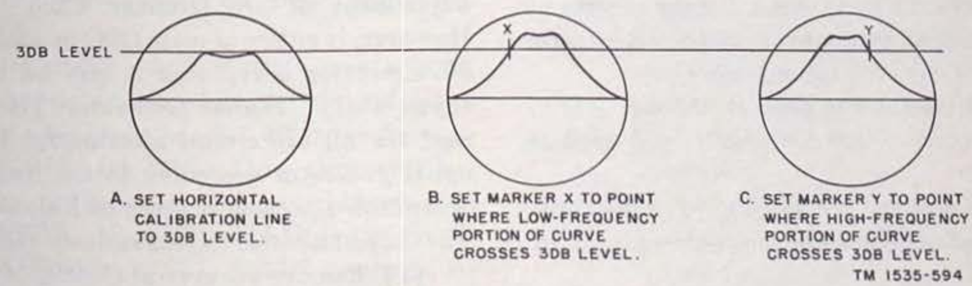


Figure 141. Signal circuits frequency response curves.

blanker marker appears clearly on the wave form. The frequency in band C to which the frequency dial is set is indicated under the hairline on the dial, and on the wave form at the point blanked out by the marker.

(8) Place the 3 DB switch of the RF ATTENUATOR in the OUT position.

(9) Turn the wave meter tuning control on the signal generator until the marker appears at the point where the left hand portion of the curve crosses the 3 DB

level, point X (B, fig. 141.) Record this frequency.

(10) Turn the wave meter tuning control until the marker appears at the point where the right hand portion of the curve crosses the 3 DB level line, point Y (C, fig. 141). Record this frequency.

(11) Adjust signal trimmer C201 for flat frequency response with a center frequency of 30 mc and the 3 DB points at 27.5 mc (±.5 mc) and at 32.5 mc (±.5 mc).

c. Adjustment of Grid Coils.

(1) Perform steps described in *a* and *b* above.

(2) Adjust L203 (by pushing the coils in or pulling them out) for a flat band pass between 27.5 mc and 32.5 mc.

(3) Replace V207. Remove V208. Remove the 220-ohm resistor placed across E202.

(4) Set GAIN control to its extreme clockwise position.

(5) Connect the traveling detector between the VERTICAL INPUT jack on the signal generator and the cathode (pin 7) of V207.

(6) Turn the wave meter tuning control on the signal generator until the wave meter dial reads 30 mc on scale C.

(7) Adjust L207 (red-blue dotted coil) to peak at 26.75 mc.

(8) Replace V208. Remove V209. Replace 220-ohm resistor across E202.

(9) Connect traveling detector to the cathode (pin 7) of V208.

(10) Turn the wave meter tuning control on the signal generator until the wave meter dial reads 32.5 mc on scale C.

(11) Adjust L208 to peak at 32.5 mc.

(12) Remove V206 and V207 and replace V209.

(13) Connect the RF OUTPUT jack on the signal generator to the plate (pin 5) of V207.

(14) Connect traveling detector to cathode (pin 7) of V209.

(15) Turn the wave meter tuning control on the signal generator until the wave meter dial reads 27.9 mc on scale C.

(16) Adjust L210 (red-green dots) to peak at 27.9 mc.

(17) Remove V208.

(18) Connect the RF OUTPUT jack on the signal generator to the plate (pin 5) of V208.

(19) Connect traveling detector to cathode (pin 7) of V210.

(20) Turn the wave meter tuning control on the signal generator until the wave meter dial reads 32.9 mc on scale C.

(21) Adjust L211 (red-violet dots) to peak.

(22) Remove V209.

(23) Connect RF OUTPUT jack on signal generator to the plate (pin 5) of V209.

(24) Unsolder wire at VIDEO OUTPUT jack J202 going to pin 7 of V212. Unsolder end of C216 going to pin 6 of V212.

(25) Wire in spare coil (yellow dot) from junction of L214 and C216 to VIDEO OUTPUT jack.

(26) Connect traveling detector to VIDEO OUTPUT jack.

(27) Turn the wave meter tuning control on the signal generator until wave meter dial reads 30.25 mc on scale C.

(28) Peak L212 (brown-violet).

(29) Replace all tubes in their sockets.

(30) Check adjustment of C201 as described in *b* above.

171. Afc Circuits Alinement

(fig. 142)

Check the alinement of the afc if. stages whenever a tube or other part is replaced. Usually adjustment of afc trimmer C226 is sufficient. However, if either of coils L232 or L233 in the afc discriminator is replaced it may be necessary to adjust them. Signal Generator TS-452A/U is used for all afc circuit alinement. Prepare the signal generator according to the instructions in paragraph 170, then proceed as follows.

a. Adjustment of Afc Trimmer C226.

(1) Remove afc crystal CR202. Connect the RF OUTPUT jack on the signal generator to the afc crystal jack.

(2) Connect a 560-ohm resistor across R230, and a 220-ohm resistor across R233.

(3) Connect the traveling detector between the VERTICAL INPUT jack on the signal generator and the cathode (pin 7) of V214.

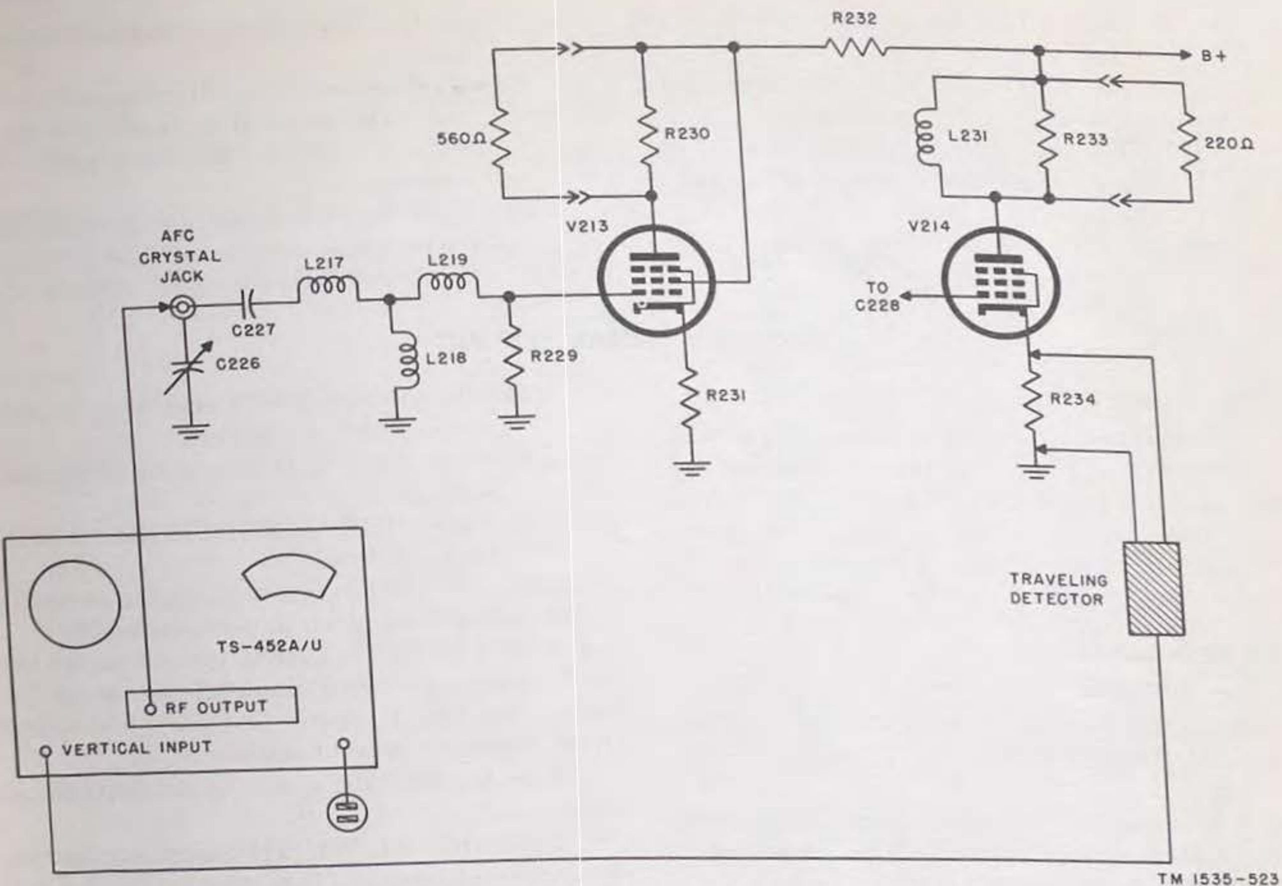


Figure 142. Test setup for alinement of afc trimmer C226.

(4) Place selected RF ATTENUATOR switches on the signal generator (but not the 3 DB switch) at IN.

(5) Throw the 3 DB switch of the RF ATTENUATOR in the signal generator to IN.

(6) Place on the oscilloscope screen a horizontal calibrating line, corresponding to the amplitude of the attenuated wave form (A, fig. 141). Once this level has been established, do not change the VERTICAL AMPL GAIN or the HORIZONTAL AMPL GAIN controls, or vary any of the RF ATTENUATOR switches, except as specified later.

(7) Adjust the MARKER AMPLITUDE control on the signal generator until the blanker marker appears clearly on the wave form. The frequency on band C to which the frequency dial is set is indicated under the hairline on the dial and on the wave form at the point blanked out by the marker.

(8) Place the 3 DB switch of the RF ATTENUATOR in the OUT position.

(9) Turn the wave meter tuning control on the signal generator until the marker appears at the point where the left hand portion of the curve crosses the 3 DB level, point X (B, fig. 141). Record this frequency.

(10) Turn the wave meter tuning control until the marker appears at the point where the right hand portion of the curve crosses the 3 DB level point Y (C, fig. 141). Record this frequency.

(11) Adjust afc trimmer C226 for a flat response with the 3 DB points at 27.5 mc and at 32.5 mc.

(12) Turn the wave meter tuning control on the generator until the wavemeter dial reads 30 mc on scale C.

(13) Adjust L219 for centering of the 30 mc marker.

(14) Remove the 220- and 560-ohm resistors.

b. Adjustment of Discriminator.

(1) Keep the wave meter dial set at 30 mc. Keep the generator output connected to the afc crystal jack.

(2) Connect the traveling detector to the junction of R235 and R236. The curve on the scope should be as shown in figure 47.

(3) Turn the wave meter tuning control until the wave meter dial reads 27.5 mc on scale C. Adjust L232 for a peak at the marker.

(4) Turn the wave meter tuning control until the wave meter dial reads 32.5 mc on scale C. Adjust L233 for a peak at the marker.

Section V. FINAL TESTING

172. General

This final testing section is intended as a guide for determining whether a repaired receiving system meets the original specifications. Entire test procedures for the receiving system are given. The final testing chart (fig. 222) summarizes the final testing procedure for the entire radar set.

173. Bandwidth

(fig. 143)

Measure the bandwidth by means of Test Set TS–147/UP and Oscilloscope TS–239A/AP as follows:

a. Disconnect the wave guide from the duplexer. Connect Directional Coupler CU–78/UP between the duplexer and the wave guide.

b. Connect Cord CG–91/U between TRIGGER jack J303 on the receiver-transmitter and TRIGGER in jack on the test set.

c. Connect Cord CX–337/U between 115 V AC receptacle on the test set and a 115-volt ac outlet.

d. Connect Cord CG–332/U between SIGNAL INPUT jack on the oscilloscope and VIDEO OUT jack J201 in the receiving system. Connect an 82-ohm resistor between VIDEO OUT jack and ground.

e. Connect the other Cord CG–332/U between TRIGGER jack J302 on the receiver-transmitter and EXTERNAL SYNC jack on the oscilloscope.

f. Connect Cord CX–337/U between POWER INPUT jack on the oscilloscope and a 115-volt ac outlet.

g. Place the test set in operation and adjust it as follows:

(1) Place the 115 V AC switch in the ON position. Allow 2 or 3 minutes for the test set to warm up.

(2) Place TEST switch in the dot position between TRAN and RECV.

(3) Place DBM control to about +15 dbm.

(4) Place POWER SET control in its maximum clockwise position.

(5) Place the PHASE control in its mid-position.

(6) Place SIGNAL WIDTH control in the MIN position.

h. Place the oscilloscope in operation according to the instructions given in paragraph 110.

i. Adjust SIGNAL FREQ. control on the test set for maximum signal amplitude on the oscilloscope. Set TEST control to RECV and adjust DBM control to prevent saturation.

j. Tune the receiving system of the radar set, if necessary.

k. Turn SIGNAL WIDTH control on the test set clockwise to obtain a band pass curve. Adjust PHASE control to hold pattern on the oscilloscope screen.

l. Adjust FREQUENCY meter control so that the pip is on top of the band pass curve. The reading of the FREQUENCY dials at this point should be between 9,345 and 9,405 mc.

m. Increase the DBM setting by 3 DB. Detune FREQUENCY meter. Mark the height of the band pass curve.

n. Restore DBM to its original setting.

o. Rotate FREQUENCY dial to cause the frequency pip to move across the oscilloscope screen. Observe the FREQUENCY dial readings at the two points where the pip passes through the 3 DB points (as determined in *g* above).

p. The difference in frequency between the two 3 DB points should be between 4.5 and 5.5 mc.

174. Sensitivity

(fig. 143)

The sensitivity of the receiving system is determined by measuring the minimum discernible signal by means of Test Set TS–147/UP and Oscilloscope TS–239A/AP as follows:

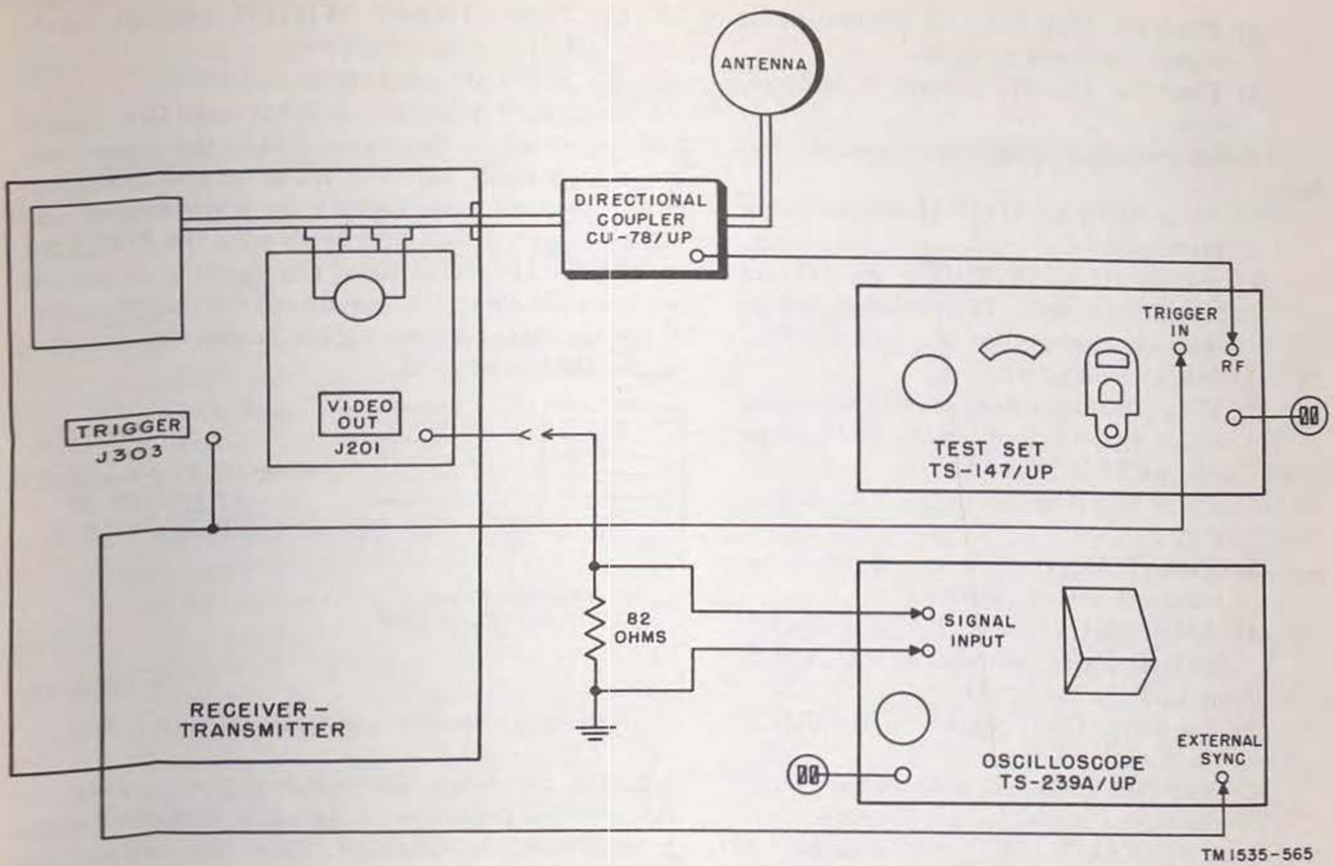


Figure 143. Bandwidth and sensitivity, test setup.

a. Disconnect the wave guide from the duplexer. Connect Directional Coupler CU–78/UP between the duplexer and the wave guide.

b. Connect Cord CG–91/U between TRIGGER jack J303 on the receiver-transmitter and TRIGGER IN jack on the test set.

c. Connect Cord CX–337/U between 115 V AC receptacle on the test set and a 115-volt ac outlet.

d. Connect Cord CG–332/U between SIGNAL INPUT jack on the oscilloscope and VIDEO OUT jack J201 in the receiving system. Connect an 82-ohm resistor between VIDEO OUT jack and ground.

e. Connect the other Cord CG–332/U between TRIGGER jack J302 on the receiver-transmitter and EXTERNAL SYNC jack on the oscilloscope.

f. Connect Cord CX–337/U between POWER INPUT jack on the oscilloscope and a 115 volt ac outlet.

g. Place the test set in operation and adjust it as follows:

(1) Place the 115 V AC switch in the ON position. Allow 2 or 3 minutes for the test set to warm up.

(2) Place TEST switch in the TRAN position.

(3) Place the DBM in the maximum counterclockwise position.

h. Place the oscilloscope in operation by following the instructions given in paragraph 110.

i. Place the A. F. C. OPERATION-MAN. TUNE switch on the receiver chassis in the A. F. C. OPERATION position.

j. Turn the GAIN control in the indicator until one-half inch of grass is showing on the test oscilloscope.

k. Turn the test set to receiver frequency in the following manner:

(1) Adjust METER BALANCE control until meter pointer is at balance.

(2) Place TEST switch in the RECV position.

(3) Place DBM control in the +15 position.

(4) Place the POWER SET control in its maxim clockwise position.

(5) Place the PHASE control in midposition.

l. Obtain frequency modulated signal as follows:

(1) Place SIGNAL WIDTH control in the MIN position.

(2) Adjust SIGNAL FREQ control for maximum signal. If signal does not appear on the oscilloscope, place TEST switch in dot position.

(3) Vary DBM control to prevent saturation of the signal as seen on the oscilloscope.

m. Check METER BALANCE.

(1) Place TEST switch in the TRAN position.

(2) Place DBM control in the maximum counterclockwise position.

(3) Adjust METER BALANCE control until the meter pointer is at BALANCE.

n. Bring back the fm signal.

(1) Place the TEST switch in the RECV position.

(2) Turn the DBM control clockwise until the signal is seen on oscilloscope.

o. Turn SIGNAL WIDTH control to the CW position, while adjusting the PHASE control to keep the curve on the oscilloscope screen steady.

p. Rotate the FREQUENCY control to either end of the frequency range to detune the frequency meter.

q. Adjust POWER SET control until the meter pointer moves to the SET POWER line.

r. Bring back the fm signal again.

(1) Turn SIGNAL WIDTH control carefully counterclockwise.

(2) Select the mode used in *l* above.

s. Turn the DBM control slowly until the signal just disappears in the grass. When the signal becomes very small, turn the DBM control counterclockwise (reducing signal) in 1 db steps and move the signal back and forth with the PHASE control for identification of the signal as it moves horizontally along the base line of the oscilloscope. When the signal is least visible, record the reading of the DBM dial as M.

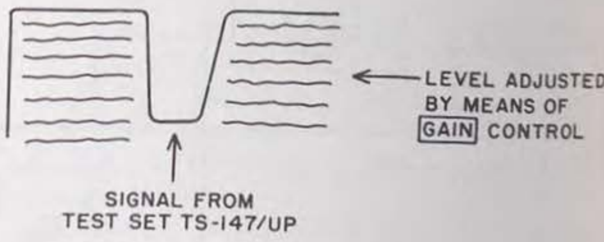


Figure 144. Receiver sensitivity, test wave form.

t. The minimum discernible signal power, or the received performance figure in decibels below 1 milliwatt, is obtained from the following formula:

Min. discernible signal = M + 30.5

where 30.5 is the attenuation of the cable and the directional coupler.

For example, if the DBM reading is 63, the minimum discernible signal power is 63 + 30.5 = 93.5 dbm. A sensitivity of at least 90 is required.

CHAPTER 12

TROUBLESHOOTING IN SYNCHRONIZING AND INDICATING SYSTEM

Section I. TROUBLESHOOTING PROCEDURES

Caution:

1. The PPI has 5 kv applied to it through a high voltage cap. Be sure interlock switch S103 operates to cut off the PPI power supply when the top cover is removed. Discharge capacitors C117 and C118 with a screwdriver before working around the PPI power supply.
2. The failure of selenium rectifiers can result in the liberation of poisonous fumes and the deposit of poisonous selenium compounds. If rectifier CR102 (fig. 151) burns out or arcs over and produces a strong odor, provide adequate ventilation immediately. *Avoid inhaling the fumes and do not handle the damaged rectifier until it has cooled.*

175. Reference Data

The following chart lists the illustrations that may prove helpful in troubleshooting the synchronizing and indicating system.

Fig. No.	Description
72	Synchronizing circuits, schematic.
148	Indicator, voltage and resistance chart.
149	PPI, voltage and resistance chart.
146	Range mark and video circuits, wave forms.
145	Multivibrator and sweep circuits, wave forms.
214	Range and Azimuth Indicator IP–193/-SPN–11, schematic.
218	Range and Azimuth Indicator IP–193/-SPN–11, wiring diagram.
220	Power distribution diagram.
147	Indicator, tube location chart.
159	Antenna, schematic.

176. General Information

a. Normal Operation. When POWER switch S105 is turned on, a trigger from the master blocking oscillator in the transmitting system sets the indicator multivibrator in motion. The multivibrator does three things. It provides an unblanking pulse that prevents the return trace from being visible on the PPI; it sets the sweep circuits into operation; and it turns on the range mark circuits. RANGE switch S101 controls the length of the sweep and the number of range marks for each sweep. As soon as the antenna horn is made to rotate, the synchronizing circuits cause the sweep to rotate and produce fore and aft heading flashes. When HIGH VOLTAGE switch S301 in the transmitting system is turned ON, returning echoes pass through the video circuits where their amplitude is controlled by CONTRAST control R160. The range marks also pass through the video circuits. Their amplitude is varied by RINGS control R165.

b. Obvious Trouble.

(1) If +320 v or +300 v reg are not available, the entire indicator will be inoperative.

(2) If −300 v reg is not available, the PPI will be inoperative.

(3) If fuse F102 is open, high voltage is not available for the PPI, and the PPI will be blank.

(4) If fuse F101 is open, none of the tube filaments or dial lamps will light and synchro alinement relay K101 will not operate.

(5) If SYNCHRO fuse F803 on the convenience panel is open, the synchronizing circuits will be inoperative.

177. Operational Test

Follow the instructions given in trouble shooting based on starting procedure (par. 115). When trouble in the synchronizing and indicating system is indicated, refer to the synchronizing and indicating system troubleshooting charts (par. 180–182).

178. Test Points

(figs. 145 and 146)

Be sure the transmitting, rf, and receiving systems are operating properly before making tests in the synchronizing and indicating system.

a. Trigger. Check the wave form on the 3 mile range at TRIGGER jack J101. If it is not as indicated in figure 116, check cables W705 and W709.

b. Multivibrator. Check the wave form at the junction of R102 and R103 (fig. 155). If it is not as shown in figure 145, make a voltage and resistance check in multivibrator stage V101A.

c. Sweep Circuits. Test the output of the sweep circuits at the grid (pin 5) of V104. If the wave form is not as shown, trouble is in the sweep circuits. Check the wave forms at the other test points indicated in figure 145 to pin down the exact stage. Use the voltage and resistance chart to find faulty part.

d. Range Mark Circuits. Check the output of the range mark circuits at the plate (pin 5) of range mark peaking amplifier V108B. If it is not as indicated, trouble is in the range mark circuits. Use the other wave forms indicated in figure 146 to pin down the faulty stage.

e. Video Circuits.

(1) Plug the line cord of Square Wave Generator TS-583A/U into a 115 v ac outlet.

(2) Place the POWER switch on the square wave generator in the ON position.

(3) Place the EXT.-60~switch on the generator in the 60~position.

(4) Connect one end of a cable between one of the OUTPUT terminals of the generator and ground and the other end of the cable to VIDEO jack J103 in the indicator.

(5) Conncet and adjust Oscilloscope TS-34A/AP according to the instructions given in paragraph 110.

(6) View the signal present at the cathode (pin 11) of the PPI. If it is not present, or if it is present but distorted, the video circuits are not operating properly.

f. PPI. Read the voltage at H. V. TEST jack J102. If it is not 50—which represents 5,000 volts—check the PPI high voltage rectifiers.

g. Synchronizing Circuits. Check the voltage between terminals A 12 and A 13 on TB804 in the convenience panel. It should be 115 volts. If this reading is correct, use an ohmmeter to check the continuity between A 11 and A 10 on TB804. It should have continuity except when synchro alinement relay K101 contacts are closed manually.

Section II. SYNCHRONIZING AND INDICATING SYSTEM TROUBLESHOOTING CHARTS

179. General

a. Not all the symptoms presented in the following charts are definitely due to trouble in the synchronizing and indicating system. Some symptoms listed—such as reduced target echoes—may be due to trouble in the transmitting, rf, or receiving systems. In any such case, it is best to check the transmitting, rf, and receiving systems before trouble shooting the synchronizing and indicating system.

b. The tube troubleshooting chart and the crystal troubleshooting chart indicate what tubes or crystals may be at fault. If the fault is not remedied after replacement of the tube or crystal, refer to the general troubleshooting chart.

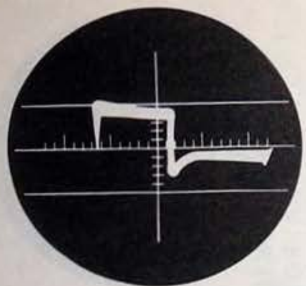
c. The general troubleshooting chart does not give all possible symptoms. For the symptoms listed, the chart can merely guide you to the circuits or to the stage at fault. To find the exact part at fault, take voltage and resistance readings, and compare them to those given in the voltage and resistance charts (fig. 148 and 149).

d. Some parts of the synchronizing circuits are located in the antenna. Other parts of the synchronizing circuits are located in the indicator. These parts are connected by means of cables which have their interconnection points on the terminal boards at the bottom of the receiver-transmitter. Therefore, the terminal boards present a convenient testing point for the synchronizing circuits, and the cabling diagram (fig. 219) is convenient for troubleshooting these circuits.

e. The indicator is connected to the receiver-transmitter through the junction box. The junction box, therefore, is another convenient test point for pulse, voltage, or resistance.

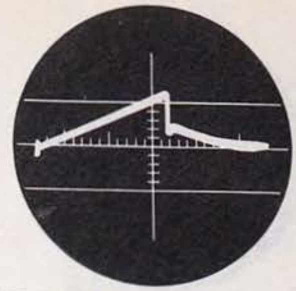
180. Tube Troubleshooting Chart

The following list is a summary of abnormal PPI presentations and the tube or tubes that may be the cause of the trouble.



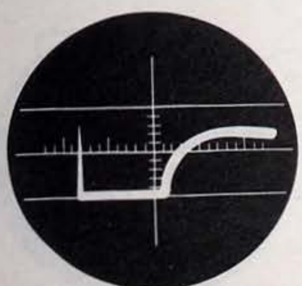
ONE—SHOT MULTIVIBRATOR V101A

TEST POINT: JUNCTION OF R102 AND R103
ATTENUATION: 54 db
SWEEP: START-STOP
SPEED: MEDIUM



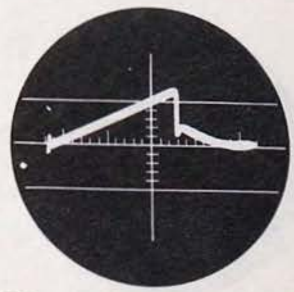
SWEEP VOLTAGE AMPLIFIER V103

TEST POINT: GRID, PIN 1
ATTENUATION: 12 db
SWEEP: START-STOP
SPEED: SLOW



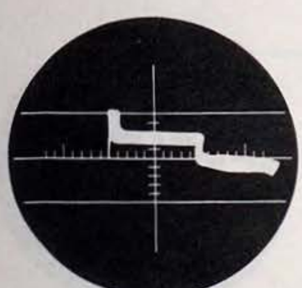
ONE—SHOT MULTIVIBRATOR V101B

TEST POINT: PLATE, PIN 5
ATTENUATION: 60 db
SWEEP: START-STOP
SPEED: SLOW



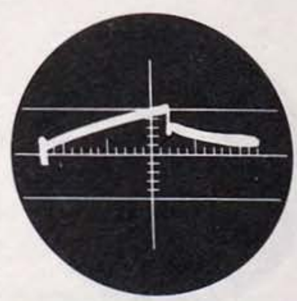
SWEEP CURRENT AMPLIFIER V104

TEST POINT: CATHODE, PIN 3
ATTENUATION: 12 db
SWEEP: START-STOP
SPEED: SLOW



ONE—SHOT MULTIVIBRATOR V101B

TEST POINT: CATHODE, PIN 6
ATTENUATION: 52 db
SWEEP: START-STOP
SPEED: MEDIUM



SWEEP CURRENT AMPLIFIER V104

TEST POINT: GRID, PIN 5
ATTENUATION: 26 db
SWEEP: START-STOP
SPEED: SLOW

NOTES:

1. WAVE SHAPES TAKEN WITH OSCILLOSCOPE TS-34A/AP.
2. RANGE SWITCH ON 3 MILE RANGE.
3. EXTERNAL SYNC INPUT TO TRIGGER JACK J303.
4. H PLATES SWITCH IN NORMAL POSITION.

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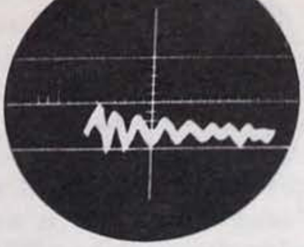
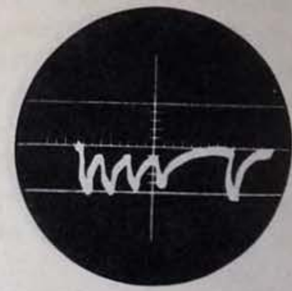
Figure 145. Multivibrator and sweep circuits, wave forms.



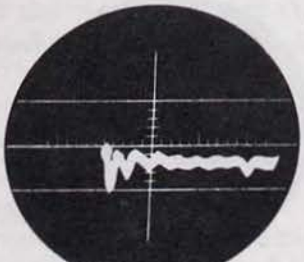
RANGE MARK OSCILLATOR V107A

TEST POINT: PLATE, PIN 2
ATTENUATION: 58 db
SWEEP: START-STOP
SPEED: MEDIUM



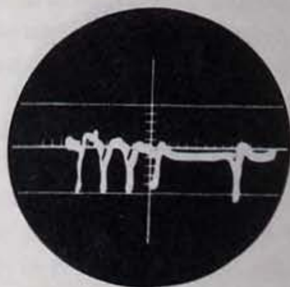
RANGE MARK INVERTER AMPLIFIER V108A

TEST POINT: PLATE, PIN 2
ATTENUATION: 60 db
SWEEP: START-STOP
SPEED: MEDIUM



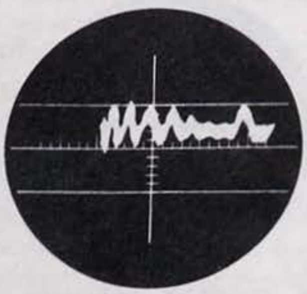
RANGE MARK LIMITER AMPLIFIER V107B

TEST POINT: GRID, PIN 4
ATTENUATION: 44 db
SWEEP: START-STOP
SPEED: MEDIUM



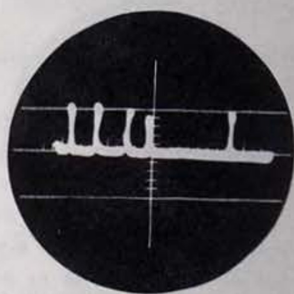
RANGE MARK PEAKING AMPLIFIER V108B

TEST POINT: PLATE, PIN 5
ATTENUATION: 46 db
SWEEP: START-STOP
SPEED: MEDIUM



RANGE MARK LIMITER AMPLIFIER V107B

TEST POINT: PLATE, PIN 5
ATTENUATION: 56 db
SWEEP: START-STOP
SPEED: MEDIUM



VIDEO MIXING AMPLIFIER V109B

TEST POINT: PLATE, PIN 2
ATTENUATION: 26 db
SWEEP: START-STOP
SPEED: MEDIUM

NOTES:

1. WAVE SHAPES TAKEN WITH OSCILLOSCOPE TS-34A/AP.
2. [RANGE] SWITCH ON [3] MILE RANGE.
3. [EXTERNAL SYNC] INPUT TO [TRIGGER] JACK J303.
4. [H PLATES] SWITCH IN [NORMAL] POSITION.

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Figure 146. Range mark and video circuits, wave forms.

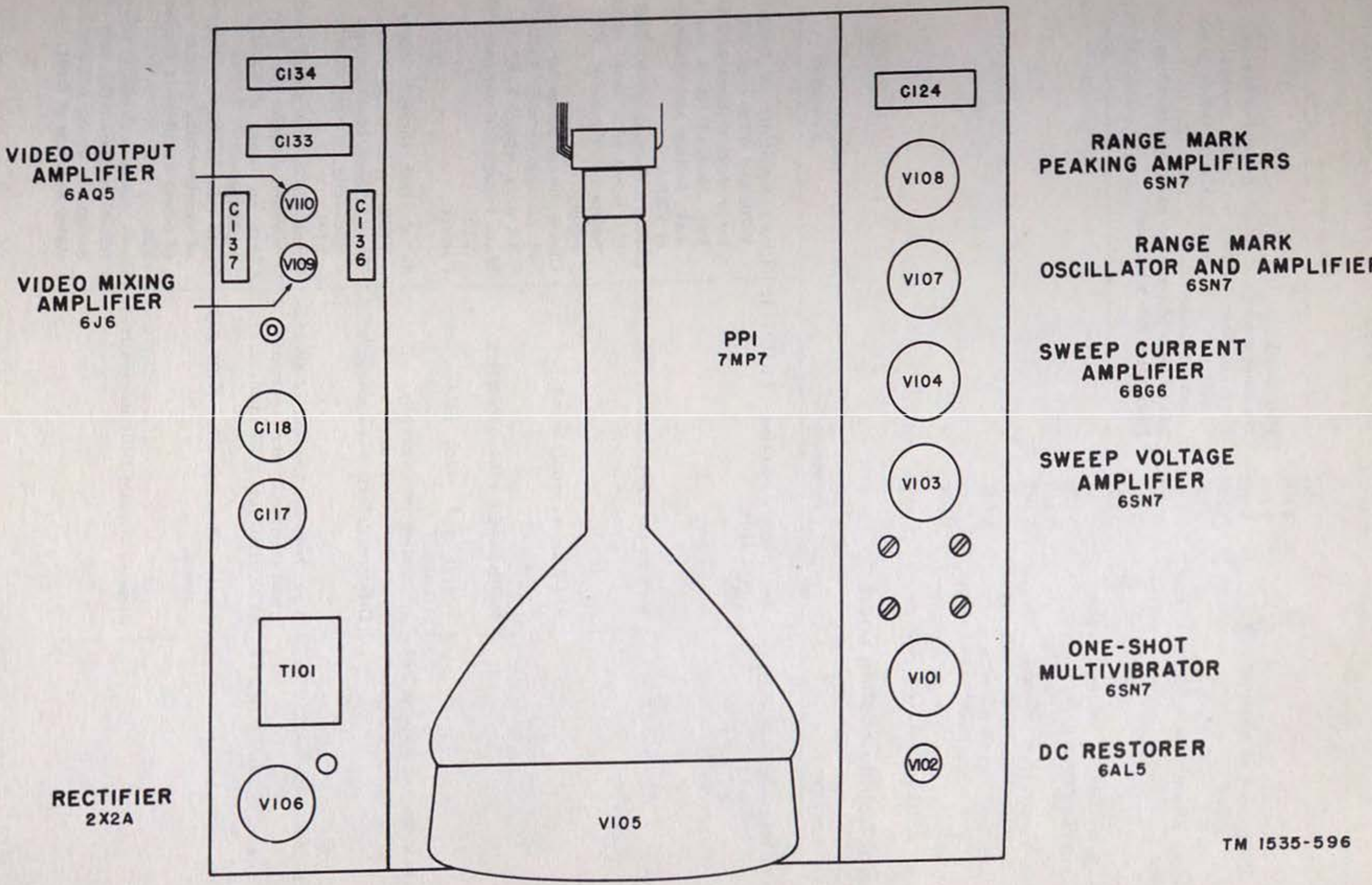


Figure 147. Indicator, tube location chart.

Symptom	Tube
PPI Blank	V101
	V106
	V105
No sweep. Bright spot in center of PPI	V102
	V103
	V104
No range rings. Sweep, heading flashes, and video present	V107
	V108
	V109
No range rings, no echoes, or weak echoes. Sweep and heading flashes present	V109
	V110
Distance between range rings unequal	V102
Range rings brighter than usual with dark areas after each mark, weak echoes	V109
Hole in center of PPI sweep larger than hole at center of cursor	V104

181. Crystal Divide Troubleshooting Chart

Picture symptom	Crystal
PPI Blank	CR101
No range marks and video. Sweep line appears	CR104
No range rings. Sweep and video present	CR103
Picture gets dimmer as RANGE switch is advanced clockwise	CR101
Range rings bloom when passing over echoes	CR103
Dark areas following flash	CR104

182. General Troubleshooting Chart

Symptom	Probable trouble	Correction
PPI blank on all ranges	No trigger reaching TRIGGER jack J101.	Check continuity of trigger cables W705 and W709 (par. 107). Check for presence of trigger at TRIGGER jack J303. If it is not present, make voltage and resistance check of V307A.
	No 5 kv for PPI	Check voltage at H. V. TEST jack. If it is not 50 v, make voltage and resistance check of PPI power supply.
	PPI filament supply is out	Check voltage across terminals 3 and 5 of transformer T102. If not 6.3 volts, replace T102.
	Multivibrator V101 inoperative	Make voltage and resistance check of V101.
	Trigger and video cables interchanged.	Correct.
No sweep. Spot appears at center of PPI	Inoperative sweep circuits	Signal trace through stages V102–V104.
	Defective deflection coil assembly	Check brushes, brush springs. Check continuity across deflection coil L101.
Sweep rotates counterclockwise	Wires between transmitter synchro and receiver synchro reversed.	Check wiring with aid of power distribution diagram (fig. 220).
Antenna horn rotates, but sweep on PPI does not rotate.	SYNCHRO fuse F803 open	Check for cause of blowing before replacing.
	Synchro alinement relay K101 *stays* closed.	Check relay contacts. Check wiring of synchronizing circuits with aid of power distribution diagram (fig. 220).
	Receiver synchro B101 inoperative	Check wiring with aid of power distribution diagram (fig. 220). Check continuity across rotor and across stator windings of B101.

182. General Troubleshooting Chart—Continued

Symptom	Probable trouble	Correction
Sweep and video present, but no range marks.	Inoperative range mark circuits	Signal trace through stages V107 and V108.
	RINGS control defective	Check control with ohmmeter. Replace if defective.
	Video mixing amplifier V109B inoperative.	Make voltage and resistance check of this stage.
Sweep visible, but video and range marks are not visible.	Video circuits inoperative	Make voltage and resistance check of stages V109 and V110.
Intensity of PPI presentation is low	Defective multivibrator (low amplitude of unblanking pulse).	Make voltage and resistance check of one-shot multivibrator V101.
	Improper PPI grid bias	Check crystal diode CR104 and other parts in the grid circuits of PPI.
Intensity of PPI presentation is very high. INTENSITY control has no effect.	Low second anode voltage	Check PPI power supply (par. 202).
	Open INTENSITY control R135	Check control with ohmmeter. Replace if defective.
	Short to ground from resistors R132, R133, or R144.	Check with ohmmeter. Repair if defective.
No heading flashes	Heading flash circuit inoperative	Check resistance of R184, R185 and R186. Check continuity across C141 and C142.
	Defective heading flash cam switch S502 (in antenna).	Connect voltmeter between S on plug P101 and ground. Voltage should fall to zero when sweep passes 0° and 180° points. (If voltmeter does not read at all, test continuity from indicator to junction box to receiver-transmitter to antenna.)
FOCUS control has no effect on focus	Defective FOCUS control R138	Take resistance reading of R138. Replace if defective.
	Open focus coil L102	Check resistance across focus coil L102. It should be approximately 300 ohms.
SYNCHRO fuse keeps blowing	Synchro alinement cam (in indicator) has moved from its correct position.	Readjust synchro alinement cams (par. 194).
Weak video	Low gain in video circuits	Check tubes V109 and V110. If tubes are ok, make voltage and resistance checks.
No noise on PPI	Low gain in video circuits	Check tubes V109 and V110. If tubes are satisfactory, make voltage and resistance checks.
	Defective video cable	Check continuity between VIDEO OUT jack J201 on receiver chassis and VIDEO jack J103 in indicator.
Different bearing obtained on the same target when position of RANGE switch is changed.	Focus coil not centered	Center focus coil (par. 192).
Approaching targets disappear too soon near the center of the PPI.	Too much SUPPRESSOR	Turn SUPPRESSOR counterclockwise. If there is too much clutter, turn GAIN control counterclockwise.
Center of sweep varies with position of RANGE switch.	Defective DCR V102B	Replace V102.
No picture or faint picture on strong signal peaks.	Defective PPI	Replace tube (par. 183).

Symptom	Probable trouble	Correction
Sweep line not visible. INTENSITY control in extreme clockwise position results in picture with a faint sweep.	Defective PPI	Replace tube (par. 183).
Range rings too dim. Sweep and video normal.	Range mark circuits weak	Check tubes V107 and V108. Replace defective tubes.
PPI presentation not oriented correctly	Synchro alinement relay K101 inoperative.	Check for 125 vdc at terminal 3 of TB101. If voltage is not present, check continuity back to fuse F101. If voltage is present, check continuity across cam switches S104 and S501, and between them.
	Synchro alinement cam switch S104 not closing, or closing at wrong time.	Check cam switch S104 for continuity. Replace if defective. If S104 is all right check adjustment of synchro alinement cams (par. 194).
	Synchro alinement cam switch S501 (in antenna) open.	Check continuity between A 8 and A 13 on TB804 on receiver-transmitter terminal boards. If open, repair cam switch S501.
Spoking (pronounced light and dark radial areas) on PPI.	Synchro gears meshing at wrong point.	Loosen screw holding idler gear and move idler gear slightly. Check other synchro alinement adjustments (par. 194).
	Dirt on synchro gears	Clean gears.
Range rings missing on one range; normal on other ranges.	Defective contact on RANGE switch S101.	Check section 1 of RANGE switch S101. Adjust defective contacts.
	Misadjustment of or open in one of tuning coils of Z101.	Adjust one of range controls (1, 3, 8 or 20 in fig. 153). If trouble does not clear, check continuity of appropriate coil. If open, replace Z101.
PPI blank on one range, normal operation on all other ranges.	Defective contact on RANGE switch S101.	Check section 2 of RANGE switch S101. Adjust defective contacts.
Range rings bloom over echo returns	Defective crystal CR103	Check CR103. Replace if defective.
Sweep is short for all ranges	Defective sweep circuits	Check dcr V102B. Signal trace V101 through V104. Use voltage and resistance checks to determine exact part of fault.
Abnormal picture in a small sector of PPI	Receiver synchro slip rings dirty	Remove plug located between the two brush holders on the deflection coil assembly exposing the two slip rings. Dampen a cloth with Solvent, Dry Cleaning Fluid (SD), and hold against rings while rotating the synchro by hand.

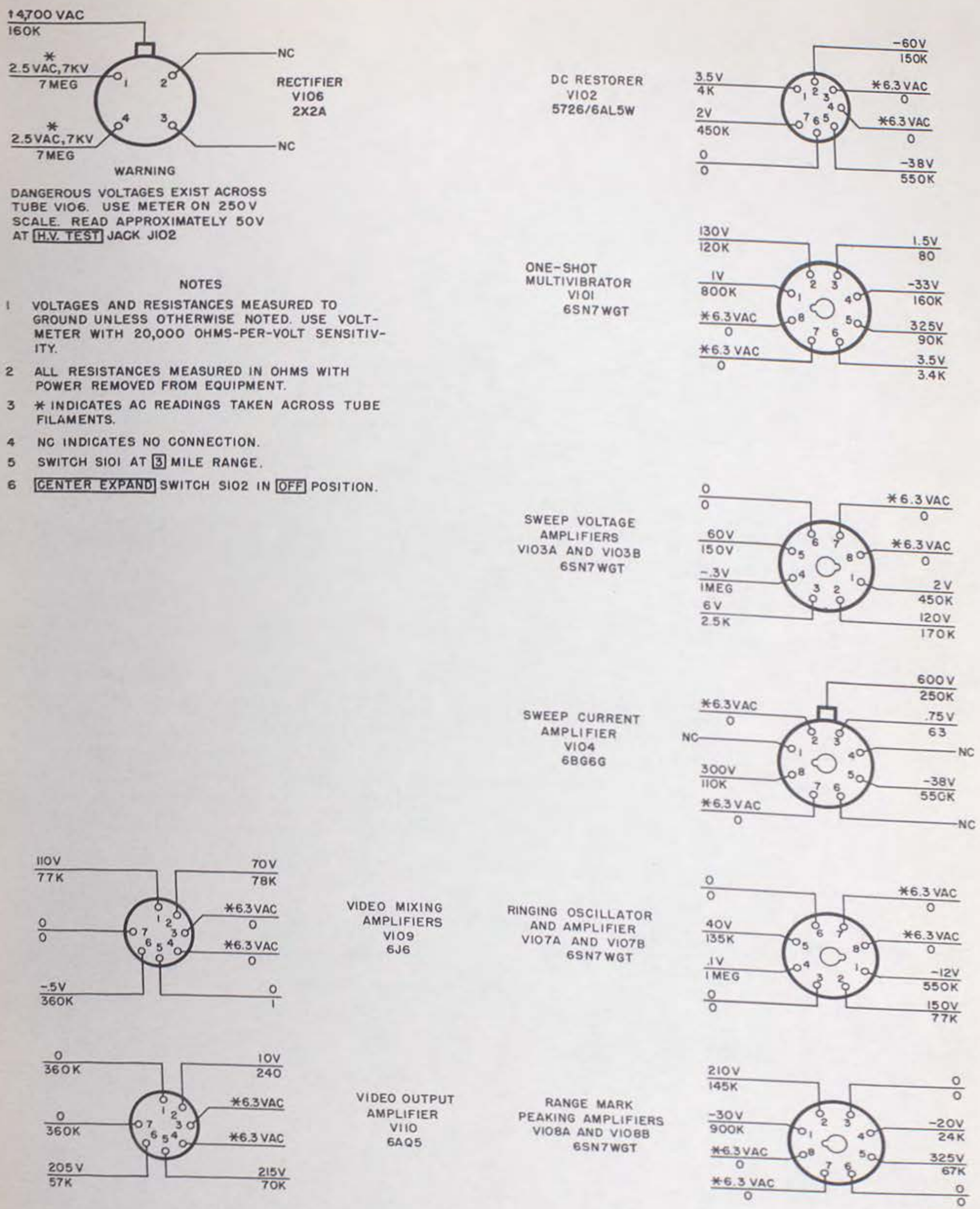
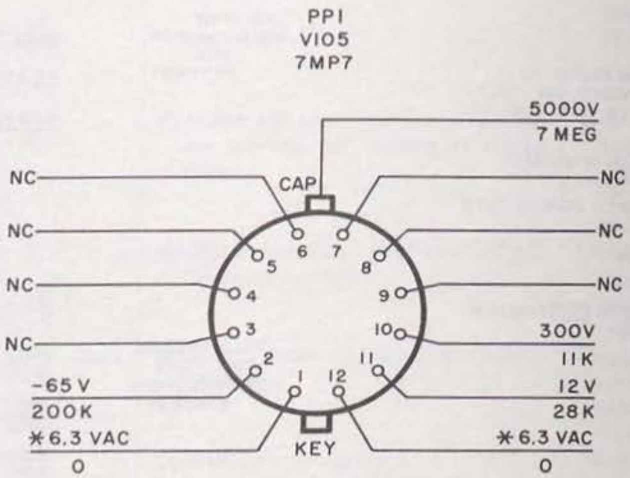


Figure 148. Indicator, voltage and resistance diagram.



NOTES

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND UNLESS OTHERWISE NOTED. USE VOLTMETER WITH 20,000 OHMS-PER-VOLT SENSITIVITY.
2. ALL RESISTANCES MEASURED IN OHMS WITH POWER REMOVED FROM EQUIPMENT.
3. * INDICATES AC READINGS TAKEN ACROSS TUBE FILAMENTS.
4. NC INDICATES NO CONNECTION.
5. SWITCH S101 AT [3] MILE RANGE.
6. [CENTER EXPAND] SWITCH S102 IN [OFF] POSITION.

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Figure 149. PPI, voltage and resistance diagram

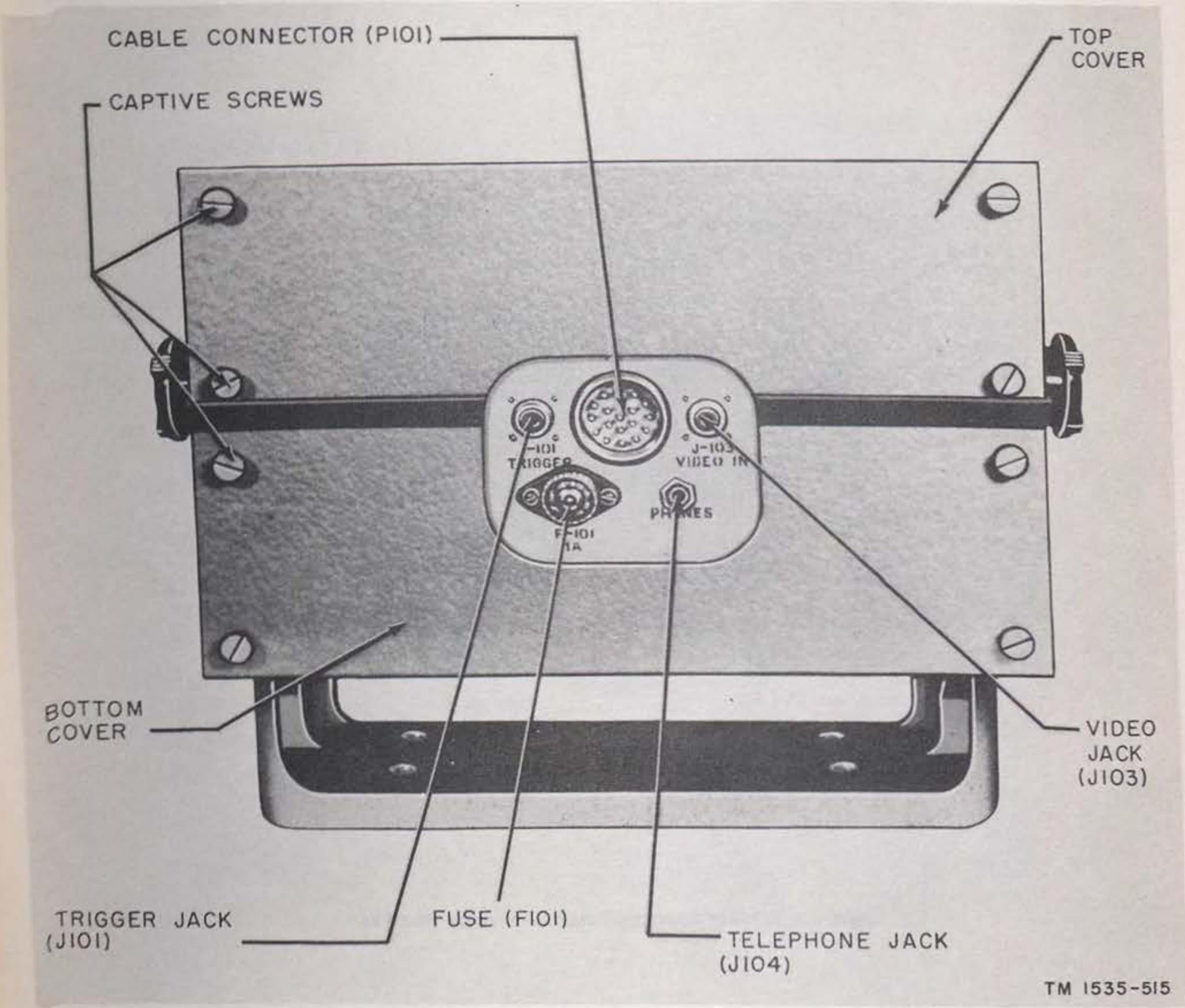


Figure 150. Indicator, back view.

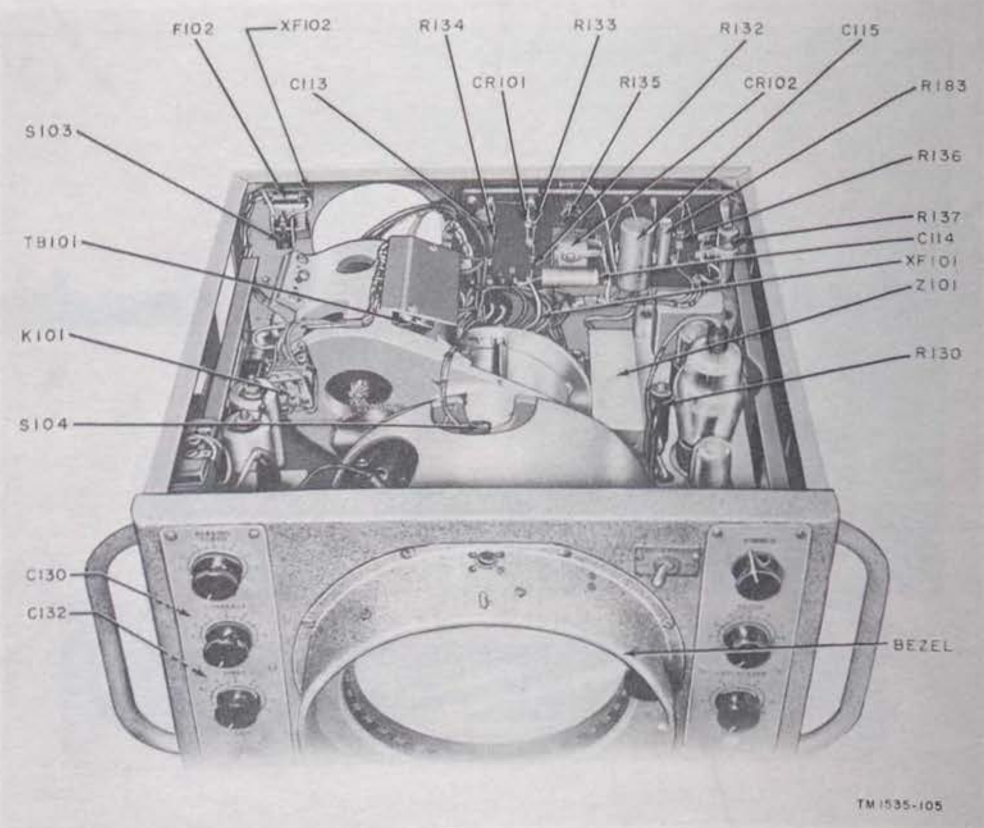


Figure 151. Indicator, top front view, parts location.

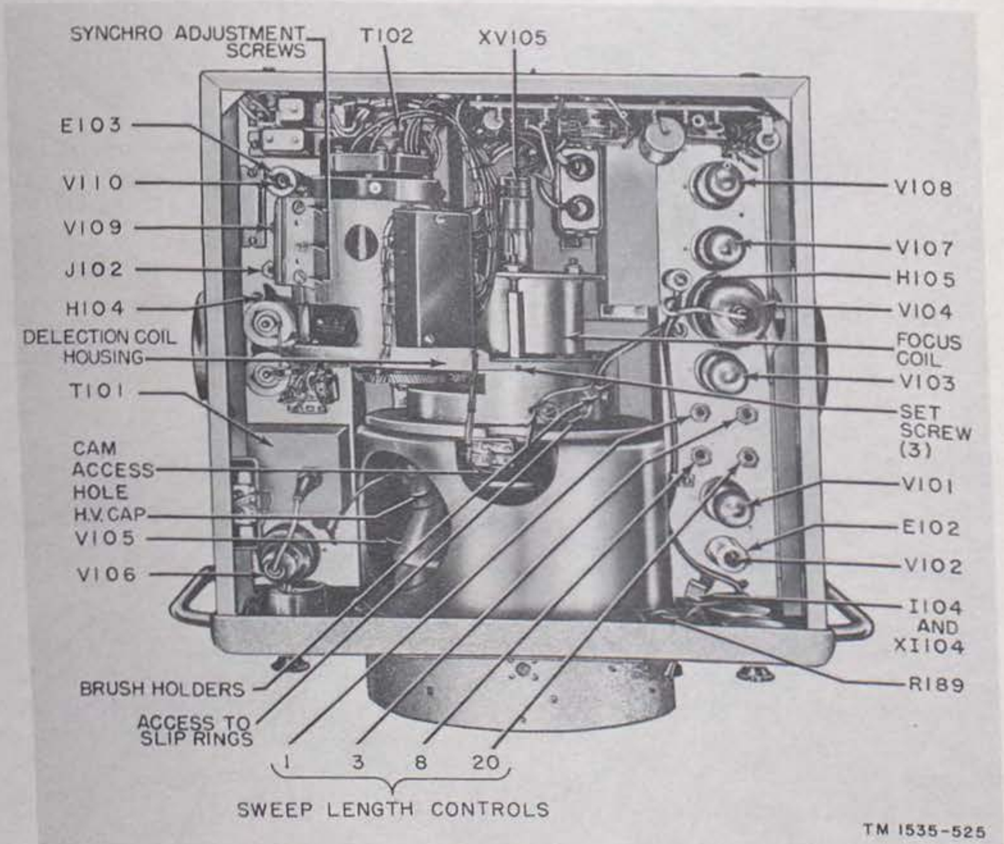


Figure 152. Indicator, bottom view, parts location.

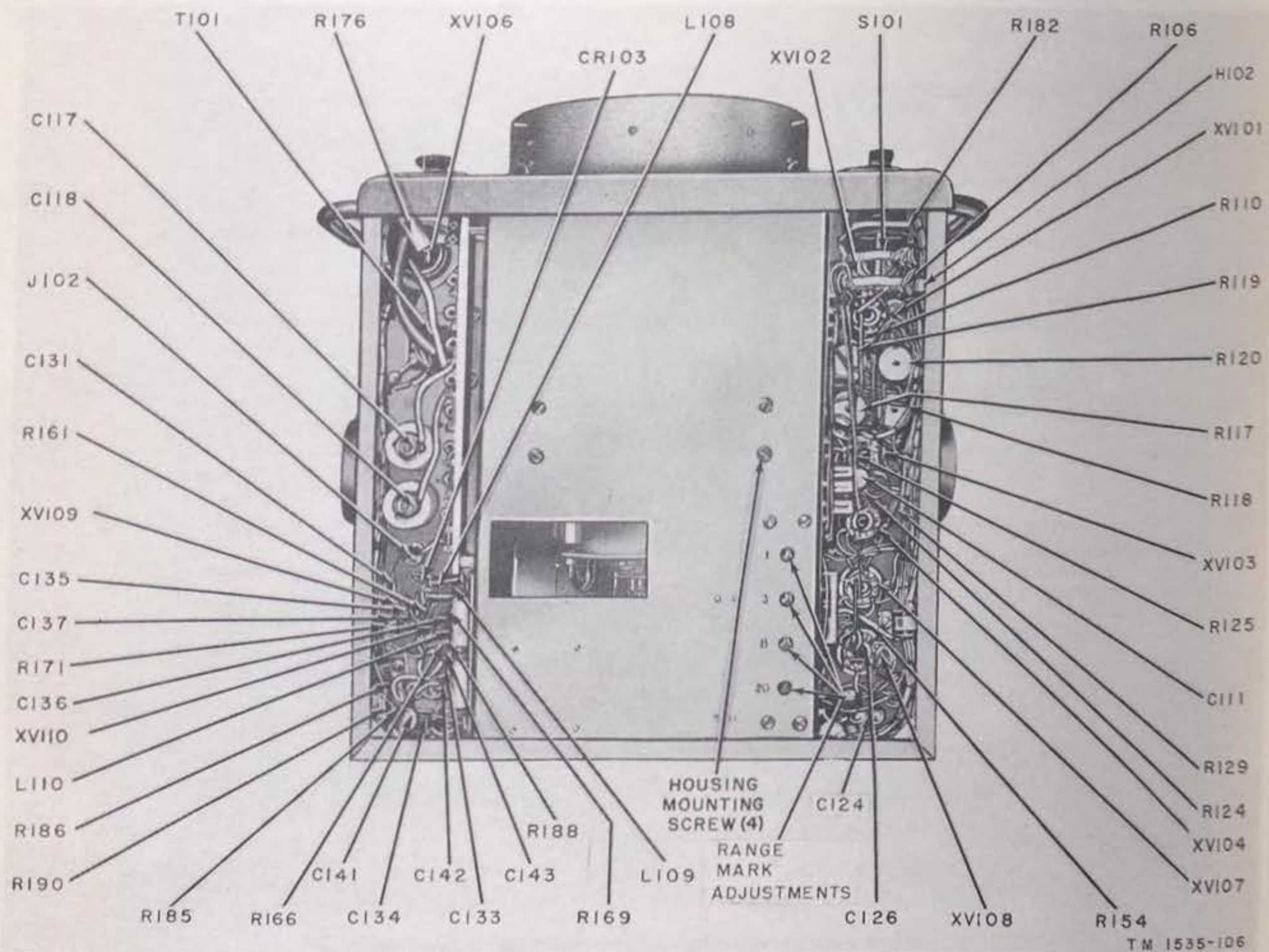


Figure 153. Indicator, bottom view, parts location.

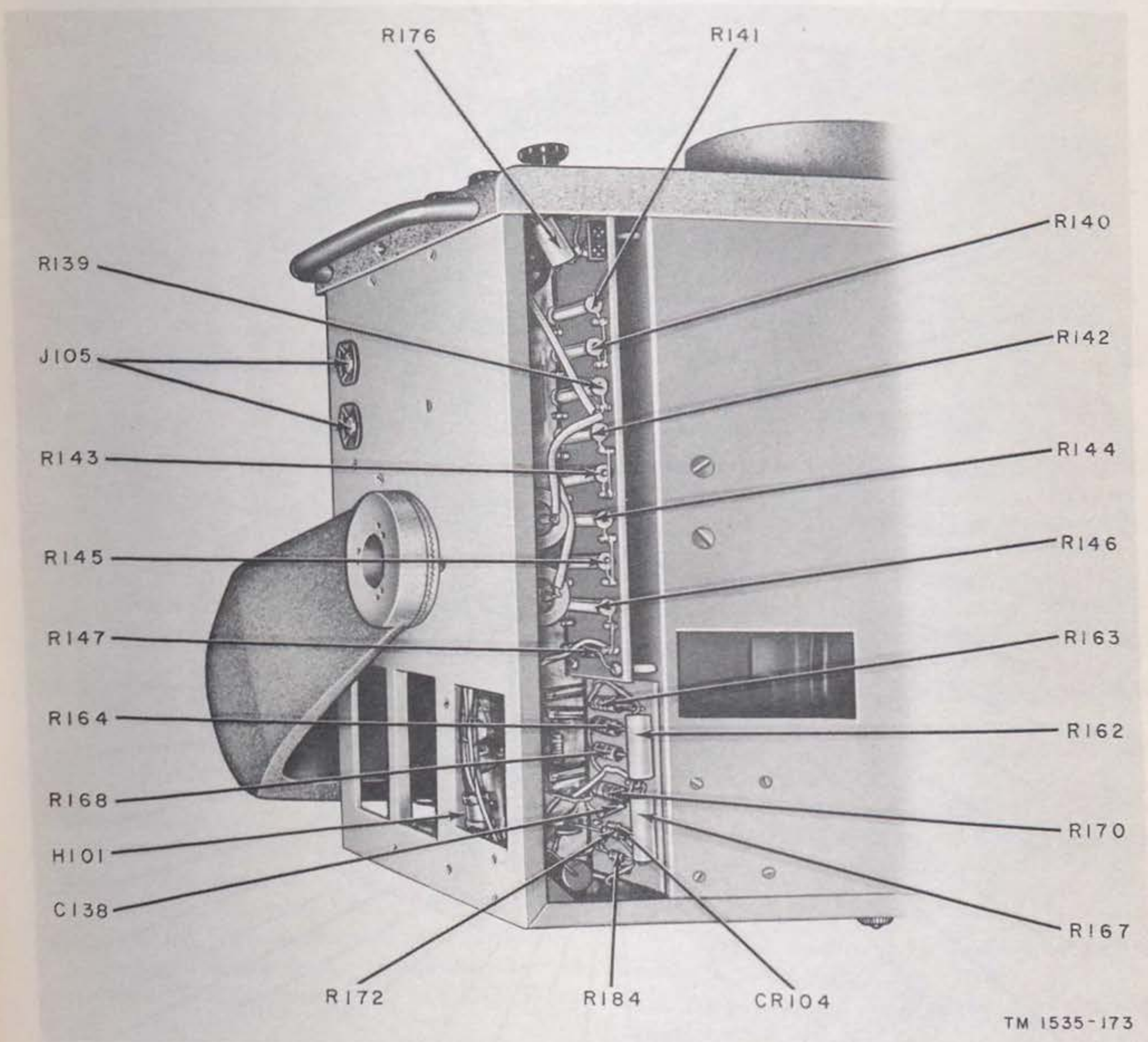


Figure 154. Indicator, left side, bottom view, parts location.

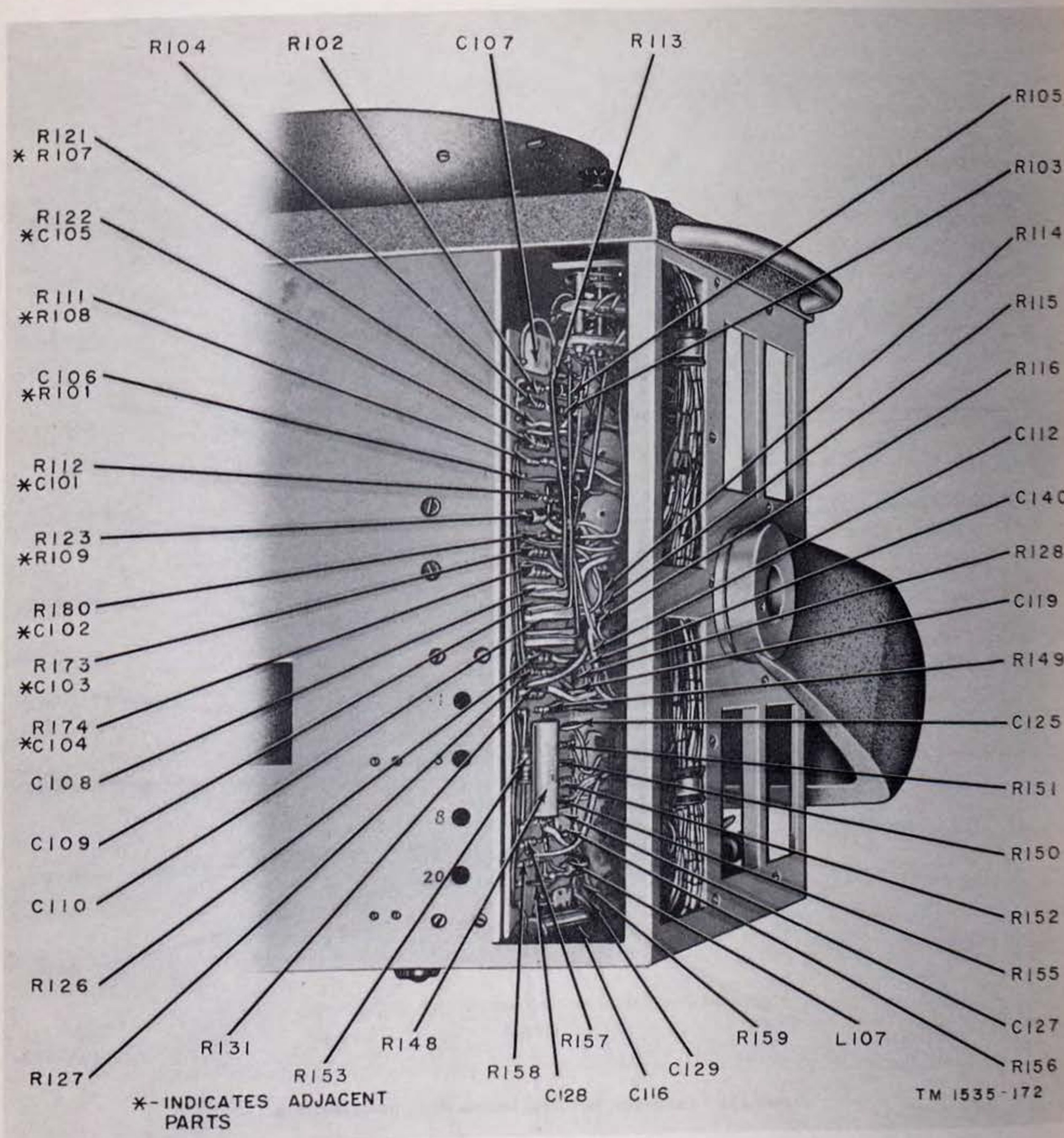


Figure 155. Indicator, right side, bottom view, parts location.

Section III. REPLACEMENT OF PARTS

183. Cathode-Ray Tube (PPI)

Transfer the cathode-ray tube from its special carton directly to the indicator (*a* through *h* below).

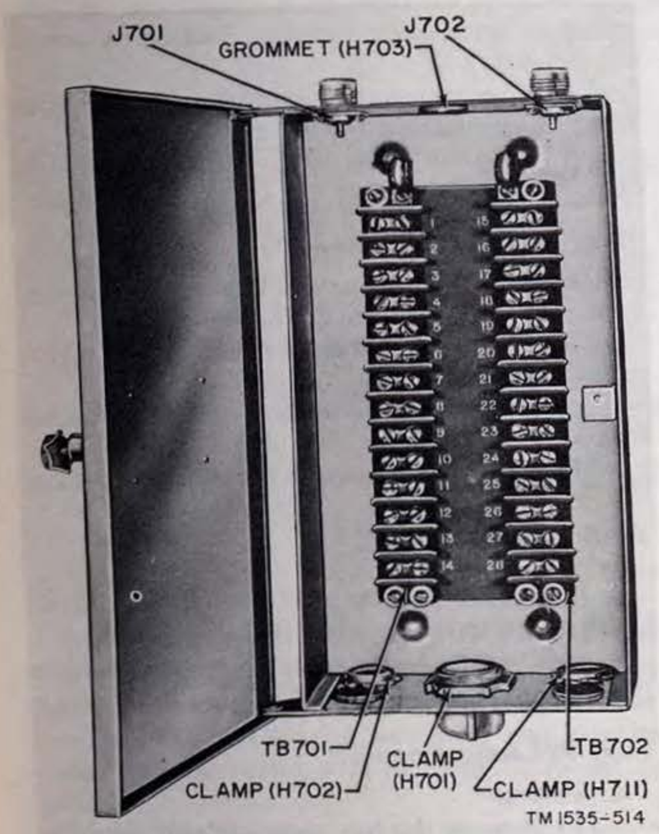


Figure 156. Junction box.

Cautions:

1. Always wear goggles and gloves when handling a cathode-ray tube.
2. Use both hands when lifting the tube.
3. Never lay the tube down on hard surfaces.
4. Do not drop tools on the face of the tube.

a. Place POWER switch S105 in the OFF position.

b. Remove the 12-pin female socket from the base of the tube.

c. Disconnect the PPI high voltage cap from the cathode-ray tube. Short the lead from high voltage cap to chassis.

d. Loosen trunnion knobs; tilt the front of the indicator upward slightly; then tighten the trunnion knob.

e. Remove the eight machine screws (fig. 207) from the outer bezel rim. Take out the scale and cursor assembly.

f. Remove the cathode-ray tube by gently pushing at the tube base while another person gently pulls at the face of the tube.

g. Remove the rubber shock ring from the face of the tube. Place the defective tube in the carton supplied with the new tube.

h. Reverse the above procedure when inserting the new cathode-ray tube.

Note. The following precautions should be observed when installing a new cathode-ray tube:

1. Do not force the tube. If binding occurs, investigate the reasons before continuing.
2. Be sure that the 45° cutaway on the tube neck yoke is facing toward the upper left corner.
3. Make certain the dial light contact finger engages the mating contact in the upper right section of the housing.

184. Deflection and Focus Coils

a. Remove the cathode-ray tube by following the instructions given in paragraph 183.

b. Remove the eight fillister-head screws which hold deflection coil L101 to its mounting plate.

c. Remove the idler gear holding screw, and, if necessary to unmesh the deflection coil gear, loosen the three synchro adjustment screws that hold the receiver synchro in place.

d. Pull out the deflection and focus coils as a unit.

e. Disconnect and tag the leads at their coil terminations.

f. To disconnect deflection coil L101 from focus coil L102, remove the three self-locking hex. nuts from the rear of the focus coil.

185. Focus Coil

To remove focus coil L102 independently of deflection coil L101:

a. Disconnect the cathode ray tube from its socket (par. 183).

b. Remove the three self-locking hex. nuts from the rear of the focus coil.

c. Pull out focus coil.

d. Disconnect and tag leads that terminate at the focus coil.

Caution: When replacing focus coil, make certain it does not come into contact with the deflection coil.

186. Receiver Synchro

a. To remove receiver synchro B101, remove the idler gear holding screw (fig. 163).

b. Remove the three synchro adjustment screws (fig. 163).

c. Disconnect and tag cables.

187. Antenna Drive Motor

a. Remove the four captive bolts on the antenna pedestal (fig. 4) and remove the drive housing cover plates.

b. Remove antenna drive motor B502 and the antenna drive motor mounting plate by removing the four hex-head bolts.

c. Unbolt the antenna drive motor from the antenna motor mounting plate.

d. Disconnect the antenna drive motor leads.

e. When replacing the antenna drive motor, reverse the procedure indicated in *a* through *e* above. Connect the antenna drive motor leads according to the terminations shown in figure 159.

Note. Do not use force to engage the antenna drive motor coupling. If the antenna drive motor is not properly alined, it will not seat properly.

188. Transmitter Synchro (in Antenna)

a. Disconnect the cables. Tag each lead for easy replacement.

b. Remove the three bolts (dogs) (10, fig. 187) that hold transmitter synchro B501 to its mounting bracket.

c. Remove transmitter synchro. The coupling breaks loose without the use of tools.

d. Replace the transmitter synchro by reversing the above procedure.

189. Range Ring Assembly

a. Remove the four screws holding the housing mounting to the bottom of the indicator.

b. Remove the four nuts and bolts holding Z101 to the mounting.

c. Remove the leads attached to Z101 and label them.

d. To replace Z101, reverse the above procedure.

Section IV. ALINEMENT AND ADJUSTMENTS

Caution: High voltages are exposed when the indicator covers are removed. Be extremely careful not to come in contact with parts or wiring in the indicator. Use an insulated screwdriver when making adjustments.

190. General

The alinement and adjustment procedures for the receiving system are presented in this section. The alinement chart (fig. 221) summarizes the complete radar alinement procedure.

191. Location of Adjustment Controls

a. Sweep length controls R117, R118, R119 and R120 are located on the upper right side of the indicator (fig. 152).

b. Range adjustment screws 1, 3, 8 and 20 are located on the bottom of the indicator (fig. 153).

c. INTENSITY control R135 is mounted on the resistor board at the rear of the indicator (fig. 151).

d. Internal focus control R137 is mounted at the left of the INTENSITY control.

e. Focus coil hex. nuts (3), for sweep centering, are located around the focus coil.

f. Synchro alinement cam switch S501 is located in the antenna pedestal (fig. 157).

g. Synchro alinement cam switch S104 is located in the indicator (fig. 152).

h. Heading flash cam switch S502 is located in the antenna pedestal (fig. 157).

192. PPI Adjustments

a. General.

(1) Remove the top cover plate of the indicator and close or place a jumper across the interlock switch.

(2) Turn on POWER switch S105.

(3) Set ANTENNA MOTOR switch S802 in the receiver-transmitter in the OFF position.

(4) Set CONTRAST control R160 in the 0 position.

(5) Set SUPPRESSOR control R181 in the 0 position.

(6) Set GAIN control R177 in the 0 position.

(7) Set RANGE switch S101 in the 3 position.

(8) Wait approximately 3 minutes until transmitter time-delay relay K302 closes.

b. Intensity Adjustment. Turn INTENSITY control R135 clockwise until the sweep is just visible.

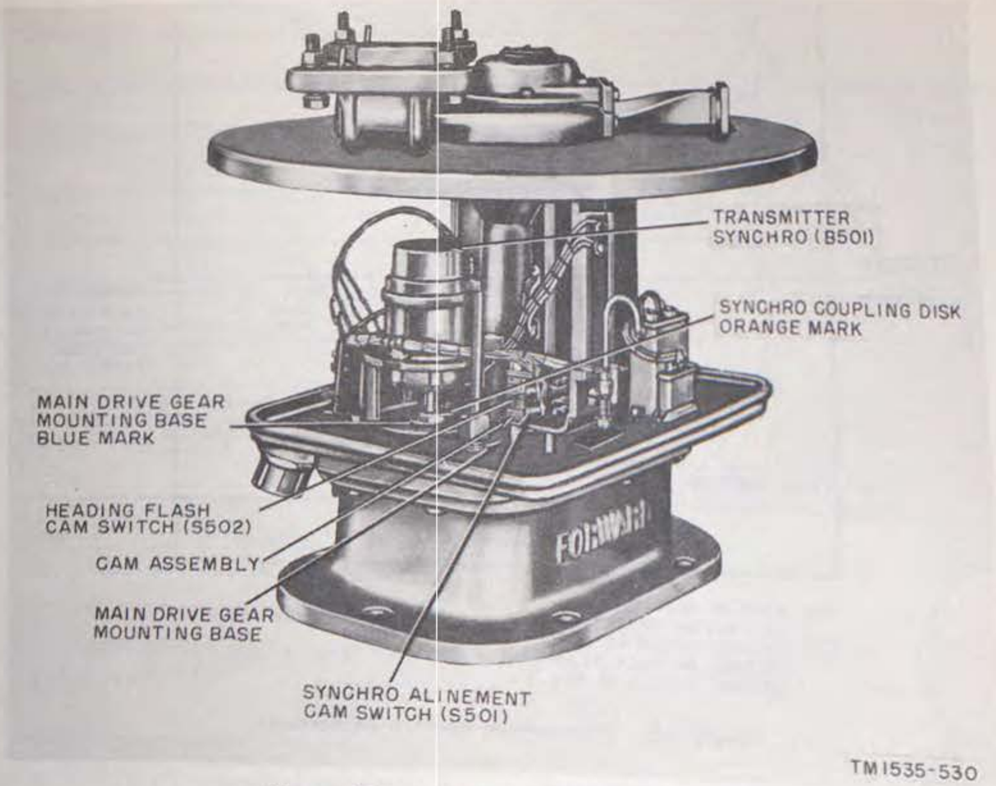


Figure 157. Antenna pedestal, front view.

c. Focus Adjustment. Set CONTRAST and GAIN controls about midway on their respective scales. If sharp focus cannot be obtained by rotating FOCUS control between 1 and 5 on its scale, internal focusing is required. Proceed as follows:

(1) Set FOCUS control R138 between 3 and 4.

(2) Place indicator POWER switch S105 to its extreme counterclockwise position.

(3) Move the slider on internal focus control R137 slighly.

Warning: The sliding arm of this control is at a 300-volt potential.

(4) Turn indicator POWER switch clockwise.

(5) Check the focus. If it is not sharp enough, repeat procedures in (2), (3), and (4) above as often as necessary.

(6) Place ANTENNA MOTOR switch S802 in the ON position.

(7) With CENTER EXPAND switch S102 in the OFF position, adjust FOCUS control R138 until the inner range ring is sharp and clear.

d. Sweep Centering.

(1) Place CENTER EXPAND switch S102 in the OFF position.

(2) Set the cursor at 0°–180°.

(3) Tilt focus coil L102 by turning the hex. nuts until the beginning of the sweep coincides with the small circle scribed at the center of the cursor.

Caution: Be certain that this adjustment does not cause the focus coil to come in contact with the deflection coil.

e. Sweep Length Adjustments. The CONTRAST control R160 for these adjustments must be set in the 0 position.

(1) Place RANGE switch S101 in the 1 position. Adjust sweep length control 1 (R117) (fig. 152), so two rings are visible on the PPI. Set the outer ring just inside the azimuth scale.

(2) Place the RANGE switch in the 3 position. Adjust sweep length control 3 (R118) so three rings are visible on the PPI. Set the outer ring just inside the azimuth scale.

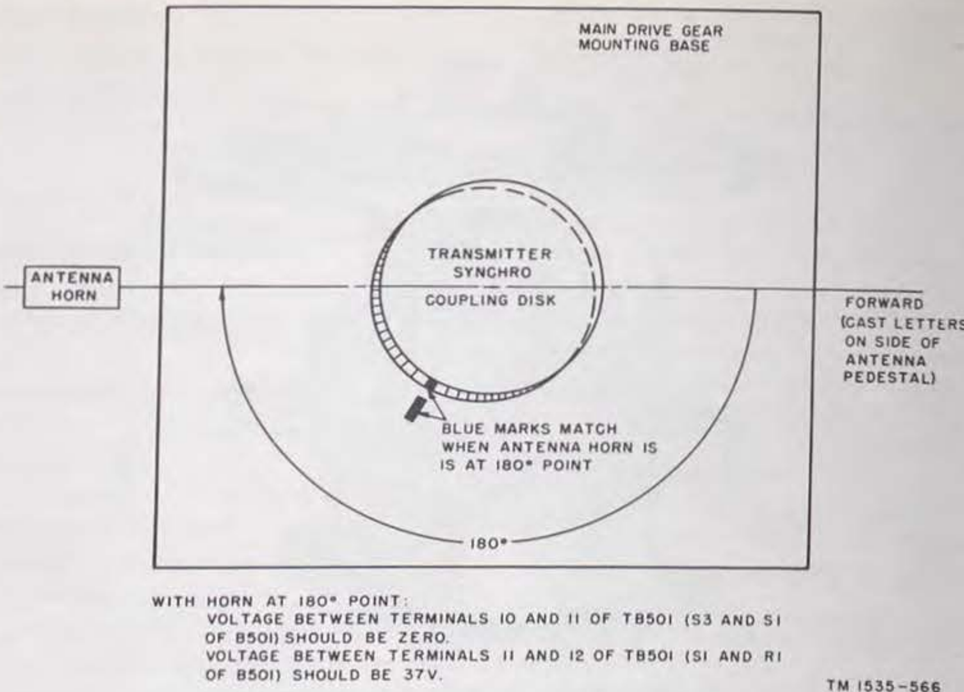


Figure 158. Transmitter synchro adjustment.

(3) Place the RANGE switch in the 8 position. Adjust sweep length control 8 (R119) so that four rings are visible on the PPI. Set the outer ring just inside the azimuth scale.

(4) Place the RANGE switch in the 20 position. Adjust sweep length control 20 (R120) so that four rings are visible on the PPI. Set the outer rings just inside the azimuth scale.

Note. After these adjustments have been made, operate the radar system on each range while viewing targets. Determine if any readjustments are needed.

193. Adjustment of Transmitter Synchro

a. Place antenna motor switch S503 in the OFF position.

b. Disconnect the external leads to terminal 10 and 11 of terminal board TB501 (fig. 184).

c. Loosen the three screws that hold the transmitter synchro to the main drive gear mounting base of the antenna pedestal.

d. Rotate the antenna horn clockwise by turning the synchro coupling disk by hand. Stop the antenna horn at 180°. This position is indicated when the blue mark on the synchro coupling disk matches the blue mark on the main drive gear mounting base (fig. 158).

e. Turn on indicator POWER switch S105.

Warning: Leave the antenna motor switch (S503) in the OFF position.

f. Place the voltmeter, set on the 250-volts ac scale, across terminals 10 and 11 of antenna terminal board TB501.

g. Rotate the transmitter synchro case, by hand, until the voltmeter reads zero.

h. There are two zero voltage settings. To make certain you have the correct setting, connect the voltmeter between terminals 11 and 12 of terminal board TB501. The voltmeter should read 37 volts. If the voltmeter reads approximately 193 volts, rotate the transmitter synchro case 180°.

i. Reconnect the external leads to terminals 10 and 11 of terminal board TB501.

194. Synchro Alinement

Note. Do not adjust synchro alinement cam switches unless new switches have been installed.

a. Synchro Alinement Cam Switch S501 (in Antenna).

(1) Place POWER switch S105 in the OFF position.

(2) Remove the antenna pedestal cover plates. If possible, do this on a dry day to prevent excessive moisture from entering the antenna pedestal.

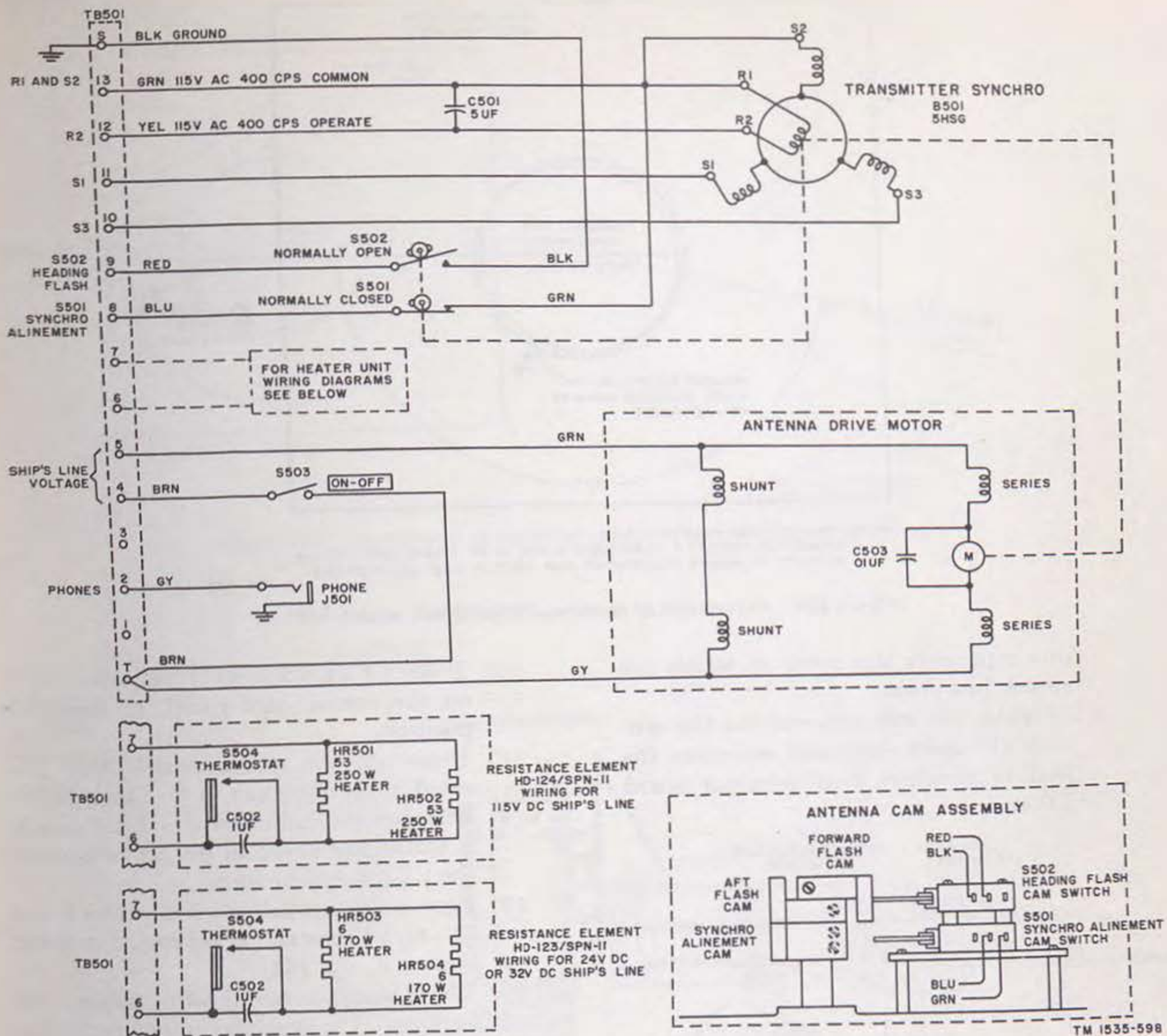


Figure 159. Antenna, schematic.

(3) Place antenna motor switch S503 in the OFF position.

(4) Rotate the antenna horn *clockwise* by manually tuning antenna drive motor B502. Stop the antenna horn at 168°. This position is indicated by the matching of the orange mark on the side of the synchro coupling disk with the orange mark on the main drive gear mounting base of the antenna pedestal (fig. 157).

(5) Loosen the two setscrews on the synchro alinement cam (fig. 157).

(6) Remove the external lead connected to terminal 8 of terminal board TB501.

(7) Connect an ohmmeter across terminals 8 and 13 of terminal board TB501. In this position the ohmmeter reads the resistance across the contacts of synchro alinement cam switch S501.

(8) If the meter reads infinity, rotate the cam in a clockwise direction until the meter reads zero.

(9) With the aid of a screwdriver gently rotate the cam counterclockwise until the ohmmeter suddenly switches to infinity;

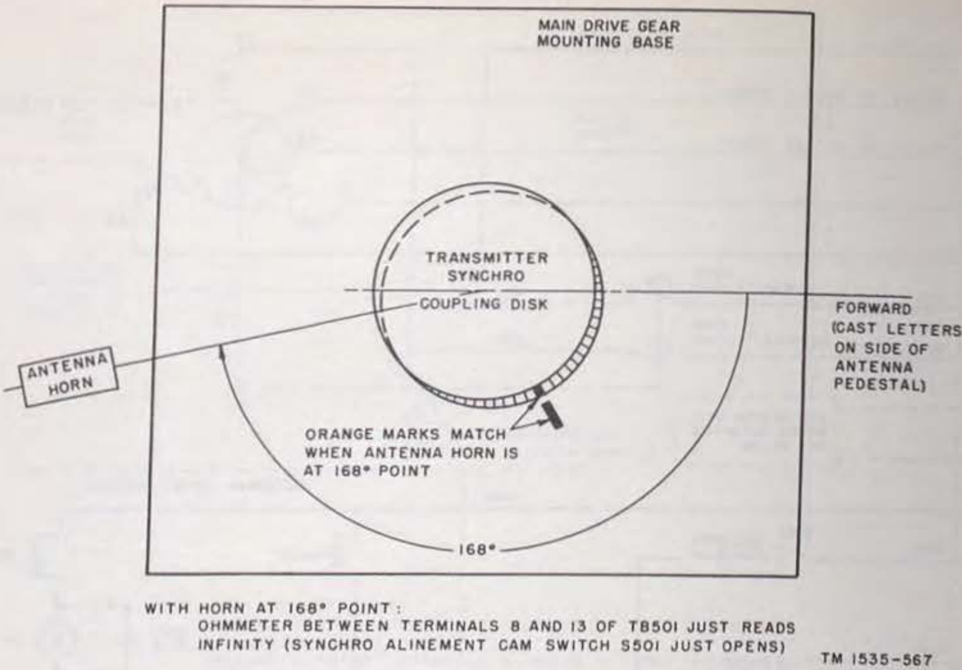


Figure 160. Adjustment of synchro alinement cam switch S501.

this represents the point at which the switch just opens.

(10) Tighten the two setscrews on the synchro alinement cam and reconnect the lead to terminal 8 of terminal board TB501.

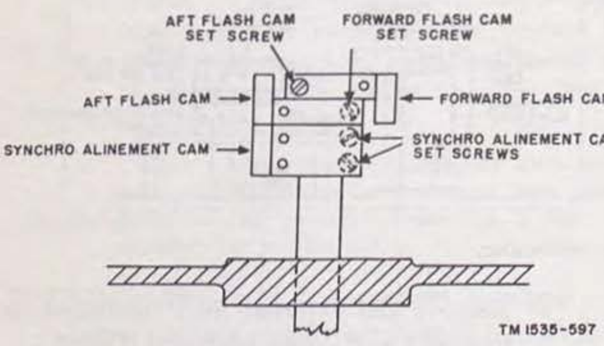


Figure 161. Antenna synchro alinement and heading flash cams.

(11) Check the accuracy of the adjustment by rotating the synchro coupling disk by hand. At the instant the switch contacts open, the orange marks must match within $\pm 1/32$ inch.

b. Synchro Alinement Cam Switch S104.

(1) Stop the antenna horn at 180°, as outlined in *a* above.

(2) Place ANTENNA MOTOR switch S802, on the convenience panel, in the OFF position.

(3) Place antenna motor switch S503 (located in the antenna) in the ON position.

(4) Turn on the indicator POWER switch. A stationary sweep in the aft position of the PPI should be seen.

(5) Loosen synchro adjustment screws B and C. Hand-tighten synchro adjustment screw (A, fig. 163).

(6) Work the receiver synchro toward the back until the synchro pinion gear is disengaged from the idler gear.

(7) Check the centering of the sweep by spinning the deflection coil by hand. The sweep should rotate directly behind the small circles scribed in the center of the cursor. If it does not, readjust the focus coil (par. 192*d*).

(8) With the aid of the Allen wrench held on the clip at the left of the receiver synchro, loosen the synchro alinement cam set screw.

(9) Move the synchro alinement cam slightly. Rotate the idler gear very slowly in a clockwise direction, until the instant the synchro alinement cam switch S104 oper-

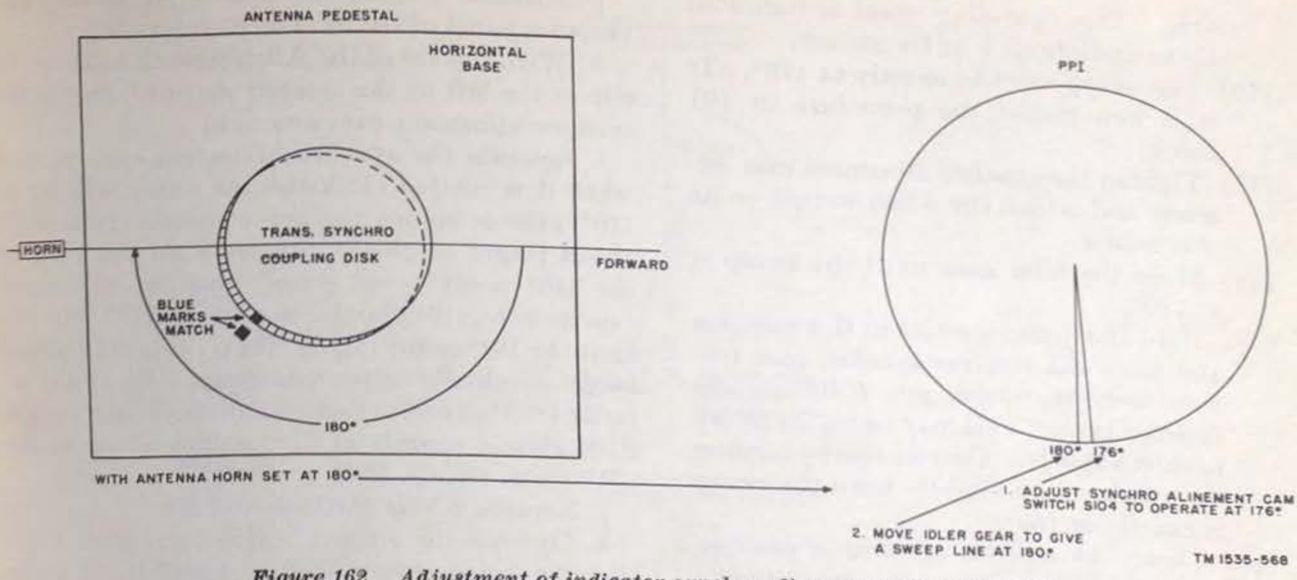


Figure 162. Adjustment of indicator synchro alinement cam switch S104.

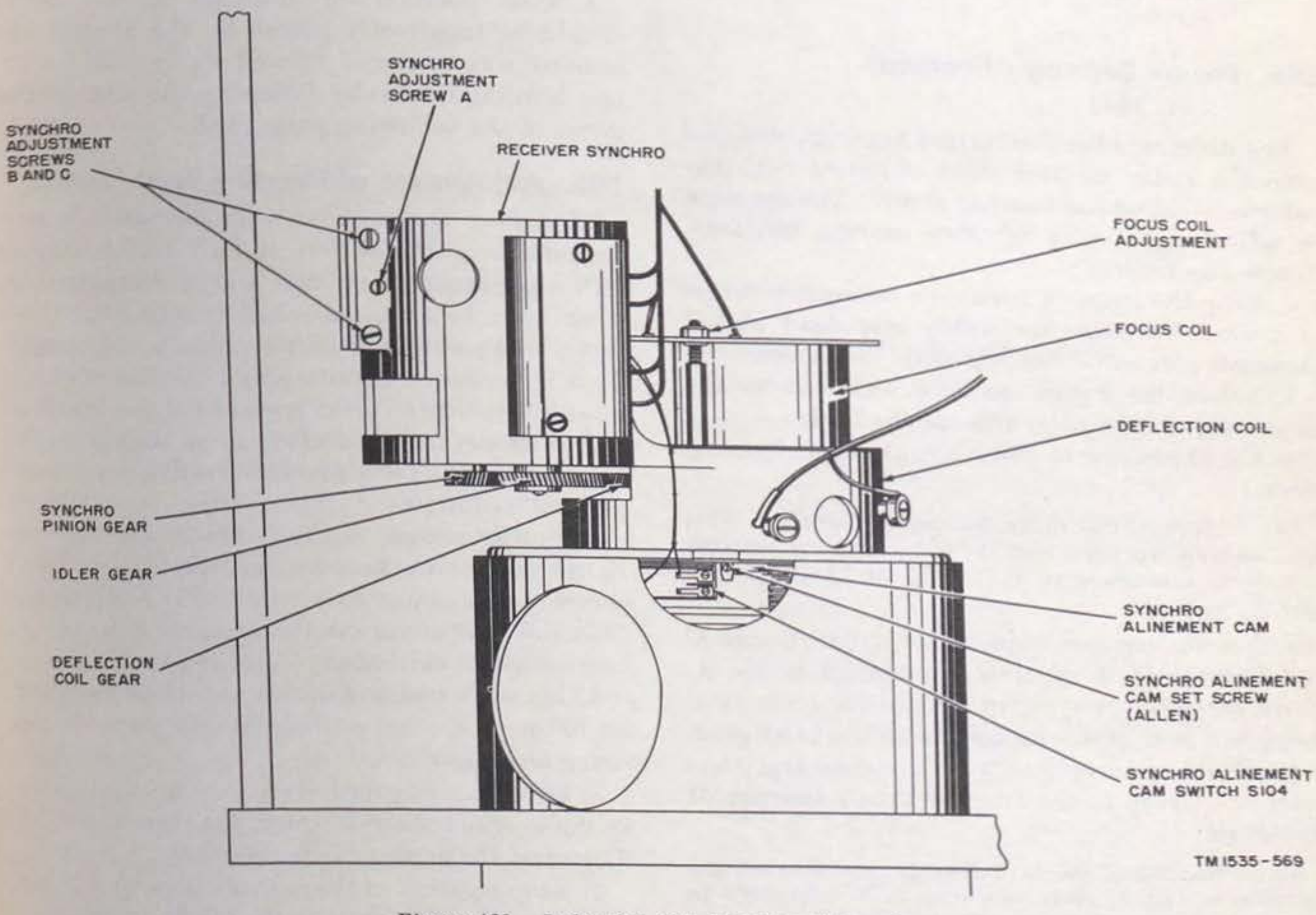


Figure 163. Indicator, line drawing of top view.

ates. This operating point is indicated by an audible click of the switch.

(10) The sweep must be exactly at 176°. If it is not, repeat the procedure in (9) above.

(11) Tighten the synchro alinement cam setscrew and return the Allen wrench to its clip holder.

(12) Move the idler gear until the sweep is at 180°.

(13) Hold the deflection coil in this position and push the receiver synchro case forward until its pinion gear fully engages its idler gear. This may cause the sweep to shift slightly. Correct this by turning the synchro case slightly until the sweep is exactly at 180°.

(14) Clamp the receiver synchro in position by loosening the synchro case setscrew and tightening the synchro adjustment screws.

195. Picture Bearing Alinement

(fig. 164)

The difference between target bearings obtained with the radar set and those obtained with the pelorus is called the bearing error. The set must be adjusted to make accurate bearing readings. Proceed as follows:

a. Stop the antenna horn on a stationary target of known bearing, preferably one dead ahead. Determine its exact bearing with the pelorus.

b. Select the range position that places the target close to the outer edge of the PPI.

c. Use the cursor to determine the *exact* bearing error.

Note. Though the radar bearing be incorrect, S104 still operates at 176°, and the antenna horn and the PPI sweep are alined at the 180° point (A and D, fig. 164).

d. Loosen synchro adjustment screws B and C and hand-tighten synchro adjustment screw A. Work the receiver synchro toward the back until its pinion gear is disengaged from the idler gear.

e. Rotate the receiver synchro case and thus move the sweep to the true (pelorus) bearing of the target.

Note. Because of the 10:1 gearing ratio between the transmitter and receiver synchros, it is necessary to move the receiver synchro case 10 times the bearing error.

f. Loosen synchro adjustment screw A and tighten synchro adjustment screws B and C.

g. Remove SYNCHRO fuse F803 in the convenience panel of the receiver-transmitter.

h. With the aid of the Allen wrench held on the clip at the left of the receiver synchro, loosen the synchro alinement cam setscrew.

i. Relocate the synchro alinement cam so that when it is rotated clockwise the sweep will be at 176° plus or minus the error noted. If a dead ahead target originally appeared on the PPI at the 355° point (−5° error), synchro alinement cam switch S104 should operate at 176° plus 5° or at the 181° point (B, fig. 164). If a dead ahead target originally appeared on the PPI at the 5° point (+5° error), synchro alinement cam switch S104 should operate at 176° minus 5° or at the 171° point (E, fig. 164).

j. Replace SYNCHRO fuse F803.

k. Operate the radar. After the initial rotation, the system should operate smoothly. A jerky operation indicates misalinement.

l. Note position of heading flashes. They should be incorrectly placed by the amount the bearing was corrected (C and F, fig. 164). Correct heading flashes by following the instructions given in the following paragraph.

196. Adjustment of Heading Flash Cams

Whenever the antenna cam assembly is disassembled, or if the fore-and-aft flashes on the PPI are inaccurate, the fore-and aft-heading flash cams must be adjusted. Before adjusting these cams, make sure the picture bearing is correct. This is necessary because any adjustment of the receiver synchro to provide correct target bearings will shift the fore-and aft-heading flashes by the same amount. To adjust the heading flash cams proceed as follows:

a. Station a man at the indicator and another at the antenna. Remove the antenna pedestal covers, and connect handsets to PHONES jacks J501 and J104 at the antenna and indicator. Connect a 4.5-volt dry battery in series (fig. 38).

b. Have the man at the indicator place the radar set in operation and adjust the controls for clear, sharp heading flashes.

c. If the heading flashes are inaccurate, the man at the antenna should inform the man at the indicator of the error and its direction.

d. Stop rotation of the antenna horn by placing the antenna switch S503 in the OFF position.

e. Loosen the forward flash cam setscrew (fig. 161). Shift the forward flash cam in the proper

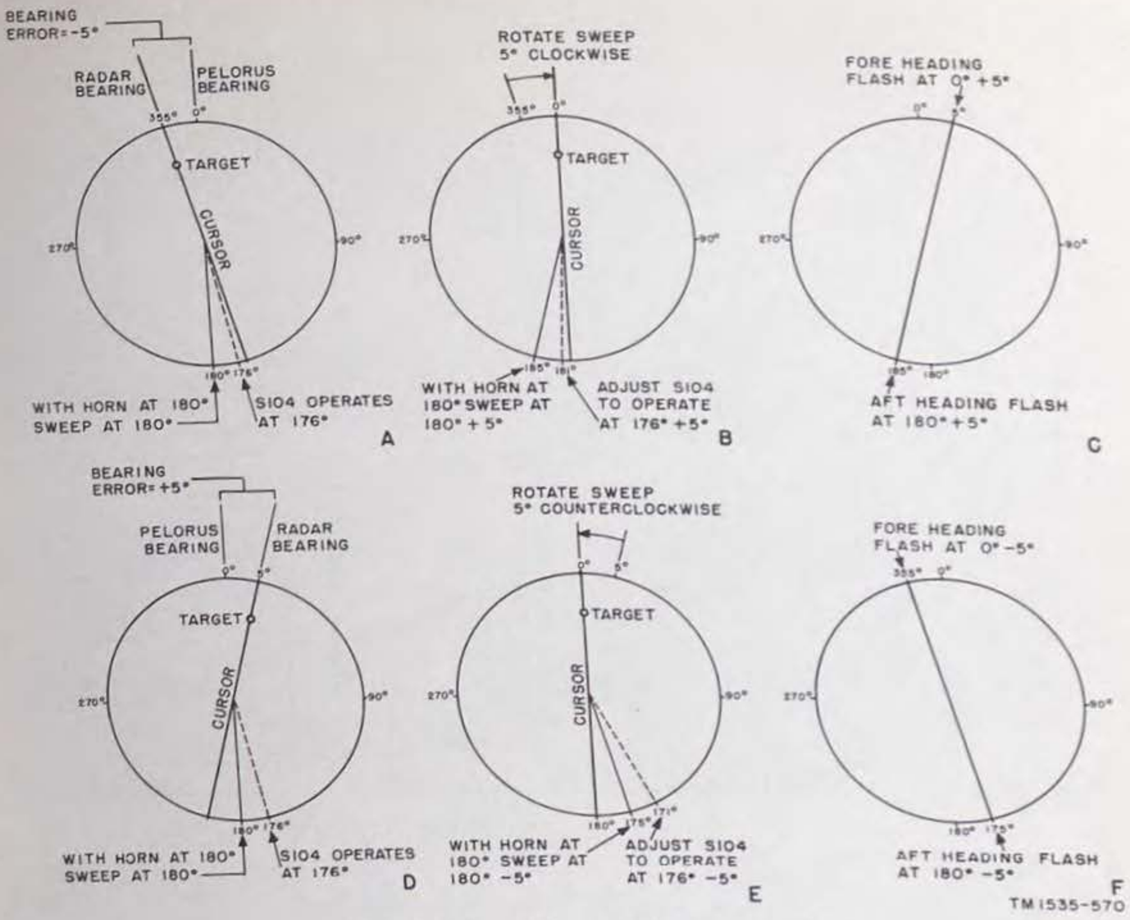


Figure 164. Picture bearing adjustment.

direction to compensate for the error, and tighten the setscrew.

f. Place antenna switch S503 in the ON position and have the man at the indicator observe the heading flashes. They should occur at 0°. If they do not, repeat instructions in *b* through *e* above to obtain an accurate forward heading flash.

g. Loosen the aft flash cam setscrew; shift the aft flash cam in the proper direction to compensate for the error; then tighten the setscrew.

h. Place antenna switch S503 in the ON position and have the man at the indicator observe the heading flashes. If they do not occur at 180°, repeat instructions given in *g* above and this paragraph.

i. Whenever possible, observe targets directly forward and aft and see that they coincide with the heading flashes.

j. Shut off power, set antenna switch S503 in the ON position, and replace the antenna pedestal covers.

197. Range Mark Calibration

The four controls (marked 1, 3, 8, and 20 in figure 153) on range ring assembly Z101 vary the frequency of range mark oscillator V107 and, hence, the distance between the range rings on the PPI. Adjustments are made with Range Calibrator TS–102/AP and Oscilloscope TS–239A/AP as follows:

a. Connect Range Calibrator TS–102/AP and Oscilloscope TS–239A/AP to the radar set (fig. 165). Connect indicator ground to ground terminal on oscilloscope.

b. Place the radar set in operation and allow it to warm up for at least 10 minutes. Place the GAIN control at zero.

c. On the range calibrator, set the MARKET POLARITY switch for a negative output, the SYNC POLARITY switch for a positive output, and the REPETITION FREQ to 2000.

d. On the oscilloscope, set NORMAL-VERTICAL PLATE switch to VERTICAL PLATE

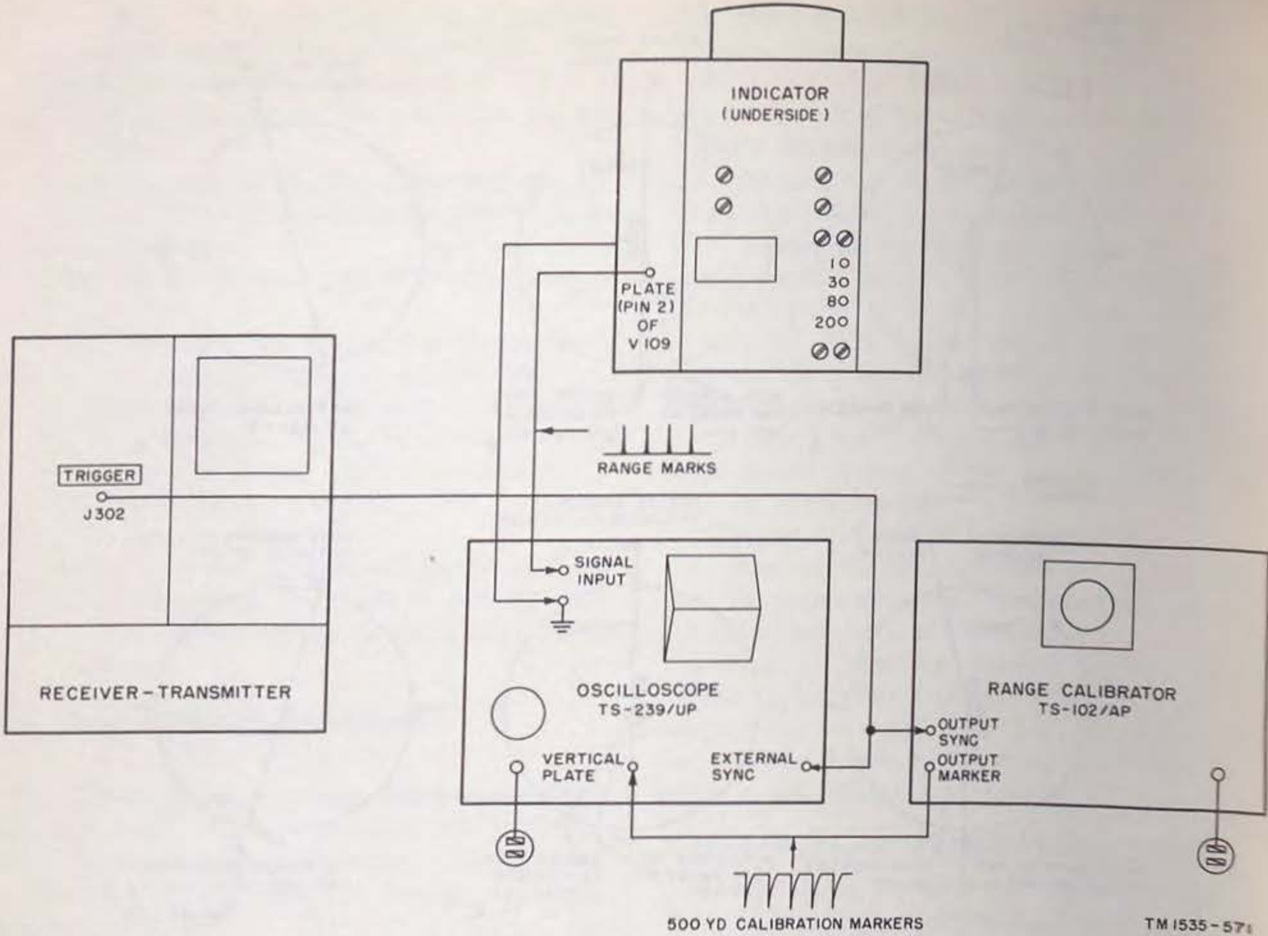


Figure 165. Calibration of range marks.

and adjust the oscilloscope (par. 110) so that the positive range marks and negative 500-yard calibration markers appear with sufficient amplitude.

e. Place the RANGE switch in position 1 and adjust the oscilloscope for a stationary pattern with at least five negative calibration markers appearing on the scope face.

f. Adjust the PHASE ADJ control on the range calibrator so that the first positive range mark just falls off the negative leading edge of the first 500-yard calibration marker.

g. Turn adjustment 1 so that the positive range marks all fall together off the sharp negative leading edge of alternate negative calibration markers (A, fig. 166).

h. Place the RANGE switch in the 3-mile position.

i. Adjust the oscilloscope controls so that at least 13 negative calibration markers appear on the oscilloscope face.

j. Turn adjustment 3 so that the positive range marks all fall together off the sharp negative leading edge of every fourth calibration marker (B, fig. 166).

k. Place the RANGE switch in the 8-mile position.

l. Adjust the oscilloscope controls so that at least 17 negative calibration markers appear on the oscilloscope face.

m. Turn adjustment 8 so that the positive range marks all fall together off the sharp negative leading edge of every eight calibration marker (C, fig. 166).

n. Place the RANGE switch in the 20-mile position.

o. Adjust the oscilloscope controls so that at

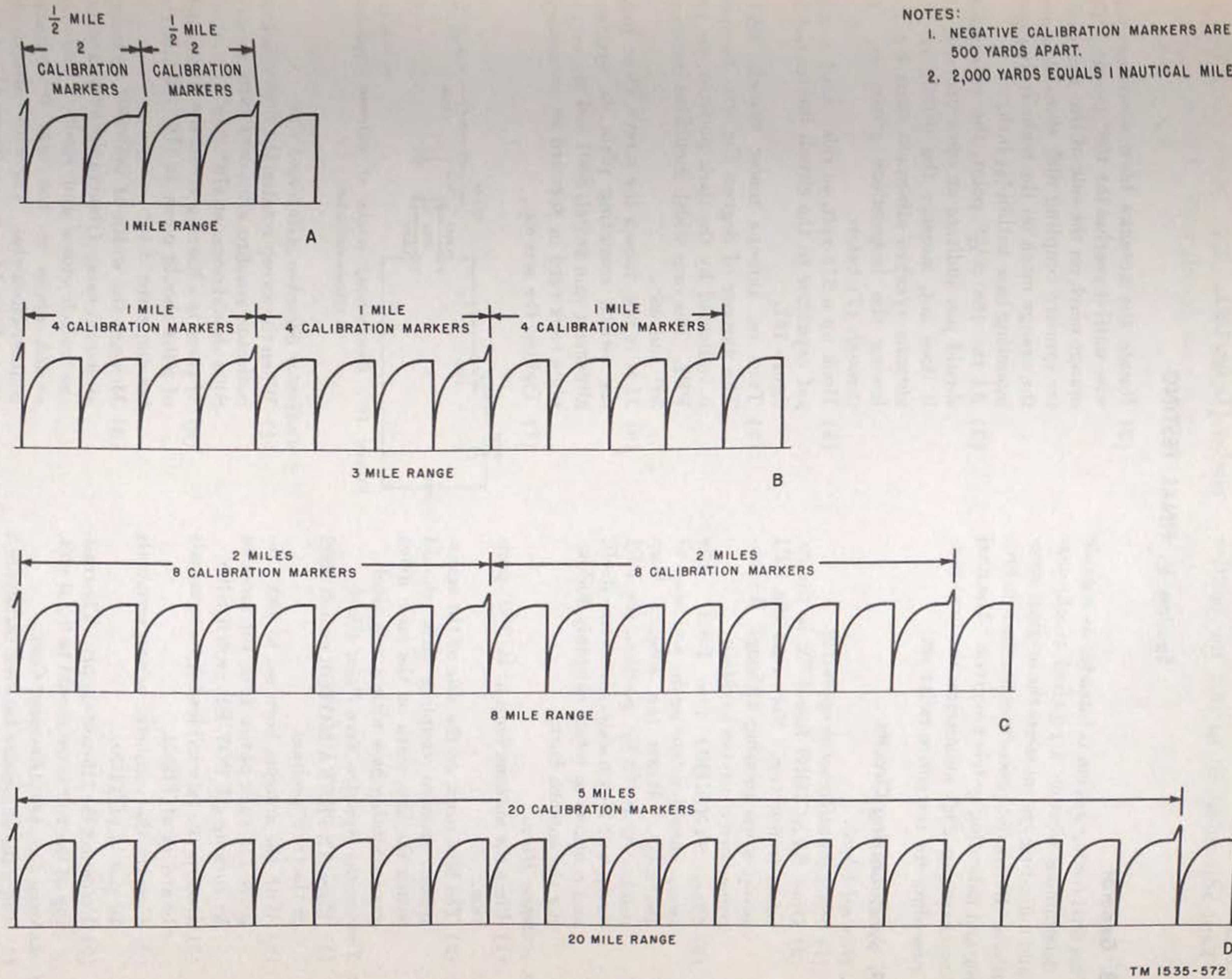


Figure 166. Use of calibration markers to position range marks.

least 21 negative calibration markers appear on the oscilloscope face.

p. Turn adjustment 20 so that the positive range marks all fall together off the sharp negative leading edge of every twentieth calibration marker (D, fig. 166).

Section V. FINAL TESTING

198. General

This final testing section is intended as a guide for determining whether a repaired synchronizing and indicating system meets the original specifications. Entire test procedures for the synchronizing and indicating system are given. The final testing chart (fig. 222) summarizes the final testing procedure for the entire radar set.

199. Synchronizing Circuits

a. General Check.

(1) Place the radar set in operation.

(2) Open SYNCHRO fuse F802 in the receiver-transmitter. Note that the PPI sweep stops rotating although the antenna horn continues to rotate.

(3) Close SYNCHRO fuse F802. The sweep should rotate again and stop at $180° \pm 1/2°$. When the antenna horn reaches its $168° \pm 1/2°$ position, the PPI sweep will kick backward, reverse itself, and continue to rotate smoothly following the antenna horn.

b. Antenna Horn.

(1) Place the antenna horn at its 180° position.

(2) The blue mark on the side of the transmitter synchro coupling disk should match the blue mark on the main drive gear mounting base within $\pm 1/32$ inch.

c. Transmitter Synchro Zero Point Check.

(1) Place ANTENNA MOTOR switch S802 in the OFF position.

(2) With the antenna horn set to 180°, remove 115 volts power from the antenna by turning off POWER switch S105.

(3) Remove the external lead from terminals 10 and 11 of TB501.

(4) Connect the voltmeter across terminals 10 and 11 of TB501.

(5) Reconnect the 115-volt supply. The reading of the voltmeter should be $0 \pm .3$ volt.

d. Antenna Synchro Alinement Cam.

(1) Place the ohmmeter between terminals 8 and 13 of TB501.

(2) Rotate the antenna horn counterclockwise until it reaches the 168° point. The orange mark on the side of the transmitter synchro coupling disk should match the orange mark on the main drive gear mounting base within $1/32$ inch.

(3) At the $168° \pm 1/2°$ point, the ohmmeter should just indicate an open circuit. If it does not, measure the width of the antenna synchro alinement cam by following the instructions given in (4) through (7) below.

(4) Hook up a 115-volt, ac relay and a 100-$\mu\mu$f capacitor in the circuit indicated in figure 167.

(5) Turn on antenna motor switch S503. The number of degrees the cam is open is indicated by the dark portion on the PPI. The cam width should be between 30° and 36°.

(6) If it is not, loosen the screws that hold the switch mounting plate to synchro alinement cam switch S501 and move the plate backward or forward as necessary.

(7) Tighten the screws.

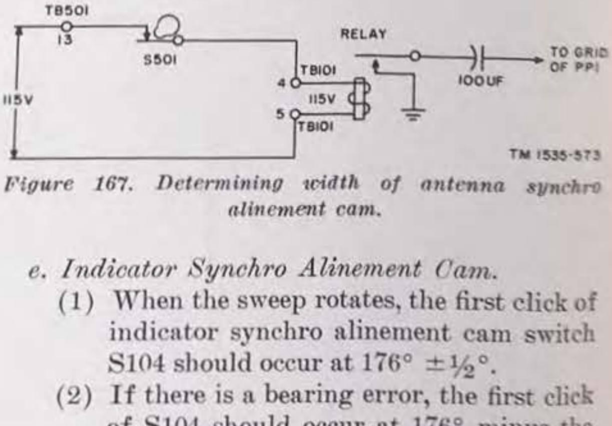


Figure 167. Determining width of antenna synchro alinement cam.

e. Indicator Synchro Alinement Cam.

(1) When the sweep rotates, the first click of indicator synchro alinement cam switch S104 should occur at $176° \pm 1/2°$.

(2) If there is a bearing error, the first click of S104 should occur at 176° minus the bearing error $\pm 1/2°$.

(3) Measure the width of indicator synchro alinement cam. Observe the sweep when the switch closes and again when the switch opens as the cam is rotated counter-clockwise. The width should be 10° to 20°. If it is not, loosen the lower

screw on the switch mounting plate and move the plate back and forth.

f. Heading Flash. Note when heading flashes occur on the PPI. They should occur at 0° ±½° and 180° ±½°.

200. Center Expand Switch

a. Place the set in operation.

b. Place the CENTER EXPAND switch in the ON position. The circle on the PPI should be ½ inch ±⅛ inch.

CHAPTER 13

TROUBLESHOOTING IN POWER SYSTEM

Section I. TROUBLESHOOTING PROCEDURES

Cautions:

1. High voltages are present in all the power group components and in the power supplies. Be especially careful when working with the PPI power supply, which produces 5,000 volts and the modulator power supply, which produces 3,000 volts.
2. When testing voltage at a terminal of a terminal board or of a power plug, make sure that the meter lead does not short the terminal under test to another terminal close to it. A short produced this way may cause a fuse to blow.

201. Reference Data

Fig. No.	Description
220	Power distribution diagram.
219	Radar Set AN/SPN-11(*) cabling diagram.
169	Low-voltage power supplies, voltage and resistance chart.
171	Modulator power supply, voltage and resistance chart.
170	Keep-alive power supply, voltage and resistance chart.
172	PPI power supply, voltage and resistance chart.
168	Low-voltage power supplies, tube location.

202. Testing Power System

a. Starting Procedure. Perform the procedures given in the troubleshooting based on starting procedure chart (par. 115). If the chart indicates that trouble lies in the power system, perform the instructions given in *b* through *e* below to localize the trouble to one of the power supplies or to a component in the power group.

b. Fuse Table. Check all fuses. Refer to the fuse table (par. 116) for information concerning rating, purpose, and location of each fuse. Determine the cause of the blown fuse before replacing the fuse.

c. Testing Power Supplies.

(1) Read test meter M401 with test meter switch S401 in the MOD. H. V. position. If it does not read approximately 300 (representing 3,000 volts), the trouble is in either the modulator circuits or the modulator high-voltage power supply. Replace modulator tube V305. If the voltage reading does not improve, disconnect resonant charging choke L302 from the junction of L301 and R305. If the reading is still incorrect, the trouble is definitely in the modulator power supply.

(2) Read test meter M401 with test meter switch S401 in the +140V position. If it does not read approximately +140 volts, read the voltage at terminal 10 of TB401. If this voltage is incorrect, disconnect the lead going to cable W804. If the voltage is still not +140 or slightly higher, the trouble is definitely in the +140-volt power supply.

(3) Read test meter M401 with test meter switch S401 in the +320V position. If it does not read approximately +320 volts, read the voltage at terminal 13 on TB401 and terminal 5 on TB801. If these are incorrect, disconnect the leads to these terminals and read the voltage again. If voltage is still not +320V or slightly higher, the trouble is definitely in the +320-volt power supply.

(4) Read test meter M401 with test meter switch S401 in the +300V REG. position. If it does not read approximately +300 volts, read the voltage at terminal 8 on TB401 and terminal 4 on TB801. If these are incorrect, disconnect the lead from pin 5 of V404. If the voltage at this point is not +300 volts or slightly

higher, the trouble is in the +600- +300-volt power supply. Read the voltage at terminal 3 of TB801. If it is not +600 volts or slightly higher, the trouble is in the +600-volt section of the power supply.

(5) Read test meter M401 with test meter switch S401 in the −300V REG. position. If it does not read approximately −300 volts, read the voltage at terminal 1 of TB401 and at terminal 6 on TB801. If these are incorrect, disconnect the lead from pin 2 of V407 and read the voltage at that point. If that voltage is not −300V or slightly higher, the trouble is definitely in the −300-volt supply.

(6) Read the voltage at the keep alive electrode of the TR tube. If the voltage is not approximately −900 volts, disconnect the lead. If the lead voltage is not approximately −900 volts, the trouble is in the keep-alive power supply.

(7) Read the voltage at the H. V. TEST jack in the indicator. If it is not approximately 50 (representing 5,000 volts), disconnect the high-voltage cap from the PPI and read the voltage at the H. V. TEST jack again. If it is not approximately 50, the PPI power supply is faulty.

d. Testing Power Group Components.

(1) Read test meter M401 with test meter switch S401 in the 115V AC position. If the test meter does not read 115 volts, try to adjust the voltage with R412. If the test meter still cannot be made to read 115 volts, check fuse F402. If the fuse is not open, check the voltage on the voltage regulator. If the voltage regulator is incorrect, check the line voltage applied to the switch box. If this is correct, the trouble is in the power group.

(2) Check F804. If it is satisfactory, read the voltage across 8 and 9 of TB601. If the voltage across these points is not 115 volts, the motor generator is not producing ac.

(3) Check the voltage between 1 and 15 of TB601. If line voltage is read, the starter is operating properly. The trouble is probably in the motor generator. If the line voltage cannot be read, the starter is probably defective.

(4) Read the voltage between 14 and 12 of TB601, and then between L2+ and A1L1. If line voltage is read between these points, the trouble is in the motor starter. If voltage cannot be read between these points, the switch box is probably defective.

e. Cable Continuity Check. Use the power distribution diagram (fig. 220), the cabling diagram (fig. 219), and the antenna schematic (fig. 159) to check for continuity of cables whenever voltage is read in one component and not in another to which the cable is connected.

203. Use of Terminal Boards

Many terminal boards are provided for use in testing continuity between components and between different parts of the receiver-transmitter. Terminal board TB601 on top of the motor generator is used as an interconnection point among the components in the power group and between the motor generator and the receiver-transmitter. At the bottom of the receiver-transmitter are three terminal boards (TB801, TB803, TB804). (TB802 does not have power system test points.) Here can be found test points for practically every circuit that involves more than one component. Another terminal board (TB401) on the receiver-transmitter serves as an interconnection point for all voltages feeding the receiver chassis. In addition, there are terminal boards in the antenna (TB501), in the indicator (TB101), and in the junction box (TB701 and TB702). The tables below show the voltages that should be read between various points on the terminal boards, and what these voltages represent.

a. Motor Generator (TB601).

Terminals	Voltage	Description
1 and 7 (also 10, 14, 15).	Line voltage (24, 32, or 115 volts dc).	Voltage applied to series field.
4 (also 6) and 7 (also 10, 14, 15).	Line voltage (24, 34, or 115 volts dc).	Voltage applied to shunt field; to B801; and to R601 in series with dc winding.
5 and 4 (also 6)	Varies with setting of R601.	Voltage across R601.
8 and 9	115 volts ac	Motor generator output voltage.

b. Receiver-Transmitter.

(1) *Terminal Board TB801.*

Terminals	Voltage	Description
1 and 7		Receiver gain.
2 and 7		Receiver stc.
3 and 7	+600v dc	B+ plate supply.
4 and 7	+300v dc	B+ plate supply.
5 and 7	+320v dc	B+ plate supply.
6 and 7	−300v dc	Grid bias supply.
8 and 9	115v, 400 cps	Input to J105, T101, and T102.
10 and 9	115v, 400 cps	Input to R1 and R2 of B101.
11 and 12		Output of S1 and S3 of B501.

(2) *Terminal Board TB803.*

Terminals	Voltage	Description
MG1 and MG2	Ship's line voltage.	Input to B502.
MG3 and MG5	Ship's line voltage.	Input to S504, HR501 and HR502, and motor starter or contactor.
MG3 and MG6	Ship's line voltage.	Input to motor generator shunt winding, to dc winding through R601, and to B801.
MG6 and MG7	Ship's line voltage.	Input to B801 in dc installation.
MG8 and MG9 (Fused).	115v, 400 cps	Motor generator output for all units of the radar set.
MG8 and MG10	115v, 400 cps	Motor generator output for all units of the radar set.

(3) *Terminal Board TB804.*

Terminals	Voltage	Description
A4 and A5	Ship's line voltage.	Input to B502.
A6 and A7	Ship's line voltage.	Input to HR501, HR502, and S504.
A12 and A13	115v, 400 cps	Input to R1 and R2 of B501.

(4) *Terminal Board TB401.*

Terminals	Voltage	Description
1 (also 2) and 11	−300 v	Afc bias and reflector voltage.
3 (also 4, 5) and 7	115 v ac	To receiver filament transformer T201.
8 (also 9 and 11)	+300 v	B+ for V203 and V216.
10 and 11	+140 v	Receiver B+.
12 (also 13 and 11).	+320 v	Stc B+.
14		Stc line.
15		GAIN line.

c. Antenna (TB501).

Terminals	Voltage	Description
T (also 4)		Continuity to antenna drive motor windings when S503 is ON.
2		PHONES.
T (also 4) and 5	Line voltage (24, 32, or 115 volts dc).	Across antenna drive motor.
6 and 7	Line voltage (24, 32 or 115 volts dc).	Across heaters and thermostat.
8 and 13	Continuity (when S501 is closed).	Synchro alinement.
9 and S	Open (when S502 is open).	Heading flash.
10 and 11	0 volt (antenna horn at 180°).	Across S1 and S3 of transmitter synchro.
11 and 12	37 volts (antenna horn at 180°).	Across S1 and R2 of transmitter synchro.
12 and 13	115 volts ac	Voltage across R1 and R2 of transmitter synchro.

d. Indiactor Power Plug P101.

Terminals	Voltage	Description
A		GAIN line.
B		PHONES.
C and I	+300 v	B+.
E and I	−300 v	Bias.
G and I	+320 v	B+.
H and Q	115 v ac	Input to transformer receptacles and relay K101.
J and H	115 v ac	Voltage to receiver synchro B101.
K and L	Continuity (when POWER switch S105 on).	
M		SUPPRESSOR.
N and I	+600 v	B+.
O	Continuity to S3 (if K101 is de-energized).	Synchro alinement.
P	Continuity to S1 (if K101 is de-energized).	Synchro alinement.
R	Continuity to K101 (if S104 is operated).	Synchro alinement.
S and I	Continuity (when S502 is operated).	Heading flash.

(1) *Terminal Board TB701.*

Terminals	Voltage	Description
1		GAIN line.
2		SUPPRESSOR line.
3 and 7	+600 v	B+.
4 and 7	+300 v	B+.
6 and 7	−300 v	Bias.
5 and 7	+320 v	B+.
8 and 9	115 v ac	Ac input.
9 and 10	115 v ac	Ac input to receiver synchro B101.
11	Continuity to S1 (if K101 is de-energized).	Synchro alinement.
12	Continuity to S3 (if K101 is de-energized).	Synchro alinement.
14	Continuity to K101 (if S104 is closed).	Synchro alinement.
13 and 7	Continuity (when S502 is closed).	Heading flash.

(2) *Terminal Board TB702.*

Terminals	Voltage	Description
15 and 16	Continuity (when POWER switch S105 is ON).	
17		PHONES.

204. Testing Power Group

The following procedures are used to test for grounds, open, and short circuits in the power group. Although the techniques discussed are in reference to the motor generators, they may be applied to the motor starters and voltage regulators.

a. Preliminary Test Procedure.

(1) Place the operating handle of the switch box in the off position.

(2) Remove the motor generator brush access cover (fig. 202).

(3) Remove the cover to terminal board TB601.

(4) Remove the brushes from their brush holders. Do not remove pigtail leads.

b. Testing Field Windings for Grounds.

(1) Touch one test prod of Multimeter TS-352/U to the motor generator frame.

(2) Touch the other test prod to the brush-holder terminal.

(3) If a reading is obtained on the meter, a ground is present.

(4) Inspect the leads.

(5) If the ground is in a lead, tape the defective section with several layers of rubber tape and then with two layers of friction tape.

(6) If the ground is in the winding itself and cannot be easily located, install a new field winding assembly.

c. Testing Field Windings for Open Circuits.

(1) Touch one test prod to each brush-holder terminal.

(2) If no reading is obtained, the winding is open.

(3) Inspect the external leads and wiring, and repair any defective point which is discovered.

(4) If the open is in the winding itself and cannot be easily located, install a new field winding assembly.

d. Testing Field Winding for Short Circuits.

(1) Inspect the external leads and field windings for signs of overheating or burned insulation.

(2) If the defective point is in an external lead, repair with rubber and friction tape.

(3) If the defective point is in the field winding and is accessible, use a high heat-resistant varnish or shellac to repair the defective insulation. Apply a coat of fungicide over the varnish or shellac.

(4) If the short circuit cannot be located, replace it with a new field winding assembly.

Note. During operation, a humming noise in the winding is an indication of a short circuit. However, this test is inconclusive and should be used only as a preliminary test.

e. Testing Motor Armature Windings for Open Circuits.

(1) Touch one test prod to one of the commutator bars.

(2) Touch the other test prod to each of the commutator bars in turn.

(3) A reading should be obtained with the test prod on any bar. If no reading is obtained in any position of the test prod, an open is indicated.

(4) Repeat the procedure in (1), (2), and (3) above; use each commutator bar as a reference point in (1) above.

(5) If an open is indicated, replace the armature assembly.

f. Testing Motor Armature Windings for Grounds.

(1) Touch one test prod to the frame of the motor generator.

(2) Touch the other test prod to each of the other commutator bars in turn.

(3) If a reading is obtained, either the armature winding or the commutator bar is grounded.

(4) If a ground is indicated, replace with a new armature assembly.

g. Testing Motor Armature Windings for Short Circuits.

(1) Inspect the armature windings for signs of overheating or burned insulation. If many turns in one coil are short circuited, that coil will run hotter than other coils that are in good condition.

(2) Perform the procedure in *f* above, if the procedure in (1) above fails to indicate the defective point. Grounds at two points in the winding could short-circuit the intervening portion, and winding will test grounded.

(3) If a short circuit is indicated, replace the armature assembly.

Section II. POWER SYSTEM TROUBLESHOOTING CHARTS

205. General

a. Whenever a power system failure is suspected, check all fuses. See the fuse table (par. 116). .

b. The power system is tied in with all the other systems of the radar set. Often a power supply part breaks down because of a short in one of the systems to which the voltage from this power supply is fed. Therefore, in addition to troubleshooting the power supply at fault, be sure to check for shorts in all the systems and all the cables to which the power supply voltage is fed. Use the power distribution diagram (fig. 220), the cabling diagram (fig. 219), and the appropriate schematics (figs. 212, 213, 214, and 159) in this check.

c. The troubleshooting charts do not give all possible symptoms. For the symptoms listed, the charts merely guide you to the probable cause of trouble. To be sure that a part is at fault, take voltage and resistance readings and compare them with those given in the voltage and resistance charts (figs. 169–172).

d. Power and filament transformers often go bad. To help determine if any of the transformers are faulty, the following chart of resistance readings for the power and filament transformers is provided.

Transformers	Terminals	Resistance readings
T401 power supplies power transformer.	1 and 2	Less than 1 ohm.
	3 and 4	Less than 1 ohm.
	5 and 6	Less than 1 ohm.
	7 and 8	3 to 4 ohms.
	7 and 9	10 ohms.
	7 and 10	15 ohms.
	7 and 11	20 ohms.
	7 and 12	23 ohms.
T402 power supplies filament transformer.	1 and 2	3 to 4 ohms.
	3 and 4	Less than 1 ohm.
	5 and 6	Less than 1 ohm.
	7 and 8	Less than 1 ohm.
	9 and 10	Less than 1 ohm.
T301 modulator power supply power transformer.	1 and 2	1 ohm.
	1 and 3	1 ohm.
	1 and 4	1 ohm.
	1 and 5	1 ohm.
	6 and 7	2,000 ohms.
	7 and 8	2,000 ohms.
T303 modulator power supply filament transformer.	1 and 2	1 ohm.
	3 and 4	Less than 1 ohm.
	5 and 6	Less than 1 ohm.
	7 and 8	Less than 1 ohm.
	9 and 10	Less than 1 ohm.
	11 and 12	Less than 1 ohm.
T201 receiving system filament transformer.	1 and 2	3 ohms.
	3 and 4	Less than 1 ohm.
	5 and 6	Less than 1 ohm.
T101 PPI power supply power transformer.	On Kenyon transformer.	
	1 and 2	10 ohms.
	3 and 4	13,500 ohms.
	5 and 6	Less than 1 ohm.
	On Chicago transformer.	
	1 and 2	6 ohms.
	3 and 4	Less than 1 ohm.
	5 and 6	28,000 ohms.
T102 indicator filament transformer.	1 and 2	3 to 4 ohms.
	3 and 4	Less than 1 ohm.
	4 and 5	Less than 1 ohm.

206. Power Supplies, Troubleshooting Chart

Symptom	Probable trouble	Correction
No reading of test meter at MOD. H. V. position of test meter switch.	HIGH VOLTAGE switch S301 in OFF position.	Place in ON position.
	Interlock switch S302 open	Close.
	Fuse F301, F302 or F401 open	Check fuses F301 and F401. Determine cause of fuse opening before replacing.
	Defective modulator power supply	Check tubes V303 and V304. Check resistances of T301. If filaments do not light, check continuity across 11 and 12 of T303.
	Time delay circuit inoperative	Check continuity across K301 coil and contacts. Make voltages and resistance check of V301.
	+320 volt supply inoperative	Refer to this abnormality below.
	Shorted line filter Z302	Make continuity check. Replace if defective.
	Defective modulator in transmitting system.	Check modulator.
No reading of test meter at +140 V. position of test meter switch.	Fuse F401 or F402 open	Check fuses F401 and F402. Determine cause of trouble before replacing.
	Inoperative rectifier V401	Check tube V401 and associated parts.
	Defective transformer T401 or T402	Check resistances of coils in T401 and T402. Replace transformers if defective.

206. Power Supplies, Troubleshooting Chart—Continued

Symptom	Probable trouble	Correction
No reading of test meter at +320 V. position of test meter switch.	Fuse F401 or F402 open	Check fuses F401 and F402. Determine cause of trouble before replacing.
	Inoperative rectifier V402	Check tube V402 and associated parts.
	Defective transformer T401 or T402	Check resistances of coils in T401 and T402. Replace transformers if defective.
No reading of test meter at +300 V. REG. position of the test meter switch.	Fuse F401 or F402 open	Check fuses F401 and F402. Determine cause of trouble before replacing.
	Inoperative rectifier V403 or voltage regulators V404 and V405.	Check for +600 V at 3 of TB801. If present, V402 is all right. Check V404, V405, and associated parts. If +600 V are not present at this point, check V403 and associated parts.
	Defective transformer T401 or T402	Check resistance of T401 and T402 windings. Replace transformers if defective.
No reading of test meter at −300 V. REG. position of test meter switch.	Fuse F401 or F402 open	Check fuse F401 and F402. Determine cause of trouble before replacing.
	Inoperative rectifier V406 or voltage regulators V407 and V408.	Check tubes V406, V407, V408, and associated parts.
	Defective transformer T401 or T402	Check resistance of T401 and T402 windings. Replace transformer if defective.
No reading of test meter at 115 V. position of test meter switch.	Improper adjustment of R412 (fig. 173).	Adjust R412 to make test meter read 115 V.
	Fuse F402 open	Check fuse F402. Determine cause of opening before replacing.
	Defective rectifier CR401	Check CR401 with crystal rectifier test set.
	Interlock switch S103 open	Close.
Reading at H. V. TEST jack J102 not 50 v (representing 5 kv).	Fuse F102 open	Check fuse F102. Determine cause of opening before replacing.
	Inoperative rectifier V106	Check tube V102 and associated parts.
	Defective transformer T101	Check resistances of T101 windings. Replace transformer if defective.
No reading on test meter at any test meter switch position.	Defective test meter	Replace test meter.
Low reading on test meter at all positions of test meter switch.	Poor electrical connection to test meter.	Check test meter switch rotor for dirt and corrosion. Check test meter connections for looseness. Clean or tighten connections as required.

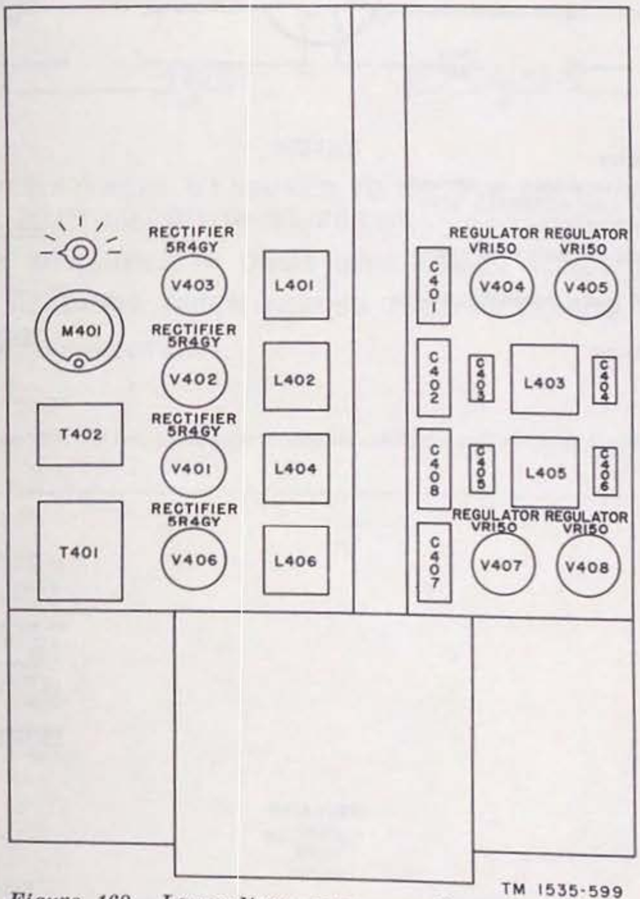


Figure 168. Low-voltage power supplies, tube location chart.

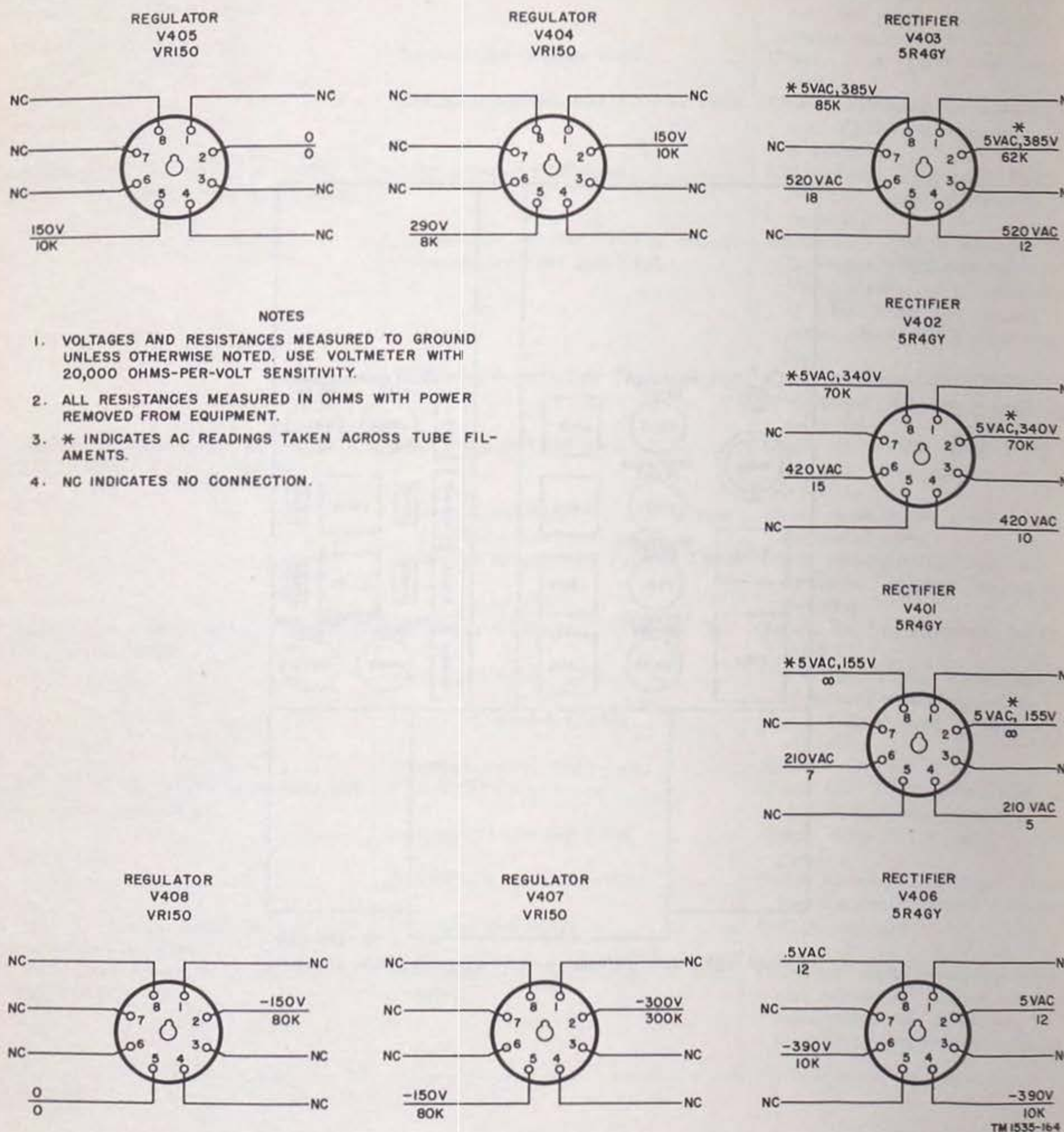
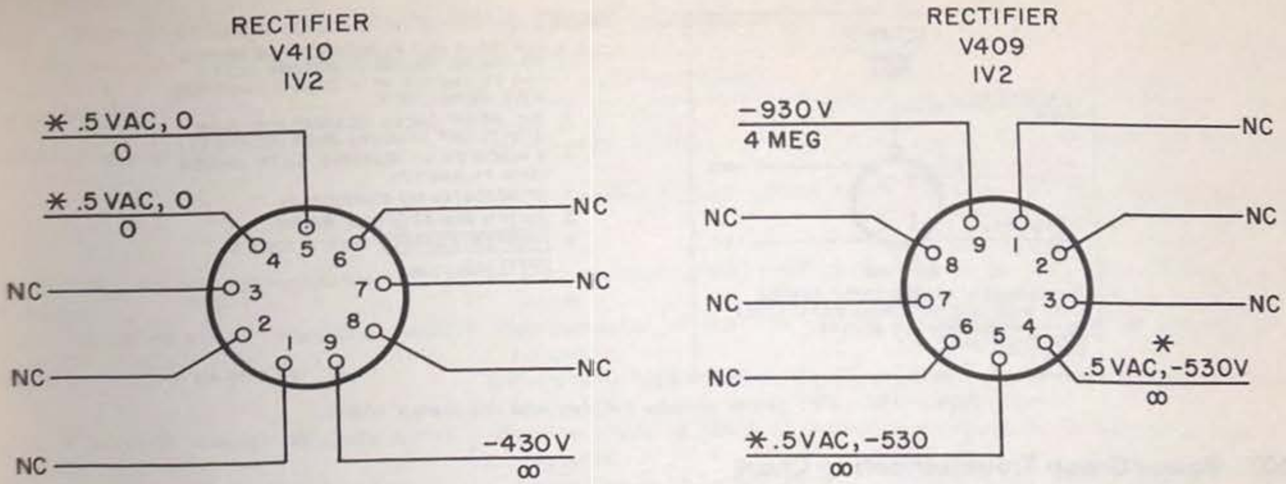


Figure 169. Low-voltage power supplies, voltage and resistance chart.



NOTES

1 VOLTAGES AND RESISTANCES MEASURED TO GROUND UNLESS OTHERWISE NOTED. USE VOLTMETER WITH 20,000 OHMS-PER-VOLT SENSITIVITY.

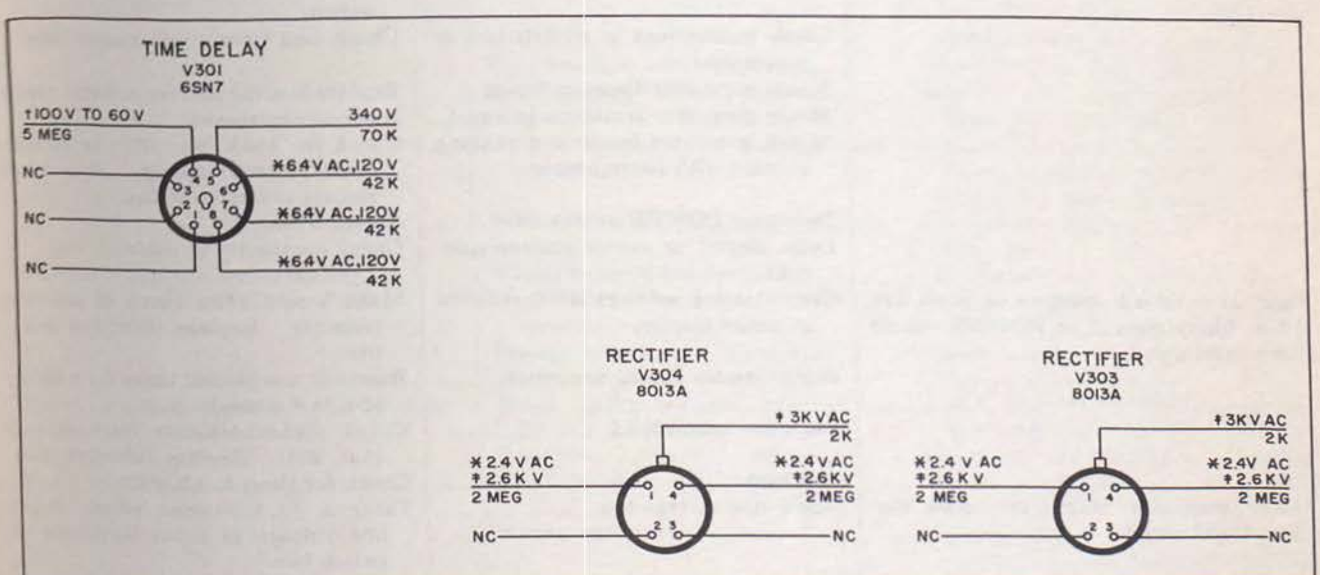
2 ALL RESISTANCES MEASURED IN OHMS WITH POWER REMOVED FROM EQUIPMENT.

3 ✱ INDICATES AC READINGS TAKEN ACROSS TUBE FILAMENTS.

4 NC INDICATES NO CONNECTION.

TM 1535-159

Figure 170. Keep-alive power supply, voltage and resistance chart.



NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND UNLESS OTHERWISE NOTED. USE VOLTMETER WITH 20,000 OHMS-PER-VOLT SENSITIVITY.
2. ALL RESISTANCES MEASURED IN OHMS WITH POWER REMOVED FROM EQUIPMENT.
3. ✱ INDICATES AC READINGS TAKEN ACROSS TUBE FILAMENTS.
4. NC INDICATES NO CONNECTION.
5. † METER CAUSES VOLTAGE DROP. AT 60V NEON TUBE V302 IS EXTINGUISHED.
6. ♦ INDICATES HIGH VOLTAGE SWITCH S301 IN ON POSITION.

TM 1535-600

Figure 171. Modulator power supply, voltage and resistance chart.

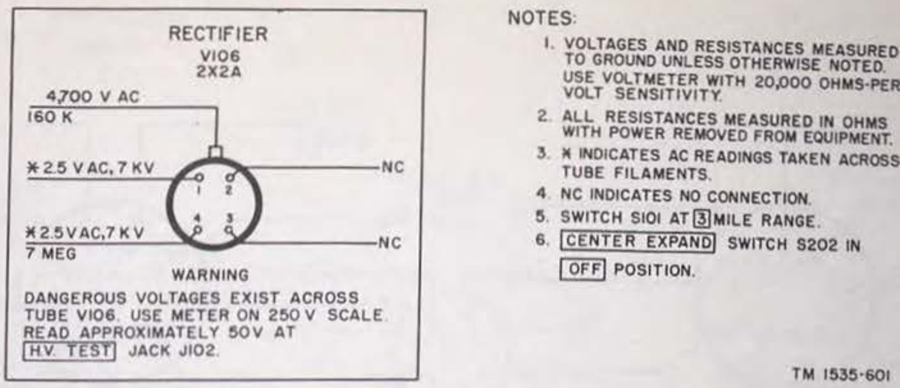


Figure 172. PPI power supply, voltage and resistance chart.

207. Power Group Troubleshooting Chart

Symptom	Probable trouble	Correction
Motor generator fails to start when POWER switch is turned ON.	Switch box fuse F601 or F602 open	Check fuses F601 and F602. Determine cause of blowing before replacing. If fuses are all right, check fuse clips. Clean and bend as necessary.
	Motor starter thermal overload switch open.	Press RESET on motor starter.
	Motor starter inoperative	Make continuity checks in motor starter. Replace defective part. Check for dirt in motor starter mechanism.
	Loose connections in switch box or motor starter.	Check and tighten all connections.
	Motor generator bearing frozen	Replace bearing and recondition shaft.
	Motor generator armature jammed	Remove obstruction.
	Motor generator brush not making contact with commutator.	Check for weak (par. 217) or broken brush tension spring. Repair or replace defective spring.
	Defective POWER switch S105	Repair S105.
	Open circuit to motor starter solenoid.	Check continuity of cables.
Thermal overload operates or main line fuse blows each time POWER switch is turned on.	Open starting resistors R603 or R604 in motor starter.	Make a continuity check of starting resistors. Replace defective resistor.
	Motor starter timing incorrect	Readjust mechanical timer for a delay of 3 to 4 seconds.
	Defective motor field	Check motor field for open circuit (par. 204). Replace defective field.
	Overload	Check for short in all units.
Motor generator starts but does not reach full speed.	Ship's line voltage low	Using a dc voltmeter, check ship's line voltage at input terminals of switch box.
	Motor brushes improperly located ahead of neutral.	Check to see that locating point on brush assembly is lined up with point on motor end bell.
	Motor starter accelerating contacts do not close.	Accelerating contacts dirty or pitted and require cleaning (par. 218). Torsion spring defective. Replace spring.
	Ship's line voltage too high	Use dc voltmeter to check ship's line voltage at input terminals of switch box.

207. Power Group Troubleshooting Chart—Continued

Symptom	Probable trouble	Correction
Motor generator runs too rapidly	Defective motor field	Check for ground or open in motor field (par. 204).
	Motor brushes located behind neutral.	Check to see that locating point on brush assembly is lined up with point on motor end bell.
No reading on voltage regulator meter M601.	Motor generator ac field winding defective.	Check for open or short circuit in ac winding (par. 204).
Low reading on voltage regulator meter M601.	Misadjustment of R601 in voltage regulator.	Readjust for 115-voltmeter reading.
	Defective ac field winding	Check for short circuit in ac winding (par. 204).
High reading on voltage regulator meter M601.	Misadjustment of R601 in voltage regulator.	Readjust for 115-voltmeter reading.
Excessive sparking at motor brushes	Commutator in bad condition	Clean commutator (par. 215) and reseat brushes (par. 216). Check height of mica insulation between commutator segments and undercut if necessary.
	Excessive vibration	Check to see that brushes ride freely in brush holders.
	Broken or weak brush tension spring	Repair or replace brush spring and adjust brush spring pressure (par. 217).
	Brushes too short	Replace brushes (par. 211).
	Short or open circuit in motor armature.	Check commutator for metallic particles between segments. Check for short or open in armature winding (par. 204). Repair or replace defective armature.
	Poor brush fit on commutator	Reseat brushes (par. 216).
	Brushes stick in brush holders	Remove and clean brushes. Sand down sides of brushes.
	Grounded, open, or shorted field winding.	Check field winding for grounds, opens, or shorts (par. 204). Repair or replace defective field.
	Defective filter capacitor on brush assembly.	Check filter capacitors and replace if defective.
Audible brush chatter or hissing	Wrong type of brushes	Substitute correct type of brush.
	High mica between commutator segments.	Undercut mica.
	Incorrect brush spring pressure	Check and adjust brush spring pressure (par. 217).
Selective commutation (one brush takes more load than it should).	Brush spring pressure low on one brush.	Check and adjust brush spring pressure (par. 217).
	Unbalanced circuits in armature	Check for high-resistance connections.
Field coils overheat	Short circuit in field windings	Check field windings for short circuit (par. 204).
	Poor ventilation	Check air space around motor generator and clear any obstructions.
Armature overheats	Short circuit in armature	Check commutator for metallic particles between segments. Check for short circuit in armature winding (par. 204).
	Poor ventilation	Check air space around motor generator and clear any obstructions.
	Armature striking pole pieces	Check bearings for excessive wear, and replace.

207. Power Group Troubleshooting Chart—Continued

Symptom	Probable trouble	Correction
Commutator overheats	Excessive sparking at brushes	See above checks.
	Excessive spring pressure on brushes	Check and adjust brush spring pressure.
	Poor ventilation	Check air space around motor generator and clear any obstructions.
	Brushes off neutral	Check alinement of brush-assembly location point with point on motor end bell.
Noisy motor generator operation	Armature striking a pole piece	Check bearings for excessive wear. Check for loose armature or field winding. Replace bearing or tighten winding.
	Loose mountings or parts	Check mountings and tighten all bolts, screws, and connections.
Motor generator operation causes rf interference.	Defective filter capacitor on brush assembly.	Check filter capacitors and replace defective capacitor.
	Excessive sparking at brushes	See above checks for commutator overheating.
	Ground in armature or field winding	Check for ground in armature or field winding (par. 204).
	Loose connections	Check and tighten all connections.
	Dirty commutator	Clean commutator (par. 215).
Motor starter solenoid core and operating rod do not operate.	No power input to operating coil L602.	Check wiring and connections (fig. 76). Check fuses F601 and F602 in switchbox. Check operation of POWER switch (S105) in indicator. If defective, replace.
	Foreign object in mechanism prevents operation.	Remove obstruction.
No voltage applied to motor generator, antenna drive motor, and blower.	Motor starter accelerating contacts badly burned.	Check blowout coil L601. Clean contacts (par. 218).
	Motor starter resistors R603 and R604 open.	Check starting resistors for continuity with an ohmmeter.
	Thermal overload switch S602 is open.	Press RESET button.
	Loose connections	Tighten all connections.
	Open circuit in operating coil L602	Check operating coil for continuity with an ohmmeter. If defective, replace (par. 241*a*).
Motor starter operating coil overheats	Cutout switch not operating properly	Check operation of cutout switch and clevis (7, fig. 196).
Voltage is unsteady	Dirty or pitted contacts	Check and clean contacts (par. 218).

Section III. REPLACEMENT OF PARTS

208. Low-Voltage Power Supply Parts

a. The parts of the modulator power supply and the low-voltage power supplies are all mounted on the hinged panel of the receiver-transmitter (fig. 173). Transformer T303 can be replaced by removing the four nuts located at the rear of the hinged panel. Transformers T301, T401, and T402 are fastened to the front of the hinged panel by machine screws which can be removed.

b. The keep-alive power supply parts are mounted on a bakelite chassis at the rear of the hinged panel. Remove the four screws that hold the bakelite chassis and tip the chassis forward. Be careful not to damage the wiring beneath the chassis.

c. The PPI power supply parts are located on a subchassis of the indicator. Transformer T101 is easily removed by removing the four screws that hold it to the subchassis.

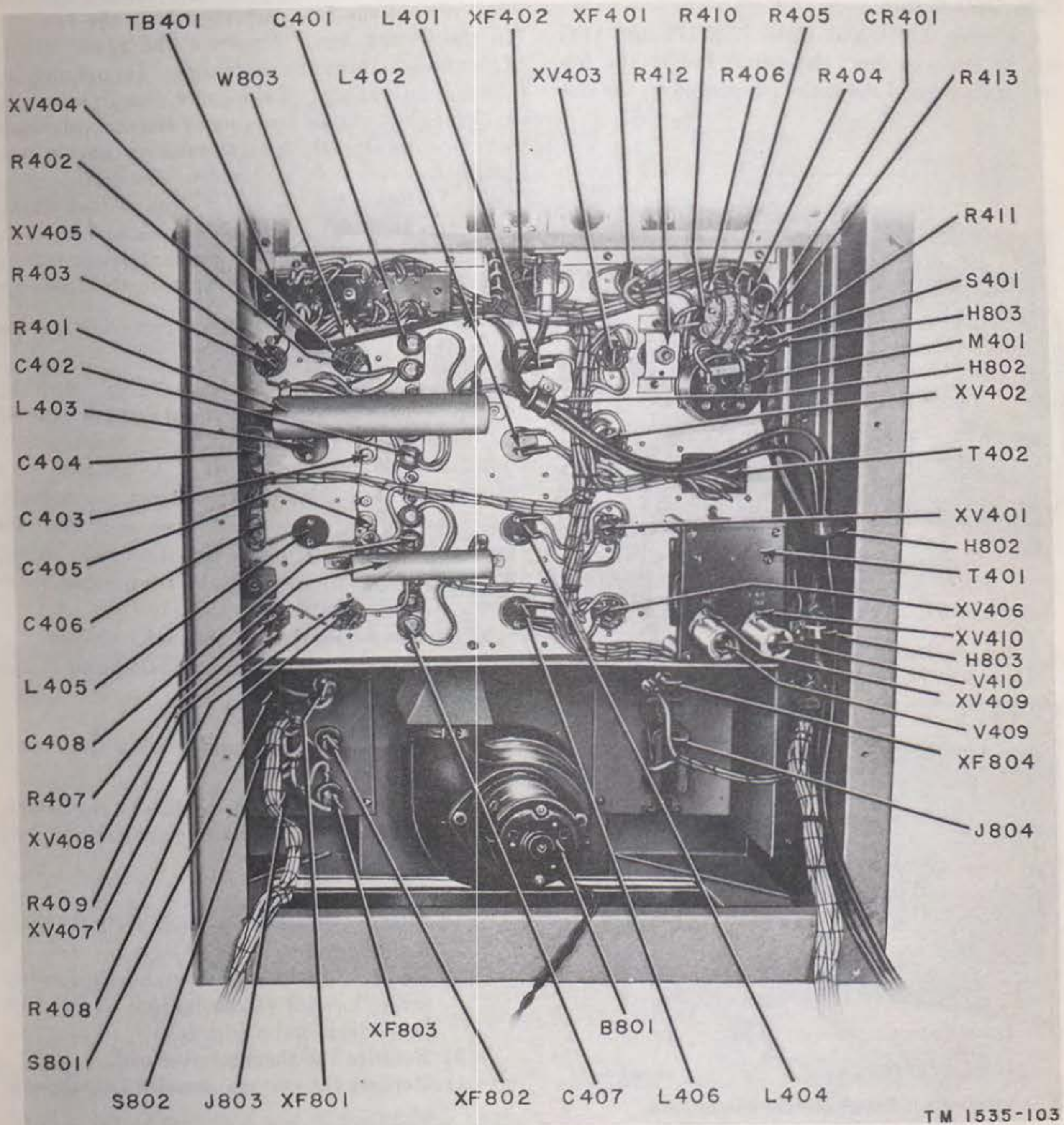


Figure 173. Hinged panel, rear view showing power supply parts.

d. When removing any of the above transformers, always unsolder and label the leads attached to the transformer terminals.

209. Switch Box

a. Clamps H615 and H616 (fig. 174 and 175) may be removed from the switch box in the following manner. Loosen the two screws on the line side of each fuse and disconnect the leads of cable W712. Loosen the screw on clamp H616 and remove cable W712 from the clamp. Remove the nut on clamp H616. Lift the nut and clamp H616 from the switch box. Repeat the above procedure at the load side of each fuse to remove cable W710 and clamp H615.

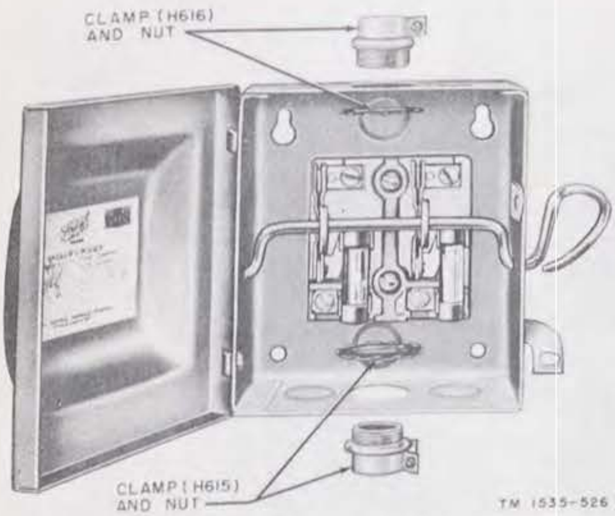


Figure 174. Switch Box SA-284/SPN-11.

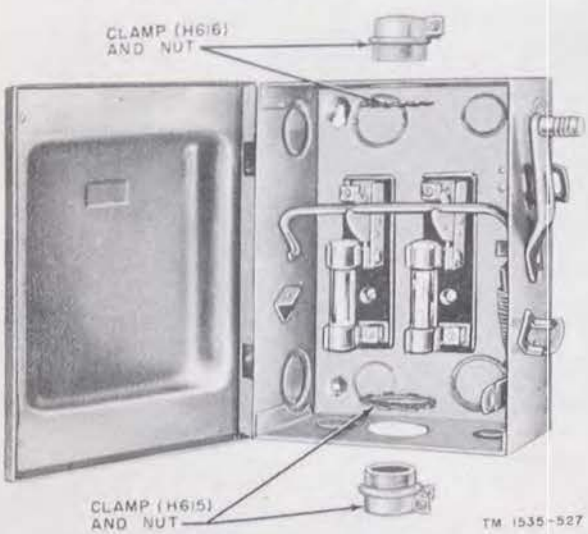


Figure 175. Switch Box SA-283/SPN-11.

b. The fuses supplied with the switch box are of the renewable link type. To renew a fuse link, first remove the fuse cartridge from the fuse clips in the switch box. Unscrew the brass ferrules from both ends of the cartridge. Do not misplace the slotted washer. Take a new fuse link and pass it through the large opening of the cartridge until it protrudes slightly from the slot on the other end. Bend the link flat and screw the ferrule down tight. Then pass the slot of the slotted washer over the free end of the fuse link and bend the link flat. Screw on the other ferrule tightly. Then replace the fuse cartridge in the fuse clips on the switch box.

210. Motor Starter Parts

a. General. Motor Starter SA-287/SPN-11, which is used with a ship's supply of 115 volts dc, is illustrated in figure 197. Motor Starters SA-286/SPN-11 and SA-285/SPN-11 are used for a ship's supply of 32 volts and 24 volts, respectively. They are similar in appearance and they are shown in figure 196. In the discussion below, whenever a part is called out by number, refer to one of these figures to find it.

b. Heater Element for Thermal Overload.

(1) Remove the two heater mounting screws (16).

(2) Lift out the heater (17).

(3) Insert the new heater, replace the screws, and tighten them.

Caution: When replacing the heater, be sure that the replacement heater is of the correct type.

c. Thermal Overload.

(1) Disconnect the three leads from the thermal overload (18).

(2) Remove the thermal overload mounting screw located at the bottom of the unit below terminal 3 (fig. 200).

(3) Remove the thermal overload.

(4) Replace the thermal overload with a new unit.

(5) Reassemble and reconnect the thermal overload as before.

d. Operating Coil Shunt Resistor (40).

(1) Remove terminal screw 2 (4) and remove the solder lug at the end of the resistor lead.

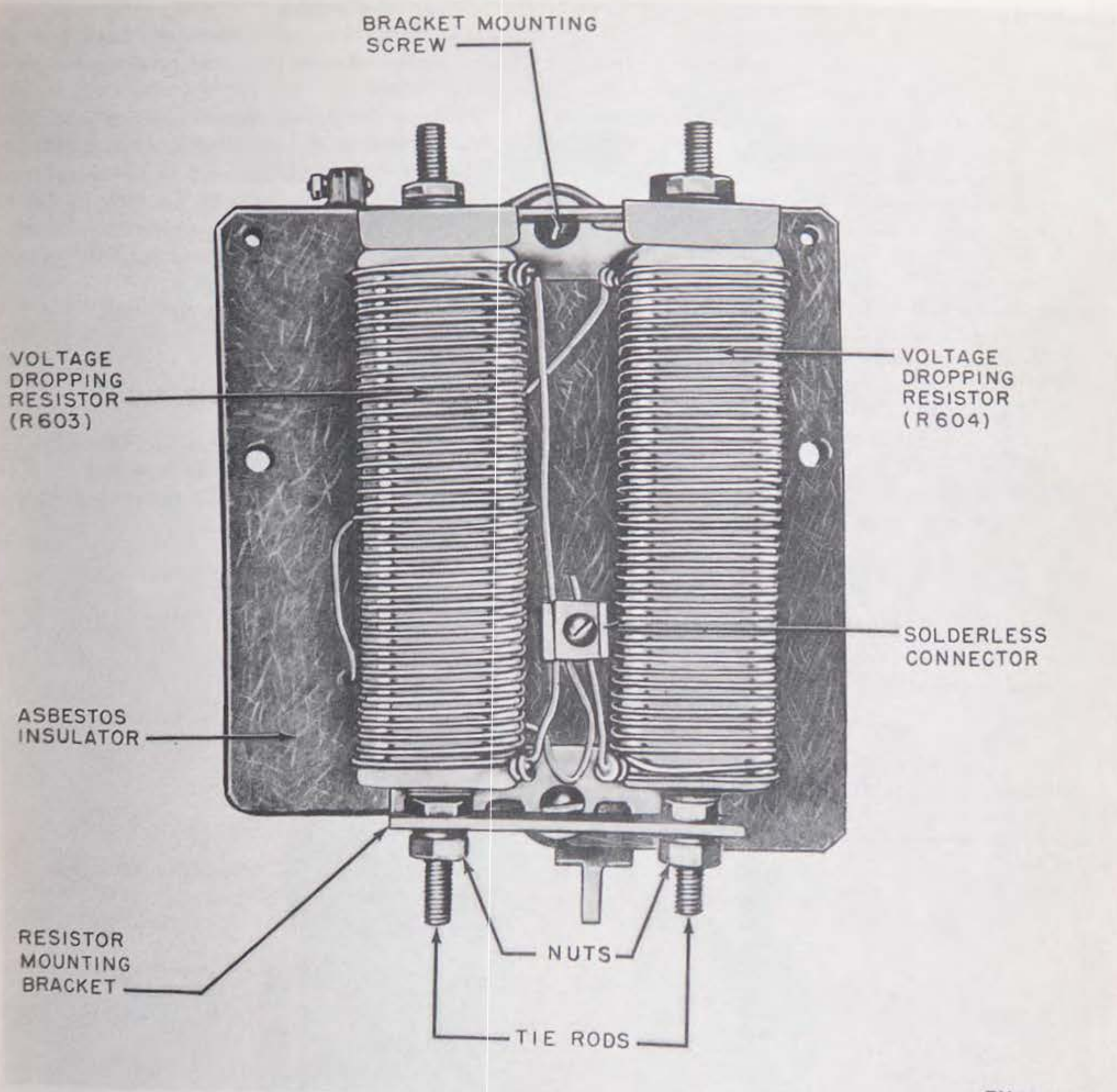


Figure 176. Motor Starter SA-286/SPN-11, rear view.

(2) Remove the screw that holds the solder lug at the other end of the resistor to the motor starter base.

(3) Remove the resistor.

(4) Unsolder the lugs from the resistor leads.

(5) Solder these lugs to the lead of the new resistor after first installing tubing on the leads.

(6) Reassemble all parts in reverse order of disassembly.

Caution: Be sure that the resistor used as a replacement is of the correct value for the equipment used.

e. Voltage Dropping Resistors R603 and R604 for Motor Starters SA–285/SPN–11 and SA–286/SPN–11 (fig. 176).

(1) Disconnect the three resistor leads from the FLD terminal and from the two stationary accelerating contact terminals, and pull them out through the base of the motor starter.

(2) Remove the solderless connector.

(3) Loosen the nut at one end of the tie rod and slide the resistor out of the resistor mounting bracket.

(4) Remove all nuts and washers from one end of the tie rod and slide the resistor off the tie rod.

(5) Replace the resistor.

(6) Reassemble all washers and nuts in exactly the same order as they were originally.

(7) Slide the resistor into the slots on the resistor mounting bracket.

(8) Reassemble all parts in the reverse order of disassembly.

(9) Push the leads through holes in the motor starter base and reconnect them as before.

f. Voltage Dropping Resistors R603 and R604 for Motor Starter SA–287/SPN–11 (fig. 177).

(1) Disconnect the three resistor leads from the FLD terminal (23, fig. 197) and from the two stationary accelerating contact terminals, and pull them out through the base of the motor starter.

(2) Remove the solderless connector.

(3) Remove the nuts and washers from the mounting bolts.

(4) Lift off the upper resistor (R603)

(5) Lift off the spacers.

(6) Lift off the lower resistor (R604).

(7) Replace the resistor, as required.

(8) Reassemble all parts in the reverse order of disassembly.

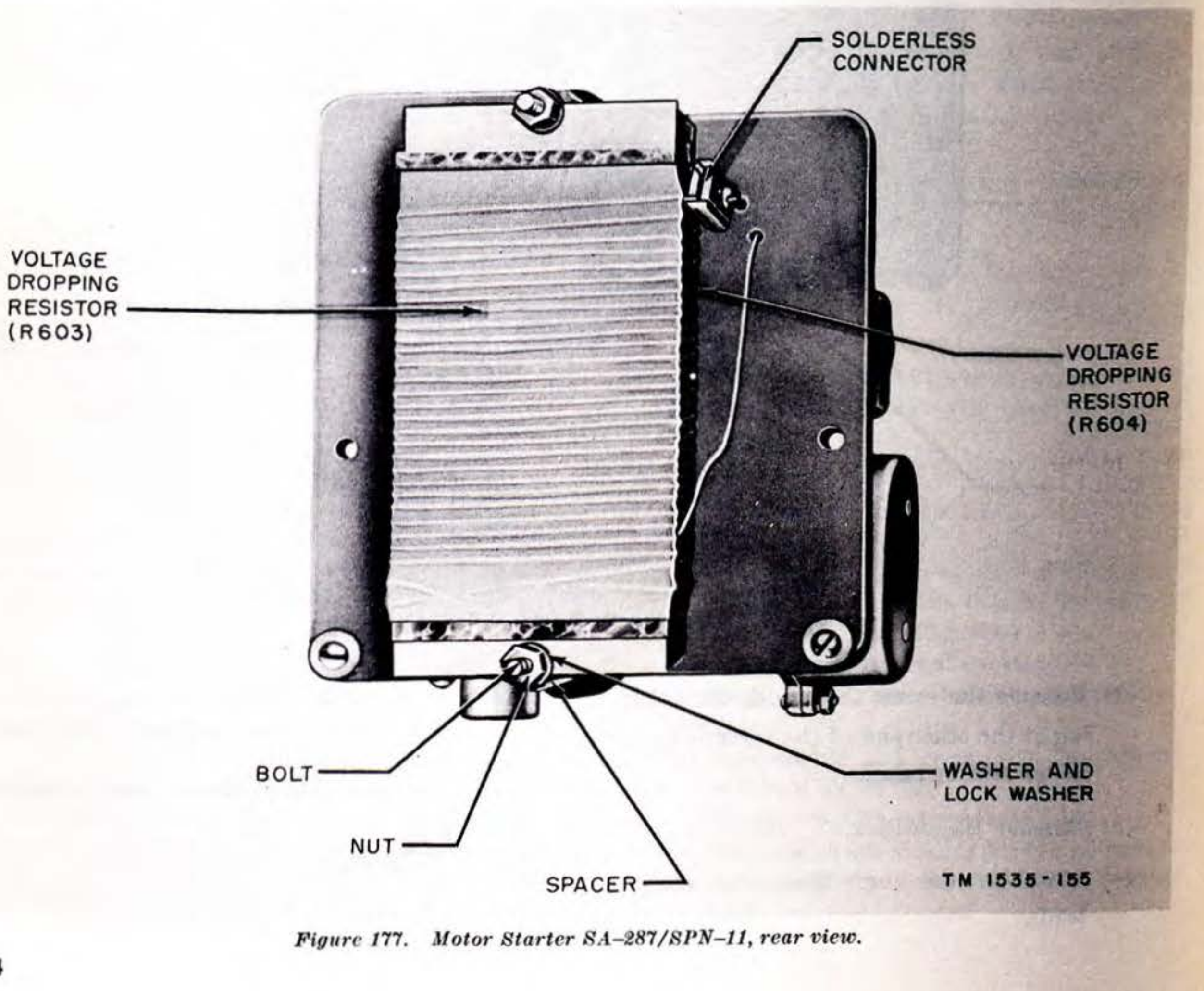


Figure 177. Motor Starter SA–287/SPN–11, rear view.

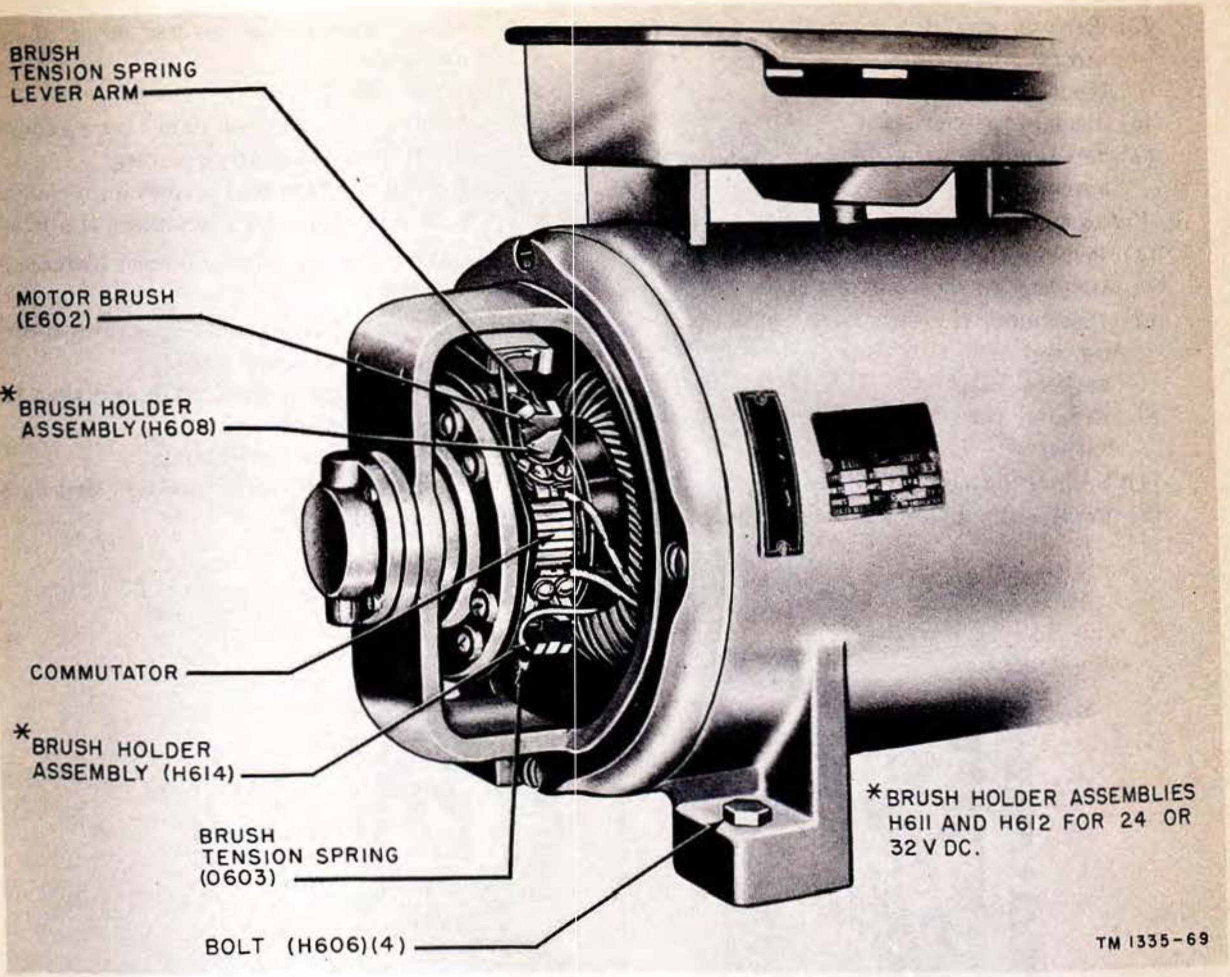


Figure 178. Motor end bell, cover removed.

(9) Push the leads through holes in the motor starter base and reconnect them as before.

211. Motor Generator Parts

a. To change brushes, use the following procedure:

(1) Remove the brush access cover (fig. 202).

(2) Remove the solder lug at the end of the pigtail lead by loosening the terminal screw (fig. 203).

(3) Lift up the brush tension spring lever arm (fig. 178) with the index finger of one hand and pull the brush out of the brush holder with the other hand. Keep the brush in line with the axis of the brush holder as the brush is removed.

(4) Lower the spring lever arm carefully into place.

(5) Clean the inside of the brush holder with a clean, dry cloth.

b. To insert a new brush, reverse the procedure in *a* above.

c. Check the brush spring pressure (par. 217) after installing new brushes.

212. Voltage Regulator Parts
(fig. 179)

a. Rheostat R601.

(1) Remove the rheostat knob by loosening the knob retaining screw.

(2) Remove the control panel by removing the 10 panel mounting screws.

(3) Disconnect the three leads by removing the three terminal nuts and washers.

(4) Remove the four mounting bracket screws on the control panel and lift out the rheostat and mounting bracket.

(5) Remove the two rheostat mounting screws and separate the rheostat from the mounting bracket.
(6) Replace the rheostat.
(7) Reassemble in the reverse order of disassembly.

b. Voltmeter M601.

(1) Remove the 10 panel mounting screws and remove the control panel.
(2) Disconnect the two wire leads by removing the two terminal nuts and washers.
(3) Remove the two mounting nuts and washers.
(4) Remove the meter from the control panel.
(5) Replace the meter with a new one.
(6) Reassemble in the reverse order of disassembly.

c. Terminal Strip.

(1) Remove the control panel by removing the 10 panel mounting screws.
(2) Loosen the terminal screws on terminals 1, 2, 3, and 4, and disconnect the wires.

Note. Tag the wires to prevent confusion at reassembly.

(3) Remove the two mounting screws at each end of the terminal strip.
(4) Lift out the terminal strip and then the insulation board.
(5) Replace the terminal strip.
(6) Reassemble in the reverse order of disassembly.

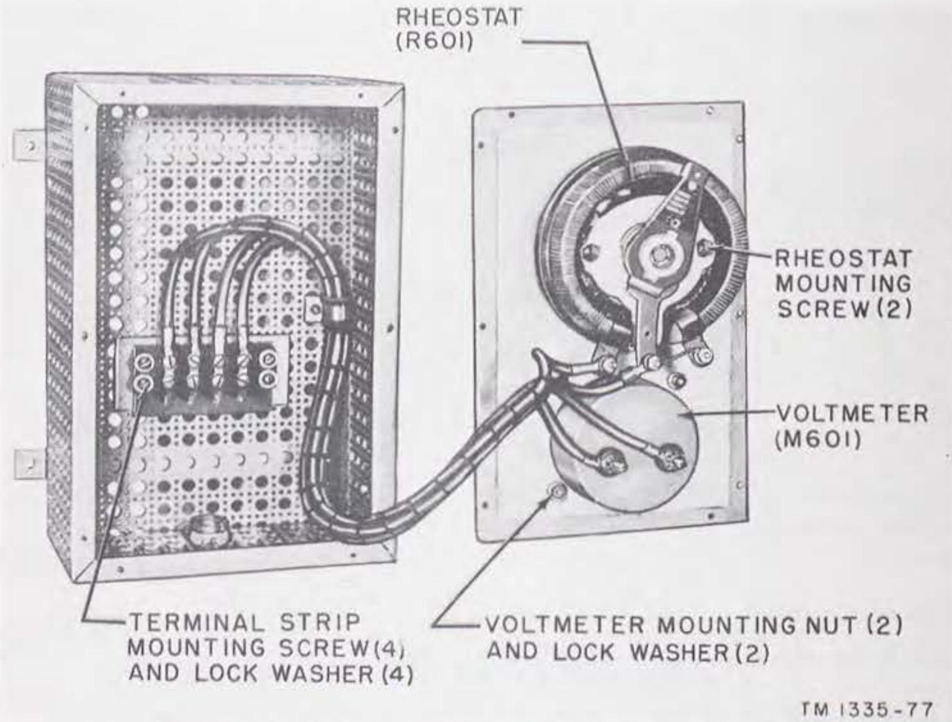


Figure 179. Voltage regulator, showing replaceable parts.

Section IV. ADJUSTMENTS

213. Time Delay Adjustment

Remove the cathode lead (pin 6) of tube V301 from its connection at the junction of resistors R327 and R328.

a. To increase the time delay, connect the cathode lead to the junction of resistors R328 and R329; for a greater increase in delay, connect the lead to the free end of resistor R329.

b. To decrease the time delay, connect the cathode lead to the junction of resistors R326 and R327; to decrease the delay further, connect the lead to the junction of resistors R325 and R326.

214. Mechanical Timer Adjustments

If the delay effected by the mechanical timer in the motor starter is too long or too short, it may be adjusted as follows:

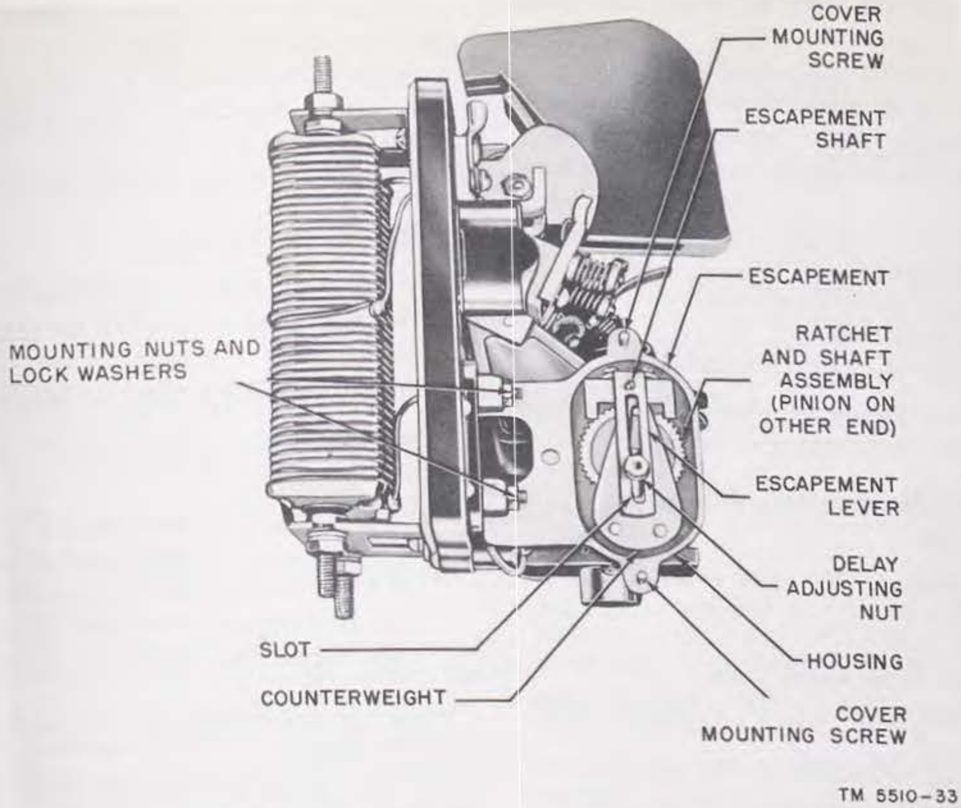


Figure 180. Mechanical timer, cover removed.

a. Remove the cover from the motor starter case by loosening the screw at the bottom center of the case and lifting off the cover.

b. Remove the two mechanical timer cover nuts and lockwashers (24, fig. 196 and 197) and lift the timer cover off the cover mounting screws.

c. Slightly loosen the delay adjusting nut.

d. Slide the nut and its shaft in the slot to change the operating time of the timer; slide it up to decrease the time, or slide it down to increase the time. Then tighten it securely.

e. Replace the timer cover and reassemble the unit in the exact reverse order of disassembly in *a* and *b* above.

215. Cleaning the Commutator

The commutator surfaces should be smooth and free from nicks, pitting, and dirt. A slight discoloration of the commutator surfaces is normal. To clean the commutator, proceed as follows:

a. Remove the brush access cover (fig. 202).

b. Insert the cleaning tool (4, fig. 112) and rub the canvas surface against the exposed commutator surface.

c. Rotate the armature to expose and clean the next commutator surface.

d. Repeat steps in *b* and *c* above until all commutator surfaces have been cleaned.

e. When the commutator surfaces are badly pitted, proceed as follows:

(1) Cut a strip of No. 0000 sandpaper 6 inches long and 1½ inches wide.

Caution: Never use emery cloth or a file for this cleaning procedure.

(2) Fold the sandpaper over the cleaning tool.

(3) Repeat the procedure in *b*, *c*, and *d* above.

(4) After using sandpaper, remove the sandpaper dust from between the commutator segments.

216. Seating Brushes

New or old brushes must be seated to conform with the surface of the commutator. Perform the following operations to properly seat a brush.

a. Cut a long strip of sandpaper No. 0000 slightly wider than the width of the brush.

b. Remove all the brushes from the brush holders.

c. Place the strip of sandpaper around the commutator, with the sanded side toward the brush.

d. Lower one brush into contact with the sandpaper and draw the sandpaper in the direction of normal rotation.

e. Lift the brush and return the sandpaper to its original position.

f. Repeat the step in *d* and *e* above until the brush is properly seated.

g. Perform this procedure for each brush.

Caution: Never use emery cloth. Emery dust will short circuit the commutator segments.

217. Adjusting Brush Spring Pressure
(fig. 181)

Check the pressure of the brush tension springs after the installation of new brushes in the following manner.

a. Remove the brush access cover.

b. Cut a loop of string approximately 3 inches long.

c. Loop one end of the string over the hook at the bottom of a spring balance.

d. Hook the other end of the string under the tip of the brush spring lever arm (fig. 181).

e. Slide a piece of paper between the brush and the commutator. Hold the paper with one hand.

Note. The paper should not move easily.

f. Grasp the spring balance in the other hand.

g. Pull the spring balance slowly away from the commutator and exert a slight pull on the paper.

h. When it is possible to slide the paper freely, record the reading obtained on the calibrated scale of the spring balance. It should read 6 ounces.

i. If the balance reading is incorrect, loosen the setscrew that holds the brush spring mounting stud in the brush holder assembly.

(1) If the pressure is low, rotate the brush spring mounting stud in a clockwise direction.

(2) If the presure is high, rotate the brush spring mounting stud in a counterclockwise direction.

j. Tighten the setscrew. Measure the brush spring pressure again by following the instructions given in *c* through *h* above.

k. Repeat the above procedure until the balance reads 6 ounces.

l. Replace the brush access cover.

218. Cleaning Contacts

a. General. Before attempting to clean any of the various contacts, identify the type of material to be cleaned. The contacts may be tin plated copper, silver plated, silver, or tungsten.

Caution: Never use a file or sandpaper on plated contacts.

b. Tin Plated Silver or Silver Plated Contacts.

(1) Clean tin plated silver or silver plated contacts with a cloth or brush that has been dipped in solvent (SD).

(2) Polish the contacts with a clean, dry cloth.

(3) If the contacts are corroded, proceed as follows.

(*a*) Dress the contacts with a piece of crocus cloth or a crocus stick.

(*b*) Clean the contacts with a clean cloth moistened with carbon tetrachloride.

Caution: Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Make sure adequate ventilation is provided.

(*c*) Polish the contacts with a clean, dry cloth.

Note. The brown discoloration that is found on silver and silver plated contacts is silver oxide. Since silver oxide is a good conductor, do not remove the discoloration from non-corroded contact.

(4) Replace badly pitted contacts.

c. Tungsten Contacts

(1) Clean the contacts with crocus cloth.

(2) If the contacts are very dirty, use a burnishing tool or a fine-grit hone. Be sure the face of the contact is flat and the edges are slightly beveled.

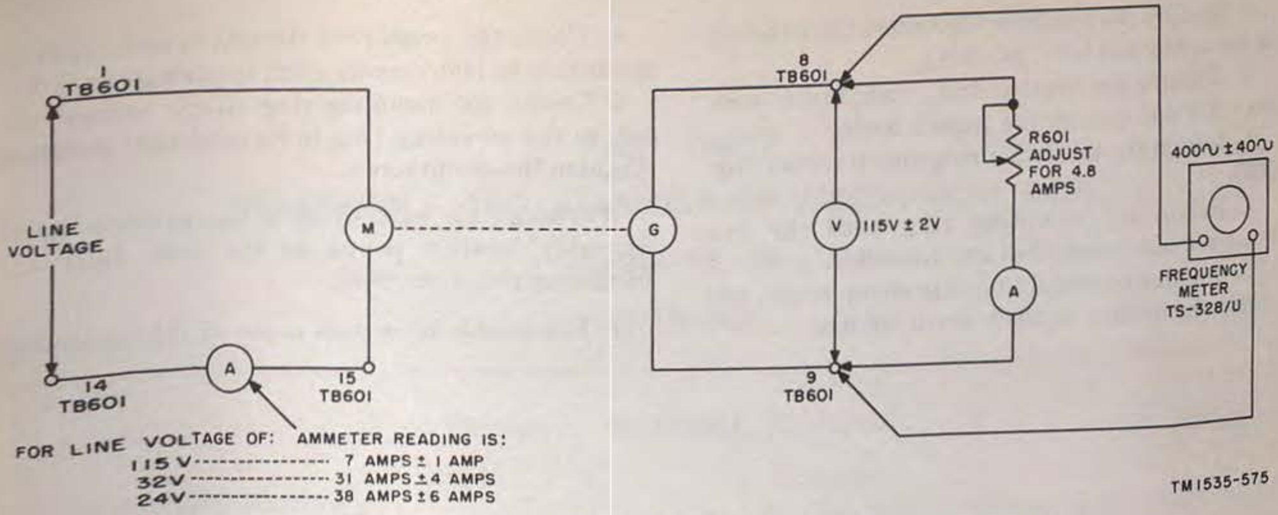


Figure 181. Testing motor generator.

Section V. FINAL TESTING

219. General

This final testing section is intended as a guide for determining whether a repaired power system meets the original specifications. Entire test procedures for the power system are given. The final testing chart (fig. 222) summarizes the final testing procedures for the entire radar set.

220. Testing Motor Generator
(fig. 181)

a. Disconnect the leads going from voltage regulator rheostat R601 to terminals 5 and 6 of TB601. Connect this rheostat in series with an ammeter (0 to 10 amp) across the output (terminals 8 and 9 of TB601) of the motor generator (fig. 181).

b. Turn on the power.

c. Adjust the rheostat until the ammeter reads 4.8 amperes.

d. Place an ac voltmeter across terminals 8 and 9 of TB601. The voltage reading should be 115 V±2 V.

e. Connect Frequency Meter TS–328/U across terminals 8 and 9 of TB601. The frequency reading should be 400 cps ±40 cps.

f. Turn off the power. Remove the strap that connects terminals 14 and 15 of TB601 and connect the ammeter between these two terminals.

g. Turn on the power. For a line voltage of 115 volts dc, the meter should read 7 amps ±1 amp. For a line voltage of 32 volts, the meter should read 31 amps ±4 amps. For a line voltage of 24 volts, the meter should read 38 amps ±6 amps.

221. Checking Brush Spring Pressure

a. Check the pressure of the two top brush springs in the motor generator according to the

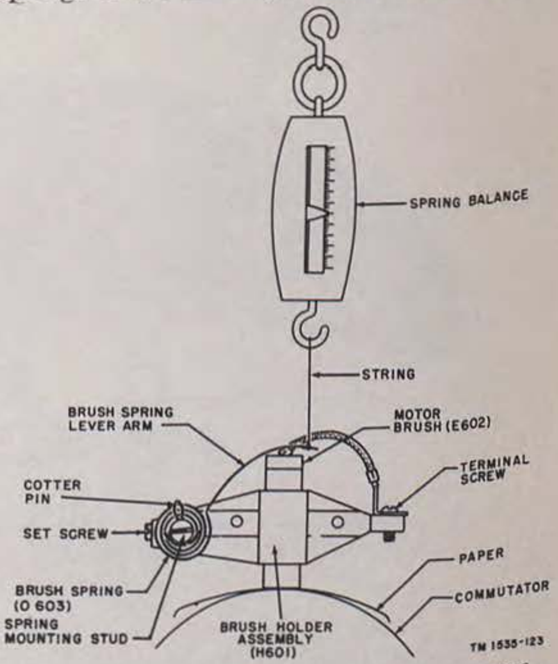


Figure 182. Adjustment of brush spring pressure.

instructions given in paragraph 217. The brush spring pressure should be 6 ounces ±.6 ounces.

b. Remove the two filter capacitor leads and the four field leads by loosening the appropriate terminal screws (fig. 203). Tag all wires.

c. Remove the two filter capacitors from the top of the motor end bell (par. 244).

d. Remove the brushes from their brush holders. Do not remove the pigtail leads.

e. Loosen the mounting ring clamp screws (fig. 203).

f. Rotate the mounting ring until the two bottom brush assemblies are accessible.

g. Tighten the mounting ring clamp screw, and insert the brushes in their brush holders.

h. Check the pressure of the two brush springs according to instructions given in paragraph 217.

i. Loosen the mounting ring clamp screw and return the mounting ring to its original position. Tighten the clamp screw.

Warning: Be sure to aline the motor brush assembly location points on the end bell and mounting ring (par. 244).

j. Reassemble in reverse order of disassembly.

PART THREE

DISASSEMBLY AND ASSEMBLY OF MECHANICAL PARTS

CHAPTER 14

ANTENNA

Section I. ANTENNA PEDESTAL

222. Rotating Assembly

(fig. 183)

The rotating assembly consists of the antenna reflector, antenna horn, and the side lobe suppressor mounted on the rotating mounting base.

a. Reflector.

(1) To remove reflector E503, remove the four hex.-head nuts. Secure the reflector to the rotating mounting base.

(2) Remove the three bolts that secure each mounting foot A 502 to the reflector proper.

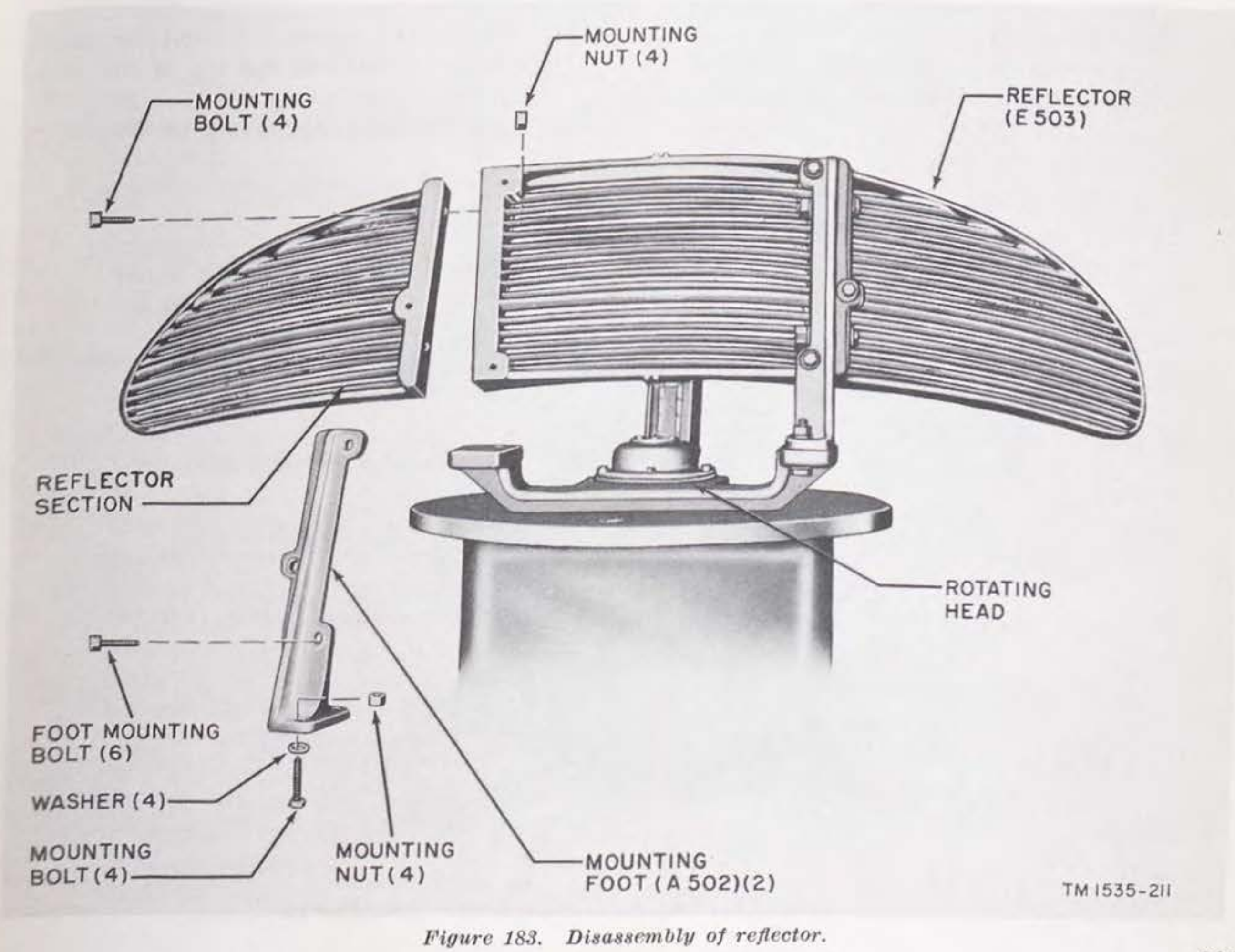


Figure 183. Disassembly of reflector.

(3) Each side section is attached to the center section by two hex.-head nuts and bolts. Remove these bolts to separate reflector sections.

(4) Reassemble the reflector by reversing the procedure given in (1), (2), and (3) above.

b. Antenna Horn and Side Lobe Suppressor. The antenna horn, E502, and side lobe suppressor are removed as a unit. The horn is separated from the wave guide termination by the removal of the four flange screws. The side lobe suppressor is secured under the two upper flange screws (fig. 129).

223. Drive Housing, Minor Parts (fig. 184 and 185).

Loosen the four captive screws (fig. 4) and remove the two drive housing covers.

a. Terminal Board (TB501). Remove the terminal board by following the procedure below.

(1) Disconnect all the wires and tag them.

(2) Remove the four screws (H518) and washers (H544) that secure the terminal board to the mounting bracket (A 501).

(3) Remove the terminal board and insulator plate (E501).

(4) Assemble by reversing the procedures in (1) through (3) above.

b. Capacitor (C501). Remove the capacitor by disconnecting the two wires and removing the two screws (H522) and lockwashers (H549). Assemble by reversing this procedure.

c. Capacitor (C502). Remove the capacitor by disconnecting the two wires and removing the two screws (H524). Assemble by reversing the disassembly procedure.

d. Heater Elements and Thermostat. Remove a heater element by removing the two terminal lugs (E504) and screws (H519). Remove the thermostat by removing the two screws (H523). Assemble by reversing the disassembly procedure.

e. Cam Switches. Remove the heading flash cam switch (S502) and the synchro alinement cam switch (S501) by disconnecting the wires and removing the two screws (H515). Assemble by reversing the disassembly procedure.

f. Drive Housing Gasket (O 544). Replace the drive housing gasket (O 544) by following the procedure below.

(1) Remove the screws that hold the gasket clamp (A 501) to the top of the main drive gear mounting.

(2) Lift out the gasket clamp (A 501).

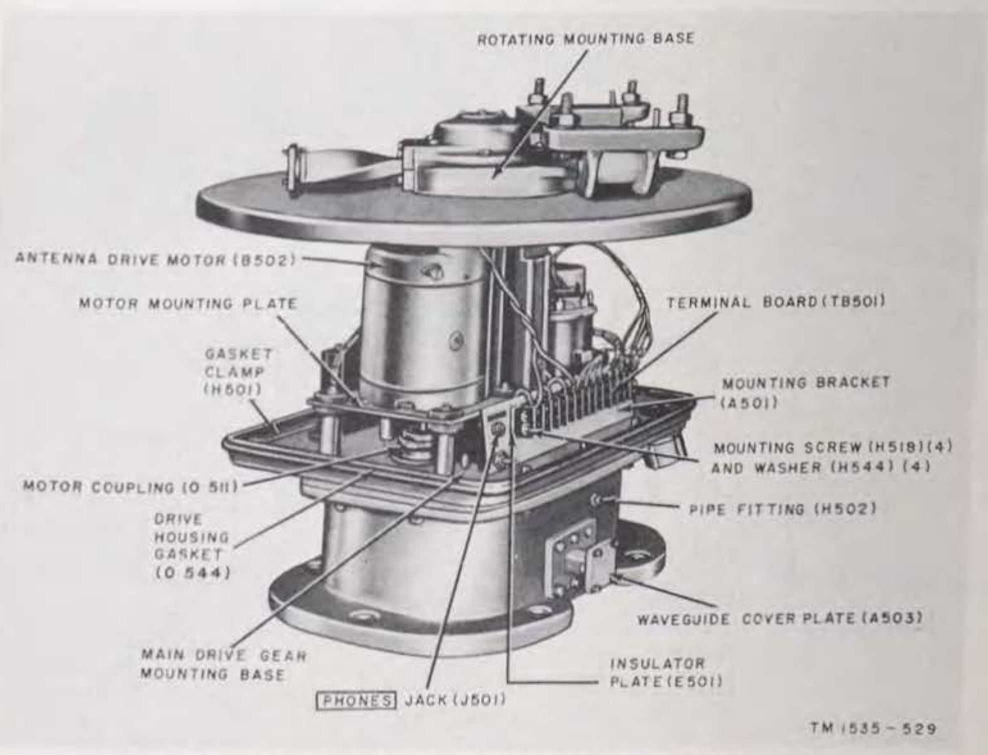


Figure 184. Antenna pedestal, showing rear view of drive housing.

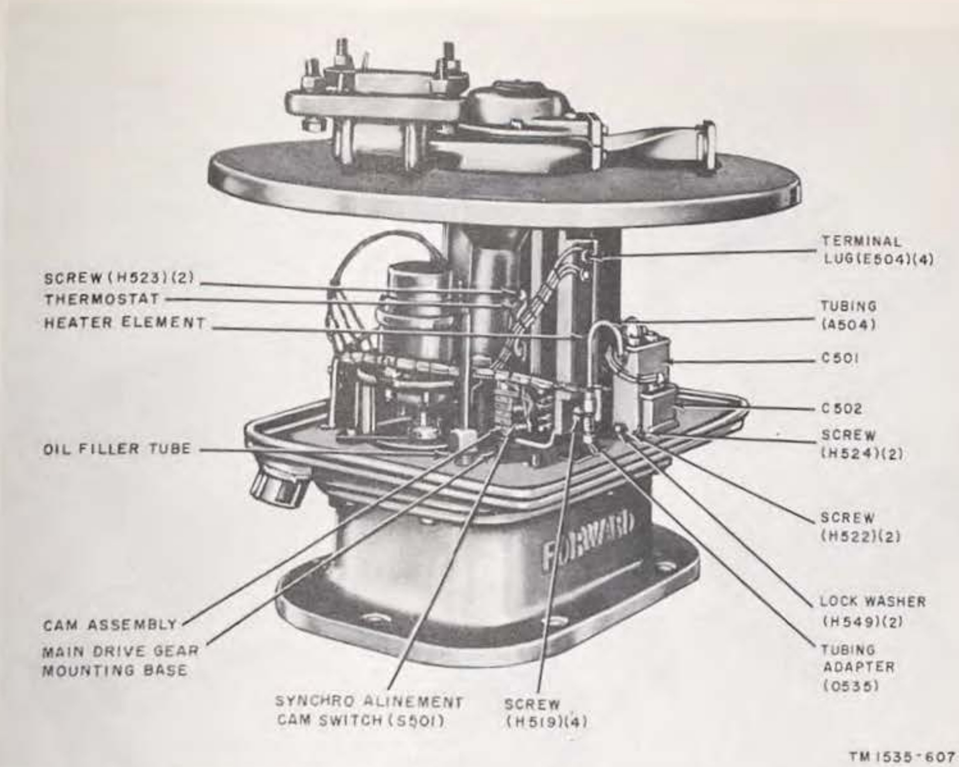


Figure 185. Antenna pedestal, showing front view of drive housing.

(3) Remove the drive housing gasket (O 544).

(4) Assemble by reversing the procedure in (1) through (3) above. Before installing a new gasket, apply glyptol to the top surface of the main drive gear mounting and the gasket.

224. Antenna Drive Motor

(fig. 186)

a. Removal.

(1) Disconnect the antenna drive motor leads (1) from terminal board TB501 (fig. 184). Tag the leads to avoid confusion during the assembly procedure.

(2) Loosen the two setscrews (23) in the motor coupling (18). Loosen the two setscrews (20) in the motor coupling (21).

(3) Remove the four screws (24) and four lockwashers (22) from the motor mounting plate (15).

(4) Remove the antenna drive motor. The motor couplings (18 and 21) and coupling disk (19) will break free of the armature shaft (38).

(5) Remove the motor mounting plate (15) by removing the four bolts (30), four lockwashers (29), four washers (28), four spacing collars (26), and four motor mounting spacers (25). Remove the four vibration mounts (16, 17, 27 and 31), to completely disassemble the motor mounting plate (15).

b. Disassembly. When the antenna drive motor is to be disassembled, perform the procedure in *a*(1) through (4) above.

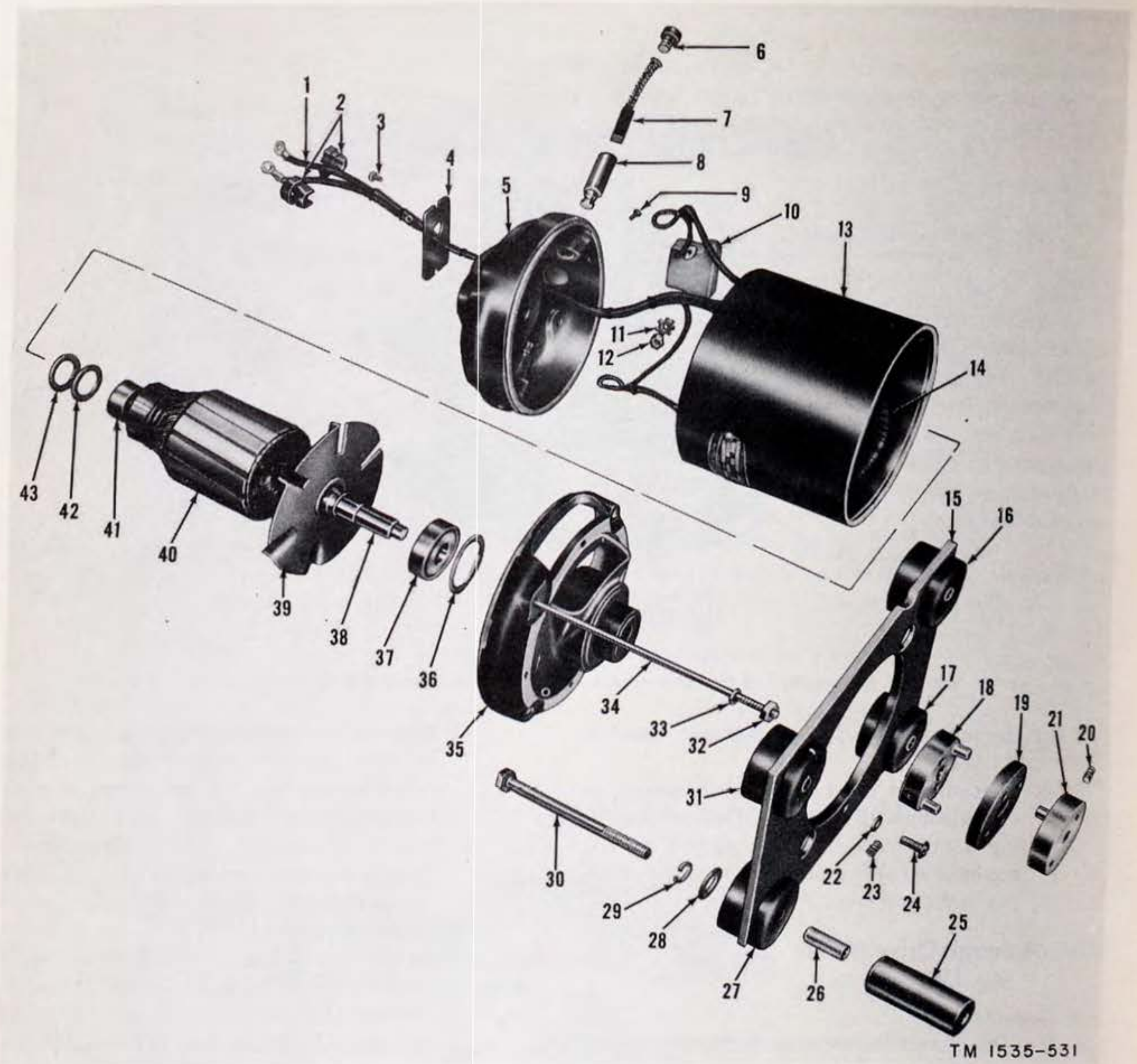
(1) Remove the eight nuts (32) and eight washers (33) from the four studs (34) on the motor end bells (and brush housings) (5 and 35).

(2) Remove the motor end bell (35).

(3) Remove the ring (36) and bearing (37) from the armature shaft (38).

(4) Remove the two cover plate mounting screws (3) and slide the cover plate (4) and collar (2) along the antenna drive motor leads (1). Remove both halves of the collar (2) from the cover plate (4).

(5) Remove the two plugs (6) and lift the two motor brushes (7) out of each brush holder (8).



1 Antenna drive motor leads
2 Collar
3 Cover plate mounting screw (2)
4 Cover plate
5 Motor end bell and brush housing
6 Plug (2)
7 Brush (2) (E505, E506)
8 Brush holder (2)
9 Capacitor mounting bolt (2)
10 Capacitor (C503)
11 Lockwasher (2)
12 Nut (2)
13 Motor frame
14 Field windings
15 Motor mounting plate
16 Vibration mount (A 507)
17 Vibration mount (A 508)
18 Motor coupling (O 511)
19 Coupling disk (O 512)
20 Setscrew (2)
21 Motor coupling (O 511)
22 Lockwasher (4) (H548)
23 Setscrew (2)
24 Screw (4) (H517)
25 Motor mounting spacer (4)
26 Spacing collar (4) (O 555)
27 Vibration mount (A 510)
28 Washer (4) (H543)
29 Lockwasher (4) (H547)
30 Bolt (4) (H526)
31 Vibration mount (A 509)
32 Nut (8)
33 Washer (8)
34 Stud (4)
35 Motor end bell
36 Ring
37 Bearing (O 556)
38 Armature shaft
39 Fan
40 Armature
41 Bearing (O 557)
42 Ring
43 Ring

Figure 186. Antenna drive motor, mounting plate and coupling, exploded view.

(6) Remove the motor end bell and brush housing (5).

Caution: Perform this operation with extreme care to avoid damaging the antenna drive motor leads (1), and the internal connections of the capacitor (10) and field windings (14).

(7) Remove each brush holder (8) from the motor end bell and brush housing (5).

(8) Remove the two capacitor mounting bolts (9), two nuts (12), and two lockwashers (11), and lift the capacitor (10) out of the motor end bell and brush housing (5).

(9) Remove the rings (42 and 43) and the bearing (41) from the armature shaft (38).

(10) Remove the armature shaft (38), fan (39), and armature (40) from the motor frame (13) at the motor mounting plate end of the motor frame.

Caution: Perform this operation with extreme care to avoid damaging the field windings (14).

c. Assembly. Assemble the antenna drive motor by reversing the procedures in *a* and *b* above.

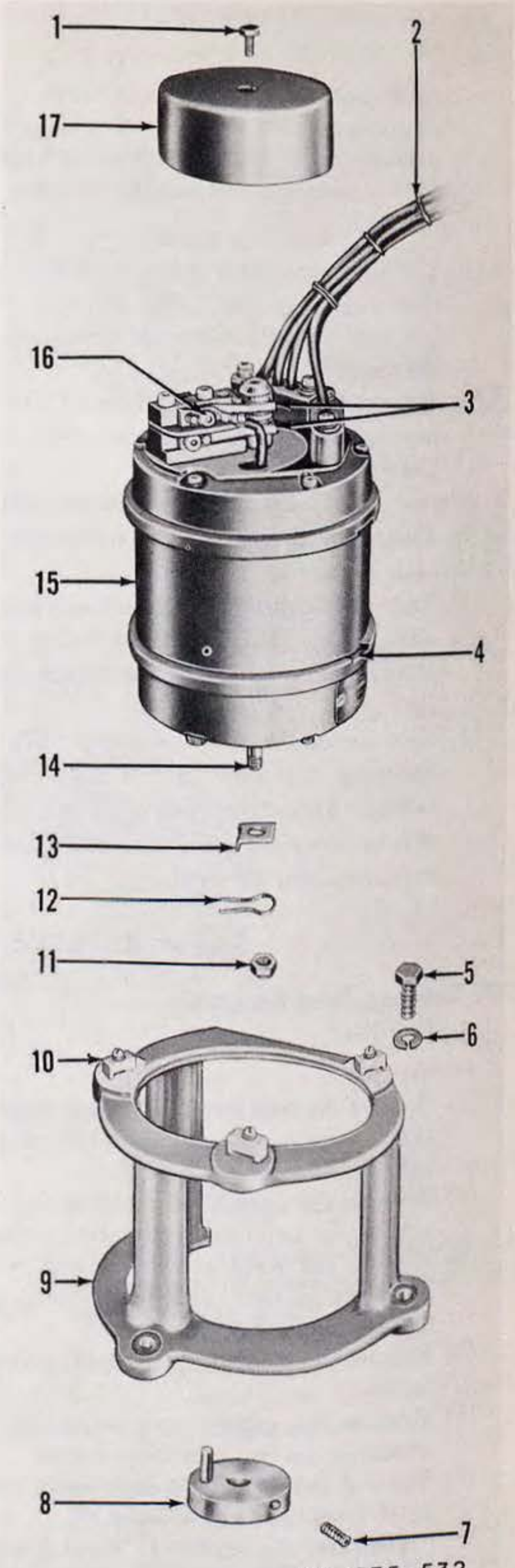
225. Transmitter Synchro

(fig. 187)

a. Removal.

(1) Disconnect the five transmitter synchro leads (2) from terminal board TB 501 (fig. 184). If necessary, tag the leads to avoid confusion at the time of assembly.

(2) Loosen the three mounting dogs (10).



1 Screw
2 Synchro leads (5)
3 Brushes (2)
4 Flange (4)
5 Screw (3)
6 Lockwasher (3)
7 Setscrew (2)
8 Synchro coupling disk (O 510)
9 Synchro mounting
10 Mounting dog (3)
11 Nut
12 Synchro coupling spring
13 Synchro coupling spring retainer
14 Shaft
15 Synchro frame
16 Brush terminal nut
17 Brush access cover

Figure 187. Transmitter synchro and mounting, exploded view.

(3) Loosen the two setscrews (7) on the synchro coupling disk (8).

Caution: The setscrews on the synchro coupling disk should be loosened to avoid damaging the synchro coupling spring (12) when the transmitter synchro is removed.

(4) Lift the transmitter synchro off the synchro mounting (9). The synchro coupling spring (12) will break free without the use of tools.

(5) Remove the synchro mounting (9) by removing the three screws (5) and three lockwashers (6).

b. Disassembly. When the transmitter synchro must be disassembled, perform the procedure in *a*(1) through (4) above.

(1) Remove the nut (11), the synchro coupling spring (12), and the synchro coupling spring retainer (13) from the shaft (14).

(2) Remove the brush access cover (17) by removing the two screws (7). The brushes (3) and brush terminal nut (16) will be accessible after the brush access cover has been removed.

c. Assembly. The transmitter synchro is assembled by reversing procedures in *a* and *b* above.

226. Cam Assemblies

The heading flash and synchro alinement cam assemblies are illustrated in figures 185 and 159. The fore heading flash cam assembly is at the top, the aft heading flash cam assembly is in the center, and the synchro alinement cam assembly is at the bottom. Each assembly consists of a bushing and cam. Refer to paragraph 225 for disassembly of cam switches S501 and S502.

a. Removal (fig. 192).

(1) Loosen the mounting screw (1) and lift the fore heading flash cam assembly (2) off the cam shaft (37). Remove the cam washer (3).

(2) Loosen the mounting screw (4) and remove the aft heading flash cam assembly (5). Remove the cam washer (6).

(3) Loosen the two mounting screws (7) and remove the synchro alinement cam assembly (8).

b. Assembly. The cam assemblies are assembled by reversing the procedure in *a* above. For proper reassembly, the synchro alinement cam must make electrical contact with cam switch S501 when the antenna reflector is facing aft.

Section II. WAVE GUIDE JOINT ASSEMBLIES

227. Rotating Joint Assembly

(fig. 188)

a. Disassembly.

(1) Remove the four cover mounting screws. Lift the cover and gasket O 538 off the wave guide cap.

(2) Remove the upper joint clamp by removing the two clamp mounting screws.

(3) Remove the wave guide cap and wave guide cap gasket O 539 by removing the five cap mounting screws.

(4) Remove the wave guide joint adjustment screw.

(5) Remove the captive nut assembly by loosening the two retaining screws.

(6) Remove locknut H506 and lockwasher H546 from the main drive shaft.

Caution: Be extremely careful when removing the locknut. The threads of the main drive shaft may be damaged by careless removal.

(7) Lift rotating joint assembly W502 from the main drive shaft.

(8) Remove the lower joint clamp and gasket by removing the two clamp mounting screws.

b. Reassembly. Reverse the disassembly procedure (*a.* above) to reassemble the rotating joint assembly.

228. Fixed Joint Assembly

(figs. 189 and 190)

a. Disassembly.

(1) Drain the oil from the gear housing by removing pipe fitting H502.

(2) Free the gear housing from the antenna pedestal by freeing the wave guide flanges and removing the six mounting screws H536, nuts H535, and washers H552 and H545. Remove gasket O543.

(3) Remove the 10 mounting screws and lockwashers that secure the gear housing to

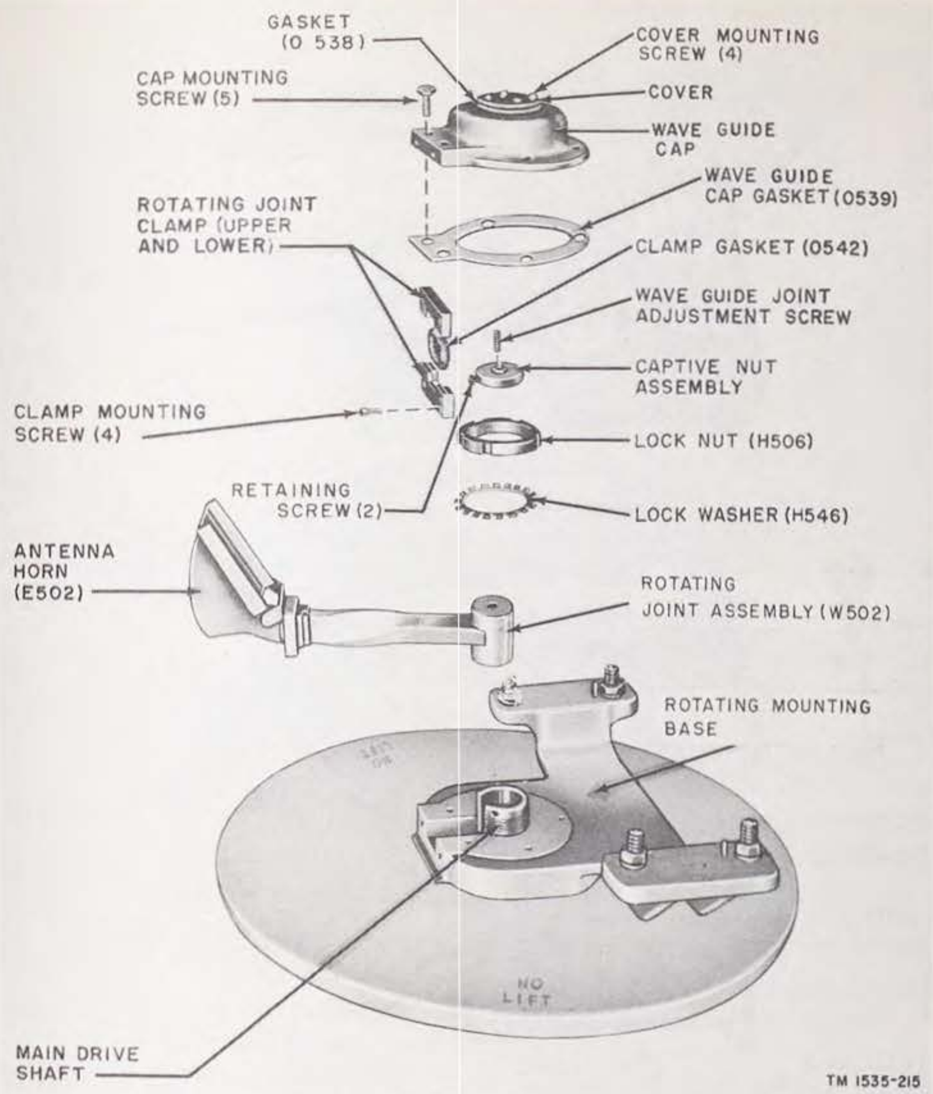


Figure 188. Rotating joint assembly, exploded view.

the main drive gear mounting. Separate the gear housing from the main drive gear mounting. Remove sleeve bearing O509 from the top end of the fixed joint assembly W501.

Caution: Avoid bending fixed joint assembly W501.

(4) Remove the gear housing gasket O540.

(5) Remove the upper and lower joint clamps by removing the two mounting screws and lockwashers in each clamp. Remove both halves of gasket O565.

(6) Remove the four mounting screws and lockwashers that secure the fixed assembly W501 to the gear housing. Remove the fixed joint assembly W501 from the bottom of the gear housing.

Caution: Perform this operation with extreme care to prevent damage to fixed joint assembly W501.

(7) Remove gasket O537.

b. Assembly. Assemble the fixed joint assembly by reversing the procedure in *a* above.

229. Gear Housing

(fig. 190)

a. Removal. Remove the gear housing by performing the procedure in paragraph 228*a*(1) through (4).

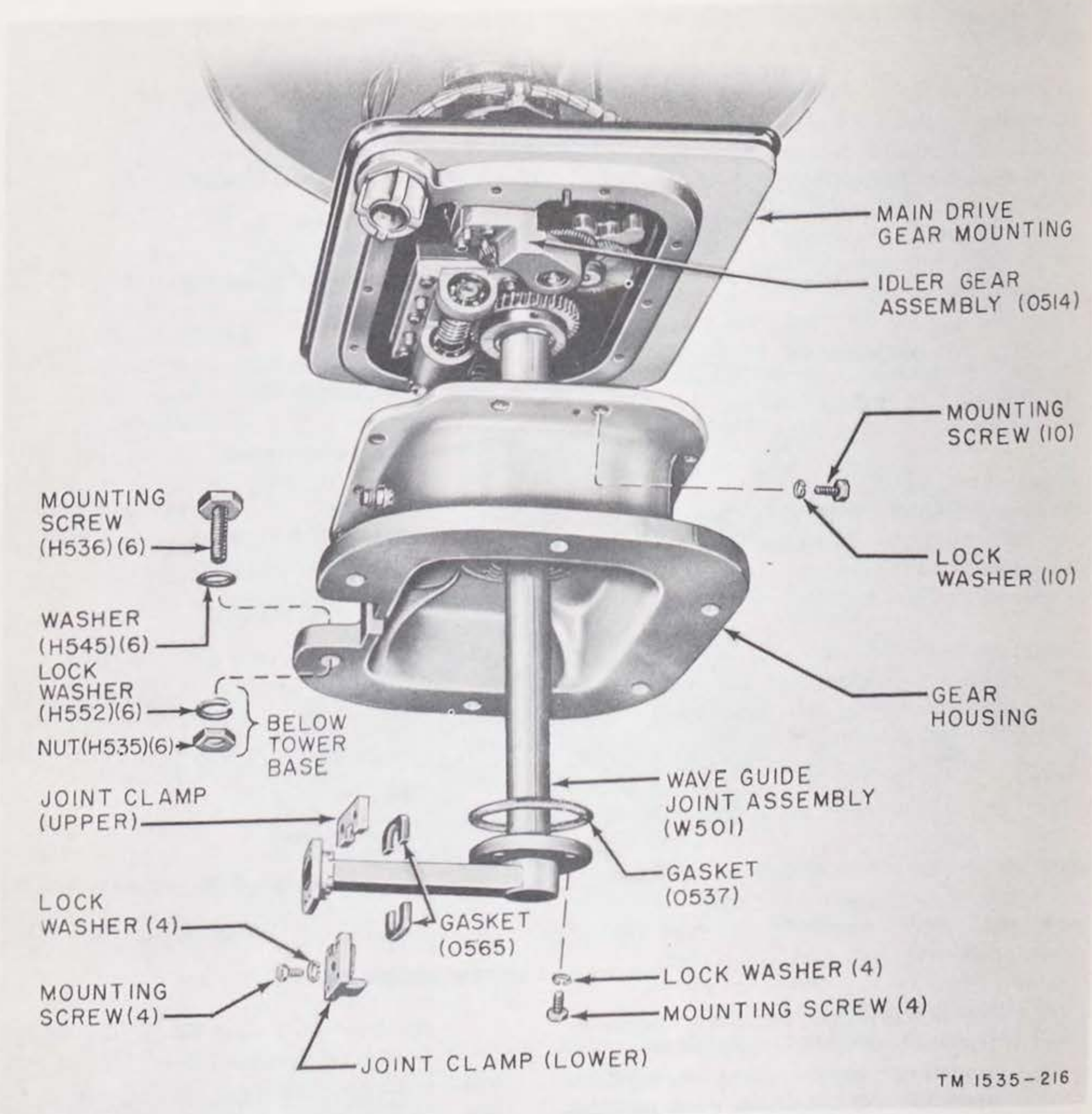


Figure 189. Fixed joint assembly, exploded view.

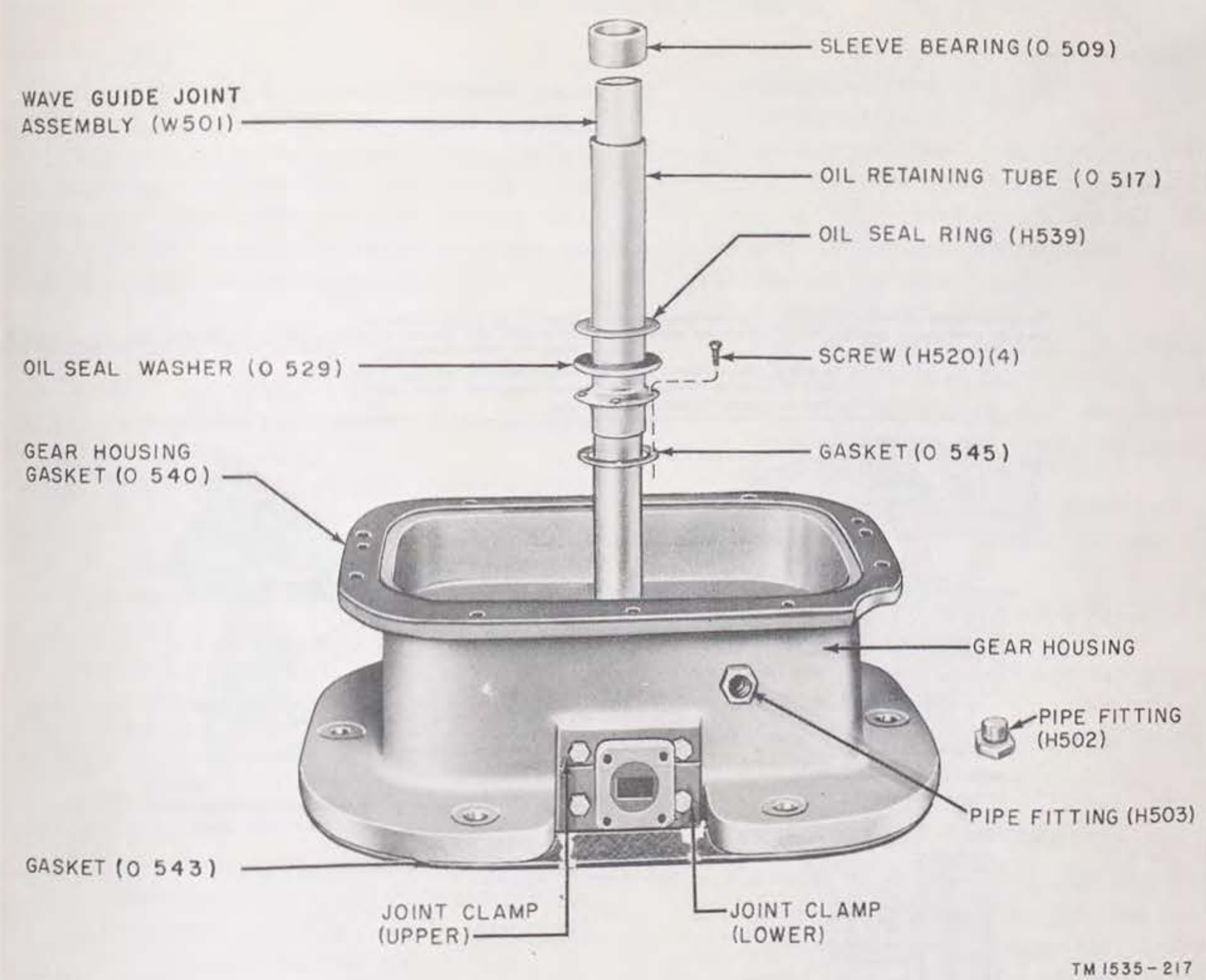


Figure 190. Gear housing.

b. Disassembly.

(1) Remove pipe fitting H503.

(2) Remove oil seal ring H539 and oil seal washer O529.

(3) Remove the four screws H520 that secure oil retaining tube O517 to the gear housing. Lift oil retaining tube O517 out of the gear housing.

(4) Remove gasket O545.

c. Assembly. Assemble the gear housing by reversing the procedures in *a* and *b* above. Seal pipe fitting H503 and gasket O545 with glystol. Before applying the glyptol, be sure the gear housing is dry and free of oil.

230. Lubrication

(fig. 191)

The oil in the gear housing should be drained every six months.

a. Drain the old oil by removing the pipe fitting H502 (fig. 190). Replace the pipe fitting.

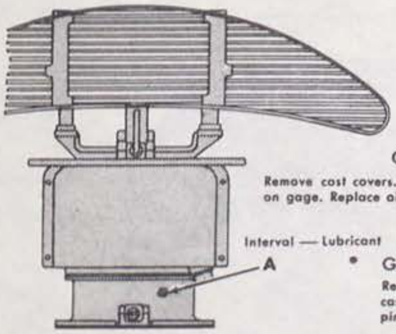
b. Refill the gear housing with three pints of oil OE20. Pour the oil through the oil filter tube.

Caution: Do not overfill.

Intervals given are maximums for normal 8-hour day operation. For abnormal conditions or activities, intervals should be adjusted to compensate.

Clean fittings before lubricating.
Clean parts with Solvent, dry-cleaning (SD), or with Oil, fuel, Diesel. Dry before lubricating.

CAUTION: This equipment uses high voltages that may be fatal if contacted by operating personnel. Use necessary precautions before servicing. Disconnect from power source before servicing.



ANTENNA AS-599/SPN-11
(Aft end view)

Lubricant — Interval

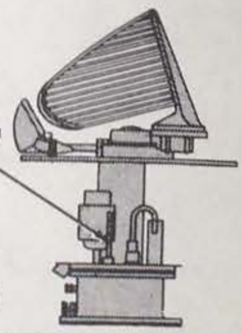
Gearbox Oil Level Gage * Q

Remove cast covers. Check level; fill to full mark on gage. Replace oil level gage and cast covers.

Interval — Lubricant

A * **Gearbox Drain Plug**

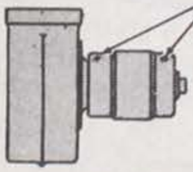
Remove plug and drain. Replace plug. Remove cast covers and oil level gage, and fill with three pints. Replace oil level gage and cast covers.



ANTENNA AS-599/SPN-11
(starboard side view, upper pedestal covers removed)

Q * **Blower Motor Bearings**

Open hinged chassis of receiver-transmitter unit. Apply 10 drops at each bearing.



BLOWER UNIT
(located in Radar Receiver
- Transmitter RT-268/SPN-11)

KEY

LUBRICANT (All temperatures)	INTERVALS
* — Lubricating Oil, General Purpose per MIL-L-15016A; Navy symbol 2135	Q—Quarterly A—Annually

TM 1535-576

Figure 191. Lubrication of antenna and blower unit.

231. General

The main drive gear mounting contains main drive gear assembly O 515, idler gear assembly O 514, the main drive shaft assembly, the synchro gear assembly, the cam gear assembly, and the antenna drive motor gear assembly. Paragraphs 232 through 237 contain the disassembly and assembly procedure for each assembly.

232. Idler Gear Assembly

a. Removal (fig. 192).

(1) Remove the two screws (18) and two lockwashers (17).

(2) Lift out the idler gear assembly (15) from the main drive gear mounting.

Caution: Do not damage the two dowel pins (16) during the removal procedure.

b. Disassembly (fig. 193).

(1) Loosen the two setscrews (1) in the cam idler gear (2).

(2) Lift the cam idler gear (2) and the synchro idler gear (4) off the idler gear shaft (5).

(3) Separate the cam idler gear (2) from the synchro idler gear (4) by removing the two screws (10) and the two dowel pins (3) from the synchro idler gear (4).

(4) Remove the retainer ring (6) from the idler mounting bracket (8).

(5) Lift out the bearing (7) and the idler gear shaft (5) from the idler mounting bracket (8).

(6) Remove the retainer ring (9) with a Waldes No. 2 pliers.

(7) Remove the bearing (7) from the idler gear shaft (5).

c. Assembly. To assemble the assembly, reverse the procedure in *b* above.

d. Remounting. To remount the assembly, reverse the procedure in *a* above.

233. Synchro Gear Assembly

To gain access to the synchro gear assembly, remove the idler gear assembly O 514 as discussed in paragraph 232*a*.

a. Disassembly (fig. 192).

(1) Remove the synchro coupling disk (par. 225*a*.

(2) Remove the two setscrews (28) and lift the synchro spur gear (29) off the synchro shaft (25).

(3) Remove the three oil seal retainer screws (30) that secure the oil seal retainer (27) to the main drive gear mounting. Remove the oil seal retainer (27).

(4) Remove the oil seal (26).

(5) Remove the retainer ring (24).

(6) Remove the synchro shaft (25) and the bearing (23) from the main drive gear mounting by tapping from the synchro coupling end of the shaft (within the drive housing).

(7) Lift the grease seal (19), grease washer (20), and washer (21) off the synchro shaft (25).

(8) Remove the retainer ring (22) using a Waldes No. 2 pliers.

(9) Remove the bearing (23) from the synchro shaft (25).

b. Assembly. To assemble, reverse the procedure in *a*(1) through (9) above.

234. Main Drive Shaft Assembly

a. Disassembly (*Lower Section*) (fig. 192).

(1) Loosen the four setscrews (43) that hold the main shaft worm gear (45) to the main drive shaft. Remove the main shaft worm gear (45).

(2) Loosen the four setscrews (47) and remove the main shaft spur gear (46). Remove the key (44).

(3) Remove the retainer ring (48).

(4) Remove the bearing (49).

(5) Remove the two washers (50 and 52) and the oil seal (51).

b. Disassembly (*Upper Section*) (fig. 194). To disassemble the upper section of the main drive shaft assembly, remove the rotating joint assembly as discussed in paragraph 227*a*. If the main drive shaft must be removed from the main drive gear mounting, perform the procedure in *a* above also.

(1) Remove the key (5).

(2) Remove the retainer ring (6) and remove the bearing (7).

(3) Remove the main drive shaft (8) from the main drive gear mounting.

(4) Remove the bearing (2).

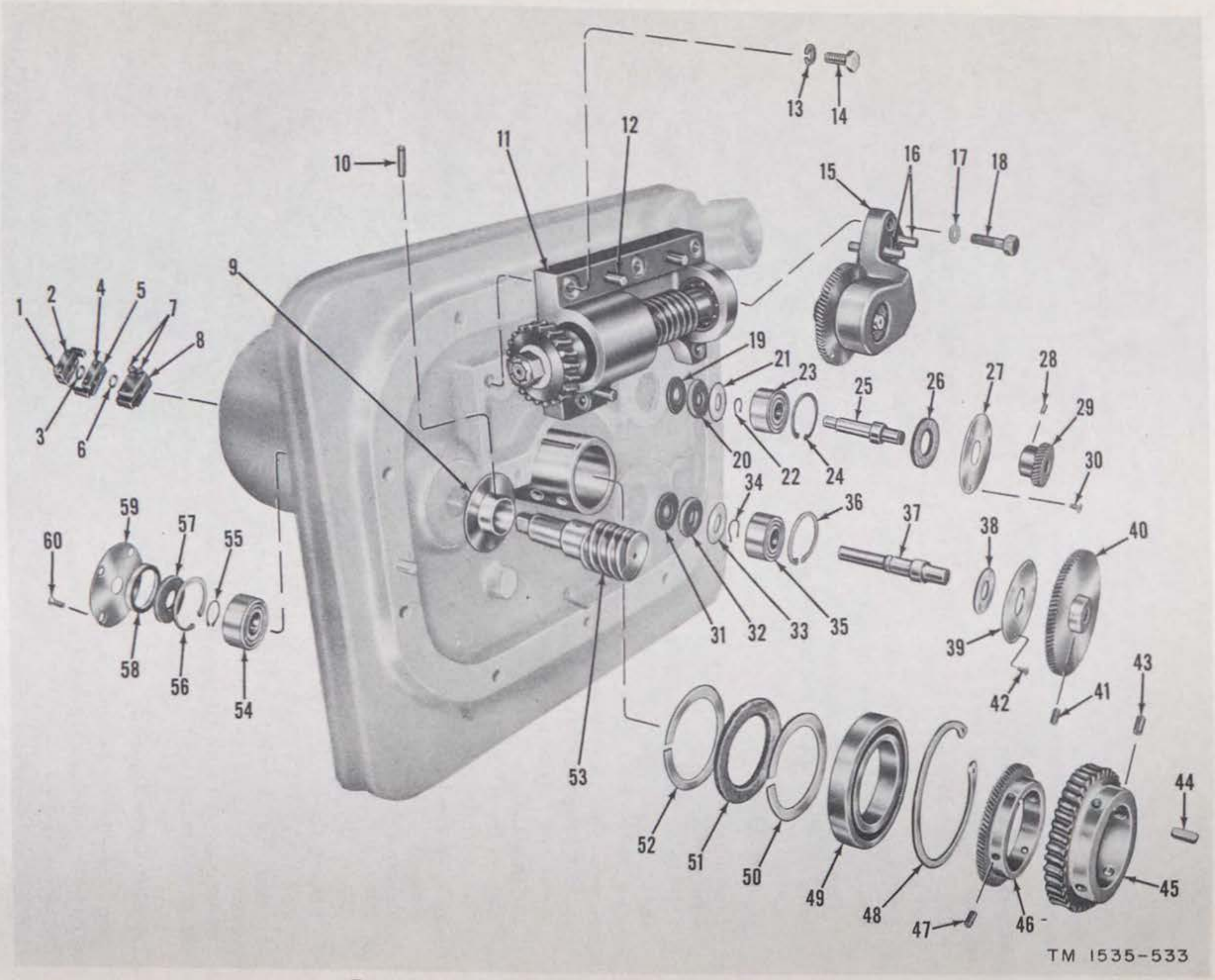
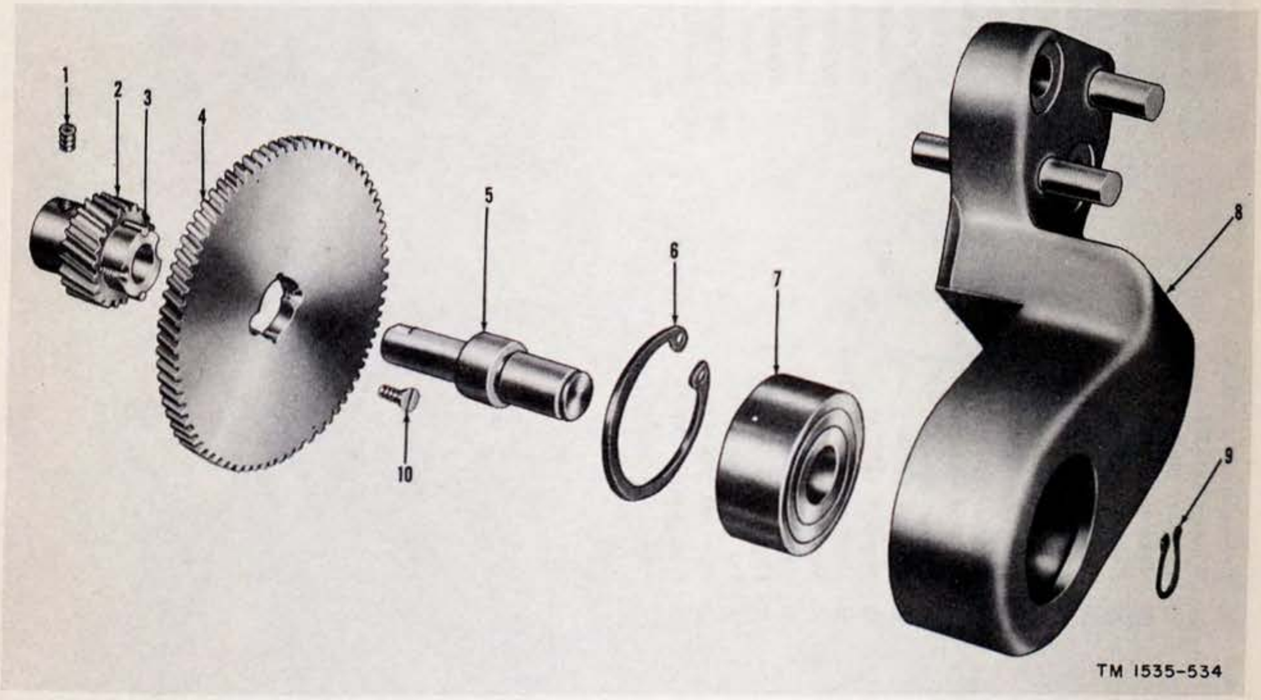


Figure 192. Main drive gear mounting assembly, exploded view.

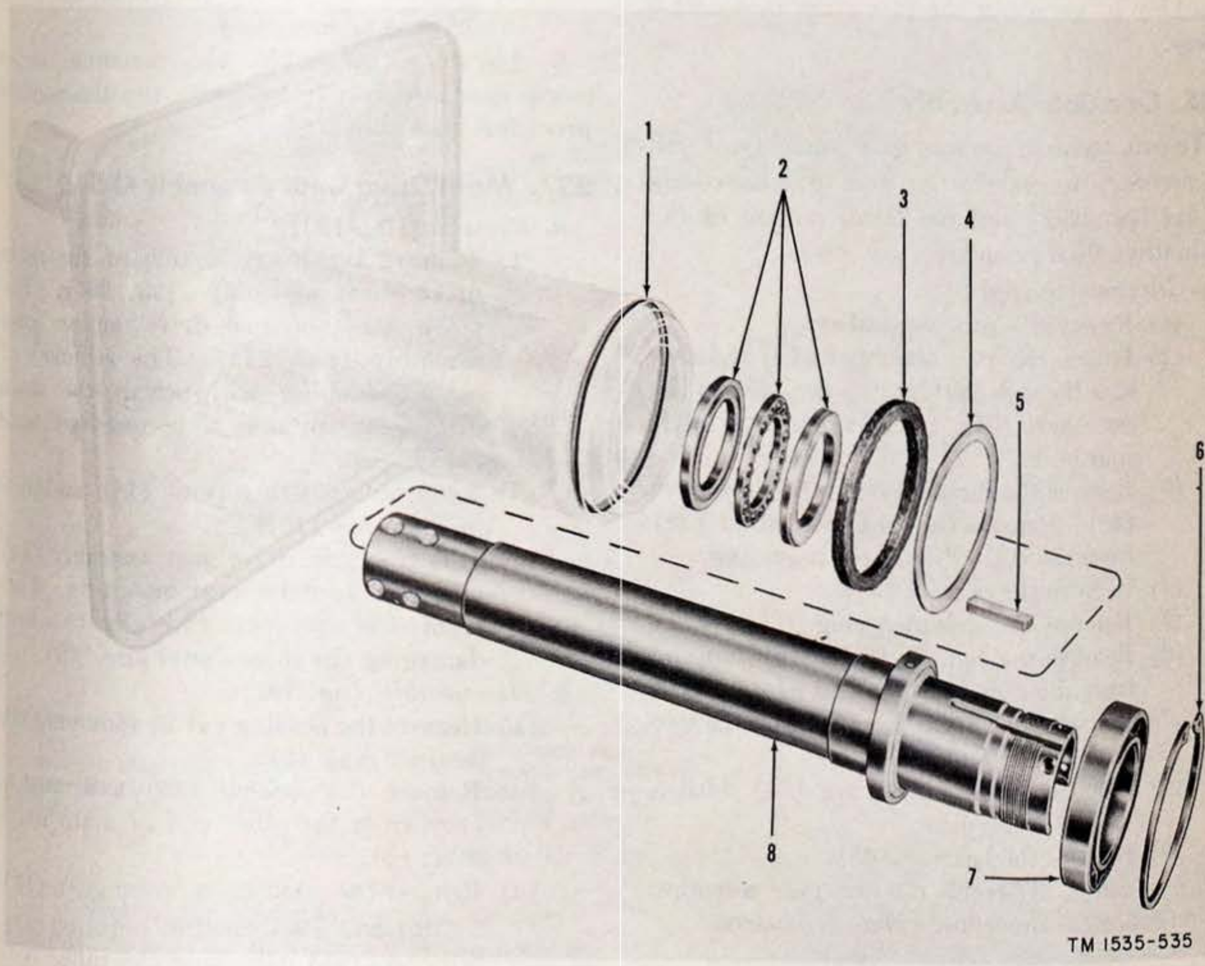
1 Mounting screw
2 Fore heading flash cam assembly
3 Cam washer
4 Mounting screw
5 Aft heading flash cam assembly
6 Cam washer
7 Mounting screw (2)
8 Synchro alinement cam assembly
9 Oil flinger
10 Dowel pin
11 Main drive gear assembly (O 515)
12 Dowel pin (3) (H509)
13 Lockwasher (5) (H551)
14 Mounting screw (5) (H527)
15 Idler gear assembly (O 514)
16 Dowel pin (2) (H508)
17 Lockwasher (2) (H550)
18 Screw (2) (H525)
19 Grease seal (O 527)
20 Grease washer (H532)
21 Washer (H529)
22 Retainer ring (O 563)
23 Bearing (O 558)
24 Retainer ring (O 560)
25 Synchro shaft
26 Oil seal (O 528)
27 Oil seal retainer
28 Setscrew (H528)
29 Synchro spur gear (O 550)
30 Oil seal retainer screw (3)
31 Grease seal (O 525)
32 Washer (H531)
33 Washer (H530)
34 Retainer ring (O 521)
35 Bearing (O 501)
36 Retainer ring (O 523)
37 Cam shaft
38 Oil seal (O 530)
39 Oil seal retainer
40 Cam shaft spur gear (O 547)
41 Setscrew (2)
42 Oil seal retainer screw (3)
43 Setscrew (4)
44 Key
45 Main shaft worm gear (O 553)
46 Main shaft spur gear (O 546)
47 Setscrew (4)
48 Retainer ring (O 520)
49 Bearing (O 505)
50 Washer (H541)
51 Oil seal (O 531)
52 Washer
53 Antenna drive motor worm gear and shaft (O 552)
54 Bearing (O 502)
55 Retainer ring (O 564)
56 Retainer ring (O 562)
57 Washer (H542)
58 Grease seal (O 526)
59 Retainer disk (O 513)
60 Mounting screw (4)

Figure 192—Continued.



1 Setscrew (2)
2 Cam idler gear (O 548)
3 Dowel pin (2) (H507)
4 Synchro idler gear (O 549)
5 Idler gear shaft (O 533)
6 Retainer ring (O 522)
7 Bearing (O 507)
8 Idler mounting bracket (A 505)
9 Retainer ring (O 536)
10 Screw (2) (H516)

Figure 193. Idler gear assembly O 514, exploded view.



1 Gasket (O 541)
2 Bearing (O 508)
3 Water seal (O 532)
4 Washer (H540)
5 Key (O 516)
6 Retainer ring (O 525)
7 Bearing (O 503)
8 Main drive shaft

Figure 194. Main drive shaft assembly, upper section, exploded view.

(5) Remove the washer (4) and the water seal (3) from the top of the main drive gear mounting.

(6) Remove the rubber gasket (1), if necessary.

c. Assembly. Before assembly, the two bearings (2 and 7), the washer (4), and the water seal (3) must be packed with grease. Assemble the lower and upper sections of the main drive shaft assembly by reversing the procedure in *a* and *b* above.

235. Cam Gear Assembly

To gain access to the cam gear assembly, it will be necessary to remove the idler gear assembly O 514 (par. 232) and the lower section of the main drive shaft assembly (par. 234).

a. Disassembly (fig. 192).

(1) Remove the cam assemblies.

(2) Loosen the two setscrews (41) that secure the cam shaft spur gear (40) to the cam shaft (37). Remove the cam shaft spur gear.

(3) Remove the three oil seal retainer screws (42). Remove the oil seal retainer (39) from the main drive gear mounting.

(4) Remove the oil seal (38).

(5) Remove the retainer ring (36).

(6) Remove the cam shaft (37) by tapping from the cam assembly end of the shaft.

(7) Remove the grease seal (31) and the two washers (32 and 33).

(8) Remove the retainer ring (34) with a Waldes No. 2 pliers.

(9) Remove the bearing (35).

b. Assembly. Assemble the cam gear assembly by reversing the procedure given in *a* above.

236. Antenna Drive Motor Gear Assembly (fig. 192)

a. Disassembly. Remove the parts in the order given below.

(1) Remove the antenna drive motor B501 and motor coupling (par. 224*a*).

(2) Remove the retainer disk (59) by removing the four mounting screws (60) that secure the retainer disk to the top of main drive gear mounting.

(3) Remove the grease seal (58) and the washer (57).

(4) Remove the retainer rings (55 and 56). Use a Waldes No. 2 pliers to remove the retainer ring (55).

(5) Remove the dowel pin (10) that secures the oil flinger (9) to the antenna drive motor worm gear and shaft (53).

(6) Remove the antenna drive motor worm gear and shaft (53) by tapping from the motor coupling end of the shaft. Remove the oil flinger (9) from the shaft.

(7) Remove the bearing (54) from the main drive gear mounting.

b. Assembly. Assemble the antenna drive motor gear assembly by reversing the disassemblv procedure in *a* above.

237. Main Drive Gear Assembly O 515

a. Removal (fig. 192).

(1) Remove the lower section of the main drive shaft assembly (par. 234). Remove the antenna drive motor gear assembly (par. 236). The removal of both assemblies will permit the main drive gear assembly to be removed more easily.

(2) Remove the five screws (14) and five lockwashers (13).

(3) Lift the main drive gear assembly (11) off the main drive gear mounting. Perform this operation carefully to avoid damaging the three dowel pins (12).

b. Disassembly (fig. 195).

(1) Remove the bearing (4) by removing the retainer ring (5).

(2) Remove the locknut (15) and washer (14) from the other end of main drive shaft (6).

(3) Remove the main drive worm gear (13).

Caution: Perform this operation carefully to avoid damaging the inner bore of the main drive worm gear as it is pulled past the key (2).

(4) Lift the key (2) off the main drive shaft (6).

(5) Remove the spacing post (12).

(6) Remove the retainer ring (11) and the bearing shim (10), in order.

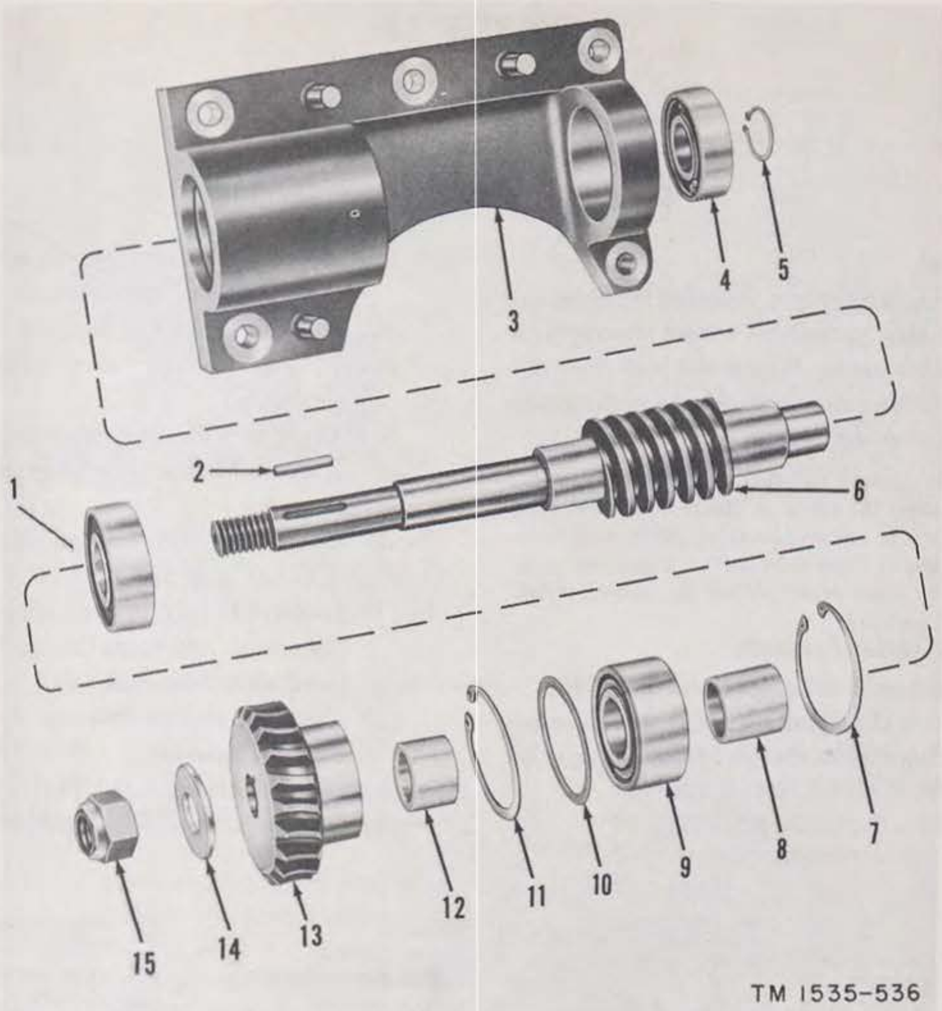
(7) Remove the bearing (9).

(8) Remove the retaining ring (7).

(9) Remove the spacing post (8).

(10) Remove the bearing (1).

(11) Lift the main drive shaft (6) out of the bracket mounting (3).



1 Bearing (O 506)
2 Key
3 Bracket Mounting (A506)
4 Bearing (O 559)
5 Retainer ring (O 519)
6 Main drive shaft (O 534)
7 Retaining ring (O 561)
8 Spacing post (H513)
9 Bearing (O 504)
10 Bearing shim
11 Retainer ring (O 518)
12 Spacing post (H514)
13 Main drive worm gear (O 551)
14 Washer (H538)
15 Locknut (H505)

Figure 195. Main drive gear assembly O 515, exploded view.

c. Assembly. To assemble the main drive gear assembly, reverse the procedure given in *b* above.

d. Remounting.

(1) Secure the bracket mounting (3, fig. 195) to the main drive gear mounting by replacing the five screws and the five lockwashers (14 and 13, fig. 192).

(2) To prevent binding or excessive backlash between the main shaft worm gear (45, fig. 192) and the gear on the main drive worm shaft (6, fig. 195), or between the antenna drive motor worm gear (53, fig. 192) and the main drive worm gear (13, fig. 195), loosen the five mounting screws (14, fig. 192) on the bracket mounting (3, fig. 195). Shift the bracket mounting (3, fig. 195) until the binding or backlash disappears.

(3) Apply power and operate the antenna until the gears are operating quietly. If excessive noise is present, repeat the procedure given in (2) above.

(4) When the gears are operating quietly, shut off the power.

CHAPTER 15

POWER GROUP

Section I. MOTOR STARTER

238. General

The following paragraphs describe replacement procedures. Each paragraph covers the replacement of a major part. Where the text does not refer to a particular model, the instructions apply to both types of motor starter.

Note. Always remove the front cover of the motor starter by loosening the screw at the bottom. Place all disassembled parts in suitable boxes or bags. This practice will avoid loss or damage to parts. Tag all wires to prevent confusion when reassembling the motor starter.

239. Motor Starter Contacts

a. Movable Accelerating Contacts (fig. 196).

(1) Remove the shunt lead (28) by removing the two screws that hold the lead to the left-hand clutch section (36).

(2) Remove the cotter pin (31).

(3) Lift off the upper spring seat (32), movable contact compression spring (33), and the lower spring seat (35).

(4) Lift off the movable accelerating contacts (37).

(5) Replace with new contact.

(6) Reassemble by reversing the above procedure.

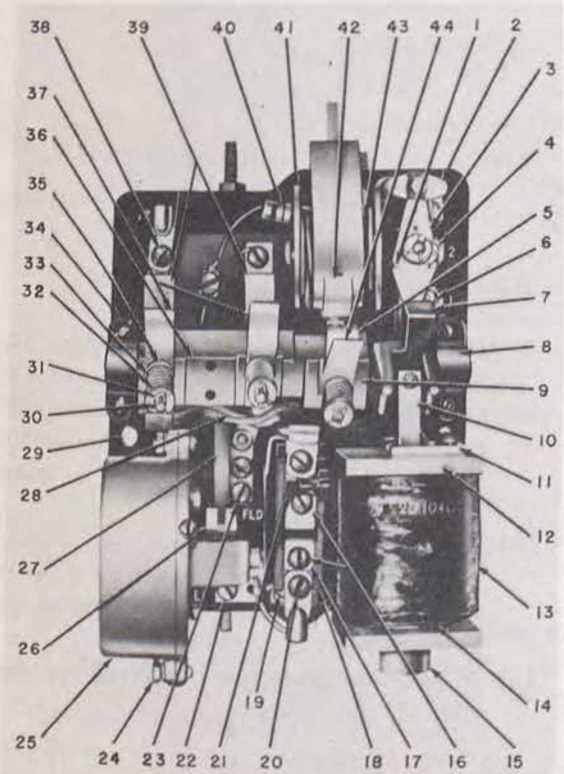
b. Movable Line Contact on Motor Starters SA–285/SPN–11 and SA–286/SPN–11.

(1) Remove the shunt lead (28) by removing the screw that holds the lead to the right-hand clutch section (9).

(2) Perform the procedures found in *a*(2) and (3) above.

(3) Lift off arcing horn (44).

(4) Lift off movable line contact (5).



1. FULCRUM
2. CUTOUT SWITCH MOVABLE CONTACT (E610)
3. CUTOUT SWITCH OPERATING LEVER (E612)
4. TERMINAL "2"
5. MOVABLE LINE CONTACT (E614)
6. TERMINAL "1"
7. CLEVIS AND OPERATING ARM
8. CLUTCH SHAFT BEARING
9. RIGHT-HAND CLUTCH SECTION
10. OPERATING ROD
11. OPERATING ROD STOP PLATE
12. OPERATING COIL FRAME
13. OPERATING COIL (L602)
14. SPRING WASHER
15. SOLENOID CORE
16. HEATER MOUNTING SCREWS
17. HEATING ELEMENT (HR601)
18. THERMAL OVERLOAD SWITCH S602
19. TERMINAL "3"
20. TERMINAL "L2"
21. RESET BUTTON
22. TERMINAL "A1" AND "L1"
23. TERMINAL "FLD"
24. MECHANICAL TIMER COVER NUT AND LOCK WASHER
25. MECHANICAL TIMER (I601)
26. GEAR SEGMENT
27. MECHANICAL TIMER OPERATING LEVER
28. SHUNT LEAD (W601)
29. MOUNTING HOLE
30. GUIDE PIN
31. COTTER
32. UPPER SPRING SEAT
33. MOVABLE CONTACT COMPRESSION SPRING (O 606)
34. CLUTCH SHAFT BEARING
35. LOWER SPRING SEAT
36. LEFT-HAND CLUTCH SECTION
37. MOVABLE ACCELERATING CONTACTS (E615, E616)
38. TERMINAL "A2"
39. STATIONARY ACCELERATING CONTACTS (E617)
40. OPERATING COIL SHUNT RESISTOR (R602)
41. POLE PIECE
42. STATIONARY LINE CONTACT (E613)
43. BLOWOUT COIL (L601)
44. ARCING HORN

TM1535-209

Figure 196. Mechanism of Motor Starter SA–286/SPN–11 and SA–285/SPN–11, front view.

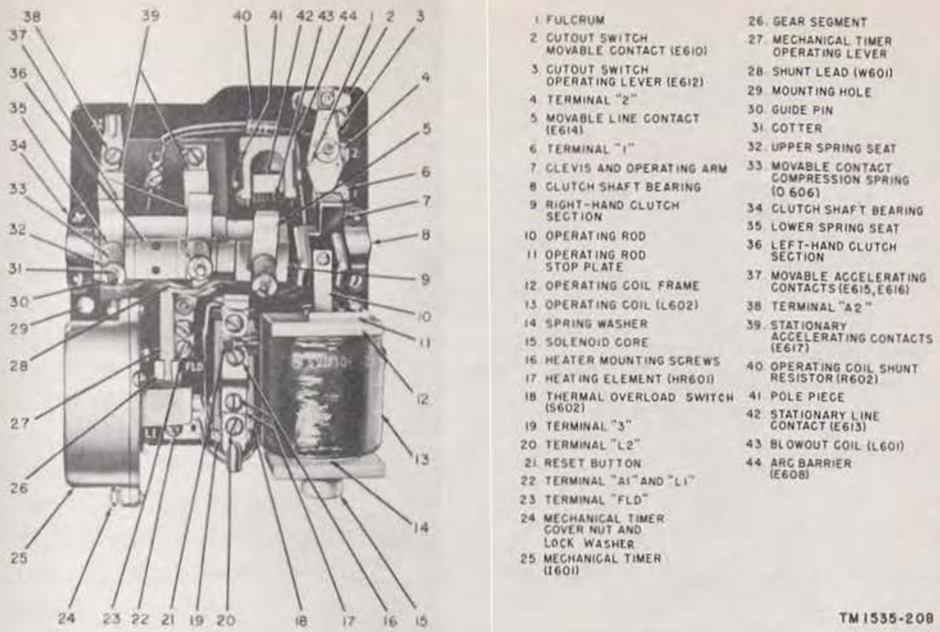


Figure 197. Mechanism of Motor Starter SA-287/SPN-11, front view.

(5) Perform the procedure found in *a*(5) and (6) above.

c. Movable Line Contact on Motor Starter SA-287/SPN-11 (fig. 197).

(1) Remove the shunt lead (28) by removing the screw that holds the cable to the right-hand clutch section (9).

(2) Perform the procedure found in *a*(2) through (6) above.

d. Stationary Accelerating Contacts (fig. 197).

(1) Remove the brass screw and leads connected to the stationary accelerating contacts (39).

(2) Remove the other screw and washers.

(3) Lift off the contact.

(4) Replace with new contact and reassemble by reversing the above procedure.

e. Stationary Line Contact of Motor Starter SA-285/SPN-11 and SA-286/SPN-11 (fig. 197).

(1) Remove the hex.-head screw and washer that holds stationary line contact (42) to blow-out coil assembly.

(2) Remove the stationary line contact (42).

(3) Replace with new contact.

(4) Reassemble in reverse order of disassembly.

f. Stationary Line Contact on Motor Starter SA-287/SPN-11 (fig. 197).

(1) Remove the arc barrier (44) by lifting it out from between the pole pieces (41).

(2) Remove upper screw from left-hand pole piece (41) and lift out stationary line contact (42).

(3) Replace with new contact.

(4) Reassemble in reverse order of disassembly.

g. Cutout Switch Movable Contact (E610) (fig. 198).

(1) Remove nut and lockwasher on top of cutout switch.

(2) Drop screw out through bottom and remove cutout switch movable contact (E610).

(3) Replace with new contact.

(4) Reassemble in reverse order of disassembly.

h. Cutout Switch Stationary Contact Studs (E609) (fig. 198).

(1) Remove the hexagonal-shaped contact stud by unscrewing with a wrench.

(2) Replace with a new stud.

(3) Tighten securely with a wrench.

i. Cutout Switch Operating Lever-Contact (E612) (fig. 198).

(1) Remove the cotter pin.

(2) Lift off the upper spring seat, compression spring (O64), and lower spring seat.

(3) Lift off the cutout switch operating lever.

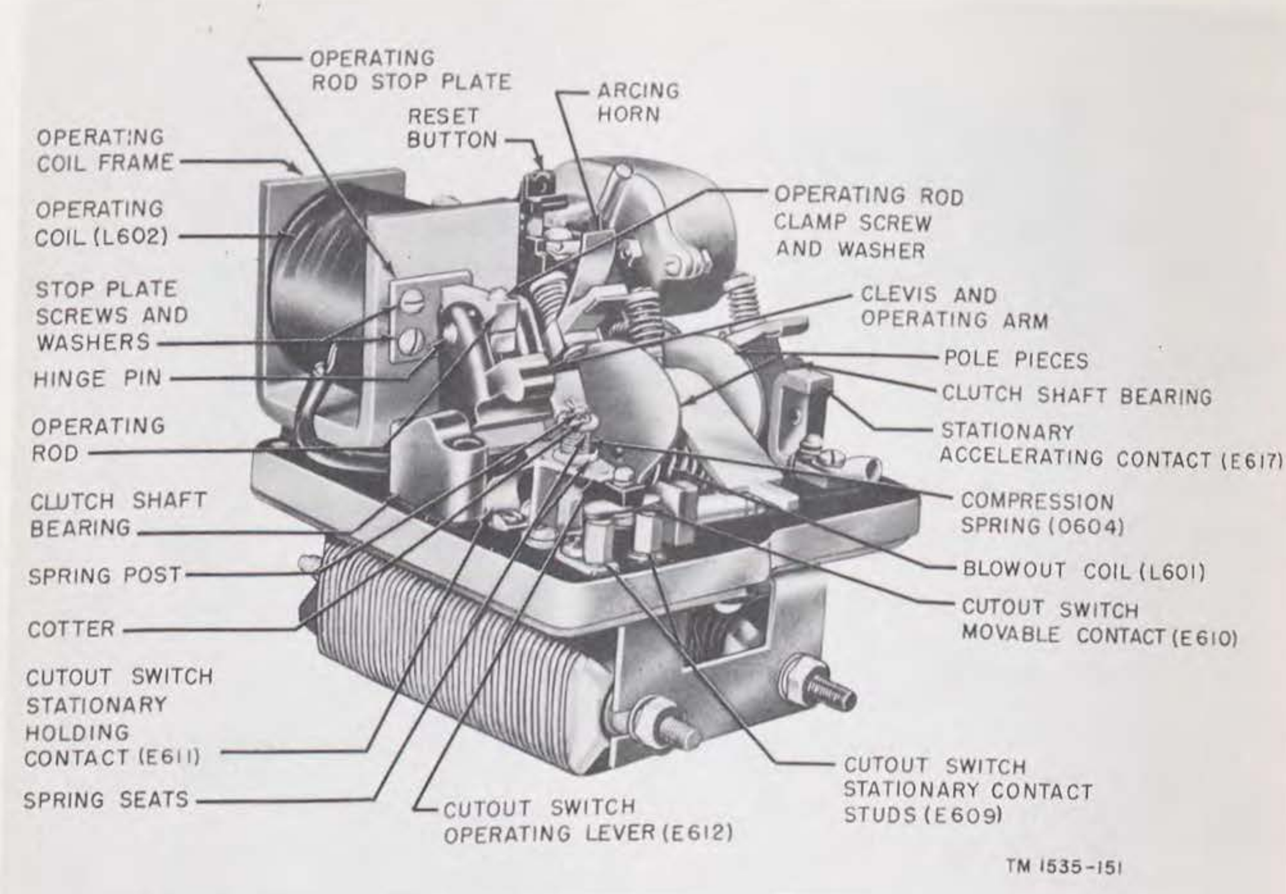


Figure 198. Motor starter, three-quarter view.

(4) Remove the cutout switch movable contact (E610) from the operating lever (O612) by removing the small nut and lockwasher.

(5) Attach the cutout switch movable contact to new operating lever.

(6) Reassemble all parts in reverse order of disassembly.

j. Cutout Switch Stationary Holding Contact (E611) (fig. 198).

(1) Perform the procedure found in *i*(1) through (3) above.

(2) Remove the screw that holds contact E611 to motor starter base and remove the contact.

(3) Replace with new contact.

(4) Reassemble all parts in reverse order of disassembly.

240. Springs and Spring Seats

a. Movable Contact Compression Springs and Spring Seats (fig. 197).

(1) Remove cotter pin (31).

(2) Lift off upper spring seat (32), movable contact compression spring (33), and lower spring seat (35).

(3) Replace necessary parts.

(4) Reassemble all parts in reverse order of disassembly.

b. Cutout Switch Compression Spring and Spring Seats. Procedure for replacement of cutout switch compression spring (O604) and spring seats (fig. 198) is identical with that described in *a* above.

c. Clutch Torsion Spring (O605), (fig. 199).

(1) Loosen the operating rod clamp screw (fig. 198) and withdraw the hinge pin.

(2) Remove the two stop plate screws and lockwashers and remove the operating rod stop plate.

(3) Remove the operating rod by withdrawing it downward through the hole in the operating coil (L602, fig. 197).

(4) Remove the four screws holding the two clutch shaft bearings (34, fig. 197) to the

motor starter base, and remove the bearings.

(5) Lift out the entire clutch and clutch shaft assembly, including the clevis and operating arm (7), movable contacts (5 and 37), and the mechanical timer operating lever and gear segment from the pinion on the mechanical timer (25, fig. 197).

(6) Remove the screws that hold the shunt lead (28, fig. 197) to the two movable accelerating contacts.

(7) Grasp the assembly in both hands (fig. 199). Pull the two sections slightly apart, and turn the left-hand section three-quarters of a turn (fig. 199).

(8) Remove the left-hand clutch section from the clutch shaft by sliding it off.

(9) Pull the old torsion spring (O 605, fig. 199) off the shaft.

(10) Place a new torsion spring on the shaft, and slide it over the sleeve so that its tip slides all the way into the spring slot in the right-hand clutch section.

(11) Slide the left-hand clutch section on the clutch shaft in such a manner that the spring slot in the left-hand clutch section engages the other spring tip (fig. 199).

(12) Rotate the left-hand clutch section three-quarters of a turn in the direction shown by the arrow in the illustration, and engage the two mitered shoulders with one another. Push the two sections all the way together.

(13) Reassemble all parts in reverse order of disassembly.

Caution: When inserting complete clutch assembly into motor starter, make sure that the gear segment and pinion mesh correctly (fig. 201).

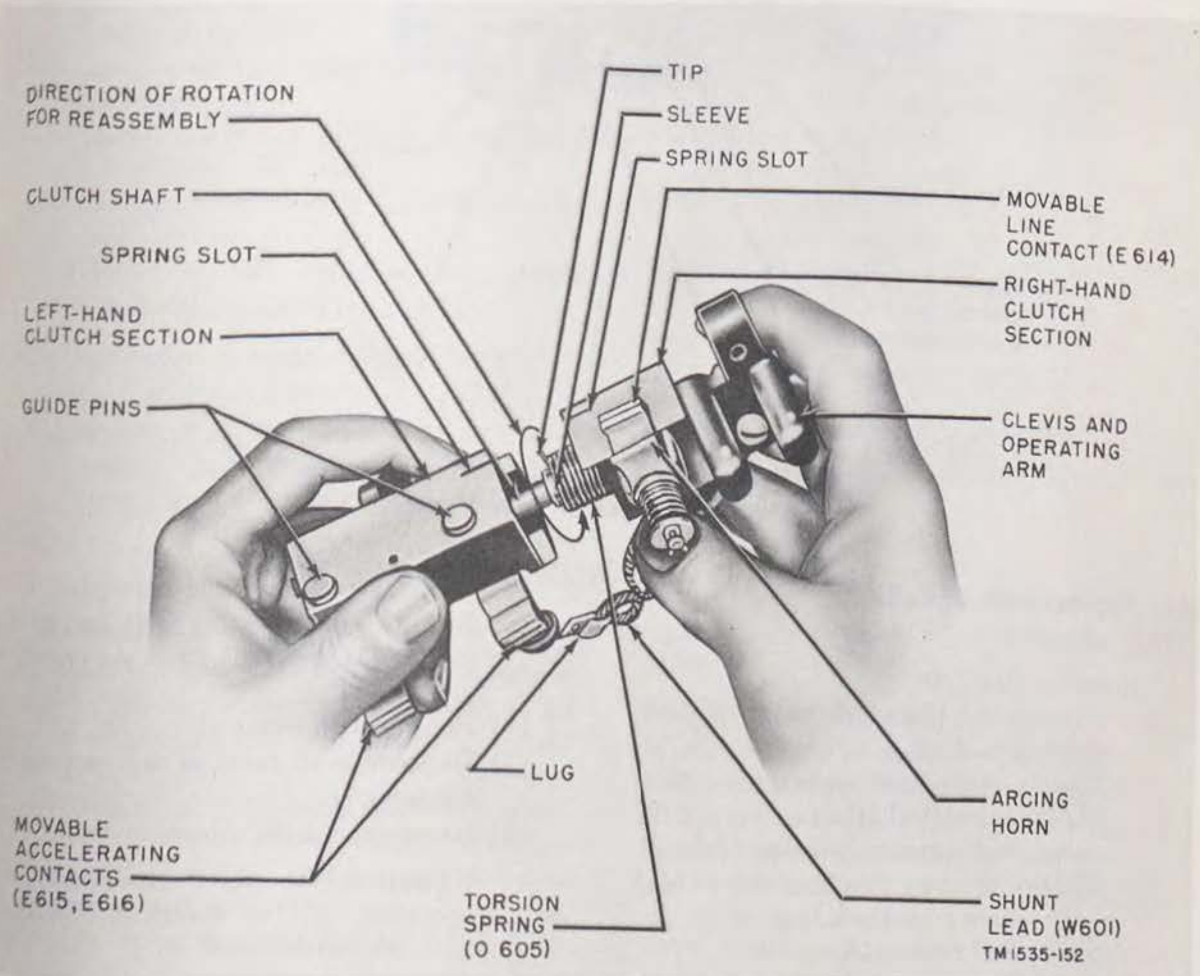


Figure 199. Clutch torsion spring adjustment.

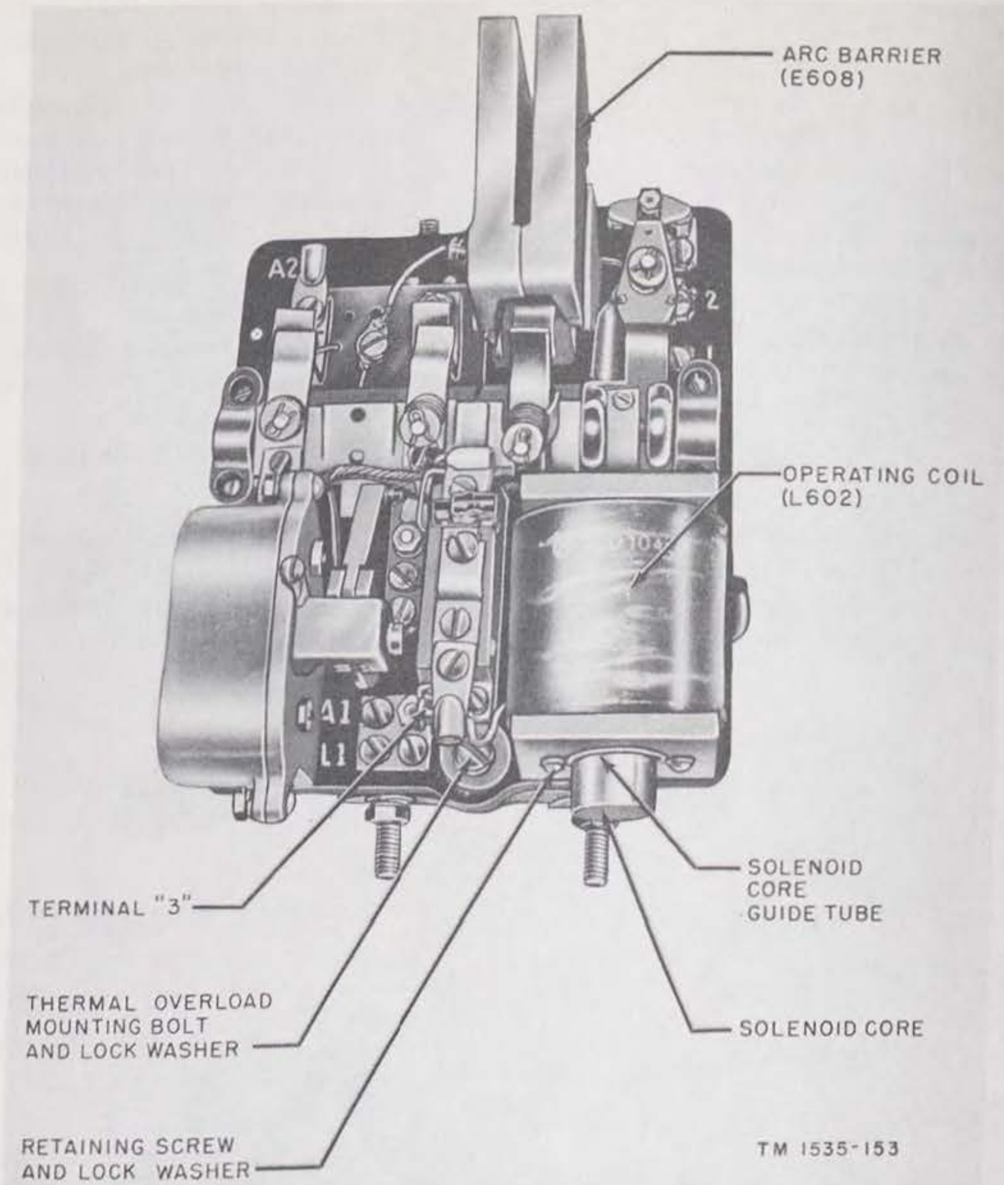


Figure 200. Motor Starter SA-286/SPN-11.

241. Replacement of Coils

(fig. 200)

a. Operating Coil L602.

(1) Perform the procedure found in paragraph 240*a* through *c*.

(2) Disconnect the three operating coil leads from terminal A 1L1, terminal 2, and the cutout switch stationary contact terminal.

(3) Remove the two retaining screws and lockwashers from the bottom of the operating coil frame (12, fig. 197).

(4) Withdraw the solenoid core guide tube.

(5) Remove the operating coil and spring washer (14, fig. 196) from the operating coil frame.

(6) Replace with new coil.

(7) Reassemble all parts in reverse order of disassembly.

(8) Reconnect the three leads as before.

Caution: Be sure the replacement operating coil is electrically identical with the one removed.

b. Blowout Coil L601 for Motor Starters SA-285 and SA-286/SPN-11 (fig. 196).

(1) Disconnect the three voltage-dropping resistor leads from the FLD terminal and from the two stationary accelerating contact terminals, and pull them out through the base of the motor starter.

(2) Remove the two resistor mounting bracket screws and lockwashers (fig. 177), and remove the entire resistor assembly.

(3) Remove the asbestos insulator.

(4) Remove the nut and lockwasher that hold the heavy lead just behind the blowout coil on the back of the starter base. Remove the lead.

(5) Remove the two screws just below this point and lift out the blowout coil and pole pieces.

(6) Remove the nut and lockwasher on the left pole piece (41, fig. 197), take off the pole piece, and remove the blowout coil L601 (43, fig. 197).

(7) Remove the stationary line contact from the blowout coil.

(8) Install the stationary line contact on a new blowout coil.

(9) Reassemble all parts in reverse order of disassembly.

(10) Reconnect all leads to their proper terminals.

242. Miscellaneous Motor Starter Parts

a. Mechanical Timer, I 601.

(1) Remove two mounting nuts and lockwashers that hold base of mechanical timer (fig. 180) to motor starter base.

(2) Remove mechanical timer.

(3) Replace with new unit.

Caution: When replacing new mechanical timer, make sure that pinion engages gear segment on operating arm in proper manner (fig. 201).

(4) Replace lockwashers and nuts, and tighten.

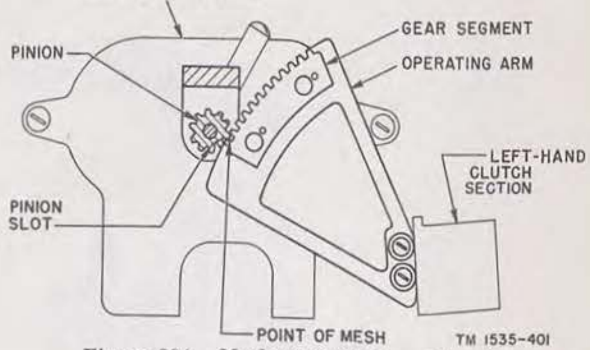


Figure 201. Mechanical timer mechanism.

b. Arc Barrier. The arc barrier on both types of motor starter is held by friction and may be removed and replaced without the use of tools.

c. Movable Line and Accelerating Contact Guide Pins (30, fig. 197).

(1) Perform the procedure outlined in paragraph 240*c*(1) through (5).

(2) Remove cotter pin.

(3) Lift off upper spring seat, movable contact compression spring, lower spring seat, and movable contact.

(4) Withdraw guide pin from bottom of assembly.

(5) Replace with new guide pin.

(6) Reassemble all parts in reverse order of disassembly.

Section II. MOTOR GENERATOR

243. General

a. The disassembly and reassembly procedures discussed in this section apply to all models of the motor generator supplied with Radar Set AN/SPN-11 (*).

b. To replace a component, carefully disassemble the major unit or subassembly until the defective part is reached. Remove the defective part and replace it with a new one. Then reassemble by reversing the procedure for disassembly.

Note. Place disassembled parts in a suitable box or bag to avoid damage or loss of parts. Tag all leads and their respective terminals to avoid mistakes during reconnection.

244. Disassembly

a. Motor End Bell Assembly (fig. 202).

(1) Remove the bearing access covers at each end of the motor generator by removing the four access cover bolts in each cover.

(2) Remove the brush access cover by removing the two mounting bolts.

(3) Disconnect the four field winding leads and two filter capacitor leads by loosening the four terminal screws. Tag the

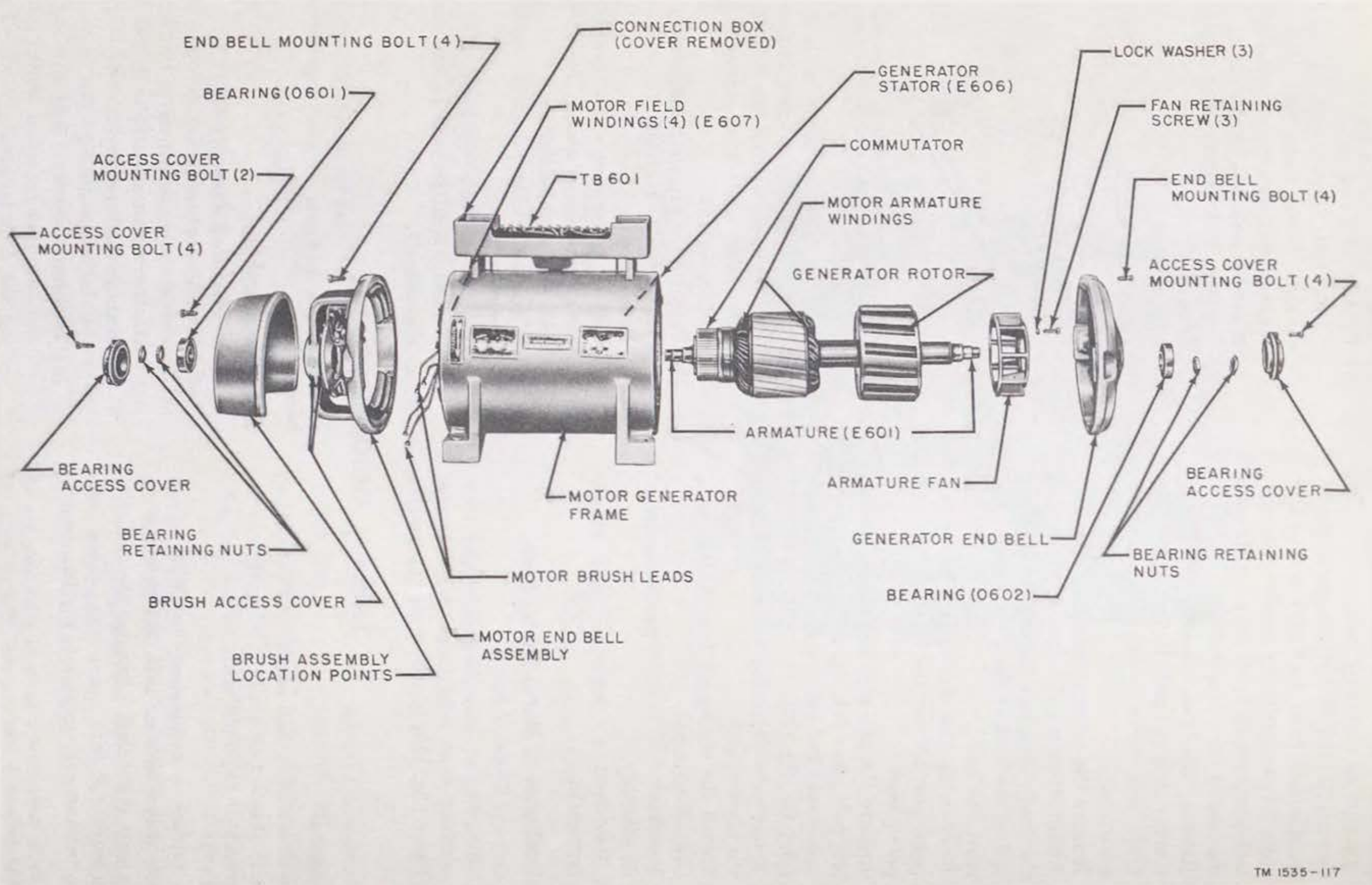


Figure 202. Motor generator, exploded view.

field winding leads to avoid confusion at reassembly.

(4) Remove the screw that secures the two filter capacitors to the top of the end bell (fig. 203), and remove the two filter capacitors C605 and C606.

(5) Apply two box wrenches to the bearing retaining nuts (fig. 202) at each end of the shaft. Turn the wrench at the motor end of the shaft in a counterclockwise direction, turn the other wrench in the opposite direction to prevent the armature from rotating. Keep turning the wrenches until the outer bearing retaining nut is removed from the motor end of the shaft. Repeat the procedure to remove the inner bearing retaining nut.

(6) Remove the four brushes from their brush holders. Leave the pigtail leads attached to their respective terminals.

(7) Remove the four end bell mounting bolts.

(8) Apply a wheel puller to the motor end bell and shaft (15, fig. 110). Turn the threaded rod slowly with an adjustable offset wrench or other suitable tool until the bearing and end bell are riding free on the smaller diameter of the shaft. Remove the end bell and bearing.

Caution: Use appropriate tools for this operation to avoid damage to the bearing and adjacent parts of the equipment.

(9) Loosen the mounting ring clamp screw (fig. 203) and lift the mounting ring and brush assemblies off the brush assembly mounting shoulder in the end bell.

(10) Remove the bearing from the motor end bell in the following manner:

  (*a*) Insert bearing remover (2, fig. 112) in the bearing housing from the inside of the end bell.

  (*b*) Place the end of the tool against the inner race of the bearing.

  (*c*) Remove the bearing by gently tapping the upper end of the tool with a mallet.

b. Motor Brush Assembly (fig. 203).

(1) Remove the four brushes from their respective brush holders. Tag each brush

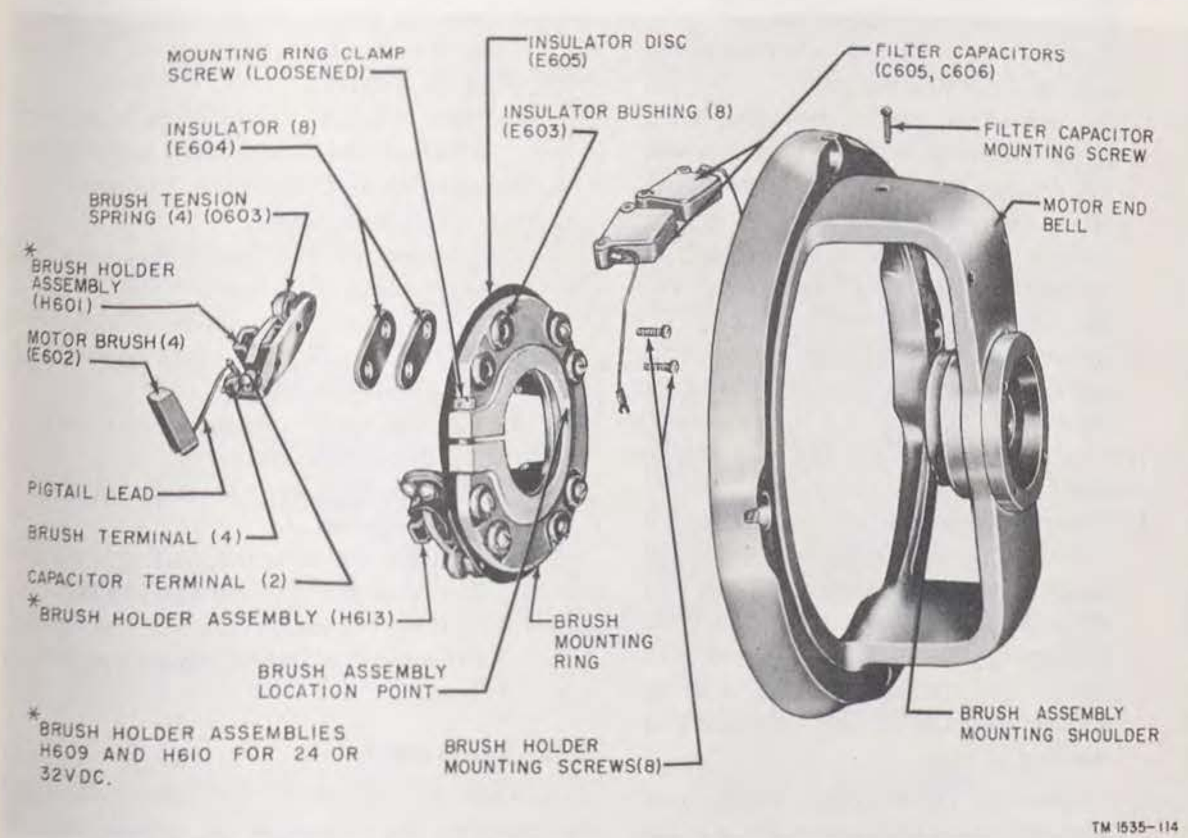


Figure 203. Motor generator, motor brush assembly, exploded view.

and brush holder to avoid mistakes at reassembly.

(2) Remove each brush by loosening the terminal screw and withdrawing the solder lug at the end of each pigtail lead.

(3) Remove the two brush holder mounting screws that secure each brush holder to the mounting ring and remove each brush holder assembly H601.

(4) Straighten out the ends of the cotter pins in each brush spring mounting stud (fig. 181), and withdraw each cotter pin.

(5) Lift off the brush tension spring (O 603).

(6) Remove the insulators E604 (fig. 203).

(7) Remove the insulator disc, E605 (fig. 203).

(8) Remove insulator bushings E603 from the back of the mounting ring (fig. 203).

c. Generator End Bell Assembly.

(1) Apply a strap wrench, pipe wrench, or other suitable locking tool to the motor end of the shaft to prevent rotation of the armature. Do not apply the locking tool to the threaded end of the shaft.

(2) Remove the outer bearing retaining nut by turning the box wrench (14, fig. 109) in a counterclockwise direction.

(3) Repeat (1) and (2) above to remove the inner bearing retaining nut.

(4) Remove the four end bell mounting bolts.

(5) Apply a wheel puller to the generator end bell and shaft. Turn the threaded rod slowly with an adjustable offset wrench or other suitable tool until the bearing and end bell are riding free on the shaft. Remove the end bell and bearing.

(6) Remove the bearing from the generator end bell by using the procedure in *a*(10) above.

d. Removal of Armature E601 and Disassembly of Armature Fan.

(1) Remove the armature by lifting it slightly and withdrawing it from the frame at the generator end of the machine (fig. 202). Use extreme care when performing this operation to avoid damaging the armature. Avoid striking armature against the field poles and field winding.

Caution: The diameter of the rotor is greater than the diameter of the motor armature (fig. 202). Therefore, the armature cannot be removed by pulling it through the frame at the motor end.

(2) Remove the armature fan by removing the three fan retaining screws and lockwashers.

e. Undercutting Commutator Mica. After a period of time, the surfaces of the commutator bars will wear down to the level of the mica insulation. This condition results in sparking at the brushes which will cause rf (radio frequency) interference and will damage the brushes and commutator bars. Therefore, the height of the mica insulation should be $\frac{1}{32}$-inch below the height of the commutator bars. To maintain this required height, undercut the mica by the following procedure.

(1) Disassemble the motor generator and remove the armature.

(2) Place the armature on a suitable workbench. Be careful not to damage the armature winding.

(3) Undercut the mica by drawing the undercutting tool (1, fig. 112) back and forth. Repeat this operation until the height of the mica is one thirty-second inch below the height of the adjacent commutator bars. Be sure to cut the full length of the groove.

(4) Blow out all carbon, mica, and copper dust that has accumulated in the grooves.

f. Disassembly of Connection Box and Terminal Board TB601 (fig. 202).

(1) Remove the four cover mounting bolts and remove the cover.

(2) Loosen the terminal screws and remove the leads. Tag all leads to avoid confusion at reconnection.

(3) Remove the two retaining screws at each end of the terminal strip.

(4) Remove the terminal strip and black insulating sheet.

(5) Remove the mounting bolt in each block insulator and lift out the blocks.

(6) Lift up the connection box and carefully draw the free leads through the clearance hole.

245. Reassembly

a. General. Reassemble the disassembled parts by reversing the procedure for disassembly. Replace all damaged or defective parts.

b. Bearings and Brush Mounting Ring.

(1) Check the bearing mounting shoulders on the armature shaft for burrs, dents, or scratches. Use steel wool to remove any damages. Clean all surfaces with a clean cloth moistened with solvent (SD) and dry thoroughly.

Caution: Do not use emery cloth or a file for this operation. They will permanently damage the surface being repaired.

(2) Check the bearing housing in the end bells for dents, scratches, or burrs, and repeat the procedure in *a* above.

(3) Remount the armature fan and insert the armature in the motor generator frame.

(4) Assemble the brush holder assemblies and mount them on the mounting ring.

(5) Mount brush assemblies and mounting ring in the motor end bell. Be sure the small round white dots on the end bell and mounting ring are lined up exactly. Failure to properly aline these brush assembly location points will result in serious damage to the equipment.

(6) Mount the end bells to the motor generator frame and bolt tightly.

(7) Mount the bearing on the armature shaft as far as possible by hand.

(8) Place the bearing inserter (3, fig. 112) over the shaft and against the inner race of the bearing.

Warning: Never exert pressure against the outer race of the bearing.

(9) Tap the bearing inserter gently with a mallet until the bearing is seated firmly against the bearing housing in the end bell.

(10) Mount the two bearing retaining nuts on each end of the shaft and tighten.

(11) Rotate the armature shaft by hand to make sure it turns freely.

(12) Complete the reassembly of the remaining components.

(13) Lubricate the equipment observing the precautions given in TB SIG 69.

Section III. RECEIVER-TRANSMITTER VENTILATING UNIT

246. General

The ventilating unit in the receiver-transmitter consists of a cleaner element O 801, a blower motor B801, a centrifugal impeller (fan), an impeller housing, and associated parts (figs. 204 and 205).

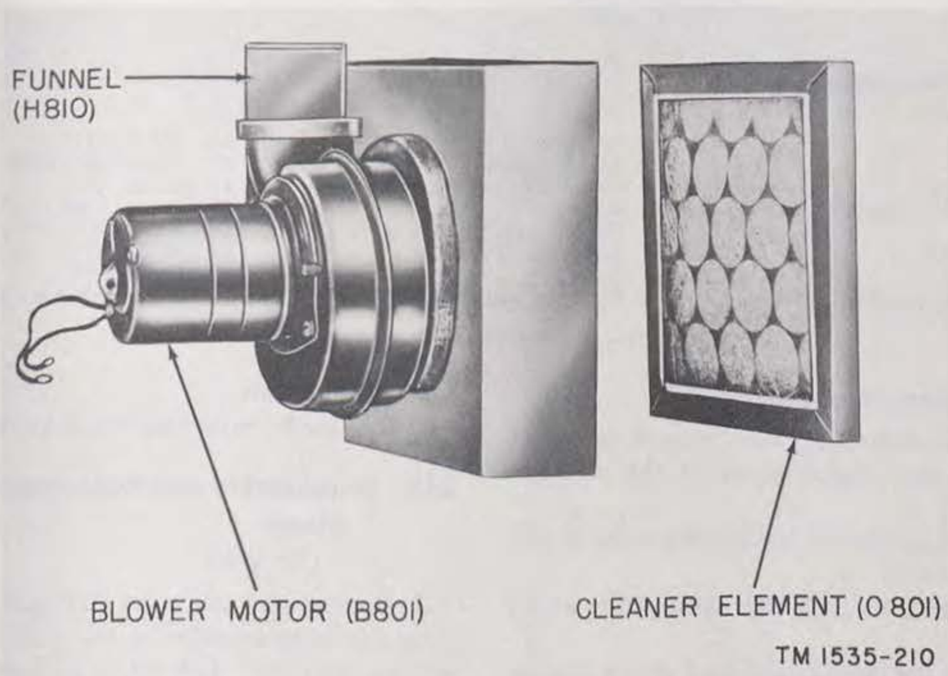
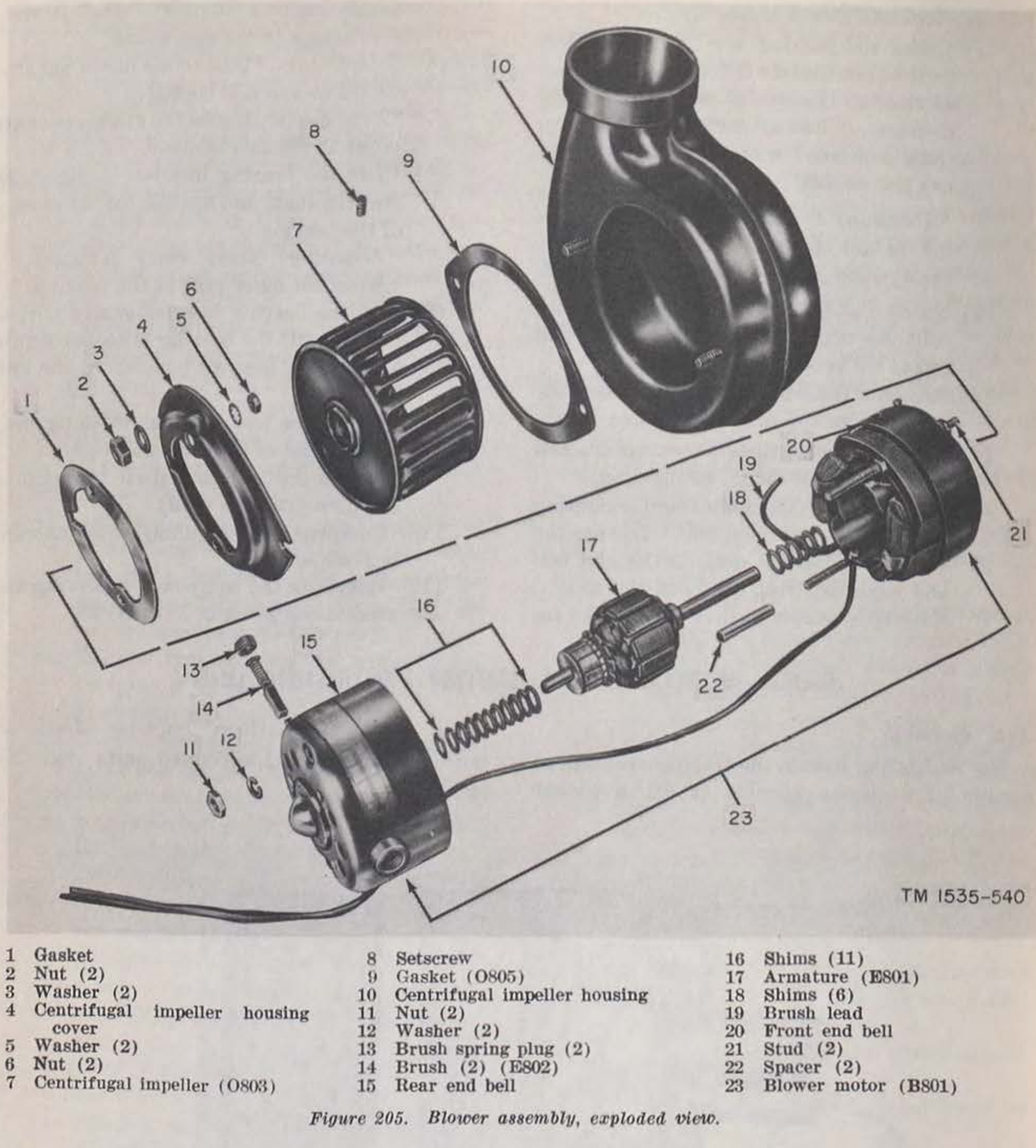


Figure 204. Blower assembly.



1	Gasket	8	Setscrew	16	Shims (11)
2	Nut (2)	9	Gasket (O805)	17	Armature (E801)
3	Washer (2)	10	Centrifugal impeller housing	18	Shims (6)
4	Centrifugal impeller housing cover	11	Nut (2)	19	Brush lead
5	Washer (2)	12	Washer (2)	20	Front end bell
6	Nut (2)	13	Brush spring plug (2)	21	Stud (2)
7	Centrifugal impeller (O803)	14	Brush (2) (E802)	22	Spacer (2)
		15	Rear end bell	23	Blower motor (B801)

Figure 205. Blower assembly, exploded view.

247. Replacement of Blower

The blower motor (fig. 204) is made accessible by opening the hinged panel of the receiver-transmitter.

a. Remove the funnel leading from the blower to the magnetron.

b. Disconnect and tag leads terminating at the blower.

c. Remove the three round-head screws that secure the blower to its mounting.

d. Remove unit.

e. Replace by reversing the above procedure.

248. Disassembly and Reassembly of Blower Motor

(fig. 205)

a. Remove the two nuts (2) and washers (3) from the bolts mounted on the centrifugal impeller housing (10). Lift off as one subassembly the blower motor (23), small gasket (1), centrifugal impeller housing cover (4), and the centrifugal impeller (7).

b. Remove the large gasket (9).

c. Remove the centrifugal impeller (7) from the motor shaft by loosening the setscrew (8).

d. Remove the two nuts (6) and washers (5) from the blower motor studs (21). Lift off the centrifugal impeller housing cover (4) and small gasket (1).

e. Remove the two brush spring plugs (13) and pull out the brushes (14).

f. Remove the two nuts (11) and washers (12) from the far ends of blower motor studs (21), and separate the blower motor rear end bell (15) from the rest of the motor. Do not remove end bell completely.

g. Unsolder the brush lead (19) from terminal inside rear end bell (15).

h. Remove rear end bell (15).

i. Remove armature (17) from front end bell (20), which holds the motor field coils. Remove two spacers (22) from studs (21).

j. Remove shims (16 and 18) from both ends of motor shaft.

CHAPTER 16

DISASSEMBLY OF INDICATOR MECHANICAL PARTS

249. General

The mechanical assemblies in the indicator include the PPI tube housing assembly, the dial and cursor housing assembly, and the deflection yoke, focus coil, and receiver synchro assembly. Paragraphs 250 through 252 outline the disassembly procedure for each.

250. PPI Housing Assembly

(fig. 206)

Caution: Put on goggles and gloves before working on the PPI housing assembly.

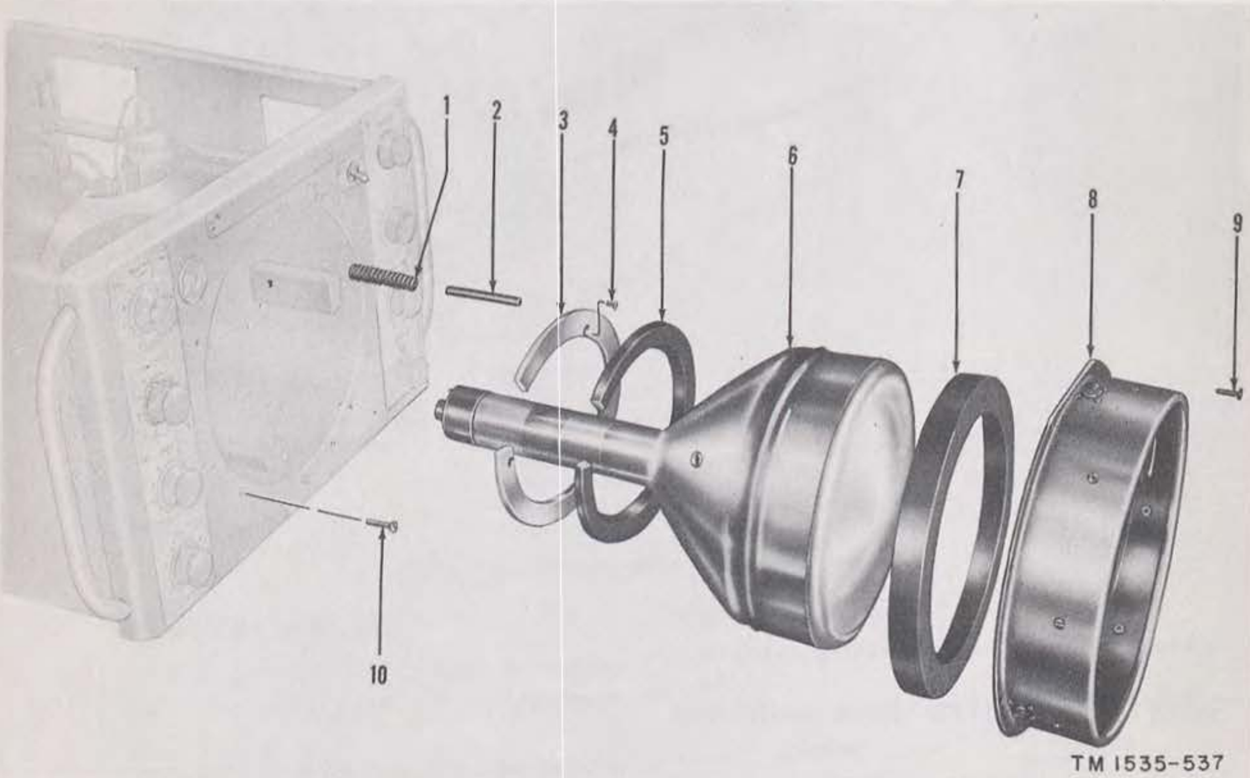
a. Disassembly. To disassemble the PPI tube housing assembly, proceed as follows:

(1) Remove the eight screws (9) that hold the dial and cursor housing assembly (8) to the indicator front panel. Remove the dial and cursor housing assembly (8).

(2) Lift off the rubber shock ring (7) from the face of PPI tube.

(3) Remove tube socket XV105 (fig. 152) connected to the base pins of the PPI tube (6) and remove the tube carefully through the front of the indicator panel.

(4) Remove, as one subassembly, the yoke (3), the yoke cushion (5), and the three yoke centering pins (2), by lifting the centering pins from their receptacles at



1 Yoke cushion spring (3) (O109)
2 Yoke centering pin (3)
3 Yoke
4 Screw (3)
5 Yoke cushion (H106)
6 PPI tube (V105)
7 Rubber shock ring
8 Dial and cursor housing assembly
9 Screw (8)
10 Screw (8)

Figure 206. PPI housing assembly, exploded view.

the base of the PPI housing. The three yoke cushion springs (1) will come loose.

(5) Pull the yoke cushion (5) from the yoke (3) to which it is glued.

(6) Remove the three screws (4) and disengage the three yoke centering pins (2) from the yoke (3).

b. Assembly. To assemble the PPI housing assembly, reverse the disassembly procedure described in *a* above.

251. Dial and Cursor Housing Assembly

(fig. 207)

a. Disassembly. To disassemble the dial and cursor housing assembly, proceed as follows:

(1) Working from the back of the assembly, remove the eight screws (28) that hold the dial backing ring (27) and the scale (26) to the scale mounting ring (10). Lift off the dial backing ring and the scale.

(2) Remove the six screws (25) that hold the dial cursor (24) to the cursor drive wheel (15). Lift off the dial cursor.

(3) Remove the two screws (48) that hold the shaft assembly bracket (34) to the scale mounting ring (10).

(4) Loosen the two Allen screws (51) that hold the cursor knob (50) on the shaft (38). Take off the cursor knob and remove the shaft assembly (34 through 39) from the scale mounting ring (10). Remove the screw (39) and disengage the shaft (38), bearing (37), spacer (36), and bearing (35) from the shaft assembly bracket (34).

(5) Remove the two roller mounting screws (9) and lift out the roller assemblies (11 through 14, and 41 through 45). Lift off the cursor drive wheel (15). Remove the roller assembly screw (14) and disengage the stud (11), bearing (12), and spacer (13). Remove the roller assembly screw (41) and disengage the stud (45), shim (44), bearing (43), and spacer (42). Lift out the spring (40).

(6) Remove the three lamp holders and lamps I 101, I 103, and I 102 (4, 8, and 49).

(7) Remove the 12 nuts (22) and split washers (21) from the 12 bolts (3) that hold the dial lamp contact assembly (17, 20, 23, 29 and 33) to the scale mounting ring (10) and the dial and cursor housing (5). Remove the two screws (1) with the nuts (32) and washers (30 and 31). Remove the entire dial lamp contact assembly (17, 20, 23, 29 and 33) with the three spacers (18), three contact insulators (19), and contact insulator (16).

(8) Remove the eight bolts (2) with nuts (7) and washers (6) that hold the dial and cursor housing (5) to the scale mounting ring (10). Take out the scale mounting ring (10).

(9) Remove the eight screws (47) and separate the eight fixed scale mounting spacers (46) from the scale mounting ring (10).

b. Assembly. Assemble the dial and cursor housing assembly by reversing the disassembly procedure described in *a* above.

252. Deflection Coil Housing Assembly

a. General. The deflection coil housing assembly includes the deflection-coil and slip-ring subassembly; the focus-coil-housing subassembly; and the receiver-synchro subassembly. The entire deflection-coil housing assembly must be removed from the indicator, along with the PPI housing, to gain access to the focus-coil-housing subassembly; otherwise indicator parts mounted near the focus coil will prevent accessibility to the attaching hardware. However, the deflection-coil and slip-ring subassembly and the receiver-synchro subassembly can be removed with the complete assembly in or out of the indicator.

b. Removal and Disassembly of Deflection-coil and Slip-ring Subassembly. To remove and disassemble the deflection-coil and slip-ring subassembly (fig. 208), proceed as follows:

(1) Remove the PPI and all associated parts as described in paragraph 250.

(2) Remove the two screws (39) and washers (40, 41, 42). Lift out the synchro alinement cam switch (43). Remove the two screws (44) and lift out synchro alinement cam switch mounting plate (45).

(3) Remove the eight screws (35) and lift out front bearing retainer (36).

(4) Through the hole in the front of deflection coil housing (2), remove the screw (46), washer (47), stud (49), bearing (48), idler gear (50), and stud washer (51).

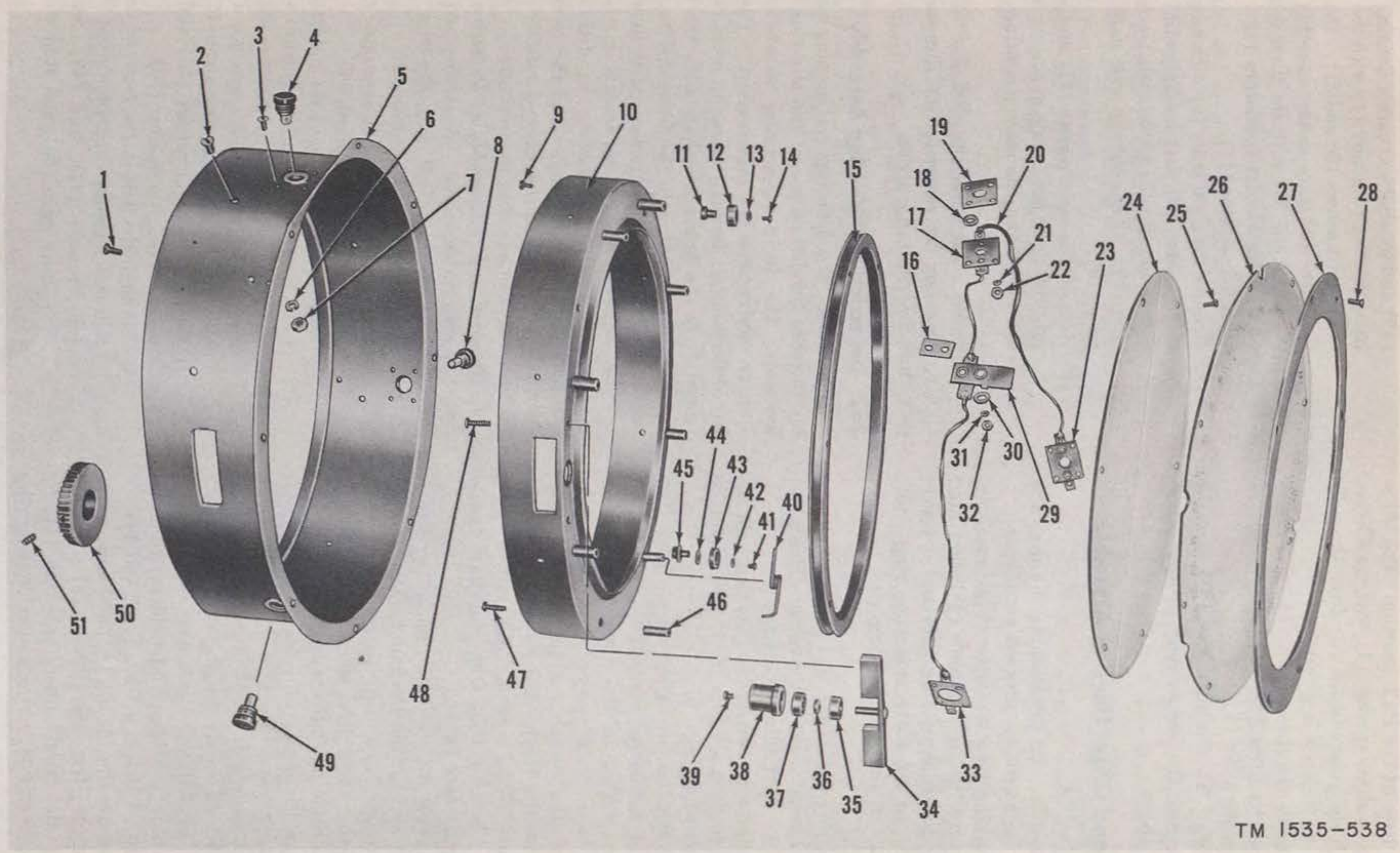


Figure 207. Dial and cursor housing assembly, exploded view.

1 Screw (2)
2 Bolt (8)
3 Bolt (3)
4 Lamp holder and lamp (I 101)
5 Dial and cursor housing
6 Washer (8)
7 Nut (8)
8 Lamp holder and lamp (I 103)
9 Roller mounting screw (2)
10 Scale mounting ring
11 Stud
12 Bearing (O 102)
13 Spacer
14 Roller assembly screw
15 Cursor drive wheel
16 Contact insulator
17 Contact for lamp (XI 101)
18 Spacer (3)
19 Contact insulator (3)
20 Contact assembly wire
21 Split washer (12)
22 Nut (12)
23 Contact for lamp (XI 102)
24 Dial cursor
25 Screw (6)
26 Scale
27 Dial backing ring
28 Screw
29 Contact
30 Washer (2)
31 Washer (2)
32 Nut (2)
33 Contact for lamp (XI 103)
34 Shaft assembly bracket
35 Bearing (O 102)
36 Spacer
37 Bearing (O 102)
38 Shaft
39 Screw
40 Spring (O 108)
41 Roller assembly screw
42 Spacer
43 Bearing (O 102)
44 Shim
45 Stud
46 Scale mounting spacer (8)
47 Screw (8)
48 Screw (2)
49 Lamp holder and lamp (I 102)
50 Cursor knob
51 Allen screw (2)

Figure 207—Continued.

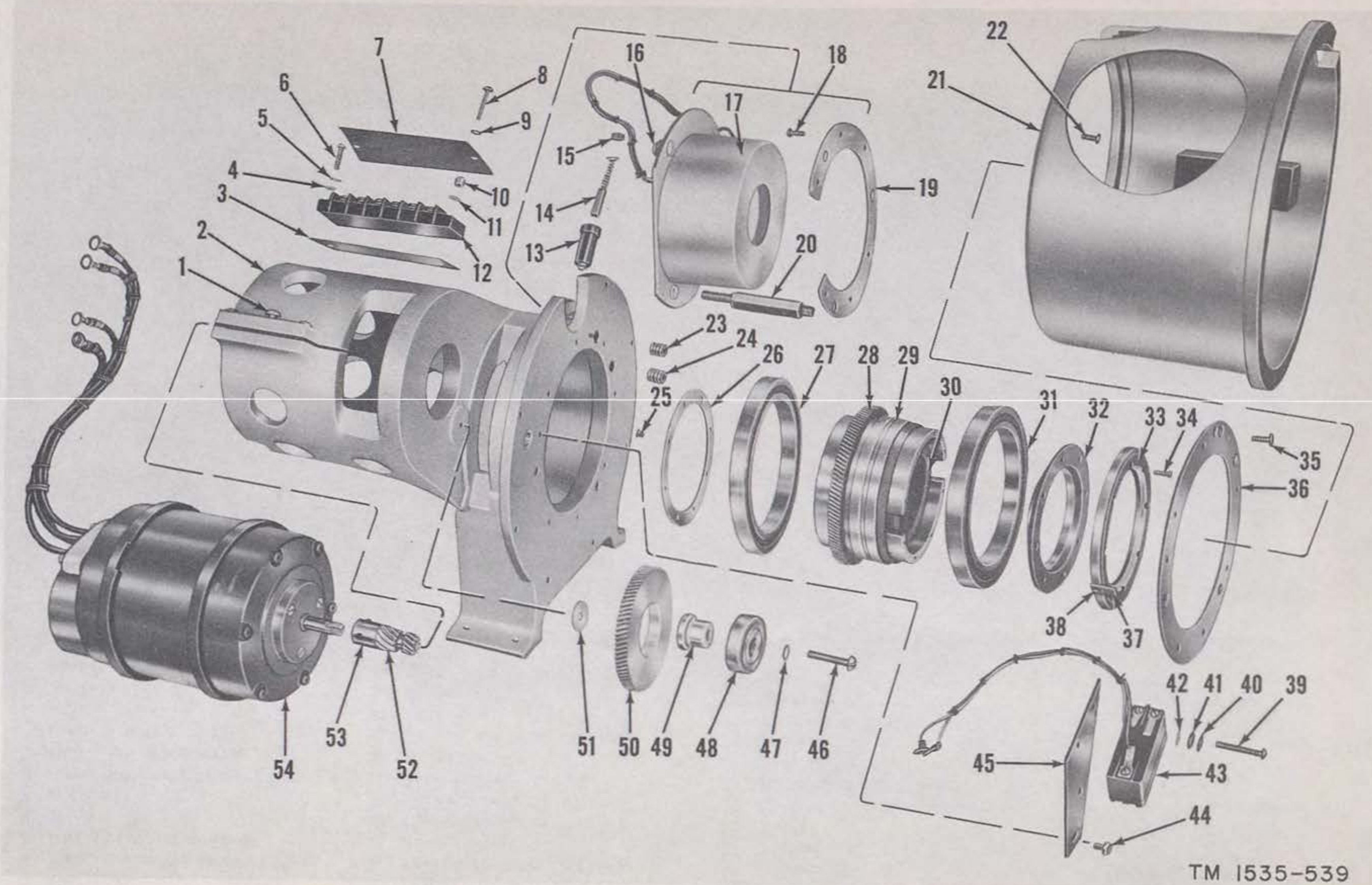


Figure 208. Deflection coil housing assembly, exploded view.

1 Synchro adjustment screw (3) (H114)
2 Deflection-coil housing
3 Insulator plate
4 Washer (2)
5 Washer (2)
6 Screw (2)
7 Cover
8 Screw (2)
9 Washer (2)
10 Spacer (2)
11 Washer (11)
12 Terminal board (TB101)
13 Brush holder (2) (H112, H113)
14 Deflection-coil brush (2) (E105, E106)
15 Plug (2)
16 Captive nut (3)
17 Focus coil housing (A102) and focus coil (L102)
18 Screw (6)
19 Bearing retainer (O 105)
20 Support bolts (3)
21 Tube housing
22 Screw (7)
23 Allen setscrew
24 Allen setscrew
25 Screw (8)
26 Rear bearing retainer (O104)
27 Bearing (O124)
28 Deflection-coil mounting and gear
29 Slip ring assembly (E101)
30 Deflection coil (L101)
31 Bearing (O123)
32 Front bearing retainer (O106)
33 Cam bearing ring
34 Screw (8)
35 Screw (8)
36 Front bearing retainer (O107)
37 Cam (O103)
38 Cam setscrew
39 Screw (2)
40 Washer (2)
41 Washer (2)
42 Washer (2)
43 Synchro alinement cam switch (S104)
44 Screw (2)
45 Synchro alinement cam switch mounting plate
46 Screw
47 Washer
48 Bearing (O101)
49 Stud
50 Idler gear (O111)
51 Stud washer
52 Idler gear and hub (O112)
53 Setscrew (2)
54 Receiver synchro (B101)

Figure 208—Continued.

(5) Loosen the two Allen setscrews (23, 24). Remove the two brush holders (13) intact with brushes (14) and plugs (15). Subparagraphs (3), (4), and (5) free the deflection-coil and slip-ring subassembly of all obstructions within deflection coil housing (2).

(6) Lift out the deflection-coil and slip-ring subassembly (28, 29, 30), which includes cam (37), cam bearing ring (33), small front bearing retainer (32), bearings (27 and 31), and rear bearing retainer (26).

(7) Remove the eight screws (34) and lift off cam (37), cam bearing ring (33), and small front bearing retainer (32). Remove the cam setscrew (38) and separate cam (37) from cam bearing ring (33).

(8) Remove the eight screws (25) and lift off the rear bearing retainer (26).

(9) Remove the bearings (27 and 31) with a bearing puller. This will free the slip ring assembly (29) and deflection coil mounting and gear (28, 30).

c. Removal and Disassembly of Receiver Synchro Subassembly. To remove and disassemble the receiver synchro subassembly, proceed as follows:

(1) Remove all wires from the terminal board (12). Access to terminals can be gained by removing two screws (8), washers (9), spacers (10), and washers (11), and then by lifting off terminai board cover (7).

(2) Loosen the three synchro adjustment screws (1). Remove receiver synchro (54) with synchro idler gear and hub (52).

(3) Remove the two setscrews (53) and lift the synchro idler gear and hub (52) off the synchro shaft.

(4) Disassemble the receiver synchro (54) exactly like the transmitter synchro (par. 225).

d. Removal and Disassembly of Focus-Coil-Housing Subassembly. To gain access to the focus-coil-housing subassembly, the complete deflection-coil-housing assembly must first be removed from the indicator. Proceed as follows and refer to figure 208.

(1) Remove the PPI and all associated parts as described in paragraph 250.

(2) Remove all leads from terminal board TB101 (12) after removing two screws (8), washers (9 and 11), spacers (10), and the terminal board cover (7). The terminal board itself need not be removed from the housing (2) for this procedure, but if its removal is desired, take out the two screws (6), and washers (4 and 5). Both the terminal board (12) and insulator plate (3) will come free.

(3) Unsolder the focus coil leads from the terminals of resistor R137 (fig. 151.)

(4) Remove the nut and bolt to remove relay K101 (fig. 151) from deflection-coil housing (2).

(5) Loosen two Allen setscrews (23, 24) through holes in front bearing retainer (36). Remove two brush holders (13) intact with brushes (14) and plugs (15). This wil free the deflection-coil brush leads and clear the housing (2) of all remaining wires.

(6) Remove the four mounting screws (fig. 153) that hold the base of the deflection-coil housing (2) to the indicator chassis.

(7) Remove the eight front panel mounting screws (10, fig. 206) that hold the tube housing (21) to the indicator.

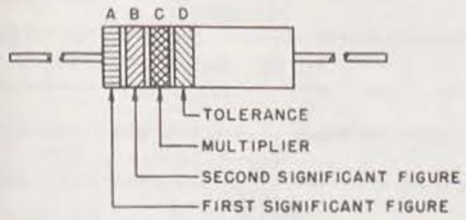
(8) Lift out the entire deflection-coil housing assembly and tube housing. Separate the tube housing (21) from the deflection-coil housing (2) by removing the seven screws (22).

(9) Loosen the three setscrews (fig. 152) and remove the support bolts (20) from the deflection coil housing (2). Remove the six screws (18) and the bearing retainer (19) will come free. Slip the focus coil housing (17) off the support bolts (20).

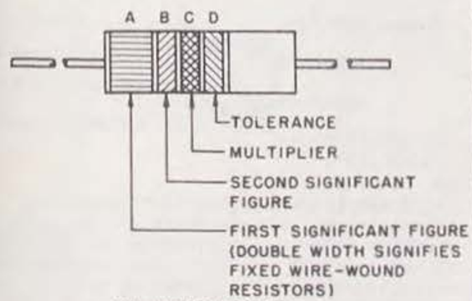
e. Assembly. Assemble each subassembly by reversing the procedures described in *b*, *c*, and *d* above.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)

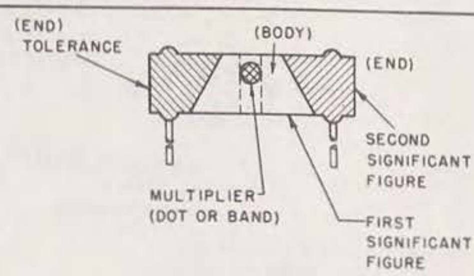


RC-COMPOSITION

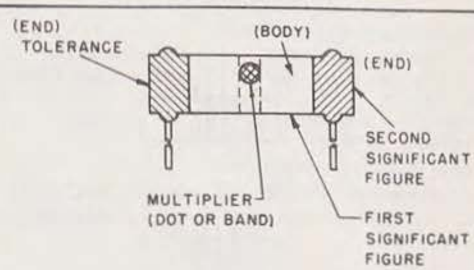


RU-WIRE-WOUND

RADIAL-LEAD RESISTORS (UNINSULATED)



RZ-COMPOSITION



RZ-COMPOSITION

RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	±20
BROWN	1	BROWN	1	BROWN	10	SILVER	±10
RED	2	RED	2	RED	100	GOLD	±5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

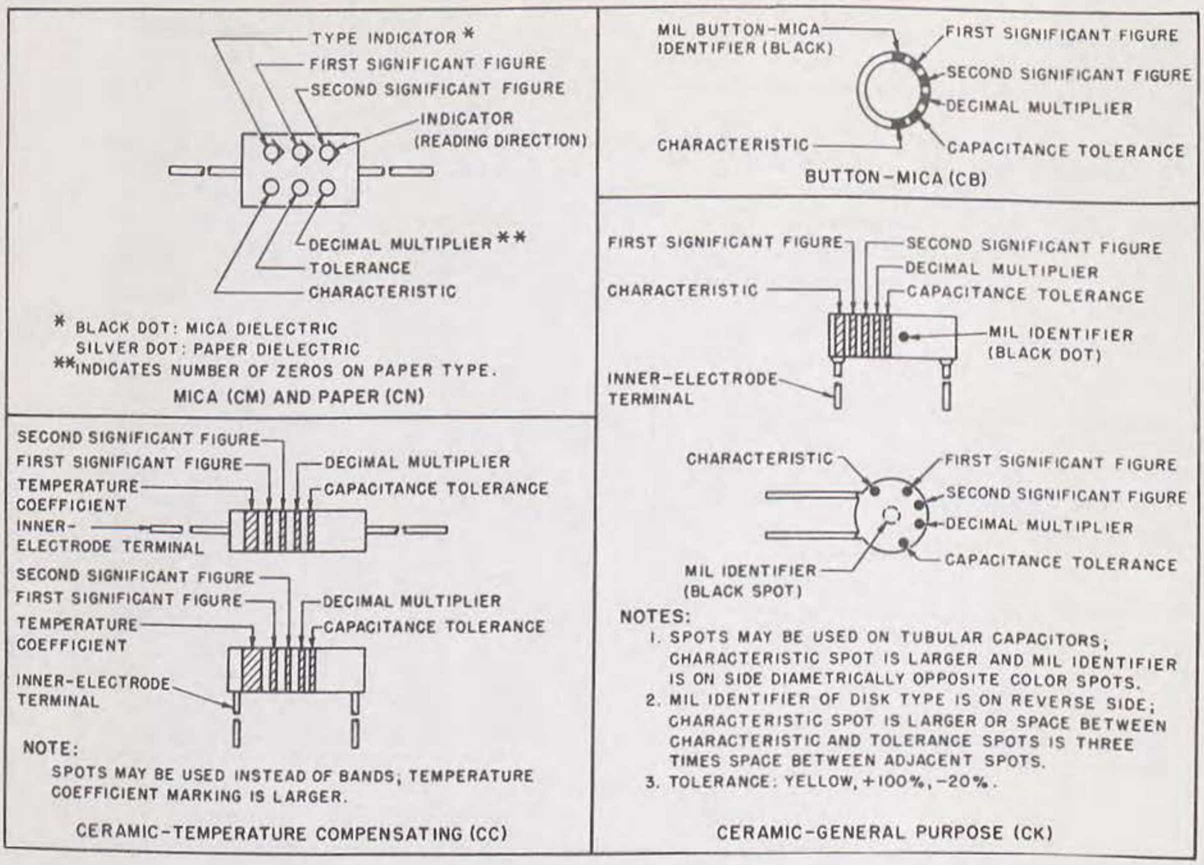
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY, BLACK END, RED DOT OR BAND; SILVER END.

STD-R1

Figure 209. Resistor color codes.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



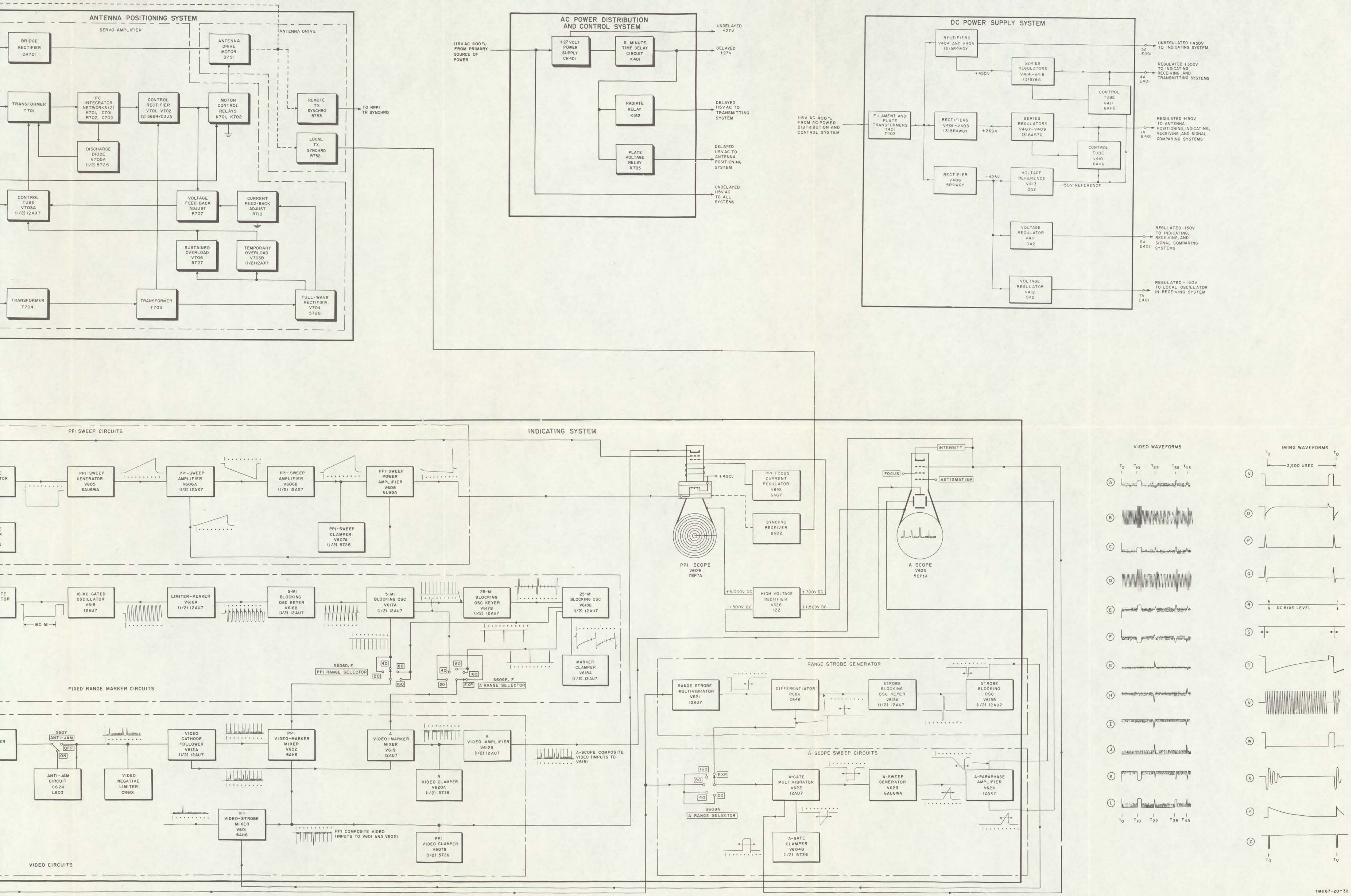
CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE [2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500) [3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

Figure 210. Capacitor color codes.



ANTENNA POSITIONING SYSTEM
SERVO AMPLIFIER
ANTENNA DRIVE
BRIDGE RECTIFIER CR701
ANTENNA DRIVE MOTOR B751
TRANSFORMER T701
RC INTEGRATOR NETWORKS (2) R701, C701 R702, C702
CONTROL RECTIFIER V701, V702 (2) 5684/C3JA
MOTOR CONTROL RELAYS K701, K702
REMOTE TX SYNCHRO B753
TO RPPI TR SYNCHRO
DISCHARGE DIODE V705A (1/2) 5726
LOCAL TX SYNCHRO B752
CONTROL TUBE V703A (1/2) 12AX7
VOLTAGE FEED-BACK ADJUST R707
CURRENT FEED-BACK ADJUST R710
SUSTAINED OVERLOAD V706 5727
TEMPORARY OVERLOAD V703B (1/2) 12AX7
TRANSFORMER T704
TRANSFORMER T703
FULL-WAVE RECTIFIER V704 5726
AC POWER DISTRIBUTION AND CONTROL SYSTEM
115V AC 400~ FROM PRIMARY SOURCE OF POWER
+27 VOLT POWER SUPPLY CR401
5 MINUTE TIME DELAY CIRCUIT K401
UNDELAYED +27V
DELAYED +27V
RADIATE RELAY K152
DELAYED 115V AC TO TRANSMITTING SYSTEM
PLATE VOLTAGE RELAY K705
DELAYED 115V AC TO ANTENNA POSITIONING SYSTEM
UNDELAYED 115V AC TO ALL SYSTEMS
DC POWER SUPPLY SYSTEM
115V AC 400~ FROM AC POWER DISTRIBUTION AND CONTROL SYSTEM
FILAMENT AND PLATE TRANSFORMERS T401 T402
RECTIFIERS V404 AND V405 (2) 5R4WGY
SERIES REGULATORS V414-V416 (3) 6Y6G
CONTROL TUBE V417 6AH6
RECTIFIERS V401-V403 (3) 5R4WGY
SERIES REGULATORS V407-V409 (3) 6AS7G
CONTROL TUBE V410 6AH6
RECTIFIER V406 5R4WGY
VOLTAGE REFERENCE V413 OA2
-150V REFERENCE
VOLTAGE REGULATOR V411 OA2
VOLTAGE REGULATOR V412 OA2
+450V
+260V
-425V
UNREGULATED +450V TO INDICATING SYSTEM 5A E401
REGULATED +300V TO INDICATING, RECEIVING, AND TRANSMITTING SYSTEMS 4A E401
REGULATED +150V TO ANTENNA POSITIONING, INDICATING, RECEIVING, AND SIGNAL COMPARING SYSTEMS 1A E401
REGULATED -150V TO INDICATING, RECEIVING, AND SIGNAL COMPARING SYSTEMS 6A E401
REGULATED -150V TO LOCAL OSCILLATOR IN RECEIVING SYSTEM 7A E401
INDICATING SYSTEM
PPI SWEEP CIRCUITS
PPI-SWEEP GENERATOR V605 6AU6WA
PPI-SWEEP AMPLIFIER V606A (1/2) 12AX7
PPI-SWEEP AMPLIFIER V606B (1/2) 12AX7
PPI-SWEEP POWER AMPLIFIER V608 6L6GA
PPI-SWEEP CLAMPER V607A (1/2) 5726
PPI-FOCUS CURRENT REGULATOR V610 6AQ7
SYNCHRO RECEIVER B602
PPI SCOPE V609 7BP7A
+450V
HIGH VOLTAGE RECTIFIER V626 1Z2
+5,000V DC
+700V DC
-1,500V DC
+1,500V DC
A SCOPE V625 5CP1A
FOCUS
ASTIGMATISM
INTENSITY
FIXED RANGE MARKER CIRCUITS
16-KC GATED OSCILLATOR V615 12AU7
160 MI
LIMITER-PEAKER V616A (1/2) 12AU7
5-MI BLOCKING OSC KEYER V616B (1/2) 12AU7
5-MI BLOCKING OSC V617A (1/2) 12AU7
25-MI BLOCKING OSC KEYER V617B (1/2) 12AU7
25-MI BLOCKING OSC V618B (1/2) 12AU7
MARKER CLAMPER V618A (1/2) 12AU7
S606D, E PPI RANGE SELECTOR
S609E, F A RANGE SELECTOR
EXP
VIDEO CIRCUITS
S607 ANTI-JAM
OFF
ON
ANTI-JAM CIRCUIT C624 L603
VIDEO CATHODE FOLLOWER V612A (1/2) 12AU7
VIDEO NEGATIVE LIMITER CR601
PPI VIDEO-MARKER MIXER V602 6AH6
A VIDEO-MARKER MIXER V619 12AU7
A VIDEO AMPLIFIER V612B (1/2) 12AU7
A-SCOPE COMPOSITE VIDEO (INPUTS TO V619)
A VIDEO CLAMPER V620A (1/2) 5726
IFF VIDEO-STROBE MIXER V601 6AH6
PPI COMPOSITE VIDEO (INPUTS TO V601 AND V602)
PPI VIDEO CLAMPER V607B (1/2) 5726
RANGE STROBE GENERATOR
RANGE STROBE MULTIVIBRATOR V621 12AU7
DIFFERENTIATOR R686 C646
STROBE BLOCKING OSC KEYER V613A (1/2) 12AU7
STROBE BLOCKING OSC V613B (1/2) 12AU7
A-SCOPE SWEEP CIRCUITS
A-GATE MULTIVIBRATOR V622 12AU7
A-SWEEP GENERATOR V623 6AU6WA
A-PARAPHASE AMPLIFIER V624 12AX7
A-GATE CLAMPER V604B (1/2) 5726
S609A A RANGE SELECTOR
VIDEO WAVEFORMS
IMING WAVEFORMS
2,500 USEC
DC BIAS LEVEL

TM1167-20-30

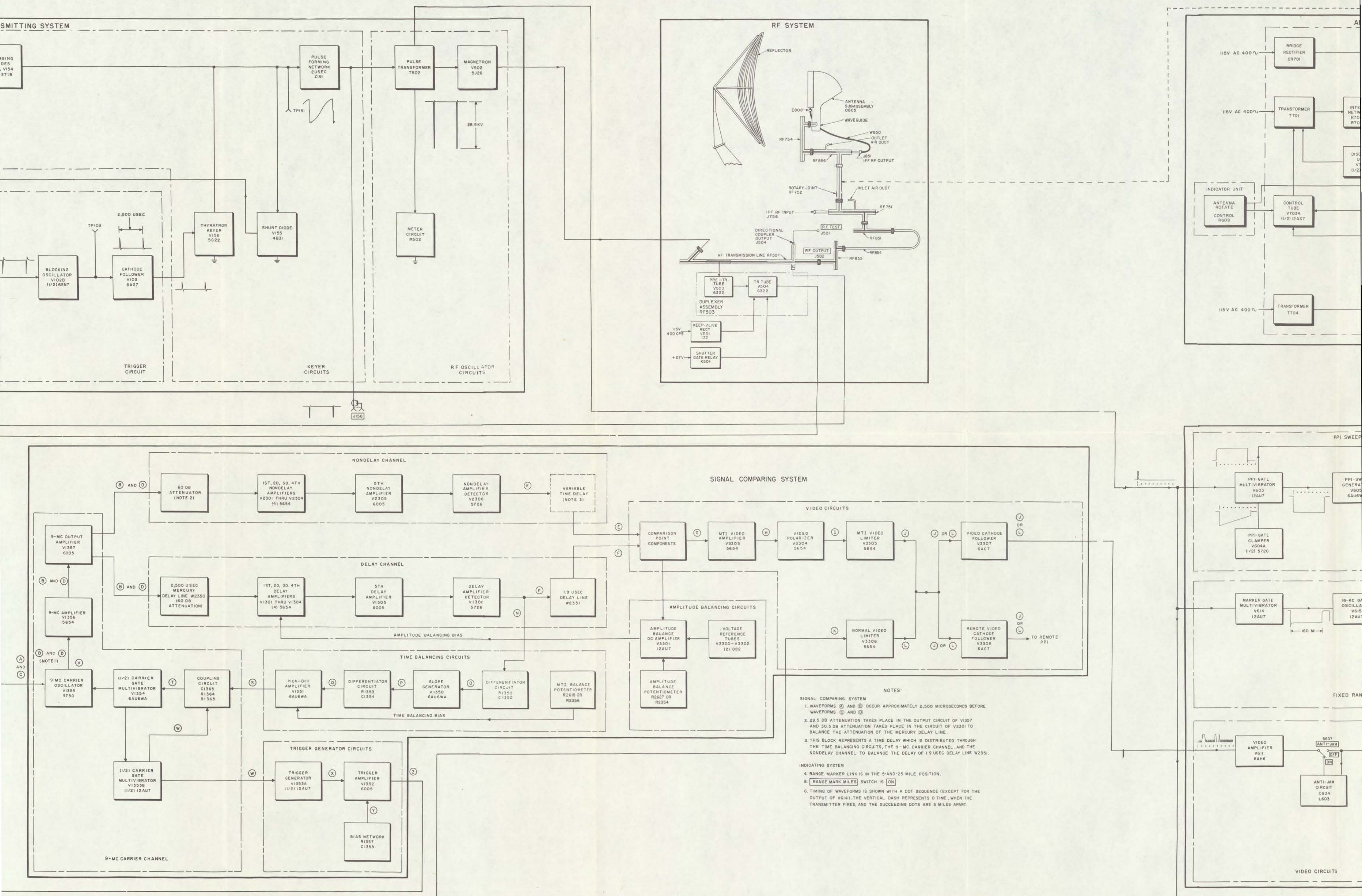
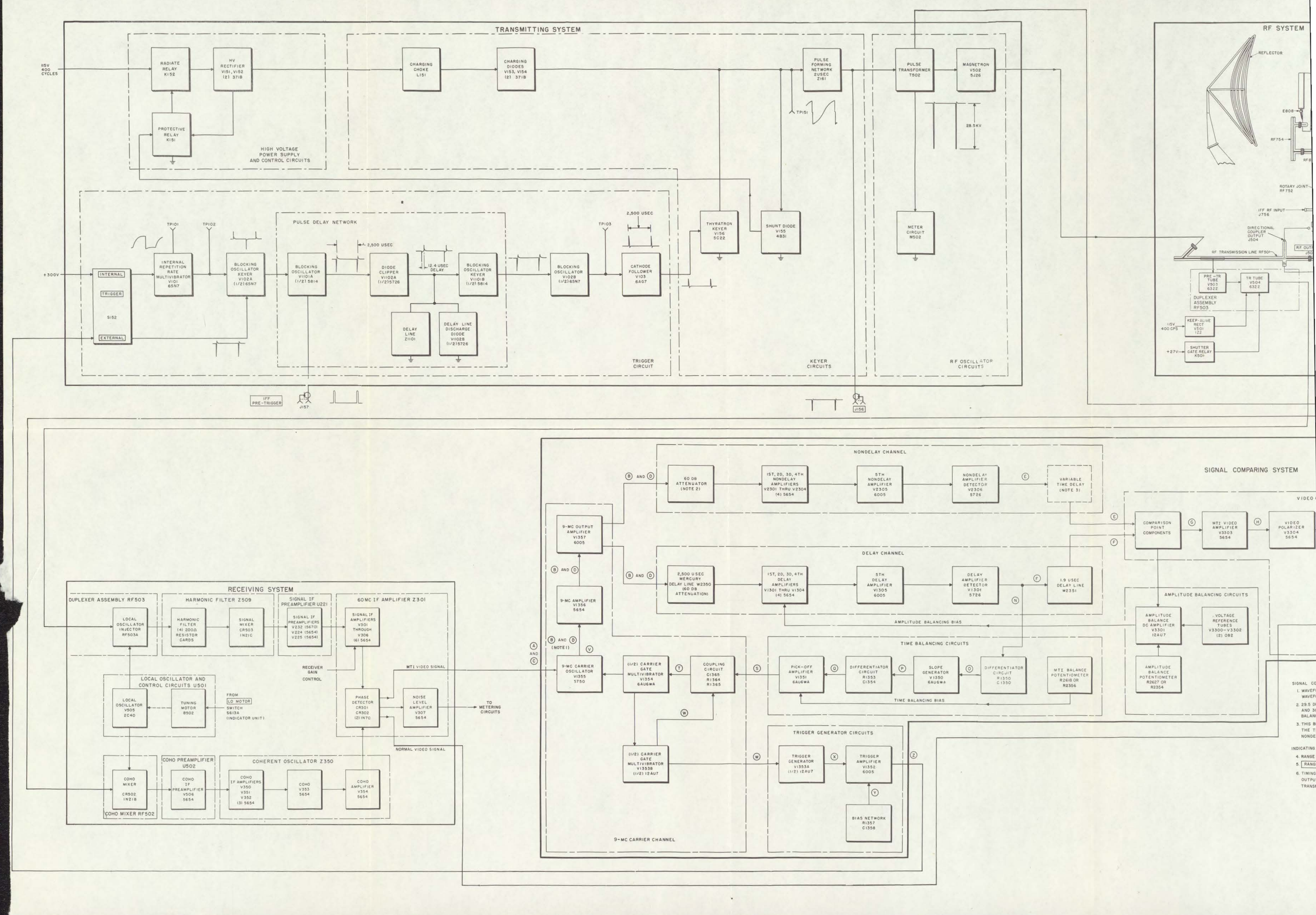
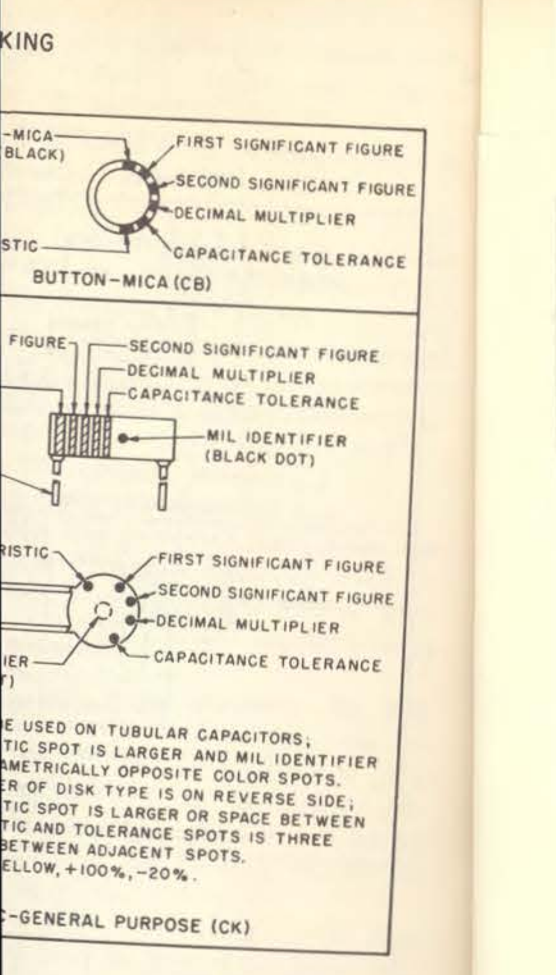


Figure 40. Radio Set AN/TPS-1D, complete block diagram.



TRANSMITTING SYSTEM
115V 400 CYCLES
RADIATE RELAY K152
HV RECTIFIER V151, V152 (2) 3718
PROTECTIVE RELAY K151
HIGH VOLTAGE POWER SUPPLY AND CONTROL CIRCUITS
CHARGING CHOKE L151
CHARGING DIODES V153, V154 (2) 3718
PULSE FORMING NETWORK 2USEC Z161
TP151
PULSE TRANSFORMER T502
MAGNETRON V502 5J26
29.5KV
METER CIRCUIT M502
THYRATRON KEYER V156 5C22
SHUNT DIODE V155 4B31
+300V
INTERNAL
TRIGGER
S152
EXTERNAL
TP101
TP102
INTERNAL REPETITION RATE MULTIVIBRATOR V101 6SN7
BLOCKING OSCILLATOR KEYER V102A (1/2) 6SN7
PULSE DELAY NETWORK
BLOCKING OSCILLATOR V1101A (1/2) 5814
2,500 USEC
DIODE CLIPPER V1102A (1/2) 5726
12.4 USEC DELAY
BLOCKING OSCILLATOR KEYER V1101B (1/2) 5814
DELAY LINE Z1101
DELAY LINE DISCHARGE DIODE V1102B (1/2) 5726
BLOCKING OSCILLATOR V102B (1/2) 6SN7
TP103
2,500 USEC
CATHODE FOLLOWER V103 6AG7
TRIGGER CIRCUIT
KEYER CIRCUITS
RF OSCILLATOR CIRCUITS
IFF PRE-TRIGGER
J157
J156
RF SYSTEM
REFLECTOR
E808
RF754
ROTARY JOINT RF752
IFF RF INPUT J756
DIRECTIONAL COUPLER OUTPUT J504
RF TRANSMISSION LINE RF501
RF OUT
PRE-TR TUBE V503 6322
TR TUBE V504 6322
DUPLEXER ASSEMBLY RF503
115V 400 CPS
KEEP-ALIVE RECT V501 1Z2
+27V
SHUTTER GATE RELAY K501
RECEIVING SYSTEM
DUPLEXER ASSEMBLY RF503
LOCAL OSCILLATOR INJECTOR RF503A
HARMONIC FILTER Z509
HARMONIC FILTER (4) 200Ω RESISTOR CARDS
SIGNAL MIXER CR503 1N21C
SIGNAL IF PREAMPLIFIER U221
SIGNAL IF PREAMPLIFIERS V232 (5670) V224 (5654) V225 (5654)
60MC IF AMPLIFIER Z301
SIGNAL IF AMPLIFIERS V301 THROUGH V306 (6) 5654
RECEIVER GAIN CONTROL
LOCAL OSCILLATOR AND CONTROL CIRCUITS U501
LOCAL OSCILLATOR V505 2C40
TUNING MOTOR B502
FROM LO MOTOR SWITCH S613A (INDICATOR UNIT)
MTI VIDEO SIGNAL
PHASE DETECTOR CR301 CR302 (2) 1N70
NOISE LEVEL AMPLIFIER V307 5654
TO METERING CIRCUITS
NORMAL VIDEO SIGNAL
COHO MIXER CR502 1N21B
COHO MIXER RF502
COHO PREAMPLIFIER U502
COHO IF PREAMPLIFIER V506 5654
COHERENT OSCILLATOR Z350
COHO IF AMPLIFIERS V350 V351 V352 (3) 5654
COHO V353 5654
COHO AMPLIFIER V354 5654
NONDELAY CHANNEL
B AND D
60 DB ATTENUATOR (NOTE 2)
1ST, 2D, 3D, 4TH NONDELAY AMPLIFIERS V2301 THRU V2304 (4) 5654
5TH NONDELAY AMPLIFIER V2305 6005
NONDELAY AMPLIFIER DETECTOR V2306 5726
E
VARIABLE TIME DELAY (NOTE 3)
9-MC OUTPUT AMPLIFIER V1357 6005
B AND D
9-MC AMPLIFIER V1356 5654
B AND D (NOTE 1)
A AND C
V
9-MC CARRIER OSCILLATOR V1355 5750
DELAY CHANNEL
2,500 USEC MERCURY DELAY LINE W2350 (60 DB ATTENUATION)
1ST, 2D, 3D, 4TH DELAY AMPLIFIERS V1301 THRU V1304 (4) 5654
5TH DELAY AMPLIFIER V1305 6005
DELAY AMPLIFIER DETECTOR V1306 5726
F
1.9 USEC DELAY LINE W2351
N
AMPLITUDE BALANCING BIAS
TIME BALANCING CIRCUITS
(1/2) CARRIER GATE MULTIVIBRATOR V1354 6AU6WA
T
COUPLING CIRCUIT C1365 R1364 R1365
S
PICK-OFF AMPLIFIER V1351 6AU6WA
Q
DIFFERENTIATOR CIRCUIT R1353 C1354
P
SLOPE GENERATOR V1350 6AU6WA
O
DIFFERENTIATOR CIRCUIT R1350 C1350
MTI BALANCE POTENTIOMETER R2618 OR R2356
TIME BALANCING BIAS
W
(1/2) CARRIER GATE MULTIVIBRATOR V1353B (1/2) 12AU7
TRIGGER GENERATOR CIRCUITS
TRIGGER GENERATOR V1353A (1/2) 12AU7
X
TRIGGER AMPLIFIER V1352 6005
Z
Y
BIAS NETWORK R1357 C1358
9-MC CARRIER CHANNEL
SIGNAL COMPARING SYSTEM
VIDEO
COMPARISON POINT COMPONENTS
G
MTI VIDEO AMPLIFIER V3303 5654
H
VIDEO POLARIZER V3304 5654
AMPLITUDE BALANCING CIRCUITS
AMPLITUDE BALANCE DC AMPLIFIER V3301 12AU7
VOLTAGE REFERENCE TUBES V3300-V3302 (2) 0B2
AMPLITUDE BALANCE POTENTIOMETER R2627 OR R2354



TOLERANCE 2			TEMPERATURE COEFFICIENT (UUF/UF/°C)
CB	CC OVER 10UUF	CC 10UUF OR LESS	CC
20	20	2	ZERO
	1		-30
2	2		-80
			-150
			-220
	5	0.5	-330
			-470
			-750
		0.25	+30
	10	1	-330(±500) 3
5			+100
10			

STD-C1

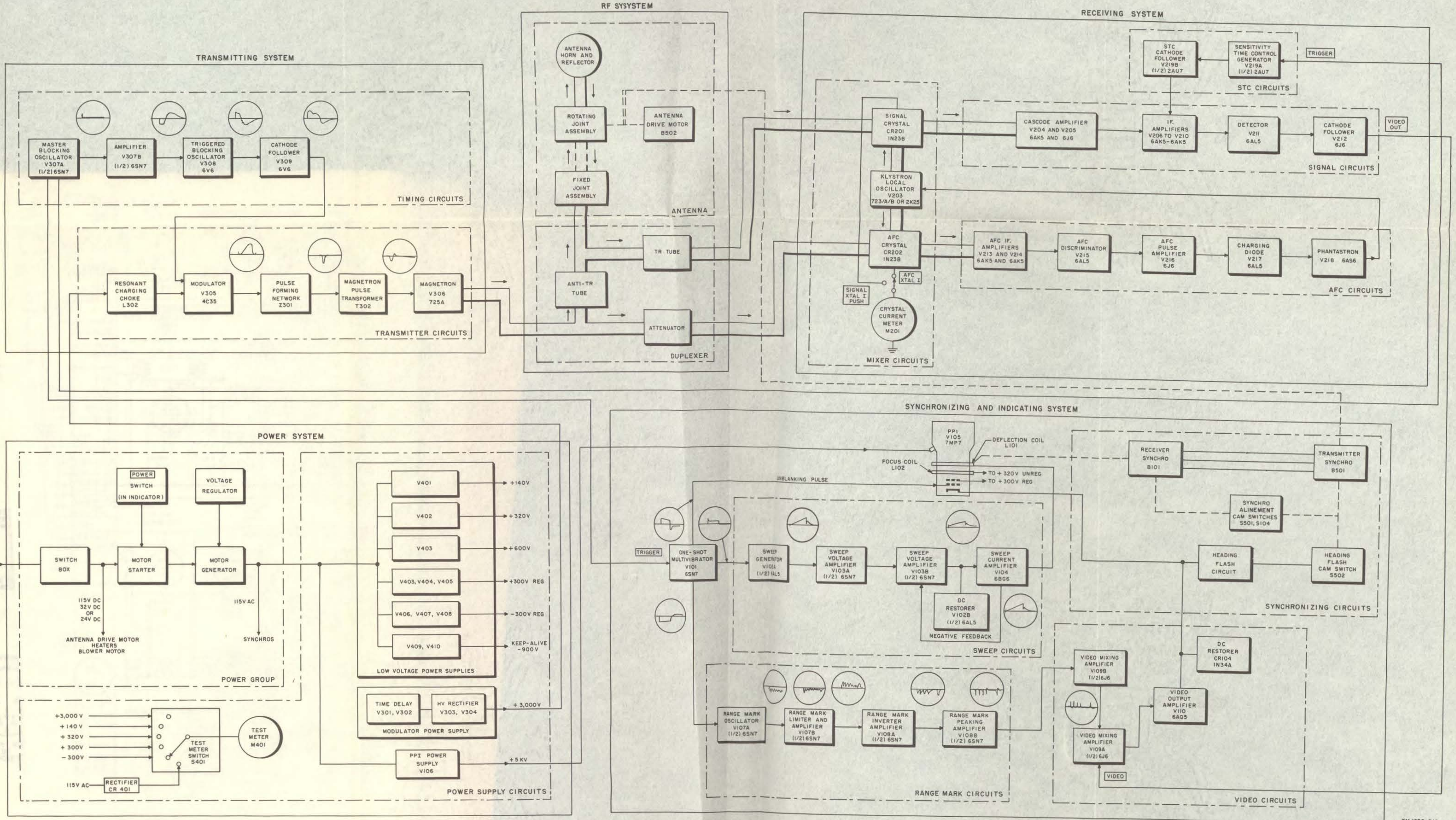


Figure 211. Complete block diagram.

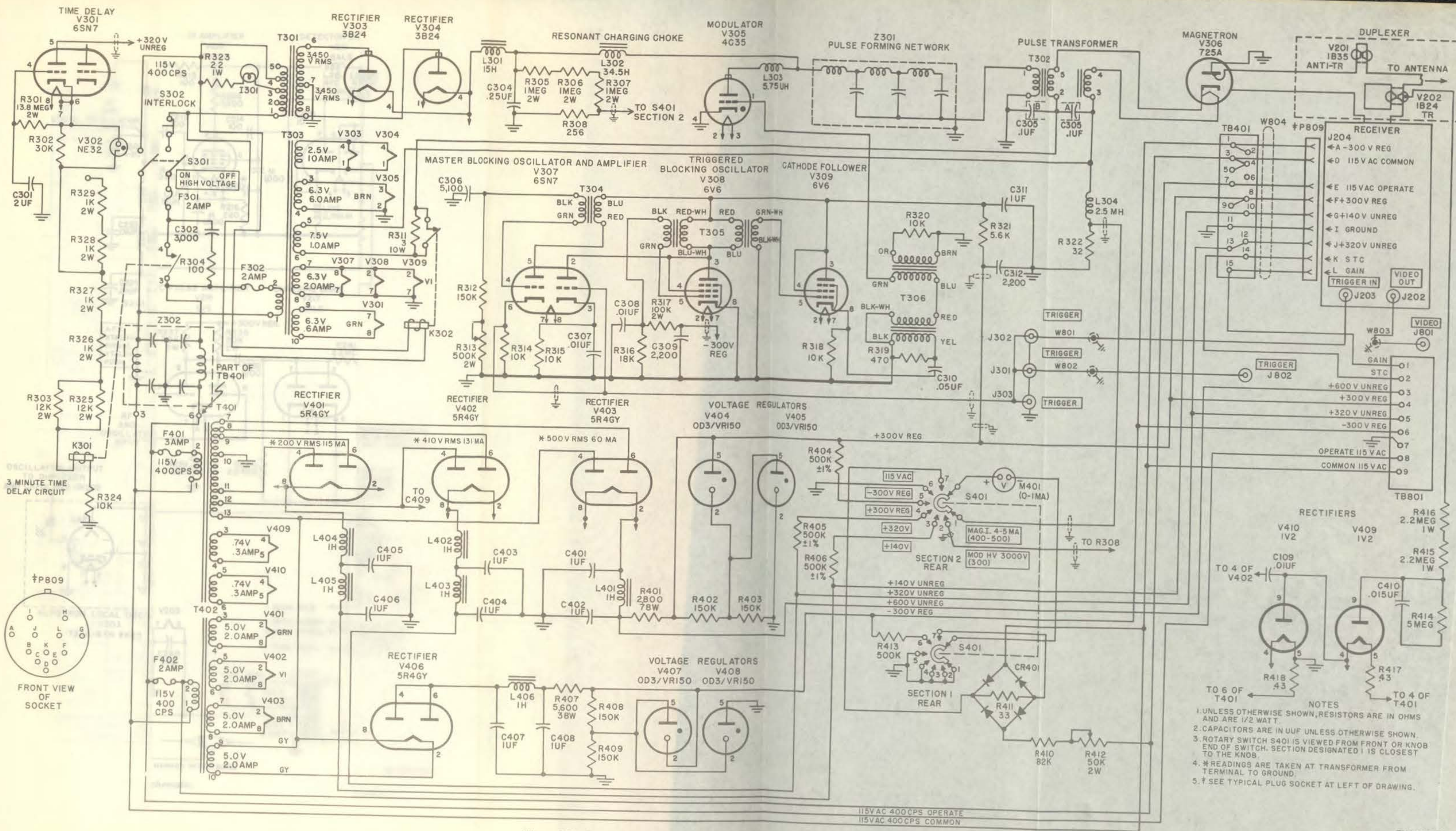


Figure 212. Receiver-Transmitter RT-268/SPN-11 (excluding receiver chassis), schematic.

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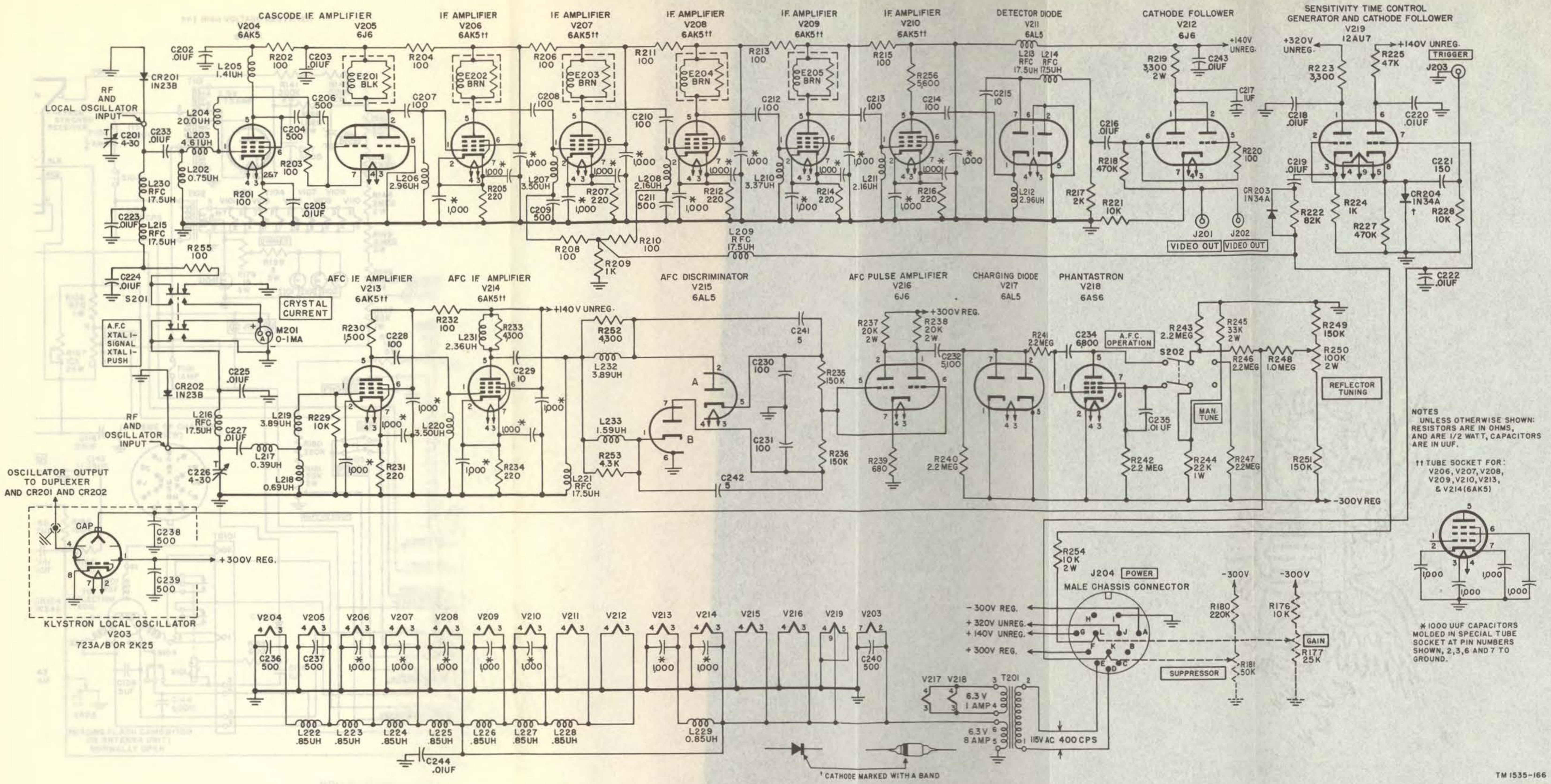

Figure 213.—Receiver R-480/SPN-11, schematic.

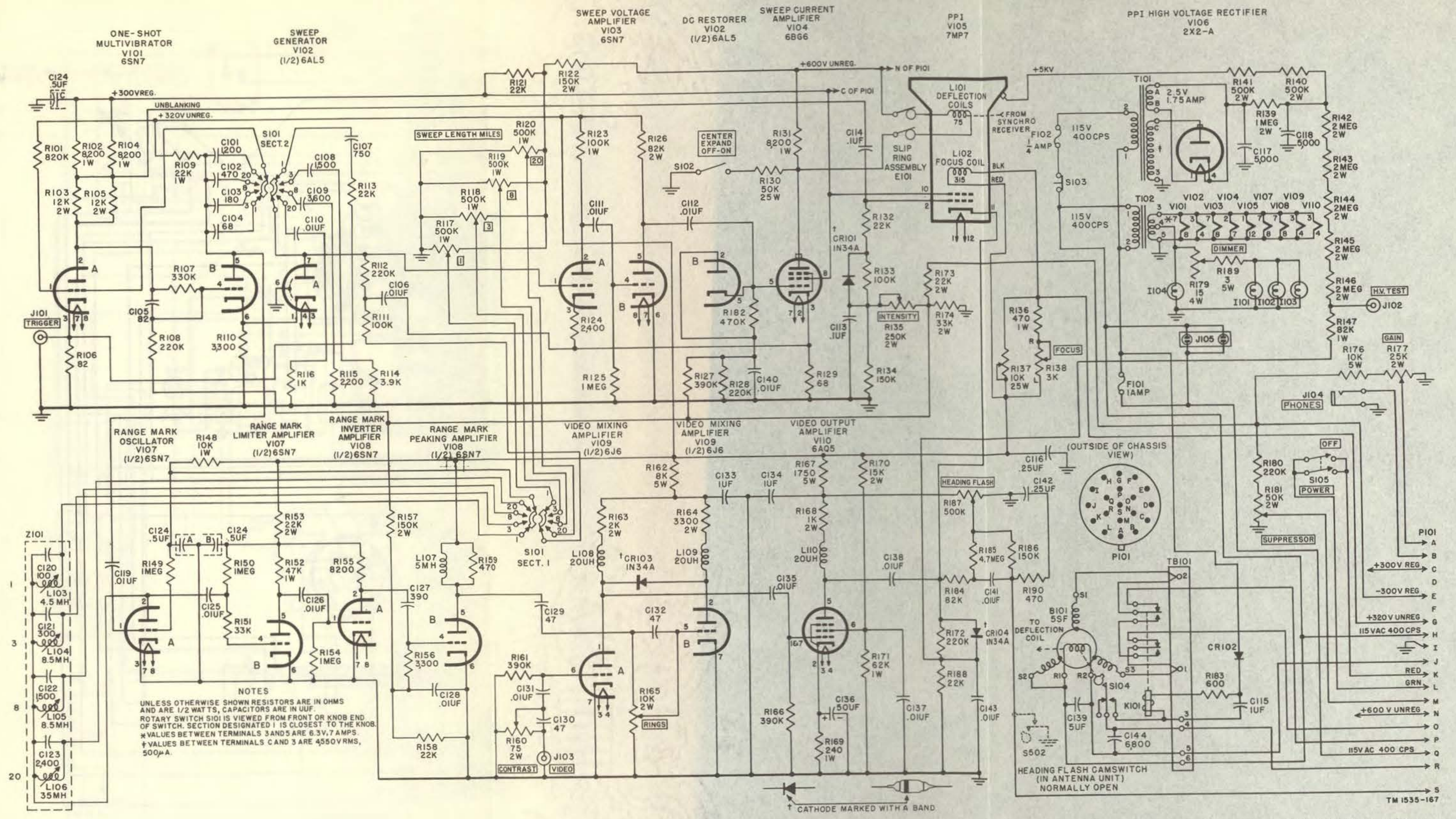

Figure 214. Range and Azimuth Indicator IP-193/SPN-11, schematic.

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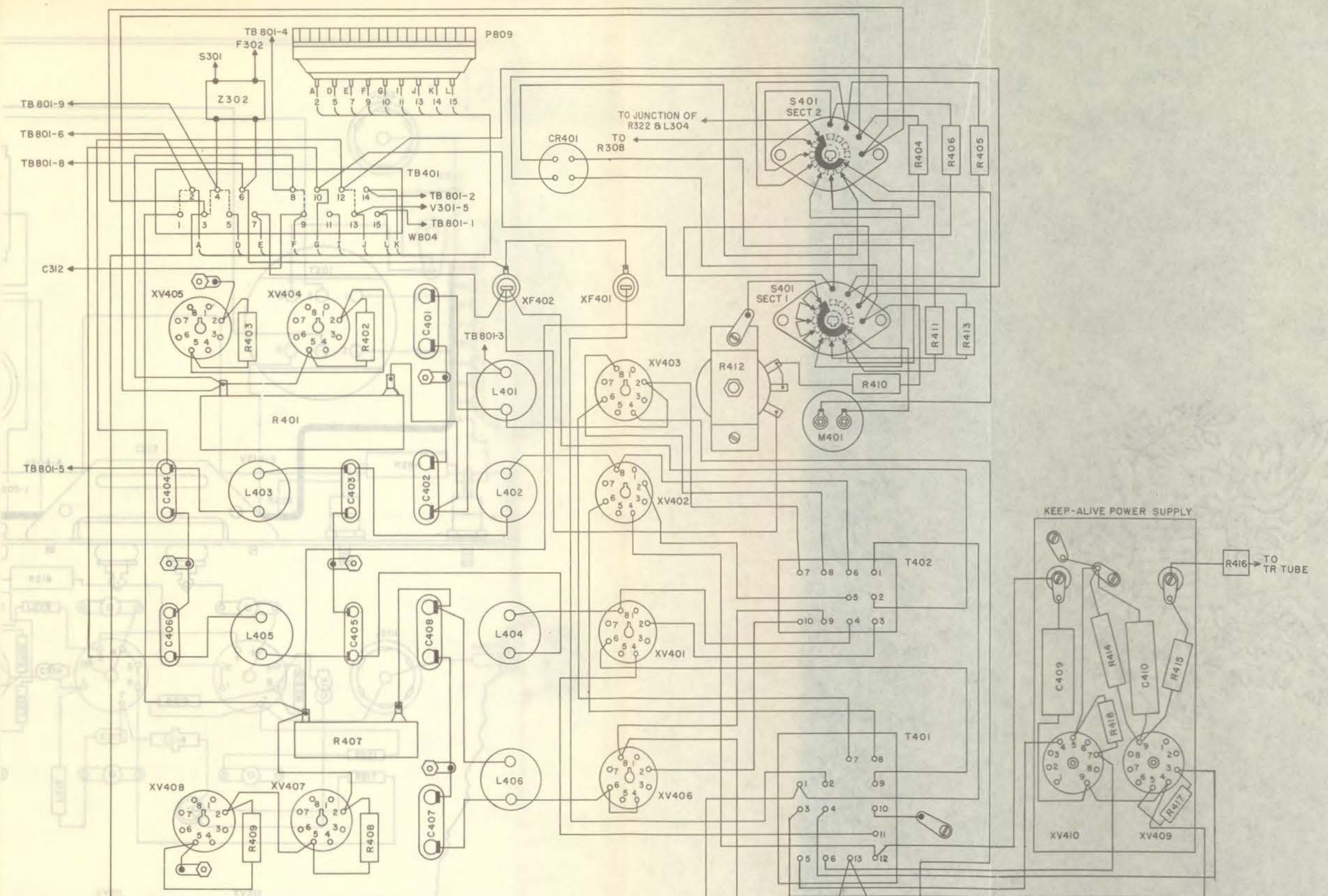

TM 1535-185

Figure 216. Receiver-Transmitter RT–268/SPN–11, low-voltage power supplies, wiring diagram.

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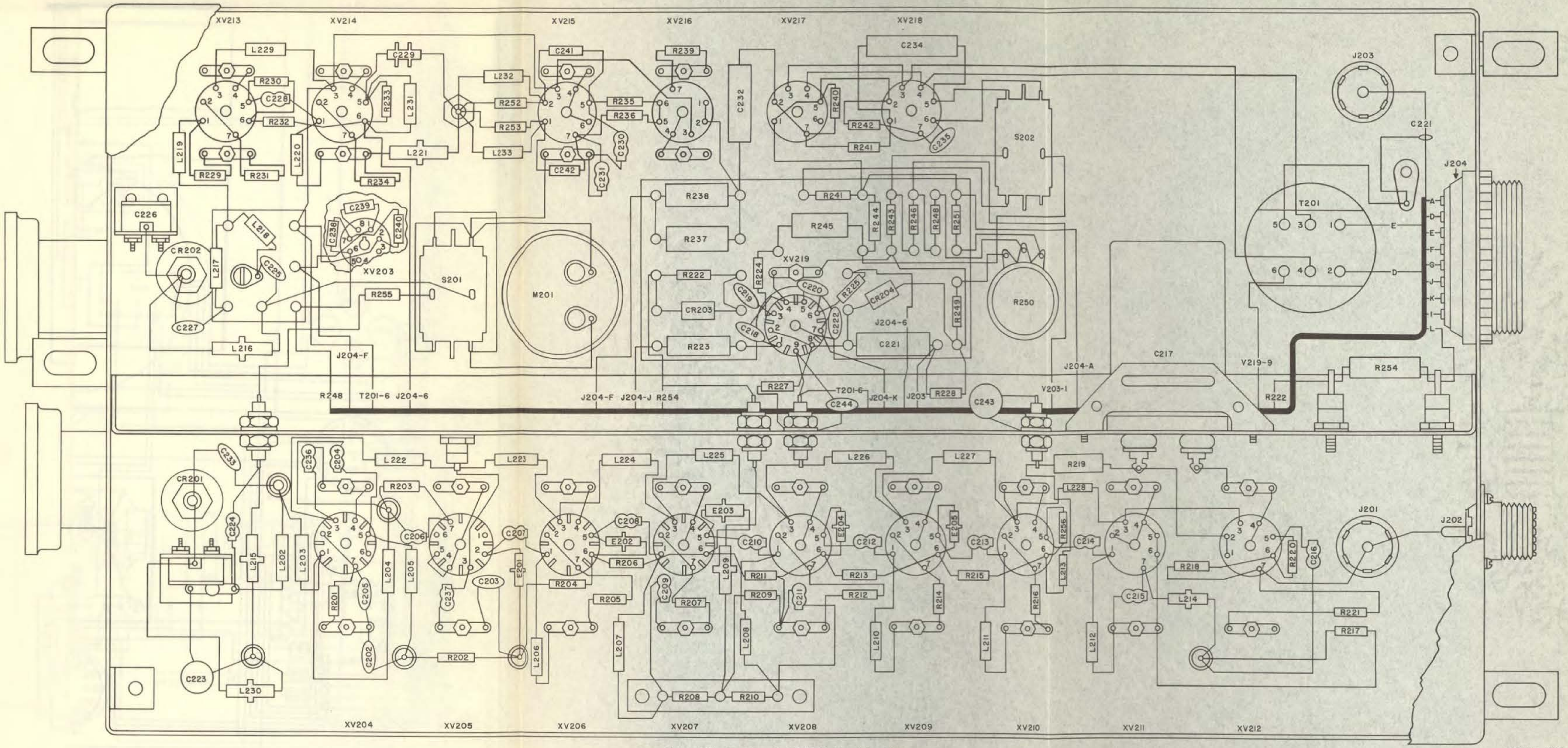

Figure 217.—Receiver R-480/SPN-11, wiring diagram.

TM 1535-160

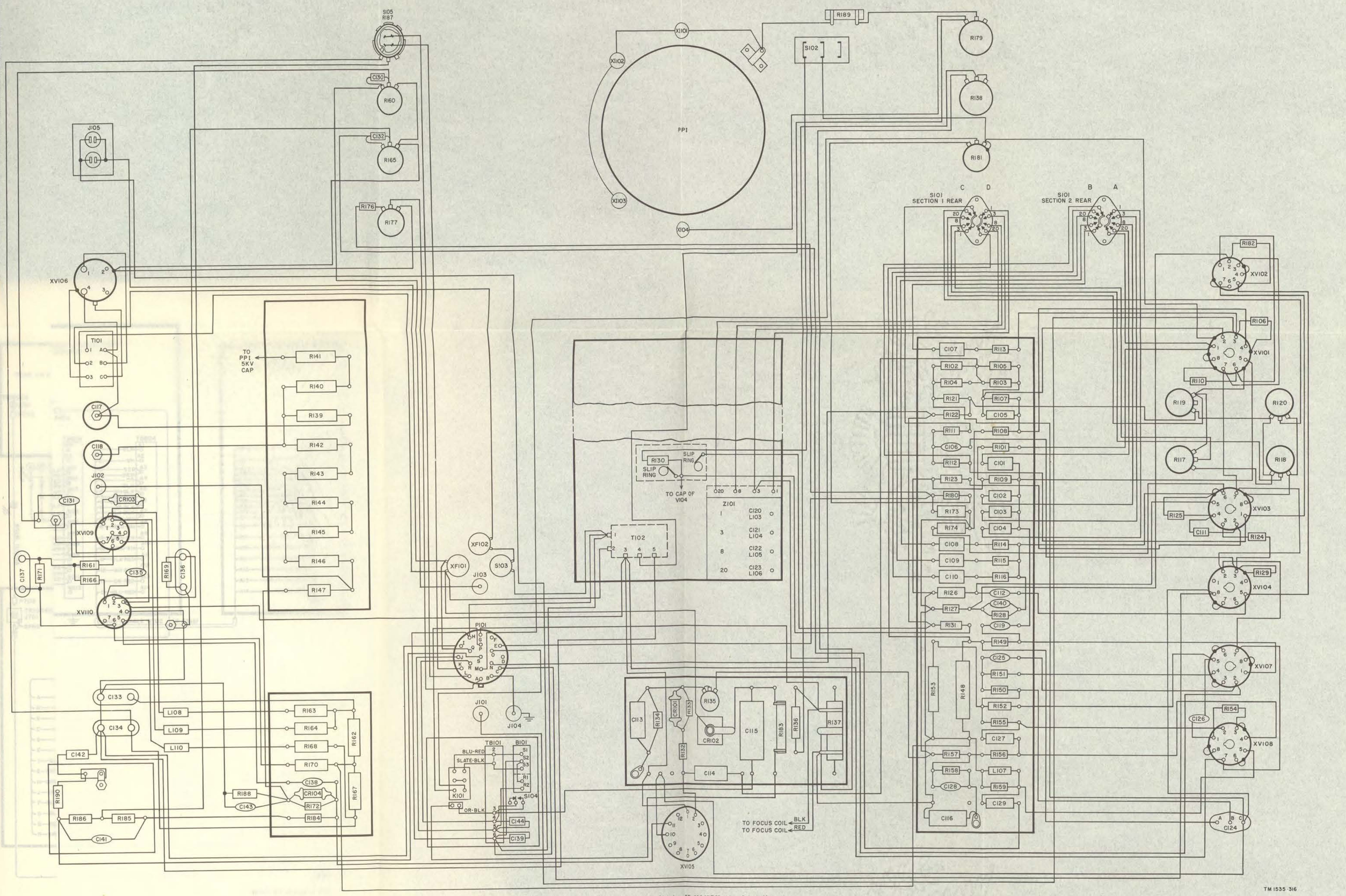

Figure 218. Range and Azimuth Indicator IP-193/SPN-11, wiring diagram.

TM 1535-316

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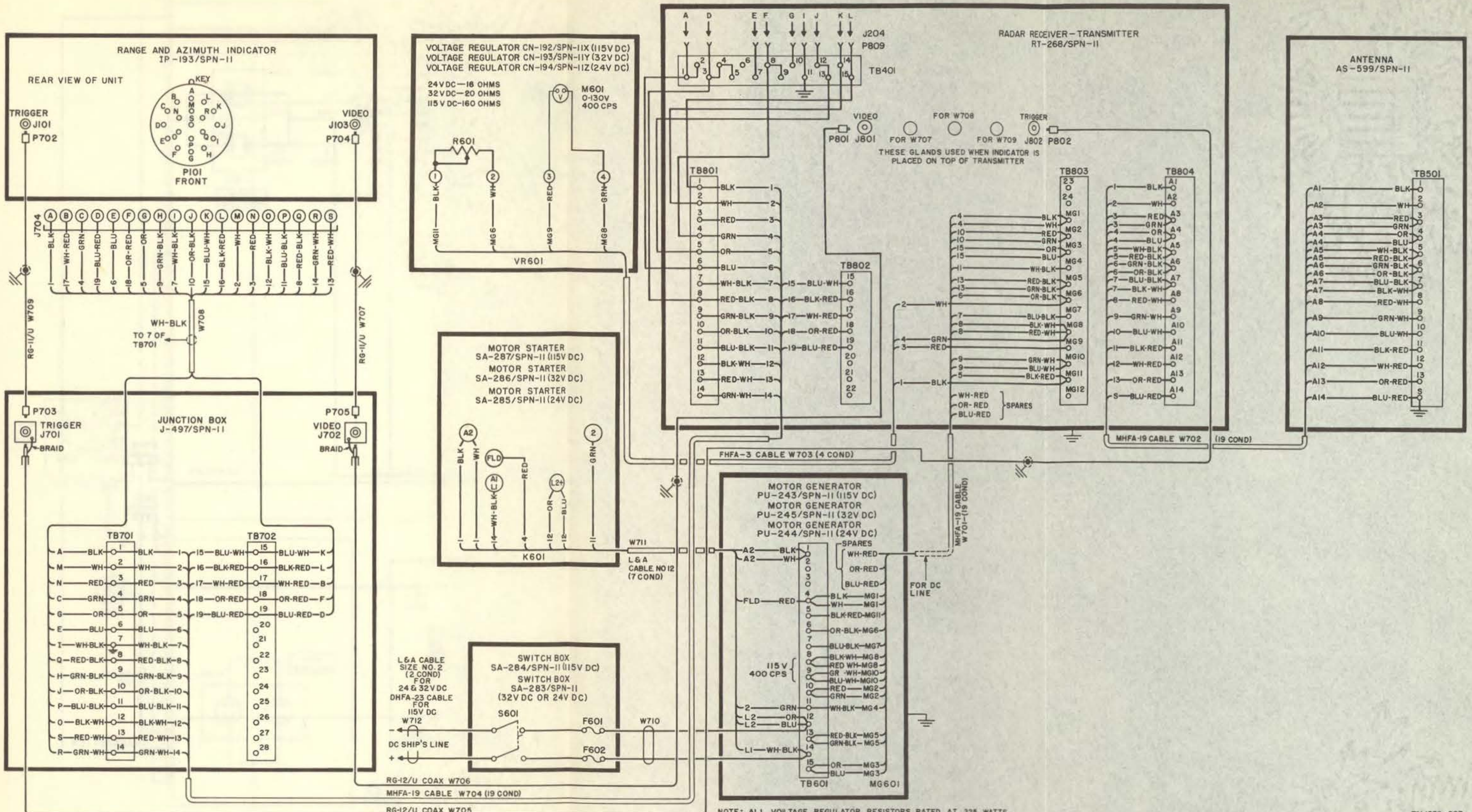

Figure 219. Radar Set AN/SPN-11(*), cabling diagram.

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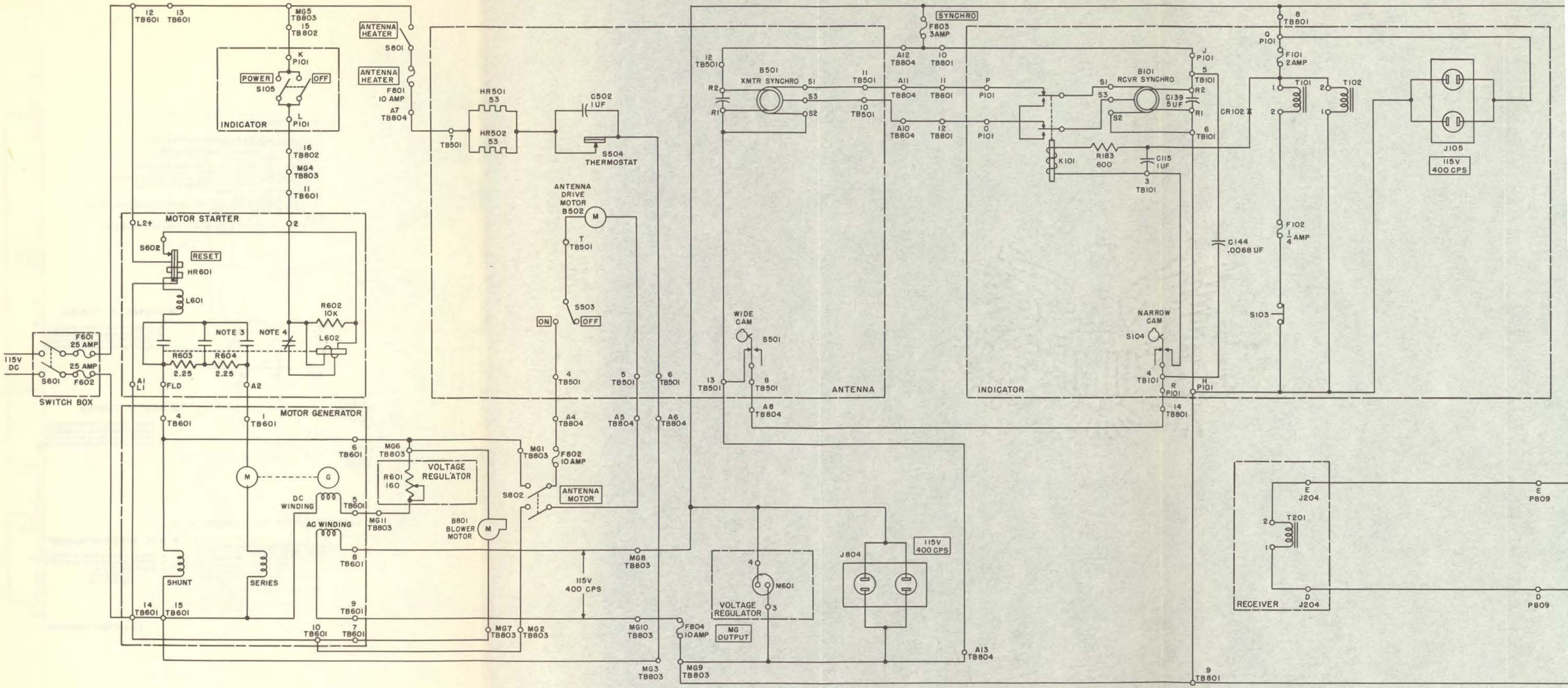


Figure 220. Power distribution diagram.

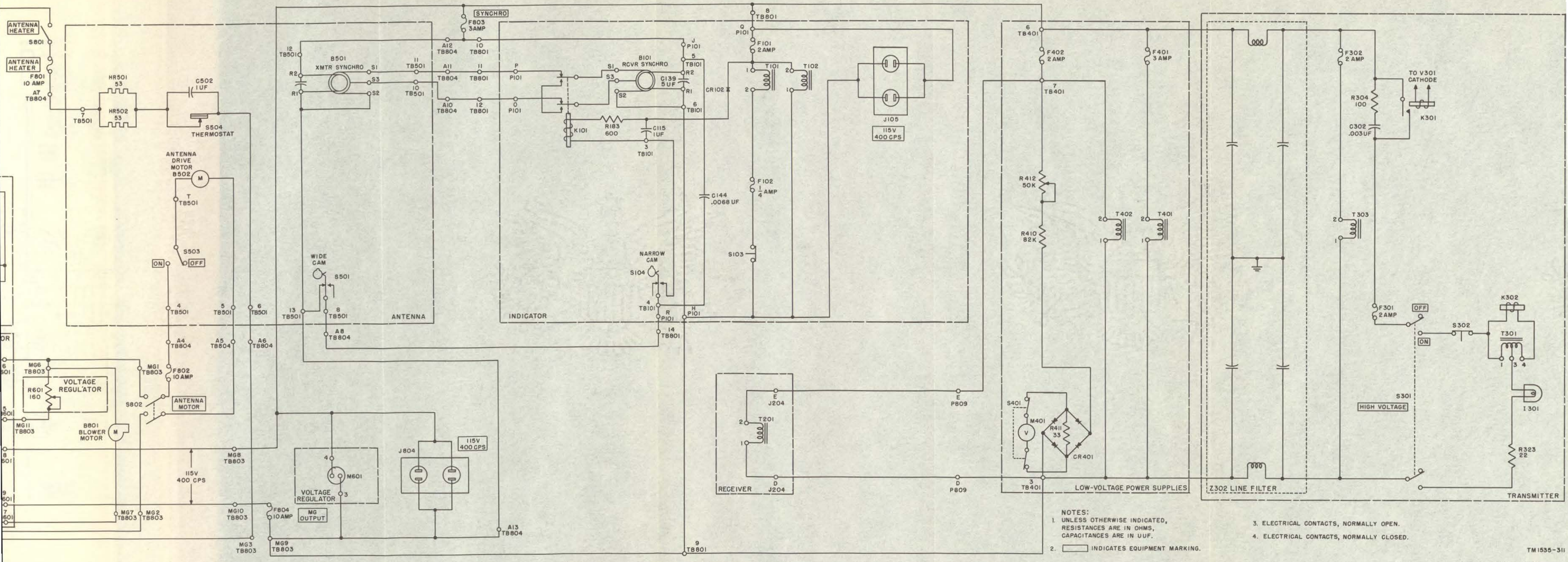
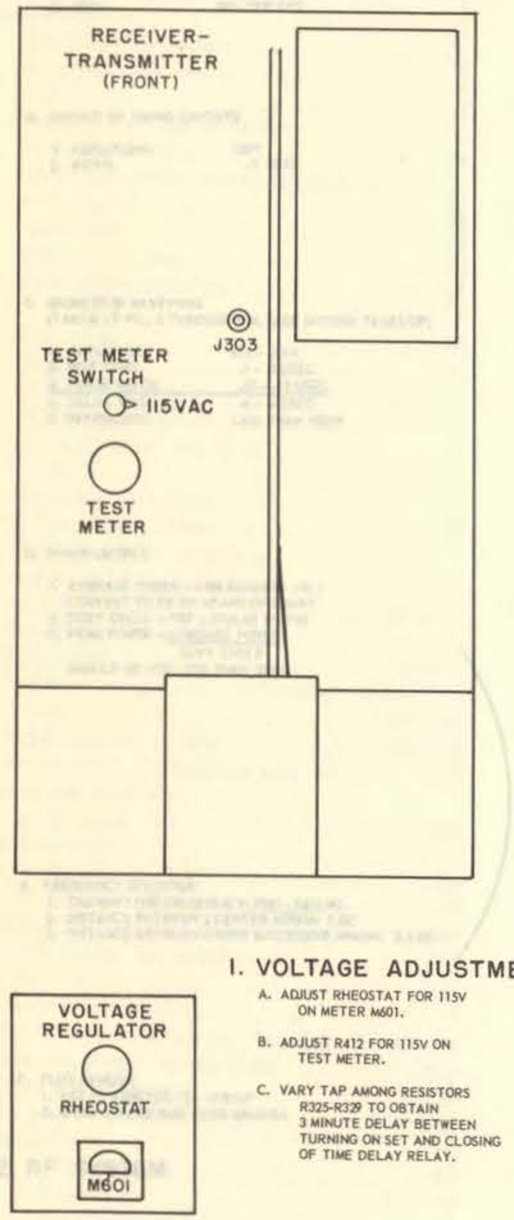
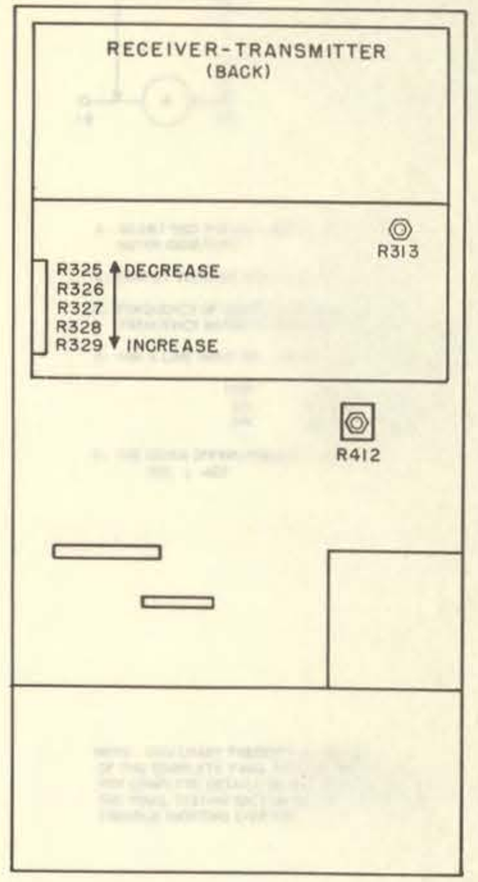


Figure 220. Power distribution diagram.





1. VOLTAGE ADJUSTMENTS

A. ADJUST RHEOSTAT FOR 115V ON METER M601.

B. ADJUST R412 FOR 115V ON TEST METER.

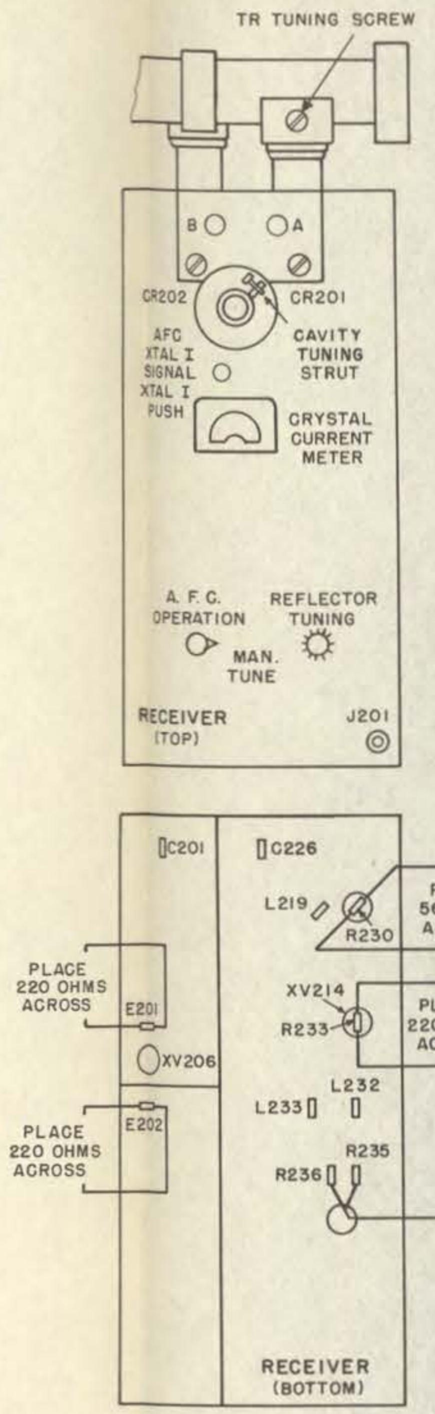
C. VARY TAP AMONG RESISTORS R325-R329 TO OBTAIN 3 MINUTE DELAY BETWEEN TURNING ON SET AND CLOSING OF TIME DELAY RELAY.

2. MASTER BLOCKING OSCILLATOR ADJUSTMENT

A. CONNECT CORD BETWEEN TRIGGER JACK J302 ON RECEIVER-TRANSMITTER AND EXT SYNC JACK ON OSCILLOSCOPE TS-34A/AP.

B. CONNECT OUTPUT OF AUDIO OSCILLATOR TS-382A/U, TUNED TO 1,000 CPS, TO SIGNAL INPUT JACK ON OSCILLOSCOPE.

C. ADJUST R313 FOR STATIONARY SINE WAVE ON OSCILLOSCOPE.

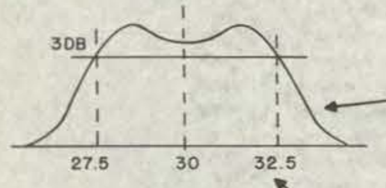


3. MIXER TUNING

A. PLACE A.F.C. OPERATION-MAN. TUNE SWITCH ON MAN. TUNE.
B. CONNECT OSCILLOSCOPE TO V201.
C. ADJUST CAVITY TUNING STRUT AND REFLECTOR TUNING FOR ECHOES ON OSCILLOSCOPE.
D. ADJUST TR TUNING SCREW FOR MAXIMUM AMPLITUDE OF ECHOES.
E. ADJUST A AND B TO KEEP CRYSTAL CURRENT BELOW .75 AMP.
F. ADJUST REFLECTOR TUNING TO PEAK AFC AND SIGNAL CRYSTAL CURRENT.
G. ADJUST CAVITY TUNING STRUT FOR MAXIMUM ECHO AMPLITUDE, COINCIDENT WITH PEAK CURRENT.
H. READJUST TR TUNING SCREW.
I. PLACE A.F.C. OPERATION -MAN. TUNE SWITCH ON A.F.C. OPERATION, ECHO AMPLITUDE SHOULD NOT CHANGE.

CHECK

KLYSTRON SHOULD OPERATE IN MODE OBTAINED IN MOST COUNTERCLOCKWISE POSITION OF CAVITY TUNING STRUT.

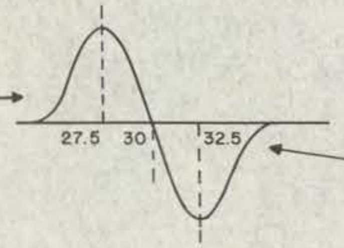


4. SIGNAL IF. TUNING

A. CONNECT TS-452A/U, TUNED TO 30MC, TO CR201 JACK.
B. PLACE 220 OHM RESISTOR ACROSS E201 AND E202.
C. CONNECT TRAVELING DETECTOR TO CATHODE OF V206.
D. ADJUST C201 FOR 3DB LINE TO CROSS CURVE AS SHOWN.

5. AFC IF. TUNING

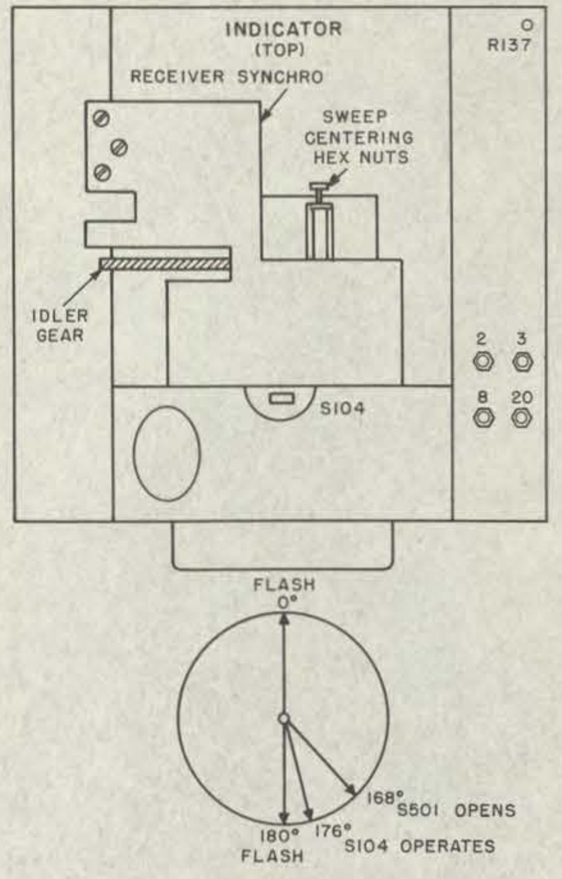
A. CONNECT TS-452A/U, TUNED TO 30 MC, TO CR202 JACK.
B. PLACE 560 OHMS ACROSS R230, 220 OHMS ACROSS R233.
C. CONNECT TRAVELING DETECTOR TO CATHODE OF V214.
D. ADJUST C226 FOR 3 DBLINE TO CROSS CURVE AS SHOWN.



6. AFC DISCRIMINATOR TUNING

A. CONNECT TS-452A/U, TUNED TO 30 MC, TO CR202 JACK.
B. CONNECT OSCILLOSCOPE AT JUNCTION OF R235 AND R236.
C. ADJUST L219 FOR 30 MC;
L232 FOR 27.5 MC
L233 FOR 32.5 MC

Figure 221. Complete alinement chart.

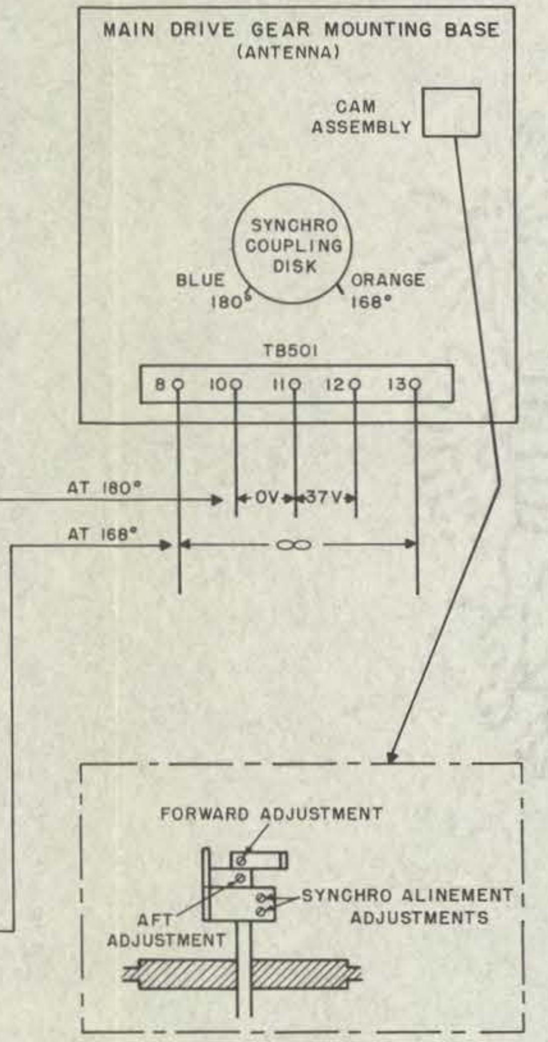


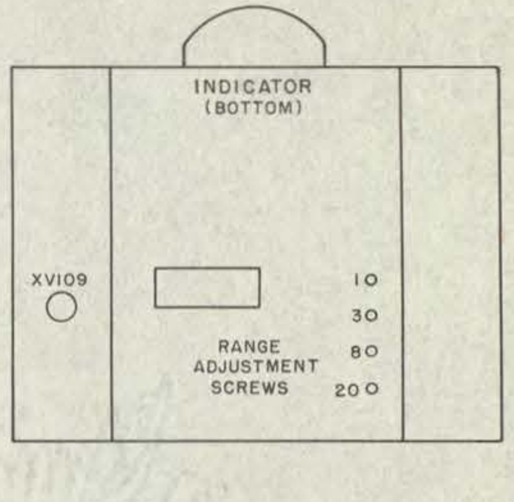
8. ALINEMENT OF SYNCHRONIZING CIRCUITS

A. WITH HORN AT 180°, ALINE ELECTRICALLY RECEIVER SYNCHRO WITH TRANSMITTER SYNCHRO. READING SHOULD BE:
B. WITH HORN AT 168° ADJUST SYNCHRO ALINEMENT CAM (ANTENNA) TO HAVE S501 OPEN. READING SHOULD BE:
C. ADJUST IDLER GEAR AND SYNCHRO ALINEMENT CAM TO MAKE S104 OPERATE AT 176°
D. ROTATE RECEIVER SYNCHRO TO CORRECT FOR BEARING ERROR.
E. ADJUST FORE AND AFT FLASH CAMS TO GIVE flashes at 0° AND 180°

7. PPI ADJUSTMENTS

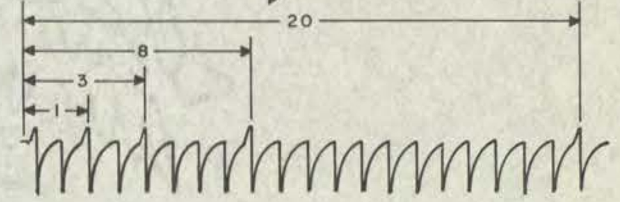
A. R137 ADJUSTS THE FOCUS.
B. WITH CENTER EXPAND SWITCH ON ADJUST SWEEP CENTERING HEX NUTS UNTIL SWEEP COINCIDES WITH CURSOR CIRCLE.
C. SWEEP LENGTH ADJUSTMENTS:
1. ADJUST 1 FOR 2 RANGE RINGS
2. ADJUST 3 FOR 3 RANGE RINGS
3. ADJUST 8 FOR 4 RANGE RINGS
4. ADJUST 20 FOR 4 RANGE RINGS





9. RANGE CALIBRATION

A. CONNECT V109 PLATE TO TS-239 OSCILLOSCOPE INPUT
B. CONNECT TS-102A/AP 500 YD. CALIBRATION MARKERS TO VERTICAL PLATES OF OSCILLOSCOPE.
C. SYNCHRONIZE TS-102A/AP AND TS-239 WITH TRIGGER FROM J303.
D. TURN RANGE ADJUSTMENT SCREWS SO POSITIVE RANGE MARKS FALL ON THE TRAILING EDGE OF THE APPROPRIATE CALIBRATION MARKERS.



NOTE: THIS CHART PRESENTS A SUMMARY OF THE COMPLETE ALINEMENT PROCEDURE. FOR COMPLETE DETAILS ON ANY SPECIFIC ALINEMENT PROCEDURE REFER TO THE ALINEMENT AND ADJUSTMENT SECTION OF THE APPROPRIATE TROUBLE SHOOTING CHAPTER.

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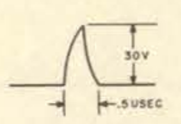
1. TRANSMITTING SYSTEM

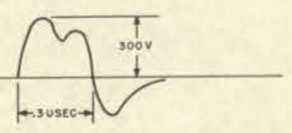
A. TRIGGER FROM MASTER BLOCKING OSCILLATOR

1. AMPLITUDE: 30V
2. WIDTH: .5 USEC
3. PRF: 900-1200 CPS



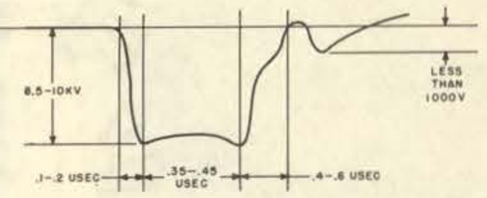
B. OUTPUT OF TIMING CIRCUITS

1. AMPLITUDE: 300V
2. WIDTH: .3 USEC



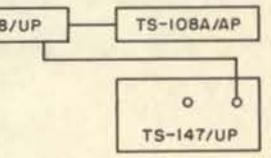
C. MAGNETRON WAVEFORM
(TAKEN AT FIL. C THROUGH VOLTAGE DIVIDER TS-265/UP)

1. AMPLITUDE: 8.5 – 10 KV
2. RISE TIME: .1 – .2 USEC
3. PULSE WIDTH: .35 – .45 USEC
4. DELAY TIME: .4 – .6 USEC
5. OVERSHOOT: LESS THAN 1000V

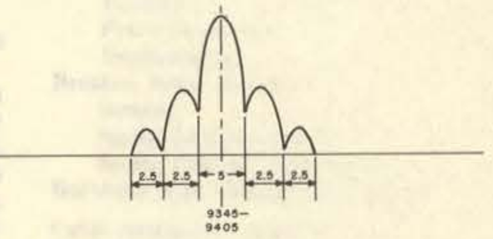


D. POWER OUTPUT

1. AVERAGE POWER = DBM READING +30.5
CONVERT TO KW BY MEANS OF CHART
2. DUTY CYCLE = PRF × (PULSE WIDTH)
3. PEAK POWER = AVERAGE POWER / DUTY CYCLE
SHOULD BE NOT LESS THAN 30 KW



E. FREQUENCY SPECTRUM
1. TRANSMITTER FREQUENCY: 9345 - 9405 MC
2. DISTANCE BETWEEN 2 CENTER MINIMA: 5 MC
3. DISTANCE BETWEEN OTHER SUCCESSIVE MINIMA: 2.5 MC



F. FLUX DENSITY
1. USE FLUXMETER TS-15B/AP
2. SHOULD READ 5050 – 5150 GAUSSES

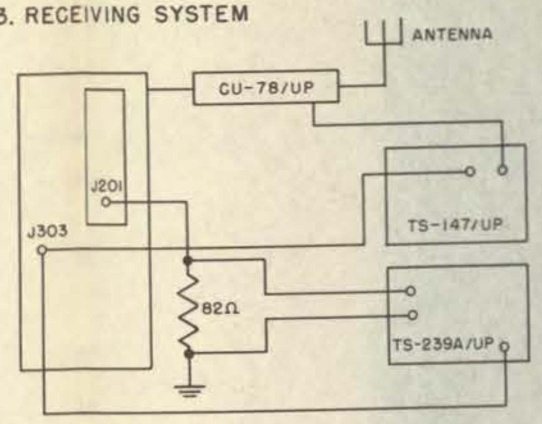
G. SPARK GAPS

1. E302 : .72" GAP
2. E301 : .36" GAP

2. RF SYSTEM

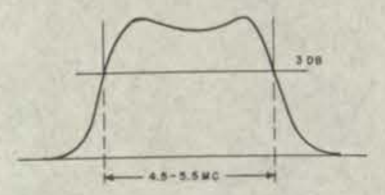
A. GAP BETWEEN REFLECTOR AND GAUGE: 1/32"
B. BACKLASH (AS MEASURED FROM END OF REFLECTOR): 1/4" OR LESS

3. RECEIVING SYSTEM



A. BANDWIDTH
1. SHOULD BE 4.5 – 5.5 MC

B. SENSITIVITY
1. CALCULATE AS FOLLOWS:
SENSITIVITY = DBM READING + 30.5
2. SHOULD BE NOT LESS THAN 90 DB



4. SYNCHRONIZING AND INDICATING SYSTEM

A. WITH HORN AT 180° THE BLUE MARKS SHOULD AGREE WITHIN 1/32". ALSO, READ OV BETWEEN 10 AND 11 OF TB 501.

B. WITH HORN AT 168° THE ORANGE MARKS SHOULD AGREE WITHIN 1/32".

C. S501 SHOULD OPEN AT 168° AND STAY OPEN FOR 33° ± 3°

D. S104 SHOULD CLOSE AT 176° AND STAY CLOSED FOR 15° ± 5°

E. FLASHES SHOULD OCCUR AT
0° ± 1/2°
180 ± 1/2°

F. THE CENTER EXPAND CIRCLE SHOULD BE 1/2" ± 1/8"

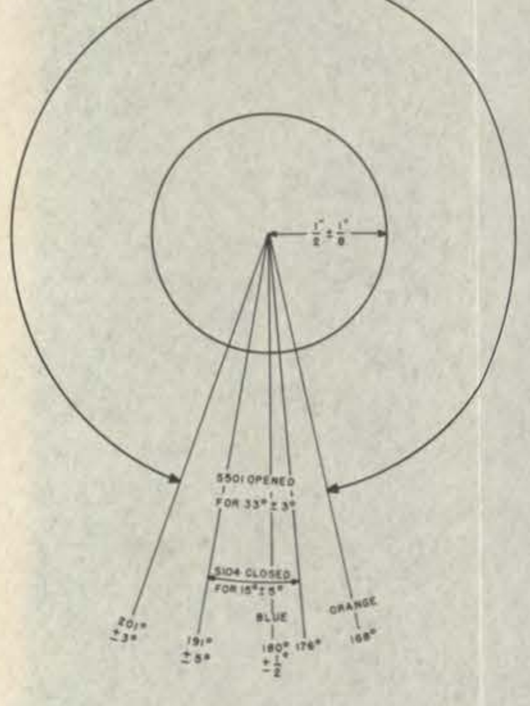
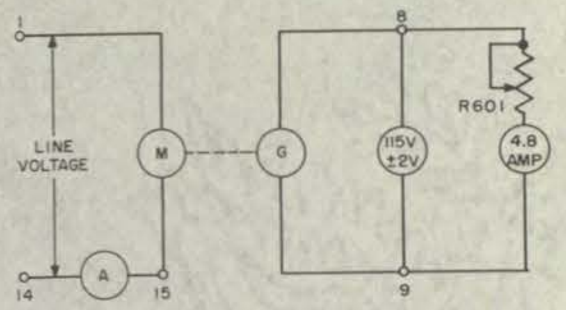


Figure 222. Complete final testing chart.

5. POWER SYSTEM



A. ADJUST R601 FOR 4.8 AMPS. OUTPUT OF MOTOR GENERATOR.

B. OUTPUT VOLTAGE SHOULD BE 115V ± 2V

C. FREQUENCY OF OUTPUT, AS MEASURED WITH FREQUENCY METER TS-328/U, SHOULD BE 400 CPS ± 40 CPS

D. FOR A LINE INPUT OF: INPUT CURRENT SHOULD BE:

115V	7 AMPS ± 1 AMP
32V	31 AMPS ± 4 AMPS
24V	38 AMPS ± 6 AMPS

E. THE BRUSH SPRING PRESSURE SHOULD BE 6OZ. ± .6OZ

NOTE: THIS CHART PRESENTS A SUMMARY OF THE COMPLETE FINAL TESTING PROCEDURE. FOR COMPLETE DETAILS ON ANY TEST REFER TO THE FINAL TESTING SECTION OF THE APPROPRIATE TROUBLE SHOOTING CHAPTER.

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[AG 413.44 (15 Nov 54)]

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