NAVSHIPS 900,946

INSTRUCTION BOOK

for

RADAR EQUIPMENTS

NAVY MODELS SR AND SR-a

WESTINGHOUSE ELECTRIC CORPORATION
2519 Wilkens Avenue Baltimore, Md.

NAVY DEPARTMENT BUREAU OF SHIPS

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CONTRACT NXsr-46032
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A to C	Original	5-0 to 5-15	Original
i to xxiii	Original	6-0 to 6-21	Original
1-0 to 1-48	Original	7-0 to 7-298	Original
2-1 to 2-168	Original	8-1 to 8-223	Original
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To: All Activities concerned with the Installation, Operation and Maintenance of the Subject Equipment.

Subj: Instruction Book for Radar Equipments, Navy Models SR and SR-a, NAVSHIPS 900,946.

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E.W. MILLS
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TABLE OF CONTENTS

Paragraph Title Page

SECTION I. GENERAL DESCRIPTION

1. RADAR EQUIPMENTS COVERED 1-1
   a. General 1-1
   b. SR Equipment 1-1
   c. SR-a Equipment 1-1

2. PURPOSE AND BASIC PRINCIPLES OF OPERATION 1-1

3. DESCRIPTION OF SYSTEMS 1-3
   a. SR System (NXsr-30306) 1-3
   b. SR System (NXsr-46032) 1-9
   c. SR-a System 1-9

4. DESCRIPTION OF MAJOR UNITS 1-9
   a. Transceiver Console CAY-43ACM (SR Only) 1-9
   b. Keyer Unit CAY-67AAD (SR Only) 1-11
   c. Monitor Receiver CAY-46AKD 1-12
   d. Monitor Scope CAY-55AFD 1-12
   e. Transceiver Console CAY-43ADK (SR-a Only) 1-13
   f. Modulator CAY-50AGU (SR-a Only) 1-14
   g. Indicator Console CAY-46ADJ 1-14
   h. Console Receiver CAY-46ADH 1-16
   i. PPI Indicators CAY-55ADV and CAY-55ADV-1 1-17
   j. Range Scope CAY-55AFB 1-19
   k. IFF Coordinator CAY-23AEV 1-20
   l. Bearing Indicator CAY-55AFC 1-20
   m. General Control Unit CAY-23AEW 1-21
   n. Cradle CAY-10313 1-22
   o. Rotation Control Unit CAY-50AEB 1-22
   p. Servo Amplifier CAY-50AEU 1-23
   q. Rectifier Power Unit CAY-20ACY 1-23
   r. Cradle CAY-10314 1-23
   s. Echo Box Antenna CAY-66AHK 1-23
   t. Synchro Unit CM-211103 1-25
   u. Amplifier Unit CM-50131 1-25
   v. Servo Generators CAY-211192 and CAY-211192A 1-26
   w. Voltage Stabilizer CG-301252 1-26
   x. Auto-Dehydrator CAKB-10AEK 1-26
   y. Antenna Pedestal CAJS-21ACP 1-27
   z. Antennas COD/CLP-66AHE and COD/CLP-66AHG 1-29
   aa. Motor Generators 1-32
   ab. Magnetic Controllers 1-34
   ac. Voltage Regulators 1-35
   ad. Pushbutton Stations 1-35
   ae. Controller Disconnect Line Switch CWU-24429 (NXsr-46032) 1-35
   af. Connector Navy Type 49261 (UG-32/U) 1-36

5. REFERENCE DATA 1-36
   a. Nomenclature 1-36
   b. Contract Number and Date 1-36
   c. Contractor 1-36
   d. Cognizant Naval Inspector 1-36
   e. Number of Packages per Shipment 1-36
   f. Cubical Contents and Weight 1-36
   g. Transmitter Data 1-37
   h. Receiver Data 1-37
   i. Power Factor 1-37
   j. Power Supply Characteristics 1-37
   k. Power Equipment 1-37
   l. Heat Dissipation of Major Units 1-38

6. TABLES 1-38

TABLE OF CONTENTS (Continued)

Paragraph	Title	Page
	SECTION II. THEORY OF OPERATION	
1.	GENERAL	2-1
2.	FUNCTIONAL DESCRIPTION OF SR EQUIPMENT	2-1
	a. Transmitting System	2-1
	b. Receiving System	2-2
	c. Indicating System	2-2
	d. Antenna Positioning System	2-7
3.	FUNCTIONAL DESCRIPTION OF SR-a EQUIPMENT	2-8
	a. Transmitting System	2-8
4.	SR TRANSMITTING SYSTEM	2-8
	a. General	2-8
	b. Keyer Unit CAY-67AAD	2-11
	c. Transmitting Oscillator	2-18
	d. Duplexer	2-18
	e. High Voltage Rectifier	2-23
	f. SR Control Circuits	2-24
	g. Filament Control Circuits	2-24
	h. Main Control Circuit	2-26
	i. Plate Voltage Control Circuits	2-27
	j. Radiation Control Circuit	2-29
5.	SR-a TRANSMITTING SYSTEM	2-30
	a. General	2-30
	b. Description	2-30
	c. Modulator CAY-50AGU	2-32
	d. High Voltage Rectifier	2-37
	e. Transmitting Oscillator	2-38
	f. Control Circuits	2-39
6.	R-F TRANSMISSION SYSTEM	2-40
	a. General	2-40
	b. Antenna Cables	2-40
	c. R-F Lines in Antenna Pedestal	2-43
7.	RADAR ANTENNAS	2-43
	a. General	2-43
	b. Blue Antenna	2-43
	c. Yellow-Green Antenna	2-45
8.	IFF ANTENNAS	2-45
	a. General	2-45
	b. H.F. IFF Antenna	2-45
	c. V.H.F. IFF Antenna	2-45
	d. U.H.F. IFF Antenna	2-45
9.	ECHO BOX ANTENNA	2-46
10.	MONITOR RECEIVER CAY-46ADK	2-46
	a. General	2-46
	b. R-F Preamplifier	2-47
	c. Local Oscillator	2-48
	d. Converter	2-48
	e. First and Second I-F Amplifiers	2-49
	f. Third I-F Amplifier	2-49
	g. Fourth I-F Amplifier	2-49
	h. Diode Detector	2-50
	i. Echo Box	2-51
	j. Power Supply	2-52

TABLE OF CONTENTS (Continued)

Paragraph Title Page

SECTION II. THEORY OF OPERATION (Continued)

11. MONITOR SCOPE 2-52
    a. General 2-52
    b. Description 2-52
    c. Trigger Amplifier 2-52
    d. Gate Circuit 2-54
    e. Sweep Circuit 2-55
    f. Video Amplifier 2-56
    g. Internal Trigger Generator 2-57
    h. Trigger Output Amplifier 2-57
    i. Range Switch 2-58
    j. Power Supplies 2-58

12. INDICATOR CONSOLE CAY-46ADJ 2-59
    a. General 2-59
    b. Trigger Circuit 2-59
    c. Console Receiver 2-59
    d. Range Scope 2-62
    e. IFF Coordinator 2-64
    f. PPI Indicator 2-65
    g. Bearing Indicator 2-65
    h. General Control Unit 2-66
    i. Termination of Pulse Lines 2-67

13. CONSOLE RECEIVER 2-67
    a. General 2-67
    b. Anti-jamming Rejection Filters 2-68
    c. Variable Selectivity Anti-jamming Circuit 2-68
    d. Third I-F Amplifier 2-70
    e. Fourth and Fifth I-F Amplifiers 2-73
    f. Detector 2-73
    g. AVC Anti-jamming Circuits 2-74
    h. Balanced Video Amplifier 2-74
    i. Video Amplifier and Cathode Follower 2-75
    j. Video Limiter and Mixer 2-75
    k. Video Output Cathode Followers 2-76
    l. Power Supply 2-77
    m. Remote Controls 2-77
    n. Interconnection Circuits 2-77

14. RANGE SCOPE 2-77
    a. General 2-77
    b. Gate Circuit 2-79
    c. Sweep Circuit 2-81
    d. Phantastron Circuit 2-84
    e. Range Marker Circuits 2-89
    f. Video Circuits 2-91
    g. Cathode Ray Tube Circuits 2-94
    h. Power Supplies 2-95

15. IFF COORDINATOR 2-96
    a. General 2-96
    b. Sequence of IFF Operation 2-97
    c. Circuits in the IFF Coordinator 2-99
    d. Multivibrator 2-99
    e. IFF Trigger Circuits 2-101
    f. IFF Delay Multivibrator 2-102
    g. Mixer Circuit 2-104
    h. Switching Circuits 2-105
    i. IFF Receiver Remote Controls 2-105
    j. Power Supply 2-106

TABLE OF CONTENTS (Continued)

Paragraph Title Page

SECTION II. THEORY OF OPERATION (Continued)

16. PPI INDICATOR 2-106
    a. Functions of a PPI Indicator 2-106
    b. Description of Circuit Functions 2-108
    c. Gate Circuit 2-111
    d. Sweep Generator 2-114
    e. Sweep Amplifier Circuits 2-114
    f. High Voltage Power Supply 2-117
    g. Range Marker Circuits 2-118
    h. Video Circuits 2-120
    i. Low Voltage Power Supply 2-122
    j. Servo System 2-123
    k. Yoke Coil 2-128
    l. Drive Gear Train 2-128
    m. Servo Gear Train 2-129
    n. Servo Operation 2-129

17. GENERAL CONTROL UNIT 2-129
    a. General 2-129
    b. Transmitter Controls 2-129
    c. Indicator Console Switch 2-129
    d. Blower Motor 2-131

18. ANTENNA POSITIONING SYSTEM 2-131
    a. General 2-131
    b. Functional Description 2-131

19. SYNCHRO UNITS 2-133
    a. General 2-133
    b. Motors and Generators 2-134
    c. Control Transformers 2-134
    d. Differential Generators 2-134

20. ANTENNA PEDESTAL 2-138
    a. General 2-138
    b. Synchro Assembly 2-138
    c. Rotating Assembly 2-141
    d. Collector Ring Assembly 2-141
    e. Circuits 2-141

21. SYNCHRO AMPLIFIER 2-141
    a. General 2-141
    b. Synchro Unit 2-143
    c. Electronic Amplifier 2-143

22. BEARING INDICATOR 2-149
    a. General 2-149
    b. Antenna Positioning Circuits 2-150
    c. Bearing Repeater Circuits 2-151

23. ROTATION CONTROL UNIT 2-152
    a. General 2-152
    b. Servo Amplifier 2-152
    c. Rectifier Power Unit 2-156

24. SERVO GENERATOR 2-156
    a. General 2-156
    b. Description 2-161

25. POWER SUPPLY SYSTEM (NXsr-30306) 2-161
    a. General 2-161
    b. Magnetic Controller CAY-211181 2-161
    c. Magnetic Controller CAY-211187 2-162
    d. Voltage Regulator CAY-211185 2-165
    e. Voltage Stabilizer 2-166

TABLE OF CONTENTS (Continued)

Paragraph	Title	Page
	SECTION II. THEORY OF OPERATION (Continued)	
26.	POWER SUPPLY SYSTEM (NXsr-46032)	2-167
	a. General	2-167
	b. Magnetic Starter	2-167
	c. Voltage Regulator	2-168
	SECTION III. INSTALLATION AND INITIAL ADJUSTMENT	
1.	GENERAL	3-1
2.	UNPACKING	3-1
3.	INSTALLATION OF MODULATOR	3-1
	a. General	3-1
	b. Installed as a Modification	3-1
	c. Installed as Part of SR-a Equipment	3-3
4.	INSTALLATION OF TRANSCEIVER	3-3
5.	INSTALLATION OF INDICATOR CONSOLE	3-3
	a. General	3-3
	b. Placing the Indicator Console	3-4
6.	INSTALLATION OF ANTENNA AND ANTENNA PEDESTAL	3-4
	a. General	3-4
	b. Assembly of Antenna to Antenna Pedestal	3-4
	c. Assembly of Antenna and Pedestal to Mast	3-21
	d. Assembly of V.H.F. IFF Antenna	3-21
	e. Assembly of U.H.F. IFF Antenna	3-21
	f. Echo Box Antenna	3-25
7.	INSTALLATION OF SYNCHRO AMPLIFIER	3-25
	a. General	3-25
	b. Mounting the Units	3-25
8.	INSTALLATION OF ROTATION CONTROL UNIT	3-25
	a. General	3-25
	b. Mounting Instructions	3-25
9.	INSTALLATION OF SERVO GENERATOR	3-26
	a. General	3-26
	b. Mounting Instructions	3-26
10.	INSTALLATION OF VOLTAGE STABILIZER	3-26
11.	INSTALLATION OF MOTOR GENERATOR	3-26
12.	INSTALLATION OF VOLTAGE REGULATOR	3-26
13.	INSTALLATION OF MAGNETIC CONTROLLER	3-26
14.	INSTALLATION OF PUSH BUTTON STATION	3-46
15.	INSTALLATION OF CONTROLLER DISCONNECT LINE SWITCH	3-46
16.	INTERCONNECTION OF MAJOR UNITS	3-46
	a. General	3-46
	b. Transceiver	3-46
	c. Modulator	3-57
	d. Indicator Console	3-57
	e. Antenna and Antenna Pedestal	3-58
	f. Echo Box Antenna	3-58
	g. Synchro Amplifier	3-58
	h. Rotation Control Unit	3-59
	i. Servo Generator	3-59
	j. Voltage Stabilizer	3-59
	k. Motor Generator	3-59
	l. Voltage Regulator	3-59
	m. Magnetic Controller	3-59

TABLE OF CONTENTS (Continued)

Paragraph	Title	Page
	SECTION III. INSTALLATION AND INITIAL ADJUSTMENT (Continued)	
16. *n.*	Push Button Station	3-59
o.	Controller Disconnect Line Switch	3-59
p.	Connections to IFF System	3-59
q.	IFF Video to Remote PPI Indicators	3-60
r.	Connection of Remote PPI Indicators	3-60
s.	Wire Number Designation	3-64
17.	INITIAL ADJUSTMENTS	3-65
a.	General	3-65
b.	Adjustment of Motor Generator Voltage	3-65
c.	Transceiver Adjustments for the SR System	3-66
d.	SR-a Transceiver Adjustments	3-71
e.	The Antenna Positioning System Adjustments	3-73
f.	Indicator Console Adjustments	3-77
	SECTION IV. OPERATION	
1.	GENERAL	4-1
2.	STARTING THE EQUIPMENT	4-1
a.	Energizing Power Equipment	4-1
b.	Energizing SR Radar System	4-1
c.	Energizing SR-a Radar System	4-4
d.	Energizing Antenna Positioning System	4-5
3.	PRE-OPERATION CHECKS AND ADJUSTMENTS	4-6
a.	General	4-6
b.	Adjustment of Operating Controls	4-6
4.	ROUTINE OPERATION	4-14
a.	General	4-14
b.	Searching Operation	4-14
c.	Ranging Operation	4-15
d.	Operation Through Jamming	4-17
5.	TRANSMITTER TUNING PROCEDURE	4-18
a.	General	4-18
b.	Tuning the SR Transceiver	4-18
c.	Tuning the SR-a Transceiver	4-20
	SECTION V. OPERATOR'S MAINTENANCE	
1.	GENERAL	5-0
2.	ROUTINE CHECKS	5-0
3.	MECHANICAL CHECKS	5-0
4.	FUSE REPLACEMENT	5-3
5.	DIAL LIGHT REPLACEMENT	5-7
6.	TUBE REPLACEMENT (Emergency Only)	5-8
a.	General	5-8
b.	Locating Defective Tubes	5-9
	SECTION VI. PREVENTIVE MAINTENANCE	
1.	GENERAL	6-0
2.	MAINTENANCE TEST SCHEDULE	6-0
3.	MECHANICAL MAINTENANCE	6-0
4.	ELECTRICAL MAINTENANCE	6-1
5.	CARE OF BRUSHES	6-2

TABLE OF CONTENTS (Continued)

Paragraph Title Page

SECTION VI. PREVENTIVE MAINTENANCE (Continued)

6. LUBRICATION.......... 6-6
   a. General.......... 6-6
   b. PPI Indicator.......... 6-16
   c. Bearing Indicator.......... 6-16
   d. Synchro Generator.......... 6-16
   e. Motor Generator.......... 6-16
   f. Antenna Pedestal.......... 6-16
   g. Transceiver.......... 6-16
   h. Rectifier Power Unit.......... 6-17
   i. Synchro Amplifier.......... 6-17
   j. Keyer Unit.......... 6-17
   k. Synchro Units.......... 6-17

SECTION VII. CORRECTIVE MAINTENANCE

1. GENERAL.......... 7-1
2. SYSTEM TROUBLE SHOOTING.......... 7-1
   a. General.......... 7-1
   b. Start-Stop Procedure.......... 7-2
   c. Signal Tracing.......... 7-16
3. TROUBLES IN TRANSCEIVER.......... 7-18
   a. General.......... 7-18
   b. Transmitter Frequency Measurement.......... 7-18
   c. Troubles.......... 7-18
4. TROUBLES IN KEYER UNIT.......... 7-21
   a. General.......... 7-21
   b. Troubles.......... 7-21
5. TROUBLES IN MONITOR RECEIVER.......... 7-22
   a. General.......... 7-22
   b. Location of Troubles.......... 7-22
6. TROUBLES IN MONITOR SCOPE.......... 7-31
   a. General.......... 7-31
   b. Location of Troubles.......... 7-31
7. TROUBLES IN MODULATOR.......... 7-31
   a. General.......... 7-31
   b. Location of Troubles.......... 7-31
8. TROUBLES IN CONSOLE RECEIVER.......... 7-32
   a. General.......... 7-32
   b. Location of Troubles.......... 7-32
9. TROUBLES IN RANGE SCOPE.......... 7-32
   a. General.......... 7-32
   b. Location of Troubles.......... 7-32
10. TROUBLES IN IFF COORDINATOR.......... 7-43
   a. General.......... 7-43
   b. Location of Troubles.......... 7-43
11. TROUBLES IN PPI INDICATOR.......... 7-44
   a. General.......... 7-44
   b. Location of Troubles.......... 7-44
12. TROUBLES IN BEARING INDICATOR.......... 7-47
   a. General.......... 7-47
13. TROUBLES IN GENERAL CONTROL UNIT.......... 7-47
   a. General.......... 7-47

TABLE OF CONTENTS (Continued)

Paragraph Title Page

SECTION VII. CORRECTIVE MAINTENANCE (Continued)

14. TROUBLES IN ROTATION CONTROL UNIT 7-47
  a. General 7-47
  b. Location of Troubles 7-47
  c. Servo Amplifier 7-48
  d. Rectifier Power Unit 7-48

15. TROUBLES IN SERVO GENERATOR 7-55

16. TROUBLES IN SYNCHRO AMPLIFIER 7-55
  a. General 7-55
  b. Amplifier Unit 7-55
  c. Synchro Unit 7-55

17. TROUBLES IN ANTENNA PEDESTAL 7-56
  a. General 7-56
  b. Location of Troubles 7-56

18. TROUBLES IN POWER EQUIPMENT 7-57
  a. General 7-57
  b. Location of Troubles 7-57

19. MECHANICAL ADJUSTMENTS IN THE TRANSCEIVER 7-59
  a. General 7-59
  b. R-F Lines 7-59
  c. Filament Transformers 7-63
  d. Voltage Regulator Assembly 7-64

20. MECHANICAL ADJUSTMENTS IN THE KEYER UNIT 7-64

21. MECHANICAL ADJUSTMENTS IN THE MONITOR RECEIVER 7-64
  a. General 7-64
  b. Echo Box 7-65
  c. Lighthouse Tube Sockets 7-65

22. MECHANICAL ADJUSTMENTS IN THE MONITOR SCOPE 7-66
  a. General 7-66
  b. Cathode Ray Tube 7-66

23. MECHANICAL ADJUSTMENTS IN THE MODULATOR 7-66
  a. General 7-66

24. MECHANICAL ADJUSTMENTS IN THE CONSOLE RECEIVER 7-66

25. MECHANICAL ADJUSTMENTS IN THE RANGE SCOPE 7-67
  a. General 7-67
  b. Changing Cathode Ray Tube 7-67
  c. Replacing Helipot 7-69
  d. Servicing Counter Gear Train 7-69

26. MECHANICAL ADJUSTMENTS IN THE IFF COORDINATOR 7-71
  a. General 7-71

27. MECHANICAL ADJUSTMENTS IN PPI INDICATOR 7-71
  a. Replacing Cathode Ray Tube 7-71
  b. Servicing the PPI Assembly 7-72
  c. Care of the PPI Assembly 7-76

28. MECHANICAL ADJUSTMENTS IN THE BEARING INDICATOR 7-78
  a. Removal of Synchro Units 7-78
  b. Removal of Slewing Mechanism 7-79
  c. Servicing of Slewing Mechanism 7-81

29. MECHANICAL ADJUSTMENTS IN THE GENERAL CONTROL UNIT 7-82

30. MECHANICAL ADJUSTMENTS IN THE ROTATION CONTROL UNIT 7-82
  a. General 7-82
  b. Removal of Dry Disc Rectifiers 7-82
  c. Removal of Fan and Motor Assembly 7-83

TABLE OF CONTENTS (Continued)

Paragraph	Title	Page
	SECTION VII. CORRECTIVE MAINTENANCE (Continued)	
31.	MECHANICAL ADJUSTMENTS IN THE SERVO GENERATOR	7-83
32.	MECHANICAL ADJUSTMENTS IN THE SYNCHRO AMPLIFIER	7-83
	a. General	7-83
	b. Adjustments in Lower Compartment	7-83
33.	MECHANICAL ADJUSTMENTS IN ANTENNA PEDESTAL	7-84
	a. General	7-84
	b. Synchrotie Assembly	7-84
	c. Synchrotie Bracket Assembly	7-85
	d. One-to-one Synchrotie Gear Assembly	7-91
	e. Idler Gear Assembly	7-91
	f. 36-to-1 Synchrotie Gear Assembly	7-93
	g. 180-Tooth Synchrotie Gear on Main Housing	7-93
	h. Backlash Adjustment of Synchrotie Gear Train	7-95
	i. Brush Block Assembly	7-96
	j. Removing Antenna Assembly	7-97
	k. Removing Drive Unit	7-97
	l. Removing Ring Gear and Slip Ring Assembly	7-103
	m. Reassembling Drive Unit	7-108
	n. Checking Backlash in Drive Unit Gear Train	7-114
	o. Ship's Head Marker Microswitch	7-115
	p. Disassembly of IFF Transmission Line	7-115
	q. Disassembly of R-F Lines in Pedestal	7-115
34.	MECHANICAL ADJUSTMENTS IN POWER EQUIPMENT	7-121
	a. General	7-121
	b. Line Disconnect Switch	7-121
	c. Magnetic Controllers	7-121
	d. Pushbutton Station	7-121
	e. Motor Generator	7-121
	f. Voltage Regulator	7-122
	g. Voltage Stabilizer	7-122
35.	WINDING DATA	7-122
36.	ELECTRICAL ADJUSTMENTS IN TRANSCEIVER	7-122
	a. General	7-122
	b. Relays	7-122
	c. Limit Switches	7-123
	d. Tuning the SR Transmitter	7-123
	e. Tuning the SR-a Transmitter	7-128
37.	ELECTRICAL ADJUSTMENTS IN MONITOR RECEIVER	7-129
	a. General	7-129
	b. Alignment	7-129
38.	ELECTRICAL ADJUSTMENTS IN CONSOLE RECEIVER	7-130
	a. General	7-130
	b. I-F Amplifier Alignment	7-130
	c. Alignment of Rejection Filters	7-130
39.	ELECTRICAL ADJUSTMENTS IN RANGE SCOPE	7-132
	a. General	7-132
	b. Range Marker Calibration	7-132
	c. Sweep Length Adjustment	7-132
	d. IFF Sweep Adjustment	7-132
	e. Focus Balance Adjustment	7-132
	f. Phantastron Adjustment	7-134
	g. Radar Video Frequency Response	7-135
	h. IFF Video Frequency Response	7-135
40.	ELECTRICAL ADJUSTMENTS IN IFF COORDINATOR	7-137
	a. General	7-137
	b. IFF Bias Adjustment	7-137
	c. IFF Delay Adjustment	7-137

TABLE OF CONTENTS (Concluded)

Paragraph	Title	Page
	SECTION VII. CORRECTIVE MAINTENANCE (Continued)	
41.	ELECTRICAL ADJUSTMENTS IN PPI INDICATOR	7-137
	a. General	7-137
	b. Intensity Adjustment	7-138
	c. Focus Coil Adjustment	7-138
	d. Preliminary Gate Adjustment	7-138
	e. Preliminary Sweep Length Adjustment	7-138
	f. Marker Calibration	7-139
	g. Gate and Sweep Lengths, Final Adjustment	7-139
	h. Anti-hunt Adjustment	7-139
	i. Orientation with Radar Antenna	7-140
	j. Video Frequency Response	7-140
42.	ELECTRICAL ADJUSTMENTS IN GENERAL CONTROL UNIT	7-140
43.	ELECTRICAL ADJUSTMENTS IN BEARING INDICATOR	7-140
	a. General	7-140
	b. Resetting Indicator Dials	7-140
	c. Slewing Motor Speed Adjustment	7-140
44.	ELECTRICAL ADJUSTMENTS IN ROTATION CONTROL UNIT	7-141
	a. General	7-141
	b. Unmodified Rotation Control Units	7-141
	c. Modified Rotation Control Units	7-142
45.	ELECTRICAL ADJUSTMENTS IN SERVO GENERATOR	7-142
46.	ELECTRICAL ADJUSTMENTS IN SYNCHRO AMPLIFIER UNIT	7-142
	a. General	7-142
	b. Anti-hunt Adjustment	7-142
47.	ELECTRICAL ADJUSTMENTS IN ANTENNA PEDESTAL	7-143
	a. General	7-143
	b. Synchro Adjustments	7-143
48.	ELECTRICAL ADJUSTMENTS IN POWER EQUIPMENT	7-144
	a. General	7-144
	b. Magnetic Controllers	7-144
	c. Voltage Regulators	7-144
	d. Motor Generator	7-144

SECTION VIII. PARTS AND SPARE PARTS LISTS

(See List of Tables)

LIST OF ILLUSTRATIONS

Figure | Title | Page

SECTION I. GENERAL DESCRIPTION

1-1 Navy Model SR and SR-a Radar Equipment 1-0
1-2 Simplified Block Diagram of SR System 1-5
1-3 Simplified Block Diagram of SR-a System 1-7
1-4 Transceiver Console CAY-43ACM (SR) 1-10
1-5 Oscillator Assembly 1-11
1-6 Keyer Unit CAY-67AAD 1-11
1-7 Monitor Receiver CAY-46ADK 1-12
1-8 Monitor Scope CAY-55AFD 1-12
1-9 Transceiver Console CAY-43ADK (SR-a Modified) 1-13
1-10 Modulator CAY-50AGU 1-14
1-11 Indicator Console CAY-46ADJ 1-15
1-12 Console Receiver CAY-46ADH 1-16
1-13 PPI Indicator CAY-55ADV (Manual Cursor) 1-17
1-14 PPI Indicator CAY-55ADV-1 (Geared Cursor) 1-18
1-15 Range Scope CAY-55AFB 1-19
1-16 IFF Coordinator CAY-23AEV 1-20
1-17 Bearing Indicator CAY-55AFC 1-21
1-18 General Control Unit CAY-23AEW 1-21
1-19 Rotation Control Unit CAY-50AEB 1-22
1-20 Servo Amplifier CAY-50AEU 1-23
1-21 Rectifier Power Unit CAY-20ACY 1-23
1-22 Echo Box Antenna CAY-66AHK 1-23
1-23 Synchro Amplifier 1-24
1-24 Servo Generator CAY-211192 or CAY-211192A 1-25
1-25 Voltage Stabilizer CG-301252 1-26
1-26 Auto Dehydrator CAKB-10AEK 1-27
1-27 Antenna Pedestal CAJS-21ACP 1-27
1-28 Blue Antenna COD-66AHE or CLP-66AHE with V.H.F. Antenna COD-66AHH or CLP-66AHH or with H.F. Antenna COD-66AHG or CLP-66AHG or Yellow Green Antenna COD-66AHF or CLP-66AHF with H.F. Antenna COD-66AHG or CLP-66AHG 1-30
1-29 V.H.F. Antenna COD-66AHH or CLP-66AHH or H.F. Antenna COD-66AHG or CLP-66AHG and U.H.F. Antenna COD-66AHJ or CLP-66AHJ 1-31
1-30 Motor Generator CAY-211182, CAY-211188 or CAY-211326 1-33
1-31 Magnetic Controllers CAY-211181, CAY-211187, or CAY-211325 1-34
1-32 Voltage Regulators CAY-211185 or CAY-211185A 1-35
1-33 Pushbutton Stations CAY-211186 and CAY-24299 1-35
1-34 Controller Disconnect Line Switch CWU-24429 1-36
1-35 Connector UG-32/U Navy Type 49261 1-36

SECTION II. THEORY OF OPERATION

2-1 SR Radar Equipment, Complete Block Diagram 2-3
2-2 SR-a Radar Equipment, Complete Block Diagram 2-5
2-3 SR Transmitting System, Block Diagram 2-9
2-4 Unterminated Artificail Line 2-11
2-5 Terminated Artificial Line 2-12
2-6 Artificial Line with Slope Compensation 2-13
2-7 Basic Circuit of Artificial Line in Keyer Unit 2-13
2-8 Keyer Unit, Schematic Diagram 2-15
2-9 Geneva Drive for Pulse Width Switch 2-17
2-10 SR Transmitting Oscillator Circuits, Simplified Diagram 2-19
2-11 Duplexer, Simplified Schematic Diagram 2-22
2-12 SR High Voltage Rectifier, Simplified Schematic 2-24
2-13 SR Transmitter Filament Control Circuits Simplified Diagram 2-25
2-14 SR Main Transmitter Control Circuit Simplified Diagram 2-26
2-15 SR Plate Voltage Control Circuit, Simplified Diagram 2-28
2-16 SR Radiation Control Circuit, Simplified Diagram 2-29
2-17 SR-a Transmitting System, Block Diagram 2-31
2-18 Trigger Circuits in Modulator 2-33
2-19 Low Voltage Rectifier in Modulator 2-34
2-20 Pulse Forming Circuits in Modulator 2-35

LIST OF ILLUSTRATIONS (Continued)

Figure Title Page

SECTION II. THEORY OF OPERATION (Continued)

Figure	Title	Page
2-21	Simplified Pulse Circuit	2-36
2-22	SR-a High Voltage Rectifier in Transceiver	2-38
2-23	SR-a Transmitting Oscillator	2-39
2-24	SR-a High Voltage and Radiation Control Circuits	2-41
2-25	SR R.F. Transmission System and IFF Antenna	2-44
2-26	SR Radar Antenna	2-45
2-27	U.H.F. IFF Antennas	2-46
2-28	Echo Box Antenna	2-46
2-29	Monitor Receiver, Block Diagram	2-47
2-30	R-F Circuits in Monitor Receiver	2-48
2-31	First I-F Amplifier in Monitor Receiver	2-49
2-32	Third I-F Amplifier in Monitor Receiver	2-50
2-33	Fourth I-F Amplifier and Diode Detector in Monitor Receiver	2-50
2-34	Echo Box Circuits in Monitor Receiver	2-51
2-35	Power Supply in Monitor Receiver	2-52
2-36	Monitor Scope, Block Diagram	2-53
2-37	Trigger Amplifier in Monitor Scope	2-53
2-38	Gate Circuits in Monitor Scope	2-54
2-39	Sweep Circuit in Monitor Scope	2-55
2-40	Video Amplifier in Monitor Scope	2-56
2-41	Internal Trigger Generator in Monitor Scope	2-57
2-42	Trigger Output Amplifier in Monitor Scope	2-57
2-43	Low Voltage Power Supply in Monitor Scope	2-58
2-44	High Voltage Power Supply and Cathode Ray Tube in Monitor Scope	2-59
2-45	Indicator Console Block Diagram	2-60
2-46	Pulse Line Terminations	2-67
2-47	Console Receiver Block Diagram	2-68
2-48	Anti-Jamming Filters	2-69
2-49	Variable Selectivity Anti-Jamming Circuits	2-69
2-50	Third I-F Amplifier	2-70
2-51	Fourth and Fifth I-F Amplifiers and AVC Tube	2-71
2-52	Detector and Balanced Video Circuits	2-73
2-53	Video Amplifier and Cathode Follower	2-75
2-54	Video Output and Cathode Follower	2-76
2-55	Receiver Power Supply	2-77
2-56	Range Scope, Block Diagram	2-78
2-57	Gate Circuit in Range Scope	2-79
2-58	Sweep Circuit in Range Scope	2-82
2-59	Phantastron Circuit in Range Scope	2-84
2-60	Adjustment Plot of Slope Controls	2-88
2-61	Adjustment Plot of ZERO SET Controls	2-88
2-62	Range Marker Circuits in Range Scope	2-90
2-63	Typical Range Scope Presentations	2-91
2-64	Video Circuits in Range Scope	2-92
2-65	Radar and IFF Blocking Action in Video Circuits	2-93
2-66	Cathode Ray Tube and High Voltage Supply Circuits	2-94
2-67	Low Voltage Power Supply Circuit	2-95
2-68	IFF Coordinator, Block Diagram	2-96
2-69	Waveforms of IFF Operation with a Radar System	2-98
2-70	Flip Flop Multivibrator in IFF Coordinator	2-100
2-71	IFF Trigger Circuit in IFF Coordinator	2-102
2-72	IFF Trigger Delay Multivibrator in IFF Coordinator	2-103
2-73	Mixer Circuit in IFF Coordinator	2-104
2-74	Switching Circuits in IFF Coordinator	2-105
2-75	Power Supply in IFF Coordinator	2-106
2-76	Basic Principles of PPI Ranging	2-107
2-77	Effect of Beam Width on Appearance of PPI Target	2-108
2-78	PPI Indicator, Block Diagram	2-109
2-79	Gate Circuit in PPI Indicator	2-111
2-80	Sweep Generator in PPI Indicator	2-113
2-81	Sweep Amplifiers in PPI Indicator	2-115
2-82	Development of Peaked Sawtooth Voltage	2-116

LIST OF ILLUSTRATIONS (Continued)

SECTION II. THEORY OF OPERATION (Continued)

Figure	Title	Page
2-83	Cathode Ray Tube and High Voltage Power Supply	2-118
2-84	Range Marker Circuits in PPI Indicator	2-119
2-85	Video Circuits in PPI Indicator	2-121
2-86	Low Voltage Power Supply in PPI Indicator	2-122
2-87	PPI Servo System, Block Diagram	2-124
2-88	PPI Servo System	2-125
2-89	Phase Relationships in Anti-Hunt Network	2-126
2-90	PPI Servo System, Mechanical Diagram	2-128
2-91	General Control Unit, Schematic Diagram	2-130
2-92	Antenna Positioning System, Block Diagram	2-132
2-93	Synchro Units, Basic Principles	2-135
2-94	Antenna Pedestal	2-137
2-95	Antenna Pedestal Gear Schematic	2-138
2-96	Antenna Pedestal, Schematic Diagram	2-139
2-97	Relayed Compass Voltage Circuits, Simplified Diagram	2-142
2-98	Servo Amplifier in Synchro Amplifier, Simplified Diagram	2-144
2-99	Equivalent Input Circuit of Synchro Amplifier	2-145
2-100	Equivalent Circuit for Positive One-speed or 36-speed Voltages	2-145
2-101	Equivalent Circuit for Negative 36-speed or One-speed Voltages	2-145
2-102	Voltage Relationships in Input Circuit of Synchro Amplifier	2-146
2-103	Bearing Indicator, Schematic Diagram	2-147
2-104	Bearing Indicator Antenna Positioning Circuits	2-150
2-105	Bearing Indicator, Antenna Bearing Repeater Circuits	2-151
2-106	Servo Amplifier Simplified Diagram	2-153
2-107	Servo Amplifier Complete Schematic Diagram	2-157
2-108	Rectifier Power Unit, Complete Schematic Diagram	2-159
2-109	Primary Power Circuits (115 V.D.C.)	2-163
2-110	Magnetric Controller CAY-211187 (230 V.D.C.)	2-165
2-111	Voltage Stabilizer, Simplified Diagram	2-167

SECTION III. INSTALLATION AND INITIAL ADJUSTMENT

Figure	Title	Page
3-1	Interconnection Panel in Transceiver, CAY-43ADK	3-1
3-2	Modulator CAY-50AGU Outline Mounting Dimensions	3-2
3-3	Transceiver CAY-43ACM, CAY-43 ADK Outline Diagram	3-5
3-4	Indicator Console, Outline Diagram	3-7
3-5	Console Receiver Outline Diagram	3-9
3-6	Range Scope Outline Diagram	3-11
3-7	IFF Coordinator Outline Diagram	3-13
3-8	PPI Indicator, Outline Diagram	3-15
3-9	Bearing Indicator Outline Diagram	3-17
3-10	General Control Unit Outline Diagram	3-19
3-11	Assembly of Antenna to Antenna Pedestal	3-22
3-12	Antenna and Pedestal Outline Diagram	3-23
3-13	Echo Box Antenna, Outline Diagram	3-27
3-14	Synchro Amplifier, Outline Diagram	3-29
3-15	Rotation Control Unit, Outline Diagram	3-31
3-16	Servo Generator, Outline Diagram	3-33
3-17	Voltage Stabilizer, Outline Diagram	3-35
3-18	Motor Generator CAY-211182 and CAY-211188, Outline Diagram	3-37
3-19	Motor Generator CAY-211326, Outline Diagram	3-39
3-20	Voltage Regulators, CAY-211185 and CAY-211185A Outline Diagrams	3-41
3-21	Magnetric Controllers CAY-211181 and CAY-211187 Outline Diagrams	3-43
3-22	Magnetric Controller CAY-211325 Outline Diagram	3-45
3-23	Push Button Station CAY-211186 and CAY-24299 Outline Diagram	3-45
3-24	Controller Disconnect Line Switch Outline Diagram	3-46
3-25	Master Interconnection Diagram	3-47
3-26	R.F. Cable, Type RG-20/U Assembly Diagram	3-49

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
	SECTION III. INSTALLATION AND INITIAL ADJUSTMENT (Continued)	
3-27	R.F. Connector, Type UG-21/U, Assembly to R.F. Cable, Type RG-10/U or RG-12/U	3-51
3-28	R.F. Connector, Type UG-36/U, Assembly to R.F. Cable, Type RG-27/U	3-53
3-29	R.F. Connector, Type UG-32/U Assembly to IFF Transmission Line	3-55
3-30	Pedestal Connection of IFF and Radar Transmission Cables	3-57
3-31	Indicator Console, Frame Wiring Diagram	3-61
3-32	RG-12/U Coaxial Cable, Assembly of Connecting Lugs	3-63
3-33	Voltage Regulator, Operating Controls	3-66
3-34	Transceiver, Operating Controls	3-67
3-35	Limit Switch and Cam Assembly in Transceiver	3-68
3-36	Keyer Pulse Waveform Development	3-68
3-37	Keyer Pulse Waveforms	3-69
3-38	Monitor Scope, Focus Balancing Control	3-71
3-39	Duplexer Spark Gap Adjustments	3-71
3-40	Time Delay Relay SR-a Modulator	3-72
3-41	Modulator Front View	3-72
3-42	Operating Controls on Indicator Console	3-73
3-43	Antenna Pedestal, Showing Synchro Inspection Door	3-74
3-44	Rotation Control Unit, Front Panel	3-75
3-45	Mounting of Synchros in Bearing Indicator	3-76
3-46	Internal Controls of Servo Amplifier	3-77
3-47	PPI Alignment Controls	3-78
3-48	PPI Focus Coil Adjustment	3-78
3-49	PPI Drive Motor	3-79
3-50	Anti-hunt Control on PPI Indicator	3-79
3-51	Adjustment of Synchro Control Transformer	3-80
3-52	IFF Line Adjustment Control in Range Scope	3-81
3-53	Controls on Left Hand Side of Range Scope Chassis	3-81
3-54	Plot of Range vs. Counter Reading	3-82
3-55	Bias Voltage Control on IFF Coordinator	3-83
3-56	Trigger Delay Control on IFF Coordinator	3-84
3-57	Console Receiver Anti-jam Controls	3-84
	SECTION IV. OPERATION	
4-1	Magnetic Starters	4-1
4-2	Voltage Regulator, Operating Controls	4-2
4-3	Transceiver, Operating Controls	4-3
4-4	Keyer Unit, Operating Controls	4-4
4-5	Monitor Scope, Operating Controls	4-4
4-6	General Control Unit, Operating Controls	4-5
4-7	PPI Indicator, Operating Controls	4-5
4-8	Rotation Unit, Operating Controls	4-6
4-9	Synchro Amplifier, Operating Controls	4-6
4-10	Monitor Receiver, Operating Controls	4-7
4-11	Console Receiver, Operating Controls	4-8
4-12	Bearing Indicator, Operating Controls	4-9
4-13	IFF Coordinator, Operating Controls	4-10
4-14	Range Scope, Operating Controls	4-11
4-15	Range Markers on Range Scope	4-12
4-16	Range Step on Range Scope	4-12
4-17	IFF Sweep on Range Scope	4-12
4-18	IFF Target on Range Scope	4-12
4-19	Targets and Range Markers on PPI Scope	4-15
4-20	Keyer Wave Forms	4-16
4-21	Modulator Adjustments	4-20

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
	SECTION V. OPERATOR'S MAINTENANCE	
5-1	Transceiver, Fuses	5-3
5-2	Monitor Scope, Fuses	5-3
5-3	Monitor Receiver, Fuses	5-3
5-4	Rectifier Power Unit, Fuses	5-3
5-5	Console Receiver, Fuses	5-4
5-6	IFF Coordinator Fuses	5-4
5-7	Modulator, Fuses	5-4
5-8	Synchro Amplifier, Fuses	5-4
5-9	PPI Indicator Fuses	5-4
5-10	Servo Amplifier, Fuses	5-4
5-11	Bearing Indicator, Fuses	5-5
5-12	Range Scope, Fuses	5-5
5-13	Dial Lamps in Geared Cursor	5-7
5-14	Dial Lamps in Manual Cursor	5-7
5-15	Dial Lamp Behind MILES Window on PPI Indicator	5-7
5-16	Dial Lamp Behind RANGE-YARDS Window on Range Scope	5-8
5-17	Dial Lamp Behind MILES Window on Range Scope	5-8
5-18	Dial Lamp in Bearing Indicator	5-8
5-19	Transceiver, Tube Locations	5-9
5-20	Monitor Scope, Tube Locations	5-10
5-21	Monitor Receiver, Tube Locations	5-10
5-22	Modulator, Tube Locations	5-11
5-23	Console Receiver, Tube Locations	5-11
5-24	PPI Indicator, Tube Locations	5-12
5-25	Range Scope, Tubes on Top of Chassis	5-12
5-26	Range Scope, Tubes on Bottom of Chassis	5-13
5-27	IFF Coordinator, Tube Locations	5-14
5-28	General Control Unit, Location of Spare Tubes	5-14
5-29	Servo Amplifier, Tube Locations	5-15
5-30	Synchro Amplifier, Tube Locations	5-15
	SECTION VI. PREVENTIVE MAINTENANCE	
6-1	Air Filter in Transceiver	6-0
6-2	Slewing Motor Brushes in Bearing Indicator	6-2
6-3	Replacing Brushes in Servo Generator	6-2
6-4	Replacing Brushes in Motor-Generator	6-3
6-5	Replacing Brushes in Antenna Drive Motor	6-3
6-6	Brushes in Antenna Pedestal	6-4
6-7	Brushes and Slip Rings on PPI Assembly	6-5
6-8	Brush Assemblies in Synchro Amplifier	6-6
6-9	Lubrication of Geared Cursor	6-7
6-10	Lubrication of PPI Assembly	6-8
6-11	Lubrication of Bearing Indicator	6-9
6-12	Lubrication of Servo Generator and Motor Generator	6-10
6-13	Lubrication of Antenna Pedestal	6-11
6-14	Lubrication of Transceiver	6-12
6-15	Lubrication of Rectifier Power Unit	6-13
6-16	Lubrication of Synchro Amplifier	6-14
6-17	Lubrication of Keyer Unit	6-15
	SECTION VII. CORRECTIVE MAINTENANCE	
7-1	Primary Power Distribution Diagram SR Equipment	7-2
7-2	Primary Power Distribution Diagram, SR-a Equipment	7-5
7-3	Servicing Block Diagram, SR and SR-a Equipment	7-7
7-4	Servicing Block Diagram, Antenna Positioning System	7-9
7-5	External Cabling Diagram SR and SR-a Equipment	7-11
7-6	Transceiver, Troubleshooting Chart	7-19
7-7	Switch and Cam Assembly on Transceiver	7-21
7-8	Keyer Unit, Troubleshooting Chart	7-23
7-9	Monitor Receiver, Troubleshooting Chart	7-25

LIST OF ILLUSTRATIONS (Continued)

Figure	Title	Page
	SECTION VII. CORRECTIVE MAINTENANCE (Continued)	
7-10	Monitor Scope, Troubleshooting Chart	7-27
7-11	Modulator, Troubleshooting Chart	7-29
7-12	Console Receiver, Troubleshooting Chart	7-33
7-13	Waveforms in the Indicator Console	7-35
7-14	Range Scope, Troubleshooting Chart	7-37
7-15	IFF Coordinator, Troubleshooting Chart	7-39
7-16	PPI Indicator, Troubleshooting Chart	7-41
7-17	PPI Indicator Test Points	7-46
7-18	Rotation Control Unit, Troubleshooting Chart	7-49
7-19	Synchro Amplifier, Troubleshooting Chart	7-51
7-20	Antenna Pedestal, Troubleshooting Chart	7-53
7-21	Brush Block Assembly in Antenna Pedestal	7-56
7-22	Transceiver R-F Line, Exploded View	7-58
7-23	R.F. Line Assembly in Transceiver	7-59
7-24	Disassembly of Duplexers and U-Section	7-60
7-25	Disassembly of Oscillator Line	7-61
7-26	Removal of Oscillator Line	7-61
7-27	Disassembly of Antenna Line and Cable	7-62
7-28	Removal of Antenna Line	7-62
7-29	Removal of Upper Duplexer Conductors and Elbow Conductor	7-62
7-30	Removal of U-shaped Conductor	7-63
7-31	Duplexer Spark Gaps	7-63
7-32	Disassembly of Lighthouse Tube Sockets in Monitor Receiver	7-65
7-33	Removal of Cathode Ray Tube in Monitor Scope	7-65
7-34	Removing Bezel from Range Scope	7-66
7-35	Disconnecting Cathode Ray Tube in Range Scope	7-67
7-36	Pushing Cathode Ray Tube Forward in Range Scope	7-68
7-37	Removing Cathode Ray Tube from Range Scope	7-68
7-38	Removing Helipot from Range Scope	7-69
7-39	Counter Gear Train, Schematic Diagram	7-69
7-40	Counter Gear Train, Exploded	7-70
7-41	Removing Range Step Switch from Range Scope	7-71
7-42	Disconnecting Cathode Ray Tube in PPI Indicator	7-71
7-43	Removing Manually Operated Cursor	7-72
7-44	Geared Cursor in Position to Permit Removal of Cathode Ray Tube	7-72
7-45	Removing Cathode Ray Tube from PPI Indicator	7-72
7-46	Replacing Yoke Coil Brushes	7-72
7-47	Removing Focus Coil	7-73
7-48	Removing Synchro Drive Gear	7-73
7-49	Removing PPI Tube Shield and Retaining Ring	7-73
7-50	PPI Assembly, Exploded View	7-74
7-51	Removing Yoke Coil and Bearings	7-75
7-52	Removing PPI Assembly from Chassis	7-76
7-53	Disassembly of Universal Coupling	7-77
7-54	Removing Geared Cursor from PPI Indicator	7-77
7-55	Geared Cursor, Exploded View	7-77
7-56	Bearing Indicator, Bezel Removed	7-78
7-57	Bearing Indicator, Dial Index Removed	7-79
7-58	Removing Bearing Indicator Dial	7-79
7-59	Bearing Indicator, Synchro Unit Removed	7-80
7-60	Removing Slewing Mechanism from Bearing Indicator	7-80
7-61	Slewing Mechanism, Exploded View	7-81
7-62	Fan and Fan Motor, Exploded View	7-82
7-63	Dry Disc Rectifier in Rectifier Power Unit	7-82
7-64	Synchro Adjustments in Synchro Amplifier	7-84
7-65	Antenna Pedestal Tools	7-85
7-66	Antenna Pedestal, Right Side View	7-86
7-67	Antenna Pedestal, Cut-away View of Right Side	7-87
7-68	Antenna Pedestal, Cut-away View of Left Side	7-88
7-69	Synchrotie Bracket Assembly, Disassembled View	7-89
7-70	One-to-One Synchrotie Gear Shaft Assembly O-1384	7-90
7-71	Idler Gear Shaft Assembly O-1385	7-92

LIST OF ILLUSTRATIONS (Continued)

Figure Title Page

SECTION VII. CORRECTIVE MAINTENANCE (Continued)

Figure	Title	Page
7-72	36-to-1 Synchrotie Gear Shaft Assembly O-1386	7-94
7-73	Brush Assemblies	7-96
7-74	Drive Gear Train, Sectional View	7-98
7-75	Drive Motor Assembly	7-99
7-76	Motor Shaft and Coupling Assembly O-1381	7-100
7-77	Internal Transmission Section O-1395	7-101
7-78	Pedestal Drive Assembly O-1383	7-102
7-79	Slip Ring Assembly O-1393	7-103
7-80	Pivot Post Assembly O-1391	7-105
7-81	Ring Gear O-1392 and Slip Ring Assembly O-1393	7-106
7-82	Bevel Gear Back-up Bearing and Eccentric Shaft	7-109
7-83	Bevel Gear Shaft Assembly Dimensions	7-110
7-84	Alignment of Reduction Gear Bearings	7-111
7-85	Intermediate Transmission Housing, Exploded View	7-113
7-86	Intermediate Transmission Housing Assembly	7-114
7-87	Disassembly of IFF Transmission Line	7-116
7-88	RF Lines in Antenna Pedestal, Schematic Diagram	7-117
7-89	RF Lines in Antenna Pedestal, Exploded View	7-118
7-90	Disconnecting RF Lines at Base of Pedestal	7-119
7-91	Disassembly of R-F Inner Line at T-joint in Base of Pedestal	7-119
7-92	Disassembly of Rotating Joint	7-119
7-93	Removing Inner Conductors from Pedestal	7-119
7-94	Removing Lines from Base of Pedestal	7-120
7-95	Preparation for Removal of Outer Conductor	7-120
7-96	Removing Outer Conductor	7-120
7-97	Overload Relay in Transceiver	7-123
7-98	Transceiver Operating Controls	7-124
7-99	Keyer Pulse Waveform Development	7-125
7-100	Keyer Pulse Waveforms	7-126
7-101	Monitor Scope, Focus Balancing Control	7-127
7-102	Time Delay Relay in Modulator	7-128
7-103	Modulator, Front View	7-129
7-104	Monitor Receiver, Alignment Controls	7-130
7-105	Console Receiver, Alignment Controls	7-131
7-106	Range Scope, Bottom View	7-133
7-107	IFF Line Adjust Control	7-134
7-108	Range Scope Controls on Left Side of Chassis	7-134
7-109	Plot of Range vs. Counter Readings	7-136
7-110	Bias Voltage Control in IFF Coordinator	7-137
7-111	Trigger Delay Control in IFF Coordinator	7-137
7-112	Alignment Controls in PPI Indicator	7-138
7-113	Focus Coil Adjustment in PPI Indicator	7-138
7-114	Drive Motor in PPI Indicator	7-139
7-115	Anti-Hunt Control in PPI Indicator	7-139
7-116	Synchro Transformer Adjustment in PPI Indicator	7-140
7-117	Synchro Adjustment in Bearing Indicator	7-141
7-118	Internal Controls of Servo Amplifier	7-142
7-119	Adjustments in Synchro Amplifier	7-142
7-120	Transceiver Console, CAY-43ACM, Schematic Diagram	7-165
7-121	Transceiver Console, Transmitting Oscillator, CAY-43ACM Schematic Diagram	7-167
7-122	Transceiver Console, CAY-43ACM, Wiring Diagram	7-169
7-123	Transceiver Console, CAY-43ADK, Schematic Diagram	7-171
7-124	Transceiver Console, CAY-43ADK, Transmitting Oscillator, Schematic Diagram	7-173
7-125	Transceiver Console, CAY-43ADK, Wiring Diagram	7-175
7-126	Keyer Unit, CAY-67AAD, Schematic Diagram	7-177
7-127	Keyer Unit, CAY-67AAD, Wiring Diagram	7-179
7-128	Monitor Receiver, CAY-46AKD, Voltage and Resistance Chart	7-181
7-129	Monitor Receiver, CAY-46AKD, Schematic Diagram	7-183
7-130	Monitor Receiver, CAY-46AKD, Power Supply Wiring Diagram	7-185
7-131	Monitor Receiver, CAY-46ADK, Wiring Diagram	7-187

LIST OF ILLUSTRATIONS (Continued)

Figure Title Page

SECTION VII. CORRECTIVE MAINTENANCE (Continued)

7-132 Monitor Scope, CAY-55AFD, Voltage and Resistance Chart 7-189
7-133 Monitor Scope, CAY-55AFD, Schematic Diagram 7-191
7-134 Monitor Scope, CAY-55AFD, Wiring Diagram 7-193
7-135 Modulator, CAY-50AGU, Voltage and Resistance Chart 7-195
7-136 Modulator, CAY-50AGU, Serial #1 to 50, Schematic Diagram 7-197
7-137 Modulator, CAY-50AGU, Serial #1 to 50, Wiring Diagram 7-199
7-138 Modulator, CAY-50AGU, Serial #51 and Above, Schematic Diagram 7-201
7-139 Modulator, CAY-50AGU, Serial #51 and Above Wiring Diagram 7-203
7-140 Indicator Console, CAY-46ADJ, Frame Wiring Diagram 7-205
7-141 Indicator Console, CAY-46ADJ, Interconnection Diagram 7-207
7-142 Console Receiver, CAY-46ADH, Voltage and Resistance Chart 7-209
7-143 Console Receiver, CAY-46ADH, Schematic Diagram 7-211
7-144 Console Receiver, CAY-46ADH, Floating Chassis Wiring Diagram 7-213
7-145 Console Receiver, CAY-46ADH, Power Supply and Video Wiring Diagram 7-215
7-146 PPI Indicators, CAY-55ADV and CAY-55ADV1, Voltage and Resistance Chart, 4 Mile Range 7-217
7-147 PPI Indicators, CAY-55ADV and CAY-55ADV1, Voltage and Resistance Chart, 20 Mile Range 7-219
7-148 PPI Indicators, CAY-55ADV and CAY-55ADV1, Voltage and Resistance Chart, 80 Mile Range 7-221
7-149 PPI Indicators, CAY-55ADV and CAY-55ADV1, Voltage and Resistance Chart, 200 Mile Range 7-223
7-150 PPI Indicators, CAY-55ADV and CAY-55ADV1, Schematic Diagram 7-225
7-151 PPI Indicators, CAY-55ADV and CAY-55ADV1, Wiring Diagram 7-227
7-152 Range Scope, CAY-55AFB, Voltage and Resistance Chart, 4 Mile Range 7-229
7-153 Range Scope, CAY-55AFB, Voltage and Resistance Chart, 20 Mile Range 7-231
7-154 Range Scope, CAY-55AFB, Voltage and Resistance Chart, 80 Mile Range 7-233
7-155 Range Scope, CAY-55AFB, Voltage and Resistance Chart, 200 Mile Range 7-235
7-156 Range Scope, CAY-55AFB, Schematic Diagram 7-237
7-157 Range Scope, CAY-55AFB, Wiring Diagram 7-239
7-158 IFF Coordinator, CAY-23AEV, Voltage and Resistance Chart 7-241
7-159 IFF Coordinator, CAY-23AEV, Schematic Diagram 7-243
7-160 IFF Coordinator, CAY-23AEV, Wiring Diagram 7-245
7-161 Bearing Indicator, CAY-55AFC, Schematic Diagram 7-247
7-162 Bearing Indicator, CAY-55AFC, Wiring Diagram 7-249
7-163 General Control Unit, CAY-23AEW, Schematic Diagram 7-251
7-164 General Control Unit, CAY-23AEW, Wiring Diagram 7-253
7-165 Rotation Control Unit, CAY-50AEB, Schematic Diagram 7-255
7-166 Rotation Control Unit, CAY-50AEB, Case Wiring Diagram 7-257
7-167 Servo Amplifier, CAY-50AEU, Voltage and Resistance Chart 7-259
7-168 Servo Amplifier, CAY-50AEU, Wiring Diagram 7-261
7-169 Rectifier Power Unit, CAY-20ACY, Wiring Diagram 7-263
7-170 Echo Box Antenna, CAY-66AHK, Wiring Diagram 7-265
7-171 Synchro Amplifier, CM-211103, Voltage and Resistance Chart 7-267
7-172 Synchro Amplifier, CM-211103, Schematic Diagram 7-269
7-173 Synchro Amplifier, CM-211103, Interconnection Diagram 7-271
7-174 Synchro Amplifier, CM-211103, Wiring Diagram 7-273
7-175 Servo Generators, CAY-211192 and CAY-211192A, Wiring Diagram 7-275
7-176 Voltage Stabilizer, CG-301252, Schematic Diagram 7-277
7-177 Voltage Stabilizer, CG-301252, Wiring Diagram 7-279
7-178 Antenna Pedestal, CAJS-21ACP, Schematic Diagram 7-281
7-179 Antenna Pedestal CAJS-21ACP, Wiring Diagram 7-283

LIST OF ILLUSTRATIONS (Concluded)

Figure	Title	Page
	SECTION VII CORRECTIVE MAINTENANCE (Continued)	
7-180	Motor Generators, CAY-211182, CAY-211188 and CAY-211326, Schematic Diagram	7-285
7-181	Magnetic Controller (115 V.) Schematic Diagram	7-287
7-182	Magnetic Controller (115 V.) Wiring Diagram	7-289
7-183	Magnetic Controller (230 V.) Schematic Diagram	7-291
7-184	Magnetic Controller, (230 V.) Wiring Diagram	7-293
7-185	Voltage Regulator, Schematic Diagram	7-295
7-186	Voltage Regulator, Wiring Diagram	7-297

LIST OF TABLES

Table No.	Title	Page
	SECTION I. GENERAL DESCRIPTION	
1-1	Cubical Contents and Weight per Shipment	1-37
1-2	Power Equipment	1-38
1-3	Equipment Supplied, Contract NXsr-30306	1-38
1-4	Equipment Supplied, Contract NXsr-46032	1-42
1-5	Equipment Supplied, Contract N5sr-7179	1-42
1-6	Equipment Required but Not Supplied, Contracts NXsr-30306 and NXsr-46032	1-42
1-7	Tube Complement, SR and SR-a Equipments	1-45
	SECTION III. INSTALLATION AND INITIAL ADJUSTMENTS	
3-1	Wire Number Designation	3-64
	SECTION IV. OPERATION	
4-1	Operating Adjustments	4-20
	SECTION V. OPERATOR'S MAINTENANCE	
5-1	Underway—Each Watch	5-0
5-2	Fuse Locations	5-5
	SECTION VI. PREVENTIVE MAINTENANCE	
6-1	Daily Checks	6-17
6-2	Weekly Checks	6-18
6-3	Quarterly Checks	6-19
6-4	Semi-Annual Checks	6-21
6-5	Annual Checks	6-21
	SECTION VII. CORRECTIVE MAINTENANCE	
7-1	Transceiver Current Readings	7-13
7-2	Coil Data	7-145
7-3	Motor Data	7-157
	SECTION VIII. PARTS AND SPARE PARTS LISTS	
8-1	List of Major Units	8-1
8-2	Combined Parts and Spare Parts List by Symbol Designation	8-4
8-3	Applicable Color Codes and Miscellaneous Data	8-220
8-4	List of Manufacturers	8-221

CONTRACTUAL GUARANTEE

The equipment including all parts and spare parts, except vacuum tubes, rubber and material normally consumed in operation, is guaranteed for a period of one year from the date of delivery of the equipment to and acceptance by the Government with the understanding that all such items found to be defective as to material, workmanship or manufacture will be repaired or replaced, f.o.b. any point within the continental limits of the United States designated by the Government, without delay and at no expense to the Government; provided that such guarantee will not obligate the Contractor to make repair or replacement of any such defective items unless the defect appears within the aforementioned period and the Contractor is notified thereof in writing within a reasonable time and the defect is not the result of normal expected shelf life deterioration.

To the extent the equipment, including all parts and spare parts, as defined above, is of the Contractor's design or is of a design selected by the Contractor, it is also guaranteed, subject to the foregoing conditions, against defects in design with the understanding that if ten per cent (10%) or more of any such said item, but not less than two of any such item, of the total quantity comprising such item furnished under the contract, are found to be defective as to design, such item will be conclusively presumed to be of defective design and subject to one hundred per cent (100%) correction or replacement by a suitably redesigned item.

All such defective items will be subject to ultimate return to the Contractor. In view of the fact that normal activities of the Naval Service may result in the use of equipment in such remote portions of the world or under such conditions as to preclude the return of the defective items for repair or replacement without jeopardizing the integrity of Naval communications, the exigencies of the Service, therefore, may necessitate expeditious repair of such items in order to prevent extended interruption of communications. In such cases the return of the defective items for examination by the Contractor prior to repair or replacement will not be mandatory. The report of a responsible authority, including details of the conditions surrounding the failure, will be acceptable as a basis for affecting expeditious adjustment under the provisions of this contractual guarantee.

The above one year period will not include any portion of time the equipment fails to perform satisfactorily due to any such defects, and any items repaired or replaced by the Contractor will be guaranteed anew under this provision.

INSTALLATION RECORD

Contract Number	NXsr-30306	Date of Contract	5 June 1943
	NXsr-46032		17 January 1944
	N5r-7197		7 April 1945

Serial Number of Equipment..

Date of Acceptance by the Navy..

Date of Delivery to Contract Destination..

Date of Completion of Installation..

Date Placed in Service...

Blank spaces in this table shall be filled in at the time of installation.

REPORT OF FAILURE

Report of failure of any part of this equipment, during its service life, shall be made to the Bureau of Ships in accordance with current instructions. The report shall cover all details of the failure and give the date of installation of the equipment. For procedure in reporting failures see Chapter 67 of the "Bureau of Ships Manual," or superseding instructions.

ORDERING PARTS

All requests or requisitions for replacement material should include the following data:

1. Navy stock number or, when ordering from an Army supply depot, the Army stock number.
2. Name of part.

If the Navy stock number has not been assigned, the requisition should specify the following:

1. Equipment model designation.
2. Name of part and complete description.
3. Manufacturer's designation.
4. Contractor's drawing and part number.
5. AWS, JAN or Navy type designation.

SAFETY NOTICES

The attention of officers and operating personnel is directed to Chapter 67 of the Bureau of Ships Manual or superseding instructions on the subject of Radio-Safety precautions to be observed.

While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed.

KEEP AWAY FROM LIVE CIRCUITS. Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside equipment with high voltage supply on. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position due to charges retained by capacitors. To avoid casualties always remove power and discharge and ground circuits prior to touching them.

DON'T SERVICE OR ADJUST ALONE. Under no circumstances should any person reach within or enter the enclosure for the purpose of servicing or adjusting the equipment without the immediate presence or assistance of another person capable of rendering aid.

DON'T TAMPER WITH INTERLOCKS. Do not depend on door switches or interlocks for protection but always shut down motor generators or other power equipment. Under no circumstances should any access gate, door or safety interlock switch be removed, short circuited, or tampered with in any way, by other than authorized maintenance personnel, nor should reliance be placed upon the interlock switches for removing voltages from the equipment.

RESUSCITATION

AN APPROVED POSTER ILLUSTRATING THE RULES FOR RESUSCITATION BY THE PRONE PRESSURE METHOD SHALL BE PROMINENTLY DISPLAYED IN EACH RADIO, RADAR OR SONAR ENCLOSURE. POSTERS MAY BE OBTAINED UPON REQUEST TO THE BUREAU OF MEDICINE AND SURGERY.

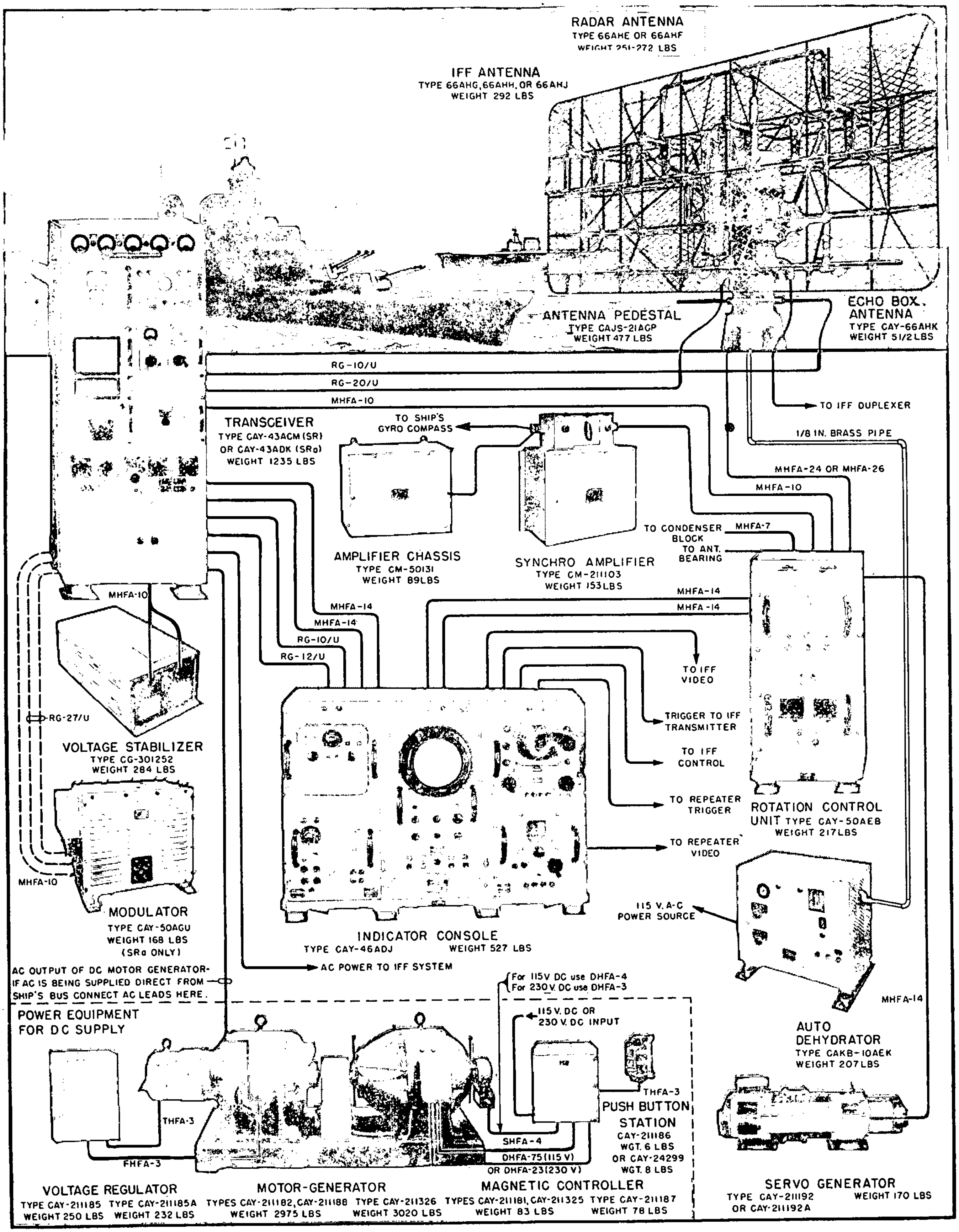


Figure 1-1. Navy Model SR and SR-a Radar Equipment

SECTION 1

GENERAL DESCRIPTION

1. RADAR EQUIPMENTS COVERED.

a. GENERAL.

(1) This instruction book covers the SR Ships Radar Equipments purchased on Contracts NXsr-30306 and NXsr-46032. The SR Equipments are to be modified in the field to become SR-a Equipments. Because of the necessary delay in making field changes, this book has been arranged to present detailed instructions for two separate systems. These systems are described in detail in the following paragraphs.

b. SR EQUIPMENT.

(1) The SR Ships Radar Equipment is shown in Fig. 1-1. Two-hundred SR Equipments were purchased on Contract NXsr-30306 and 100 SR Equipments were purchased on Contract NXsr-46032. One-hundred of the SR Equipments, purchased on Contract NXsr-30306 are provided with 115 V. D-C motor generators. The remaining one-hundred equipments are provided with 230 V. D-C motor generators. Fifty of the 115 volt equipments are supplied with Blue Antennas COD-66AHE or CLP-66AHE. The remaining fifty equipments are supplied with the Yellow-Green Antenna COD-66AHF or CLP-66AHF. The 230 volt equipments are broken down in the same way. Fifty of these equipments are supplied with the Blue Antenna and fifty are supplied with the Yellow-Green Antenna. The colors used in the names of the antennas are used to indicate the frequency band over which they operate.

(2) One-hundred SR Equipments are supplied on Contract NXsr-46032. These equipments are supplied with 230 volt motor generators. Fifty of the equipments are supplied with the Blue Antenna and fifty are supplied with the Yellow-Green Antenna.

c. SR-a EQUIPMENT.

(1) The original SR Equipments employed grid circuit keying. In order to increase the life of the transmitting tubes and simplify tuning, these equipments are to be modified in the field to transfer keying to the plate circuit of the transmitting oscillators. This is done by substituting Modulator CAY-50AGU for Keyer CAY-67AAD. This change is described in Navy Field Change No. 20. When this change is made, the Keyer is removed from the Transceiver Console CAY-43ACM and is replaced with a blank panel. The name-plate is changed to CAY-43ADK. The inclusion of the Modulator is the only modification involved in the conversion from SR to SR-a Equipments. All other field modifications for SR Equipments may be made without requiring a change in the type number.

2. PURPOSE AND BASIC PRINCIPLES OF OPERATION.

a. The SR and SR-a Equipments are complete radar equipments designed for ship installations. The SR Equipment was originally designed to provide facilities for radar searching and ranging of targets within a radius of 400 nautical miles from the ship. The equipments were later modified in the field to reduce the maximum range to 200 miles. Two types of target information are presented. During searching operations the principle target information is obtained from a PPI Indicator. As the antenna rotates continuously through 360 degrees in azimuth, a *map* of all targets within the range used is presented on the PPI Indicator so that the operator may select the target or targets to be ranged and accurately train the antenna on the desired target. A rough estimate of target range may also be obtained from the PPI Indicator. A more accurate range indication is obtained from the Type A presentation on a Range Scope. Type A presentation is that in which a vertical deflection appears on a horizontal sweep. Four ranges are provided. On the Range Scope, these ranges were originally 4, 20, 80, and 400 miles. The 400-mile range was reduced to 200 miles by Navy Field Change No. 25. The ranges available on the PPI Indicator are 4, 20, 80, and 200 miles.

b. The SR series of radar equipments operate as searching, ranging, and direction finding devices. These functions are based on a number of fundamental principles. Chief among these principles is the fact that radio waves travel in a straight line. Radio waves also travel at a constant speed of 162,000 nautical miles per second which is the speed of light. Another fundamental principle involved is that radio waves are reflected by objects much in the same way that light is reflected. If a radio wave strikes a metallic object, it induces a flow of r-f current in the object and the object becomes a radiating antenna. As the frequency is increased a somewhat similar phenomenon occurs even when the metallic object is replaced with a dielectric or non-metallic object.

c. The principles briefly described above may be employed to determine the distance to a target by using a pulse modulated transmitting oscillator, a sensitive receiver tuned to the transmitter frequency and a time measuring device such as an oscilloscope. The transmitter sends out short bursts of r-f energy at fixed intervals. The time duration of these bursts of energy is also fixed. The transmitter and receiver are both operated with the same antenna. During the time the transmitter is delivering power to the antenna, the receiver is rendered insensitive by means of a specially designed switch in its input circuit. Immediately after the end of the transmission period, this same switch connects the receiver to the antenna in place of the transmitter. The burst of energy is radiated by the antenna and if it strikes a target, part of the energy is re-radiated or reflected in all directions from the target. The portion of this reflected energy that is reflected back to the radar antenna is received and detected by the receiver.

d. If some means is used to determine the instant that transmission starts and to measure the time that elapses between the start of transmission and the instant the *echo* is received, it is possible to calculate the distance between the radar equipment and the target. An oscilloscope can be used to measure time very accurately. The SR Equipments use two types of oscilloscopes. One is a Type A oscilloscope. Its sweep starts from a point near the circumference of the tube and moves straight across the screen to a corresponding point in the circumference that is diametrically opposite the starting point. The sweep starts when transmission starts and ends at the other side of the tube just before the next period of transmission begins. It then returns very rapidly to the starting point to start again with the next period of transmission. It progresses across the screen of the tube at a constant rate of speed. Since the time in microseconds required for the sweep to cross the screen is known, it is possible to calibrate the sweep in time units. In practice, the sweep is directly calibrated in miles since the distance a radio wave will travel in a given period of time is known.

e. If it is desired to set up a 20-Mile range on the oscilloscope, the first step is to determine the time required for a radio wave to travel out 20 miles to the target and back again to the radar set. The total distance the radio wave travels is 40 miles. Since radio waves travel at a velocity of 162,000 nautical miles per second, the time required for radio waves to travel 40 miles is 40 divided by 162,000 which is equal to 0.000247 seconds or 247 microseconds. Therefore, the transmitter pulses must be at least 247 microseconds apart and the sweep on the oscilloscope must require 247 microseconds to travel across the face of the tube. If the sweep is divided into 20 equal parts the time measuring device is complete.

f. When the transmitter pulse begins, the sweep on the oscilloscope starts. At some interval before the next transmitter pulse starts, the echo is received and is fed to the oscilloscope by the receiver. The echo produces a vertical deflection on the sweep. The operator need only count the number of divisions between the start of the sweep and the echo pip to determine the number of miles between the radar set and the target.

g. In order to determine the direction of the target, a highly directional antenna is used. That is, the antenna does not radiate energy in all directions, but for all practical purposes, concentrates the energy in a narrow beam. Therefore, only targets within the area covered by this narrow beam will cause pips to appear on the oscilloscope even though the area around the radar set may contain many others. The antenna can be rotated to point the beam in any direction and the direction in which the antenna is pointing is the direction of the target that is being received. The antenna actuates an azimuth scale graduated in 360 degrees. The antenna is usually pointed directly toward true north when the azimuth scale is set to 0 degrees. When a target is received, the angular deviation of the antenna from true north is noted and if the position of the radar set is known, the azimuth bearing and the range of the target may be used to fix the location of the target. If the target is moving, successive *fixes* may be used to determine its speed and the direction in which it is moving.

h. Another method of target presentation is also used in the SR series of equipments to facilitate the location of targets for ranging. This method employs an oscilloscope whose sweep starts from the center of the tube screen and travels to the circumference. The direction in which the sweep travels away from the center of the tube is controlled by and dependent upon the direction in which the antenna is pointing at any particular instant. A 360-degree scale is placed around the circumference of the tube and the number of the scale with which the sweep coincides indicates the angular deviation of the antenna from true north in degrees. When a target echo is received, the electron beam that illuminates the screen of the tube is momentarily intensified by the output of the receiver to form a bright dot in the sweep. This method of target presentation is called Plan Position Indication but is shortened to PPI in common usage. In practice, the antenna is rotated continuously in azimuth and target dots continually appear in, and disappear from, the sweep as it swings around the center of the tube. The screen of the tube has a long persistency and the illumination produced by the dots remains for some time after the sweep has passed. Therefore, as the sweep rotates, a pattern of dots is built up on the tube. Since the radar set is represented as being in the center of the tube, all of the targets in the area within range around the radar set are shown on the PPI Tube. By rotating the antenna to make the PPI sweep coincide with a target, the operator may select any desired target for ranging and stop the antenna on it.

i. In order to keep the antenna trained on any target selected, the antenna positioning circuits are connected to the ship's gyro-compass circuits so that no matter which way the ship turns the antenna will maintain the same position to which it was set until the operator operates controls to turn it to some other position.

3. DESCRIPTION OF SYSTEMS.

a. SR SYSTEM (NXsr-30306).

(1) A simplified block diagram of the SR Equipment, purchased on Contract NXsr-30306, is shown in Fig. 1-2. The transmitting system consists of the Transceiver Console and the Keyer Unit; the Keyer Unit contains a capacity-inductance delay line. This line is terminated so that the charge on the capacitors will leak off at a predetermined rate. The voltage on the delay line triggers the transmitting oscillators in the Transceiver Console. The Keyer Unit can be adjusted to provide pulse lengths of 1, 2 and 20 microseconds at repetition rates of 60 and 200 cps. The pulses of voltage developed by the delay line are applied to the grids of the transmitting oscillators to key them. When keyed, they oscillate for the duration of the pulse width in use at the repetition rate selected.

(2) The transmitting oscillators are located in the Transceiver Console cabinet. They consist of two Type 527 tubes and the necessary resonant lines. They develop the r-f power that is radiated by the equipment. The Transceiver also contains the high voltage supply and the necessary control circuits and relays to switch the circuits into operation in the proper sequence. The output of the transmitting oscillator is coupled to the r-f transmission line through the duplexer. The duplexer is an electronic switch that connects the antenna to the transmitter during its brief periods of oscillation. At the same time, it short circuits the input circuit to the Monitor Receiver in the receiving system. During the idle periods of the transmitter, the duplexer short circuits the output circuit of the transmitter and connects the input circuit of the Monitor Receiver to the antenna through the transmission line.

(3) The transmission line carries the r-f power to the antenna radiation and also delivers the received r-f energy to the Monitor Receiver. The transmission line consists of two concentric lines. One of these lines is the radar transmission line and the other line is the transmission line for the IFF Equipment associated with the SR system. The directional assembly antenna consists of the radar antenna and the IFF Antenna. The radar antenna may be either of two models, the difference being the frequency band over which they are designed to operate. The IFF Antenna may be any one of three different models designed for different frequencies. All three IFF Antennas are supplied with each SR. One radar antenna is supplied.

(4) The Auto Dehydrator CAKB-10AEK is also a part of the r-f system. The purpose of the Auto Dehydrator is to pressurize the r-f transmission lines in the antenna pedestal with dry air. It removes moisture from the air by forcing it through a silica gel cartridge. Two separate dehydrating systems are incorporated in the Auto Dehydrator. One system runs while the other is being reactivated. The unit automatically shifts from one system to the other so that the air always passes through an active silica gel cartridge.

(5) The received r-f energy is connected to the input of the Monitor Receiver. The Monitor Receiver is part of the receiving system but it is actually located in the Transceiver Console to eliminate the long transmission line that would be required between it and the duplexer which must of necessity be located in the Transceiver Console. Two outputs are taken from the Monitor Receiver. One is the 15-mc/s i-f signal for the Console Receiver in the Indicator Console. The other is a video signal for the Monitor Scope. The gain of the Monitor Receiver determines the net gain of the entire receiving system. It can be controlled from the Console Receiver.

(6) The Monitor Scope is placed in the Transceiver Console to simplify tuning procedures. This is necessary because the Indicator Console may be located in another room where it would be difficult to observe the received echo when the transmitter is being tuned. The Monitor Scope is also designed so that it can be removed from the Transceiver Console and used as a test instrument.

(7) The Echo Box Antenna CAY-66AHK is a single folded coaxial dipole mounted in the radiation field of the radar antenna. This antenna picks up a strong r-f signal from the radar antenna and feeds it through a special transmission line to the Echo Box in the Monitor Receiver. The Echo Box reflects the signal back to the Echo Box antenna which reradiates the signal. The echo signal is then picked up by the radar antenna to serve as a test signal to test the operation of the equipment at times when no targets are available.

(8) The 15-megacycle i-f output of the Monitor Receiver is connected through the interconnecting cabling to the input of the Console Receiver CAY-46ADH in the Indicator Console. The Console Receiver contains anti-jamming circuits, i-f amplifiers, a detector, video amplifiers, and video output tubes. The video output of the Console Receiver is connected to the Range Scope, the PPI Indicator, and any remote

PPI Indicators that may be in use. In addition, the Console Receiver contains a remote gain control for the Monitor Receiver and a BAND PASS switch which remotely selects the pulse width in the Keyer Unit. It can also be used to provide a source of range marker voltage for the various PPI Indicators that may be in use.

(9) The range system consists of the Range Scope and the IFF Coordinator, both of which are located in the Indicator Console. The Range Scope is a Type A oscilloscope and is used to accurately measure the range of the target and to identify it as friend or foe. The identification function is made possible by the action of the IFF Coordinator. Trigger voltage from the transmitting system is connected into the IFF Coordinator. When the IFF system is not functioning, the IFF Coordinator feeds each radar trigger directly to the Range Scope where it is used to produce the sweep or base line on which the target echo is displayed. During IFF operation, the IFF Coordinator delays each alternate radar trigger so that it can be used to produce an IFF sweep that occurs alternately on the Range Scope with the radar sweep. The IFF Coordinator also produces a gate or blocking voltage that causes the video circuits in the Range Scope to apply radar video signals to the cathode ray tube on one cycle and IFF video signals to the tube on the succeeding cycle. This action occurs so rapidly as to make the patterns seem to appear simultaneously. The delayed IFF trigger causes the IFF echo to appear immediately beneath the radar echo so that positive identification is obtained. The IFF Coordinator and the IFF system do not function unless a switch on the IFF Coordinator is operated.

(10) The Range Scope presents Type A information on a 5-inch cathode ray tube. By means of the IFF Coordinator, the Range Scope can be made to function as two oscilloscopes. One displays radar echoes and the other displays IFF echoes. Both patterns appear on a single cathode ray tube and seem to appear simultaneously. Two separate sweep lines appear, one above the other. The Range Scope has four ranges, 4, 20, 80, and 200 miles. The 200-mile range was originally 400 miles. Four marker pips appear on each range to assist the operator in estimating the range of the target. In addition, a *range step* is provided on the 4-, 20- and 80-mile ranges to enable the operator to obtain accurate range measurements. The first SR Equipments did not include the range step on the 80-mile range. The range step raises the left hand portion of the sweep vertically above the right hand portion. The two portions are joined by the vertical step line. A control moves this line back and forth across the screen. When the line coincides with a target, the range may be read on a dial that automatically registers range within plus or minus 100 yards.

(11) The PPI Indicator, CAY-55ADV or CAY-55ADV-1 and any remote PPI Indicators in use, constitute the PPI system. The PPI system is used primarily in searching operations to enable the operator to see at a glance all of the targets in the range of the SR and to aid in the selection of the target or targets that are to be ranged. The PPI Indicator operates on ranges of 4, 20, 80, and 200 miles. The PPI Indicator permits the operator to observe the bearing and range of any of the targets that appear on it. The range markers on the PPI Indicator are actually concentric rings around the center of the tube screen, produced by bright dots in the sweep line. The sweep starts from the center of the tube and as the antenna swings around, the sweep follows it and thus indicates the direction in which the antenna is pointing at any instant. The sweep and marker circuits in the PPI Indicator are triggered by the radar trigger and video signals are obtained from the output of the Console Receiver. The CAY-55ADV and the CAY-55ADV-1 PPI Indicators are identical electrically. The difference between the two models is in the type of cursor used. A piece of transparent plastic is placed over the face of the cathode ray tube in such a way that it can be rotated. A line called a cursor line is engraved from the center of the plastic to its outer edge. When the cursor is rotated so that this line coincides with a target, the azimuth bearing may be read beneath the cursor line on the azimuth scale around the circumference of the tube. The use of the cursor makes it unnecessary to stop the antenna and adjust it so that the sweep line coincides with the target whenever it is necessary to determine the bearing of a target. The CAY-55ADV indicator has a hand operated cursor of simple construction. The CAY-55ADV-1 indicator uses a geared cursor driven by a handwheel.

(12) The antenna positioning system contains several units which will be identified and described in this and the following paragraphs. The Antenna Pedestal contains a d-c drive motor to develop power to rotate the antenna and two position-data transmitting synchro units. One of the synchros is a 1-speed coarse position transmitter which provides information to the bearing indicators. The other is a 36-speed fine position transmitter which provides the voltage by which the antenna is positioned. The data produced by the Antenna Pedestal is relative data, that is, it is indicative of the position of the antenna with respect to the direction in which the ship is sailing. When *true bearing* data is desired, the relative voltages are combined with data voltages from the ship's gyrocompass synchros. Compass data voltages are provided by the synchro amplifier. The synchro amplifier is connected to the 36-speed and 1-speed synchro transmitters of the ship's gyro compass system. It provides an amplified reproduction of these voltages for the

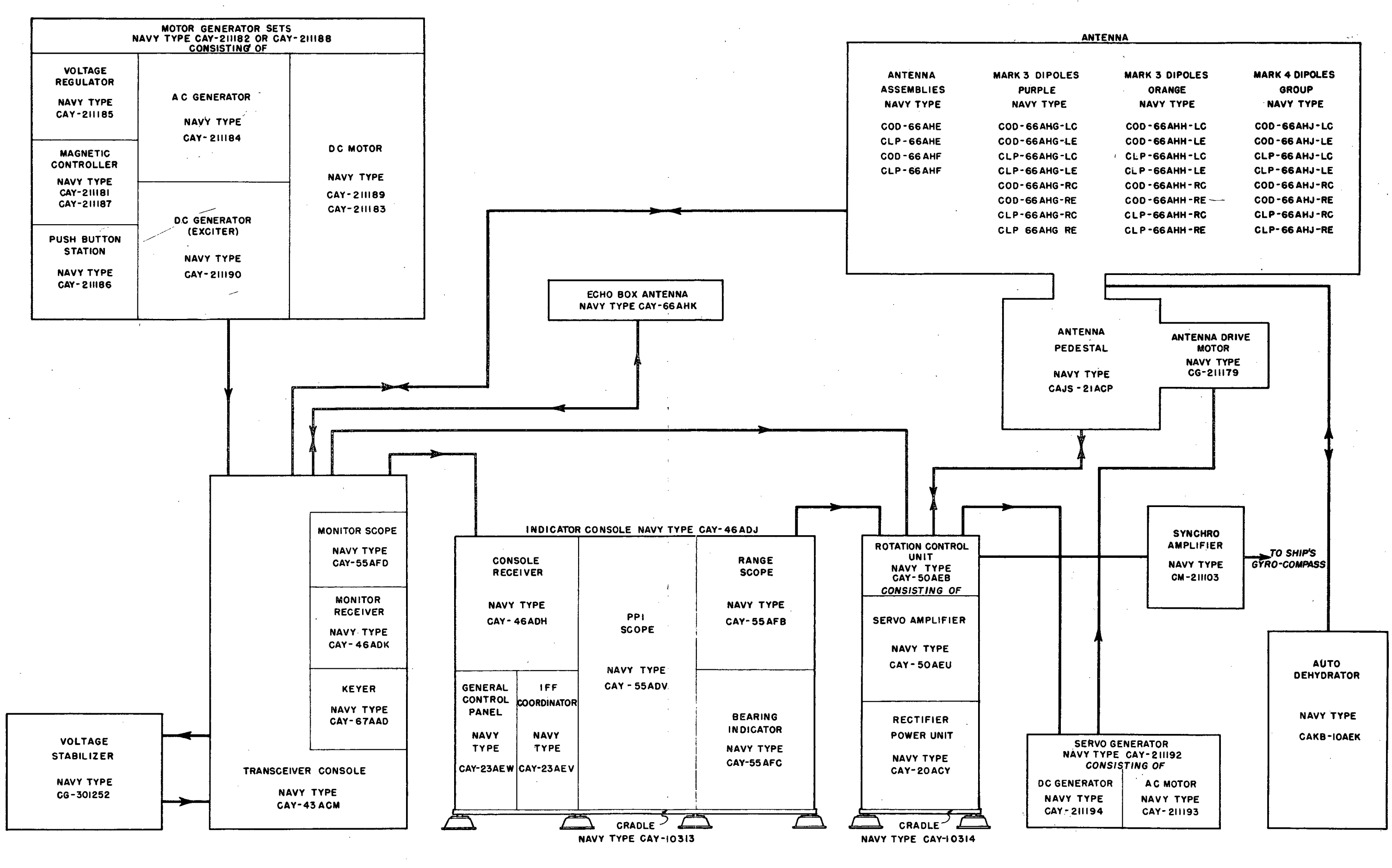


Figure 1-2. Simplified Block Diagram of SR System

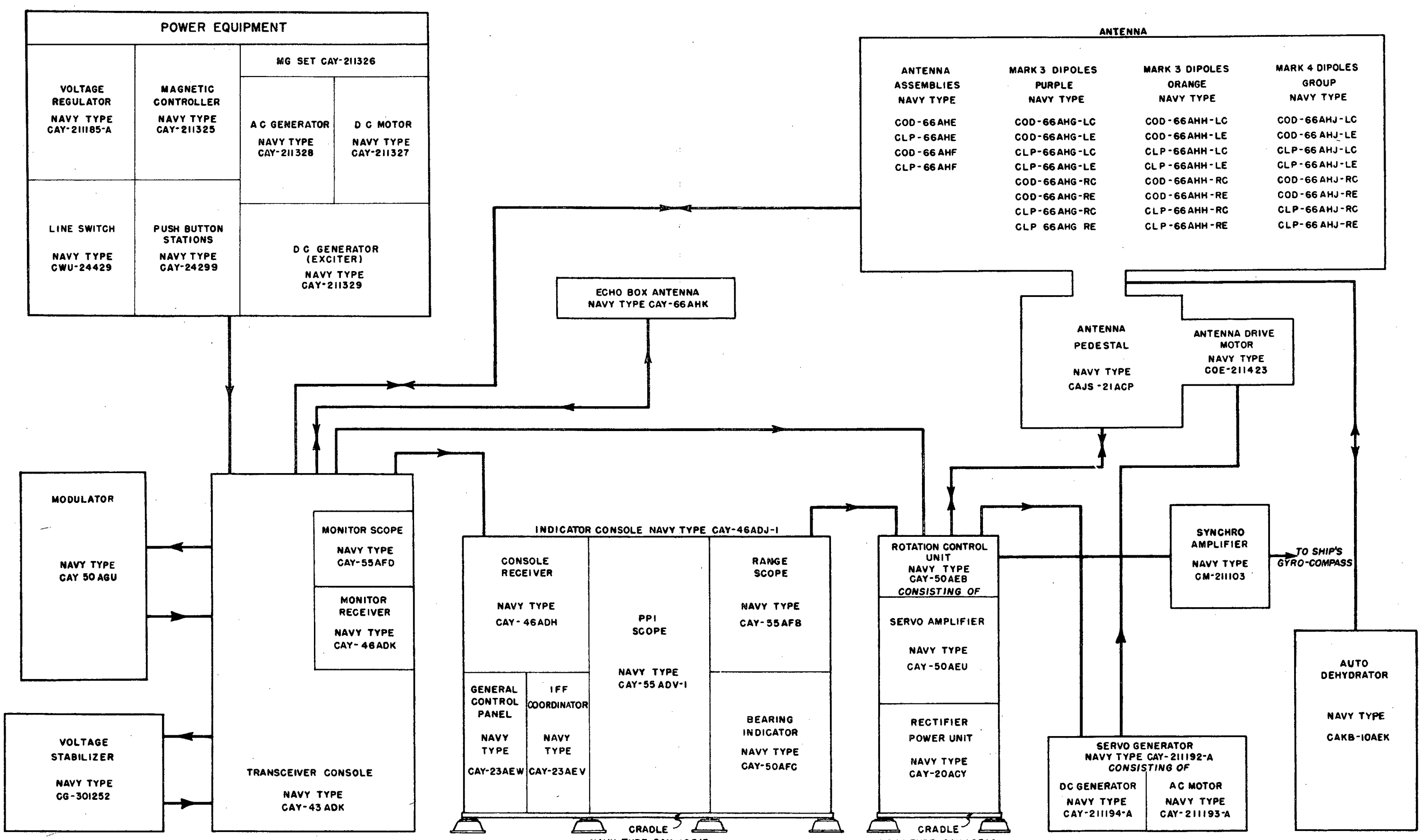


Figure 1-3. Simplified Block Diagram of SR-a System

operation of the antenna position and bearing indicating system. When the equipment is operating on relative bearing information, the compass voltages are replaced with a-c of fixed phase from the ship's circuits.

(13) The Rotation Control Unit CAY-50AEB provides the driving voltages for the antenna positioning system. It consists of two separate units. One is the Servo Amplifier CAY-50AEU. The Servo-Amplifier receives an input from the Bearing Indicator made up of the voltages from the Antenna Pedestal modified by position of the hand slewing synchro in the Bearing Indicator. Thus, the voltage applied to the Servo Amplifier is on true bearing, made up of the compass voltage representing true north modified by the position of the antenna and further modified by the position of the manual rotation control of the Bearing Indicator. On relative bearing, the compass voltage is replaced by a voltage of fixed phase, and the input to the Servo Amplifier is independent of any motion of the ship with respect to true north. The output of the Servo Amplifier is used to excite the field of the Servo Generator. The other component of the Rotation Control Unit is the Rectifier Power Unit CAY-20ACY. This unit contains a rectox dry disc rectifier that furnishes rectified d-c voltage to the field and armature of the antenna drive motor in the event of the failure of the servo system or whenever it is desirable to relieve the system from the wear attendant with continuous operation.

(14) Servo Generator CAY-211192 is the component that actually supplies power to the antenna drive motor when the servo system is in use. The field excitation voltage from the Servo Amplifier excites the field of a d-c generator in the Servo Generator. The output from the armature of this generator is used to excite the armature of the antenna drive motor. The field of the antenna drive motor normally receives its excitation from a full wave electronic rectifier in the Servo amplifier. The d-c generator in the Servo Generator is driven by an a-c motor. The Servo Generator delivers an output only when a phase displacement exists somewhere in the antenna positioning system that will produce a field excitation voltage from the Servo Amplifier in the Rotation Control Unit.

(15) The power equipment for the SR Equipment supplied on Contract NXsr-30306, may be either of two types. One type converts 115 volts d-c from the ship's line to 115 volts a-c which is required for the operation of the SR Equipment. The other type of equipment converts 230 volts d-c from the ship's lines to 115 volts a-c. The type of equipment used depends upon the voltage rating of the ship's power supply. The 115-volt d-c equipment consists of the following items:—Pushbutton Station CAY-211186, Magnetic Controller CAY-211181, Motor Generator CAY-211188 and Voltage Regulator CAY-211185. The 230 volt d-c power equipment consists of:—Pushbutton Station CAY-211185, Magnetic Controller CAY-211187, Motor Generator CAY-211182 and Voltage Regulator CAY-211185 or CAY-211185A. A voltage stabilizer, CG-301252, is used to regulate the voltage input to the Transceiver Console and the components associated with it.

b. SR SYSTEM (NXsr-46032).

(1) With three exceptions the SR equipment supplied on Contract NXsr-46032 is identical to the equipment previously described. All components are connected into the system in the same way. The exceptions are that (1) the PPI Indicator in the Indicator Console is equipped with a geared cursor and bears the Number CAY-55ADV-1, (2) the Servo Generator has been slightly modified and bears the Number CAY-211192A, and (3) only power equipment for the conversion of 230 volts d-c to 115 volts a-c is supplied. This equipment consists of the following:—Motor Generator CAY-211326, Voltage Regulator CAY-211185A, Magnetic Controller CAY-211325, three pushbutton stations CAY-24299 and Controller Disconnect Switch CWU-24429.

c. SR-a SYSTEM.

(1) Both of the SR Equipments just described are to be modified in the field to become SR-a Equipments. This change is shown in both Fig. 1-2 and Fig. 1-3. The conversion is described in Navy Field Change No. 20. As may be seen from the block diagrams, the change only affects the transmitting system. Keyer Unit CAY-67AAD is removed from the Transceiver Console. A blank panel covers its former location. The keying function is performed by Modulator CAY-50AGU. The keyer unit accomplished keying in the grid circuit of the transmitting oscillator. The Modulator accomplishes keying in the plate circuit of the transmitting oscillator. The keying frequency is 100-150 cps and the pulse width is 4 microseconds. This change was made to materially increase the life of the transmitter tubes. When this modification is made, the number of the Transceiver Console is changed from CAY-43ACM to CAY-43ADK.

4. DESCRIPTION OF MAJOR UNITS.

a. TRANSCEIVER CONSOLE CAY-43ACM (SR ONLY).

(1) GENERAL.—The components of the Transceiver Console are housed in a metal cabinet approximately 72 x 28 x 25 inches. Its total weight is approximately 1,235 pounds. Components of the transmitting oscillator, and its power supply, control circuits, and the duplexer are built permanently into the console. The Monitor Scope, Monitor Receiver, and the Keyer Unit are separate components which mount in the

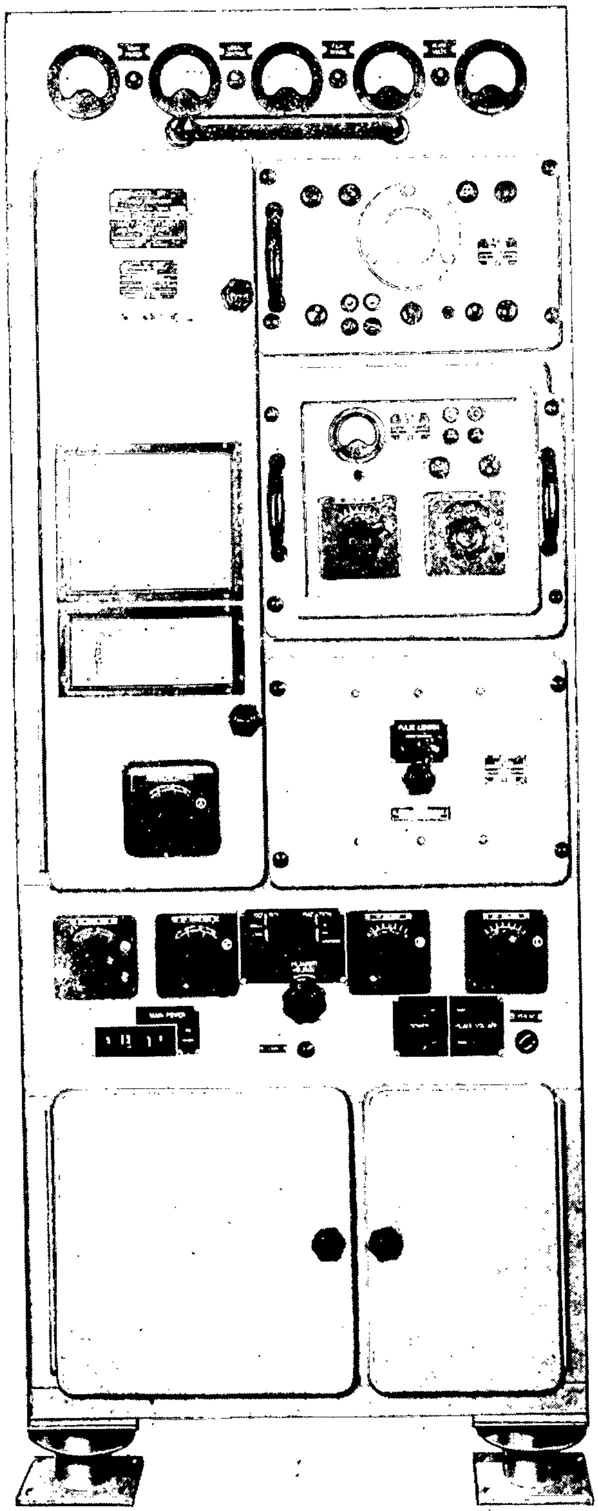


Figure 1-4. Transceiver Console CAY-43ACM (SR)

Transceiver Console. See Fig. 1-4. The cabinet is mounted on four plunger type shockmounts which raise the entire cabinet about four inches clear of the deck. However, prior to Serial No. 31, the cabinet was not shockmounted. It was attached to two U-beam type mounting flanges which bolted firmly to the deck. Dials and controls of the transmitting components are mounted on the front panels of the console. Three access doors are provided in the front of the console for access to the transmitting oscillator and the transmitting oscillator power supplies. Access to the other components may be secured by removal of the side and back shields. The plug-in-units may be reached by sliding them out of their positions.

(2) TRANSMITTING OSCILLATOR.

(a) The oscillator assembly consists of a pair of concentric cathode lines into which the two Type 527 transmitting tubes are mounted. See Fig. 1-5. These lines are mounted near the top of the cabinet and extend downward, with the tubes themselves near the center of the cabinet. This entire assembly is reached through the large rectangular door which occupies the top left-hand quarter of the cabinet. A blower motor blows air through the lines to cool the filament seals of the transmitting oscillator tubes.

(b) The grid assembly consists of two silver-plated brass tubes through which cool air is blown to the rear grid seals of the oscillator tubes that form part of the variable resonant grid circuit. The rear grid terminals of the oscillator tubes clip into springs which are attached to these two vertical silver plated brass tubes. A variable shorting bar slides up and down the vertical tubes and is controlled by the grid dial which is accessible through the hole in the oscillator door. Three other silver plated brass tubes are located below the plate and front grid oscillator tube terminals. They are used to direct a stream of cooling air from the blower motor upon the oscillator tube seals. A micarta tube, located in the right-rear section of the grid casting, connects the grid and cathode castings together for transmission of cool air from blower motor B-101 to the filament oscillator tube seals.

(c) Two pairs of coaxial lines are mounted at the back of the Console behind the transmitting oscillator. They extend vertically downward from the coaxial line across the back of the console near the top. These are, from left to right, looking from the front of the cabinet, the two transmitter loading stubs and the two stubs which make up the duplexer unit. They are all mounted rigidly against the frame members of the Console. The Console frame itself consists of a welded box-like structure with cross-members and braces. Angles and gussets are employed to make it extremely rigid.

(d) The control shafts for tuning the loading

transformer stubs and the duplexer stubs are located on the front of the console. See Fig. 1-4. Shafts extend to the back of the console in order to operate the tuning elements. The majority of the controls are

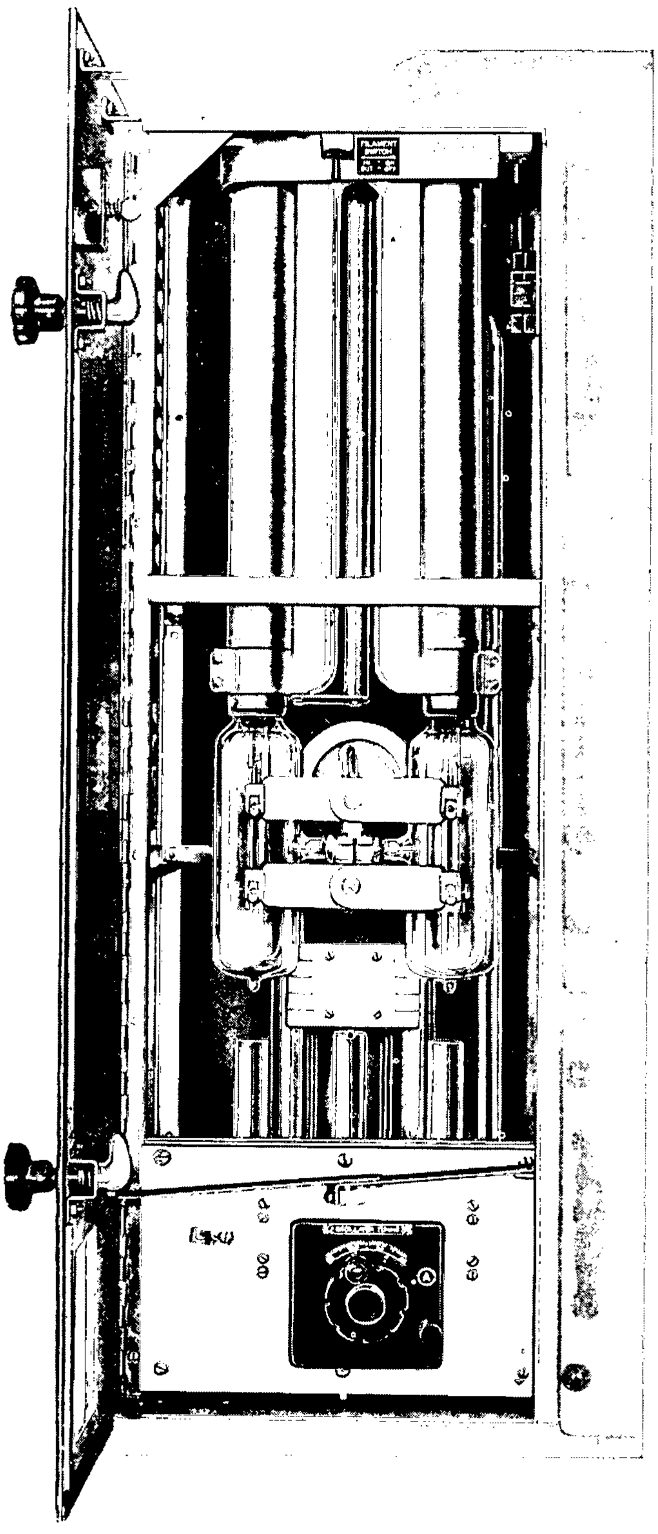


Figure 1-5. Oscillator Assembly

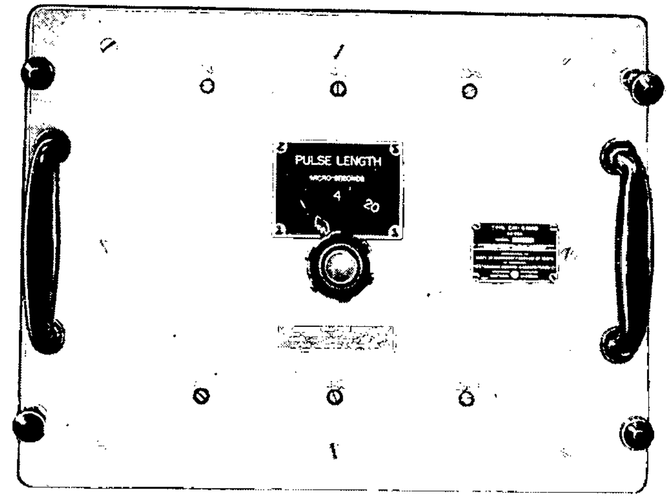


Figure 1-6. Keyer Unit CAY-67AAD

mounted on a panel section directly below the level of the transmitter and the three removable components. The power supply for the transmitting oscillators is located below the tuning controls. This supply consists of two Type 8020 rectifier tubes, a suitable filter, and a power transformer. A motor driver variac controls the output voltage. The tubes are mounted on a deck in the bottom of the Console. Meters and indicator lights which show Transceiver operation conditions are mounted in a row across the top of the Console.

b. KEYER UNIT CAY-67AAD (SR ONLY).

(1) The Keyer Unit, shown in Fig. 1-6, is built in a box-like frame measuring 18⅞ x 14⅝ x 11¼ inches, formed of aluminum angles and gussets. This construction is similar to the Monitor Receiver and Monitor Scope in the Transceiver. Its various components are mounted on a deck secured to the frame. The motor-driven switch is in the center of the deck, extending both above and below it. The front panel of the unit is assembled to the box-like structure. The PULSE LENGTH switch is mounted in the center of the front panel. A row of three screwdriver operated controls extends across the top of the panel and another row across the bottom of the panel. These are the adjustments for setting the pulse width. The unit slides forward from its permanent position when its four captive screws are loosened. The Keyer Unit is not equipped with locks to catch and hold the chassis, as are the units in the Indicator Console. Connections are made to the various terminals within the units as they are being installed in position. The Keyer Unit may be replaced with Modulator CAY-50AGU to convert the Transceiver to the SR-a Transceiver CAY-43ADK.

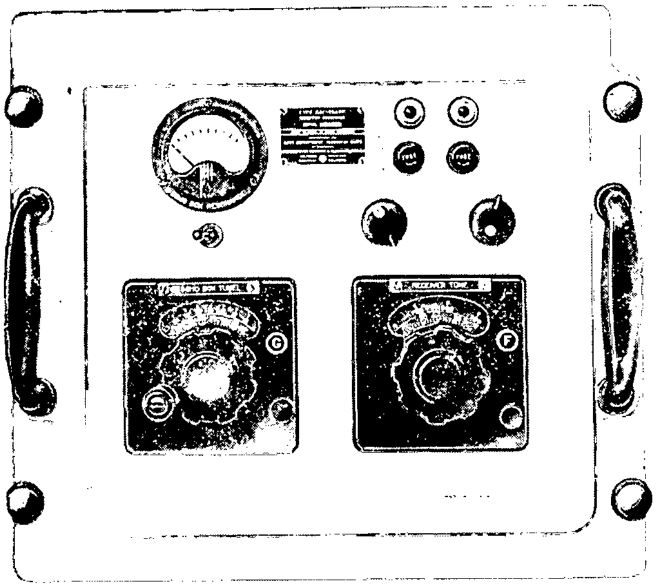


Figure 1-7. Monitor Receiver CAY-46ADK

c. MONITOR RECEIVER CAY-46AKD.

(1) The Monitor Receiver, shown in Fig. 1-7, is built in a welded aluminum box-like structure formed of aluminum angles and gussets. This structure has dimensions of 20$\frac{3}{16}$ x 14$\frac{5}{8}$ x 13$\frac{1}{4}$ inches. The chassis, carrying the main tubes, tuning components and echo box, is separately shockmounted within the main frame. It has a small front panel on which the controls and the echo box meter are mounted. Protection from shock and vibration is afforded by four shockmounts.

(2) The power transformer is mounted on a deck which is secured directly to the main frame and is not shockmounted. Connections between the transformer, as well as the main connections to the receiver circuits and echo box, are made with flexible cables so as not to damp the effect of the shockmounts.

(3) On the upper left-hand corner of the front panel is the ECHO BOX METER. In the top center is the instruction plate and to the right of this plate are the two fuse warning indicator lights and a-c power fuses. Below the fuses are two control knobs, located just above the center of the panel. The knob in the left-hand position is the I.F. GAIN control and the right-hand knob is the R.F. TRIMMER control. The large control in the lower left-hand corner is the ECHO BOX TUNE dial and the switch just above it is the ECHO BOX switch. The large tuning dial in the lower right-hand corner of the panel is the RECEIVER TUNE control for tuning the receiver.

d. MONITOR SCOPE CAY-55AFD.

(1) The Monitor Scope, shown in Fig. 1-8, is built on a small aluminum chassis and the front panel is bolted to this chassis. Dimensions of the unit are 19$\frac{9}{16}$ x 14$\frac{5}{8}$ x 9$\frac{1}{4}$ inches. This chassis slides into a heavy steel case to protect the scope from the intense magnetic fields existing around the transmitter. The steel case is equipped with a carrying handle for use when the scope is removed from its position and used as a test instrument. In the rear of this case is a set of steel clips. Around these clips are wrapped the a-c power cord and plug used when the Monitor Scope is out of the Transceiver Console. This cord is not used when the unit is in the Transceiver frame. The rear of the case has a large open slot through which protrude a coaxial plug and some banana jacks. When the scope is mounted in the Transceiver Console, these jacks make contact with a set of plugs in the Transceiver frame. The Scope receives a-c, trigger, and video voltages through these jacks. Another set of jacks is provided to supply the external trigger voltage, and to accept the signal being measured when the unit is used as a test scope.

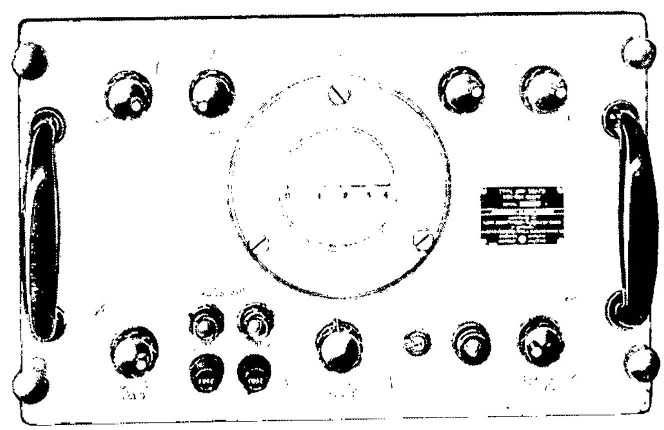


Figure 1-8. Monitor Scope CAY-55AFD

(2) The cathode ray tube is mounted in the center of the chassis. The tube face is viewed through a bezel in the upper center section of the front panel. Two controls appear in the upper left-hand section of the front panel. These are the FOCUS and V CENTER controls; the FOCUS control being nearest the edge of the panel. In a corresponding position on the right-hand side are two similar controls. The left-hand control is the H CENTER adjustment; that on the right is the INTENSITY adjustment. Below the tube is a row of controls. These are, reading from left to right, VIDEO GAIN control, two fuses and their fuse indicator lights, RANGE SELECTOR switch, POWER ON-OFF switch, POWER ON-OFF indicator light, and the SWEEP LENGTH control.

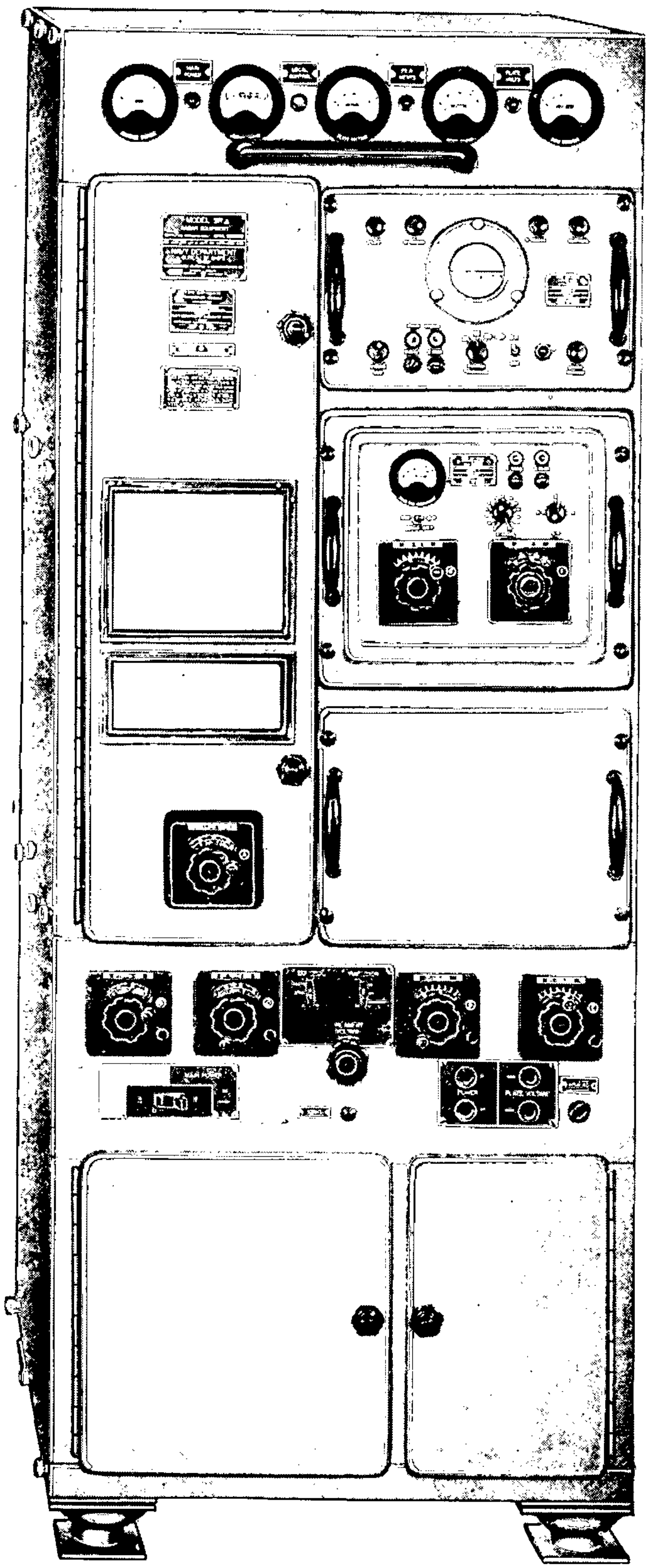


Figure 1-9. Transceiver Console CAY-43ADK (SR-a Modified)

(3) To remove the Monitor Scope from its position in the Transceiver Console, the four captive screws must be loosened. Then, the unit may be pulled forward and out of the Transceiver Console. All connections are broken automatically at the jacks when the unit is pulled out.

e. TRANSCEIVER CONSOLE CAY-43ADK (SR-a Only).

(1) GENERAL.—The components of the Transceiver Console are housed in the same cabinet as is the SR Transceiver Console. Its total weight is approximately the same as that of the SR Transceiver Console. Components of the transmitting oscillator, its power supply, control circuits, and the duplexer are built permanently into the Console. The Monitor Scope, Monitor Receiver, and the interconnection panel are separate components which mount in the Transceiver Console. See Fig. 1-9. The cabinet is mounted on four plunger type shockmounts which raise the entire cabinet about four inches clear of the deck. Dials and controls of the transmitting components are mounted on the front panels of the Console. Three access doors are provided in the front of the Console for access to the transmitting oscillator and the transmitter oscillator power supplies. Access to the other components may be secured by removal of the side and back shields. The plug-in-units may be reached by sliding them out of their positions. Transceiver Console CAY-43ADK may be a factory produced unit or it may be a field modified CAY-43ACM. If it is the latter, it will bear the nameplate CAY-43ADK and in addition, it will have a nameplate with SR-a on it. The modification consists of the removal of Keyer Unit CAY-67AAD, the installation of an interconnection panel in its place and certain minor circuit changes. The Monitor Scope and Monitor Receiver are the same in both units and are in every way interchangeable.

(2) TRANSMITTING OSCILLATOR. — The transmitting oscillator in the CAY-43ADK is mechanically identical with the one in the CAY-43ACM. The only changes are electrical and consist of the changes necessary to key the oscillator in the plate circuit by means of a keying pulse of high voltage obtained from the Modulator CAY-50AGU.

(3) INTERCONNECTION PANEL.—The interconnection panel is built in a box-like frame with $18\frac{7}{8}$ x $14\frac{5}{8}$ x $11\frac{1}{4}$ inch dimensions and formed of aluminum angles. Its various components are mounted on a deck which is bolted to the frame. Attached to the deck is a vertical terminal board with a bent angle frame for attaching the cables and leads to two connectors. These cables are connected in this manner in order to bring the power supplied from the Modulator to the Transceiver. Refer to Fig. 1-3. To the left of the terminal board, and mounted on the deck, is the

resistor assembly. Unlike the other units of the Transceiver, the interconnection panel cannot be removed from the Console. When its four captive screws are released or loosened, the front panel may be removed.

f. MODULATOR CAY-50AGU (SR-a Only).

(1) Modulator CAY-50AGU is shown in Fig. 1-10. It contains the pulse repetition frequency oscillator, low voltage power supply, pulse-forming network, output pulse transformer, and the necessary control circuit components. The electrical components of the Modulator are located in a metal cabinet which is mounted on four shockmounts. The cabinet which houses the components of the Modulator is 23½ x 15⁵⁄₁₆ x 27¼ inches in size. The front panel and top of the Modulator are equipped with ventilating louvres and are removable, being held in place by captive screws. Access to all of the parts of the unit may be obtained by removing either the top panel, front panel, or both.

(2) The components in the first fifty Modulators were mounted on the floor of the unit, except for minor parts which were mounted on small sub panels. In Modulators of Serial Number 51 and greater, the pulse-forming components are mounted on the floor of the Modulator. The fuses, fuse indicator lamps, two test jacks, frequency adjustment and the low voltage components are mounted on a removable plate or chassis. The time delay relay is mounted to the frame in the upper right hand corner. Certain minor components are mounted inside on the left-hand wall of the unit. The fuses, fuse lamps, test jacks, and frequency adjustment protrude through holes in the front panel of the cabinet. See Fig. 1-10.

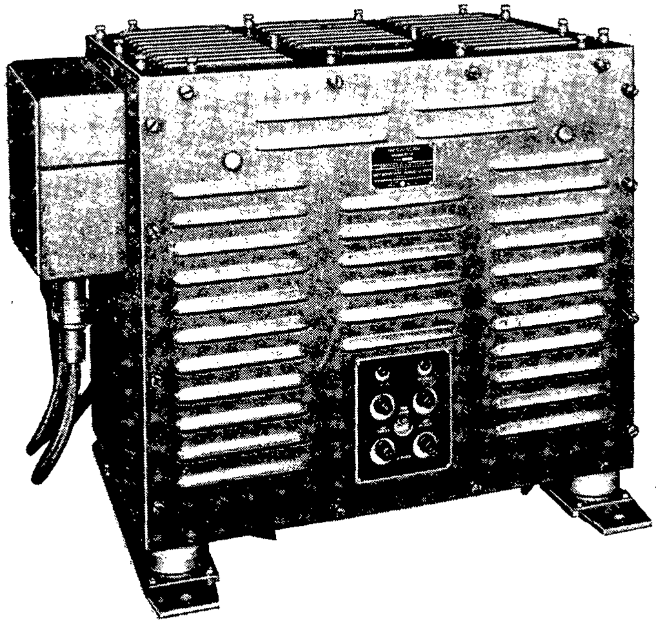


Figure 1-10. Modulator CAY-50AGU

(3) Connections to the unit from the Transceiver are made through a junction box on the left-hand side of the unit. Two connectors are provided for the high voltage and the pulse cables. The control cable is installed through a stuffing tube located conveniently in the junction box at the time the equipment is being installed.

(4) The dimensions of the unit are such that it may be located in the same position as the Auto-Dehydrator, Navy Model CAKB-10AEK if it is necessary to do so in conditions where space is at a premium. The shockmounts are equipped with skids having the same dimensions and mounting holes as the Auto-Dehydrator. These same mounting holes, etc., may be employed for installing the Modulator. The Auto-Dehydrator could then be mounted close to the Antenna with which it is associated.

g. INDICATOR CONSOLE CAY-46ADJ.

(1) The Indicator Console CAY-46ADJ consists of three aluminum cabinets bolted together to form a shielded three-section assembly. Its dimensions are 32⁵⁄₁₆ x 41⁹⁄₁₆ x 29⁹⁄₁₆ inches. These three cabinets, mounted on a shockmounted cradle, contain the six electrical components which make up the Console. The general appearance of the Console may be seen by referring to Fig. 1-11. The outline and dimensions of the individual electrical components, when removed from the Console, may be found on separate outline drawings for each unit, in Section 3 and in the descriptions of these units. Fig. 1-11 shows the location of the six components in the Indicator Console. It can be seen that the Console Receiver is located in the upper section of the left-hand cabinet. The lower part of this cabinet is split into two sections. The General Control Unit occupies the lower left-hand section, and the IFF Coordinator occupies the right-hand section. The entire center cabinet is occupied by the PPI Indicator. The Range Scope is mounted in the upper part of the right-hand cabinet and the lower section contains the Bearing Indicator. All of the various components have their major operating controls on their front panels. Each component is equipped with handles for pulling the unit out of the Console when desired.

(2) All three cabinet tops are removable, each being held in place by six Dzus type fasteners. It is only necessary to give the screwheads of these fasteners a quarter turn in order to remove the tops. Inside the top of each of the three cabinets, on a deck above the components, are the terminal boards. These boards are for the interconnection of Console components and for connecting the Console to other components of the SR and SR-a Radar Equipments. Connection of the

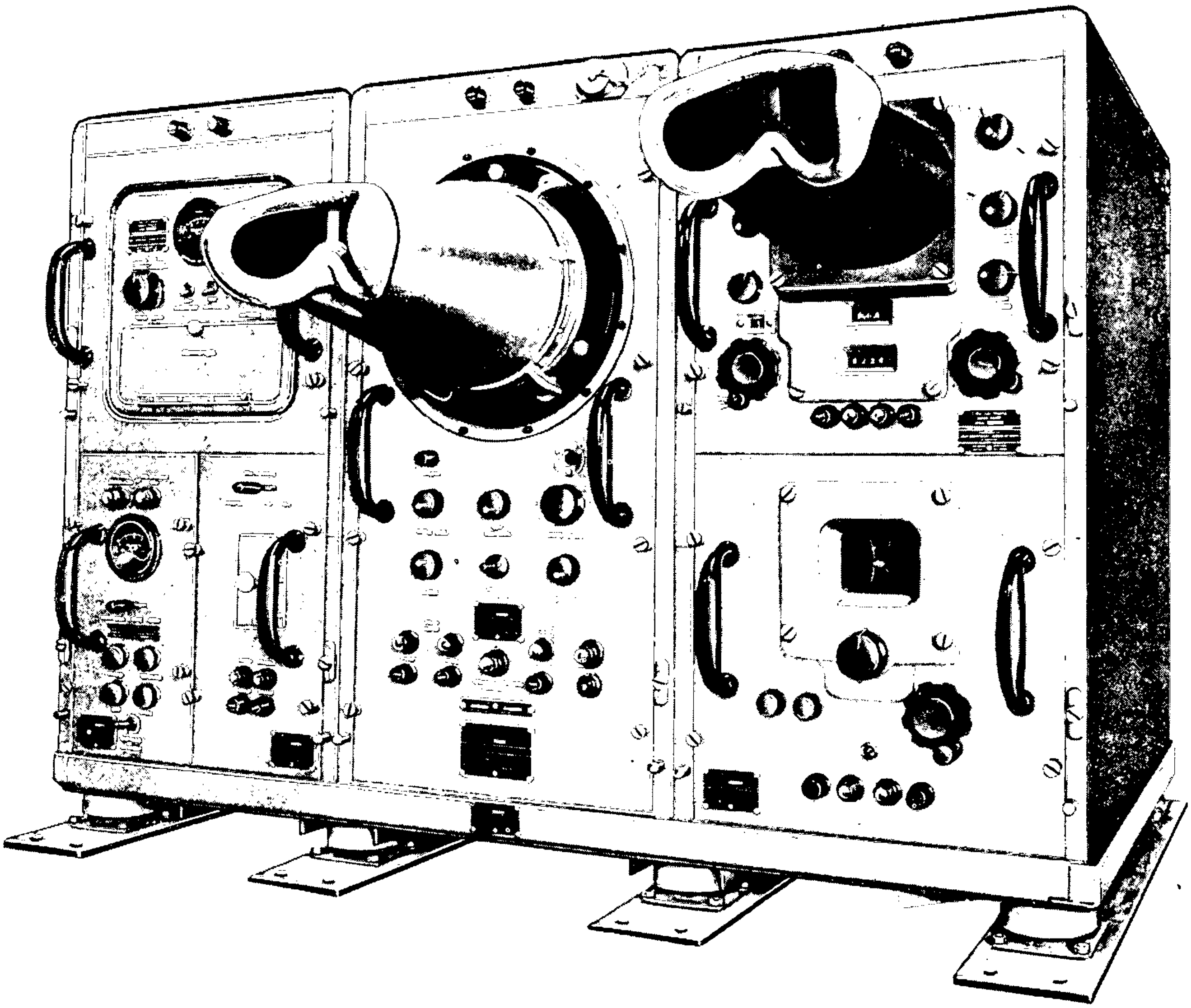


Figure 1-11. Indicator Console CAY-46ADJ

cables, coming from equipment external to the Console, is made through three junction boxes which may be located on the back of each cabinet or on the two outer sides. Spare fuses, for use in the various components, are installed in spare fuse containers mounted on the front top edge of the cabinets. An outlet for 115-volt a-c power is located on the upper right-hand corner of the center cabinet. This outlet may be used for attaching a trouble lamp or soldering iron when necessary.

(3) The chassis of each of the console's six components may be slid forward two-thirds of the way out of its cabinet for inspection or maintenance without disturbing any wires. Connections to the individual components are made with flexible cables which have sufficient slack to allow the units to be pulled forward. The components may be operated in this position. A locking mechanism holds the chassis when it is slid out of the Console and prevents it from slipping forward or backward when the ship rolls. In service, the chassis is slid completely into the Console and is rigidly held by captive screws. These screws engage in threaded inserts in the aluminum side flanges of the Console. Interlocks are provided so that removal of any component immediately shuts off the a-c power to the other components in the same cabinet. Power may be restored by twisting the small metal turn buttons which will hold the interlock switch in a closed position. When it is desired to operate the Console with one or more of the chassis slid forward

for purposes of test or maintenance, power may be obtained by closing the interlocks with the small metal turn buttons located adjacent to them.

(4) Individual components may be completely removed from the Console. In order to do this, it is first necessary to disconnect the wires which connect the unit to the terminal boards in the top of the cabinets. Removal is accomplished by pulling the units forward to the locked position and then releasing the latch mechanism. The latch is released by pushing in the two small buttons located on the Console cabinet adjacent to the lower edge of the cabinet section in which the component is located. These two buttons operate the latch mechanism and release the chassis so it may be pulled completely out of the cabinet.

b. CONSOLE RECEIVER CAY-46ADH.

(1) The Console Receiver is shown in Fig. 1-12. Various parts of the Console Receiver are mounted on two small chassis and a front panel. One chassis is rigidly mounted and contains the power supply. The other chassis is floating and contains the receiving components. These chassis are mounted within a box-like structure formed of aluminum angles, gussets and plates. All structural components are of aluminum. This box-like frame is 26$\frac{9}{16}$ x 12¼ x 12¼ inches in size. The front of the floating chassis is connected to the fixed front panel by a small auxiliary front panel. This auxiliary panel is separated from the fixed panel by a soft rubber gasket. The front chassis is shock-mounted from the box-like structure by rubber shock-mounts. The entire assembly, consisting of the auxiliary front panel and front chassis, may float within the main frame. Thus, it secures protection from vibration and shock.

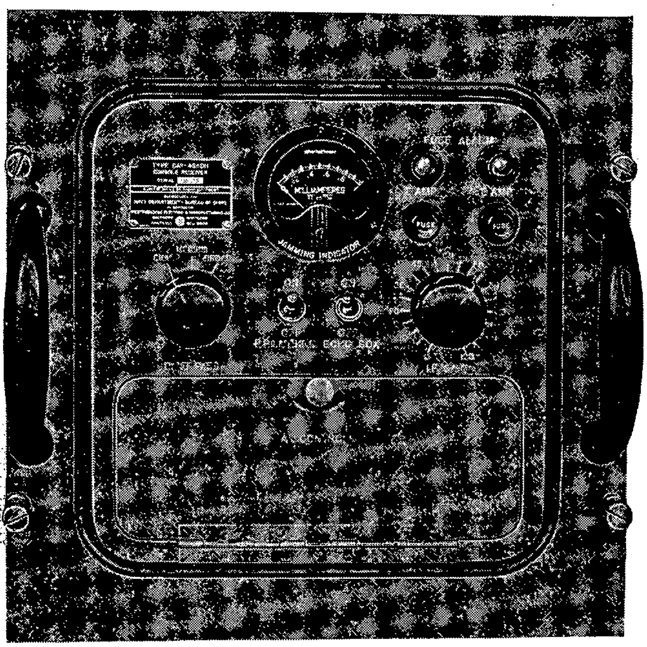


Figure 1-12. Console Receiver CAY-46ADH

(2) The front chassis contains the IF section of the receiver. Likewise, the auxiliary front panel contains the operating controls and jamming indicator meter shown in Fig. 1-12. On the lower section of the front panel is a small door which may be opened in order to operate certain anti-jamming controls.

(3) The video output section of the receiver and the power supply are located on the second small chassis which is not shockmounted, but secured directly to the aluminum frame. Power and signal input voltages are supplied through two terminal boards and a jack mounted on the right-hand side of the frame. Flexible leads, from the terminal boards in the top of the cabinet, attach to these terminal boards on the unit. The leads are cabled and the length is sufficient to permit sliding the unit forward in the cabinet for inspection and maintenance.

(4) All main operating controls are on the front panel. In the upper left-hand corner of the auxiliary front panel, inside the rubber gasket, is located the type nameplate of the unit. To the right of the nameplate, in the top center of the panel, is the JAMMING INDICATOR meter. To the right of the meter are two fuses, and above these fuses are two fuse indicator lights. These lights glow when the fuse directly below it is open. In this manner, an operator may quickly locate a blown fuse and replace it.

(5) In the second row from the top are two controls and two switches. The left-hand control is the BAND PASS control. It governs the band width of the receiver and remotely regulates the pulse width and repetition rate of the transmitter in Transceiver CAY-43ACM. When used with Transceiver CAY-43ADK this switch has no control over the pulse width which is fixed at four microseconds. In the SR-a, the BAND PASS control is used only to control the bandwidth of the i-f amplifiers in the Console Receiver. The left-hand switch is the PPI MARKER, used to apply markers to the remote PPI installations which do not generate their own markers. The other switch is the ECHO BOX which remotely turns on the echo box circuits in the Monitor Receiver.

(6) In the second row, the right hand control is the IF GAIN. It remotely controls the Monitor Receiver gain. On the lower section of the front panel marked A.J. CONTROLS, is a hinged access door which opens downward. Inside this door will be found five controls used by the operator to counteract attempts to jam the radar equipment. As supplied on Contract NXsr-30306, these anti-jam knobs are not equipped with locking devices. On Contract NXsr-46032, four of these controls are provided with locking

mechanisms which may be used to lock the controls in place after adjustments are made. The locking mechanism consists of a stainless steel disc located directly underneath the knob. Turning this disc in a clockwise direction locks the knob. This action squeezes a slotted expansion nut against the control shaft to create a friction brake. The disc should be rotated in a counterclockwise direction in order to free the control.

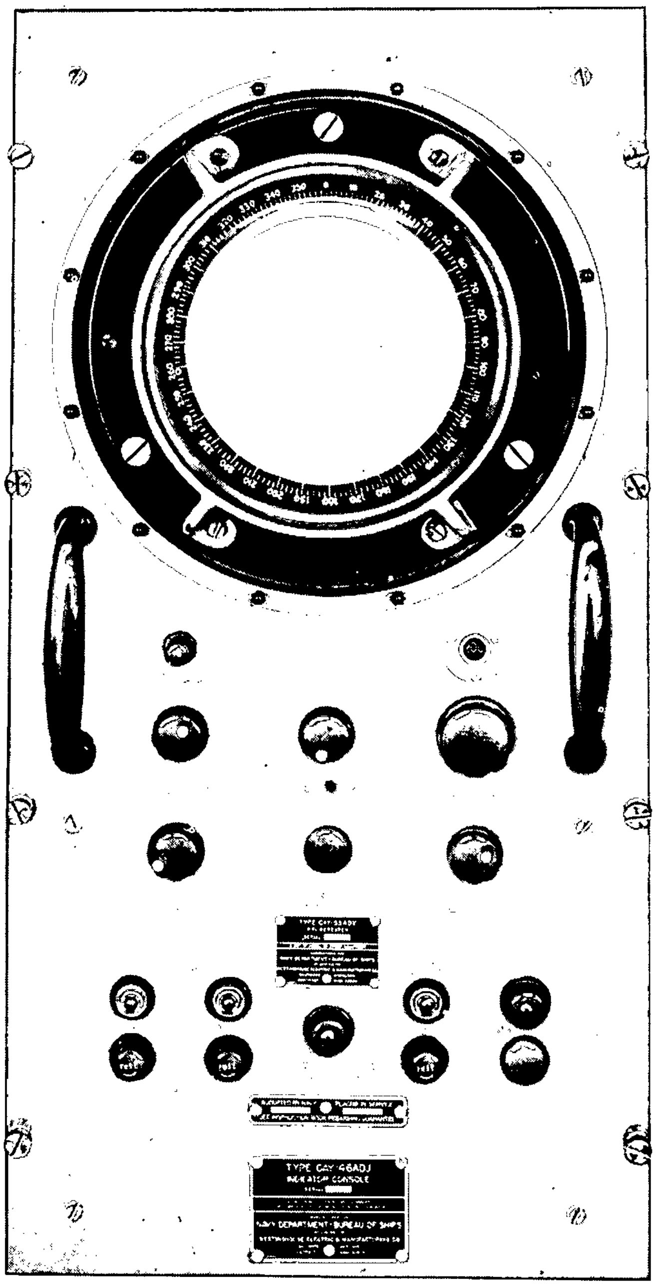


Figure 1-13. PPI Indicator CAY-55ADV (Manual Cursor)

i. PPI INDICATORS CAY-55ADV AND CAY-55ADV-1.

(1) The PPI Scope or Indicator is shown in Figs. 1-13 and 1-14. Its chassis is a box-like structure approximately 11 x 22 x 24 inches in size, made up of aluminum angles, gussets and plates welded together. A deck is placed inside, about half way up from the bottom of the frame. Another runs vertically up to the horizontal deck. The principal components of the equipment are mounted on these two decks. Another vertical deck is mounted above the first horizontal deck towards the rear of the unit. On this are mounted the servo-amplifier, video amplifier and marker output tubes. Most of the other components are mounted on the larger vertical deck. The heavier parts, such as the power transformers and chokes, are mounted along this deck close to the bottom. Smaller components are mounted above them. A small blower motor circulates air around the components, to dissipate heat and to prevent *hot spots* in the vicinity of the tubes.

(2) Components are mounted on the left-hand side of the vertical deck when looking from the front panel of the unit. Their connecting lugs extend through the deck, and most of the wiring is located on the right-hand side. The high voltage power supply is located at the very rear of this chassis, so that it will be protected when the shelf is pulled out two-thirds of the way for inspection and service. Terminal boards are mounted on the right-hand side of the vertical deck to hold resistors and capacitors. Most of the maintenance tests and checks may be made from this side. High voltage terminals are completely enclosed by a cover to protect the technician when working on the equipment.

(3) The mechanism necessary to rotate the deflection yoke and to hold the cathode ray tube is located on top of the horizontal deck. This is an assembly consisting of three large castings. They contain the synchro-control transformer, a small servo-driven motor, gears of the drive train, rotating yoke, focus coil and cathode ray tube. The synchro-control transformer and the drive motor are geared together with a 108:1 pinion gear drive. The yoke coil is geared directly to the synchro-control transformer by a 1:1 split spring gear to eliminate backlash. The yoke coil itself is mounted on two large ball bearing races placed at both ends of the coil assembly. These ball bearings are made of non-ferrous material to prevent them from becoming magnetized and deflecting the electron beam of the tube. The races are made of beryllium copper, silver-plated; while the bearings are made of Pyrex glass. The cathode ray tube is clamped in the mount by a bezel ring protruding from the front panel. A small auxiliary clamp, in the rear of the mount, grasps the neck of the tube and holds it against the bezel

ring. It also serves to center the neck of the tube in the coils. The focus coil is mounted behind the deflection yoke coils, and secured by two knurled thumb screws which can be loosened to permit adjusting the focus coil when aligning the equipment. A handle is provided on the focus coil for this purpose.

(4) In the assembly near the front of the tube are three pilot lights for illuminating the engraving on the ring of the bezel. These markings consist of a scale graduated from 0 to 360 degrees engraved around the edge of a piece of glass. These pilot lights may be dimmed by means of the DIAL DIMMER control, located on the front panel of the equipment, just to the left and below the PPI tube. As the assembly passes through the front panel, it is securely engaged by a rubber gasket which makes a water-tight junction.

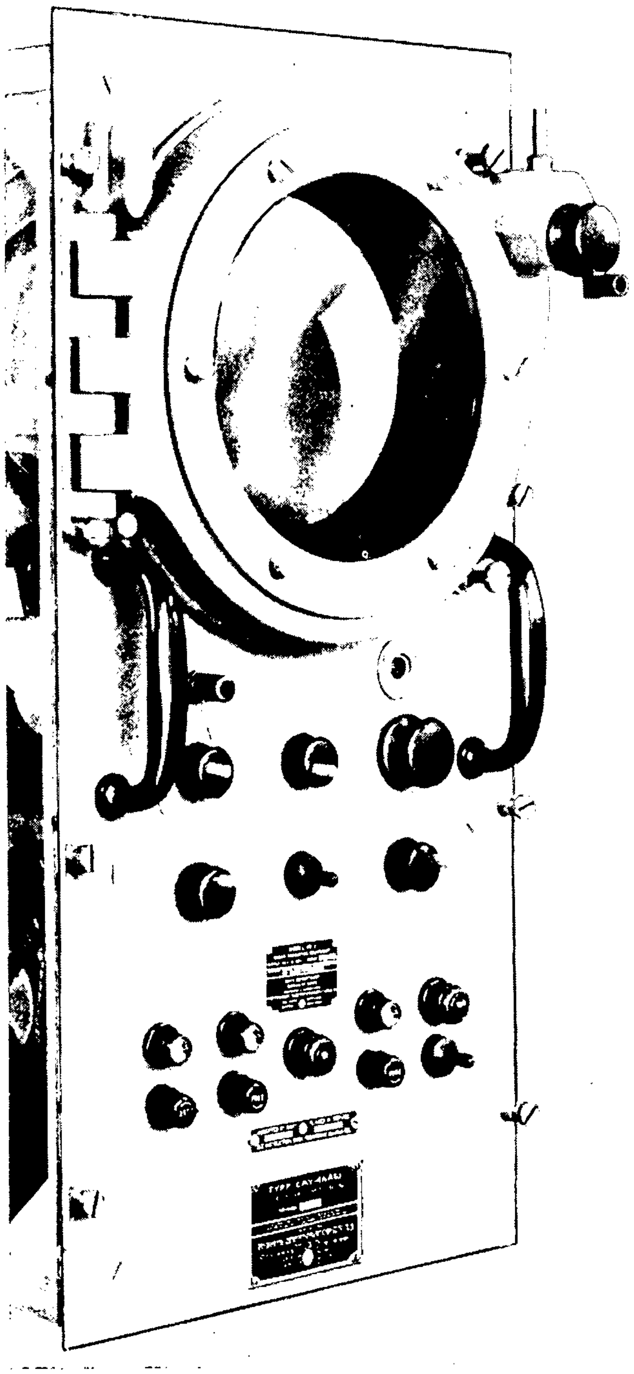


Figure 1-14. PPI Indicator CAY-55ADV-1 (Geared Cursor)

(5) On the CAY-55ADV, a small ring casting and a cursor assembly are mounted on the front panel. See Fig. 1-13. The cursor ring consists of a knurled ring which is firmly secured to another piece of Plexiglass, mounted in the front of the bearing ring. The cursor has a line drawn from its center to the edge, in such a manner as to approximate the electrical sweep of the equipment. The entire ring may be rotated by hand when it is desired to locate the bearing of a target. An amber filter and a red filter are furnished with the cursor, to provide for different light conditions. Their use is described in the operating instructions section of the handbook. The PPI Indicator CAY-55ADV-1 employs a geared cursor. The geared cursor assembly consists of a stationary engraved azimuth scale and a rotating piece of Plexiglass with a line drawn from its center to its outer edge. The Plexiglass cursor is mounted on a spur spring gear that is driven by a spur pinion which is mounted on the control shaft. The control shaft is driven by a small hand wheel on the upper right-hand corner of the cursor casting. See Fig. 1-14. The control shaft is also geared to an external shaft through two bevel gears. The external shaft permits the setting of the cursor to be mechanically transmitted to remote bearing indicators. A Plexiglass filter is mounted on the cursor frame in front of the cursor. The entire assembly is mounted on a hinge and is held in place by means of two thumb-screws on the right-hand side of the casting. When these screws are removed, the assembly can be swung away from the front panel to allow the PPI tube to be replaced or for cleaning and lubricating the cursor. When the handwheel is rotated, the cursor plate also rotates and the engraved line on the cursor plate is made to coincide with a target. The azimuth reading under the cursor line is then taken as the azimuth bearing of the target.

(6) Two large terminal blocks are bolted to the angles in the upper right-hand side of the chassis. They connect the incoming and outgoing cables from the chassis, to the main terminal blocks on the case of the assembly. A flexible cable is provided between these two sets of terminal boards, so that the chassis may be slid part way out of the case, as previously explained. The top deck is underneath a removable mounting plate. A deck is placed beneath a removable cover plate in the top of the center case in which the unit is located. All connecting wires are secured to

terminal boards located on this deck. There are two such terminal boards, a bridge-or-terminate switch, with its associated terminating resistors, and a small thermal overload breaker which is in the circuit leading to the convenience outlet on the top of the cabinet.

(7) The front panel is bolted to the frame by eight thumb screws. The main operating controls are on the front panel. The top left-hand control is the DIAL DIMMER control for dimming the dial lights. To the right of it, on the same row, is a small opening through which may be read the range on which the equipment is operating. The second row of controls from the top are the VIDEO GAIN (left), the FINE INTENSITY (center) and the RANGE SWITCH (right). On the next row are the FOCUS control (left), the CENTER EXPAND switch (center) and the MARKERS switch (left). The lower row of controls and indicators consists of the fuses and their indicator lamps (two left-hand items marked 3 AMP), the RELATIVE BEARING INDICATOR lamp (center) and another fuse and its indicator lamp (marked 2 AMPS). On the right-hand end of this double row is the ON-OFF switch and the ON-OFF indicator light. This indicator light may be dimmed by twisting the knurled ring around the lens.

j. RANGE SCOPE CAY-55AFB.

(1) The Range Scope is shown in Fig. 1-15. It is constructed in a manner similar to the other components of the console. It consists of a box-like welded aluminum structure approximately 12¼ x 12¼ x 26⁹⁄₁₆ inches. Various tubes and parts are mounted on three decks located within this framework. The front panel, however, is an aluminum casting, rather than sheet aluminum. The cathode ray tube, upon which the radar indications appear, extends from the front panel to a point approximately three-quarters of the way to the back of the structure. It is located slightly above the horizontal centerline of the unit. One of the decks is on the right-hand side of the tube, one is on the left-hand side, while the other extends across the back of the unit behind the base of the cathode ray tube.

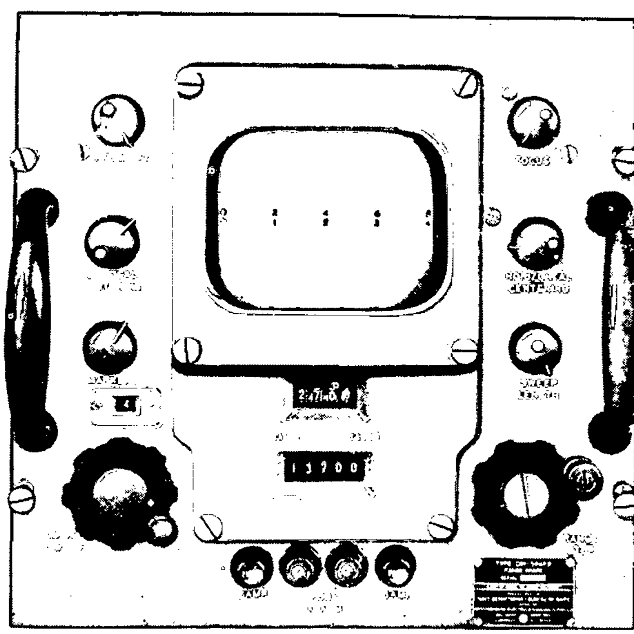


Figure 1-15. Range Scope CAY-55AFB

(2) On the left-hand deck are mounted the tubes and some of the electrical components which form the marker and video circuits. On the right-hand deck are the components of the gate and sweep circuits. The rear deck contains tubes and components of the high and low voltage power supplies. Two smaller decks are suspended from each of the two side decks. These may be called the top and bottom decks. The top deck in both cases is primarily used to mount large resistors, while the bottom deck is used to mount large capacitors. These components are usually associated with the tubes and circuits on the larger right and left-hand decks above them. On the left-hand side of the unit, about a quarter of the distance to the rear, is a small bracket which mounts the potentiometers necessary to align the various circuits of the unit. These potentiometers are all provided with locks so that, once they are set, adjustments are not easily disturbed. Three terminal boards are provided on the right-hand side of the unit for connection to the flexible cables from the terminal boards in the top of the cabinet.

(3) The bottom of the front section of the unit, beneath the cathode ray tube, is occupied by the potentiometer casting assembly. This casting assembly houses a precision potentiometer, together with the gears, shafts and bearings necessary for its operation. This potentiometer is controlled by the RANGE STEP control on the front panel. Also mounted on this casting, and geared to the potentiometer, are two small mechanical counters. These counters are also controlled by the RANGE STEP knob, and are so geared to it that they indicate the range in yards and miles. These counters are seen through small windows in the front panel of the unit. The counters are illuminated by two small lucite rods which carry the light from two pilot lights on the casting. In this manner, the counters may be read in the dark. Directly in back of the RANGE STEP knob is a small micro-switch. This switch is actuated by pushing the RANGE STEP knob in or pulling it out. When the knob is in, this switch cuts off the circuit forming the range step. When it is pulled out, it turns on the range step circuit.

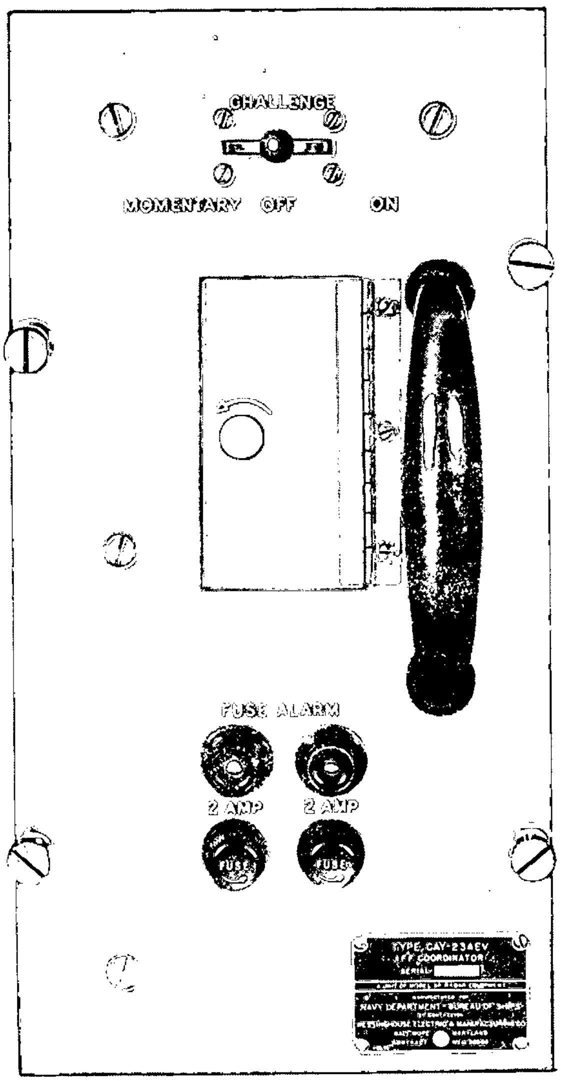


Figure 1-16. IFF Coordinator CAY-23AEV

(4) The face of the cathode ray indicator tube appears through a window in the upper center of the front panel. The entire length of the tube is surrounded by a high permeability shield. The front of the tube is supported by a rubber ring in the front of the shield and by a spring clamp arrangement at the rear. The spring clamp is also mounted on rubber, providing a full rubber floating mounting for the tube. Various knobs and controls neceessary to operate the unit are mounted on the front panel. Most of these controls are equipped with locks and detents to prevent accidental displacement when once set by the operator. The upper left-hand knob is the INTENSITY control used to set the brilliancy of the sweep on the face of the indicator tube. Below it, is the VERTICAL CENTERING control. Below the VERTICAL CENTERING control is the MARKERS ON-OFF switch. In the lower left-hand corner of the panel is the RANGE SWITCH, with the indicator window just above it. This window shows the range to which the RANGE SWITCH is set. On the right of the indicator tube, in the upper right hand corner of the panel, is the FOCUS control. Just below it is the HORIZONTAL CENTERING control and below this is the SWEEP LENGTH control. In the lower right-hand corner of the panel is the nameplate. Just above the nameplate is the RANGE STEP knob used to control position of the break in the line used for accurate ranging of target indications on the cathode ray tube. In the bottom center portion of the panel are the two fuses and their indicator lights. Directly above the fuses are the counters which operate with the RANGE STEP control. They indicate the range in yards or miles to a target which has been matched with the range step on the range sweep.

k. IFF COORDINATOR CAY-23AEV.

(1) The IFF Coordinator is shown in Fig. 1-16. It is constructed in a box-like frame of welded aluminum angles, similar to the other components of the Console. This unit is approximately $5\frac{1}{2}$ x 11 x 24 inches, or approximately half the size of the Range Scope and Console Receiver. A horizontal deck runs from the front to the rear of the frame and is located approximately three inches up from the bottom. Most of the tubes and components of the unit are mounted on this deck. Tubes are arranged in a straight line on the right-hand side of the deck. Some of the smaller components are located in a line on the left-hand side. The power supply is mounted at the rear of the deck. A terminal board is located on a bracket in the upper front right-hand side of the framework. The front panel is of sheet aluminum, and is bolted to the frame. It contains the operating controls of the unit.

(2) The major controls are located on the front panel. In the top center is the CHALLENGE switch used by the operator to interrogate targets. This switch turns the IFF equipment on and provides for the IFF indication on the Range Scope. A small door located in the center of the front panel, when opened, discloses two more controls on SR Equipments below Serial No. 90. These are the IFF RECEIVER GAIN and the ECHO SUP. control. They are remote controls for the receiver in the IFF equipment. On SR and SR-a Equipments above Serial No. 90 there are three controls under the door. In addition to the controls described above, a switch called RELAY RESET has been placed above the ECHO SUP. control. This switch is a remote control for circuits in the IFF Equipment associated with the SR or SRa Equipments.

l. BEARING INDICATOR CAY-55AFC.

(1) The Bearing Indicator is constructed in an aluminum framework similar to the other components. It is shown in Fig. 1-17. The Bearing Indicator is approximately $12\frac{1}{4}$ x $12\frac{1}{4}$ x $26\frac{3}{8}$ inches in size and

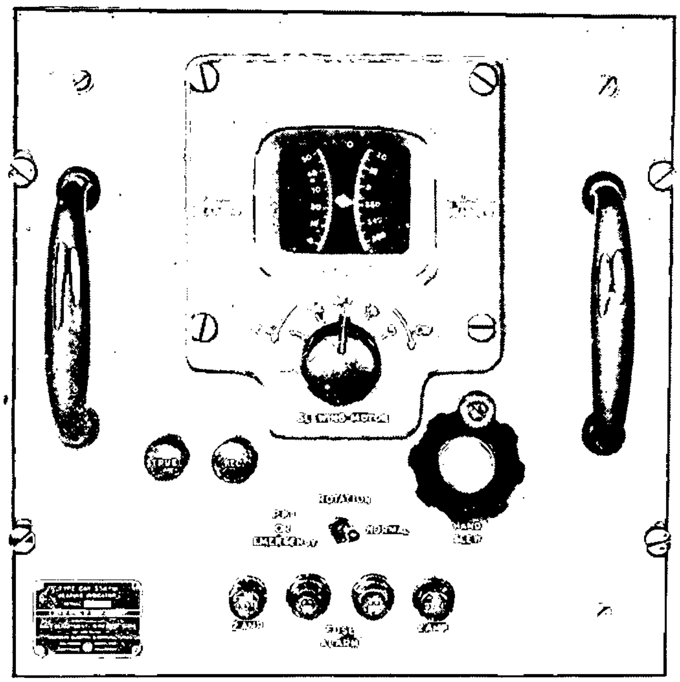


Figure 1-17. Bearing Indicator CAY-55AFC

is of welded construction. Most of the indicating mechanism is supported from the front panel or from a heavy plate which is installed vertically about four inches behind the front panel. Mounted on the back of the vertical panel are three synchros. One is a 5F and another is a 5D synchro. These are, respectively, the 1:1 true and relative bearing synchros which are connected to the indicator dials. The third is a 5CT 36:1 synchro which is geared to the slewing handwheel and is used to position the Antenna. Behind the synchro assembly, and at the top of the chassis, are located two large capacitors used to correct the power factor of the synchros. Below, and to the rear of these capacitors, is mounted the slewing motor and a gear reducer which reduces the motor speed. The output of the gear reducer is connected through a coupling to the handwheel. In this manner, it also drives the 5CT when the motor is running. Two terminal boards provided on the right-hand side of the unit, connect the flexible cables from the terminal boards in the top of the cabinet.

(2) At the rear of the unit, on a deck mounted vertically against the back of the frame, are located two dry disk rectifiers, a transformer and a capacitor. These form the power supply for the slewing motor. Also mounted on this rear deck, is a small blower motor for circulating air throughout the cabinet in which the unit is mounted. The output vent of the blower motor is directed upward so as to cool the components of the Range Scope which is mounted directly above the Bearing Indicator. Controls and indicating devices are located on the front panel. In the center top section of the panel is a window through which may be read the TRUE BEARING and RELATIVE BEARING dials of the unit. Below these dials is the SLEWING MOTOR switch. To the right, and below the slewing motor switch are the TRUE and REL bearing lights. These lights indicate to the operator which type of bearing indication is employed. On the same level as the two lights, but on the opposite side of the panel is the HAND SLEW control. In the center and slightly below the line containing the bearing lights is the ROTATION-EMERGENCY-NORMAL switch. Below this switch are two fuses and two fuse indicator lights. The type nameplate is located in the lower left-hand corner of the panel.

m. GENERAL CONTROL UNIT CAY-23AEW.

(1) The General Control Unit, shown in Fig. 1-18, is similar in construction to the IFF Coordinator.

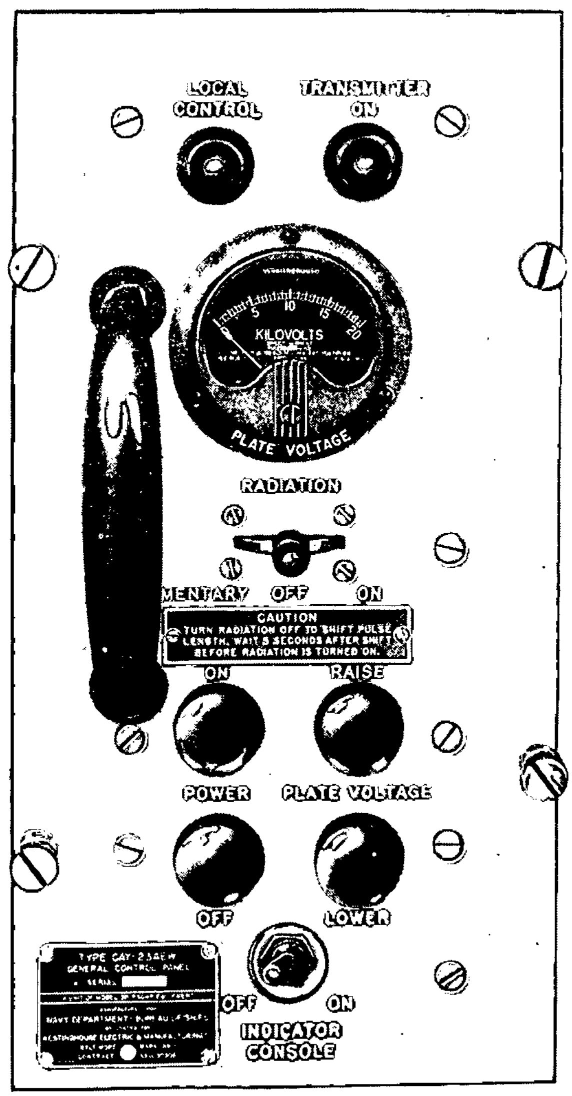


Figure 1-18. General Control Unit CAY-23AEW

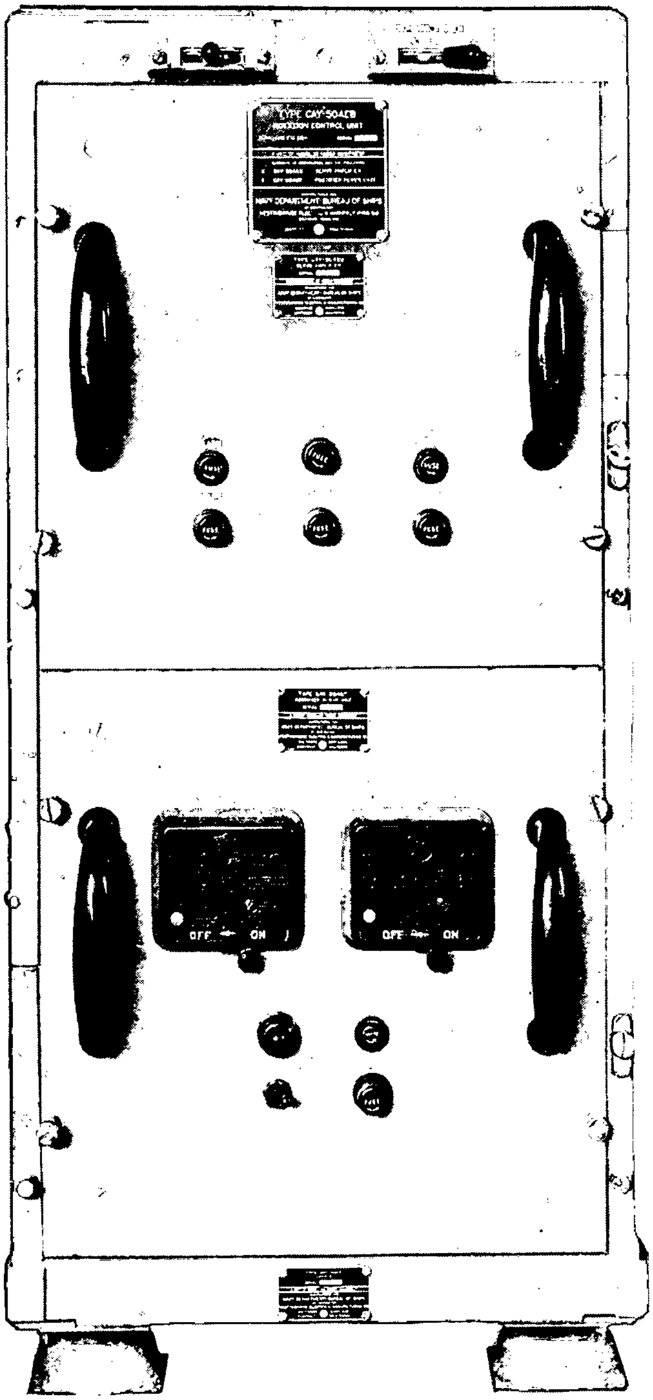


Figure 1-19. Rotation Control Unit CAY-50AEB

It is in an aluminum angle frame with a horizontal deck running the full length of the unit. Components of the General Control Unit occupy only the front half of the deck. The rear half of the deck is equipped with sockets and tube locks for storing a set of spare tubes used in the various components of the Indicator Console. A blower motor and fan assembly is located near the center of the front half of the chassis. The motor is a split-phase motor. Its phase-splitting capacitor is located near it. The fan forces air upward, to cool the Console Receiver. Terminal boards, for interconnection with terminal boards in the top of the cabinet, are located on the left-hand side of the unit. They are mounted on two brackets which are supported between the deck and the top of the frame. The controls and indicating components are mounted on the front panel of the unit. In the top center of the panel is the KILOVOLTS meter. It is used to indicate the voltage being applied to the transmitter. Below it is the RADIATION switch, for controlling the transmitter. Below this are four buttons, the POWER ON—OFF, PLATE VOLTAGE RAISE—LOWER controls which control the application of high voltage to the transmitter. Below these buttons is the INDICATOR CONSOLE—ON—OFF switch. It controls the application of power to the various components in the Console.

n. CRADLE CAY-10313.—The Cradle is a welded aluminum structure supported by eight shockmounts. It is used to support the components of the Indicator Consoles CAY-46ADJ and the CAY-46ADJ-1. Its dimensions are $49\frac{19}{32}$ x $25\frac{1}{4}$ x $3\frac{1}{8}$ inches. The Cradle is a rectangular framework with two cross members. Shockmounts are located at each corner and at the junctions of the cross members and the rails of the cradle.

o. ROTATION CONTROL UNIT CAY-50AEB. The Rotation Control Unit is shown in Fig. 1-19. The dimensions of the case of this Unit are $31\frac{5}{16}$ x $14\frac{1}{4}$ x 30 inches. It is divided into two sections containing the Servo Amplifier and Rectifier Power Unit. The Rotation Control Unit provides the voltages which direct the antenna's rotation. Interconnections to the unit are made through a junction box with dimensions of $11\frac{1}{4}$ x 4 x 8 inches. The junction box may be located on either of the two sides of the cabinet or on the back. Consequently, the dimensions of the cabinet itself must be increased by the junction box dimensions, depending upon the location of the junction box. The two electrical components are individually constructed and slide into the cabinet. The Servo Amplifier, in this unit, is placed above the Rectifier Power Unit. Connections between these two units are made on the terminal boards inside the top of the cabinet in the same manner as the indicator console. External connections to the unit also terminate at these terminal boards, being brought in through the junction box. The cabinet is shockmounted on four mounts which are bolted to the deck. This protects the components from vibration and shock. The individual units are fastened in place with screws. Inspection may be made by loosening these

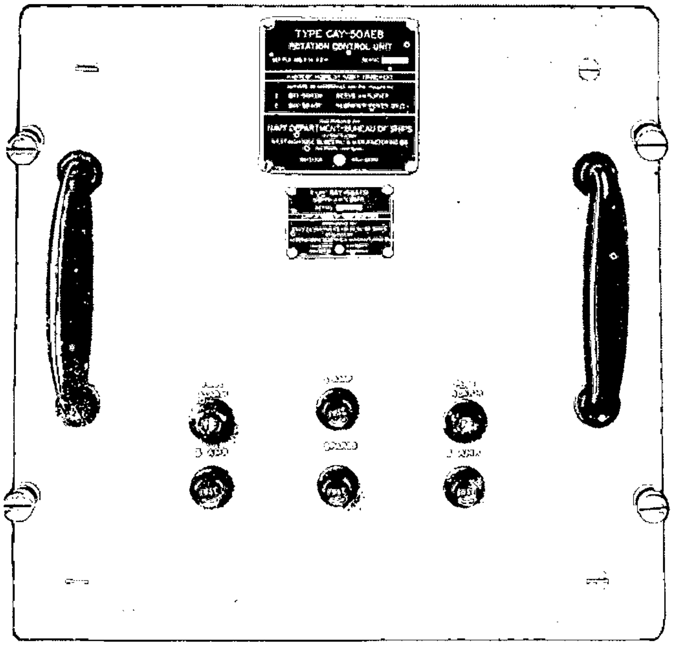


Figure 1-20. Servo Amplifier CAY-50AEU

screws and pulling the chassis forward. They may then be removed by loosening the wires to the units from the terminal boards in the top of the chassis.

p. SERVO AMPLIFIER CAY-50AEU.—The Servo Amplifier is shown in Fig. 1-20. It is built within a box-like structure of welded aluminum angles and gussets. A front panel is secured to this structure, and a deck is provided inside which runs the full length of the unit. Components of the unit are mounted on this deck, or under it. Most of the wiring is underneath the deck. The size of the box-like structure is 26⅜ x 12¼ x 12¼ inches. The front panel extends approximately 21/32 inch beyond the front dimensions in all directions. Handles are affixed to either side of the front panel for pulling the unit out of its cabinet. No operating controls are found on the front panel, all adjustments to the unit being made by alignment controls inside the unit. On the front panel, therefore, are found only the instruction and type nameplates, two active fuses and their fuse alarm indicator lights, and two containers which hold spare fuses.

q. RECTIFIER POWER UNIT CAY-20ACY.—The Rectifier Power Unit is shown in Fig. 1-21. It is assembled in a frame similar in construction to the frame of the Servo Amplifier. The size of the unit is 26⅜ x 12¼ x 12¼ inches. Components in the unit are mounted directly to the frame members. In the front end are located the operating relays. Near the center of the unit is the blower motor for cooling the rectifier used to rotate the antenna when the ROTATION switch on the Bearing Indicator is in the PPI or EMERGENCY position. This rectifier unit provides d-c voltage direct to the antenna drive motor. On the front panel of the unit are located two small circuit-breakers. The left-hand unit is the breaker for turning the circuit to the antenna motor on and is indicated as ANT. TRAIN MOTOR. The right-hand breaker controls application of power to the motor which drives the servo-generator. It is identified as the SERVO-GEN. MOTOR control. Below these breakers, in the lower center section of the panel, is the OFF-ON switch. To the right of it is a fuse with its fuse indicator light. Two handles are provided on the front panel of the unit.

r. CRADLE CAY-10314.—The Cradle is a welded aluminum structure supported by four shockmounts. It is used to support the Rotation Control Unit. Dimensions of the Cradle are 25¼ x 14 x 3⅜ inches. The framework is braced by means of spot-welded aluminum gussets. Shockmounts are located at each of the corners.

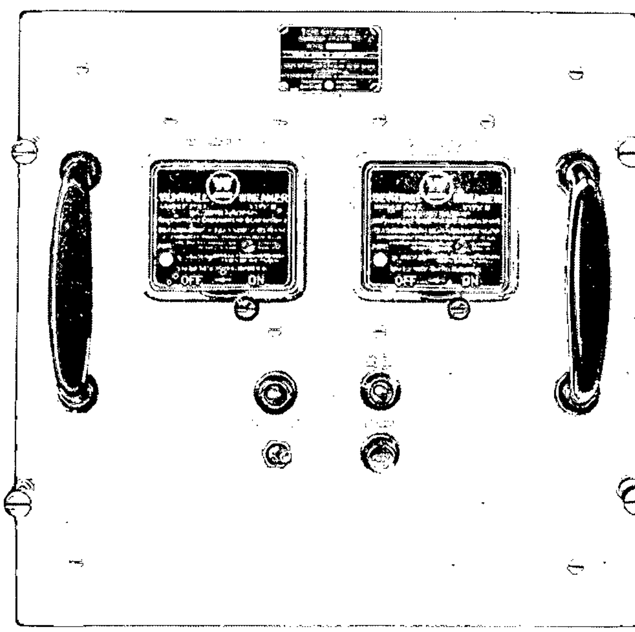
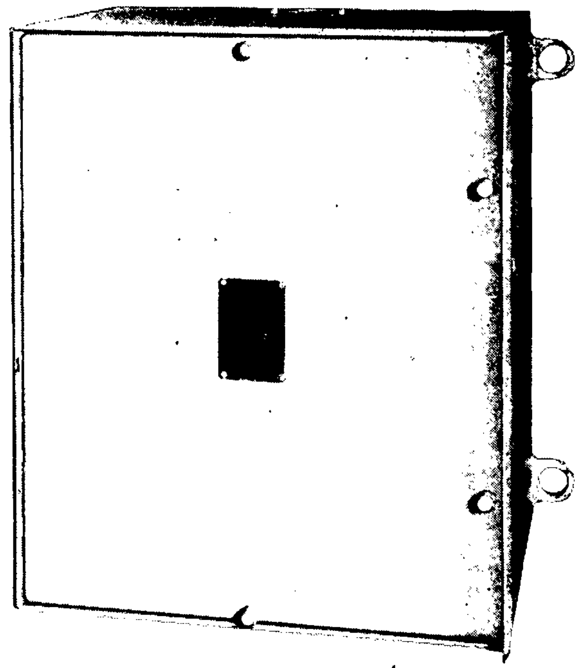


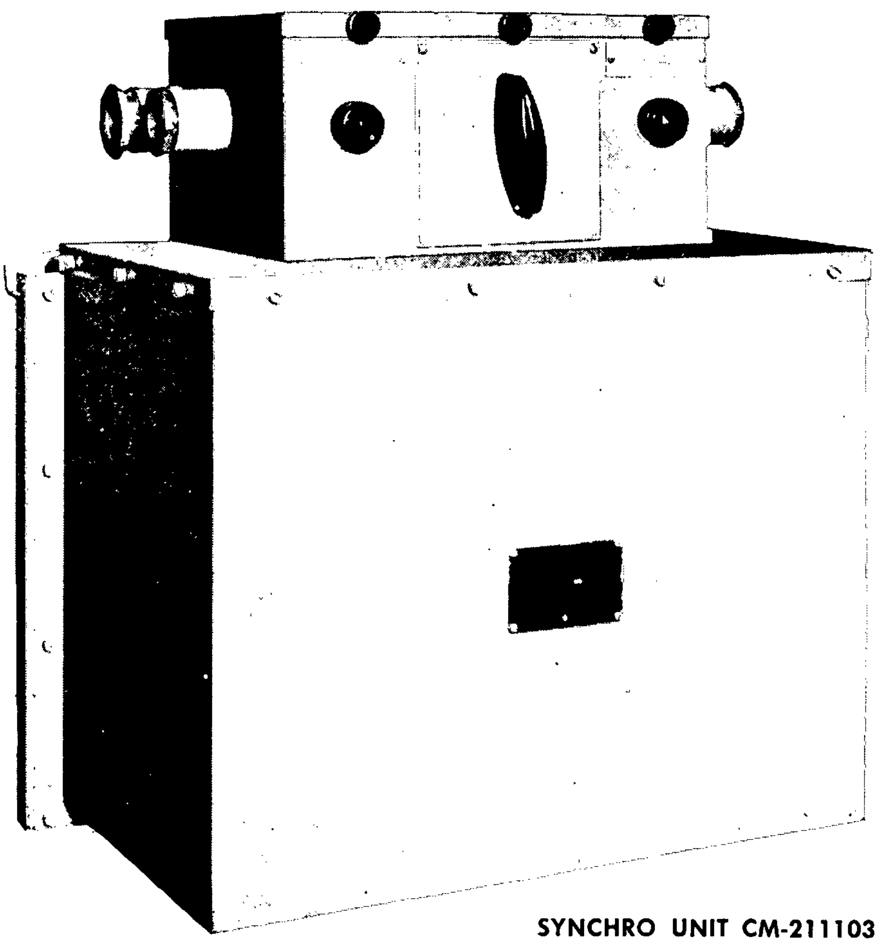
Figure 1-21. Rectifier Power Unit CAY-20ACY

s. ECHO BOX ANTENNA CAY-66AHK.—The Echo Box Antenna is shown in Fig. 1-22. It is a folded coaxial antenna with an overall length of 46⅜ inches. Its largest diameter is 2 inches. It consists of

Figure 1-22. Echo Box Antenna CAY-66AHK



AMPLIFIER UNIT CM-50131



SYNCHRO UNIT CM-211103

Figure 1-23. Synchro Amplifier

a coaxial line whose center conductor extends a quarter wavelength beyond the end of the outer conductor. The end of the outer conductor is attached to a quarter wavelength of 2 inch tubing which extends back over the outer conductor, giving the effect of folding the outer conductor back on itself. The end of the coaxial line opposite the dipole is supplied with a connector to facilitate the connection of the antenna assembly to a flexible coaxial line. This line connects at its other end to the Echo Box in the Monitor Receiver located in the Transceiver.

t. SYNCHRO UNIT CM-211103.

(1) The Synchro Unit is one of the two units shown in Fig. 1-23. The larger unit is the Synchro Unit and the smaller unit is the Amplifier Unit or tube chassis. The two units together are the Synchro Amplifier. The Synchro Amplifier is not supplied by the manufacturer but is shipped with the equipment. The Synchro Unit is contained in a metal box with dimensions of 26¾ x 22 x 20 inches. It contains a split phase drive motor, two synchros, a special commutator transformer for relaying the ship's compass voltages, and the necessary gear trains. A smaller box is mounted on top of the main cabinet to house the terminal boards, indicator lamps and a-c power switch. The left-hand indicator lamp indicates the application of compass voltage and the right-hand lamp indicates the application of a line voltage by the operation of the SYNCHRO AMPLIFIER POWER switch which is located between the two lamps. Stuffing tubes are provided on each end of this box to receive the interconnecting cables. All of the components except the switch, terminals and indicator lamps are contained in the larger compartment. When the cover assembly screws are removed, the box-like cover comes away from the base to expose the components for servicing. The Synchro unit is designed for wall mounting, the base on which the parts are mounted being placed against the wall.

u. AMPLIFIER UNIT CM-50131.—This unit is part of the Synchro Amplifier and contains a chassis on which is assembled the electronic servo amplifier which supplies operating power to the split-phase motor in the Synchro Unit. The amplifier is shown in Fig. 1-23. It is slightly smaller than the Synchro Unit, its dimensions being 24¼ x 21¼ x 17¼ inches. Eyelets are attached to one side for mounting purposes. The cover is attached with a piano type hinge and secured in its closed position by four knurled thumbscrews. A place is provided on one end for external cable connections which are brought into the cabinet to a terminal board on the side of the chassis. A terminal board beneath the chassis is fitted with male banana plugs which insert into female jacks or connectors in a terminal board on the chassis when the chassis is placed in the cabinet. The chassis is held in place by machine screws. A guide rod makes it impossible to place the chassis in the cabinet in a reversed position. Two handles are provided for lifting the chassis out of the cabinet.

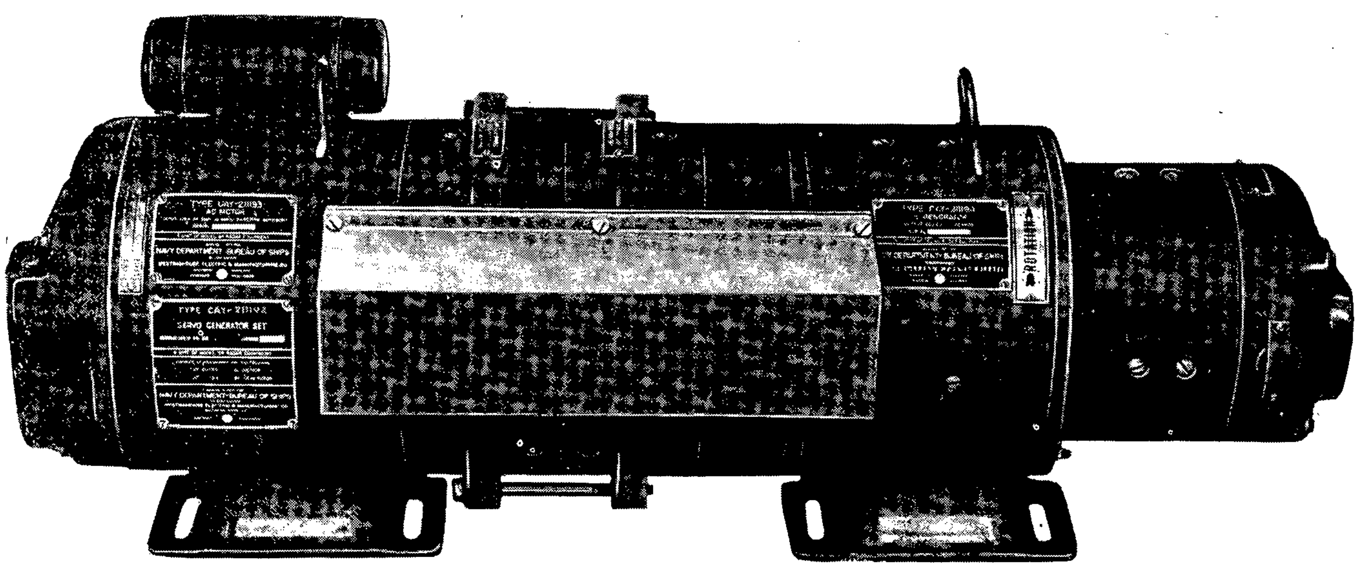


Figure 1-24. Servo Generator CAY-211192 or CAY-211192A

v. SERVO GENERATORS CAY-211192 AND CAY-211192A.

(1) SERVO GENERATOR CAY-211192 (NXsr 30306).—Servo Generator CAY-211192 is shown in Fig. 1-24. It consists of a motor driven exciter-generator combination. It is a single-shaft, integrally-constructed unit and is mounted to the deck by four mounting brackets. Lifting eyes are provided for hoisting the unit when desired. Over-all dimensions are $29\frac{13}{16}$ x $10\frac{19}{32}$ x $9\frac{13}{16}$ inches. A junction box is mounted on the side of the unit. The generator is located in the center of the unit and the exciter is on the end opposite the motor. Ventilation through the entire unit is made possible by ventilating blades and ports on the two opposite ends of the motor. A band around the center of the motor over the commutator of the generator may be removed for inspecting the commutator and brushes. Zerk fittings are provided at the points requiring lubrication.

(2) SERVO GENERATOR CAY-211192A (NXsr-46032).—Servo Generator CAY-211192A is shown in Fig. 1-24. It is similar to the CAY-211192 in construction. The dimensions are the same. There is a difference in the type of lubrication fittings. The CAY-211192A uses grease cup fittings. Retaining straps have also been placed over the brush holders on the exciter and the position of the starting capacitor on the a-c drive motor has been changed. The motor and generator are also of slightly different design. Electrically the CAY-211192A is very similar to the CAY-211192.

w. VOLTAGE STABILIZER CG-301252.—The Voltage Stabilizer, shown in Fig. 1-25, is provided to stabilize the a-c line voltage input to the Transceiver Console and its components. It is $35\frac{4}{5}$ inches long, 20 inches wide, and 17 inches high. It weighs 284 pounds. It contains three transformers, a choke, and two capacitors. Each capacitor actually consists of two capacitors in parallel. A terminal board is mounted on top of the output transformer and input and output connections are made to its terminals. Holes are provided in one end of the case to receive stuffing tubes carrying the input and output cables. The components are mounted on a heavy gauge sheet metal base to which are also attached the two ends. The top and sides are held with short stud bolts at the ends and round head machine bolts along the sides at the bottom of the unit. Eyelets for hoisting are attached at the center of each end. The Voltage Stabilizer is ventilated and cooled by means of louvres on the sides and ends.

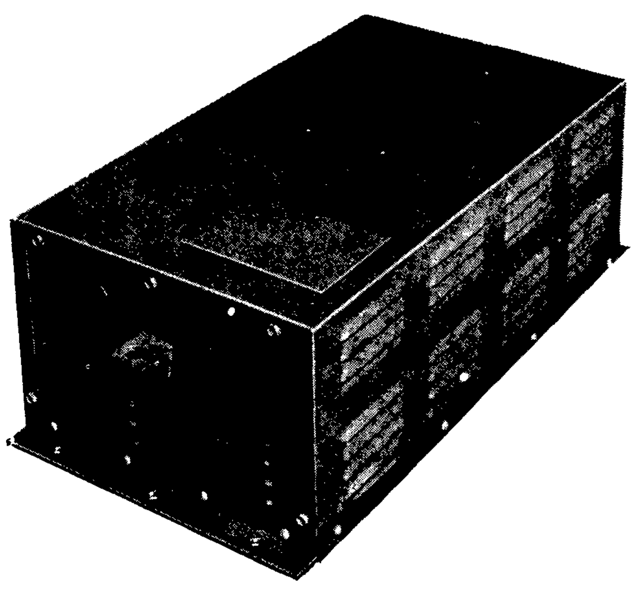


Figure 1-25. Voltage Stabilizer CG-301252

x. AUTO DEHYDRATOR CAKB-10AEK.

(1) The Auto Dehydrator is connected by a copper tube to the air-filled coaxial line in the antenna pedestal. It supplies dry air to this line under pressure in order to prevent the collection of moisture, corrosion, and the occurrence of arc-overs. The Auto Dehydrator is constructed in a metal frame and mounted on shockmounts. It is $33\frac{1}{2}$ x $22\frac{1}{2}$ x 34 inches in size. The two shockmounts on each side are joined by a metal strip. This strip slides under a bracket at the rear end. The front end of the strip is bolted to the place where the unit is mounted. See Fig. 1-26. The top, side, and end panels are perforated for ventilation and may be removed for servicing the unit.

(2) All of the controls are mounted on the front panel. In the upper left-hand corner is the LINE PRESSURE gauge. This gauge reads the pressure being applied to the line by the Auto Dehydrator. In the center top of the panel are the two reactivation pilot lights. These show which of the drying chambers is working and which is being reactivated. On the right-hand top corner of the panel is the humidity indicator. In the second row of controls, starting on the left, is the LINE PRESSURE control and opposite it on the right-hand edge of the panel is the ON-OFF switch and the power pilot light. In the third row of controls, on the left is the AIR-FLOW, or humidity control, while on the right are the two line fuses and a spare fuse.

(3) The components in the Auto-Dehydrator are located on a deck at the bottom of the unit, or secured to the front panel of one of the vertical uprights. The drive motor is on the deck, near the center of the unit with the air compressor mounted against the rear of the unit just above it. Two silica-gel drying tanks are located in the two rear corners of the unit. Most of the controls and minor components are mounted on the back of the front panel. Access to the Auto Dehydrator is obtained by removing the side and back

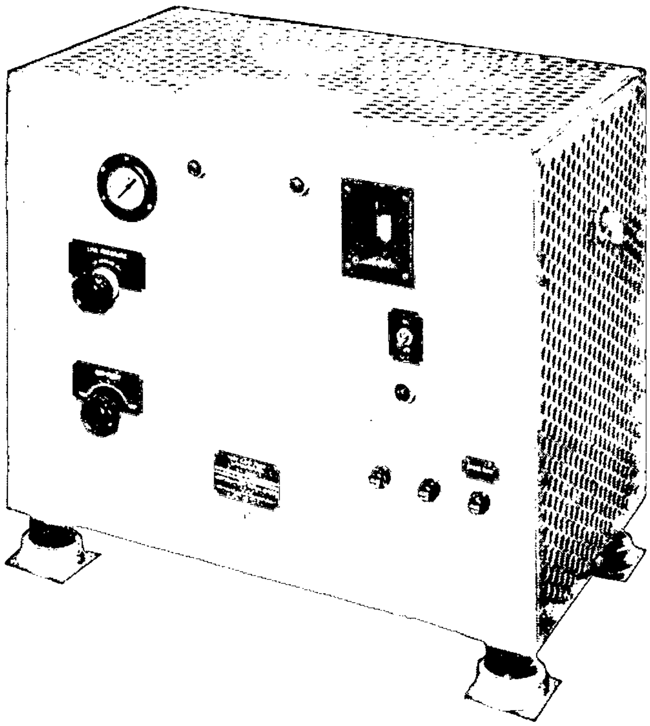


Figure 1-26. Auto Dehydrator CAKB-10AEK

shields. The dry air output is taken from a flared fitting that protrudes through the right end panel of the Auto Dehydrator.

y. ANTENNA PEDESTAL CAJS-21ACP.

(1) The Antenna Pedestal supports the antenna. It contains the drive motor which causes the antenna to rotate in azimuth and throughout 360° in either direction. It also contains the synchros which report the position of the antenna to the Indicator Console. The Antenna and Antenna Pedestal are shown in Fig. 1-27. The Pedestal derives power for rotation from a d-c drive motor through a spur gear train with a step-down ratio of 510.3 to 1. The entire assembly of this gear train is assembled in a cast aluminum housing or dome. This housing serves as a support for the antenna and revolves about a central stationary pivot or post. In addition to the gear train, gears are also provided for driving the synchro position indicators. The power output of the gear train is taken from a bevel gear which drives around a bevel ring gear which is permanently attached to the central pivot column. From this, it will be seen that the entire gear train rotates about a central axis. Since it is connected to the antenna mounting, it causes the entire upper part of the Pedestal to rotate. The Antenna is mounted on this rotating section. The rotating section is supplied with a stowing lock arrangement to prevent movement when the equipment is not in use.

(2) The rotating housing supports the Antenna, transmission, drive motor, pedestal cover, brush blocks and also covers the bevel ring gear collector ring assembly. It is made of cast aluminum and it is supported on the main pivot post by means of two sleeve type graphited bronze bearings. The bearings are self-lubricating. The flanged end of the pivot column supports the thrust load transmitted by the housing. A threaded collar, secured to the pivot column above the upper bearing of the housing, retains the bearing to the pivot column. This threaded collar is adjusted to permit .005 inch end play of the housing with respect to the pivot column. The pivot post is flanged at the bottom for retention of the thrust bearing seat and as a means of securing the pedestal to the base casting. The base casting is, in turn, secured to the top of a mast or equivalent structure. The ring bevel gear, about which the drive mechanism rotates, is attached to the pivot column. Its machined hub supports the collector ring assembly which furnishes power to the drive motor. Collector brushes rotate about the pivot post and are attached to the rotating housing. The post serves as a stationary bearing shaft for the main housing; a means for keeping the bevel gear stationary; a support for the synchrotie assembly and housing through which the wires from the synchroties and slip rings are passed. The upper end of the post is designed to secure the concentric r-f line in place and provide a rotating joint for the pressurized r-f line.

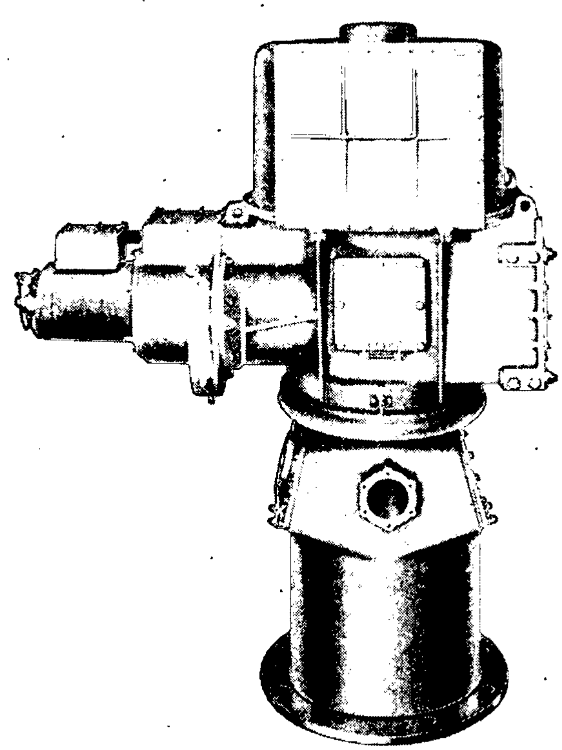


Figure 1-27. Antenna Pedestal CAJS-21ACP

(3) The synchrotie assembly, consisting of two type 6DG synchro-differential generators, provides the means for indicating the position of the Antenna. The synchro-differential generators are secured directly to a cast aluminum bracket which is, in turn, secured to the pivot post. Connections to the two 6DG units are made through two sets of connector blocks. One set is located near the 6DG units and one set is in the base of the mount. No sliding connections are required since both of these units are on the non-rotating section of the pedestal. The locating stub of the synchro mounting tube is made in two sections, both secured to the pivot post and in turn bolted to each other. A tapered end pin locates the mounting bracket in its proper position with respect to the column. The synchro units are secured to the mounting bracket by means of a clamp ring which is secured to the bracket by three screws. Loosening these screws, permits rotation of the synchro units while aligning them with respect to the synchro units in the Indicator Console.

(4) A 180-tooth ring gear, secured to the main housing, meshes with a 180-tooth gear and drives one 6DG unit at a ratio of 1:1 with respect to the rotating housing. A 30-tooth pinion of an intermediate cluster gear, meshes with the 1:1 synchro gear. In the other half of the cluster, a 180-tooth gear meshes with a 30-tooth pinion which drives the other 6DG unit at a 36:1 speed with respect to the main housing. The shaft on which the gears are mounted are each supported by a bronze bushing. The outer diameter of this bushing is eccentrically machined with respect to its bore to provide a means of adjusting the backlash between each set of mating gears. The synchro gear train is independent of the synchros. Removal of one or both synchros will not disturb the backlash setting of the gears. Backlash between the gears can be adjusted by loosening the mounting screws of the bearing and rotating the bearing slightly until the gears mesh with no backlash. Oversize mounting holes permit a slight lubrication for each bearing. The stainless steel pinions, meshing with aluminum bronze gears, require no lubrication.

(5) The antenna drive system consists of the motor, the gear case in which are mounted the high speed pinion shaft assembly, intermediate pinion shaft assembly, low speed or bevel pinion shaft assembly and bevel ring gear. The drive motor is a ½ hp d-c motor with a reversible 300-volt field, and 250-volt armature. Its speed is 3,450 rpm. when full voltage is applied. This motor is attached to the gear case housing by six 5⁄16 inch studs. The studs have cone point ends to facilitate mounting of the motor to the gear housing. Any slight misalignment between the motor and input pinion is taken up by an Oldham coupling. The speed reduction gear train, except for the bevel pinion and main ring gear, is contained in an aluminum housing which is bolted to the main rotating housing.

(6) The drive motor receives its power through the collector ring assembly. This assembly contains twelve platinum silver rings mounted integrally with and separated by molded moldarta inserts. Only six of the rings are used. This provides six spares which can be used in an emergency by interchanging leads at the brush blocks and terminal blocks. One armature and one field lead of the collector ring assembly is hooked up directly to the terminal blocks while the other two motor leads come from the motor disconnect plug which is wired directly to the terminal blocks. Removal of the motor plug will cut off the power supply to the motor. The Antenna drive motors are made by two manufacturers. The appearance of the two motors is different, but they mount on the Pedestal in exactly the same way and are completely interchangeable. The parts of the motors themselves are not interchangeable. The motor is coupled directly to a 10-tooth drive pinion which meshes with an internal gear having 101 teeth. This internal gear is keyed to the intermediate drive shaft which has a 12-tooth pinion cut into its opposite end. The intermediate drive pinion meshes with a 101-tooth internal gear that is keyed to the output bevel pinion. The bevel pinion, having 14 teeth, then meshes with the bevel ring gear which has 84 teeth. This bevel ring gear is keyed to the main pivot column. Being fixed, it causes the entire drive system to rotate about it.

(7) The speed reduction gears and bearings, with the exception of the bevel pinion and ring gear, are lubricated by oil which is circulated by the intermediate internal gear. This gear rotates through an oil reservoir located in the lower section of the intermediate transmission housing. The bevel pinion, made of stainless steel, and the level ring gear, made of aluminum bronze, are both highly polished and do not require lubrication. The oil filler plug is located on the upper right-hand side of the transmission housing, looking from the rear. On the same side, but toward the bottom, is located the oil level plug and directly below is the oil drain plug. The synchro gears require O.S. 1113 (W.A.—358 Socony) oil. The transmission has been designed with an adjustment to eliminate backlash between each set of gears. To adjust backlash between the bevel pinion and ring gear, shims are assembled between the flange of the bevel pinion support and its mounting surface. This forces the pinion toward the center of the bevel gear to reduce the backlash between the two gears. Three sizes of shims are provided for this purpose. To adjust blacklash between the motor drive pinion and the intermediate internal gear, the locating bore for the drive pinion support is bored eccentric with respect to the rotational axis of the pinion. Oversize mounting holes permit rotation of the support. This movement causes the center-to-center distance of pinion and driven gear to change depending upon which way the

support is rotated. A backlash adjustment is also provided for the intermediate gears. The locating bore in the main housing is bored eccentric with respect to the rotational axis of the output pinion. As in the case of the motor drive gear support, the mounting holes are bored oversize to permit a slight rotation of the intermediate transmission housing which would change the center-to-center distance of the intermediate gears, depending which way the housing is rotated. To reduce the bending movement of the bevel ring gear, a ball bearing, mounted eccentrically on a shaft, is assembled beneath the ring gear at the point where it meshes with the pinion. The shaft is rotated until the ball bearing just touches the ring gear. It is then locked in place by means of a lock screw. The bearing is of the sealed type and will not require any maintenance.

(8) Directly opposite the transmission opening is a square opening which has been cast in the housing to permit assembly of the bevel ring gear and collector ring assembly to the pivot column. The cast aluminum cover for this opening is hinged and secured to the main housing by means of captive screws. The two brush block assemblies, which supply power to the motor through the collector ring assembly, are located in cast openings which are 90° from the large opening and are opposite each other. The brush assemblies consist of the cover and block support made of cast aluminum and the brush block of fabricated micarta. Beginning with Serial No. 31, the brush assemblies consist of collector rings mounted integrally with and separated by molded moldarta inserts. The cover is hinged to the support, but bolts to the main housing through clearance holes in the support. The support is secured to the main housing and provides a means for securing the brush blocks in place. Each brush block contains six silver brush arms and graphite silver contacts which are silver soldered to the arms. A torsion spring, pressing from the underside of the brush arms, assures positive contact between the sliding brushes and the collector ring assembly. A braided copper head, soldered to the brush arm and terminating at a special terminal common to the incoming leads from the pedestal base, completes the circuit. The cylindrical cast cover secured to the top of the main housing supports the rotating joint and upper concentric lines. The square opening in the side of the cover, permits servicing of the synchro units without removing the cover.

(9) The base supports the Antenna Pedestal assembly and is the portion that mounts on the mast. It is a hollow aluminum casting and houses the lower T-section of the coaxial line to the antenna, the terminal blocks, telephone jack, motor disconnect plug, and safety switch. Two entrance ports for the concentric lines and power terminals are provided in the base. Removable plates provide access to the components mounted in the base. The top of the base is machined flat and is bored to receive the pivot post which is secured to the base by means of six ⅝ inch studs. Internal components are assembled through a cast opening in the bottom of the base. The T-section of the concentric line is cast integrally with the base extending horizontally from one side of the base to the other. The cast aluminum bushing, bored out to the same diameter as the horizontal section, forms the "T" at the centerline of the pedestal. The r-f line is secured to one end of the T-section and the IFF line is secured to the other end. Machined bosses on each side of the T-section mount the terminal block mounting plate. The mounting plate containing the telephone jack, power receptacle, motor disconnect plug and safety switch is also attached in the same manner. Openings are cast in the side of the base to provide access to the electrical parts. All power leads enter the base through an opening on the side and are secured to three terminal blocks. The telephone jack, motor disconnect plug and safety switch are wired directly to the terminal blocks while the 110-volt a-c receptacle is wired to the safety switch. Leads to the synchro units pass through a packing gland at the base of the pivot column, and up the inside of the pivot column. They emerge above the synchro ring gear and are secured to terminal blocks on the synchro mounting bracket.

z. ANTENNAS COD-66AHE, CLP-66AHE AND COD-66AHG, CLP-66AHG.

(1) Two different radar antennas may be used with the SR series of equipments. The antennas are similar in construction and either one may be mounted directly on the Antenna Pedestal without the use of special attachments. The two antennas are necessary in order to cover the frequency range of the equipments. The Blue Antenna covers the 215-225-MC/s band and the Yellow-Green Antenna covers the bands in the 157-205-MC/s range. In addition to the two radar antennas, three different IFF Antennas are supplied with each equipment. The choice of IFF Antennas to be assembled on either of the radar Antennas depends upon the frequency of the IFF equipment associated with the SR series of equipment.

(2) The Blue Antenna COD-66AHE, CLP-66AHE, shown in Fig. 1-28, is made by two different manufacturers as indicated by the type numbers. The antennas are interchangeable on the Antenna Pedestal. They consist of a welded steel supporting frame to which is welded a metal reflecting screen. The radar antenna array is mounted across the top of the screen. The Antenna Assembly also includes the antenna feed lines, a bazooka or impedance inverter, and part of the main r-f lines. The dimensions of the Blue Antenna are 152 x 69 x 31 11/16 inches with a turning radius of 80⅛ inches. The metal screen which forms the reflector for the antenna is welded to an outer metal frame.

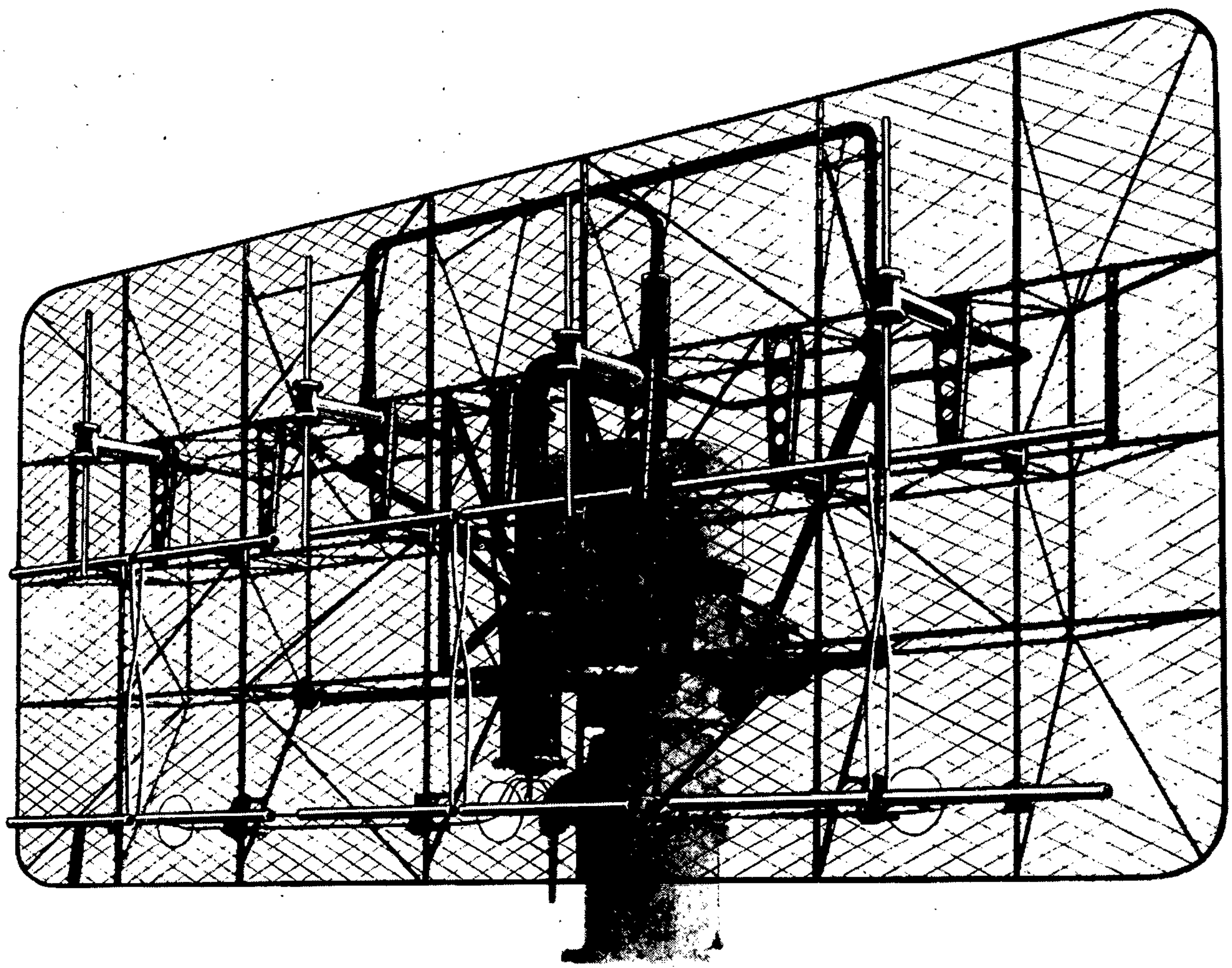


Figure 1-28. Blue Antenna COD-66AHE or CLP-66AHE with V.H.F. Antenna COD-66AHH or CLP-66AHH or with H.F. Antenna COD-66AHG or CLP-66AHG or Yellow Green Antenna COD-66AHF or CLP-66AHF with H.F. Antenna COD-66AHG or CLP-66AHG

Four side arms brace the antenna framework and terminate at a mounting position at the rear of the pedestal. Six vertical and three lateral cross-members are used to strengthen the antenna screen and provide rigid points to which the antenna dipoles may be bolted. The bazooka is located behind the bottom center of the screen. Three two-wire feed-lines are coupled to the termination of the coaxial line at the bazooka. These lines are mounted on ceramic standoff insulators behind the screen. The radar antenna consists of six pairs of radiating elements, electrically one-half wavelength long, which are mounted horizontally in front of the bottom half of the antenna screen. The three feed-lines run behind the screen and couple to the center of the three bottom pairs of radiating elements through circular apertures in the screen. R-F lines run from the center of each of the three pairs of radiating elements on the bottom to the center of a corresponding set of elements in the top row. These lines are crossed, and are electrically a half-wavelength long. Thus, the top array of dipoles are fed in phase with the corresponding dipoles below them.

(3) The radar dipole assemblies consist of the dipoles which are welded to a metallic insulator. The flange of the metallic insulator is secured to the framework by means of four bolts. The IFF dipole assembly mounted on the Blue Antenna is the V.H.F. IFF Antenna COD-66AHH or CLP-66AHH. The H.F. IFF Antenna COD-66AHG or CLP-66AHG, and the U.H.F. IFF Antenna COD-66AHJ or CLP-66AHJ are supplied as alternate assemblies.

(4) The Yellow-Green Antenna COD-66AHF or CLP-66AHF, shown in Fig. 1-28, is made by the same manufacturers that make the Blue Antenna. The physical construction of the Yellow-Green Antenna is

identical to that of the Blue Antenna, except for the length of the radar antenna dipoles. These dipoles are made longer since the Yellow-Green Antenna is designed for a lower frequency band. The Yellow-Green Antenna is shipped with H.F. IFF Antenna COD-66AHG or CLP-66AHG assembled on the reflecting screen. V.H.F. IFF Antenna COD-66AHH or CLP-66AHH are supplied as alternate assemblies. The overall dimensions of the Yellow-Green Antenna are slightly greater than the dimensions of the Blue Antenna since the lower frequency band requires longer metallic dipole insulators and the dimensions of the reflecting screen must be increased to accommodate the increased dipole length and spacing. The dimensions of the Yellow-Green Antenna are 180 x 72 x 32$^{13}/_{16}$ inches, with a turning radius of 93½ inches.

(5) The H.F. IFF Antenna COD-66AHG or CLP-66AHG is shown on the Yellow-Green Antenna in Fig. 1-28. The IFF Antennas are mounted on the top portion of the Antenna screen. The H.F. IFF Antenna consists of four dipole assemblies which are mounted vertically in front of the top half of the screen. Six brackets are assembled to the top two horizontal cross-members to hold these antennas. Only four of these brackets are employed with the H.F. system. The dipole assembly consists of two quarter-wave elements threaded on one end so that they can be screwed into

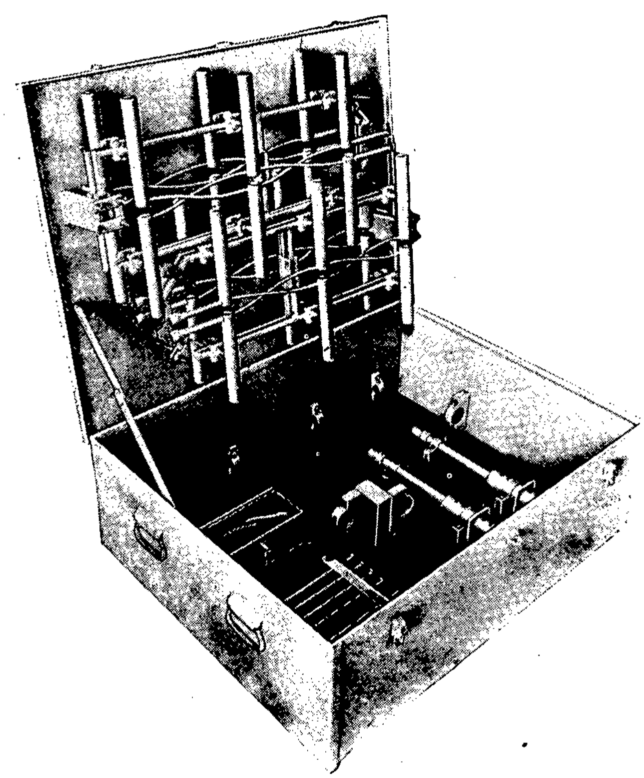


Figure 1-29. V.H.F. Antenna COD-66AHH or CLP-66AHH or H.F. Antenna ~~COD-66AHG~~ or CLP-~~66AHG~~ and U.H.F. Antenna COD-66AHJ or CLP-66AHJ

place on the bazooka. The bazooka is constructed as an integral part of the IFF transmission line. This line comes through the rotating section of the pedestal, forming the center conductor of the radar antenna coaxial line. Above the pedestal, the IFF coaxial line comes out of a quarter-wave stub on the radar coaxial line and divides into two lines which run in opposite directions behind the screen and parallel to it. This line then bends down to a point midway between the two outside IFF dipole assemblies. From this point, it joins a horizontal coaxial line which runs behind the antenna screen and parallel with it. At the end of each line is a tee which connects the line to two other coaxial lines, each feeding an IFF dipole assembly. The bazooka and transmission line which form part of the dipole assembly are removable. The bazooka is flanged and is secured to the screen bracket by means of four bolts. The H.F. dipoles may be identified by the purple bands painted around each quarter-wave element. The bazooka assembly is common to both the H.F. (purple) and V.H.F. (orange) antennas.

(6) The V.H.F. IFF Antenna COD-66AHH or CLP-66AHH is shown in Fig. 1-29. It consists of four dipole assemblies that screw into the same bazooka assembly used for the H.F. Antenna. Since both antennas are supplied with each equipment, only one set of four bazookas are supplied. The V.H.F. dipole elements may be identified by the orange band of paint on each element and by their shorter length. The ends of the dipoles are threaded studs so that they may be tightened with a wrench. The nut on the end of the dipole is drilled for a safety wire used to keep the dipole element from becoming loose due to vibration.

(7) The U.H.F. IFF Antenna COD-66AHJ or CLP-66AHJ (Mark IV Group) is shown in Fig. 1-29. It employs a different dipole assembly containing 24 dipoles. It consists of four dipole array frames which bolt to the screen brackets and two bazookas which bolt to the framework brackets and fasten to the IFF feed line. Each bazooka feeds two arrays. The IFF feed line connects to the bazooka by a plug connection to the inner coaxial line and a screw connection on the outer line. The terminal screws on the front of the bazookas pass through and bolt to the terminal lugs on the dipole array frames. Each of the four arrays consists of three sets of two dipoles. Each set of dipoles is mounted in a co-linear manner. That is, they are placed end to end. The co-linear assemblies are a half-wavelength apart in each array, and they are mounted on quarter-wave metallic insulators. Each metallic insulator is secured to the frame with four bolts and the frame in turn mounts on the screen brackets. Two bazookas are supplied. Each bazooka feeds two arrays. The dipole assemblies in each array are connected by two-wire lines one-half wavelength long. These lines cross over each other between the dipole assemblies so that all dipoles are fed in phase.

The U.H.F. Antenna is packed in a metal carrying case with the dipole elements of either the H.F. or the V.H.F. IFF Antenna, depending upon the type of radar Antenna associated with the particular equipment in question. An SR equipment purchased on Contract NXsr-30306 is shipped with an H.F. IFF Antenna attached to the radar Antenna, whether it be the Blue or the Yellow-Green. An SR equipment purchased on Contract NXsr-46032 is shipped with a V.H.F. Antenna attached to the Blue radar Antenna and an H.F. Antenna attached to the Yellow-Green radar Antenna. The four U.H.F. arrays mount on two brackets secured to the lid of the carrying case and the bazookas and H.F. or V.H.F. elements are placed in clamps on the bottom of the carrying case. Additional clamps are provided in the box to accommodate the transmission line bazooka assemblies of the H.F. and V.H.F. Antennas when the U.H.F. Antenna is in use. The lid of the carrying case is held closed by two trunk fasteners and a hasp is provided so that it can be locked. Two handles are placed on each end of the case so that it can be lifted and carried.

(8) The radio frequency line for the radar antenna begins at the bazooka. It extends upward until it is over the center of the pedestal and then travels downward vertically to the dome of the pedestal. A rotating joint, located within the pedestal section, permits rotation of the antenna continuously in any direction. The coaxial line from the IFF antenna is within and concentric to the outer conductor of the radar coaxial line. The outside of the outer conductor of the IFF coaxial line forms the inner conductor of the radar coaxial line. The inner conductor of the IFF coaxial line, is formed by a metal rod which is concentric with and inside the IFF coaxial line. In this manner, both coaxial lines pass through the rotating joint of the pedestal. Inside the pedestal base, the lines terminate at two separate couplings. Coaxial cables from the respective transmitters are connected to these connectors. One is connected to the radar transmitter from the larger connector and one to the IFF transmitter from the smaller connector. The radar connector is a tapered section just ahead of the junction. It is used to reduce the diameter of the line without affecting its impedance. Connections from the radar coaxial line at the base of the pedestal to the Transceiver are made with solid-dielectric, armored cable, Type RG-20/U. Connections from the IFF antenna termination to the IFF transmitter-receiver are made with an approved cable supplied with the IFF equipment.

aa. MOTOR GENERATORS.

(1) Motor Generator CAY-211182 is supplied on Contract NXsr-30306. It is shown in Fig. 1-30. Its overall dimensions are 86¾ x 30$^{13}/_{16}$ x 33$^{15}/_{16}$ inches. It is designed to convert 115 volts d-c into 115 volts a-c. The motor and generator are mounted on a cast steel bedplate. The two units are coupled together with a flexible coupling. A coupling guard is provided to prevent accidental contact. The d-c exciter frame is cast as an integral part of the bell housing of the generator frame. The exciter field frame bolts directly to the extended frame cast into the bell housing. The armature of the exciter is of the "quill" type, fitting directly onto an extension of the a-c generator's armature. Three terminal boxes are supplied. One is located on the side of the motor frame, another on the side of the generator frame, and the third on the side of the exciter frame. The units are of drip-proof, semi-enclosed construction. The continuous duty output rating of the generator is 115 volts, single phase, 60 cycles, 10 KW at 80% lagging power factor in ambient temperatures which range from 0° C. to 50° C. The a-c Generator CAY-211184, is of the four-pole, rotating field salient pole type, operates at a speed of 1,800 rpm., and delivers an output at 115 V. An Exciter CAY-211190 rated to deliver 125 volts is provided with four main poles and two commutating poles. It is shunt-wound. Regulation of the a-c Generator voltage is accomplished by automatic regulation of the Exciter shunt field. The Drive Motor CAY-211183 is of the shunt-wound type, with four main poles and two commutating poles. In addition to the main shunt field, the motor is also provided with a smaller shunt field which is wound differentially with respect to the main field. This arrangement tends to minimize the effect of variation in ambient temperature on motor speed. A centrifugally operated switch is mounted on the outboard end of the motor. If for any reason the motor speed rises above a pre-determined safe value, this switch will open, thus breaking the control circuit in the magnetic controller. Filters are provided in the motor-generator unit to prevent radio disturbances. These filters are mounted on the motor and generator frame. Eyelets are provided in the top of each unit frame for lifting purposes. Hinged plates secured with wingnuts provide access to the brushes on the drive motor. These plates are located on the upper side of the bell housing. Removable plates perforated for ventilation are located on the lower side of the bell housing. The motor bearings are lubricated by means of grease cups mounted on extension tubes. The Commutator of the a-c generator is accessible through small removable plates on the upper side of the generator's bell housing. These plates are secured with thumbscrews. The lower openings in the bell housing are covered with wire mesh to provide ventilation. Four hinged cover plates on the exciter frame provide access to the commutator and brushes. Motor Generator CAY-211182 is designed to operate with Magnetic Controller CAY-

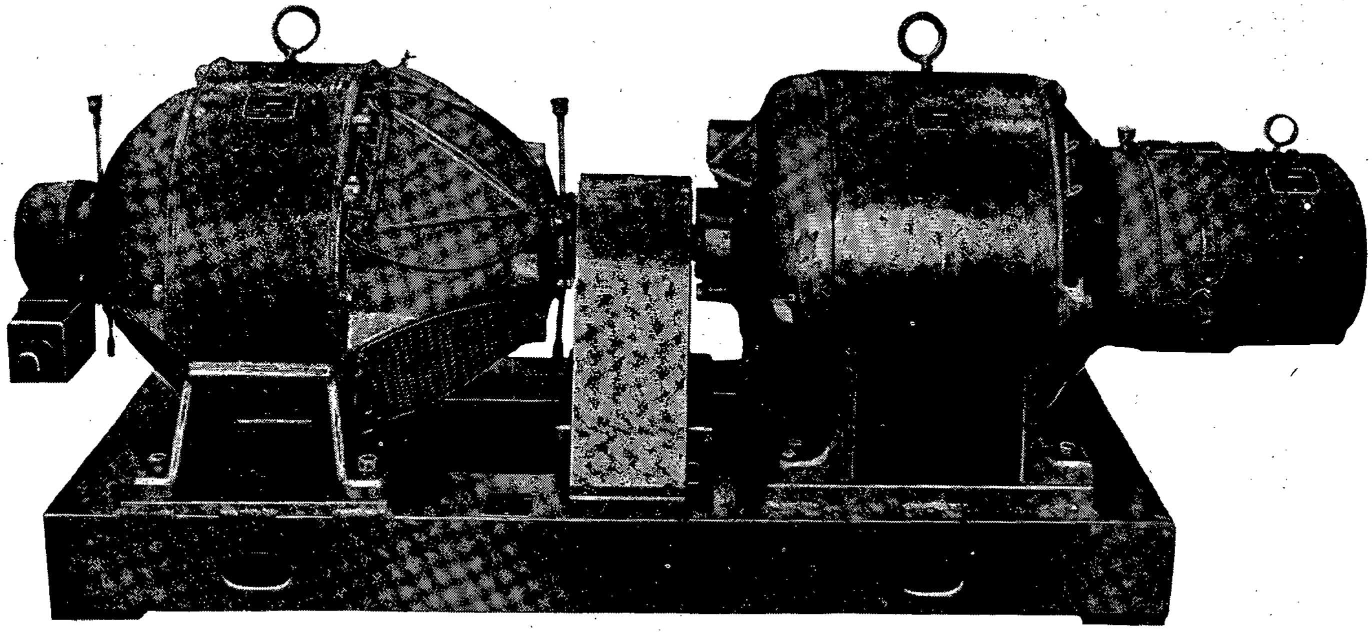


Figure 1-30. Motor Generator CAY-211182, CAY-211188 or CAY-211326

211181, Voltage Regulator CAY-211185, and Pushbutton Station CAY-211186.

(2) Motor Generator CAY-211188 is also supplied on Contract NXsr-30306. It is similar in appearance to the Motor Generator shown in Fig. 1-30. The difference between the CAY-211188 and the CAY-211182 is in the electrical design. Motor Generator CAY-211188 is designed to deliver an output of 115 volts, single phase, 60 cps., 10 KW. at 80% lagging power factor, from a 230 volt d-c input in an ambient temperature range from 0° C. to 50° C. The a-c Generator CAY-211184 and Exciter CAY-211190 are the same units used in Motor Generator CAY-211182. The 230-volt d-c Drive Motor CAY-211189 replaces the 115-volt d-c Drive Motor CAY-211183 used in Motor Generator CAY-211182. The physical characteristics of both motors are essentially the same. Motor Generator CAY-211188 is designed to operate with Magnetic Controller CAY-211187, Voltage Regulator CAY-211185 and Pushbutton Station CAY-211186.

(3) Motor Generator CAY-211326 is supplied on Contract NXsr-46032. It is similar to the Motor Generator shown in Fig. 1-30. It is used to convert 230 volts d-c, taken from the ship's power system, into 115 volts a-c, at 108 amperes. With the Motor Generator operating at 65% efficiency, the d-c input must be 83 amperes to produce an output of 108 amperes. Since the average full load requirements of the SR series is only 65 amperes, the average input need only be approximately 50 amperes. Motor Generator CAY-211326 consists of D-C Drive Motor CAY-211327, A-C Generator CAY-211328, and Exciter CAY-211329. The mechanical design of Motor Generator CAY-211326 is similar to the mechanical design of Motor Generator CAY-211182. The output rating of the generator is 115 volts, single phase, 60 cycles, 10 KW. at 80% lagging power factor in ambient temperatures which range from 0° C. to 50° C. The Generator is of the four-pole rotating field salient pole type and operates at a speed of 1,800 rpm. The Exciter, rated to deliver 125 volts, has four main coils and two commutating poles. It is shunt wound. Regulation of the a-c Generator voltage is accomplished by automatic regulation of the Exciter generator shunt field. The Drive Motor is shunt wound with four main poles and four commutating poles. Mounted on the outboard end of the motor is a centrifugal type speed regulator. Through action of this speed regulator, the motor speed is held essentially constant under conditions of varying line voltage, load, and temperature. The motor input leads and the generator's output leads are filtered to minimize radio interferences which might result from sparking of the commutator and slip rings. These filters are mounted in the motor and generator terminal boxes. Motor Generator CAY-211326 is designed to operate with Magnetic Controller CAY-211325, three Pushbutton Stations CAY-24299, Voltage Regulator CAY-21185A and Controller Disconnect Line Switch CWU-24429.

Figure 1-31. Magnetic Controllers CAY-211181, CAY-211187 or CAY-211325

ab. MAGNETIC CONTROLLERS.

(1) Magnetic Controller CAY-211181 is supplied on Contract NXsr-30306. It is shown in Fig. 1-31. The purpose of the Magnetic Controller is to start and stop the 115 volt d-c Drive Motor on Motor Generator CAY-211182. It is designed for bulkhead mounting. The component parts are mounted in a drip-proof cabinet. The cabinet is made of sheet metal and measures $10\frac{7}{8}$ x 20 x $24\frac{19}{32}$ inches. Access to the interior is through a door covering the entire front of the cabinet. This door is hung on a piano-type hinge and is secured in its closed position by two thumbscrews. The only external control is a RESET button that protrudes through the door. The component parts consist of five relay-contactors, an overload relay, three potentiometers, and two starting resistors for the Drive Motor. These parts are mounted on a micarta panel which is mounted on angle iron brackets welded to the back of the cabinet. Provision is made to bring the connecting cables into the cabinet through openings in the top and bottom of the cabinet.

(2) Magnetic Controller CAY-211187 is supplied on Contract NXsr-30306. It is shown in Fig. 1-31. It operates in a 230 volt d-c circuit to start and stop the Drive Motor on Motor Generator CAY-211188. Its component parts are mounted in a metal cabinet measuring $10\frac{15}{16}$ x 15 x $20\frac{15}{16}$ inches. The only control on the front of the cabinet is the overload relay reset pushbutton. The door is hung on a piano type hinge and is held closed by means of three thumbscrews. The parts are mounted on a micarta panel. This panel is secured to two brackets, welded to the back of the cabinet, by means of four mounting studs. Two motor starting resistors, three relay contactors, an overload relay, two potentiometers, and a cartridge type fuse are mounted on the micarta panel. The connecting cables may be brought into the cabinet through openings at the top and bottom. These openings are covered with removable plates.

(3) Magnetic Controller CAY-211325 is supplied on Contract NXsr-46032. It is shown in Fig. 1-31. It is contained in a cabinet measuring $11\frac{1}{8}$ x 16 x $22\frac{3}{8}$ inches. The cabinet is designed for wall mounting and is held by means of four mounting studs. Access to the interior of the cabinet is through a door on the front of the cabinet. The door is hung on a piano type hinge. Two pushbuttons protrude through the door in the lower left-hand corner. Lead plates secured with screws are provided at the top and bottom of the cabinet. These plates are not drilled and must be drilled for the holes required at the point of installation. The components are mounted on a micarta panel. They consist of an overload relay, two time delay relays, two field resistors, a relay contactor, two fuses, and a pushbutton station. Magnetic Controller CAY-211325 is

used to start the 230-volt d-c motor in Motor Generator CAY-211326.

ac. VOLTAGE REGULATORS.

(1) The Voltage Regulator CAY-211185 is supplied on Contract NXsr-30306. It is shown in Fig. 1-32. Its component parts are mounted in a metal cabinet that measures $16\frac{1}{4}$ x 26 x $29\frac{1}{4}$ inches. The cabinet is designed for bulkhead mounting. The purpose of the Voltage Regulator is to control the current supplied to the field of the A-C Generator by the Exciter to maintain a constant output voltage. The component parts are mounted on a micarta panel which is secured with six studs to brackets welded to the back of the cabinet. These parts consist of a 0-150 V. voltmeter, a copper oxide rectifier, two rheostats, a damping transformer, two field resistors, a voltage regulator, and a switch to select the type of operation. All connections are brought out to a terminal board in the lower left-hand corner of the panel.

(2) Voltage Regulator CAY-211185A supplied on Contract NXsr-46032, is electrically similar to the CAY-211185. It is slightly different in mechanical design. This difference consists of shielding the various components and is a mechanical modification of the rheostat located above the terminal board. The size of the cabinet and all other constructional details are the same.

ad. PUSHBUTTON STATIONS.

(1) Pushbutton Station CAY-211186 supplied on

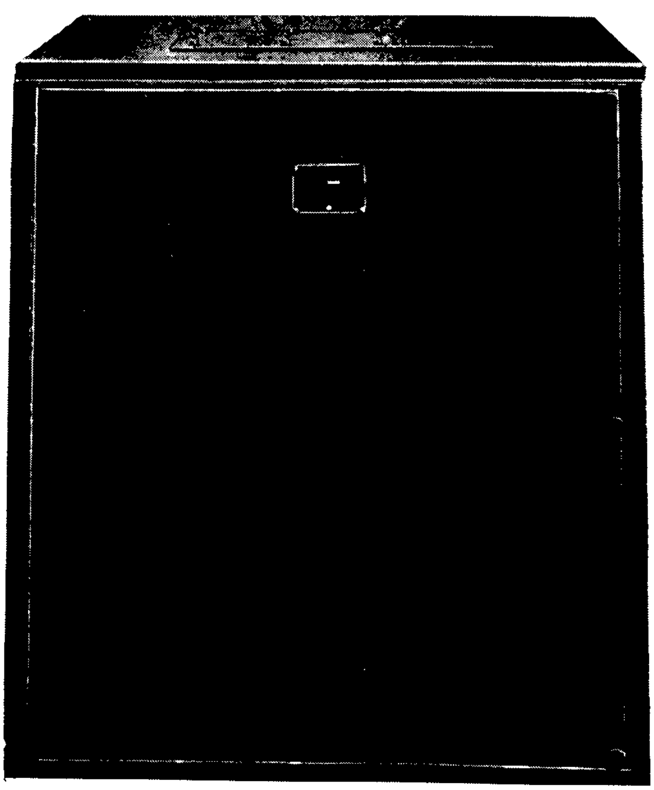


Figure 1-32. Voltage Regulators CAY-211185 or CAY-211185A

Figure 1-33. Pushbutton Stations CAY-21186 and CAY-24299

Contract NXsr-30306, is shown in Fig. 1-33. Its overall dimensions are $4\frac{7}{8}$ x $4\frac{1}{4}$ x $9\frac{1}{8}$ inches. It is used to control magnetic Controller CAY-211181 or CAY-211187. The Pushbutton Station is constructed in a water tight case. It contains two pushbutton switches. One switch is the starting switch. The other switch stops the equipment. A conduit fitting can be attached to the top of the case to bring in the cabling. Only one of these Pushbutton Stations is used.

(2) Pushbutton Station CAY-24299 supplied on Contract NXsr-46032, is shown in Fig. 1-33. It is contained in a case measuring 5 x $4\frac{1}{4}$ x $9\frac{1}{8}$ inches. The case is of water-tight construction and a complete installation may use as many as three of these Pushbutton Stations. It is not necessary to use any of them if remote control is not desired. Pushbutton Station CAY-24299 is used with Magnetic Controller CAY-211325.

ae. CONTROLLER DISCONNECT LINE SWITCH CWU-24429 (NXsr-46032).

(1) Controller Disconnect Line Switch CWU-24429 is shown in Fig. 1-34. It is housed in a case that measures $8\frac{3}{4}$ x $5\frac{3}{16}$ x $16\frac{21}{32}$ inches. This switch is designed for use with Magnetic Controller CAY-211325, Motor Generator CAY-211326, and their associated components. The switch is designed for wall mounting and four holes are provided to receive mounting screws. The switch box is drip-proof and it contains a double-pole-single-throw switch and two 200-ampere fuses. The door swings downward, being hinged at the bottom. The door is held closed by means of three fasteners. One at the top and one on each side. These fasteners are operated with a crank

just below the handle. The switch handle near the top of the door must be pushed slightly to the right and pulled straight out to open the switch and the door to the switch box. When the door is closed, the handle must again be moved to the right or the switch will not close when the door is closed.

af. CONNECTOR NAVY TYPE 49261 (UG-32/U).

(1) The UG-32/U connector is shown in Fig. 1-35. It is a government furnished item supplied with all equipments. It is used as an adapter to connect a gas filled coaxial line to a coaxial cable with a solid dielectric.

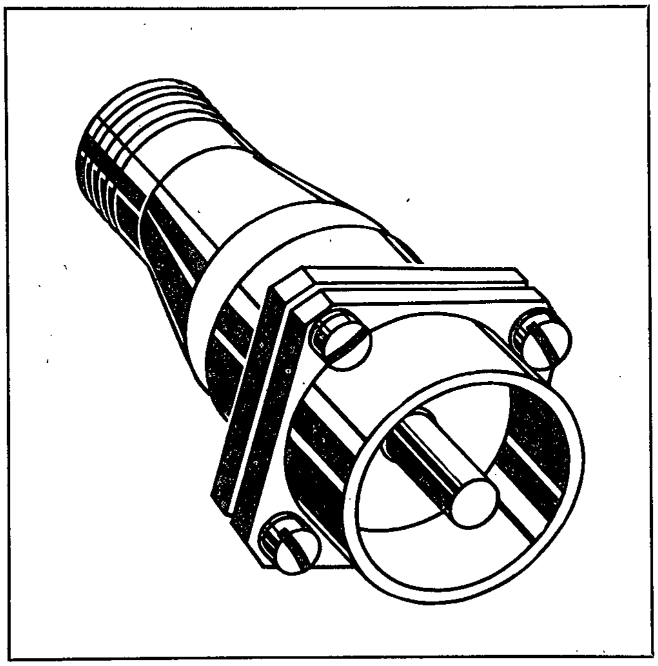


Figure 1-35. Connector UG-32/U Navy Type 49261

5. REFERENCE DATA.

a. NOMENCLATURE. The following complete equipments are involved in this instruction book.

(1) Navy Model SR.
(2) Navy Model SR-a.
(3) Modulator CAY-50AGU.

b. CONTRACT NUMBER AND DATE.

(1) Two-hundred SR Equipments were purchased on Contract NXsr-30306, dated 5 June, 1943. These equipments are to be modified in the field into SR-a equipments. One-hundred Motor Generators CAY-211182 (115 V.) and one-hundred Motor Generators CAY-211188 (250 V.) were purchased on this contract.

(2) One-hundred SR Equipments were purchased on Contract NXsr-46032, dated 17 January, 1944. With the substitution of Modulator CAY-50AGU for the Keyer Unit, these equipments also become SR-a Equipments.

(3) In order to convert the SR Equipments to SR-a Equipments, 330 Modulators CAY-50AGU were purchased on Contract N5sr-7197, dated 7 April, 1945.

c. CONTRACTOR.

(1) The contractor supplying the equipment described in this instruction book is:

Westinghouse Electric Corporation,
2519 Wilkens Avenue,
Baltimore, Maryland.

d. COGNIZANT NAVAL INSPECTOR.

(1) The cognizant Naval Inspector is:
Assistant Resident Inspector of Naval Material,
Baltimore, Maryland.

e. NUMBER OF PACKAGES PER SHIPMENT.

(1) The SR Equipments shipped on Contract NXsr-30306, together with the equipment spare parts, required 35 packing cases per complete shipment.

(2) The SR Equipments on Contract NXsr-46032, together with equipment spare parts require a total of 26 boxes.

f. CUBICAL CONTENTS AND WEIGHT.

(1) The cubical contents and weight of each SR Equipment combination are listed in Table 1-1.

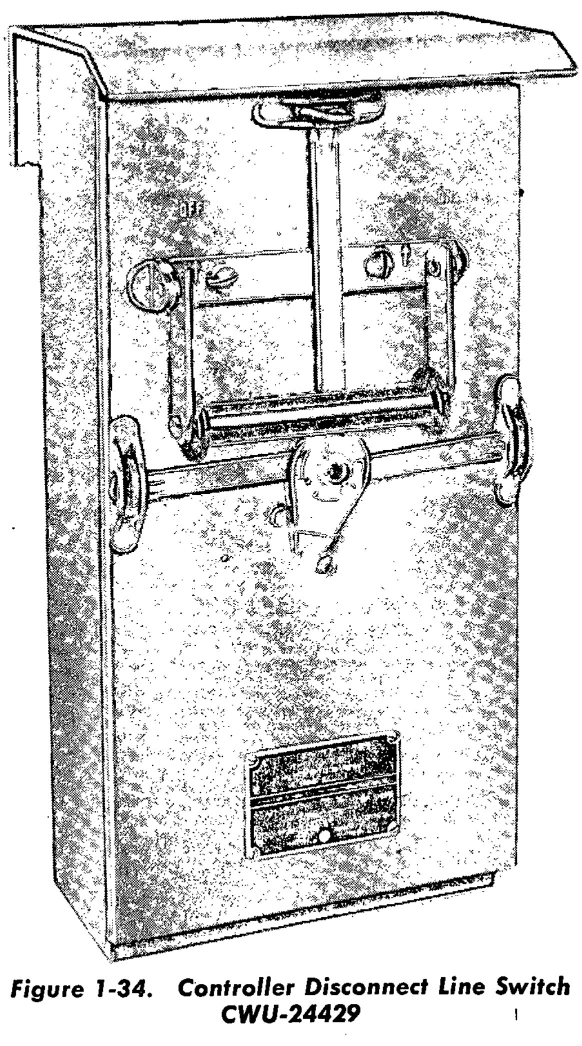


Figure 1-34. Controller Disconnect Line Switch CWU-24429

TABLE 1-1

CUBICAL CONTENTS AND WEIGHT PER SHIPMENT

Contract	D-C Voltage Supply	Antenna	Volume (Cu. Ft.)		Weight (Lbs.)	
			Crated	Uncrated	Crated	Uncrated
NXsr-30306	115 V.	Yellow-Green	860	495.72	12,818	9697
	115 V.	Blue	744	435.72	12,618	9697
	230 V.	Yellow-Green	860	494.52	12,818	9697
	230 V.	Blue	744	434.52	12,618	9697
NXsr-46032		Yellow-Green	860	497.41	12,863	9742
		Blue	744	437.41	12,663	9721

g. TRANSMITTER DATA.

(1) The peak power output of the two SR Equipments is approximately 300 kilowatts based upon an oscillator efficiency of 40%. The SR has a pulse width of 1, 4, or 20 microseconds and a corresponding repetition rate of 200 cycles per second at the 1 and 4 microsecond pulse length, and 60 cycles per second at 20 microseconds. The SR-a has a pulse length of four microseconds and a repetition rate of 125 cycles, variable over a narrow range. The peak output power varies to some extent with the various transmitter conditions obtainable.

h. RECEIVER DATA.

(1) The Receiver in the SR system consists of two separate components. These are the Monitor Receiver and the Console Receiver. The two components together form a superheterodyne receiver with an intermediate frequency of 15 mc/s. The output of the Monitor Receiver is approximately 180 milliwatts into a 50-ohm load. The input and output impedances of the Monitor Receiver are equal, being 50 ohms each. The input impedance of the Console Receiver is 50 ohms. Its output is divided into four channels with an output impedance of 68 ohms. The power output from each channel is approximately 59 milliwatts into a 68-ohm load. The total output power from the Console Receiver is 236 milliwatts.

i. POWER FACTOR.

(1) The power factor of the radar components in the SR Equipments is approximately 86%.

j. POWER SUPPLY CHARACTERISTICS.

(1) The SR Radar Components require 115 volts, single phase, 60 cps for operation. Motor Generators are supplied to convert 115 volts d-c and 230 volts d-c into 115 volts a-c where the ship's supply is a d-c source.

(2) When the SR Equipment is operating from a ship's 115-volt d-c supply, the maximum starting current required is 250 amperes. For normal operation, the Motor Generator draws approximately 100 amperes.

(3) If the SR Equipment is operated from a ship's 230-volt d-c supply, the maximum starting current is approximately 125 amperes and the current required for normal operation is approximately 50 amperes.

(4) In installations where the SR Equipment is connected directly to a 115-volt, single phase, 60 cps a-c source, the maximum starting current drawn by the equipment is approximately 80 amperes. The a-c current required for normal operation is 37 amperes without the heaters. If the heaters are used, the normal current drain is approximately 42 amperes. The total current required for the SR Equipment, IFF Equipment and other associated components is about 65 amperes.

(5) Standby operation without the heaters requires 27 amperes for the SR Equipment alone. If the heaters are used, the current required for standby operation is about 32 amperes.

k. POWER EQUIPMENT.

(1) The power equipment supplied with the SR Equipments is used to convert d-c voltage into the a-c voltage required by the SR Equipments. One set of power equipment is designed to operate from a d-c input of 115 volts. Two other sets of power equipment are designed to operate from a d-c input of 230 volts. These sets are listed as follows:

TABLE 1-2

POWER EQUIPMENT

Navy Type	Manufacturer	Manufacturer's Type	Power Factor	Voltage and Current Rating	Temperature Range
115-Volt Motor Generator CAY-211182	WECORP		86%	Input: 250 A. to Start: 116 A. full load; 100 A. normal load. Output: 108 A. full load; 65 A. normal load.	0° C. to 50° C.
230-Volt Motor Generator CAY-211188 230-Volt Motor Generator CAY-211326	WECORP		86%	Input: 125 A. to Start; 83 A. full load; 50 A. normal load. Output: 108 A. full load; 65 A. normal load.	0° C. to 50° C.

l. HEAT DISSIPATION OF MAJOR UNITS.

(1) The heat dissipated by each major unit is tabulated as follows:

Transceiver	4600 watts
Indicator Console	680 watts
Rotation Control Unit	120 watts
Servo Generator	200 watts
Modulator	500 watts
Synchro-Amplifier	160 watts
Voltage Stabilizer	68 watts
Auto-Dehydrator	640 watts
Motor Generator	5500 watts

6. TABLES.

a. The following tables list the equipment supplied, equipment required, and the operating tubes. The cables listed are also shown in the interconnection diagram in Section 3. These cables are supplied by the Navy Yard where the equipment is installed. No standard length of cables can be given since the cable lengths vary with each individual installation.

TABLE 1-3

EQUIPMENT SUPPLIED

CONTRACT NXsr-30306

Quantity Per Equipment	Name of Unit	Navy Type Designation	Overall Dimensions A: Crated B: Uncrated Height Width Depth	Volume A: Crated B: Uncrated	Weight A: Crated B: Uncrated
1	Transceiver Includes:	CAY-43ACM	A: 79 x 33½ x 30 B: 72 x 28 x 25	A: 46 B: 29	A: 1474 B: 1235
	Keyer Unit	CAY-67AAD	A: B: 11¼ x 14⅝ x 18⅞	A: B: 1.8	A: B: 62
	Monitor Receiver	CAY-46ADK	A: B: 13¼ x 14⅝ x 20$\frac{5}{16}$	A: B: 2.3	A: B: 53
	Monitor Scope	CAY-55AFD	A: B: 9¼ x 14⅝ x 19$\frac{9}{32}$	A: B: 1.5	A: B: 59
1	Indicator Console Includes:	CAY-46ADJ	A: 34½ x 50 x 36½ B: 29$\frac{13}{16}$ x 41¾ x 31$\frac{13}{16}$	A: 36.43 B: 23	A: 792 B: 527
	Cradle	CAY-10313	A: B: 3⅛ x 25¼ x 41$\frac{19}{32}$	A: B: 1.9	A: B: 15

TABLE 1-3 (Continued)

EQUIPMENT SUPPLIED

Quantity Per Equipment	Name of Unit	Navy Type Designation	Overall Dimension A: Crated B: Uncrated Height Width Depth	Volume A: Crated B: Uncrated	Weight A: Crated B: Uncrated
	General Control Unit	CAY-23AEW	A: B: 12¼ x 6³⁄₃₂ x 26⅜	A: B: 1.14	A: B: 18
	PPI Indicator	CAY-55ADV	A: B: 24⁹⁄₁₆ x 12¼ x 26½	A: B: 4.6	A: B: 128
	Range Scope	CAY-55AFB	A: B: 12¼ x 12¼ x 26⁹⁄₁₆	A: B: 2.3	A: B: 77
	Console Receiver	CAY-46ADH	A: B: 12¼ x 12¼ x 26⁹⁄₁₆	A: B: 2.3	A: B: 53
	Bearing Indicator	CAY-55AFC	A: B: 12¼ x 12¼ x 26⅜	A: B: 2.3	A: B: 70
	IFF Coordinator	CAY-23AEV	A: B: 12¼ x 6³⁄₃₂ x 26⅜	A: B: 1.13	A: B: 30
1	Rotation Control Unit Includes:	CAY-50AEB	A: 36½ x 20 x 37½ B: 30 x 14¼ x 31⁵⁄₁₆	A: 15.83 B: 7.8	A: 325 B: 217
	Servo Amplifier	CAY-50AEU	A: B: 12¼ x 12¼ x 26⅜	A: B: 2.3	A: B: 45
	Rectifier Power Unit	CAY-20ACY	A: B: 12¼ x 12¼ x 26⅜	A: B: 2.3	A: B: 77
1	Auto Dehydrator	CAKB-10AEK	A: 32½ x 22½ x 34 B: 21⅝ x 24¾ x 18	A: 14.8 B:	A: 285 B: 207
1	Servo Generator	CAY-211192	A: 14¼ x 13¼ x 33½ B: 12¼ x 12¼ x 26⅜	A: 3.7 B: 2.3	A: 207 B: 170
1	Voltage Stabilizer	CG-301252	A: 17 x 20 x 35¾ B: 10²³⁄₆₄ x 15¾ x 30⅝	A: 7.03 B: 2.9	A: 352 B: 284
1	Antenna Pedestal	CAJS-21ACP	A: 46½ x 27 x 46½ B: 78¾ x 22⅞ x 54⅝	A: 33.8 B: 57.	A: 582 B: 477
*1	Motor Generator	CAY-211182	A: 43 x 38 x 95 B: 33¹⁵⁄₁₆ x 30³⁄₁₆ x 86¾	A: 85.15 B: 51.5	A: 3230 B: 2975
*1	Magnetic Controller	CAY-211181	A: 29 x 23 x 13¾ B: 24¹⁹⁄₃₂ x 20 x 10⅞	A: 5.3 B: 3.1	A: 130 B: 83
1	Voltage Regulator	CAY-211185	A: 33 x 28 x 18½ B: 29¼ x 26 x 16¼	A: 9.9 B: 7.2	A: 304 B: 250
1	Push Button Station	CAY-211186	A: 18 x 11½ x 15 B: 9⅛ x 4¼ x 4⅞	A: 1.85 B: .1	A: 28 B: 6

* Shipped with 100 Equipments.

TABLE 1-3 (Continued)

EQUIPMENT SUPPLIED

Quantity Per Equipment	Name of Unit	Navy Type Designation	Overall Dimensions A: Crated B: Uncrated Height Width Depth	Volume A: Crated B: Uncrated	Weight A: Crated B: Uncrated
†1	Motor Generator	CAY-211188	A: 43 x 38 x 95 B: 33 15/16 x 30 3/16 x 86 3/4	A: 90.2 B: 51.5	A: 3230 B: 2975
†1	Magnetic Controller	CAY-211187	A: 24 1/2 x 18 x 13 1/2 B: 20 5/16 x 15 x 10 5/16	A: 3.4 B: 1.8	A: 108 B: 76
**1	Blue Antenna Assembled with H.F. IFF Antenna	COD-66AHE or CLP-66 AHE	A: 157 1/2 x 79 x 45 B: 152 x 69 x 31 11/16	A: 324 B: 187	A: 760 B: 251
	COD or CLP-66AHG Shipped with Echo Box Antenna	CAY-66AHK	B: 46 3/8 x 2 x 2	B: 0.1	B: 5.5
††1	Yellow-Green Antenna Assembled with H.F. IFF Antenna COD or CLP-66AHF. Shipped with:	COD-66AHF or CLP-66 AHF	A: 186 1/2 x 82 x 46 1/2 B: 180 x 72 x 32 13/16	A: 410 B: 246	A: 800 B: 272
	Echo Box Antenna	CAY-66AHF	B: 46 3/8 x 2 x 2	B: 0.1	B: 5.5
1	V.H.F. IFF Antenna and U.H.F. IFF Antenna	COD or CLP-66AHH, COD or CLP-66AHJ	A: 52 x 39 x 16 1/2 B:	A: 19.3 B:	A: 422 B: 292
2	PPI Cathode Ray Tubes		A: 23 x 21 x 23 3/4	A: 6.64	A: 66
2	Transmitter Tubes				B: 16
1	Transceiver and Monitor Receiver Equip. Spares		A: 18 1/2 x 17 1/2 x 29	A: 5.43	A: 200 B: 171
1	Transformer for Transceiver		A: 23 1/2 x 14 x 23	A: 4.3	A: 230 B: 184
1	Transceiver Spare Parts		A: 28 x 20 x 22	A: 7.22	A: 154 B: 109
1	Keyer and Monitor Scope Spare Parts		A: 21 1/2 x 17 1/2 x 35	A: 7.61	A: 163 B: 148
1	Bearing Indicator, IFF Coordinator, and General Control Unit Spare Parts; Indicator Console Cases.		A: 18 1/2 x 17 1/2 x 29	A: 5.43	A: 148 B: 103
1	PPI Indicator Spare Parts		A: 18 1/2 x 17 1/2 x 29	A: 5.43	A: 167 B: 135
1	Console Receiver and Range Scope Spare Parts		A: 18 1/2 x 17 1/2 x 29	A: 5.43	A: 170 B: 135
1	Rotation Control Unit Spare		A: 18 1/2 x 17 1/2 x 29	A: 5.43	A: 146 B: 96

TABLE 1-3 (Concluded)

EQUIPMENT SUPPLIED

Quantity Per Equipment	Name of Unit	Navy Type Designation	Overall Dimensions A: Crated B: Uncrated Height Width Depth	Volume A: Crated B: Uncrated	Weight A: Crated B: Uncrated
1	Antenna Pedestal Spare Parts		A: 21½ x 17½ x 35	A: 7.61	A: 185 B: 144
1	Auto Dehydrator and Antenna Spare Parts		A: 21½ x 17½ x 35	A: 7.61	A: 188 B: 185
1	Servo Generator Spare Parts		A: 23 x 14½ x 9	A: 1.73	A: 75 B: 53
1	56 Tubes Consisting of: 14 Tubes for Monitor Scope 8 Tubes for Rotation Control Unit 24 Tubes for Monitor Receiver 12 Tubes for Transceiver		A: 44½ x 21½ x 23½	A: 12.94	A: 107 B: 27
1	34 Tubes for PPI Indicator		A: 33 x 12½ x 20	A: 4.77	A: 54 B: 16
1	74 Tubes Consisting of: 12 Tubes for IFF Coordinator 30 Tubes for Range Scope 32 Tubes for Console Receiver		A: 34¾ x 11 x 22½	A: 4.97	A: 56 B: 24
1	Synchro Amplifier Spare Parts		A: 27 x 19 x 16 B:	A: 4.6 B: 3.7	A: 165 B: 120
1	230 Volt Motor, Motor Generator		A: 23¼ x 19 x 14½	A: 3.7	A: 191 B: 150
1	Spare Parts for: Magnetic Controller Exciter Generator Voltage Regulator		A: 29 x 23½ x 17½	A: 6.97	A: 262 B: 219
1	Spare AC Generator Armature		A: 52 x 18 x 18	A: 9.78	A: 350 B: 280
1	Spare Parts for 115 V. DC Motor Armature		A: 44 x 18 x 18	A: 8.3	A: 300 B: 240
1	Wrenches MK-3 and MK-4		A: 59 x 39 x 16½	A: 19.3	A: 423 B: 292

* Shipped with 100 Equipments. † Shipped with 100 Equipments.
** Shipped with 50 * Equipments and 50 † Equipments.
†† Shipped with 50 * Equipments and 50 † Equipments.

TABLE 1-4

EQUIPMENT SUPPLIED
CONTRACT NXsr-46032

All items in Table 1-3 are supplied except for the power equipment which is replaced by the items in this table.

Quantity Per Equipment	Name of Unit	Navy Type Designation	Overall Dimensions A: Crated B: Uncrated Height Width Depth	Volume A: Crated B: Uncrated	Weight A: Crated B: Uncrated
1	Motor Generator	CAY-211326	A: 43 x 38 x 95 B: $33\frac{13}{16}$ x $31\frac{7}{8}$ x $87\frac{3}{8}$	A: 90.2 B: 54.4	A: 3230 B: 3020
1	Magnetic Controller	CAY-211325	A: $24\frac{1}{2}$ x 18 x $13\frac{1}{2}$ B: $22\frac{3}{8}$ x 16 x 11	A: 3.4 B: 2.3	A: 50 B: 24
1	Voltage Regulator	CAY-211185A	A: 33 x 28 x $18\frac{1}{2}$ B: $29\frac{1}{4}$ x 26 x $16\frac{1}{4}$	A: 10.0 B:	A: 304 B: 232
1	Controller Disconnect Line Switch	CWU-24429	A: 19 x 8 x $10\frac{1}{2}$ B: $16\frac{21}{32}$ x $5\frac{13}{16}$ x $8\frac{3}{4}$	A: 1.0 B: 0.7	A: 42 B: 28

TABLE 1-5

EQUIPMENT SUPPLIED
CONTRACT N5sr-7179

Quantity Per Equipment	Name of Unit	Navy Type Designation	Overall Dimensions A: Crated B: Uncrated Height Width Depth	Volume A: Crated B: Uncrated	Weight A: Crated B: Uncrated
1	Modulator	CAY-50AGU	A: 36 x 28 x 42 B: $23\frac{1}{2}$ x 18 x $27\frac{1}{4}$	A: 24.6 B: 6.7	A: 344 B: 168
	Modulator Tubes		A: 33 x 23 x 17	A: 7.42	A: 76 B: 46

TABLE 1-6

EQUIPMENT REQUIRED BUT NOT SUPPLIED
CONTRACTS NXsr-30306 AND NXsr-46032

Quantity Per Equipment	Name of Unit	Navy Type Designation	Required Characteristics
1	Synchro Amplifier	CM-50131	Government Furnished.
1	Synchro Capacitor	MK-3-# 216891	30-30-30 Total 90 MF. 45 MF. Between Terminals. G.F.E.
1	Synchro Unit	CM-211103	Government Furnished.
1	Cable to Auto-Dehydrator	DCOP-2	2-Conductor; Dia. 0.33″; 1.5 KV Insulation, Insulation Resistance 100 Meg./1000 Ft. Impervious Sheath.
1	Cable, Controller to D-C Motor (230 V.)	DHFA-3	2-Conductor; Dia. 0.53″; 2 KV Insulation, Insulation Resistance 100 Meg./1000 Ft. Metal Armor.
1	Cable, Controller to D-C Motor (115 V.)	DHFA-4	2-Conductor; Dia. 0.778″; 2 KV Insulation, Insulation Resistance 100 Meg./1000 Ft. Metal Armor.

TABLE 1-6 (Continued)

EQUIPMENT REQUIRED BUT NOT SUPPLIED

Quantity Per Equipment	Name of Unit	Navy Type Designation	Required Characteristics
1	Cable, Controller to D-C Motor (230 V.)	DHFA-23	2-Conductor; Dia. 0.992"; 2KV Insulation, Insulation Resistance 250 Meg./ 1000 Ft. Metal Armor
1	Cable, Alternator to Transceiver	DHFA-50	2-Conductor; Dia. 1.224"; 2 KV Insulation, Insulation Resistance 200 Meg./ 1000 Ft. Metal Armor.
1	Cable, Controller to D-C Motor (115 V.)	DHFA-75	2-Conductor; Dia. 1.474"; 2 KV Insulation, Insulation Resistance 175 Meg./ 1000 Ft. Metal Armor.
1	Cable, Pushbutton to Controller	FHFA-3	Overall Dia. 0.865"; 4 Conductor 2 KV Insulation. 100 Meg./1000 Ft. Insulation Resistance.
1	Cable, Voltage Regulator to Alternator	FHFA-3	
1	Cable, Transceiver to IFF System	MHFA-4	
1	Cable, Indicator Console to IFF Transmitter	MHFA-4	
1	Cable, (Rec. Gain) Indicator Console to IFF Equipment.	MHFA-4	
1	Cable, (Control) Indicator Console to IFF Equipment.	MHFA-7	7 Conductors. Overall Dia. 0.859" Insulation Resistance 100 Meg./1000 Ft. Conductor Resistance 4.24 Ohms/1000 Ft.
1	Cable, Rotation Control Unit to Synchro Capacitor.	MHFA-7	
1	Cable, Transceiver to Voltage Stabilizer.	MHFA-10	10 Conductors. Overall Dia. 1.037". Otherwise same as MHFA-7.
1	Cable, Transceiver to IFF Equipment.		
1	Cable, Transceiver to Ships Compass.	MHFA-10	
1	Cable, Transceiver to Rotation Control Unit.	MHFA-10	
2	Cable, Indicator Console to Rotation Control Unit.	MHFA-14	14 Conductors. Overall Dia. 1.118". For other data see MHFA-7.
1	Cable, Synchro Amplifier to Rotation Control Unit.	MHFA-14	
1	Cable, Rotation Control Unit to Radar Repeater System.		

TABLE 1-6 (Continued)

EQUIPMENT REQUIRED BUT NOT SUPPLIED

Quantity Per Equipment	Name of Unit	Navy Type Designation	Required Characteristics
1	Cable, Rotation Control Unit to Servo Generator.	MHFA-14	
2	Cables, Transceiver to Indicator Console.	MHFA-14	
1	Cable, Antenna Pedestal to Rotation Control Unit.	MHFA-24 or	24 Conductors; Dia. 1.375″; 2 KV Insulation, Insulation Test 100 Meg./1000 Ft. Metal Armor.
		MHFA-26	Similar to MHFA-24 except that it has 26 Conductors.
1	Cable, (Trigger) Indicator Console to IFF Transmitter.	RG-10/U	52 Ohms Impedance; 29.5 MMF/Ft.; Dia. 0.475″; 4 KV Operating Voltage Vinyl Cover.
1	Cable, Transceiver to Echo Box Antenna.	RG-10/U	
1	Cable, (Video) IFF to Indicator Console.	RG-10/U	
1	Cable, Transceiver to Indicator Console	RG-10/U	
1	Cable, Antenna Pedestal to IFF Transmitter.	RG-10/U	
4	Cable, (Video) Indicator Console to PPI Repeaters.	RG-12/U	75 Ohms Impedance; 20.5 MMF/Ft. 4 KV operating voltage; Dia. 0.475″. Vinly Cover.
4	Cable, (Trigger) Indicator Console to PPI Repeaters.	RG-12/U	
1	Cable, Transceiver to Indicator Console.	RG-12/U	
1	Cable, Transceiver to Antenna Pedestal.	RG-20/U	52 Ohms Impedance; 29.5 MMF/Ft.; Dia. 1.195″; 14 KV operating voltage. Vinly Cover.
1	Cable, Pushbutton to Controller	THFA-3	3-Conductor 7 Strand; Dia. 0.56″; 2 KV Insulation; Insulation Resistance 100 Meg./1000 Ft.
1	Cable, Voltage Regulator to Exciter.	THFA-3	
1	Cable, Overspeed Switch to Motor.	THFA-3	
1	Cable, Controller to D-C Motor.	SHFA-4	4-Conductor; Dia. 0.5″; 2 KV Insulation; Insulation Resistance. 100 Meg./1000 Ft. Metal Armor.

TABLE 1-6 (Continued)

EQUIPMENT REQUIRED BUT NOT SUPPLIED

Quantity Per Equipment	Name of Unit	Navy Type Designation	Required Characteristics
1	Cable, Controller to 115 V. D-C Supply.		
1	Cable, Controller to 230 V. D-C Supply.		
1	Cable, Antenna Pedestal to X6J Circuit.		
1	1/8″ Brass tubing. Auto-Dehydrator to Antenna Pedestal.		
1	Connector.	UG-32/U	Type 49261. Government Furnished.
	NOTE: The following cables are required for conversion to SR-a.		
1	Cable, Modulator to Transceiver.	MHFA-10	See MHFA-10 Above.
2	Cables, Modulator to Transceiver.	RG-27/U	38 Ohms Impedance; Dia. 0.675″; 50 MMF/Ft.; Max. Operating Voltage 15 KV. Armored.

TABLE 1-7

TUBE COMPLEMENT

SR AND SR-a EQUIPMENTS

Unit	Circuit Symbol	Tube Type No.	Function
Transceiver	V-107	GL8020	Rectifier
	V-108	GL8020	Rectifier
	V-109	527	Oscillator
	V-110	527	Oscillator
*Modulator	V-2001	5U4G	Low Voltage Rectifier
	V-2002	6SN7GT	Blocking Oscillator
	V-2003	807	Cathode Follower
	V-2004	371B	Circuit Isolating Diode
	V-2005	371B	Damping Diode
	V-2006	5C22	Thyratron Discharge Tube
Monitor Receiver	V-201	GL446A	R.F. Amplifier
	V-202	955	Oscillator
	V-203	GL446A	Mixer

*SR-a Only.

TABLE 1-7 (Continued)

TUBE COMPLEMENT

Unit	Circuit Symbol	Tube Type No.	Function
Monitor Receiver (Continued)	V-204	6AC7	1st I.F. Amplifier
	V-205	6AC7	2nd I.F. Amplifier
	V-206	6AC7	3rd I.F. Amplifier
	V-207	6AC7	4th I.F. Amplifier
	V-208	6H6	Detector A.V.C.
	V-209	955	Echo Box Rectifier
	V-210	OD3/UR-150	Voltage Regulator
	V-211	OD3/UR-150	Voltage Regulator
	V-212	5U4G	Rectifier
Monitor Scope	V-301	6SN7GT	Pulse Amplifier Gate
	V-302	6SN7GT	Gate Sweep
	V-303	6SN7GT	Internal Trigger Generator
	V-304	3BP1	Cathode Ray
	V-305	5U4G	Low Voltage Rectifier
	V-306	RKR72	High Voltage Half-Wave Rectifier
	V-307	6AG7	Video Amplifier
PPI Scope	V-501	807	Gate Tube
	V-502	6SN7GT	Sweep Tube Feed Back Amplifier
	V-503	6SN7GT	Feed Back Amplifier D.C Restorer
	V-504	807	Sweep Output
	V-505	6SN7GT	Shock Oscillator Marker Feedback
	V-506	6SN7GT	Blocking Oscillator Trigger Pulse Shaper
	V-507	6SN7GT	Blocking Oscillator Video Restorer
	V-508	6AG7	Video Amplifier

TABLE 1-7 (Continued)

TUBE COMPLEMENT

Unit	Circuit Symbol	Tube Type No.	Function
PPI Scope (Continued)	V-509	5U4G	Low Voltage Rectifier
	V-510	6SN7GT	Bias Rectifier
	V-511	RKR72	High Voltage Rectifier
	V-512	7BP7	Cathode Ray PPI
	V-513	OD3/VR-150	Voltage Regulator
	V-514	6SL7GT	First Servo Amplifier Second Servo Amplifier
	V-515	807	Servo Output
	V-516	6SN7GT	Trigger Amplifier Gating Tube
	V-517	OD3/VR-150	Voltage Regulator
Range Scope	V-600	6SN7GT	Pulse Amplifier Sweep Circuit Cathode Follower
	V-601	6AG7	Gate Tube
	V-602	6SA7	Phantastron
	V-603	6SN7GT	Phantastron Cathode Follower Phantastron Diode
	V-604	6AG7	Phantastron Output
	V-605	5CP7 or 5CP1	Cathode Ray Tube
	V-606	6SN7GT	Sweep Tube Gate Tube
	V-607	6SN7GT	Sweep Amplifier Sweep Amplifier
	V-608	6AG7	Video Output Amplifier
	V-609	5U4G	Low Voltage Rectifier
	V-610	6SN7GT	Marker Oscillator Tube Marker Feedback Tube
	V-611	6SN7GT	Sharpener Tube Feedback Amplifier
	V-612	6SN7GT	Blocking Oscillator Tube IFF Video Tube
	V-613	6AC7	Radar Video Tube
	V-614	RKR-72	High Voltage Rectifier

TABLE 1-7 (Continued)
TUBE COMPLEMENT

Unit	Circuit Symbol	Tube Type No.	Function
Console Receiver	V-701	6AC7	First I.F. Amplifier
	V-702	6AC7	Second I.F. Amplifier
	V-703	6AC7	Third I.F. Amplifier
	V-704	6AC7	Fourth I.F. Amplifier
	V-705	6AC7	Fifth I.F. Amplifier
	V-706	6AG7	A.C.V. Amplifier
	V-707	6H6	Detector Detector
	V-708	6AC7	Balanced Video Amplifier
	V-709	6AC7	Balanced Video Amplifier
	V-710	6SN7GT	Video Output to Range Scope
	V-711	6SN7GT	Radar and IFF Video Amplifier Marker Amplifier
	V-712	6AG7	Video Output to PPI
	V-713	6AG7	Video Output to PPI
	V-714	6AG7	Video Output to PPI
	V-715	5U4G	Rectifier
	V-716	6AG7	Video Output to PPI
IFF Coordinator	V-901	6AG7	Eccles-Jordan Multivibrator
	V-902	6AG7	Eccles-Jordan Multivibrator
	V-903	6SN7GT	Clipper Tube IFF Transceiver Trigger Output
	V-904	6SN7GT	Mixer Mixer
	V-905	6SN7GT	Delay Multivibrator Delay Multivibrator
	V-906	5U4G	Rectifier
Rotation Control Unit	V-1101	6SL7GT	Amplifier
	V-1102	807	Output
	V-1103	807	Output
	V-1104	5U4G	Field Rectifier for Antenna Drive Motor
Synchro Amplifier	V-101	5U4G	Rectifier
	V-102	6H6	36-Speed Limiter
	V-103	6SK7	First Servo Amplifier
	V-104	6F6	Second Servo Amplifier
	V-105	6L6G	Push-pull Output Amplifier
	V-106	6L6G	Push-pull Output Amplifier

SECTION 2

THEORY OF OPERATION

1. GENERAL.

a. The SR and SR-a Radar Equipments operate over a frequency range of 175 to 225 megacycles. This range is divided into three bands. The lowest band is 175 to 185 mc/s; the center band is from 195 to 205 mc/s; the highest band is from 215 to 225 mc/s. The Range Scope displays Type A radar and IFF target indications on any one of four ranges. These ranges are 4, 20, 80, and 400 nautical miles. The PPI Indicator displays targets on ranges of 4, 20, 80, and 200 miles. Facilities are provided for the connection of as many as twelve remotely located PPI indicators. The SR and SR-a Radar Equipments are similar to each other, the SR-a being a modified version of the SR. The major difference between the two equipments is in the transmitting systems. This difference is discussed in separate paragraphs in the functional description that follows. Since the remaining systems in the two equipments are essentially the same, separate discussions are not required.

2. FUNCTIONAL DESCRIPTION OF SR EQUIPMENT.

a. TRANSMITTING SYSTEM.

(1) A complete block diagram of the SR Radar Equipment is shown in Fig. 2-1. The a-c power input is located in the Transceiver. Power from the input circuit is connected through the control and switching circuits to a Voltage Stabilizer to obtain regulated voltage for various components in the system. The transmitting components in the Transceiver consist of the Keyer Unit, transmitting oscillator, power supply, control circuits, and the duplexer.

(2) Keyer Unit CAY-67AAD contains a three-section pulse delay line which is used to fix the width of the transmitted pulse of r-f energy and its frequency of repetition. A switching system in the Keyer Unit, controlled from the Console Receiver, connects the three sections in various combinations to obtain pulse lengths of one and four microseconds at repetition frequencies of 200 cps, and a pulse length of 20 microseconds at a repetition frequency of 60 cps. Note that the shorter pulse lengths are used with the higher repetition frequencies. This is because the longer ranges obtained with the lower repetition frequencies require a higher average power output from the transmitter and because the minimum range which is important on the shorter ranges, is fixed by the pulse length. Therefore, the 400-mile range requires a low repetition rate with a long pulse length and the shorter ranges, such as the 4-mile range, require a very short pulse length to permit ranging of targets close to the radar equipment. The pulse delay line in the Keyer Unit is connected to the grid circuits of the transmitting oscillator to make it a self-pulsing oscillator.

(3) The transmitting oscillator consists of two triodes operating in a push-pull line oscillator arrangement. The transmitting oscillator, controlled by the Keyer Unit, generates short bursts of r-f energy at repetition rates of 60 or 200 cps and for pulse time durations selected by the switching arrangement in the Keyer Unit. Plate voltage for the transmitting oscillator is supplied by a high voltage rectifier built into the Transceiver. The input a-c power for the high voltage rectifier is obtained from the voltage stabilizer. In addition to the r-f output, a trigger pulse output is developed and delivered to the Monitor Scope and to the Indicator Console where it is distributed to the IFF Coordinator and to the PPI Indicator. Through the IFF Coordinator, the trigger pulse is delivered to the Range Scope and to the IFF transmitter. The trigger pulse is also distributed to the remote PPI indicators from the Indicator Console. The purpose of this trigger pulse is to synchronize the triggering of the various sweep, gate, and range marker circuits.

(4) The General Control Unit is located in the Indicator Console. It permits the operator to turn on, turn off, and regulate the Transceiver. The controls consist of a set of push-buttons which control the motor-driven voltage regulator in the Transceiver that raises and lowers the voltage being applied to the transmitting oscillator. An emergency stop-button is also included to turn off the Transceiver when desired. A kilovoltmeter indicates the voltage applied to the plates of the transmitting oscillator. A switch is also incorporated for turning the components on and off in the Indicator Console.

(5) The output of the transmitting oscillator is connected to the antenna transmission line through a duplexer. The duplexer is an electronic switch that connects the transmitting oscillator to the antenna system during transmission periods and disconnects it during idle periods. When the duplexer disconnects the transmitting oscillator from the transmission line, it simultaneously connects the Monitor Receiver to the

same transmission line. When the transmitting oscillator fires, the duplexer connects the transmitter to the line and disconnects the Monitor Receiver. This arrangement permits the transmitting and receiving systems to be operated with the same antenna. If the duplexer were not used, power from the transmitter would enter the Monitor Receiver and result in serious damage.

(6) The output from the duplexer is delivered through the antenna transmission line to the Antenna Pedestal CAJS-21ACP. Through the transmission line in the Antenna Pedestal, the r-f power is delivered to the Radar Antenna where it is radiated out into space. The Radar Antenna rotates on the Antenna Pedestal and since the Antenna is directional, it must be pointed directly at a target in order to receive echoes from it. Therefore, the bearing of the Antenna with respect to true north, or the ship's heading, is the bearing of the target from the point of observation. The bearing data is electrically transmitted back to the Bearing Indicator in the Indicator Console, to the PPI Indicator, and to the remote PPI indicators. The bearing data is displayed on these units for the information of the various operators. The Antenna Pedestal may be rotated continuously, or moved from one target to another, by means of controls located in the Bearing Indicator. These energize circuits in the Rotation Control Unit that control the output of the Servo Generator which supplies d-c power to the Antenna Drive Motor. The IFF Antenna is also mounted on the Antenna Pedestal with the Radar Antenna and the IFF transmission line passes up through the Pedestal with the radar transmission line. The IFF Antenna and the IFF trigger circuits in the IFF Coordinator are the only IFF components built into or supplied with the SR Equipment.

b. RECEIVING SYSTEM.

(1) The reflected signal from the target is picked up by the Radar Antenna and travels down the Antenna cable to the duplexer which couples the signal into the input circuits of the Monitor Receiver. The duplexer also short circuits the output circuit of the transmitting oscillator so that the received energy will not be dissipated in the transmitter. The signal is amplified and converted to the intermediate frequency in the Monitor Receiver. The Monitor Receiver has two i-f stages. An i-f output is taken from the first stage and delivered to the input circuits of the Console Receiver. The output of the second i-f amplifier is coupled to a detector and the video output is coupled by cable to the Monitor Scope. The Monitor Receiver also contains the Echo Box which is turned on and off at the Console Receiver. The Echo Box is excited by the radiated output of the Radar Antenna. After a short delay caused by the time required for the signal to *ring* the Echo Box, an echo signal is radiated by the Echo Box Antenna. This signal is picked up by the Radar Antenna and the artificial echo thus made to appear on the oscilloscopes may be used to tune the equipment in the absence of an echo from a real target. The Echo Box also contains a rectifier and a meter which may be used to measure the relative radiated power.

(2) The video output from the Monitor Receiver is amplified in the Monitor Scope and used as vertical deflecting voltage on a cathode ray tube. The Monitor Scope displays a Type A presentation of the received echo which may be observed when tuning the Monitor Receiver. The echo on the Monitor Scope may also be used to tune up the transmitting oscillator. Another function of the Monitor Scope is that of a test oscilloscope. The Monitor Scope is designed to be removed from the Transceiver when it is used for test purposes. An internal trigger generator triggers the sweep circuits and its output may also be used to trigger the circuits of any component that is being tested with the Monitor Scope.

(3) The Console Receiver functions as an i-f amplifier, detector and video amplifier. Its output is supplied as video signals to the Range Scope, the PPI Indicator in the Console, and to any remote PPI indicators associated with the radar equipment. It is not a complete receiver, since it does not contain a radio frequency converter and a pre-amplifier. These functions are performed by the Monitor Receiver in the Transceiver. The Console Receiver accepts the target indication signals in the form of a pulsed 15-megacycle i-f signal. It amplifies and demodulates the i-f signal to secure video signals. These video signals are again amplified and supplied to the indicating scopes in the Indicator Console and to remote PPI indicators. Also, the Console Receiver contains certain components which reduce the effect of jamming of the radar set by enemy action. These circuits, and their use will be explained later in a complete description of the Console Receiver circuits.

c. INDICATING SYSTEM.

(1) The Range Scope provides a range indication on a *Type A* scope with a horizontal sweep. The range is measured as being proportional to the linear distance from the start of the sweep on the left-hand side of the scope to a target wherever it may fall on the sweep line. Range indications may be roughly estimated from a scale over the face of the tube or by comparison with a set of range markers. These markers appear as vertical indications along the sweep line. Four markers are provided; they divide the length of the sweep into four sections. On the 4-mile range, the distance between markers represents 1 nautical mile; on the 20 mile sweep, 5 miles; on the 80 mile sweep, they are 20 miles apart and on the 400 mile

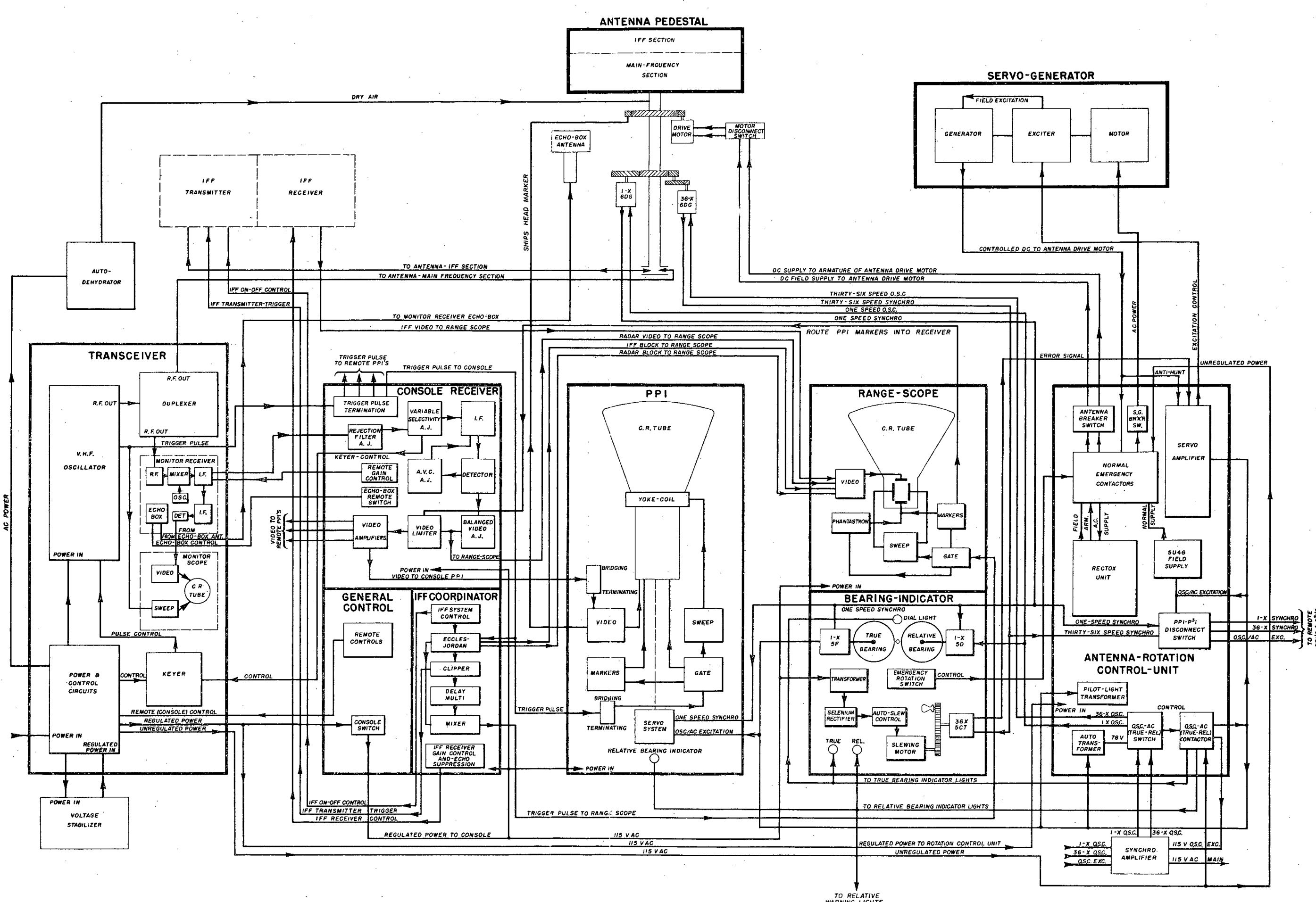


Figure 2-1- SR Radar Equipment, Complete Block Diagram

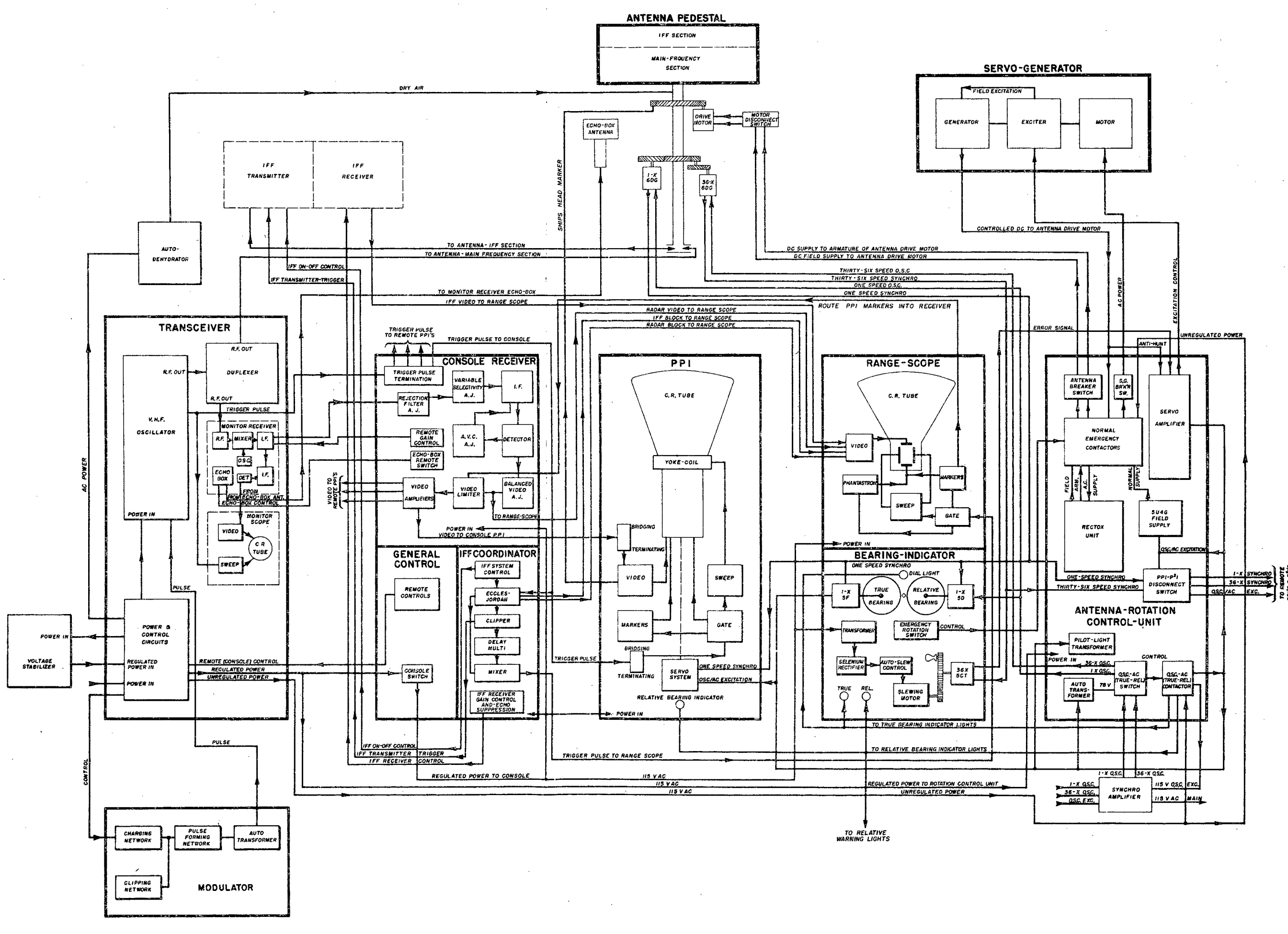


Figure 2-2. SR-a Radar Equipment, Complete Block Diagram

range, 100 miles apart. By comparison of the target's position with the nearest range marker, the operator can estimate range to the target. In addition to the range markers, the Range Scope provides a *range step* on the 4-mile, 20-mile, and 80-mile ranges, which is movable along the sweep line. When the right-hand edge of the step, which appears as a vertical line, is placed along-side of the target by operating the RANGE STEP control, the target range may be accurately determined from two sets of veeder counters. The counters may be viewed through small windows directly below the scope. In addition to the *Type A* radar display, the scope produces a *Type A* display of IFF signals on the indicator tube. These signals are caused to appear on a horizontal IFF sweep line which appears below the range sweep line. The IFF reply back signals appear below the sweep line while the radar signals appear above it. The IFF signals are made to appear directly below the corresponding radar signal due to the action of the IFF coordinator which will be explained later in this section. IFF signals are only displayed when the operator operates the CHALLENGE switch on the IFF Coordinator to its MOMENTARY or ON position.

(2) The IFF Coordinator is used to apply IFF signals to the Range Scope so that they appear on the face of the indicator tube in proper relation to the radar indications received from targets being interrogated. The IFF Coordinator does this by alternately blocking the IFF video signals from the IFF equipment and the radar video signals from the Console Receiver. In other words, one sweep of the cathode ray tube shows radar indications while the sweep which immediately follows shows IFF signals. However, the sweeps are so rapid that, due to the persistence of the fluorescent material on the face of the tube, both sweeps seem to appear simultaneously. Since there is some delay inherent in triggering an IFF system on an interrogated target, the IFF Coordinator compensates for this delay to make the IFF signals appear directly below the radar signal of the interrogated target. The IFF Coordinator is triggered by a pulse from the transmitter in the Transceiver. Trigger pulses (with a delay incorporated into the pulse for triggering the IFF sweep) are provided by the IFF Coordinator for the Range Scope. Certain remote controls for the IFF equipment are built into this unit so that the SR operator may regulate the IFF equipment from the Indicator Console.

(3) The PPI scope displays *both* range and azimuth of targets lying in the beam of the Radar Antenna. The sweep line of the PPI indicator starts at the center of the tube and extends radially outward to the edge of the tube face. The bearing of a target is determined by a directed line from the center of the tube, through the target, to the azimuth scale at the circumference. The range of the target is determined by the proportional distance between the center of the indicator tube and the target. For example, on the 20-mile range, a target appearing halfway out along the sweep would be 10 miles away. The range is determined by comparing the target's position with range markers which appear as dots along the sweep line on the face of the tube. Due to the persistency of the PPI tube, these markers trace out concentric rings as the sweep rotates. Four such markers appear on each range. On the 4-mile range the markers appear 1 mile apart. On the 20-mile range they are 4 miles apart and on the 80-mile and 200-mile range they are 20 and 50 miles apart respectively. By comparison of the position of the target with the markers, the operator may estimate the approximate range of the target. Due to the persistency of the cathode ray tube, the targets remain on the face of the tube face for a short interval of time. When the sweep is rotating, the PPI Indicator displays a map of any targets that are within the range on which the SR Equipment is operating. When the antenna is being scanned to cover one sector, the PPI will only indicate the targets that are located in this sector. The bearing of the target is obtained by rotating the cursor until the cursor line coincides with the center of the target indication. The bearing in degrees is the number that appears on the azimuth scale under the cursor line.

d. ANTENNA POSITIONING SYSTEM.

(1) The Bearing Indicator displays the position of the antenna at all times. When the amplitude of a target is maximum on the face of the Range Scope, the Bearing Indicator indicates the direction in which the antenna is pointing at the time, to accurately give the bearing of the target. Two types of bearings are given by the Bearing Indicator. One of these is true bearing and the other is relative bearing. When the radar equipment is operating on true bearing, indications on the dials show the bearing of the target with reference to True North. When the radar equipment is operated on relative bearing, the bearing of the target is exhibited with reference to the heading of the ship. The Bearing Indicator contains the antenna positioning controls. By operating a handwheel on the front panel, the operator may move the antenna in azimuth to any position desired. In addition, the operator may cause the antenna to be automatically rotated in azimuth for searching operations. A switch on the front panel of the unit can be operated to energize a d-c motor, which continuously rotates the handwheel. Thus, the antenna will rotate continuously while the switch is in one of its ON positions. Two speeds in either direction may be selected with this switch. The output voltage used to control the rotation of the antenna is connected to the input of the Servo Amplifier in the Rotation Control Unit.

(2) The Rotation Control Unit contains the Servo Amplifier and the Rectifier Power Unit as shown in Fig. 2-1. The control voltage from the Bearing Indicator is connected to the input circuits of the Servo Amplifier. The d-c output of the Servo Amplifier is zero when the Antenna Pedestal is at rest, positive for one direction of antenna rotation, and negative for the opposite direction of antenna rotation. The output of the Servo Amplifier is used to excite the field of an exciter generator on the Servo Generator. The Rectifier Power Unit supplies power for the Servo Amplifier during normal operation. For emergency operation, the output of a dry disc rectifier in the Rectifier Power Unit is used to excite the d-c generator field in the Servo Generator.

(3) When the SR Equipment is operating on true bearing the Synchro Amplifier relays the ship's compass voltage to the Antenna Pedestal Synchro Units which deliver an output voltage that is proportional to the bearing of the ship with respect to True North, plus the bearing of the Antenna with respect to the ship's heading. The output of the synchros in the Antenna Pedestal consists of two components. One is used to position the Bearing Indicator dials and the other voltage excites the Servo Control Synchro in the Bearing Indicator. When the system is operating on true bearing, the output of the Synchro Amplifier is added to the relative voltage to correct the relative bearing to true bearing. When the system is operating on relative bearing the output of the Synchro Amplifier is disconnected from the Antenna Pedestal. In true bearing operation the output of the Synchro Amplifier maintains the position of the Antenna.

(4) The Servo Generator consists of an a-c motor which drives an exciter and a d-c generator. The output from the Servo Amplifier is applied to the field of the exciter. The d-c output of the exciter is applied to the field of the d-c generator and the output of the d-c generator is connected through the cabling to the d-c drive motor on the Antenna Pedestal.

(5) The Antenna Pedestal supports the Radar and IFF Antennas and contains the rotating mechanism. The d-c drive motor, which is controlled by the Rotation Control Unit through the Servo Generator, delivers power through a gear train to rotate the Antenna Pedestal. The gear train also drives two synchro units and their output is used to indicate the position of the Antenna to the Bearing Indicator. Exciting voltage for these synchro units is obtained from the Synchro Amplifier.

(6) The Auto Dehydrator is used to supply dry air to the air filled coaxial lines in the Antenna Pedestal. The Auto Dehydrator receives a-c power from the unregulated circuits in the Transceiver. Its output of dry air is carried through copper tubing to the base of the Antenna Pedestal where it is connected into the coaxial lines.

3. FUNCTIONAL DESCRIPTION OF SR-a EQUIPMENT.

a. TRANSMITTING SYSTEM.

(1) A modification of the SR transmitting system consists of replacing the Keyer Unit with a Modulator. The Keyer Unit in the SR Equipment functioned with the transmitter to produce keying in the grid circuit. That is, the transmitter functioned as a grid blocking oscillator. The high voltages used in the oscillator increase the possibility of excessive electron velocities in the tubes when grid keying of this type is used and the oscillator is not correctly tuned. If the electron stream is accelerated beyond the practical limit, the life of the tubes is materially shortened. In order to eliminate possible occurrences of this trouble, the method of keying was changed to plate modulation. The Modulator that replaces the Keyer Unit contains a delay line that is used as a pulse forming network. The delay line is charged with the output of the high voltage power supply in the Transceiver Console and is then discharged through the transmitting oscillator tubes. Therefore plate voltage is only applied to the tubes during the duration of the pulse. Only one pulse width and repetition rate are available. The pulse width is 4 microseconds and the pulse repetition frequency is 100-150 cps.

(2) Fig. 2-2 shows a block diagram of the SR-a Equipment. An examination of this diagram shows that the only difference between the SR and SR-a is in the substitution of the Modulator for the Keyer Unit. All other circuits and components are the same. Various minor modifications were made from time to time which are described in the discussions of the various units. These modifications are common to both the SR and SR-a.

4. SR TRANSMITTING SYSTEM.

a. GENERAL.

(1) The Transceiver Console contains the transmitting oscillator and most of the circuits and components closely associated with it. The Monitor Receiver is located in the Transceiver Console to eliminate the necessity for a long line between the duplexer and the input to the Monitor Receiver. This reduces the line losses to a minimum. The Monitor Scope is located in the Transceiver Console to enable the operator to observe the transmitted and received pulses during tuning operations on the transmitting oscillator and the Monitor Receiver. Figure 2-3 shows a block diagram of the SR Transmitting System. The system consists of the Keyer Unit, Transmitting oscillator and the duplexer. The control circuits are not represented in the diagram.

(2) The transmitting oscillator is a push-pull oscillator controlled by the Keyer Unit which periodi-

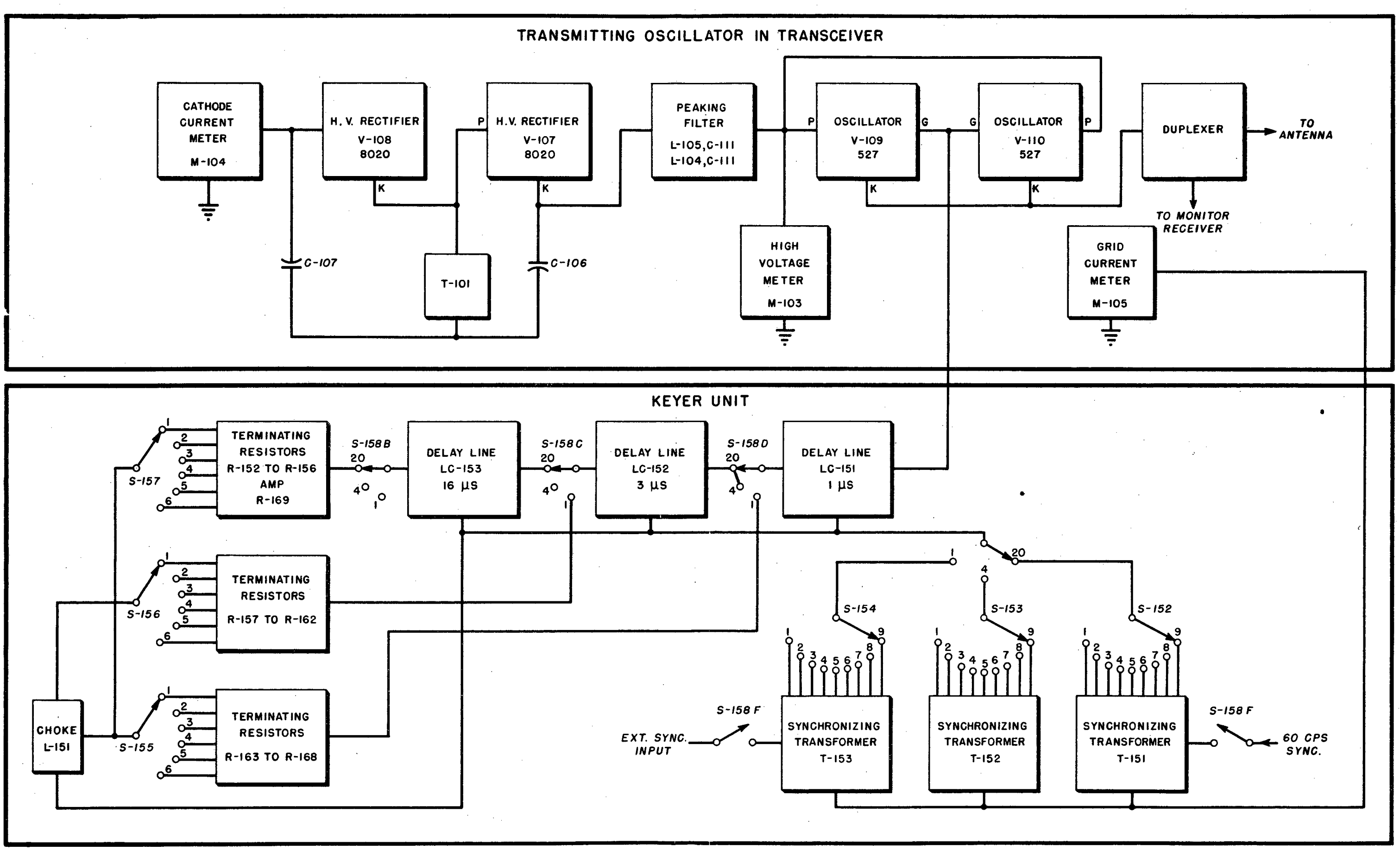


Figure 2-3. SR Transmitting System Block Diagram

cally provides a blocking voltage to the grids of the oscillator tubes. The Keyer Unit is not a part of the Transceiver Console. The other transmitting components in the Transceiver Console are the duplexer, high voltage power supply and the control circuits.

b. KEYER UNIT CAY-67AAD.

(1) The Keyer Unit controls the grid voltage on the transmitting oscillator to produce the various pulse widths and repetition rates. The block diagram in Fig. 2-3 shows the major components in the Keyer Unit. Three artificial lines are used to provide the pulse reflections that determine the pulse width. A switching arrangement connects delay line LC-151 into the grid circuit to provide a one-microsecond pulse. If a four-microsecond pulse is desired, delay line LC-152 is connected in series with LC-151. The third delay line LC-153 is connected in series with the other two to provide a 20-microsecond pulse. Three sets of terminating resistors are provided. There is one set of resistors for each line and the total value of resistance used to terminate the line is selected with an individual switch for each resistor set. The terminating resistance determines the length of time that elapses between pulses. Three synchronizing transformers are provided to apply 60-cycle modulation to the waveform of the reflected voltage in the line. The modulation is necessary to correct the shape of the waveform to provide efficient operation of the transmitting oscillator. There is one transformer for each pulse width since different characteristics are required for each pulse. Two keying frequencies can be obtained from the Keyer Unit. When the 60-cps keying frequency is used, the pulse width is 20 microseconds, and the time interval between pulses is 16,646.6 microseconds. Thus the duty cycle for a pulse repetition rate of 60 cps is 16,666.6 microseconds. The other keying frequency is 200 cps, and the duty cycle is 5,000 microseconds. Either a one-microsecond or four-microsecond pulse may be used at this frequency. The time interval between the one-microsecond pulses is 4,999 microseconds. The time interval between the four-microsecond pulses is 4,996 microseconds.

(2) The transmitting oscillator requires a normal Class C operating bias during the oscillating period and a disabling bias to maintain the tubes at plate current cut-off between pulses. The bias voltage is supplied by the action of the delay line in the Keyer Unit. During the oscillating period, the current drawn by the grids of the oscillator tubes charges the line. During the charging period, the voltage drop across the line is about —2000 volts d-c which is sufficient for normal Class C operation of the tubes. When reflection occurs in the line its capacitors charge up to a negative voltage that is large enough to stop the flow of plate current and keep the tubes inoperative

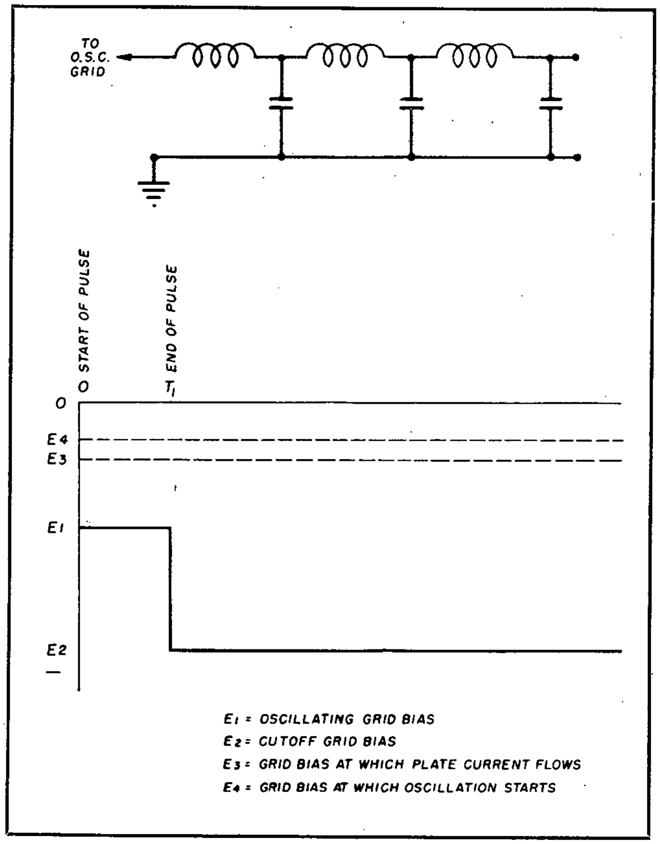


Figure 2-4. Unterminated Artificial Line

until the capacitors have had sufficient time to discharge through the terminating resistors. In order to obtain a pulse with nearly perpendicular leading and trailing edges the delay line must appear as a low impedance of 67 ohms to the charging current at the beginning and end of the pulse, and as a high impedance during the pulse and during the idle period between pulses.

(3) When the transmitting oscillator is turned on, —2000 volts of grid bias appear on the grids due to the rectified grid current flowing through the impedance of the line. A simplified schematic diagram of an artificial delay line is shown in Fig. 2-4. It should be noted that this delay line is not terminated. Consequently, the steep wavefront caused by the instantaneous appearance of grid current from the transmitting oscillator tubes will be reflected due to the unterminated end of the line. Since the end of the line is not terminated, the impedance is infinite and a reflected negative voltage will appear at the grids, adding to the voltage already present. Therefore, the grid bias is nearly doubled when the reflected wave appears. The increased voltage is sufficient to disable the oscillator tubes and stop all oscillation. Since there is no discharge path for the capacitors, they retain their charge and the transmitting oscillator cannot start again until leakage in the line dissipates the

charge. The grid bias conditions resulting from this condition of the delay line are shown in Fig. 2-4. E_1 is the normal operating bias of the oscillator. E_2 is the disabling bias resulting from the reflection in the line. E_3 is the bias at which the tubes start to draw plate current and E_4 is the potential at which the magnitude of the plate current is sufficient to provide a feedback voltage that will sustain oscillations. The period of time during which the transmitter oscillates is the time that elapses from the instant potential E_4 is reached until the instant at which the reflected voltage wave appears at the grids of the tubes. This time interval is a function of the inductance and capacity in the line.

(4) The delay action of the line, is caused by the charging action of the grid current that flows into the line. The grid current charges each capacitor beginning with the one nearest to the grids and charging each capacitor in succession until the capacitor at the end of the line is reached. The capacitors may be considered to be charged to one-half of the voltage that would cause the grid current to flow in the line. When the last capacitor is charged current ceases to flow and the magnetic fields that have built up around the inductors collapse. The collapse of the indu-r fields induces a charging current that flows in the same direction taken by the original charging current. This current charges the capacitors in succession beginning with the capacitor at the end of the line and building up the voltage until the grid end of the line is reached. The large negative voltage that now appears across the line drives the grids so far below cut-off that the feedback voltage cannot drive them into conduction and all oscillation ceases.

(5) If a resistor much larger than the 67-ohm surge impedance of the line is used to terminate the line, the initial action is the same as it is in an unterminated line, but during the time the tubes are disabled the resistor gradually discharges the line. The time required to discharge the line is determined by the value of the resistor and the capacitors in the line. The discharge time is equal to the idle period between pulses. A circuit that will periodically block the grid of an oscillator is shown in Fig. 2-5. Note that where the voltage E_2 went negative and remained at a constant level in Fig. 2-4, it rises exponentially in Fig. 2-5. The slope of this curve is a function of the resistance and capacitance in the circuit. The inductance has no effect since the rate of change is much too slow to encounter in an inductive reactance. In practice the terminating resistance is adjustable in steps in the Keyer Unit to provide for variations in tube characteristics and in tuning. Fig. 2-5 is an elementary type of circuit, presenting some decided disadvantages. It will be noticed that the discharge through the resistor

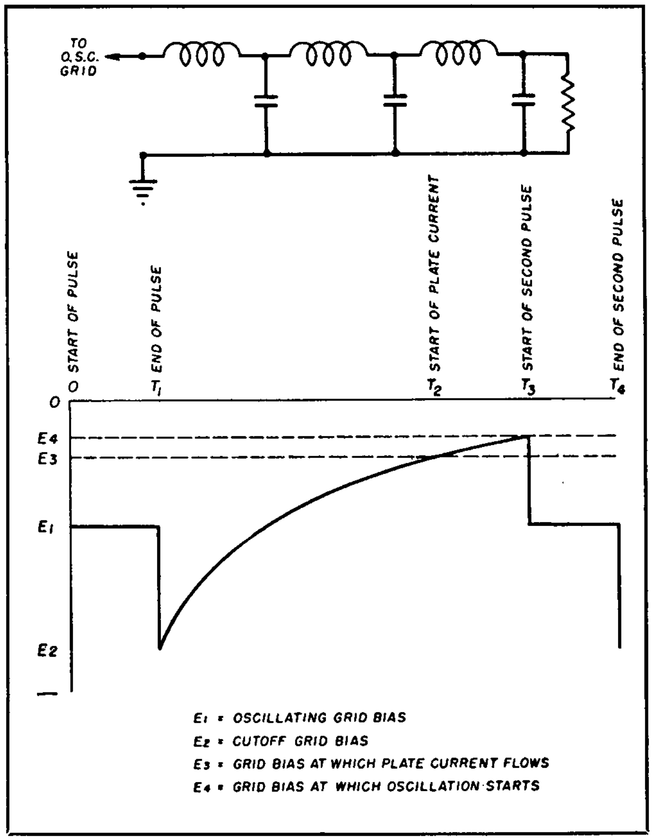


Figure 2-5. Terminated Artificial Line

is an exponential curve. While the voltage rises rapidly when there is a large voltage across the resistor, it slows down considerably when the voltage is reduced. Therefore, the curve assumes a gradual slope near the point at which the tubes begin to draw plate current. This instant is indicated as T_2 in Fig. 2-5. Since the slope is gradual, there will be a relatively large time interval between the instant the tubes begin to draw plate current and the instant they begin to oscillate. The small amount of plate current flowing in the tube is not sufficient to develop a feedback voltage from the cathode load that will sustain oscillations. Consequently the power represented by this current is dissipated as heat in the tube. This added heating of the plates raises the average plate temperature and results in a reduction in the efficiency of operation. Another disadvantage in the elementary line shown in Fig. 2-5 arises from the fact that a very small change in the voltage at which the tubes begin to oscillate results in a relatively large change in the time that elapses between pulses. This factor must be considered because a minor change in tuning adjustments changes the amount of regenerative feedback and would therefore affect the voltage level at which oscillations would start.

(6) A third disadvantage is a slight difference in

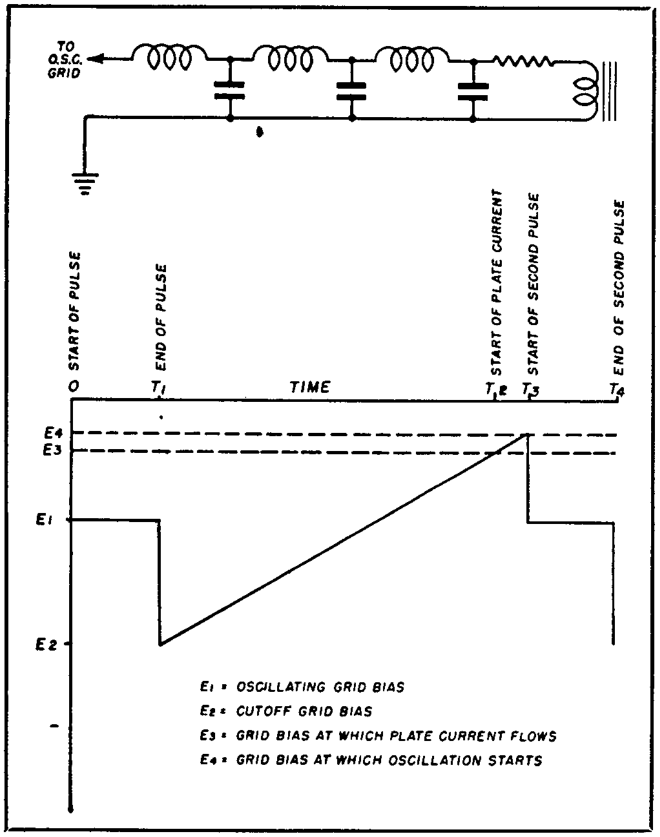


Figure 2-6. Artificial Line with Slope Compensation

the negative point to which the grid is driven. This represents a large change in the time necessary for the grid to recover to the firing level. In order to correct these undesirable features, it is necessary to change the slope of the curve formed by the rising grid voltage. The curve may be made effectively linear by adding an inductance in series with the discharging resistor. Such a circuit is shown in Fig. 2-6. The inductance tends to prevent rapid discharge at the beginning of the rise by storing part of the voltage rise in the form of a magnetic field. As the flow of current decreases through the resistor and inductor in series, the lines of force around the inductor collapse. The current induced by the collapse of the field around the inductor is added to the current flowing through the resistor to increase the slope of the discharge curve. The combined discharge curves of the inductor and resistor is a straight line as shown in Fig. 2-6. Fig. 2-7 shows the basic circuit used in the Keyer Unit. It is similar to the circuit in Fig. 2-6 except that a parallel-resonant circuit has been placed in series with the pulse-forming network and r-f ground. This parallel-resonant circuit is tuned to the repetition frequency to stabilize the repetition rate. Fig. 2-7 shows bias conditions obtained by the addition of this resonant circuit. The resonant circuit is excited by the repetition frequency and produces a sine wave voltage at this frequency. Losses in the circuit are replaced by the energy taken from the pulses passing through it. This sine wave voltage, since it is in series with the delay line, is imposed on the discharge wave developed by the delay line and the discharge resistor and inductor and maintains the repetition frequency at a very accurate rate. Also, due to the imposition of the sine wave on the linear slope shown in Fig. 2-6, the slope is steepened toward the perpendicular just before the firing point of the tube is reached. This serves to reduce still further the period of time between the instant the tubes begin to draw current and the time they begin to oscillate. The time constant, as determined by the values of capacitance and resistance in the line determines the frequency of the exciting pulses applied to the parallel resonant circuit. This frequency must be selected with the terminating resistor adjustment so that it lies in the frequency bandwidth of the tuned circuit. The time constant should be adjusted so that the repetition rate does not pull out of step when the parallel resonant circuit is tuned through its range. If the terminating resistance is not correctly adjusted multiple or double pulsing will occur.

(7) The pulse that triggers the transmitting oscillator must also be used to synchronize various compo-

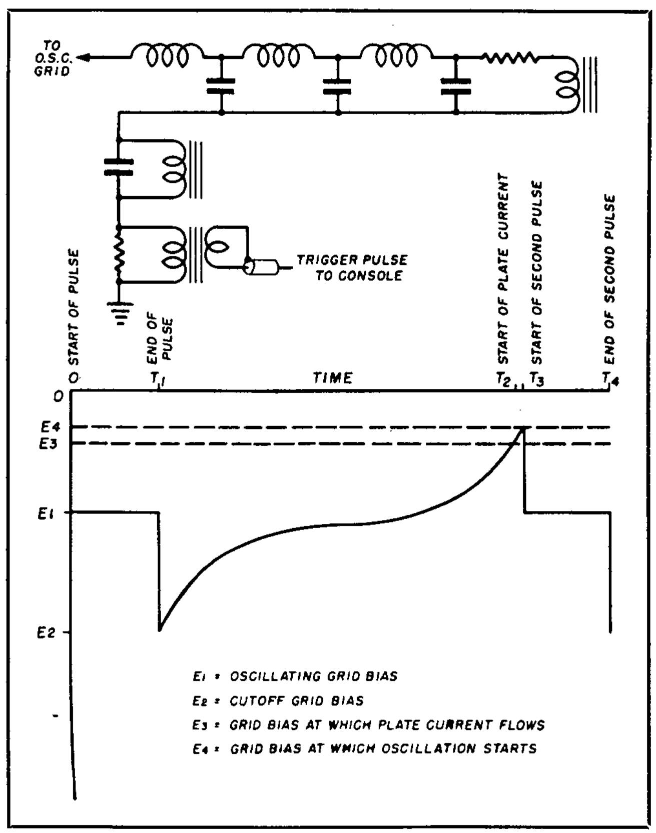


Figure 2-7. Basic Circuit of Artificial Line in Keyer Unit

nents in the system. The synchronizing pulse is obtained by connecting a resistance-capacity voltage divider between the parallel resonant circuit and ground. This divider is shown in Fig. 2-7. The trigger voltage that appears across the resistor in this divider is applied across the primary of a small output transformer. The transformer inverts the negative pulse to a positive pulse. The output from the transformer appears across a voltage divider from which two outputs are taken. One output is synchronizing voltage for the various components. The other output is applied to the Monitor Scope to trigger its sweep circuits.

(8) Since each delay line has a terminating resistor adjustment, three screwdriver operated tap switches are brought out to the control panel of the Keyer Unit. These controls are marked R1 MICROSECOND PULSE, R4 MICROSECOND PULSE and R20 MICROSECOND PULSE. The synchronizing transformers are also tuned with screwdriver operated tap switches marked L1 MICROSECOND PULSE, L4 MICROSECOND PULSE and L20 MICROSECOND PULSE. There is an L and R adjustment for each pulse width. These adjustments must be carefully made in order to insure a stable repetition frequency. Therefore, the resultant waveform, obtained through adjustment of the L and R controls, must be observed on an externally connected oscilloscope. If the controls are not properly regulated, the Type 527 oscillator tubes might draw excessive plate current between pulses, cause multiple pulsing, jittery operation and very seriously shorten oscillator tube life.

(9) To enable the operator to properly set the positions of controls L and R, jack J-106 has been added to the control panel of the Keyer Unit located in the Transceiver on all SR Radar Equipments above set serial #70. This jack provides a convenient outlet for the operator to connect an external oscilloscope to observe the grid discharge waveform. When the L and R controls are moved, the manner in which the grid voltage discharges between pulses, also changes. These changes can be seen by looking at the waveform of the grid voltage discharge on the oscilloscope connected through test jack J-106. Jack J-106 is connected between ground and the junction of resistors R-119 and R-120. These resistors are connected between terminal 1 on the Keyer Unit and ground. Approximately 5% of the grid voltage appears across resistor R-119. This voltage is used as deflection voltage on the vertical plates of the external oscilloscope.

(10) A simplified diagram of the Complete Keyer Unit circuits is shown in Fig. 2-8. A 110 volt 60 cps synchronizing voltage is applied to the primary of transformer T-151 through contacts 2 and 5 of switch section S-158F in order to stabilize the repetition rate on the 20 microsecond pulse position. This is done to insure the proper frequency of trigger voltage to the IFF input which is located in the Indicator Console. The primaries of transformers T-152 and T-153 are brought out to terminals 30 and 31. From there they connect to terminals 15 and 16 on terminal board E-102 which is located below the voltage regulator in the lower front left-hand corner of the transceiver unit. External synchronizing voltages may be applied through these terminals to synchronize the repetition rate of the SR Equipment with the repetition rates of other transmitters, which might be in the same vicinity operating on the same repetition rate. Note in Fig. 2-8 that the inductance and capacity elements of the grid line are in three sections, LC-151, LC-152, and LC-153. These are all used in series for the longest pulse width and delay time. They are cut out of the circuit in sections for the shorter pulses. LC-151 alone is used for the 1-microsecond pulse, LC-151 and LC-152 are used in series for the 4-microsecond pulse, and LC-153 is added in series with the two other units for the 20-microsecond pulse. Inductor L-151 and Resistor R-151 are the discharging inductance and resistance. Note that the 4-microsecond pulse resistor group is coupled to a tap on the inductor while the 1- and 20-microsecond resistors employ all of this inductance.

(11) With the Keyer Unit adjusted for the 20-microsecond pulse, the circuit starts at terminal 40, which is the terminal connection to the grids of the oscillator tubes, passes through LC-151, S-158D, LC-152, S-158C, LC-153, S-158B, S-157 and whichever resistors S-157 has connected into the circuit, L-151, R-151, S-158E, S-152, T-151 to terminal 32 which leads to the pulse transformer T-108 and to grid current meter M-105 in the Transceiver Console. When the equipment is in standby condition, relay contacts K-106D open, removing the short circuit from resistor R-108 in the negative return to the power supply. The —4,000 volts appearing across resistor R-108 is applied to terminal 32 as a disabling bias for the oscillator tubes. At the same time relay contacts K-106E disconnect terminal 32 from the resistor and pulsing transformer which supply trigger pulses to the other components of the equipment. The circuits for the other pulse widths and repetition rates may be traced similarly from the complete schematic.

(12) In order to provide control over the selection of the pulse width and repetition rate from the Console Receiver in the Indicator Console, a special switching arrangement is employed. Drive motor B-151 drives a geneva mechanism that rotates switch S-158 to the position that selects the desired pulse width. The pulse switching circuit is shown in Fig. 2-9. Motor B-151 can receive exciting voltage from three sources. If the LOCAL-REMOTE switch in the Transceiver is in the LOCAL position, the pulse width

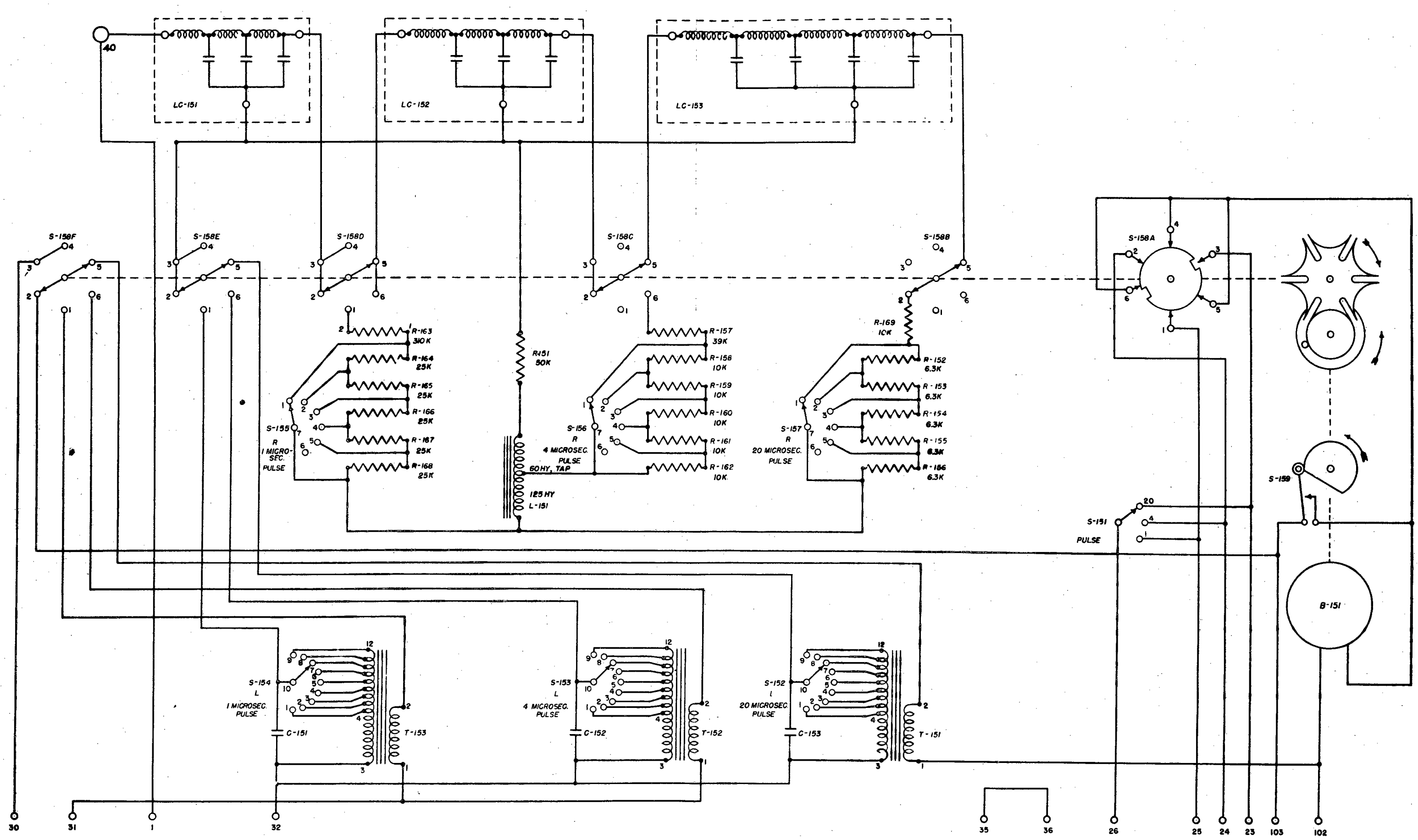


Figure 2-8. Keyer Unit, Schematic Diagram

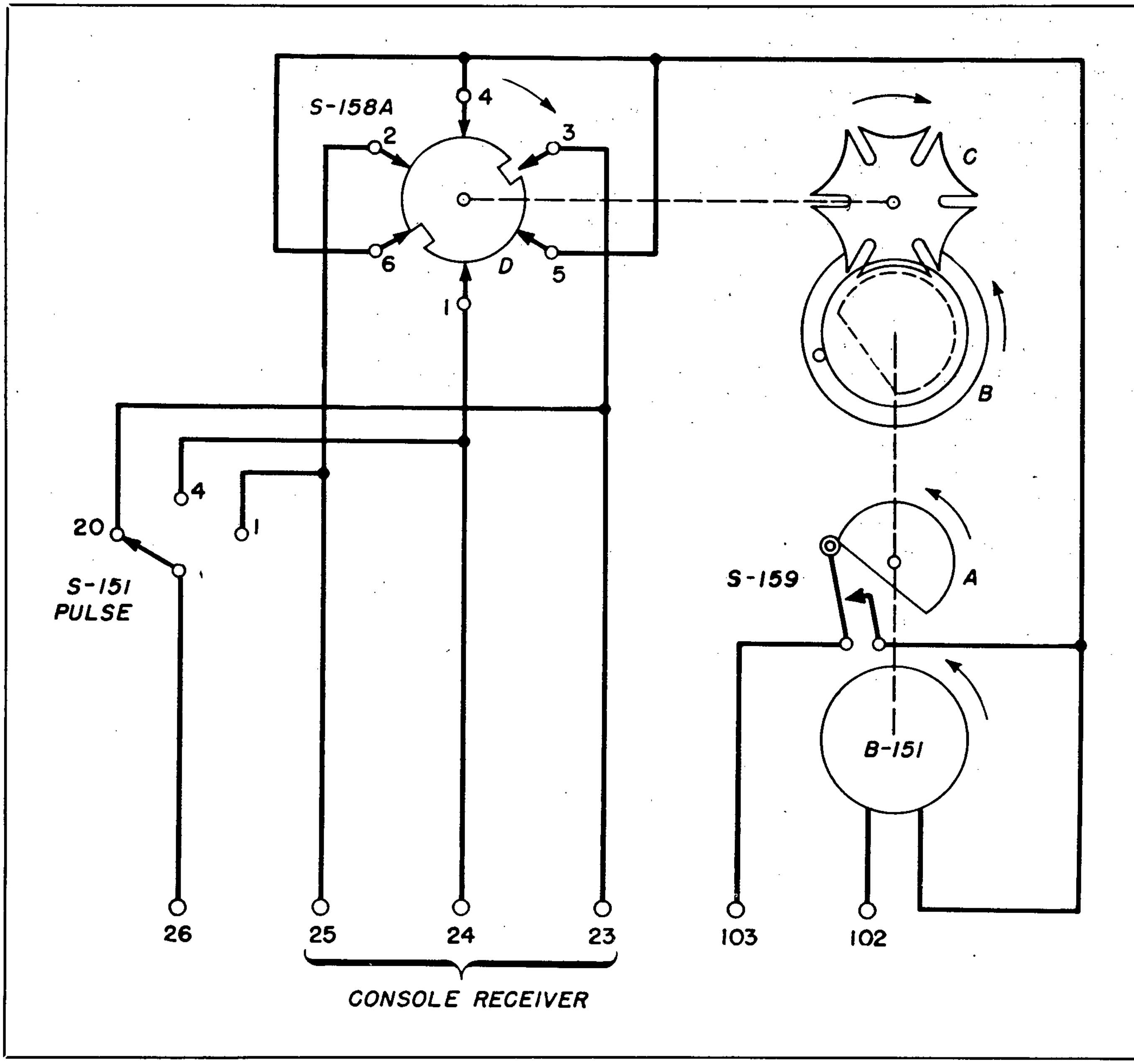


Figure 2-9. Geneva Drive for Pulse Width Switch

is controlled by switch S-151 in the Keyer Unit. In the REMOTE position, the BANDWIDTH switch at the Console Receiver is used to control the pulse width and is connected to terminals 23, 24, and 25 at the Keyer Unit. For the following explanation assume that the equipment is operating in LOCAL control and that switch S-151 has been placed in the 4-MICROSECOND position. The circuit begins at the a-c terminal 26, goes through switch S-151 to contact 2 on switch section S-158A. From this point the circuit passes through the switch and comes out on contacts 4, 5, and 6 and from these contacts goes through a common lead to the motor. The other side of the motor is connected to terminal 102 which is the other side of the a-c line. When the switch is operated, voltage is applied to the motor and it rotates in the direction shown by the arrow near the cam A that operates switch S-159. The starwheel drive gear B rotates in the same direction and at the same rate of speed as the switch cam A. During the greater part of the revolution cam A holds switch S-159 open. The starwheel drive gear rotates in a counterclockwise direction until its drive pin engages in the slot on the starwheel. When the drive gear reaches this position it presents the flat surface (indicated by the dotted line) of its cam to the starwheel. In this position, the starwheel is unlocked and free to turn. As the drive gear continues to rotate, its drive pin turns the starwheel in a clockwise direction until the slot reaches a position where the pin becomes disengaged. During this portion of the cycle Cam A allows switch S-159 to close. The positioning plate C of switch S-158A is mounted on the same shaft with the starwheel. When the pin on the drive gear disengages from the starwheel, the positioning plate has reached a position where one of its slots is directly beneath contact 2 and this circuit through the switch to drive motor B-151 is opened. If switch S-158 were allowed to stop the drive motor at this point, the flat surface of the cam on the drive gear would still be beneath the starwheel and it would be free to change position as a result of heavy vibration. However, switch S-159 is now closed due to the position of cam A, and motor B-151 is connected to the a-c voltage present on terminal 103. Thus, the motor continues to run after switch S-158A has opened the motor circuit. The motor runs until cam A again opens switch S-159. During this time the starwheel drive gear has rotated until the round surface of its cam is completely in contact with the starwheel as shown in Fig. 2-9. In this position, the starwheel is locked and cannot be moved. The action just described occurs for all three pulse width positions of S-151 and is controlled in REMOTE operation by a switch section in the Console Receiver similar to switch S-151. After the switch has assumed a selected position the motor cannot run again until the control switch, in this case S-151, is moved to a new position.

c. TRANSMITTING OSCILLATOR.

(1) A simplified diagram of the transmitting oscillator is shown in Fig. 2-10. This figure shows all of the circuits, except the high voltage rectifier, that are necessary to produce r-f energy at the antenna. For simplicity only the one-microsecond artificial line is shown in the Keyer. The resonant transmission lines in the oscillator have been replaced with conventional L and C symbols. The tuning stubs and Duplexer lines have been similarly treated.

(2) The transmitting oscillator is a tuned-grid-tuned-cathode push-pull oscillator employing Type 527 triode tubes. These tubes are designated in the circuit as V-109 and V-110. The Type 527 tube has two grids. This feature permits the tube to be connected into the circuit in such a way as to cancel out the inductive reactance in the leads brought out from the grid. Fig. 2-10 shows that the oscillator is a conventional circuit with the load impedance in its cathode circuit. The cathode load is fixed-tuned. All tuning is accomplished in the grid circuit by moving a shorting bar along the two-wire line to effectively change its inductance and shunt capacitance. The filaments are connected to the filament supply through coaxial lines that are a quarter-wavelength long. The center conductors connect to one side of the filament and the outer conductors carry the other side of the filament. The ends of the coaxial lines opposite the cathodes are grounded to form a quarter-wave resonant line that places the cathodes at high r-f potential. The plates of V-109 and V-110 are at r-f ground potential through the capacity of the high voltage lead and the filter in the power supply.

d. DUPLEXER.

(1) The output from the oscillator is taken from the cathode lines. A fifty-ohm transmission line is mounted between the cathode lines, completely filling up the space between them. The outer conductor of this line is welded to the cathode lines. The inner conductor of the fifty-ohm line is also a quarter-wavelength long. The outer conductor has two slits diametrically opposite each other which divides it into two sections that become a part of the resonant cathode lines. The inner conductor is connected to the cathode of V-109 at the top of the cathode line. This arrangement acts as an impedance inverter to match the high output impedance of the oscillator to the low impedance of the transmission. The way this is accomplished is shown in Fig. 2-10, which will be used to illustrate the principles involved. At the point where the transmission line is grounded, the characteristic impedance is 50 ohms. Since the split line is a quarter-wavelength long, it has a high impedance at its open end. In Fig. 2-10, the outer conductor and the cathode lines are represented by an inductor and capacitor. The inductor is shown as the primary of a transformer whose secondary winding is the inner conductor of the transmission line. The end of the secondary winding opposite the end of the primary winding is opposite in phase polarity to the end of the primary winding. If this point were grounded directly to the outer conductor, the outer conductor would be at a high impedance and a high potential at the point where it enters the unsplit portion of the transmission line. Therefore, some other point of connection must be found. In Fig. 2-10, it can be seen that the end of the inner conductor can be connected to the opposite end of the cathode load since both points are at the same potential due to the transformer action. Since the inner conductor is part of a quarter-wave resonant line the point where it enters the outer conductor is a point of low impedance.

(2) The output in the transmission line is matched to the duplexer and transmission line system by means of two tuning stubs. These stubs are coaxial lines with an over-all length equal to one-half wavelength. The two tuning stubs are located at points on the transmission line that are one-eighth of a wavelength apart. The free end of the stubs are short circuited and they have a movable shorting disc whose position can be varied to change the length of the stub. In practice the shorting discs are adjusted to a position

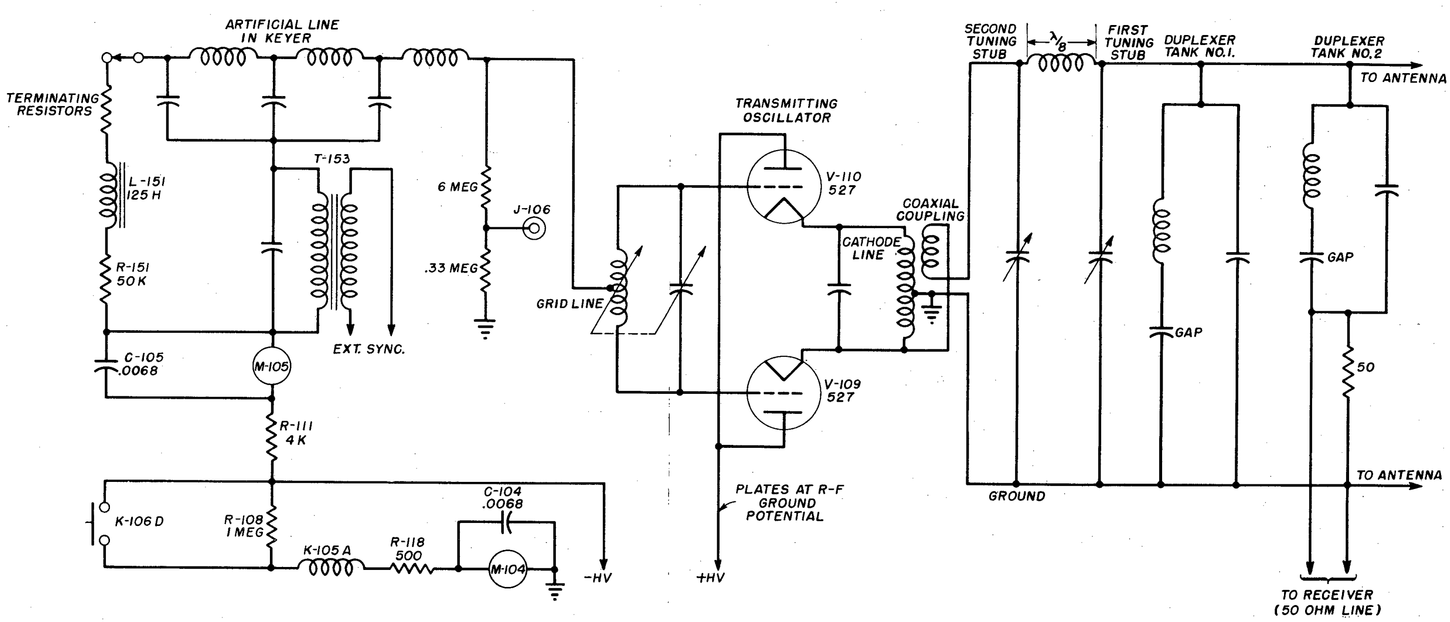


Figure 2-10. SR Transmitting Oscillator Circuits, Simplified

where the length of the line is between a quarter-wavelength and a half-wavelength. This makes the stub appear as a pure capacitance to the junction of the transmission line and the stub. The one-eighth wavelength of transmission line between the two stubs appears as an inductance to the frequency being transmitted through the line. As shown in Fig. 2-10, this arrangement forms a pi network that can be used to match the sending impedance of the oscillator line to the receiving impedance presented by the duplexer line. The adjustments of the two tuning stubs are dependent upon each other. When the capacitance present by one stub is approaching a maximum, the capacitance of the other stub is approaching a minimum.

(3) The duplexer is a device that performs two services. First, it prevents the transmitter energy from being coupled to the receiver where it would burn up the input circuit. The second function is to couple the received energy to the receiver and prevent any of this energy from being dissipated in the transmitter. Two duplexer stubs with an overall physical length of a half wavelength are used. The duplexer is shown in simplified form in Fig. 2-11. In Fig. 2-10, general duplexer principles are represented with conventional L and C symbols. Fig. 2-10 will be used to illustrate a general statement of the principles involved. Fig. 2-11 will be used to illustrate the actual occurrences that take place when the circuit is operating. In Fig. 2-10, duplexer tank No. 1 is shown nearest to the tuning stubs. The purpose of this tank is to short circuit the line during receiving periods so that none of the received energy is lost in the transmitting oscillator. During transmission the short circuit across the line is removed. The inductance in the duplexer stub is in series with the capacity of the spark gap and this series circuit which is connected across the line is shunted by the capacitance in the line. The capacity of the gap and the shunt capacitance of the line are approximately equal. When the transmitter fires, the pulse of energy travels down the line to the duplexer stub and builds up a high potential across the gap in the stub. The gap rapidly ionizes and arcs over. This effectively places the inductances of the stub in series with a very low resistance across the transmission line. The line now appears as a parallel resonant circuit to the transmitted signal and as such presents a very high impedance across the transmission line. Consequently the transmitted signal passes by the duplexer stub to the second duplexer stub. Here again the spark gap breaks down and the parallel impedance permits practically all of the energy to pass out to the antenna. Since the line current flowing through a parallel circuit is minimum at the resonant frequency, very little current flows through the 50-ohm resistance and the voltage across it is negligible. Since the voltage across this resistance is connected to the receiver input circuits, it can be seen that only a very minute portion of the transmitted energy appears at the receiver input. When the reflected pulse appears, its voltage is many times too low to ionize the spark gap. The circuit now appears as a series resonant circuit consisting of the inductance of the line in series with the capacitance of the spark gap. The effect of the shunt capacitive reactance of the capacity of the line is negligible; since the line current flowing through a series resonant circuit is high, an appreciable voltage drop appears across the 50-ohm resistance, across the receiver transmission line and the received echo is coupled to the receiver with very little loss. A small portion of the received signal travels down the line to the first duplexer stub and excites it to set up a series resonant condition. The stub therefore appears as a short circuit across the transmission line. In order to prevent this short circuit from appearing at the second duplexer stub and effectively shortcircuiting the input to the receiver, the stubs are located a quarter wave-length apart on the transmission line. Therefore, the short-circuit across the line that is presented by the first tuning stub is reflected to the second tuning stub as a very high impedance.

(4) Fig. 2-11 shows a simplified schematic of the duplexer that closely approximates its actual physical construction. The action of the duplexer depends upon the characteristics of a quarter-wavelength transmission of line and a half-wavelength of transmission line. If a quarter-wavelength of line is short circuited at one end, the current at that point will be high and the voltage will be zero. At the open end of the line the voltage will be high and the current will be zero. Thus, the impedance at the open end of the line is theoretically infinite if the effect of resistance is neglected. A half-wave may be considered as two quarter-wave lines with their high impedance ends connected together. Therefore a short circuit at one end reflects a short circuit at the opposite open end.

(5) At the instant the transmitter fires, a pulse of r-f energy appears at point A in Fig. 2-11 and travels down the transmission line to point B. Enough of the energy is diverted at point B to excite the duplexer tank. Before the spark gap ionizes, the effect of the tank is the same as that of a half-wave line, and the spark gap is located at the point of highest impedance, which is the point of highest voltage. A relatively small voltage at point B will be built up by the resonant line so that the potential is sufficient to ionize the gap. Before the gap ionizes, it presents a capacitance in series with the line that effectively shortens it to approximately one-half wavelength. When the gap fires, this capacitance is replaced with a

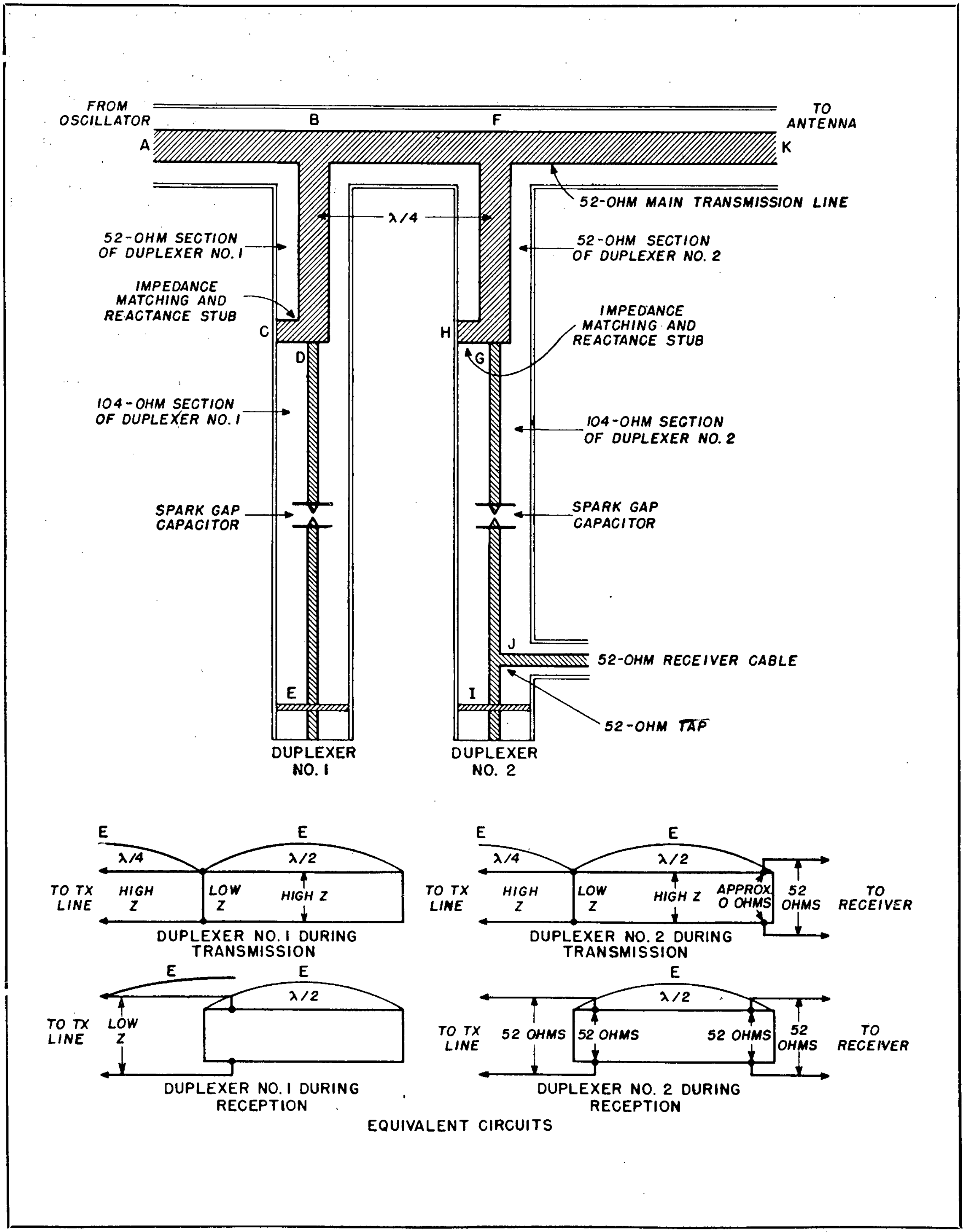


Figure 2-11. Duplexer, Simplified Schematic Diagram

very low resistance and the inductance formerly canceled out by the gap, now appears in the line to add to its length.

(6) Without the stub CD, the short circuit at E would be reflected back to some point between B and C when the gap is ionized and the line would appear as an inductance at point B. The stub CD is placed across the duplexer tank at a point where it effectively places a capacitive reactance in parallel with the inductive reactance at point B. To make the distance from B to C appear as the electrical equivalent of a quarter-wavelength, this parallel circuit is resonant at the applied frequency and consequently the impedance of the tank at point B appears as a very high resistance across the main transmission line. As a result, the transmitted signal is free to travel on down the line toward the antenna with very little loss in the duplexer stub. In effect, the shorting stub CD shifts the standing wave along the duplexer stub so that a high current point appears at CD. This effectively places CD a half-wavelength from the short circuit at E and a quarter-wavelength from Point B. Since CD appears as a short circuit, the quarter-wavelength of line between point CD and point B will present a high impedance across the main transmission line at point B. The effective lengths of the lines when the gaps fire are shown in Fig. 2-11.

(7) When the transmitted pulse of r-f energy reaches point F in Fig. 2-11 it excites the second duplexer tank and ionizes the spark gap. The impedance reflected at point F is a very high resistance and is obtained in the manner described for the first duplexer tank. The high resistance at point F does not permit any appreciable amount of current to flow into the duplexer stubs. Since the amount of current required to maintain the arc in the spark gap is very minute, the voltage appearing across the stub between points I and J is so small as to be negligible. Consequently, very little of the transmitted energy appears in the input circuits of the receiver. The small amount of voltage that does leak through is negligible so far as its effect upon the operation of the receiver is concerned.

(8) When the received pulse appears at point F its voltage is not sufficient to ionize the spark gap. The capacitance of the gap, in series with the line, reduces the electrical length of the line. A very minute part of the received energy travels down the line to point B where it excites duplexer tank No. 1 and causes it to appear as a very low impedance at point B. The low impedance at point B prevents energy from entering the transmitting oscillator and is inverted to a very high impedance at Point F which is a quarter-wavelength away. The impedance of duplexer stub No. 2 is 50 ohms at point F due to the action of stub HG and the ionized spark gap. The de-ionized spark gap presents a capacitance in series with the line that shortens it. This reduces the magnitude of the current through the stub HG so that it reflects a reactance to point F that cancels the reactance of the tank and makes it appear as a coaxial line with 50 ohms surge impedance connected across the main transmission line. Therefore, the received signal voltage may be considered as being applied across a 50-ohm tap at the top of the duplexer tank. The coaxial line to the receiver is tapped in at point J which is also a 50-ohm impedance point. Because the circuit is resonant, the tank acts as a halfwave coupling transformer with a one-to-one ratio and practically all of the received energy is coupled into the receiver.

e. HIGH VOLTAGE RECTIFIER.

(1) The high voltage rectifier is shown in Fig. 2-12 which is a simplified diagram of the circuit. Its function is to supply d-c power at 15,000 volts for the transmitting oscillator. The rectifier tubes, V-107 and V-108 are Type GL-8020 half wave rectifiers connected in a voltage doubling circuit. The 115-volt input is applied to the primary winding of transformer T-101 through relay contacts K-101D and K-106F. For the purpose of the explanation that follows, assume that terminal 3 is positive on the positive half of the voltage cycle that appears across the secondary winding of transformer T-101. When terminal 3 is positive, V-108 conducts and charges capacitor to the polarity indicated in Fig. 2-12. During this time, V-107 is cut off and has no function in the circuit except possibly to prevent any charge that may exist on capacitor C-107 from being dissipated back through the transformer winding. When the negative half of the cycle appears, V-108 is cut off and V-107 conducts. During this time, capacitor C-107 is charged to the polarity indicated in Fig. 2-12. Capacitors C-107 and C-108 are connected so that their charges add and the voltage between points A and B is very nearly equal to twice the voltage that appears across the secondary winding of transformer T-101. The maximum current which can be taken from the supply is determined by the overload relay K-105 in conjunction with relay K-101, shown in Fig. 2-15. Plate current, used by the oscillator tubes, flows to ground through resistor R-108, relay K-105, resistor R-118 and meter M-104. M-104 is the PLATE CURRENT meter on the front of the Transceiver Console. When relay contacts K-106D are closed, resistor R-108 is short circuited. When contacts K-106D are open the bleeder current through resistor R-108 provides sufficient bias voltage to disable the oscillator tubes. The primary of T-101 is fused by F-110 and F-109 which are not shown in Fig. 2-12. These fuses protect the rectifier tubes on overloads which occur too fast for overload relay K-105 to follow. When the current exceeds a predetermined maximum, relay K-105 will pull up, and break the

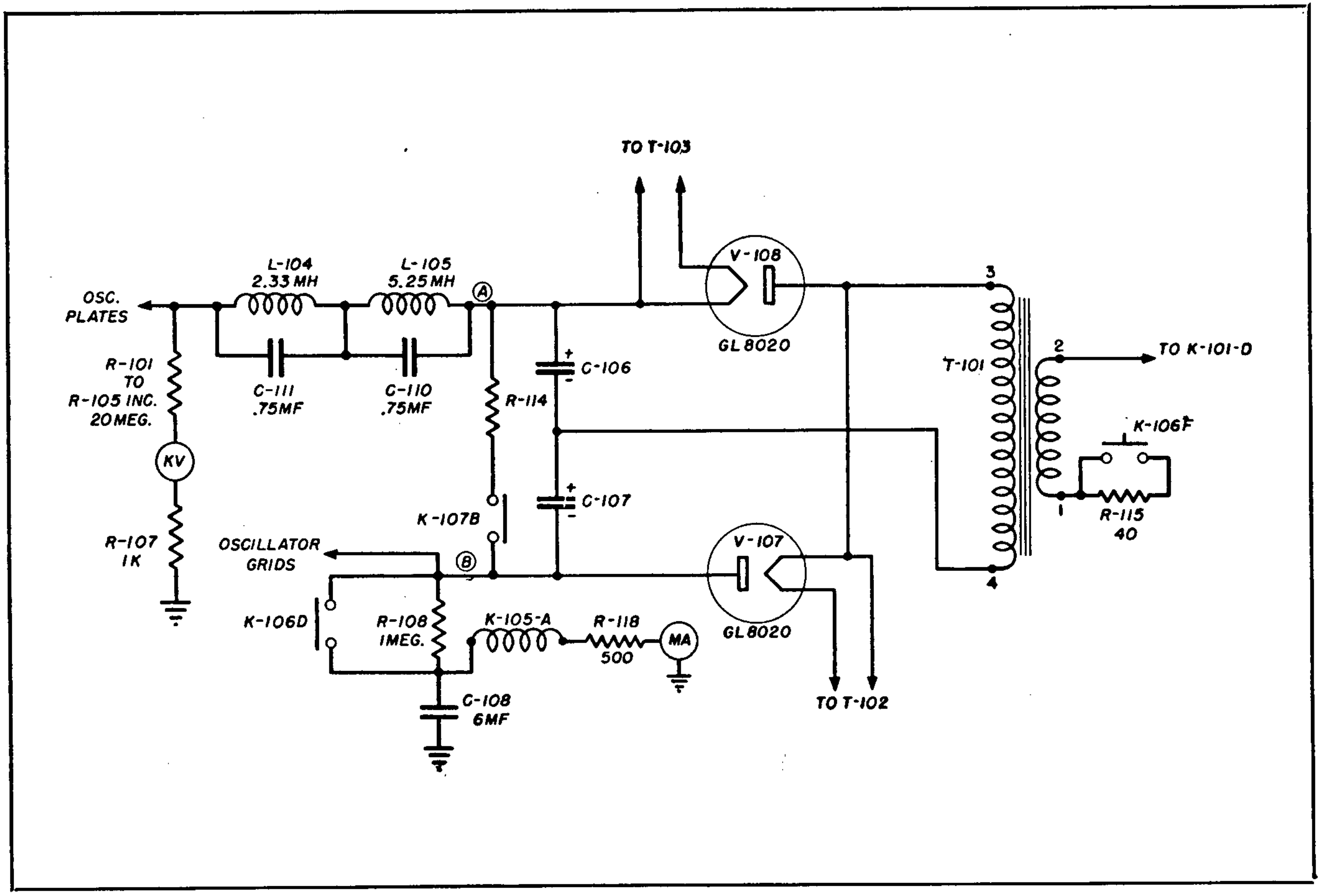


Figure 2-12. SR High Voltage Rectifier, Simplified Schematic

energizing circuit to the coil of relay K-101. Relay K-101 will drop out and remove the plate voltage from the oscillator tubes. Relay K-107, shown in Fig. 2-15, also drops out; closing its contact K-107B. This discharges filter capacitors C-106 and C-107 through resistor R-114. When the equipment is in standby operation, relay K-106 is de-energized and contacts K-106F open to insert resistor R-115 in series with the primary winding of transformer T-101. This drops the plate voltage applied to the oscillator tubes.

f. SR CONTROL CIRCUITS.

(1) The control circuits of the SR Equipment are located in the Transceiver, Indicator Console, and the Magnetic Starter. The control circuits provide interlock protection, fix the sequence in which the various circuits may be energized, and permit the remote control of the equipment. The control circuits are divided into such major divisions as the filament control circuits, main control circuits, oscillator plate voltage control circuits, radiation control circuits, primary power control circuits, and the pulse width control circuits. The pulse width control circuit has already been described in connection with the Keyer Unit. The other circuits are described in the following paragraphs.

g. FILAMENT CONTROL CIRCUITS.

(1) Fig. 2-13 shows the filament control circuit in the Transceiver Console. This circuit controls the application of power to the filaments of the transmitting oscillator tubes. Power from the Motor Generator is connected to the Transceiver Console at terminals 02 and 03 in Fig. 2-13. Switch S-101 is the MAIN POWER switch that controls the application of power to the Transceiver Console and to the Voltage Stabilizer. The Voltage Stabilizer supplies regulated voltage to the Monitor Scope, Monitor Receiver, and the Indicator Console. It will be discussed in a separate paragraph. When the MAIN POWER switch is closed, power is applied to transformer T-107 through fuses F-103 and F-104. Transformer T-107 is a pilot lamp transformer and supplies power for the MAIN POWER ON, FILAMENT ON, PLATE VOLTS, and LOCAL CONTROL pilot lamps. The only one of these lamps that lights when the MAIN POWER switch is closed is the MAIN POWER ON lamp I-101. At the same time the MAIN POWER ON lamp is illuminated, relay K-102 is energized. This relay is connected across the a-c line through fuse F-107, and switch S-102. Switch S-102 is normally closed. It is located inside the door to the oscillator compartment

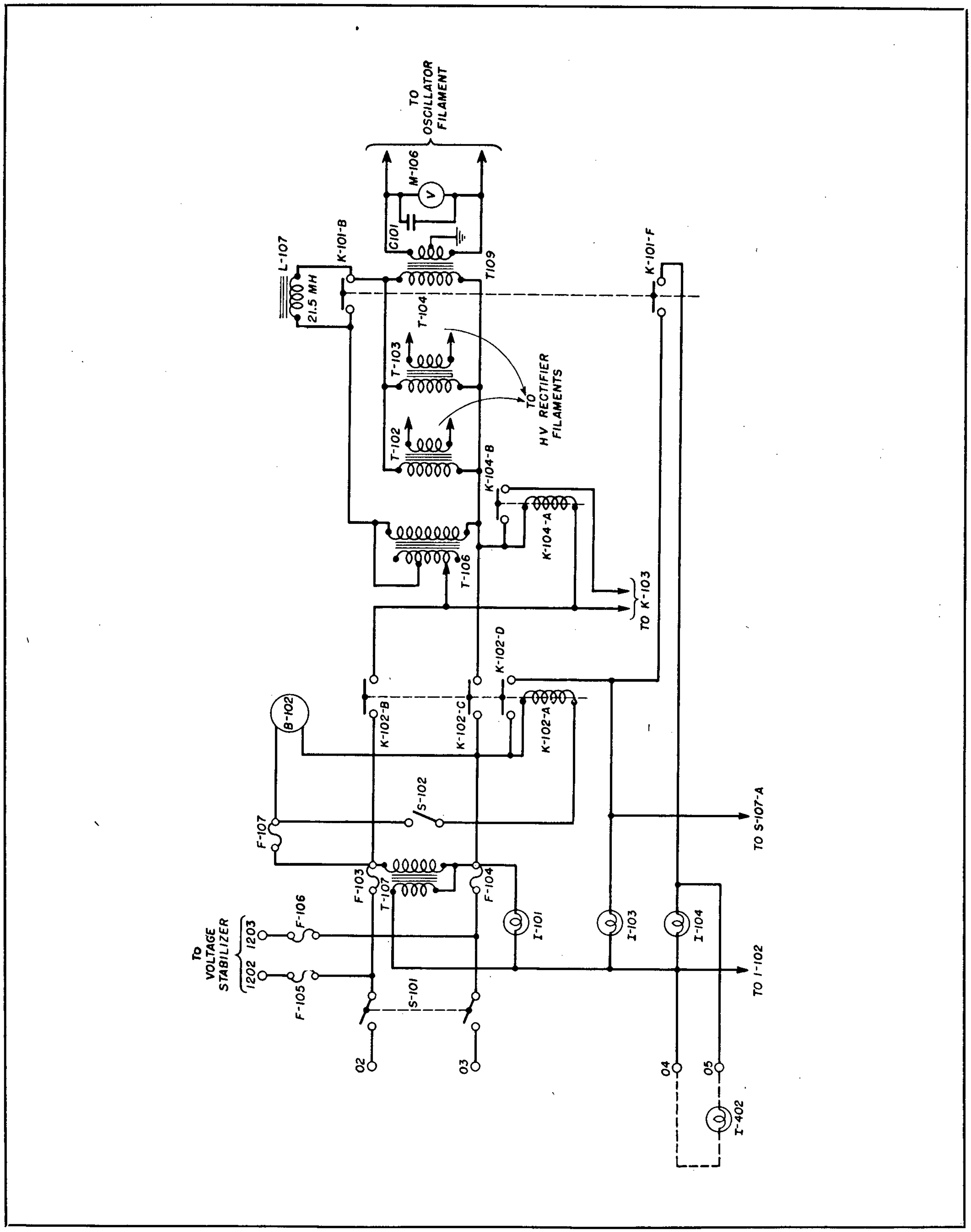


Figure 2-13. SR Transmitter Filament Control Circuits, Simplified Diagram

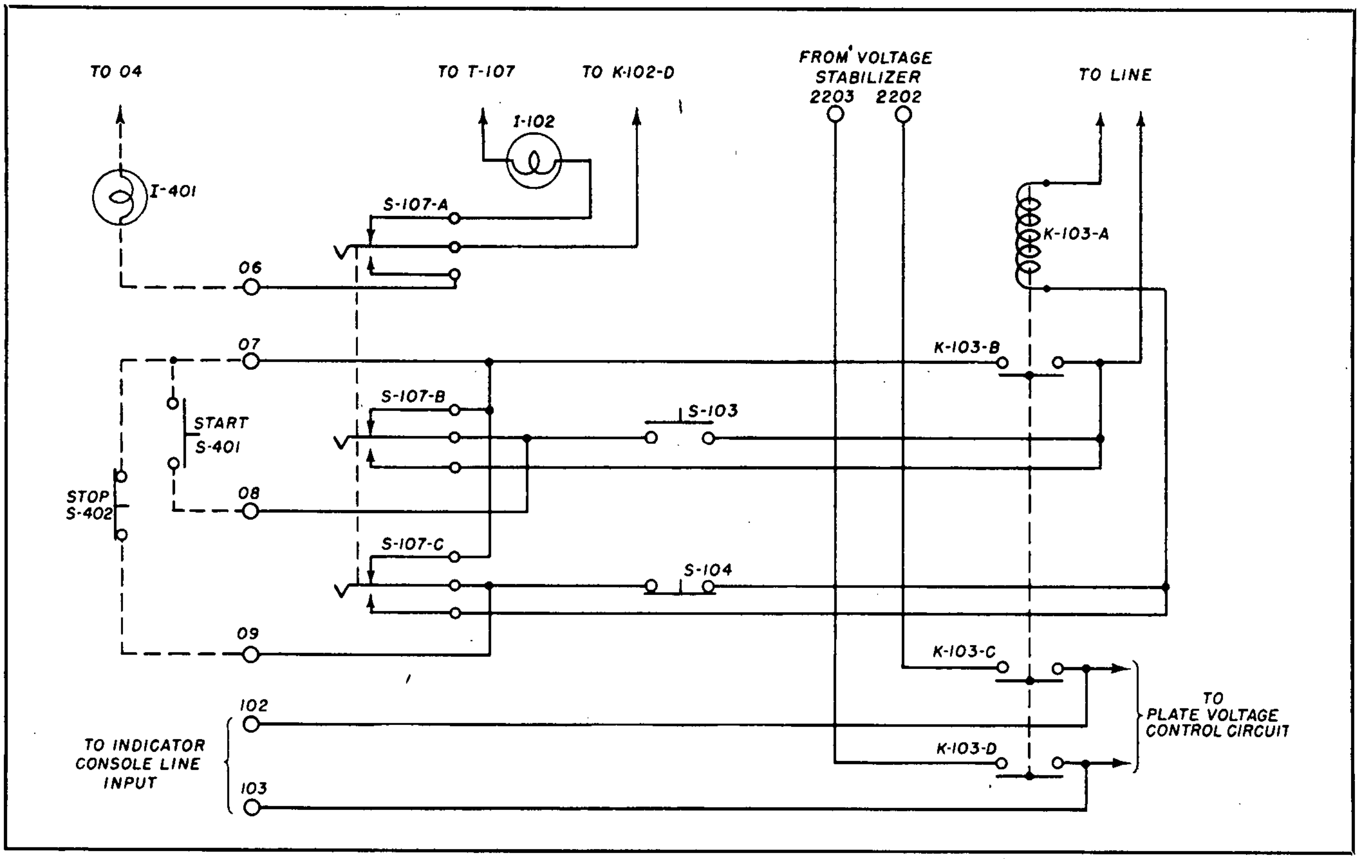


Figure 2-14. SR Main Transmitter Control Circuit, Simplified Diagram

and its function is to permit the oscillator tubes to be turned off without also turning off the power motor B-102 which starts at the same time that relay K-102 is energized. This feature permits the tubes to be cooled quickly whenever it is necessary to replace one of them.

(2) When relay K-102 is energized, contacts K-102-B and K-102-C close to apply power to the rest of the filament control circuit. Contacts K-102-C also close, connecting FILAMENT ON lamp I-103 across the output of transformer T-107 and making the output of the transformer available to switch S-107-A and relay contacts K-101-F. The closing of the contacts of relay K-102 applies power to the variable-ratio transformer T-106. This transformer regulates the amount of voltage applied to the primaries of the filament transformers and is manually controlled by the FILAMENT VOLTAGE INCREASE control on the front panel. The output from transformer T-106 is connected to the primaries of the filament transformers of the high voltage rectifier and the transmitting oscillator through inductor L-107. This inductor is short circuited through relay contacts K-101-B when the relay is energized. In standby operation the relay contacts are open and inductor L-107 is in the circuit to drop the voltage across the primaries of the filament transformers and lower the filament voltage to a level that permits the filaments to be kept warmed up so that the equipment may be immediately placed in operation. Relay K-101 is in the plate voltage control circuits shown in Fig. 2-15, and is energized when plate voltage is applied to the transmitting oscillator tubes. When contacts K-101-B are closed the voltage across the primaries of the filament transformers is raised and the filament voltage is increased to the proper operating potential.

(3) When contacts K-102-B and K-102-C are closed, power is also applied to the time delay relay K-104. This relay controls the action of the plate voltage control circuits and they cannot operate until the relay has completed its timing cycle. This prevents the application of plate voltage to the plates of the high voltage rectifier tubes until the oscillator filaments have had sufficient time to warm up.

b. MAIN CONTROL CIRCUIT.

(1) The main control circuits in the Transceiver are shown in Fig. 2-14. The function of this circuit is to transfer control of the Transceiver to the Indicator Console or from the Indicator Console to the Transceiver Console. The components represented by dotted lines in Fig. 2-14 are the remote control components located in the General Control unit of the Indicator Console. The transfer of control is accomplished through the action of the LOCAL-REMOTE

switch S-107. When switch section S-107-A is in the LOCAL position as shown in Fig. 2-14, the LOCAL CONTROL lamp I-102 lights when the closing of the MAIN POWER switch operates relay K-102 to close its contacts K-102-D. When this switch section is in the REMOTE position, the LOCAL CONTROL lamp I-401 in the General Control Unit is connected to relay contacts K-102-D through terminal 06 and the switch section. Lamp I-401 has its own transformer and does not depend upon transformer T-107 for power. Switch section S-107-B selects the POWER ON switch that is to be used. When this switch section is in the LOCAL position as shown in Fig. 2-14, it transfers control to the POWER ON switch S-103 in the Transceiver Console. In the REMOTE position, the POWER ON switch S-401 in the General Control Unit, is connected into the circuit through terminals 07 and 08 and S-103 is disconnected. When switch section S-107-C is in the LOCAL position, it connects the POWER OFF switch S-104 into the circuit. This switch is located in the Transceiver. In the REMOTE position, the POWER OFF switch S-402 in the General Control Unit is connected into the circuit through terminals 07 and 09.

(2) One side of the relay coil K-103-A is connected to the a-c line at one of the terminals of transformer T-106. This transformer is shown in Fig. 2-13. The other side of the relay coil connects to the other side of the a-c line through the POWER OFF switch S-104, two sections of the LOCAL REMOTE switch S-107-B and S-107-C, the POWER ON switch S-103, in Fig. 2-14 and contacts K-104-B in Fig. 2-13. Relay K-104 is a time delay relay and its function is to prevent the application of plate voltage to the high voltage rectifier tubes until the filaments of the transmitting oscillator have warmed up. When relay K-103 operates, contacts K-103-B close and short circuit the POWER ON switch S-103 to keep the relay energized after the switch is released. Contacts K-103-C and K-103-D close energizing relay K-101 which is shown in Fig. 2-15. The closing of these contacts also makes power from the Voltage Stabilizer available to the Indicator Console. When the POWER OFF switch S-104 is pressed, it breaks the circuit to the coil of relay K-103 removing plate voltage from the high voltage rectifiers and breaking the power circuit to the Indicator Console.

i. PLATE VOLTAGE CONTROL CIRCUITS.

(1) The plate voltage control circuits are shown in Fig. 2-15. As stated in the previous paragraph, the operation of relay K-103 closes contacts K-103-C and K-103-D and applies line voltage to the coil of relay K-101, through relay contacts K-105-C and the limit switch S-111 which are both normally closed. When relay K-101 is energized, contacts K-101-B close and short circuit inductor L-107 to raise the filament voltage. These contacts are shown in Fig. 2-13. Contacts K-101-F also close, applying power to the PLATE VOLTS Lamp I-104. Contacts K-101-C close, connecting one side of the voltage regulator T-105 to one side of transformer T-101 in the high voltage rectifier. Contacts K-101D connect the other side of the voltage regulator transformer to the other side of the high voltage transformer T-101 and also energize relay K-107. When this relay is energized, its normally closed contacts open removing bleeder resistor R-114 from across the output of the high voltage rectifier.

(2) Relay contacts K-101-E close to short circuit the limit switch S-111 which opens when the plate voltage is raised. Contacts K-101-G are normally closed and they open when the relay is energized, removing the line connection to one side of the reset coil K-105-B which resets the overload relay K-105 when it turns off the equipment. Contacts K-101-H are normally open when the equipment is turned off. When the relay operates, these contacts close, completing the red circuit to the drive motor B-101 of the voltage regulator T-105. When relay K-101 is energized, the plate voltage may be raised by pressing the RAISE pushbutton switch S-105 when the equipment is in LOCAL operation. When the equipment is in REMOTE operation, the voltage may be raised by pressing RAISE switch S-404 in the General Control Unit. This circuit is shown in Fig. 2-15. The blue lead from the drive motor is connected to one side of the a-c line through fuse F-108. When the RAISE switch is operated, it connects the black lead of the motor to the other side of the a-c line through limit switch S-110, LOWER switch S-106 and the front contact of switch section S-107-D. This starts motor B-101 which opens limit switch S-111 and closes switch S-109. The motor can continue to run when switch S-111 opens because relay contacts K-101-E have closed, short circuiting the switch. If the RAISE switch is held closed, the motor drives the voltage regulator until the oscillator plate voltage reaches 15,000 volts. When this limit is reached, switch S-110 opens the black lead circuit and stops the motor. When switch S-119 is closed it short circuits RADIATION switch S-108 and energizes relay K-106. The action of this relay removes the short circuit from resistors R-108 and R-115. Resistor R-108 provides disabling bias for the transmitter tubes and resistor R-115 is placed in series with the primary winding of transformer T-101 to lower the oscillator plate voltage. Switch S-119 remains closed until the voltage regulator has rotated about 45 degrees from its lower limit to raise the high voltage rectifier output to about 5,000 volts.

(3) When the LOWER switch is pressed, the red lead of the motor is connected to the line through the lower limit switch S-109, RAISE switch S-105, the

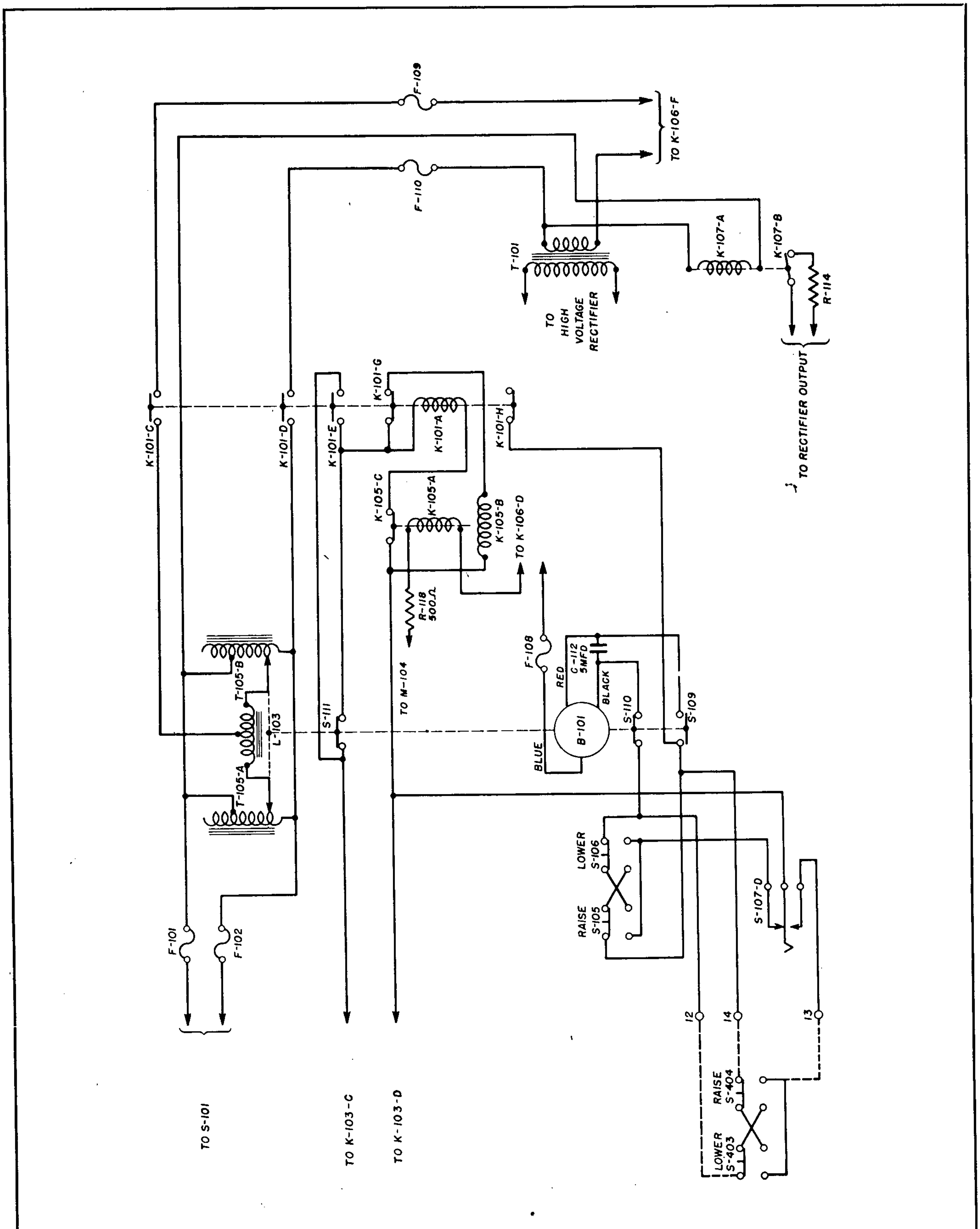


Figure 2-15. SR Plate Voltage Control Circuit, Simplified Diagram

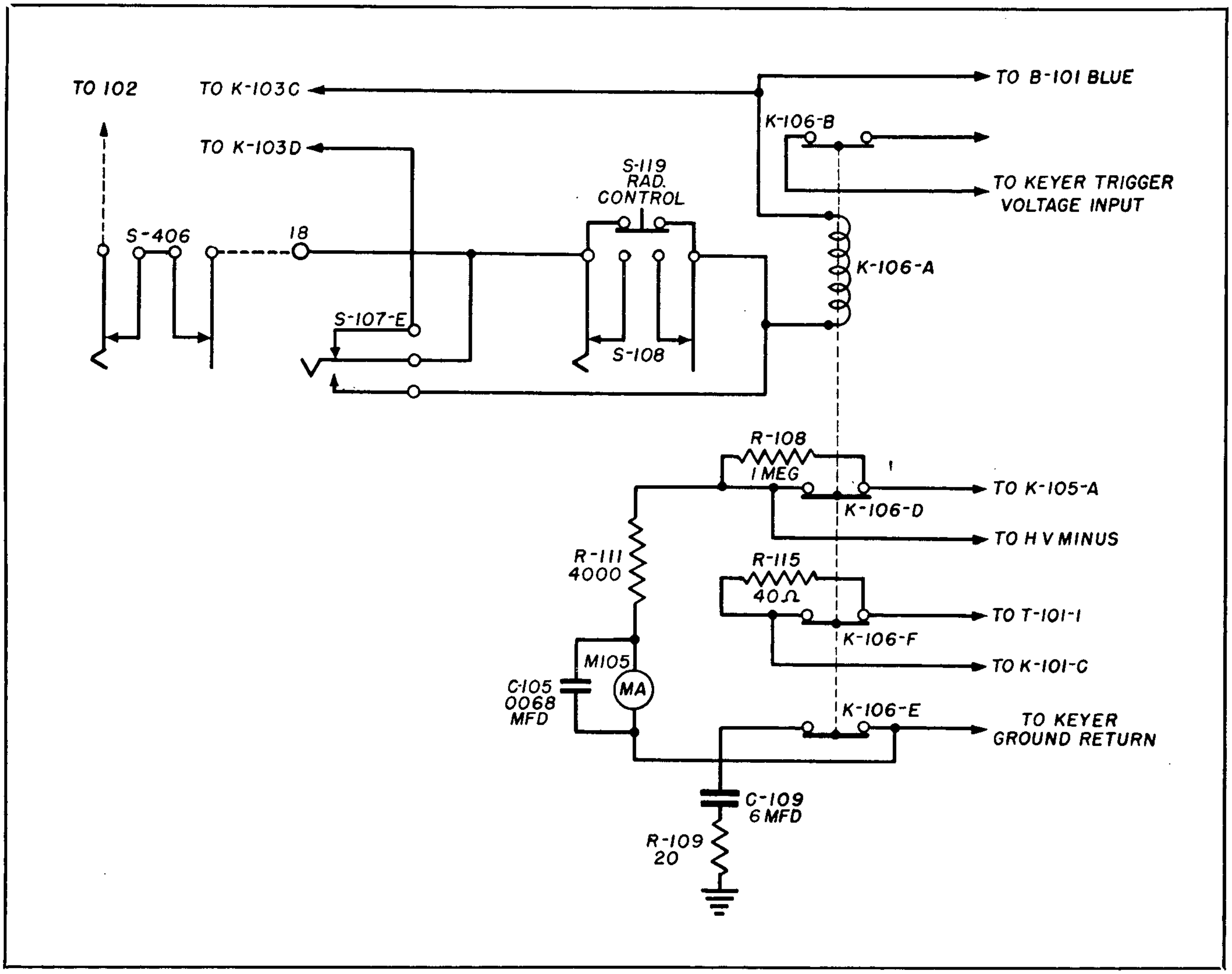


Figure 2-16. SR Radiation Control Circuit, Simplified Diagram

LOWER switch S-106 and switch section S-107-D. This circuit causes the motor to run in a direction that lowers the voltage output from voltage regulator transformer T-105. The motor continues to run when switch S-106 is closed, until the lower limit switch S-109 opens breaking the circuit to the motor.

(4) If relay K-105 operates due to an overload on the high voltage power supply, contacts K-105C open, breaking the energizing circuit to relay K-101. This opens contacts K-101E, removing the short circuit across switch S-111 which is closed only when the plate voltage is below 600 or 700 volts. The voltage regulator must then be returned to its lower limit to close switch S-111 before relay K-101 can again operate. Power to return the plate voltage to its lower limit is obtained through contacts K-101H which close when relay K-101 is de-energized. This connects the red lead from the motor to the line through switch S-109 and causes the motor to run in such a direction as to reduce the voltage regulator to the lower limit voltage output position. At this point, switch S-109 opens the circuit. When switch S-111 closes, current flows to the reset coil of relay K-105 (coil K-105B) which closes contact K-105-C of the relay. The plate voltage can now be raised again, by operation of the RAISE button.

j. RADIATION CONTROL CIRCUIT.

(1) The radiation control circuit is shown in Fig. 2-16. The function of this circuit is to control the application of plate voltage and operating bias to the transmitting oscillator. The action in this circuit is initiated by operating RADIATION switch S-108 for local operation, or RADIATION switch S-406 in the General Control Unit for remote operation. When the RADIATION switch is in its OFF position, the circuit through it is completed as shown in Fig. 2-16. Since the switch is in series with one side of the a-c line to relay K-106, this relay is energized. In its energized position all contacts on relay K-106 are open. When the relay is de-energized, a spring load on its

armature closes the contacts. When the RADIATION switch is in the MOMENTARY position or in the ON position, the circuit to the relay is broken and the relay is de-energized. This permits the spring to close the relay contacts. Contacts K-106-B apply any external synchronizing voltage in use to the circuits in the Keyer Unit. Contacts K-101-D short circuit resistor R-108 to remove the disabling bias from the transmitting oscillator tubes. Contacts K-101-F short circuit resistor R-115 to raise the output voltage from the high voltage rectifier to the normal operating level set by the voltage regulator. Contacts K-101-F connect the output trigger pulse transformer T-108, to the transmitter grid circuit to obtain synchronizing voltage for the Indicator Console.

(2) When the RADIATION switch is in the off position, relay K-106 is energized and all of its contacts are open. When contacts K-101-B open, they remove any external synchronizing voltage that may be in use. A negative bias is applied to the grids of the transmitter tubes through the opening of contacts K-106D. The opening of contacts K-106D places resistor R-108 between ground and the negative terminal of the power supply. Current flowing from ground to the power supply, causes the ungrounded end of resistor R-108 to become negative with respect to ground. This end of the resistor is connected to the grids of the Keyer tubes through resistor R-111, the GRID CURRENT meter M-105, and the keyer circuits. It applies a bias of approximately —4,000 volts to the grids of the oscillator tubes. Contacts K-106E remove the ground from the keyer circuit at the same time that blocking bias is applied. Contacts K-106F connect resistor R-115 in series with the primary winding of power transformer T-101. The resulting voltage drop decreases the input to the transformer and reduces the rectifier voltage output. This voltage decrease offsets the corresponding increase in voltage due to removal of the load of the oscillator tubes from the rectifier circuits. It prevents the charge on high voltage capacitors from rising and thus enables the transmitter to start oscillating at approximately the same plate voltage that was being applied when oscillations ceased. It also prevents any flash-overs which might occur if the voltage were allowed to rise with no load across the rectifier.

(3) A microswitch S-119, operated by a cam on the shaft of plate voltage regulator T-105, is used to insure proper starting of the transmitter. The switch is placed across the terminals of RADIATION switch S-108 and when the cam closes the switch, it short circuits the RADIATION switch so that regardless of its position radiation is off until the voltage has been raised to about 5,000 volts.

5. SR-a TRANSMITTING SYSTEM.

a. GENERAL.

(1) Transceiver CAY-43ADK is a modification of Transceiver CAY-43ACM. The removal of the Keyer Unit, and the installation of a resistor and terminal assembly in its place, modifies the Transceiver into the CAY-43ADK model. This modification is required because of the SR-a type of modulation. Where the SR Equipment employed a self-pulsed grid type of modulation, the SR-a Equipment employs plate modulation. The SR Equipments in the field are converted to SR-a Equipments under the instructions contained in Navy Field Change No. 20. With the exception of the changes in the Keyer compartment already noted, and the control circuit changes required, the component parts of the two Transceivers are identical.

b. DESCRIPTION.

(1) A block diagram of the SR-a transmitting system is shown in Fig. 2-17. Since the transmitting oscillator has already been clearly shown in the block diagram of Fig. 2-3, it is shown here as one block. The tuning tanks and duplexer are also omitted for the same reason. It will be noticed that the modulator stages constitute the major portion of the system in the diagram. The low voltage rectifier in the Modulator supplies plate power for a blocking oscillator and its associated cathode follower. A-c power is supplied to the low voltage power supply in the Modulator when the MAIN POWER switch on the Transceiver is placed in the ON position. This switch also supplies a-c power to the primaries of the filament transformers and to the time delay relay located in the Modulator. The time delay relay is adjusted for a delay of five minutes. Under normal operation it is impossible for the pulse forming network to receive high voltage from the high voltage rectifier in the Transceiver until five minutes have passed and the time delay relay in the Modulator has closed and operated relay K-101 in the Transceiver. On Modulator units above serial No. 50, a shorting switch S-2005 is provided to short the contacts of relay K-105. This enables the equipment to be started without the five minute delay period if the relay opens due to shock or very short cessation of power. This switch is to be used only after a few seconds shut-down while the thyratron V-2006 is warm. Otherwise the thyratron will be seriously damaged. This relay applies full filament voltage to the Transmitting Oscillator tubes, and also closes the circuit to the motor-driven voltage regulator B-101 so that the high voltage may be raised or lowered by operation of the RAISE or LOWER button. The RADIATION switch in the SR Transceiver has no control until the plate voltage has been

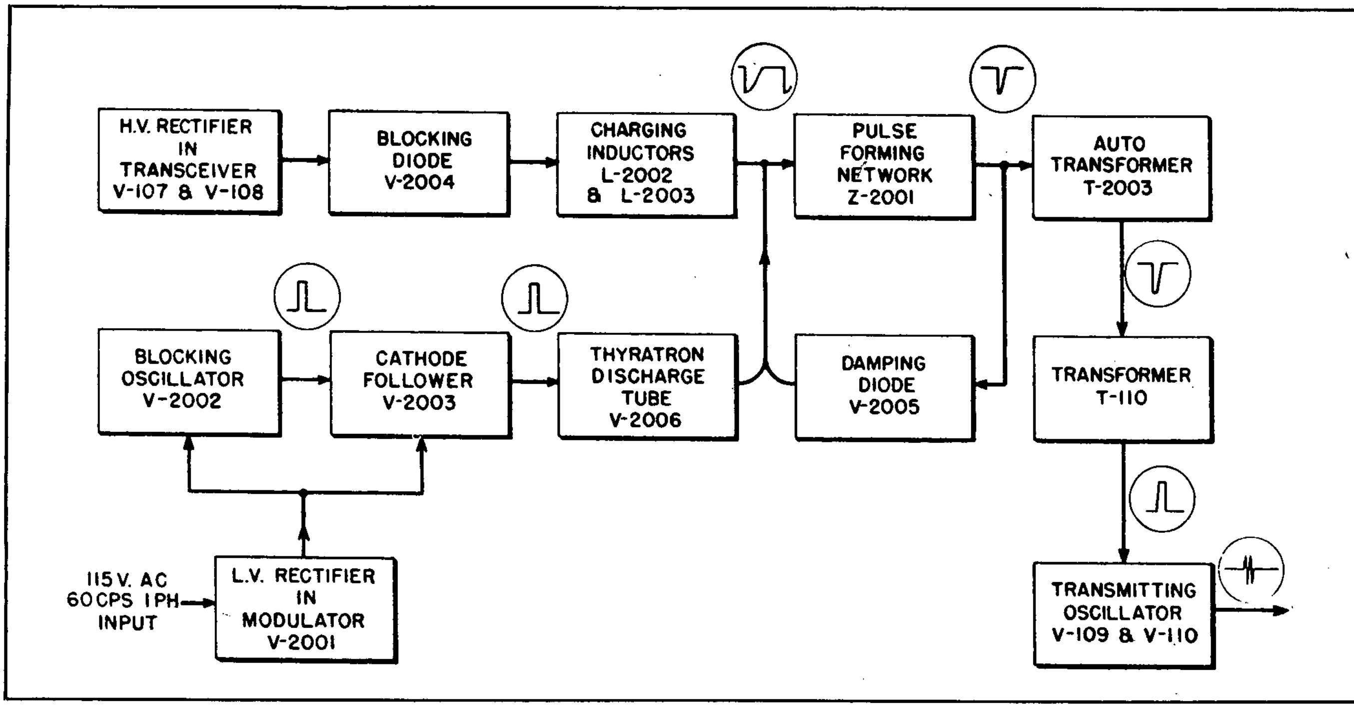


Figure 2-17. SR-a Transmitting System, Block Diagram

raised to approximately five kilovolts. This is due to the setting of the microswitch S-119 which does not permit the radiation relay, K-106, to close until the voltage has risen to approximately five kilovolts. On the SR-a Equipments, the connection of this switch in the circuit is such that the RADIATION switch has control at all times. *The RADIATION switch should be ON before the RAISE button is pressed so that the voltage applied to the modulator will be the operating voltage under load.*

(2) The blocking oscillator, V-2002, represented in Fig. 2-17, is a single-swing type which establishes the pulse repetition rate of the equipment. Its output is a positive pulse of voltage approximately 4 microseconds wide. The repetition rate is adjusted for normal operation, to approximately 125 cycles per second. The blocking oscillator operates at all times, regardless of the position of the RADIATION switch on the Transceiver.

(3) The cathode follower, V-2003, is a beam power amplifier that accepts the positive voltage pulse from the blocking oscillator and provides a low-impedance power output suitable for application to the grid of the thyratron discharge tube. This low-impedance output is necessary because the impedance of the grid-cathode circuit is very low when the Thyratron is firing.

(4) The thyratron discharge tube, V-2006, discharges the pulse-forming network when it is fired by the application to its grid of the positive pulse from the cathode follower. When the RADIATION switch is in the OFF position, a relay grounds the grid of the thyratron to prevent it from firing. When the RADIATION switch is in the ON, or KEY position, the relay opens and the positive pulse from the cathode follower will discharge the thyratron and operate the equipment.

(5) The high voltage rectifier, V-107 and V-108, located in the Transceiver, provides the high voltage d-c supply to charge the pulse-forming network, through the blocking diode and the charging inductors.

(6) The blocking diode, V-2004, prevents the charge on the pulse-forming network from being dissipated in the high voltage rectifier circuits when the pulse-forming network has charged to a voltage above that supplied by the high voltage rectifier. This charging action is explained in the following paragraphs.

(7) The charging inductors, L-2002 and L-2003, together with the capacitance in the pulse-forming network, form a resonant circuit at a frequency of approximately 130 cycles per second. After the thyratron, V-2006, has discharged the network the point in the circuit represented by the junction of the charging inductors and the pulse-forming network is suddenly dropped from a potential of approximately 10,000 volts above ground to ground potential. The full voltage from the high voltage rectifier now appears across the inductors. After ionization ceases in the thyratron, following the discharge of the pulse-forming network, the network charges through the inductors at a rate determined by the resonant frequency of the circuit formed by the inductors and the capacitance of the pulse-forming network. Following

the slope of a sine wave at the resonant frequency (approx. 130 cps) the voltage across the network rises rapidly to *twice* the voltage applied by the high voltage rectifier, as the magnetic field around the inductors collapses. At this point, the voltage across the line will place the cathode of the damping diode at a potential *higher* than the potential of its plate. Consequently the tube will not conduct, and the potential existing across the line will remain until the line is discharged by the action of the Thyratron.

(8) The pulse-forming network, Z-2001, is an artificial transmission line. The network stores the energy received from the charging inductors and discharges it, when the thyratron shorts the line, in the form of a short pulse of energy determined by the electrical constants of the line. The time required to discharge the line, through the transformer, T-2003, is approximately four microseconds and the voltage amplitude of the discharge is approximately five kilovolts. This is due to the fact that, although the line is charged up to approximately 10-kv, half of the voltage is dissipated in the internal impedance of the line and only half of the voltage can appear across the load. On Modulators with serial numbers 51 and above, two resistors, totaling 12 megohms have been connected from the high side of network to ground to discharge the network when the equipment is turned off.

(9) The damping diode, V-2005, is placed across the pulse-forming network to prevent oscillation following the discharge of the line. Such an oscillation would have a tendency to develop a series of small pulses following the main pulse as the oscillation decayed. It might also develop an inverse current through the thyratron which would injure the tube.

(10) Two pulse transformers are shown in the block diagram. The auto transformer, T-2003, in the Modulator acts as a step up transformer for the voltage developed by the discharge of the pulse-forming network. The second transformer, T-110, which is in the Transceiver, inverts and steps up the voltage until it is applied to the transmitting oscillator tubes as a 15-kv pulse of voltage.

(11) The transmitting oscillator tubes, V-109 and V-110, operate in the same type of oscillator used in the SR Equipment. No change has been made in the oscillator except the substitution of grid leak resistors for the Keyer circuits and the addition of a pulse transformer to apply the high voltage keying pulses to the plates of the tubes. When the 15-kv pulse of voltage is applied, the tubes oscillate, generating the pulse of r-f energy which is transmitted by the equipment.

c. MODULATOR CAY-50AGU.

(1) The action of the Modulator is controlled by a blocking oscillator which generates the trigger pulse for the modulation pulse circuits. All of the circuits in the SR-a system are synchronized to the output frequency of the blocking oscillator. The blocking oscillator is shown in Fig. 2-18. It employs half of a 6SN7-GT tube designated as V-2002 in the circuit. The other half of this tube is not used. The circuit is designed to deliver a narrow pulse of voltage and rest a fixed period of time between pulses. The width of the pulse is approximately eight microseconds and the time between pulses varies with the repetition rate over a range of 6,666 to approximately 16,666 microseconds. These figures are based on a nominal frequency range of 60 to 150 cps. Actually the greater portion of this range cannot be used since other considerations require that the repetition be set at 120 cps.

(2) The Range Scope was originally designed with a 400-mile range but was later modified by reducing the range to 200 miles when the Modulator was added. Where the Modulator is being used with an unmodified Range Scope, the 400-mile range will be shortened at a repetition rate of 120 cps because the recovery time of the sweep circuits in the Range Scope is too long to display a 400-mile sweep at repetition rates above 100 cps. For this reason, the 400-mile range was reduced to 200 miles by a field modification, since the repetition rate must be 120 cps to prevent objectionable jitter in the targets. Jitter is caused by a beat frequency between the 120 cps ripple voltage from the low voltage power supply and the output of the blocking oscillator. When the output frequency of the oscillator is exactly equal to the ripple frequency in the power supply, the amplitude of the beat frequency is zero and the images on the scopes are sharp and steady. If the frequency is set very much above 120 cps., there is danger of arc-back in the Thyratron, also the high voltage power supply in the Transceiver is overloaded and the transformer heats up. If the frequency is too low, the temperature of the Thyratron drops appreciably, with possible damage to the filament. It also increases the length of time required for it to discharge the pulse-forming network. This results in a much longer output pulse than is desirable.

(3) The blocking oscillator operates with grid-leak bias. The grid current drawn on the positive peaks of the cycles charges capacitor C-2003 to a voltage sufficient to place the grid below cut-off. At the instant when power is first applied to the circuit, the grid potential is zero and the tube draws current through the plate winding between terminals 3 and 4 of transformer T-2002. The sudden surge of current through this winding induces a current in the winding between terminals 1 and 2 with a voltage that is increasing in a positive direction. Consequently as the grid capacitor C-2003 charges from the rectified grid current, its tendency to drop the grid potential is cancelled by the increase in voltage across the grid winding of the transformer. This action maintains the grid potential above ground and the plate current rises

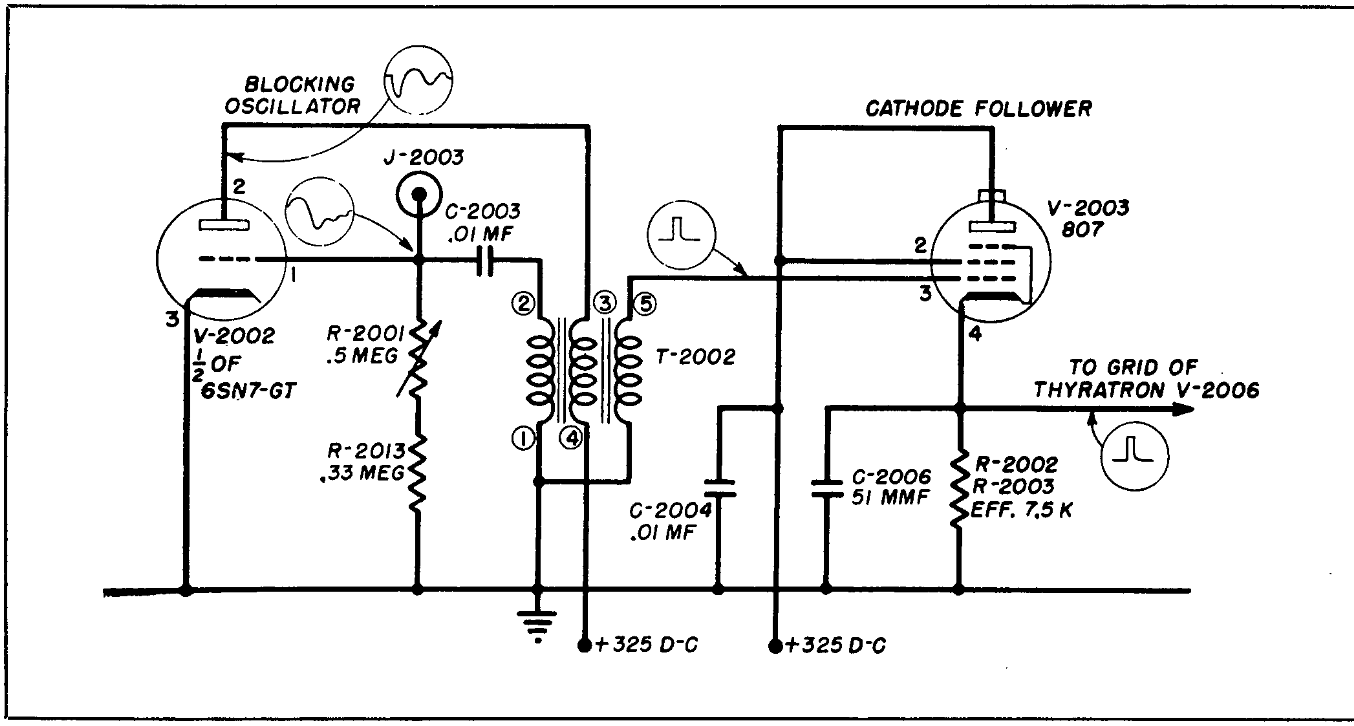


Figure 2-18. Trigger Circuits in Modulator

as rapidly as the inductance of the transformer permits. When plate current saturation is reached, the output voltage from the transformer to the grid drops to zero and the grid starts to drop to the negative potential to which capacitor C-2003 is charged. This causes a decrease in the plate current which causes a negative voltage to be applied to grid 1 of V-2002. This causes the grid to drop faster and almost immediately the grid is driven very far below cut-off. When the plate current drops to zero, the output from the transformer is again zero and the grid assumes the negative potential to which the grid capacitor is charged. The capacitor discharges toward ground potential through resistors R-2001 and R-2013. The rate of discharge and consequently the frequency of the oscillator is fixed by the size of capacitor C-2003 and the adjustment of potentiometer R-2001. When the grid potential rises to a point just above cut-off, plate current again begins to flow and the cycle is repeated.

(4) When current flows in the plate winding of transformer T-2002, a current is induced in the winding between terminals 5 and 1. The pulse of voltage across this winding is connected to grid 3 of the cathode follower V-2003. The cathode follower is shown in Fig. 2-18. The tube employed is an 807. The function of this circuit is to match the output impedance of the blocking oscillator to the input impedance at the grid of the thyratron discharge tube, V-2006. The reason for this is that the input impedance of the thyratron is very low when the tube is firing and if it were directly coupled to transformer T-2002, it would place a short circuit across the secondary winding 5-1. The output of the cathode follower is a rapidly rising positive pulse of voltage which is applied to the grid of V-2006 through coupling capacitor C-2005. This causes the thyratron to fire and discharge the pulse-forming network.

(5) Plate voltage for the blocking oscillator and the cathode follower is supplied by a low voltage rectifier in the Modulator. The circuit of this rectifier is shown in Fig. 2-19. The circuit is a full-wave rectifier circuit using a type 5U4G tube designated as V-2001. The primary power input circuit to the transformer T-2001 is fused on both sides of the line by fuses F-2001 and F-2002 and the fuses are shunted with warning lamps I-2001 and I-2002 to indicate an open fuse. Interlock relay K-2002 shunts the primary winding of transformer T-2001 and closes the interlock circuit when power is applied to the rectifier input circuit. Transformer T-2001 contains three filament windings. One is for the rectifier tube V-2001, another winding supplies voltage for the blocking oscillator and the Thyratron and the third winding supplies heater voltage for the cathode follower. Filament voltages for the blocking diode and the damping diode are provided by transformers T-2005 and T-2004, which do not appear in the figure. These transformers have the tube sockets built into the top of the transformer, and thus provide good isolation of the high voltages which appear between the filaments of the tubes and ground. The output of the rectifier circuit is filtered by the single-stage choke-input filter consisting of inductor L-2001 and capacitor C-2001 and is rated at 300 volts d-c.

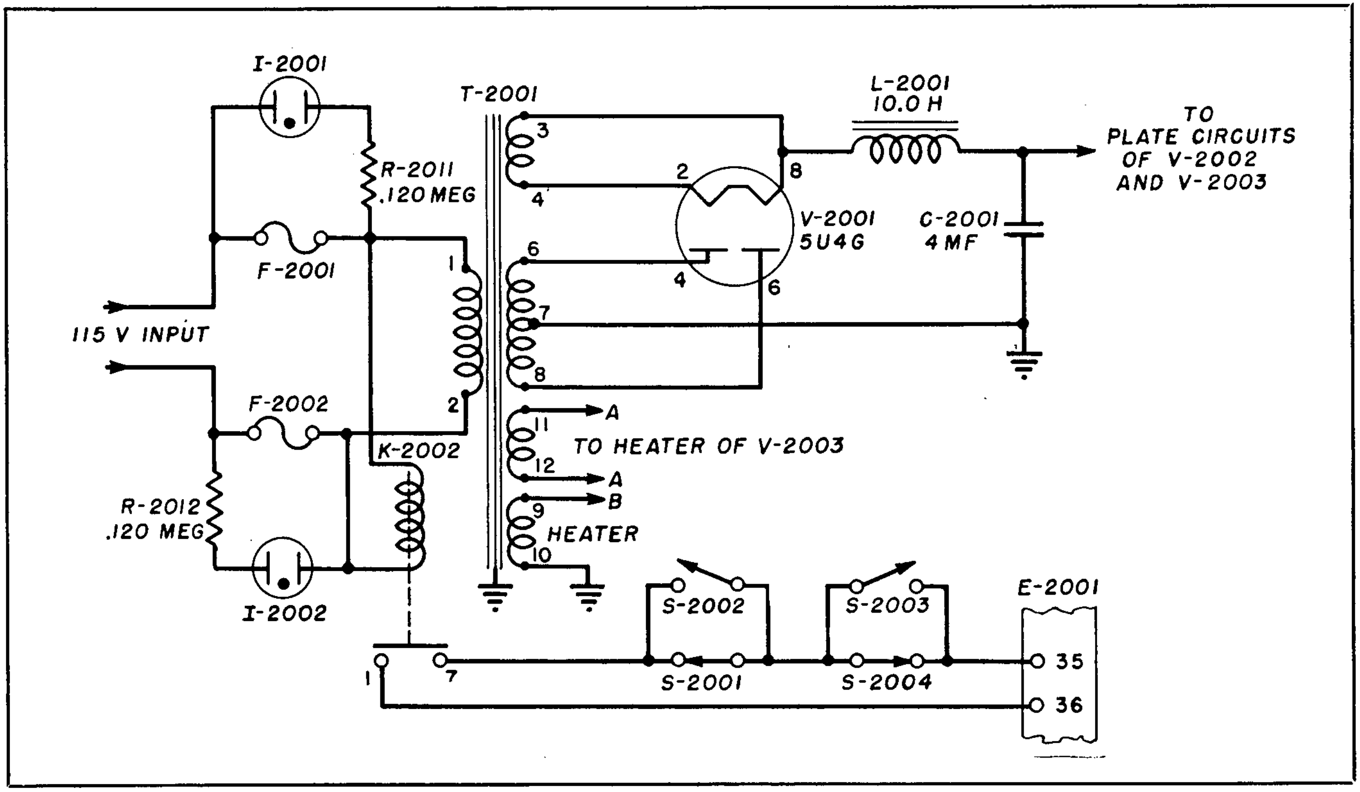


Figure 2-19. Low Voltage Rectifier in Modulator

(6) The output from the cathode follower V-2003 is capacitively coupled to grid 1 of the thyratron discharge tube V-2006. This tube is a part of the pulse-forming circuit shown in Fig. 2-20. The purpose of this tube is to discharge the pulse forming network to produce the modulating pulses applied to the plates of the transmitting oscillator tubes. In order to produce a narrow pulse of approximately four microseconds with a nearly perpendicular leading edge, it is necessary to have the discharge current rise to maximum proportions almost immediately and the resistance in the discharge path must be low enough that the pulse forming network can discharge in the time specified. These objectives are attained by using a type 5C22 hydrogen-filled thyratron tube to discharge the line. This tube is V-2006 in Fig. 2-20. It is characteristic of a thyratron that its plate current increases from zero to maximum almost immediately. This action occurs because of the gas in the tube. When the grid potential increases in a positive direction to the point where plate current can flow, positive ions are formed in the gas due to collision. Enough of the ions collect around the grid to neutralize its electrostatic field while other ions attracted to the cathode neutralize the space charge. When this occurs, maximum plate current flows. It can be seen therefore, that the rapidity with which the plate current rises to maximum is a function of the time required to ionize the gas in the tube. Since hydrogen has the most simple atomic structure of any of the elements it is the easiest to ionize and is therefore used in this application.

(7) The high potentials present in the pulse forming circuit make it necessary to provide maximum protection for the thyratron against inverse peak voltage. As the temperature of a thyratron increases, its inverse peak voltage rating decreases. Therefore, the heater voltage of V-2006 is purposely set at a value that would be too low for efficient operation if there were no other contributing factor, and the remainder of the temperature is supplied by the heat produced by ionic bombardment of the cathode. This arrangement insures against excessive operating temperatures. For this reason, it is very important that the repetition be set at 120 cps. If the repetition rate exceeds 120 cps, the average current increases and the inverse peak voltage rating of the tube decreases. Also the excessive current drain overloads the high voltage power supply. If the repetition rate falls below 120 cps, the average current decreases but since the temperature decreases faster than the current there is danger that the plate current will exceed the emission capabilities of the cathode which will cause the cathode to disintegrate. The grid circuit is also protected against high potentials during the discharge period by spark gap, SG-2001, connected between the grid and ground. If the grid exhibits any tendency to approach the plate potential through coupling by the ion stream, the spark gap arcs over.

(8) The pulse-forming network is a conventional artificial line with lumped inductance and capacitance.

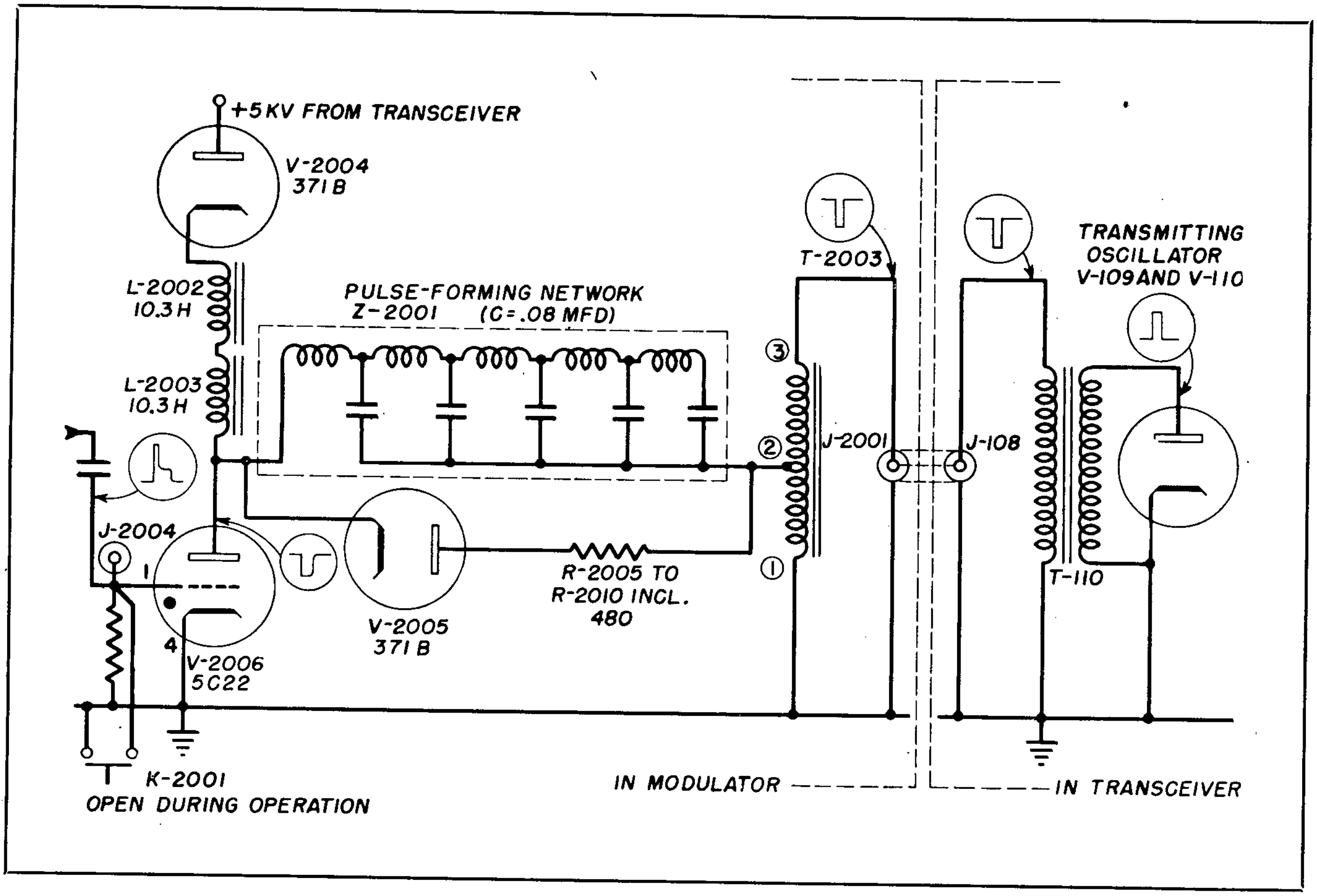


Figure 2-20. Pulse Forming Circuits in Modulator

This line is Z-2001 in the figure. Charging current for the line is obtained from the high voltage power supply in the Transceiver through the blocking diode V-2004 and the charging inductors L-2002 and L-2003. During the period in which V-2006 is cut off, the electron flow through V-2004 charges the line. Inductors L-2002 and L-2003 together with the capacity of 0.08 mf in the pulse-forming line, form a series LC circuit that is resonant at approximately 130 cps. The inductive reactance in the artificial line and pulse transformer T-2003 is so small at this frequency that its effect is negligible.

(9) To understand the action of the circuit, consider it at the instant when V-2006 has deionized. The pulse line has been discharged and the cathode of V-2004 is at ground potential for that instant only. The 5000-volt potential from the high voltage rectifier is applied to the plate of V-2004. In this condition the tube conducts and a charging circuit is established from the power supply, through V-2004, the charging inductors, the pulse line, part of the winding of the auto-transformer T-2003, and the ground return back to the power supply. The action of the circuit is illustrated in Fig. 2-21. The equivalent circuit is the series LC circuit on the left-hand side of the figure. Switch section 1 represents the blocking diode V-2004 and switch section 2 represents the thyratron V-2006. In order to represent the instant at which the thyratron has deionized, switch section 1 is closed and switch section 2 is open. This establishes the charging circuit previously described. In this circuit the reactance of L_L and L_T are negligible. At the instant switch section 1 is closed, there is no current flowing in the circuit and capacitor C has no charge having previously been discharged. Therefore the potential of the junction of L_L and C is zero or ground potential. Since there is a potential of 5000 volts d-c applied across the circuit, the entire voltage drops at zero degrees is across the inductor L as represented in Fig. 2-21 by the E_L curve. All of the voltage appears across the inductor because voltage cannot rise across a capacitor instantaneously. The current is zero in the circuit at the beginning of the cycle because it cannot rise instantaneously in an inductor. This condition cannot continue to exist for immediately current I begins to flow, charging the capacitor and as it increases, building up a magnetic field around the inductor. As the capacitor voltage E_c rises in a positive direction, the inductor voltage E_L falls toward ground potential so that the sum of their combined voltages always equals the supply voltage of 5,000 volts. At 90 degrees when the circuit has progressed through a

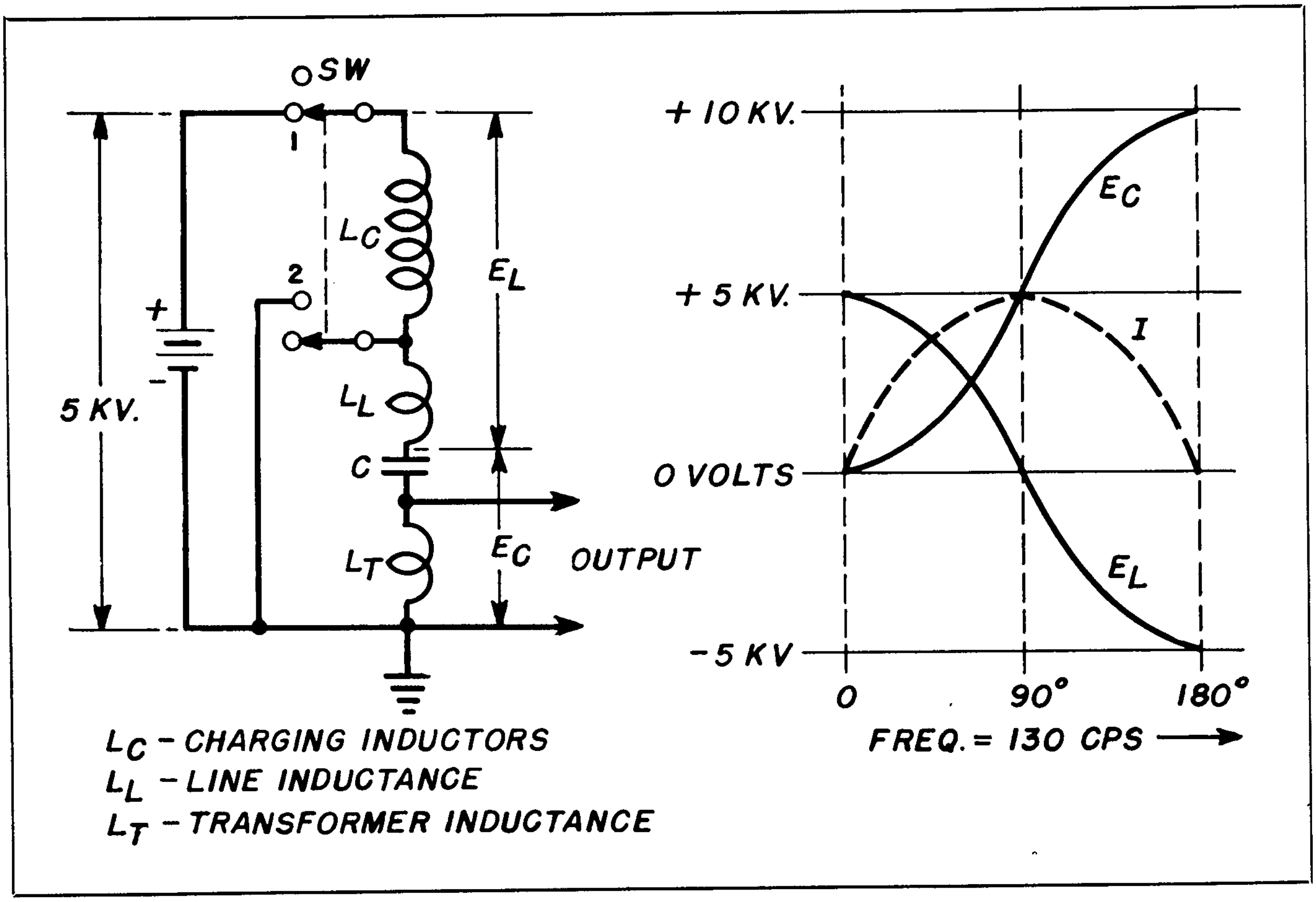


Figure 2-21. Simplified Pulse Circuit

quarter-cycle, the inductor voltage is zero and the capacitor voltage has risen to 5000 volts. At this point current would cease to flow through the blocking diode if it were not for the fact that maximum current is now flowing through the inductor and it cannot instantaneously decrease to zero because of the inductor's magnetic field. As the field collapses, it induces a current flowing in the same direction as the original current producing the field. The collapsing field of the inductor causes the voltage across it to swing negative, and the additional current flowing into the capacitor increases its charge so that the sum of the two voltages is still equal to the supply voltage. This continues until the current has decayed to zero, at which time the voltage across the capacitor has risen to nearly 10,000 volts positive with respect to ground and the inductor voltage has fallen to 5000 volts negative with respect to ground. At 180 degrees the action ceases where the current tends to reverse its phase since V-2004 cannot conduct in a reverse direction and therefore blocks further flow of current. The result is that a series LC circuit, resonant at 130 cps, after oscillating through one-half of a cycle has been forced to stop on the peak of the cycle where its capacitor voltage is maximum. This is the condition that exists at 180 degrees as shown in Fig. 2-21.

(10) Since the capacitor cannot discharge back through the blocking diode, it remains charged until a trigger pulse arrives at the grid of the thyratron V-2006. When the thyratron conducts, the capacity in the pulse line is discharged almost immediately. The factors that prevent an instantaneous discharge are the circuit resistance, tube resistance, and the reactance of the inductance in the pulse line and transformer T-2003. The sudden surge of current through transformer T-2003 produces a voltage across the transformer that exists for about four microseconds. The magnitude of the output voltage is not affected by a change in repetition rate since the blocking diode prevents any discharge from taking place and the line is charged in slightly more than half of the time that elapses between pulses. If it were not for the blocking diode, the discharge would have to be timed to occur at the exact instant that the capacitor reached its maximum charge.

(11) When the thyratron V-2006 conducts, the voltage drop across it is very small and its plate is brought very near to ground potential. This would place an almost direct short circuit across the high voltage power supply if it were not for the action of the charging inductors L-2002 and L-2003. The combined reactance of these inductors is very high at the

frequencies represented by the leading edge of the pulse and the component frequencies of the pulse. The high reactance prevents any appreciable flow of current during the time of the pulse and consequently the inductors appear as an almost open circuit across the power supply. The discharge time of the pulse line Z-2001 is much shorter than its charging time since the charging inductors are not in the discharge circuit. The time required for the line to discharge determines the time duration of the pulse and is a function of the total values of inductance and capacity in the line and the number of LC sections as expressed by the equation:

$$\text{Pulse width in microseconds} = 2N\sqrt{LC}$$

During the time when the thyratron is firing, the line is discharging through the pulse transformer T-2003 and the thyratron. The impedance of the transformer and thyratron is approximately the same as the impedance of the artificial line. Before the discharge, the line is charged to approximately 10 kv. During the discharge time, half of the voltage drop appears across the internal impedance of the line and half appears across the discharge path, namely the section of the transformer T-2003 between terminals 2 and 1, the resistance of the thyratron being considered negligible. The five kv. drop across the line (one-half the total drop) may be considered as a five kv. wave traveling down the line. As this takes place, the voltage across each section is reduced by five kv. When this wave reaches the end of the line, it is met by an open circuit, and therefore reflected back as another five kv. wave of the same polarity. This wave returns from section to section down the line. No further reflections occur at the terminated end, since the termination is of the proper impedance. Thus the voltage across the line is reduced to zero in a period which is approximately twice the apparent electrical length of the line forming the network. The pulse transformer T-2003 steps up the five kv. pulse and its output is, in turn, connected to another pulse transformer, T-110, in the Transceiver which further steps up the voltage pulse to approximately 15 kv. and applies it to the plate circuit of the transmitting oscillator tubes.

(12) A damping diode, V-2005, shunts the pulse forming line as shown in Fig. 2-20. V-2005 is a type 371-B half-wave rectifier tube used as a damping diode across the pulse-forming network. Its purpose is to prevent oscillation of the line following its discharge. Such an oscillation would affect the operation of the Modulator in two ways. First, it would produce a small train of pulses after the main pulse. These could possibly cause the transmitting oscillator to be keyed a number of times instead of only once during each duty cycle. Second, any such oscillation would tend to pass through the thyratron in the wrong direction and thus damage the tube. The damping diode prevents this action since its cathode is connected to the high side of the line. When the line is charged, this places the cathode at a higher potential than the plate and consequently the diode will not pass current. When the line has discharged, and the tendency exists for the voltage to swing negative on the high end of the line, the cathode of the damping diode becomes negative with respect to the plate and the diode will pass current and act as a short circuit across the line to any voltage of the wrong polarity. This prevents any oscillation in the circuit and consequently limits the output to the transmitting oscillator tubes to one single pulse of positive voltage.

(13) An interlock circuit shown in Fig. 2-19 is provided which prevents the Transceiver from supplying high voltage to the Modulator when either the top or front shield is removed from the unit. These two interlock switches are S-2001 and S-2004. Two toggle switches, S-2002 and S-2003, are provided in shunt across these two interlock switches and may be closed to operate the equipment without either or both shields when desired for test or maintenance. These two interlock circuits provide protection by preventing the application of high voltage from the Transceiver even if relay K-2002 has closed following its five-minute time delay period.

(14) Relay K-2001 is an a-c operated relay which disconnects the grid of the thyratron tube V-2006 from ground when pulses are desired from the Modulator. This relay is shown in Fig. 2-20. A-c voltage is applied to terminal 16 of the terminal board by a jumper between this terminal and terminal 2202. Terminal 16 is connected to one of the contacts of relay K-106-B in the Transceiver. The other contact of K-106-B is connected to the relay coil through terminal 31 and through the relay coil to terminal 2202. Thus, when relay K-106 is closed, a-c voltage is applied across the relay coil. This serves to open the relay, which is normally closed, and to remove the ground from the grid of the thyratron V-2006. This permits the thyratron to fire since the required positive pulse from the blocking oscillator and the cathode follower are present at all times when the a-c voltage is applied to the low voltage power supply in the Modulator.

d. HIGH VOLTAGE RECTIFIER.

(1) The high voltage rectifier used in the SR-a Equipment is shown in Fig. 2-22. Since the Modulator requires only 5,000 volts, the original rectifier circuit has been changed from a voltage doubler circuit to a half-wave rectifier circuit. To accomplish this the rectifier tubes V-107 and V-108 are connected in parallel and the filter capacitors C-106 and C-107 are connected in parallel. The rectifiers are type GL-8020 tubes. In order to reduce the output voltage during standby, resistor R-115 is placed in series with the

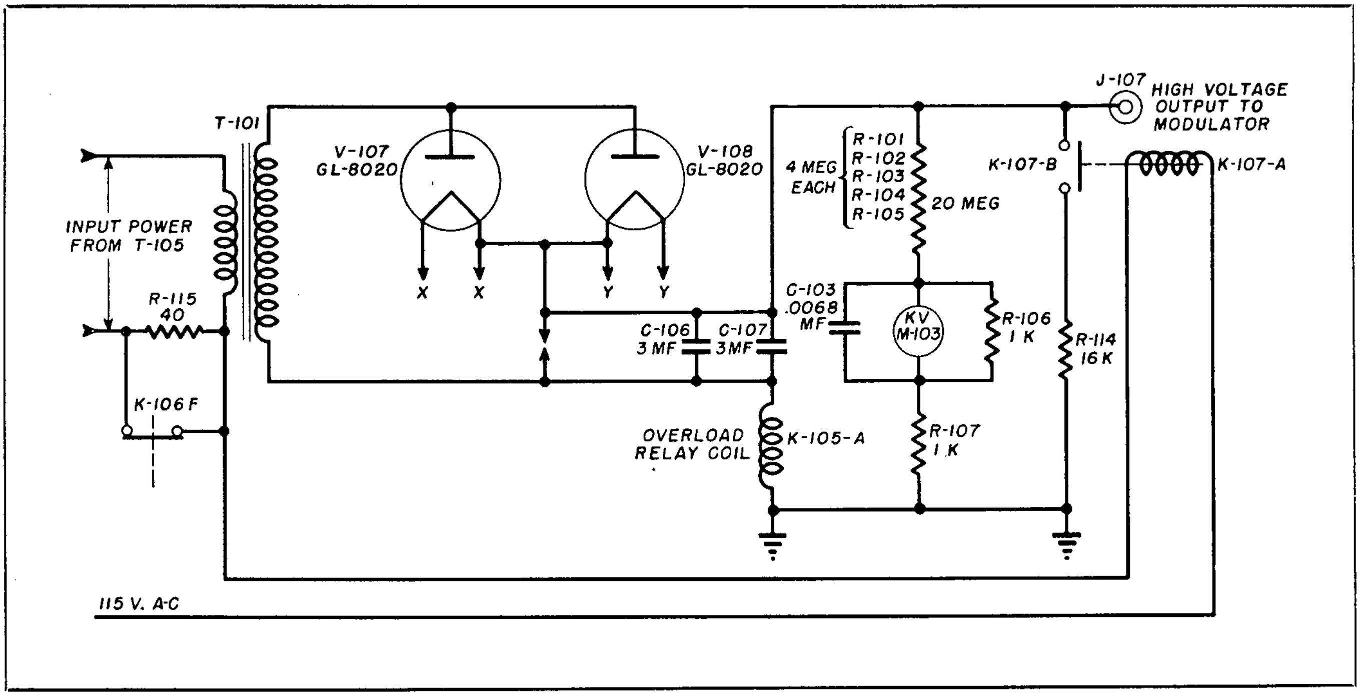


Figure 2-22. SR-a High Voltage Rectifier in Transceiver

primary of transformer T-101. During operation, relay contacts K-106-F close to short circuit resistor R-115 and raise the voltage to 5,000 volts. Relay coil K-105-A is placed between the negative terminal of the power supply and ground. If the current drain becomes excessive this relay is energized and its contacts open, de-energizing relay K-101 which opens the circuit to the primary of the high voltage transformer T-101. The output voltage of the power supply is indicated on meter M-103 which is placed in series with a 20-megohm multiplier across the output. The meter multiplier consists of five 4-megohm resistors. Resistor R-114 is a bleeder resistor that is connected across the output of the power supply when relay contacts K-107-B close or when the access door to the power supply is opened. Opening this door closes the switch that is built into relay contacts K-107-B. Relay K-107 is normally energized during operation and under this condition its contacts are open. When power is turned off, its contacts close and the high voltage capacitors are discharged through the low resistance of the bleeder. The output from the power supply is taken from connector J-107 and applied to the pulse forming network in the Modulator.

e. TRANSMITTING OSCILLATOR.

(1) The transmitting oscillator is shown in Fig. 2-23. With two exceptions it is the same as the transmitting oscillator used in the SR Equipment. The modulating pulse is applied to the plates. The pulse has an amplitude of approximately 15 kv. and is obtained from the output of transformer T-110 as shown in Fig. 2-23. The input to this transformer is a 6 to 8 kv. pulse obtained from the output of the Modulator. The other principle change is in the grid circuit where the Keyer Unit circuits have been replaced with the resistors as shown in the figure. The capacity which is charged by the flow of grid current is the distributed capacity in the grid circuit which is sufficiently large at the frequencies involved.

(2) The trigger pulse for the indicating components of the equipment is secured from the grids of the transmitting oscillator tubes and applied across the primary of the trigger output transformer T-108 as shown in Fig. 2-23. Adjustable resistor R-116 is a potentiometer across the secondary of this transformer to limit the amplitude of the trigger pulse and to permit it to be adjusted so as to provide a proper triggering pulse for the operation of the equipment under diffierent possible conditions. The method of adjusting the amplitude is relatively simple. The CHALLENGE switch on the IFF Coordinator Unit is placed in the ON position and the amplitude of the trigger pulse is adjusted by a screw-driver until both the IFF sweep and the Range sweep appear steadily on the face of the Range Scope in the Indicator Console. This adjustment was not included in the SR Equipments, and it is made by a screwdriver through one of the holes in the lower left-hand side panel of the transceiver where the potentiometer is located.

(3) The plate current through the transmitting oscillators is measured by meter M-104, which is in series with the cathode circuit of the transmitting oscillator tubes V-109 and V-110. This meter, the CATHODE CURRENT meter, is in the top row of meters on the Transceiver, and measures the exact current flowing in the plate-cathode circuit of the trans-

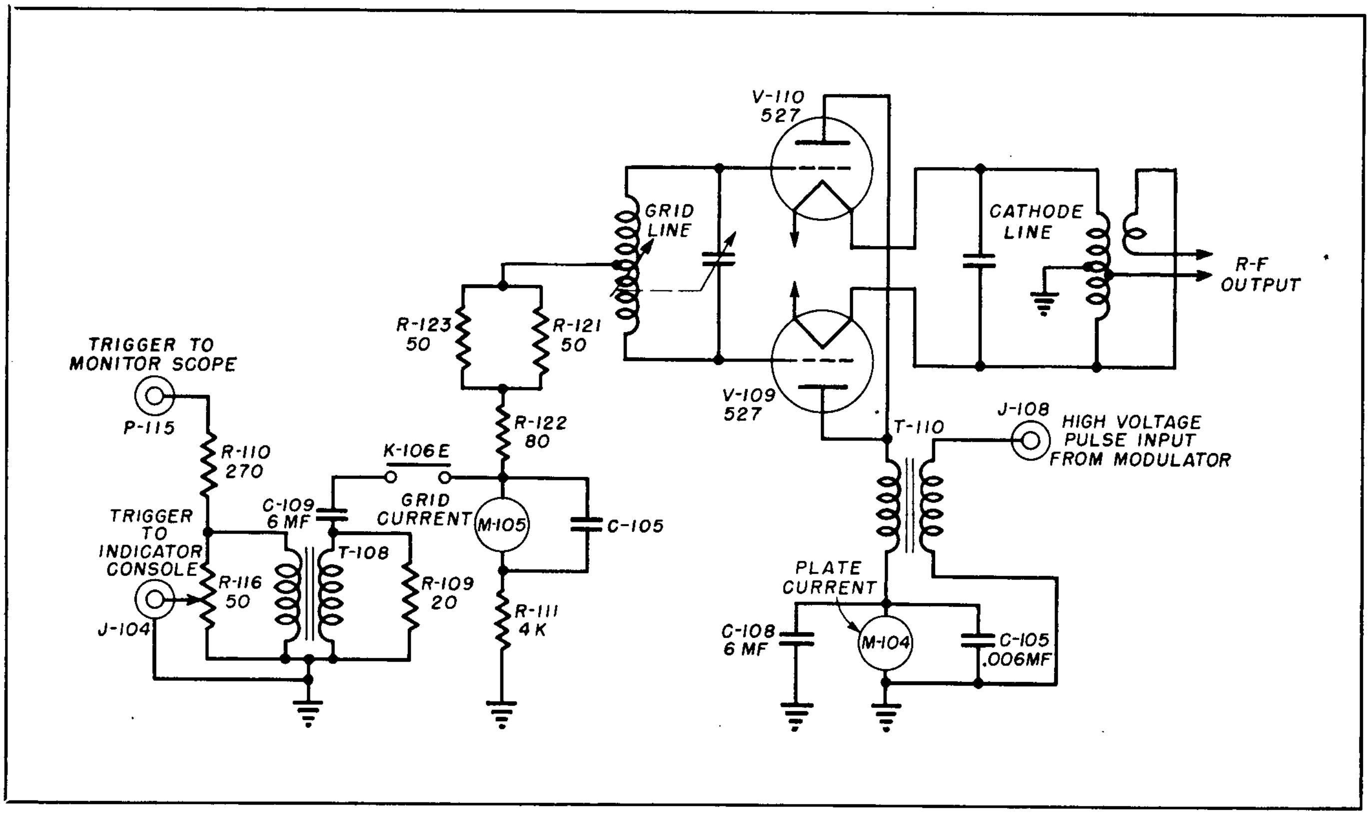


Figure 2-23. SR-a Transmitting Oscillator

mitting oscillator tubes. The voltage from the high voltage rectifier in the Transceiver is metered by PLATE VOLTS meter M-103 on the Transceiver and PLATE VOLTS meter M-401 on the General Control Unit in the Indicator Console. This is *not* the actual voltage applied to the transmitting oscillator tubes as in the former SR Equipments, but represents the actual voltage applied to the Modulator. This voltage is approximately one-third of the voltage applied to the oscillator tubes, as explained previously. Since the voltage applied to the plates of the transmitting oscillator remains the same, the high voltage rectifier circuit has been changed from a voltage doubler to a half-wave rectifier, and its maximum output is five kv. When the voltage reads five kv. on the PLATE VOLTS meter M-103 and the transmitting oscillator tubes are drawing their normal current load, the meter reading indicates that the peak voltage being supplied to the tubes is in the order of 15 kv. The other metering circuits of the Transceiver perform the same in the SR-a Equipments as in the SR Equipments.

f. CONTROL CIRCUITS.

(1) The filament control and main control circuits are identical in Transceivers CAY-43ACM and CAY-43ADK. The control circuits for the SR-a Equipment which involve the Modulator are different from the corresponding circuits in the SR Equipments. These differences in general, involve the introduction of time delay relay K-2002 in the Modulator, which is required to allow a time delay of five minutes for the type 5C22 thyratron to warm up sufficiently for proper operation. It will be noted from Fig. 2-24 that relay K-2002 is connected so that it acts to connect and disconnect terminals 35 and 36. The main contactor relay K-101 cannot energize and apply power to the high voltage rectifier until terminals 35 and 36 are connected. Relay K-2002 operates with a five minute delay to prevent the application of high voltage until the thyratron V-2006 has had sufficient time to warm up. When the MAIN POWER switch S-101 is in the ON position, power is available through the voltage stabilizer at terminals 2202 and 2203 in the Transceiver. See Fig. 2-24. This a-c power is connected to the correspondingly numbered terminals in the Modulator and when the MAIN POWER switch is operated, the low voltage power supply and the filament supply in the Modulator are turned on. Also, relay K-2002 starts its five minute timing period. At the same time, relay K-102 in the Transceiver is closed and a-c is applied to the filament circuits of the transmitting oscillator tubes. See Fig. 2-13. Timing relay K-104 is started, and following its closing, the POWER ON button may be pressed to close relay K-103. When this relay operates, contacts K-103-C and K-103-D close and apply power to the circuit which closes relay K-101. However, this circuit is held open by the time delay relay K-2002 in the Modulator and cannot operate until relay K-2002 has completed its 5-minute time

delay. Switch S-2005 is placed across the contacts of time delay relay K-2002 to short out the relay and permit the equipment to be started following any brief cut-off of power which might cause the relay to recycle. This switch is *not to be used for starting the equipment following a shutdown of more than a few seconds.* To do so would apply high voltage to the Thyratron V-2006 before its cathode has warmed up and ruin the thyratron. This switch is supplied to quickly restart the equipment if an explosion or shock opens the relay or causes the power to go off for a few seconds.

(2) No further action occurs until relay K-2002 closes. At the end of the five minute period, relay K-2002 closes and energizes relay K-101. When K-101 closes, the FILAMENT meter on the Transceiver that indicates the voltage applied to the filaments of the transmitting oscillator will suddenly jump from its low value to the full rated value. This is due to the shorting out of Inductor L-107 by contacts B of relay K-101. See Fig. 2-13. When relay K-101 is closed, contact H closes to supply power to the RAISE button S-105 to permit the voltage across the primary of high voltage power transformer T-101 to be raised by operation of motor-driven voltage regulator T-105, in the same manner as in the former SR equipments. However, before raising the voltage, RADIATION switch S-108 should be placed in the ON position. As soon as the RADIATION switch S-108 is closed, relay K-106 will close and its contacts K-106-F will apply full voltage to the primary of T-101. Closing relay K-106 will also open the relay K-2001 in the Modulator and permit the pulses from the timing circuits to trigger V-2006 in the Modulator and supply the proper voltage to the transmitting oscillator tubes. Consequently, when the voltage is raised, it will be under load and will be an accurate determination of the power being supplied to the tubes. In the SR equipments, the PLATE VOLTAGE meter indicated the actual voltage applied to the transmitting oscillator tubes. *However, in the SR-a Equipments, the voltage read on this meter is the voltage applied to Modulator CAY-50AGU.* This voltage is about one-third of the voltage applied to the oscillator tubes. This means that the voltage should be raised to about five kilovolts in order to secure the operating voltage of 15-kv. on the plates of the tubes.

(3) If the RADIATION switch, S-108, is not ON when the voltage is raised, the meter reading will not represent the full load potential, and the voltage will actually increase when the RADIATION switch is operated. This will overload the transmitting oscillator tubes and should be avoided. The RADIATION switch, S-108, breaks the circuit to relay K-106 and its contacts close. Contacts K-106-B close to energize relay K-2001 in the modulator. This removes the short circuit from the grid of V-2006. Contacts K-106-F close, short circuiting resistor R-115 to raise the output of the power supply to 5 kv. The RAISE and LOWER buttons cause the motor-driven voltage regulator to raise or lower the high voltage when the POWER ON or POWER OFF buttons are pushed, as described in paragraph 4*i* of this section. It should be pointed out that the five-minute time delay relay K-2002 in the Modulator will not recycle, unless the MAIN POWER switch is first turned OFF or unless a fuse in the main a-c circuit open up. When the high voltage is raised, following any stoppage of the equipment, the RADIATION switch should be ON so that resistor R-115 is short circuited. If the switch is OFF and the voltage is raised to 5 kv. with resistor R-115 in the circuit, operating the RADIATION switch will cause the voltage to suddenly rise to an abnormal value. In the SR-a Equipments, the connections of switch S-119, one of the cam-operated switches in the voltage regulator assembly, have been changed so that the RADIATION switch will be effective at all voltages instead of at 4.5 kv. as on the SR series equipments.

6. R-F TRANSMISSION SYSTEM.

a. GENERAL.

(1) The radio frequency system of the Navy Model SR Radar Equipment includes the parts and components which conduct r-f energy from the Transceiver to the Antenna where it is radiated into space. These same components pick up the returning echo signals from the target and conduct them to the receiving components of the Transceiver Console. Part of the duplexer is involved in this system. However, since the duplexer is an integral part of the Transceiver, it was described in relation to the Transceiver.

b. ANTENNA CABLES.

(1) The line which conducts the r-f energy from the Transceiver to the Antenna Pedestal, is a 50-ohm solid dielectric RG-20/U cable. The cable which conducts the IFF Transmitter pulse, and returns the IFF echo signal to the IFF Receiver, is an RG-10/U. The output of the transmitting oscillator is coupled through the tuning stubs and the duplexer to the Antenna Cable. The output of the Transceiver is 50 ohms, matching the input impedance of the cable. From this point, the r-f energy is conducted to the base of the Antenna Pedestal by the RG-20/U solid dielectric line. The output from the IFF Transmitter is also conducted to the base of the Pedestal by coaxial line. At this point, both lines couple to the T-joint at the base of the Pedestal. The radar coaxial coupling is on one side of the Pedestal and the IFF connector on the other. The Radar Transmitter output is connected to the large coaxial coupler extending from the T-junction, and the output of the IFF transmitter is connected to the small coaxial coupler. These couplers are tapered to match the impedance of the cables to

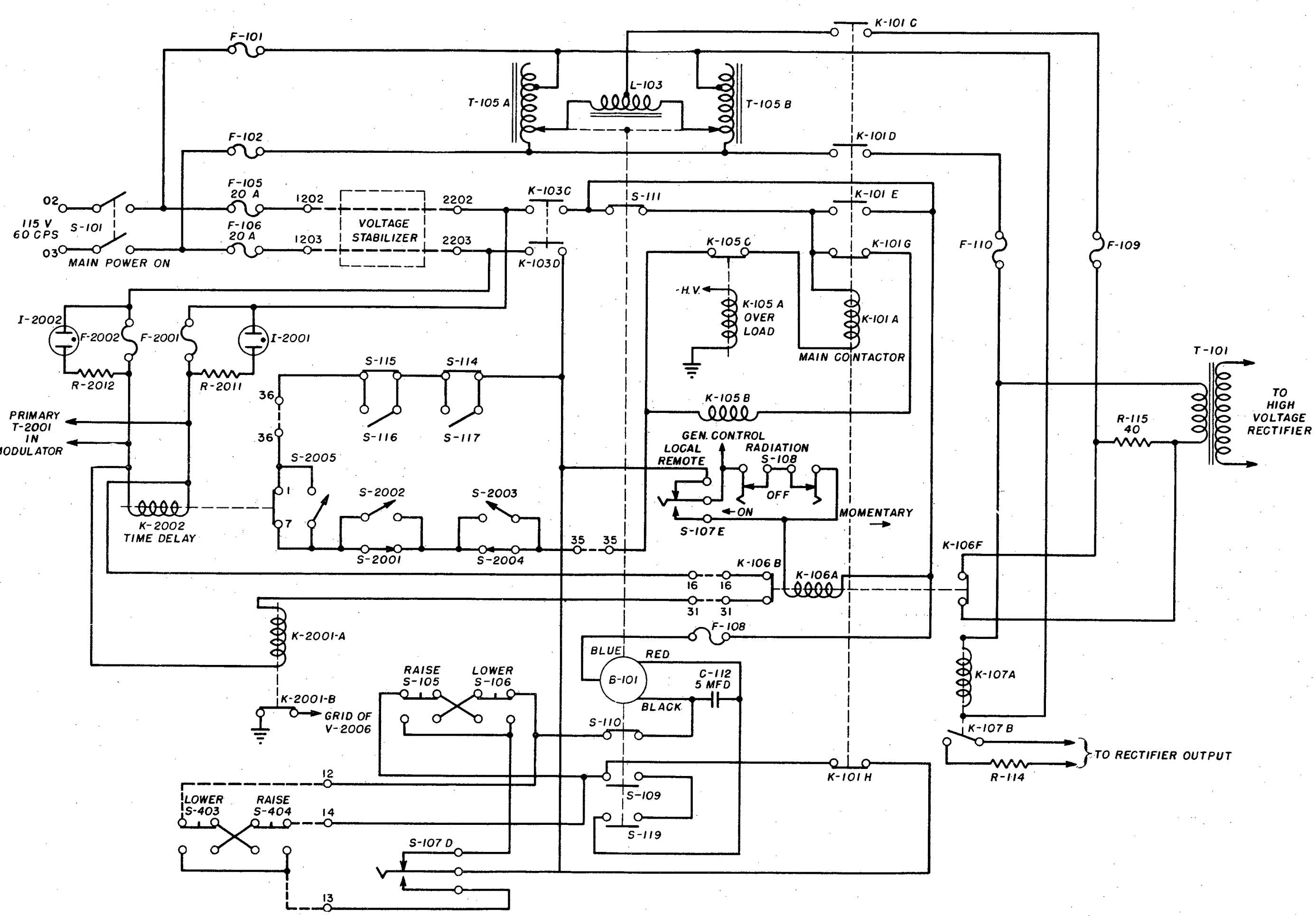


Fig. 2-24. SR-a High Voltage and Radiation Control Circuits

the impedance of the transmission lines in the Antenna Pedestal.

c. R-F LINES IN ANTENNA PEDESTAL.

(1) The radar and the IFF lines connect to their respective antennas through a double concentric line. This line passes through the center of the Pedestal as shown in Fig. 2-25. The inner coaxial line is the transmission line for the IFF equipment. This line consists of a center conductor with ceramic spacers and a metal tube surrounding it. This copper tube forms the outer conductor of the IFF concentric line and also serves as the inner conductor for the radar transmission line. Ceramic spacers center this tube inside another tube. This second tube forms the outer conductor for the radar coaxial line. Since these lines are concentric at the point where they pass through the Antenna Pedestal base, a common rotary joint is located in the middle of the Pedestal base for the two concentric lines. See Fig. 2-25. Radio frequency energy from the radar Transmitter in the Transceiver and the IFF Transmitter are connected to the system as indicated in Fig. 2-25. The tapered sections are used as reducing sections to match the air dielectric lines in the Antenna Pedestal to the solid dielectric cables.

(2) From an examination of Fig. 2-25, it may be seen that a short circuit would be placed across the radar transmission line if the outer conductor of the IFF line were grounded at the T-joint. To prevent this, the radar line extends back to the IFF connector where it is short circuited. The length of this section of line is electrically a quarter-wavelength long. Therefore, the reflected impedance at the T-joint is almost infinite and the r-f energy is free to pass the T-joint and travel up the line in the Antenna Pedestal to the Antenna. Since the impedance of the vertical section of transmission line in the Pedestal is 50 ohms, practically all of the energy enters it and very little energy is dissipated in the quarter-wave section.

(3) The same condition is in effect in the upper section of the vertical coaxial section where the radar and IFF lines separate. The radar line to the impedance balancing converter is connected at a point that is a quarter-wave length below the short circuited point in the coaxial line. This forms a quarter-wave section which reflects a high impedance at the point where the radar line turns to go to the converter. Radio frequency energy, therefore, flows in the low-impedance line to the converter. The impedance balancing converter is used to balance both sides of the coaxial line to ground electrically. Since one side of the coaxial line from the Transmitter operates at ground potential, it is necessary to raise this grounded side above ground potential before feeding the energy to the antenna dipoles.

(4) The impedance balancing converter is shown schematically in Fig. 2-25. Both the main radar and the IFF Antennas are balanced by means of converters, as shown. Consider the main radar balancing converter shown in Fig. 2-25. The converter consists of a quarter wave section of line placed concentrically with the main coaxial transmission line feeding the radar Antenna. The end of this quarter-wave section that is farthest from the end of the transmission line is grounded to the outer conductor of the coaxial line. The opposite end of the converter is open circuited, since it is closed with an insulating material. The operation of the converter is as follows. A quarter wave section of coaxial line short-circuited at one end presents an infinite impedance at the other end. The outside of the coaxial line is at ground potential throughout its length to the point where the converter is connected. This point is represented as A in Fig. 2-25. The outside of the converter is at ground potential as shown. Since an infinite impedance appears across the open end of the converter and the outside of the converter is at ground potential, the outer conductor of the coaxial line, which is the inner conductor of the converter, is removed from ground by the infinite impedance. The high impedance point of the outer conductor is represented by point B in Fig. 2-25. This balances the transmission line feeding the dipoles with respect to ground. The converter used with the IFF dipoles operates in a similar manner.

7. RADAR ANTENNAS.

a. GENERAL.

(1) Either of two antennas may be used in the SR system to radiate energy from the radar Transmitter. They are known as the Blue Antenna and the Yellow-Green Antenna. The two antennas are alike mechanically and functionally; their only difference is that they operate on different frequency bands and the length of the dipoles of the two antennas is slightly different. Two antennas are necessary with the SR system in order that the desired frequency range may be covered.

b. BLUE ANTENNA.

(1) The Blue Antenna is designed to cover the frequency range of 215 mc. to 225 mc. The Antenna consists of a metal screen on which are mounted the dipoles which form the radiating elements of the radar and IFF systems. Also included in the antenna assembly is an impedance balancing converter and connecting feed-lines. These lines feed radio frequency energy to the radiating dipoles. The Antenna is shown in Fig. 2-26. The metal screen which forms the reflector for the Antenna is formed around an outer metal frame. Four side arms brace the antenna framework and terminate at a mounting position at the rear of the pedestal. Eight vertical and three lateral cross-members are used to strengthen the an-

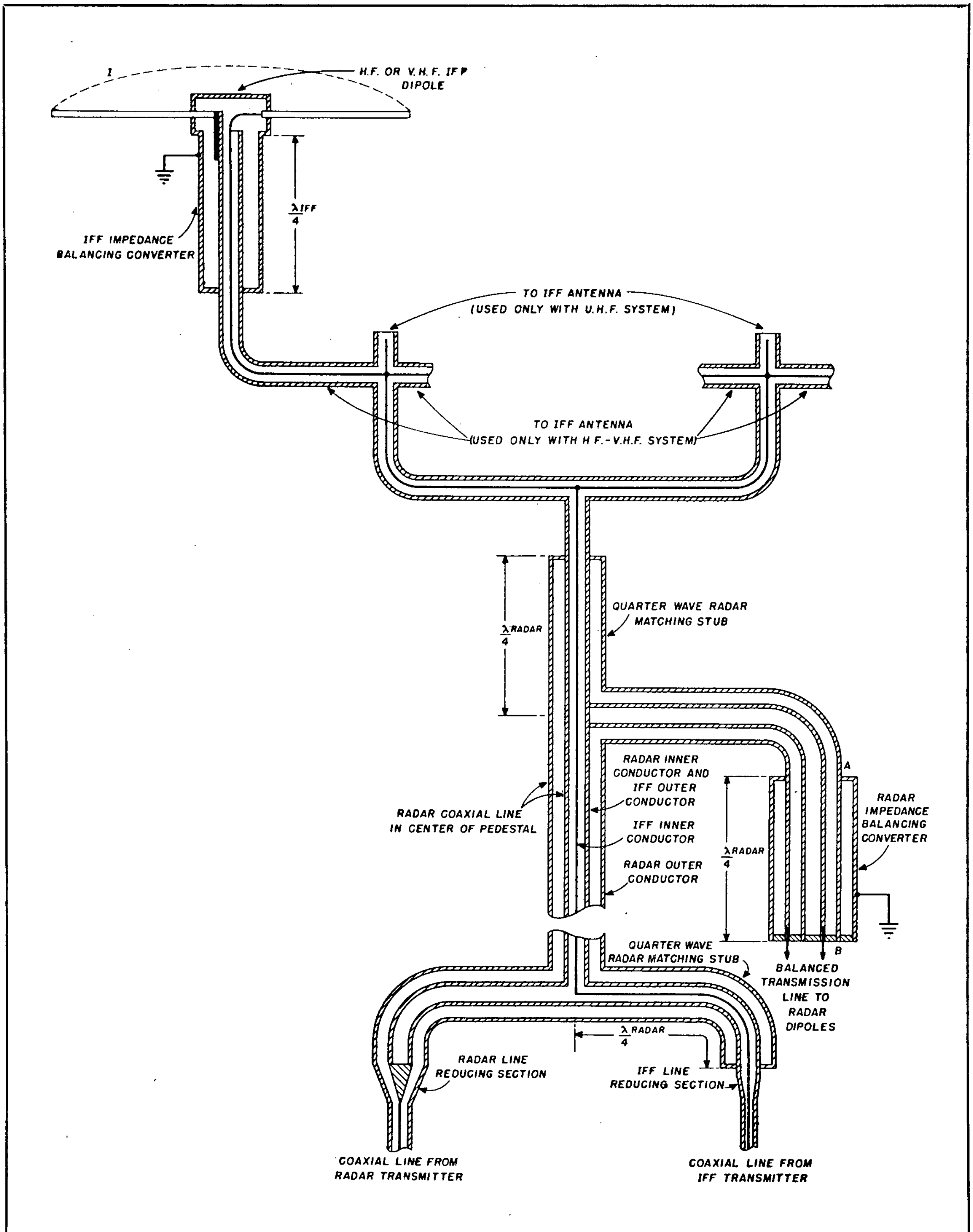


Figure 2-25. SR R.F. Transmission System and I.F.F. Antenna

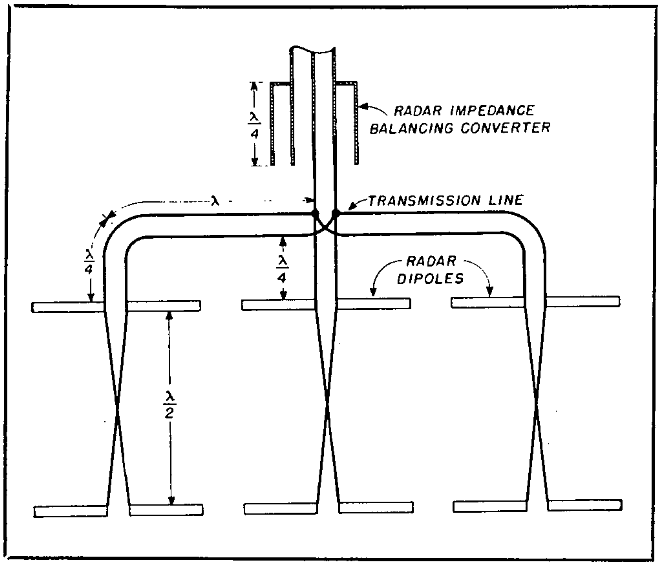


Figure 2-26. SR Radar Antenna

tenna screen and provide rigid points to which the antenna dipoles may be bolted. The converter is located behind the bottom center of the screen. Three two-wire feed-lines are connected in parallel to the termination of the coaxial line at the converter. The three feed-lines run behind the screen and couple to the center of the three bottom pairs of radiating elements through circular apertures in the screen. This parallel connection, together with the balancing converter, matches the 50-ohm line to the three feed-lines.

(2) Three sets of four half-wave dipoles form the radiating array for the radar transmitter. They are placed in front of a diamond mesh metal screen to reflect the radiation of the dipoles and minimize back radiation. Each of the three open wire feed-lines feeds a group of half-wave antenna elements. The half-wave antennas are fed in phase by the feed-lines. See Fig. 2-26. They are voltage-fed, since the feed is to the end of the elements. Each feeds a pair of antenna elements directly. From the first pair of elements, a second pair is fed by a half-wave line which is crossed. Since the lines are each a half-wave long electrically, the two pairs of half-wave antennas are fed in phase with the first pair. Thus, the array consists of twelve half-wave antennas fed in phase. The feed-line to the center four elements is quarter-wave long. The end sets of antennas are fed with lines a full wave long plus impedance changing quarter-wave section. The characteristic impedance of the quarter-wave sections from the full-wave lines has been chosen so that less current is fed to the outside dipole sections. The ratio is approximately 1.4 to 1 with the center set of dipoles carrying 1.4 times the current of each of the two end sets. Its purpose is to reduce the radiation of side lobes by the antenna. The result of this is to narrow the radiated beam and increase the directive effect of the antenna pattern.

c. YELLOW-GREEN ANTENNA.

(1) The Yellow-Green Antenna is identical in construction and function to the Blue Antenna, with the exception of a slight difference in the dimensions of the reflector and the length of the dipoles. This change in dimensions is such that the Yellow-Green Antenna covers the frequency range of 190 mc. to 200 mc.

8. IFF ANTENNAS.

a. GENERAL.

(1) Three sets of IFF Antennas are provided to be used with the Blue or the Yellow-Green radar Antenna. They are the high-frequency, very-high frequency, and ultra-high-frequency antennas. The selection of the antenna to be used depends upon the frequency range to be covered. The names of these antennas are abbreviated to H.F., V.H.F., and U.H.F., respectively. The IFF Antenna sections are mounted on the top portion of the main radar Antenna screen. Eight brackets are assembled to the main radar Antenna to hold the IFF Antenna. Four brackets are used with the H.F. and V.H.F. systems and the other four are used with the U.H.F. system.

b. H.F. IFF ANTENNA.

(1) The H.F. IFF Antenna shown in Fig. 2-25 consists of four sets of vertical current-fed half-wave antennas. R-F energy is coupled to these antennas by means of a coaxial line from the top of the Antenna Pedestal. The transmission line is coupled to the dipole assemblies through impedance balancing converters to provide a proper balance to ground for both dipole elements. The operation of this converter is the same as that used for the main radar Antenna previously described. The H.F. Antenna is of the proper length to be resonant at 165 ±5 mc.

c. V.H.F. IFF ANTENNA.

(1) The V.H.F. IFF Antenna shown in Fig. 2-25 is identical in construction to the H.F. Antenna, with the exception that the dipoles are slightly shorter, so that the V.H.F. Antenna is resonant at a higher IFF frequency. It is designed to be resonant at 183 ±4 mc. When the frequency of the IFF equipment is changed from H.F. to V.H.F., the Antenna changes require only that each of the four sets of H.F. dipoles be unscrewed from the converter feeding them, and that they be replaced by the V.H.F. dipoles.

d. U.H.F. IFF ANTENNA.

(1) The U.H.F. IFF Antenna system shown in Fig. 2-27 employs a different dipole assembly containing 24 dipoles, and is tuned to an IFF frequency range of 470 mc. to 493.5 mc. The antenna is vertically polarized and is two dipoles high and 12 dipoles wide. The antenna consists of four voltage fed dipole arrays fed by two impedance balancing converters. The

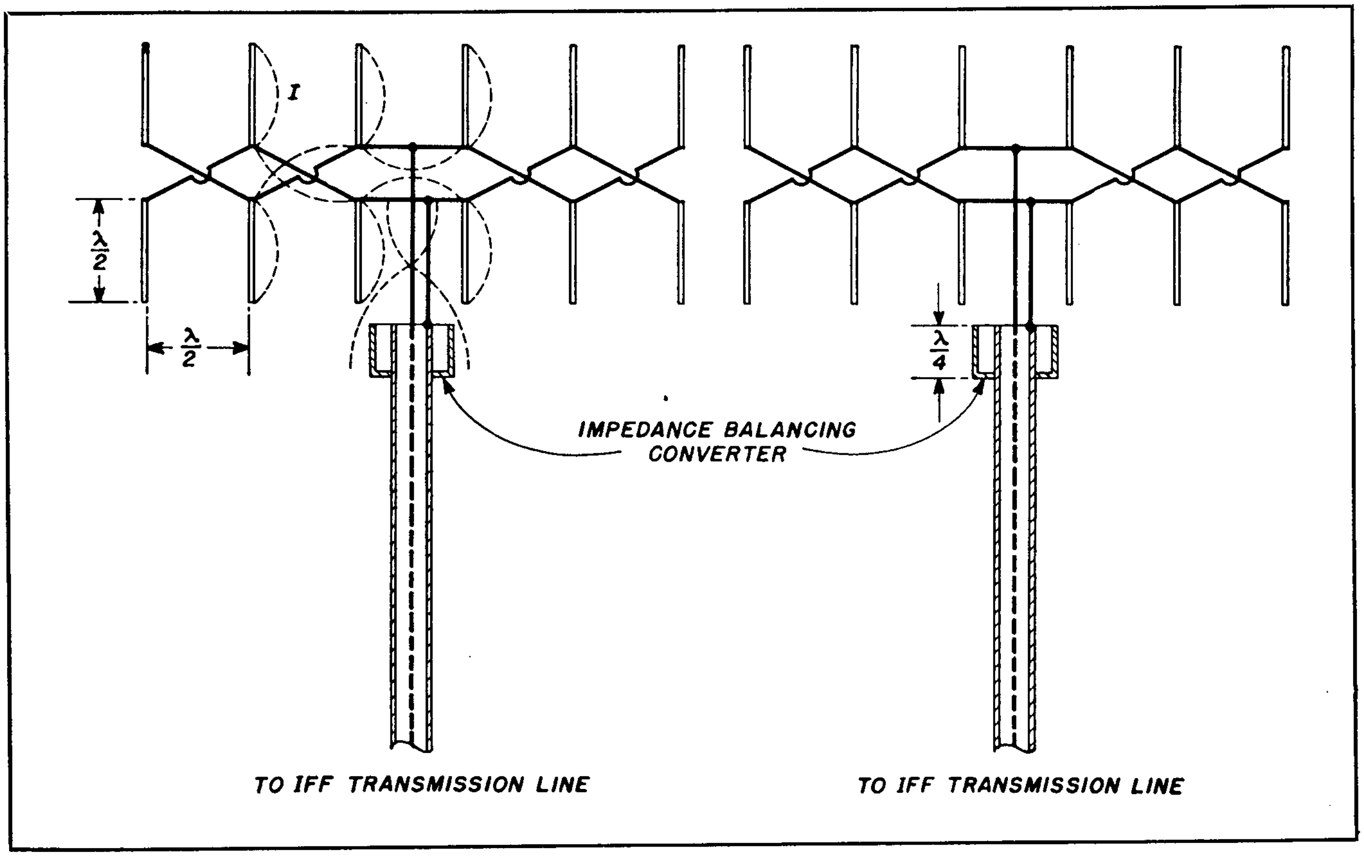


Figure 2-27. U.H.F. I.F.F. Antennas

dipole frames and converters bolt to the screen brackets, and the converters attach to the IFF coaxial line. Connection to the converter is completed by a plug connection to the inner coaxial conductor of the IFF line and a screw connection on the outer conductor of the IFF line. The terminal screws on the front of the converters pass through and bolt to the terminal lugs on the dipole array frames. In order to change from the V.H.F. Antenna to the U.H.F. Antenna it is necessary to remove the four H.F. or V.H.F. feed-lines from the T-joints and replace them with the U.H.F. array.

9. ECHO BOX ANTENNA.

a. The Echo Box Antenna supplies the Echo Box in the Monitor Receiver with the signal picked up from the Transmitter. It consists essentially of a current-fed half-wave dipole, and is shown schematically in Fig. 2-28. As shown, the center conductor of the coaxial input line is extended a quarter-wavelength beyond the outer conductor. The outer conductor is folded back upon itself as shown to form a quarter-wave shield. This shield is in effect a quarter-wave coaxial line, short-circuited at the end nearest the extended center conductor of the input line, and open-circuited at the other end. The center conductor of this line is formed by the outer conductor of the input line. An infinite impedance is presented at the end of the shield a quarter-wavelength from the short-circuited end which connects to the outer conductor of the input line. The effect of this arrangement is to form a half-wave antenna, current-fed in the center. No matching sections are necessary, since the center impedance of a half-wave antenna is approximately 70 ohms—the same as that of the coaxial line. The current distribution on the antenna is as shown in Fig. 2-28.

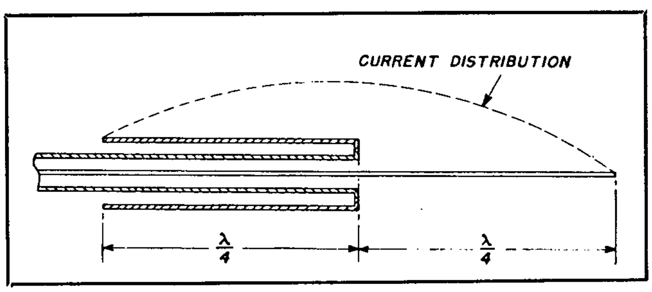


Figure 2-28. Echo Box Antenna

10. MONITOR RECEIVER CAY-46ADK.

a. GENERAL.

(1) The Monitor Receiver is the same in both the SR and SR-a equipments. It is the first component in the receiving system and since it must be located as near to the duplexer as possible, it is assembled in a compartment in the Transceiver cabinet. The purpose of the Monitor Receiver is to amplify and convert the received signal to a signal of lower frequency that can

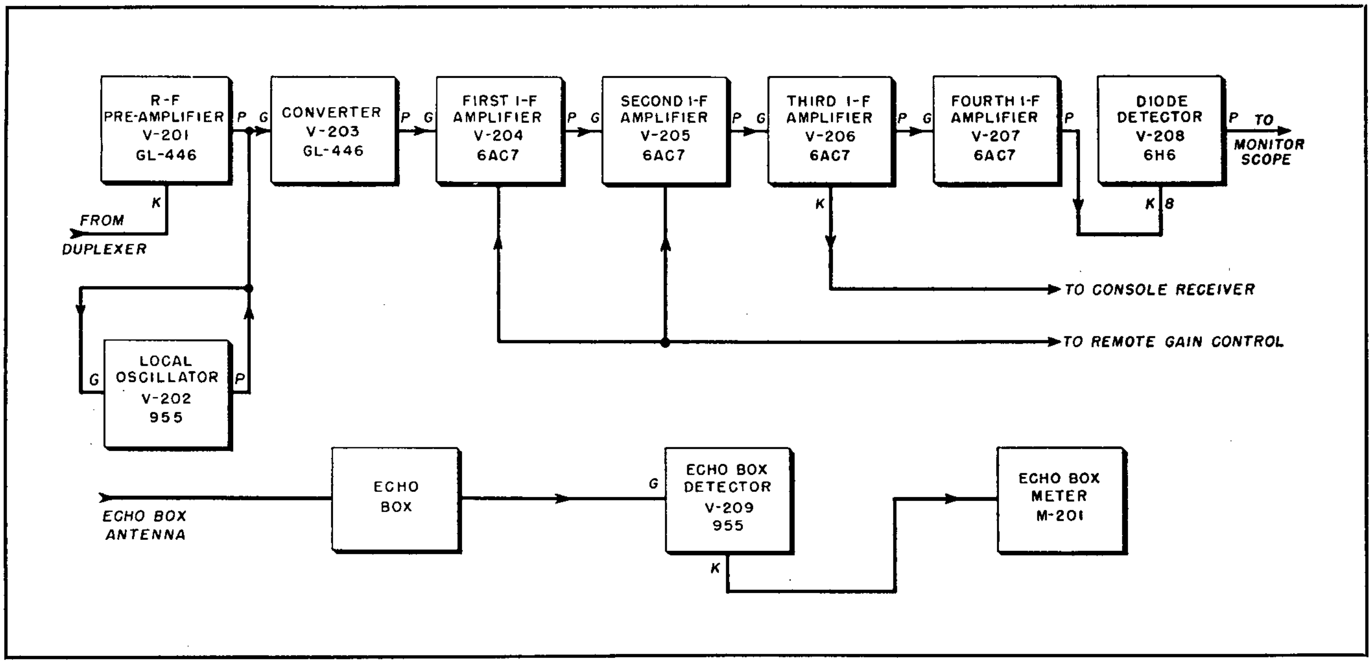


Figure 2-29. Monitor Receiver, Block Diagram

be transmitted to the Indicator Console with a minimum amount of loss. A block diagram of the Monitor Receiver is shown in Fig. 2-29. The input from the duplexer is applied to the cathode of the r-f preamplifier V-201. The r-f pulse is amplified in this stage and the output is injected on the grid of the converter V-203.

(2) The local oscillator V-202 generates a frequency that is 15 mc/s above the received signal. The output of the local oscillator is injected on the control grid of the converter tube. The heterodyned signals are rectified by the converter to produce a difference frequency of 15 mc/s which is coupled to the input of the first i-f amplifier. There are four stages of i-f amplification. The gain of the first two stages may be controlled from the front panel of the Monitor Receiver or it may be controlled remotely from the Indicator Console. The third i-f amplifier delivers two outputs. The one taken from its cathode is coupled through the interconnecting cabling to the Console Receiver in the Indicator Console. The other output taken from the plate of V-206 is coupled to the fourth i-f amplifier. The fourth i-f amplifier is necessary to provide sufficient amplitude for the video signal to the Monitor Scope. The output of the fourth i-f amplifier is coupled to the diode detector which demodulates the signal to produce a video signal for the Monitor Scope. The echo box circuits are also located in the Monitor Receiver. The r-f energy picked up by the Echo Box Antenna is coupled to the echo box. The resonant energy in the echo box is coupled to the grid of a diode detector where it is rectified and the rectified current is measured with a d-c milliammeter.

(3) In addition to the circuits represented in the block diagram in Fig. 2-29, the Monitor Receiver also contains its own power supply. The power supply provides heater voltages and d-c plate voltage for all of the tubes in the Monitor Receiver. The circuits shown in the block diagram are described in the following paragraphs.

b. R-F PREAMPLIFIER.

(1) The r-f preamplifier is shown in the simplified diagram of the r-f circuits in Fig. 2-30. The tube is designated V-201 and is a type GL-446. This type of tube is commonly called a *lighthouse* tube because its physical appearance resembles the appearance commonly associated with lighthouses. The r-f input from the duplexer is coupled into the cathode circuit. The cathode circuit consists of a parallel resonant LC circuit in series with the cathode resistor of V-201 and ground. This circuit is tuned by capacitor C-201 which is controlled from the front panel. The input voltage is coupled in at a tap on inductor L-201 that has an impedance of 50 ohms when the circuit is tuned to its resonant frequency. The cathode of V-201 is coupled to a tap on the inductor located at a point where the impedance equals the input impedance of the tube. The r-f signal taken from this point is capacitively coupled to the cathode of V-201 through the built-in capacitor in the base of the tube. The capacity between the metal shell of the tube and the cathode is approximately 100 mmf. This capacitance shunts the cathode resistor and the voltage across the tuned circuit is coupled directly to the cathode. The grid of V-201 is ground. This arrangement prevents regeneration and stabilizes the circuit. As the cathode potential changes with the input signal, the plate current varies accordingly and the output across the

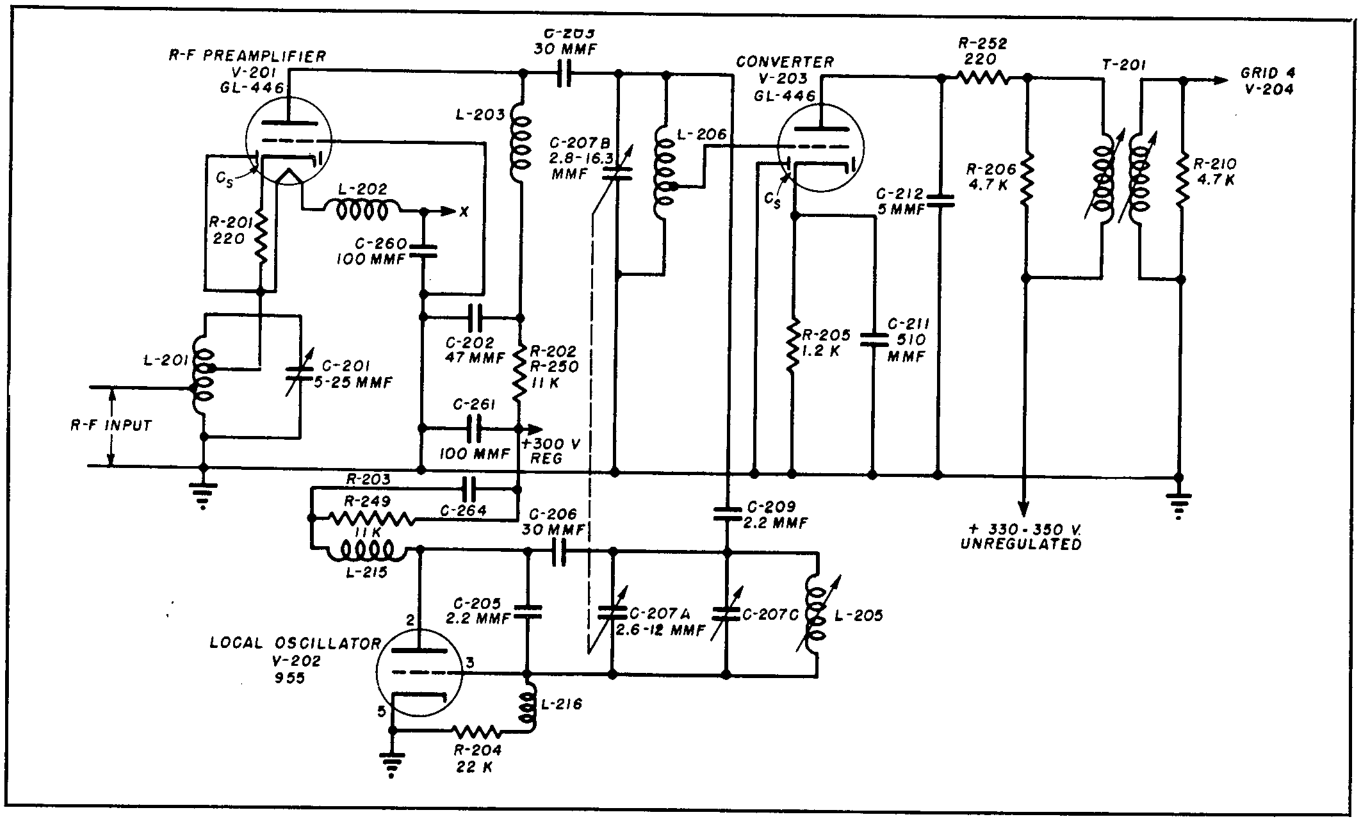


Figure 2-30. R-F Circuits in Monitor Receiver

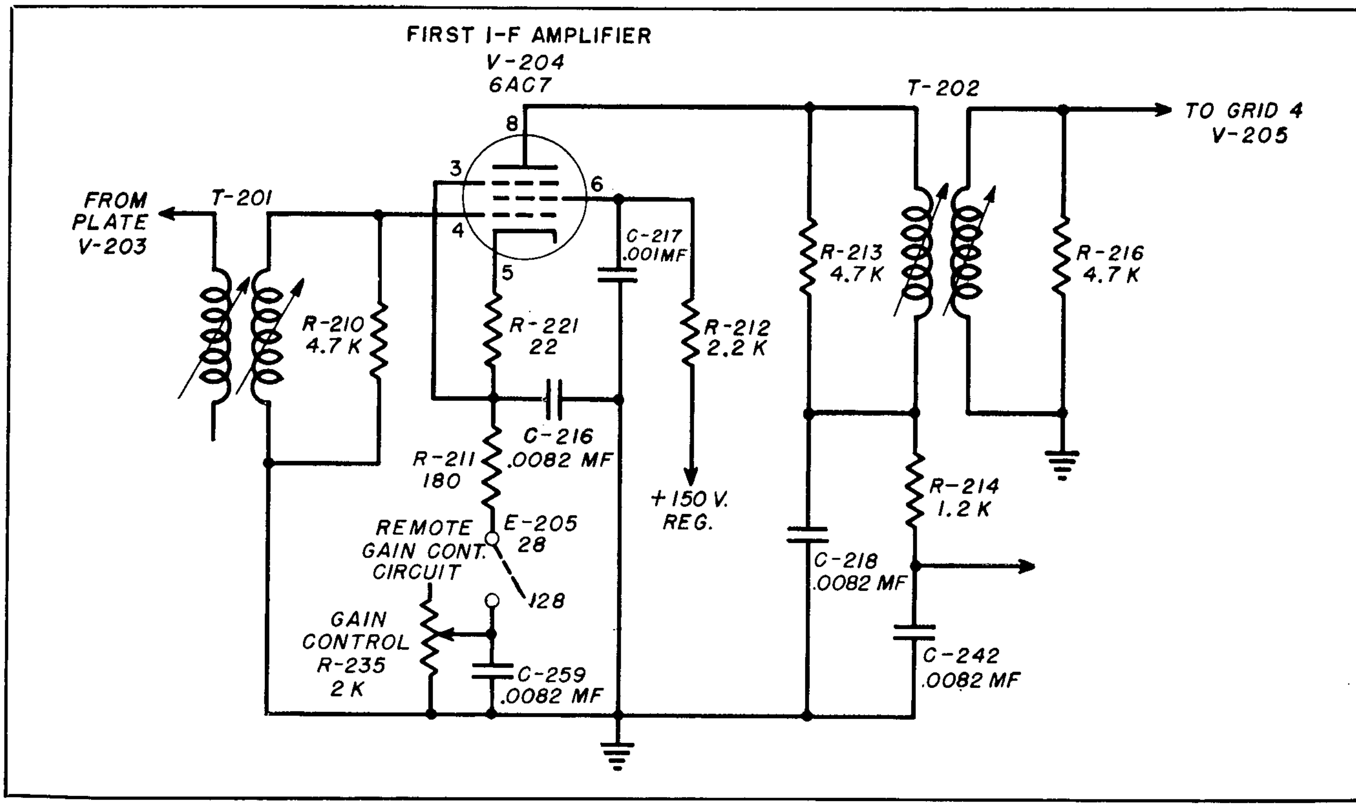
plate load is an amplified reproduction of the input signal. The heater of V-201 is connected to the output tap on inductor L-201 and is at the same r-f potential with the cathode. This prevents the cathode-heater capacity from by-passing part of the signal to ground and therefore reduces losses in the circuit. Inductor L-202 and capacitor C-260 act as an r-f filter preventing r-f energy from entering the rest of the heater circuits. The plate of the amplifier is shunt fed through the r-f choke L-203. Resistor R-202 and capacitors C-202 and C-261 act as a decoupling circuit for the regulated plate supply. This circuit is necessary to prevent the local oscillator from being affected by the r-f signal frequency. The plate load is capacitively coupled to the plate of V-201 through capacitor C-203. The plate load is a parallel resonant circuit consisting of inductor L-206 and capacitor C-207-B. This capacitor is ganged with capacitor C-207-A in the local oscillator circuit so that the preamplifier always tracks accurately with the local oscillator. The output from the local oscillator is coupled to the top of inductor L-206. The r-f signal frequency and the local oscillator are heterodyned at this point and the heterodyned frequencies are coupled directly to the grid of the converter from the low impedance tap on inductor L-206. The impedance looking in at the tap is equal to the input impedance of the converter.

c. LOCAL OSCILLATOR.

(1) The local oscillator is V-202 in Fig. 2-30. It employs a type 955 triode in an ultra-audion oscillator circuit. This type of oscillator is equivalent to a Colpitts oscillator and depends upon the plate-grid and grid-cathode capacitances to effect the voltage division necessary to obtain the correct phase and amplitude of driving voltage on the grid. The plate is shunt fed through resistor R-203 and the plate load is inductor L-205 and capacitors C-207-A and C-207-C. C-207-A is the tuning capacitor and it is ganged to capacitor C-207-B in the plate circuit of V-201 to enable the two circuits to be tuned simultaneously. Capacitor C-207-C is a trimmer capacitor used to tune the circuit so that it tracks with the preamplifier. The output of V-201 is 15 mc/s above the r-f signal and capacitively coupled through capacitor C-209 to the top of inductor L-206 in the grid circuit of the converter.

d. CONVERTER.

(1) The converter, shown in Fig. 2-30, employs a type GL-446 tube as a square law detector. A triode is used in this stage because its equivalent noise resistance is much lower than the resistance encountered in other types of tubes. Bias for V-203 is obtained from the resistor R-205 in its cathode circuit. The cathode is by-passed to ground through capacitor C-211 and the shell-to-cathode capacity of the tube. The plate is by-passed for r-f by means of capacitor C-212. The reactance of this capacitor is so high at the intermediate frequency that it has no effect on



Figure, 2-31. First I.F. Amplifier in Monitor Receiver

the i-f signal. This capacitor together with resistor R-252 form an r-f decoupling network in the plate circuit. The plate load is the primary winding of the first i-f transformer T-201. Resistor R-206 shunts this winding to broaden its frequency response so that the side band frequencies of the signal will not be lost. Transformer T-201 is permeability tuned. The secondary winding of the transformer is shunted with resistor R-210 to obtain a wide bandwidth as previously described. The output is connected to the grid of the first i-f amplifier V-204.

e. FIRST AND SECOND I-F AMPLIFIERS.

(1) A simplified schematic diagram of the first i-f amplifier is shown in Fig. 2-31. Since the first and second amplifiers are similar except for part numbers only one stage is shown. The amplifiers employ type 6AC7 tubes designated as V-204 in the first stage and V-205 in the second stage. The amplifiers are transformer coupled with permeability tuned coils. The capacitance required to resonate the coils is their own distributed capacity and the tube capacities. The 22-ohm resistor R-221 is not by-passed in order to obtain a small amount of degeneration which is necessary to prevent the amplifier from being detuned when its bias is varied with the gain control. The gain may be controlled remotely from the Indicator Console or with the potentiometer R-235 in the Monitor Receiver. When the gain is controlled locally, the LOCAL-REMOTE switch in the Transceiver connects terminal 28 to terminal 128. See Fig. 2-31. When the gain is remotely controlled, the LOCAL-REMOTE switch connects terminal 28 to the gain control in the Console Receiver. The other end of this control is grounded. The output of the second i-f amplifier is transformer-coupled to the grid of the third i-f amplifier.

f. THIRD I-F AMPLIFIER.

(1) The third i-f amplifier is shown in Fig. 2-32. Two output voltages are taken from this amplifier. The input voltage appears across the secondary winding of transformer T-203 which is shunted by resistor R-220 to increase its bandwidth. The amplifier operates as a cathode follower and the output for the Console Receiver is taken from the cathode through coupling capacitor C-221 and appears across the 47-ohm resistor R-227. The resistance of R-227 is made low to match the impedance of the coaxial line to the Console Receiver. The plate load for the amplifier is the tuned inductor L-210. This inductor is resonated by capacitor C-230 and the inductor is tuned by adjusting the position of a powdered iron core. The voltage across the inductor is coupled to the grid of the fourth i-f amplifier through capacitor C-229.

g. FOURTH I-F AMPLIFIER.

(1) The fourth i-f amplifier is similar to the third i-f amplifier except that its cathode is by-passed. The tube used is a 6AC7 designated V-207. The circuit is shown in Fig. 2-33. The amplifier operates with

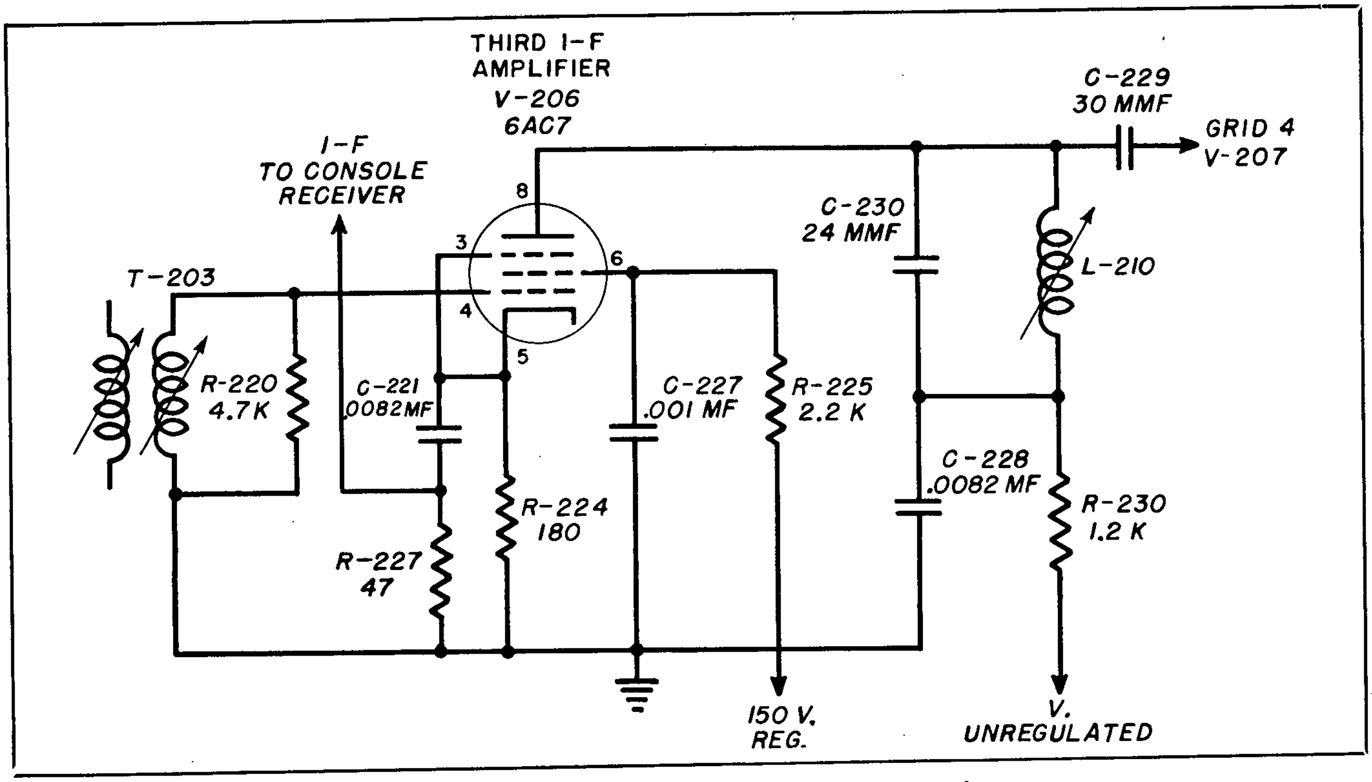


Figure 2-32. Third I.F. Amplifier in Monitor Receiver

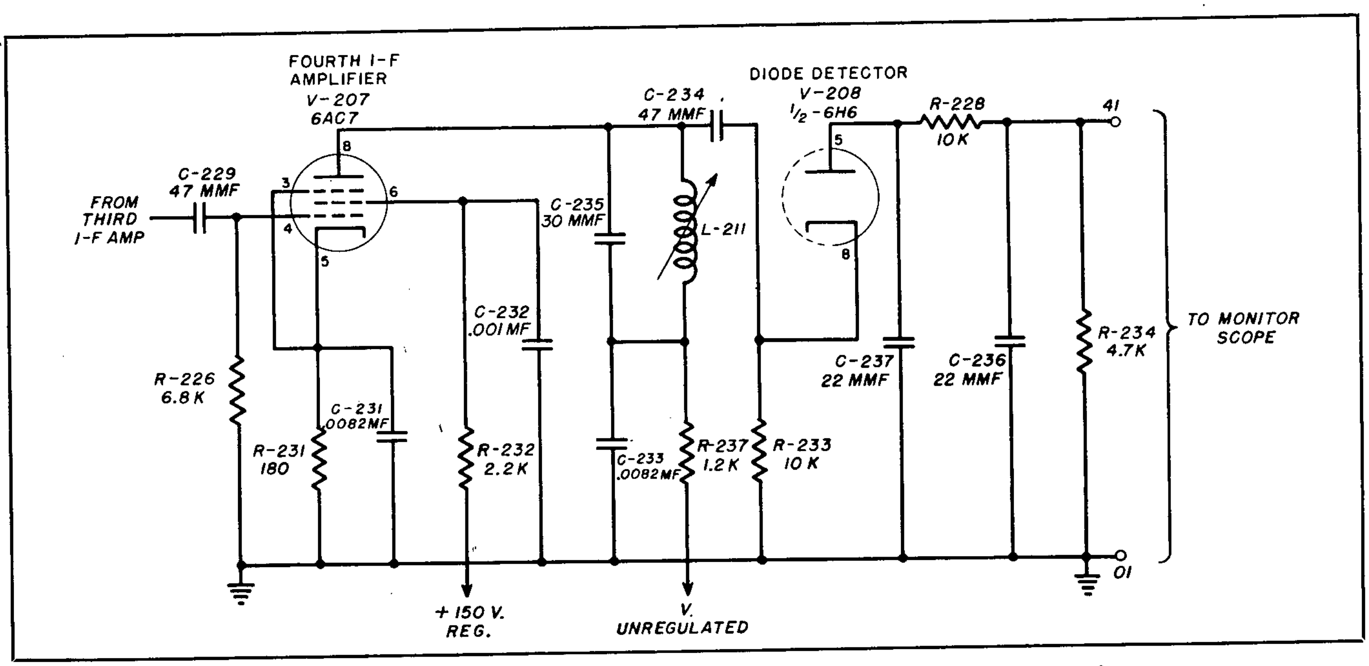


Figure 2-33. Fourth I.F. Amplifier and Diode Detector in Monitor Receiver

class A bias obtained from the drop across a resistor in its cathode circuit. Screen voltage is obtained from the regulated supply and plate voltage is obtained from the unregulated supply. The output across the plate load is coupled to the cathode of the diode detector.

b. DIODE DETECTOR.

(1) The diode detector is shown in Fig. 2-33. It employs one-half of a type 6H6. The other half of the tube is not used, and all of its elements are grounded. The i-f voltage is coupled to the cathode of V-208 through capacitor C-234. Since the diode can conduct in only one direction current flows only during the negative half of the cycle when the cathode is negative with respect to the diode plate. The diode current flows from the cathode to the plate through

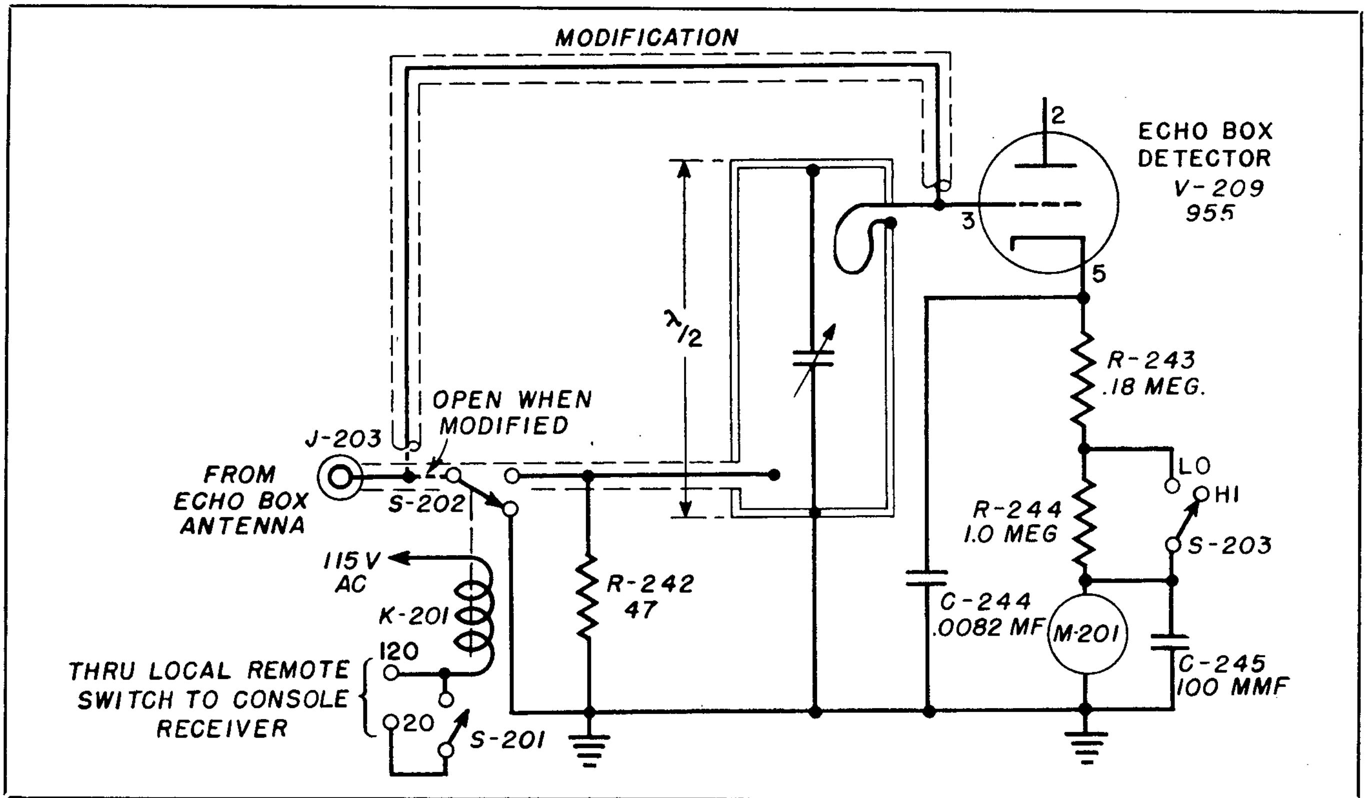


Figure 2-34. Echo Box Circuits in Monitor Receiver

resistors R-228, R-234, and R-233, back to the cathode. The voltage appearing across resistor R-234 is the video output that is coupled to the Monitor Scope. Resistor R-228 and capacitors C-236 and C-237 form a decoupling network to isolate the detector from the Monitor Scope circuits.

i. ECHO BOX.

(1) The echo box circuits are shown in Fig. 2-34. The Echo Box Antenna is connected to connector J-203. Relay K-201 operates switch S-202 to connect the antenna to the resonant line when measurements are to be made and to ground the antenna when the circuit is not being used. It is necessary to ground the antenna to prevent it from radiating an *echo* pulse caused by the *ringing* effect of the transmitted pulse on the echo box. The coaxial antenna line is terminated with the 47-ohm resistor R-242 to obtain a flat line. The signal is injected into the echo box by means of a small exciting probe. The echo box is the electrical equivalent of a half-wavelength and consists of a length of coaxial line short circuited at both ends. An adjustable capacitor in series with the inner conductor tunes the line to one-half wavelength at the transmitter frequency. The resonant line appears as a parallel resonant circuit, excited by an input coupled to a low impedance tap. The output is obtained by means of a coupling loop inserted in the line. The outer conductor of the line is grounded and when the voltage swings positive, the grid of V-209 is made positive and current flows through the type 955 tube which is used as a rectifier. The diode current flows through the meter M-201 and resistors R-243 and R-244. Although the resistors are connected in series with the meter it is calibrated in micro-amperes. Switch S-203 short circuits resistor R-244 to permit greater meter deflection for weak currents.

(2) In the SR equipments, relay K-201 could be operated from the Console Receiver or the Monitor Receiver depending upon the position of the LOCAL-REMOTE switch. The relay operated to connect or ground the antenna as previously described. In the SR-a Equipments the circuit has been modified as shown by the dotted line in Fig. 2-34. When this cable is added, the connection to switch S-202 is removed and the switch, probe, and resistor are permanently removed from the circuit. The input voltage from the antenna is directly connected at the grid of V-209. The energy from the antenna is inductively coupled to the resonant line through the coupling loop, and the diode rectifier and meter shunt this loop. As the tuned line is brought into resonance the circulating current in its inductance increases to high proportions. If a high current is flowing in one winding of a transformer, a proportionally high current will flow in the other winding. In this case, when the line is tuned to resonance the current through the coupling loop increases. This lowers the voltage applied to the grid of V-209 and causes a corresponding reduction in

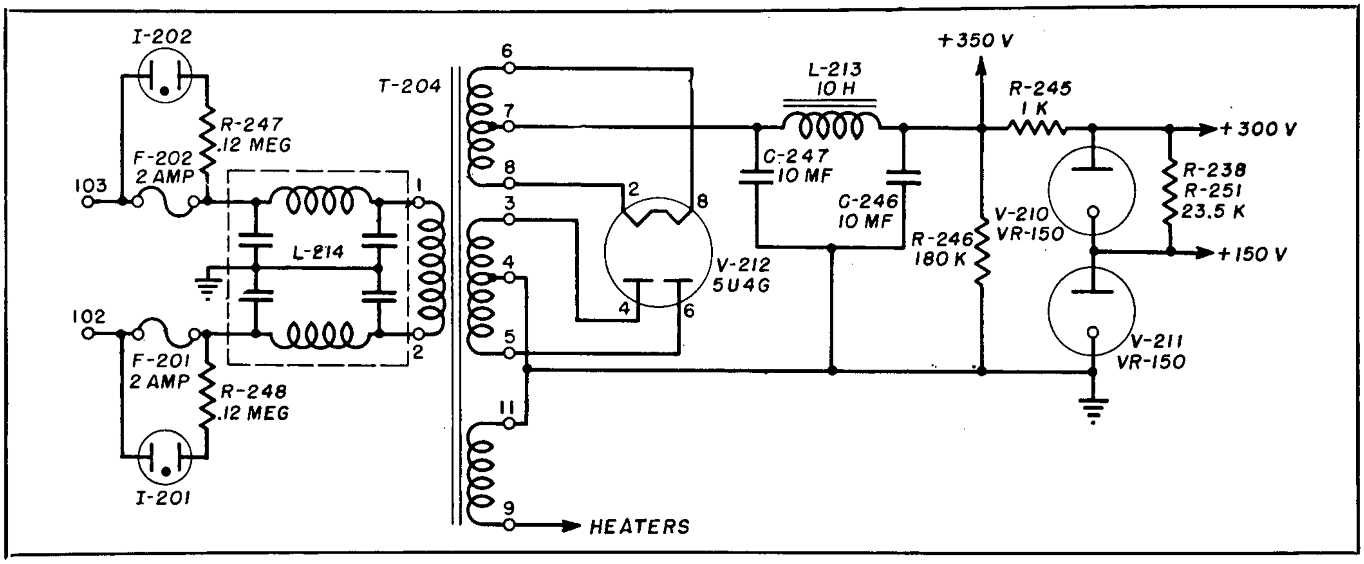


Figure 2-35. Power Supply in Monitor Receiver

the rectified current with the result that the meter deflection decreases.

j. POWER SUPPLY.

(1) The power supply in the Monitor Receiver supplies plate and heater voltages for all of the tubes in the Receiver. The circuit is shown in Fig. 2-35. The a-c input voltage passes through the r-f line filter L-214 to the primary winding of the power transformer T-204. The output of this transformer consists of heater voltage for the rectifier tube V-212, high voltage for its plates and heater voltage for the receiving tubes in the circuit. V-212 is a type 5U4G used in a full-wave rectifier circuit. The rectifier heater winding is center tapped and the tap is connected to a capacitor input filter. This filter consists of capacitor C-247, inductor L-213 and capacitor C-246. A bleeder resistor, R-246 is connected across the output of the power supply to improve the voltage regulation. The output voltage taken from this point is applied to the plates of the i-f amplifiers and the converter. Two series connected voltage regulator tubes V-210 and V-211 in series with resistor R-245, are connected across the output of the power supply. Resistors R-238 and R-251 shunt V-211 to insure sufficient current flow in the 150-volt circuit. The voltage regulators are type VR-150 tubes. The total drop across both tubes is 300 volts and this voltage is applied to the plates of the r-f preamplifier and the local oscillator. The 150-volt potential taken from V-211 is used as screen voltage in the Monitor Receiver.

11. MONITOR SCOPE.

a. GENERAL.

(1) The Monitor Scope serves two purposes in the Model SR Radar Equipment. Its primary aim is to provide a Type "A" radar indication at the Transceiver position. In this manner, operation of the equipment may be monitored at that point. It provides this indication on a three-inch cathode ray tube. While the radar display is relatively complete, the scope does not provide the facilities for accurately ranging the targets which are incorporated in the Range Scope in the Indicator Console. The secondary purpose of the scope is to serve as a complete test unit. When removed from its rack, it can be used in servicing other units of the equipment. Consequently, it is equipped with an internal sweep triggering circuit. It is also equipped to provide a trigger output for triggering the component with which it is being used.

b. DESCRIPTION.

(1) The overall operation of the Monitor Scope is shown in the block diagram, Fig. 2-36. As shown, either of two trigger inputs may be used. If the Monitor Scope is being used as a part of the Transceiver, it is triggered externally by the radar transmitted pulse. If the Monitor Scope is being used as a test instrument, it generates its own trigger and also triggers the equipment with which it is being used. The gate circuit generates a square block of voltage which is used to unblank the cathode ray tube and permit the signal to be viewed for the time duration of the gate. The input video signal is amplified by the video amplifier and is applied to the vertical plates of the cathode ray tube. The signal is expanded horizontally by the sweep circuit, which is triggered by the block of gate voltage. The individual circuits will be considered in the following paragraphs.

c. TRIGGER AMPLIFIER.

(1) The trigger amplifier, V-301A, receives the trigger pulse from the Transmitter. See Fig. 2-37. It amplifies and inverts the pulse and applies it to the gate circuit. Test Jack J-306 shows the waveform.

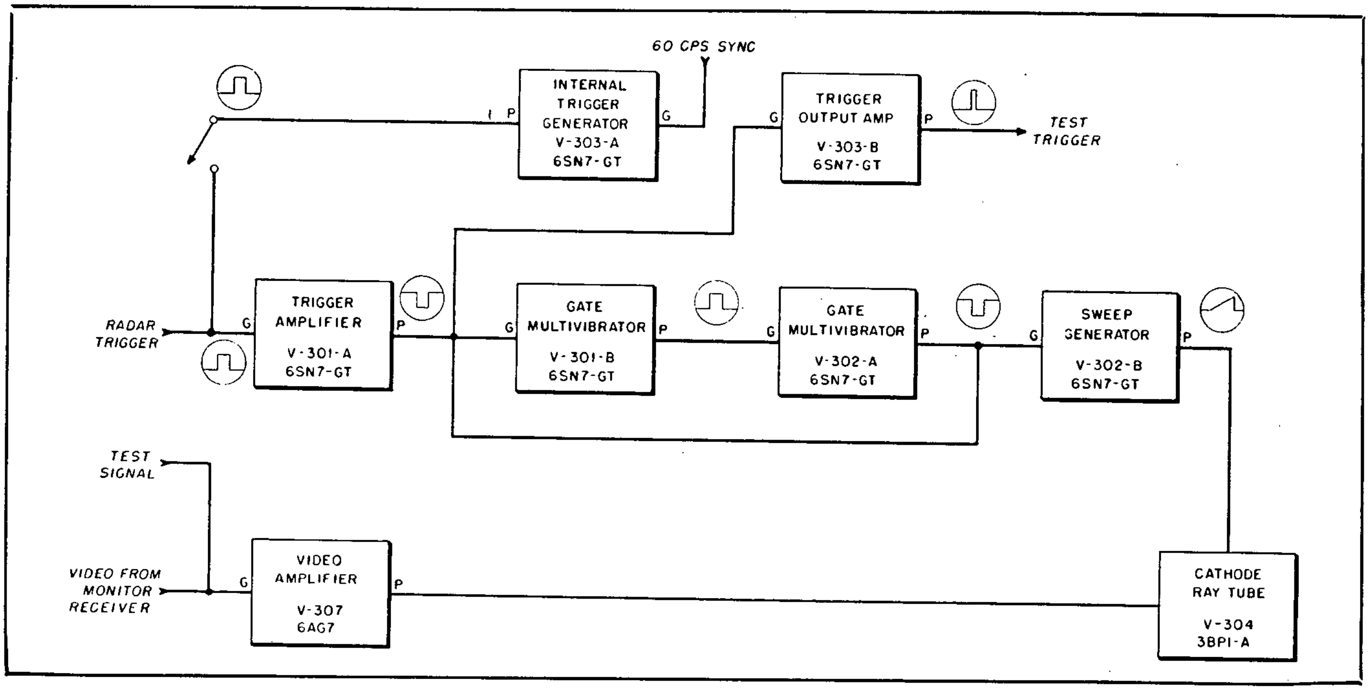


Figure 2-36. Monitor Scope, Block Diagram

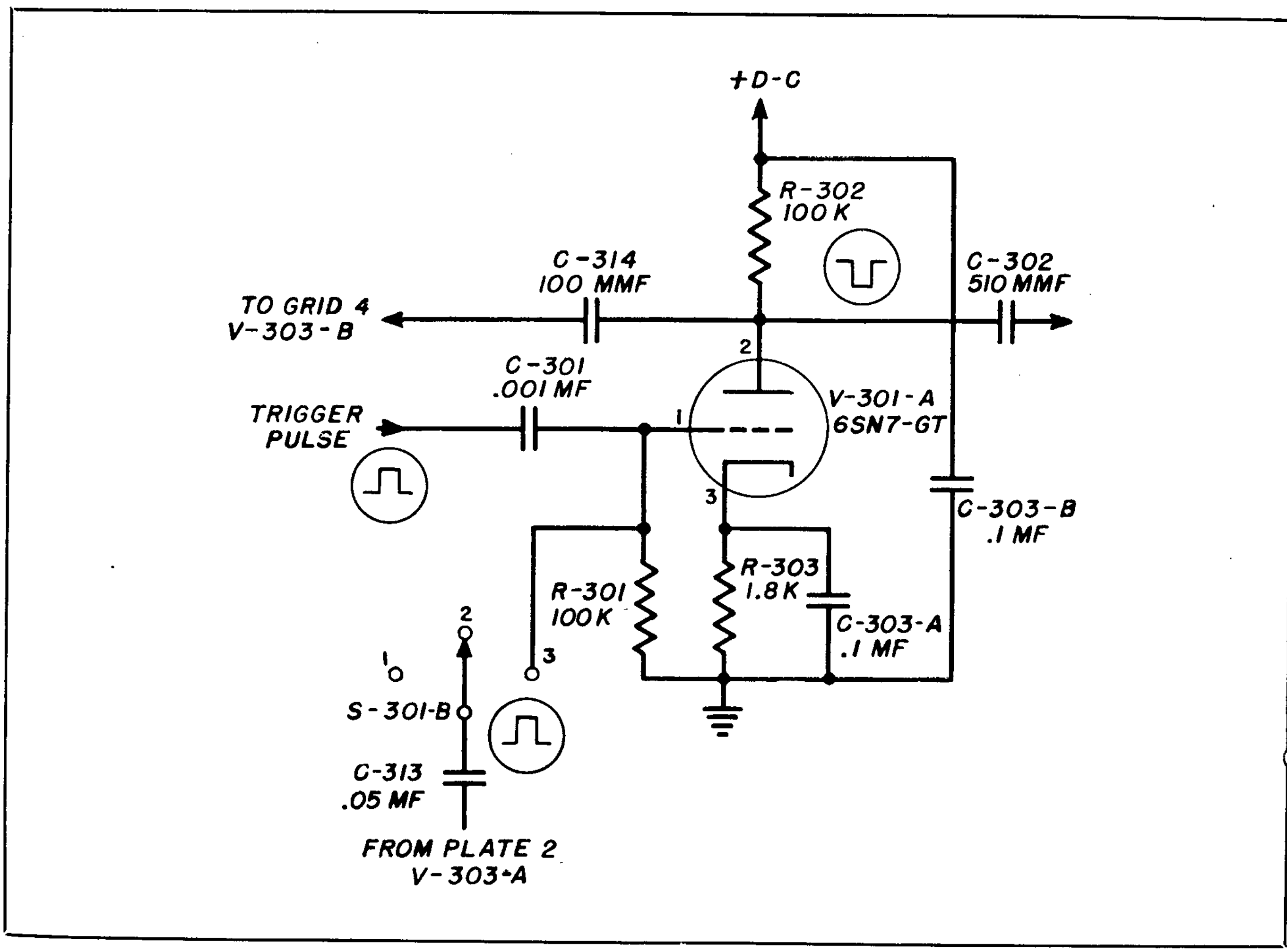


Figure 2-37. Trigger Amplifier in Monitor Scope

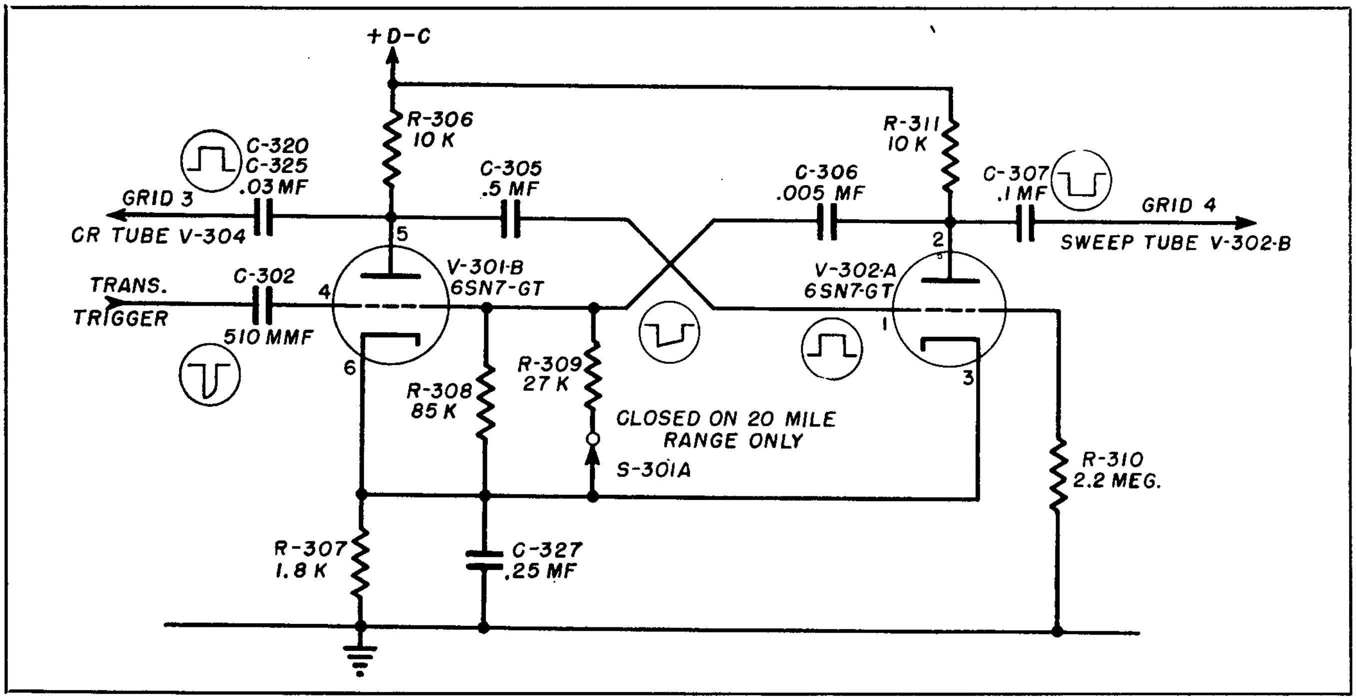


Figure 2-38. Gate Circuits in Monitor Scope

This pulse is applied to the grid of V-301A which is one-half of V-301, a type 6SN7GT double triode tube. The tube amplifies and inverts the trigger pulse and applies it to the grid of V-301B.

d. GATE CIRCUIT.

(1) The gate circuit shown in Fig. 2-38 develops a block of positive voltage when triggered by the trigger amplifier. This positive block of voltage is applied to the cathode ray tube to unblank the tube. It also generates a negative block of voltage which is used to start the sweep circuits and produce the sweep trace on the cathode ray tube.

(2) The gate circuit consists of V-301B and V-302A, two halves of a type 6SN7GT tube. These tubes are shown in Fig. 2-38, as separate tubes. The circuit receives the pulse from the trigger amplifier after it has been differentiated by C-302, R-308, and R-307. Due to the inversion characteristics of V-301A, a negative voltage is applied to the grid of V-301B. Normally at rest, the gate circuits are standing with V-302A in a cut-off condition and V-301B drawing current at a saturation level. Because the grid resistor of V-301B is returned to the common cathode of the two tubes, and the grid resistor of V-302A is returned to ground, the circuit is unbalanced. It will always return to the resting condition, with V-302A cut off due to the voltage drop across cathode resistor R-307 which is common to both tubes.

(3) The negative pulse from V-301A is coupled to the grid of V-301B by coupling capacitor C-302. This negative pulse is sufficient to drive the grid of V-301B negative to the extent that it will cut off the flow of plate current through the tube. Since this section of the tube was drawing heavy current prior to the appearance of the trigger pulse, voltage at its plate was low. When the tube is cut off by the trigger pulse, the voltage at its plate rises almost vertically due to the steep waveform of the trigger.

(4) The positive voltage rise is applied to the grid of V-302A by coupling capacitor C-305. This causes V-302A, which has been at cut-off previously, to draw current. The voltage at its plate drops rapidly and is coupled back to the grid of V-301B by capacitor C-306. Thus the grid of V-301B is driven further in a negative direction. In this condition, V-301B is cut off and V-302A is drawing maximum current.

(5) The length of time that the circuit will stay in this condition depends upon the time it takes for the grid of V-301B to return to normal bias. At this point, the tube will again draw current. This in turn depends upon the value of the tuning resistors in use and capacitor C-306. On the 20-mile range, R-308 and R-309 in parallel are the tuning resistors. R-308 is permanently connected to the common cathodes of the two tubes. R-309 is connected in parallel with it on the 20-mile range by RANGE SWITCH section S-301A. On the 80-mile range, R-308 alone forms the tuning resistor. C-306 must be charged through these resistors. This produces the gate width for the sweep. Resistance in the grid of V-301B causes the grid to rise gradually to the point where V-301B again begins to draw current. When this happens, the voltage at the plate of V-301B starts to drop. This drop is coupled to the grid of V-302A, which draws less current. Therefore, the voltage at the plate of V-302A

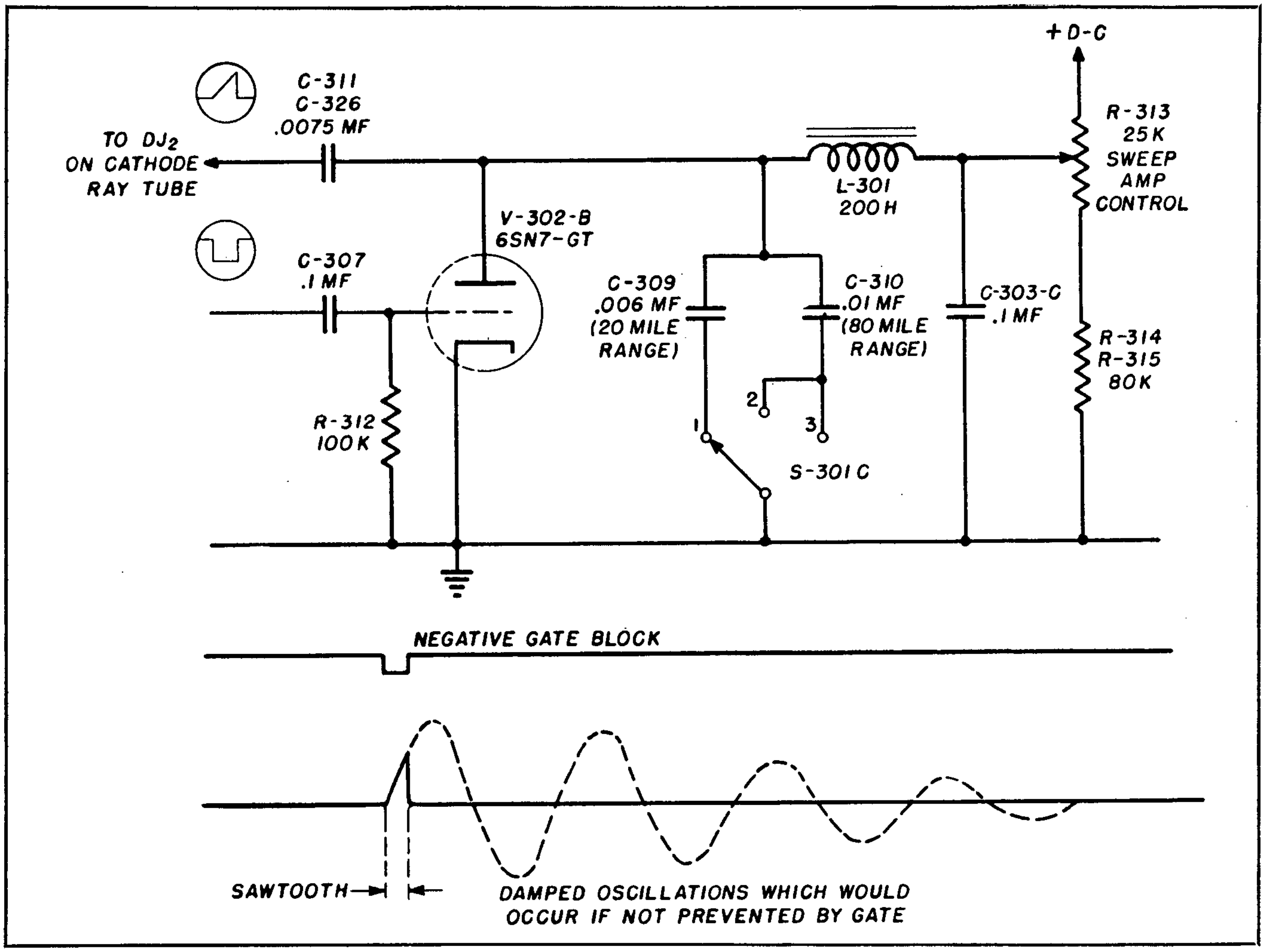


Figure 2-39. Sweep Circuit in Monitor Scope

also begins to rise. The rise is coupled to the grid of V-301B by coupling capacitor C-306. This rise is added to the rise of grid voltage due to the timing circuit. Consequently, the voltage on the grid of V-301B is driven rapidly in a positive direction and the circuit flips back to its resting condition. V-301B is again drawing current and V-302A is cut off. The circuit will remain in this condition until another trigger pulse appears.

(6) The result of the action causes a positive block of voltage to appear in the plate of V-301B and a negative block to appear in the plate of V-302A. The positive block of voltage is used to unblank cathode ray tube V-304. It is applied to grid 3 of this tube through resistor R-304 and capacitors C-325 and C-320 in parallel. Grid 3 is the intensity grid of the tube. The positive pulse causes the indication on the tube to brighten during the period in which this block exists.

e. SWEEP CIRCUIT.

(1) This circuit is comprised of V-302B, the sweep generator tube and its associated components. See Fig. 2-39. A negative block of voltage is applied to the grid of V-302B by coupling capacitor C-307. Value of the tube's grid resistor is such that the time constant of C-307 and R-312 will cause the grid to remain negative during the entire negative block period. The action of this circuit is shown on Fig. 2-39. The negative block drives the tube to cut-off. However, due to the presence of inductance L-301 across the plate circuit, the voltage will not rise instantaneously to the value of the voltage supply. The current that has been flowing through the inductance is cut off suddenly by the tube. Thus the voltage across the inductance starts to rise. This rise would ultimately reach far beyond the d-c supply voltage level. If permitted, the circuit would produce damped oscillations as shown in Fig. 2-39. However, the gate block and the constants of the tuned circuit are such that only the first part of the first cycle of oscillation is permitted to appear. Following this, the negative gate block ends, the tube again draws current, and the rise of voltage at the plate of the tube ends.

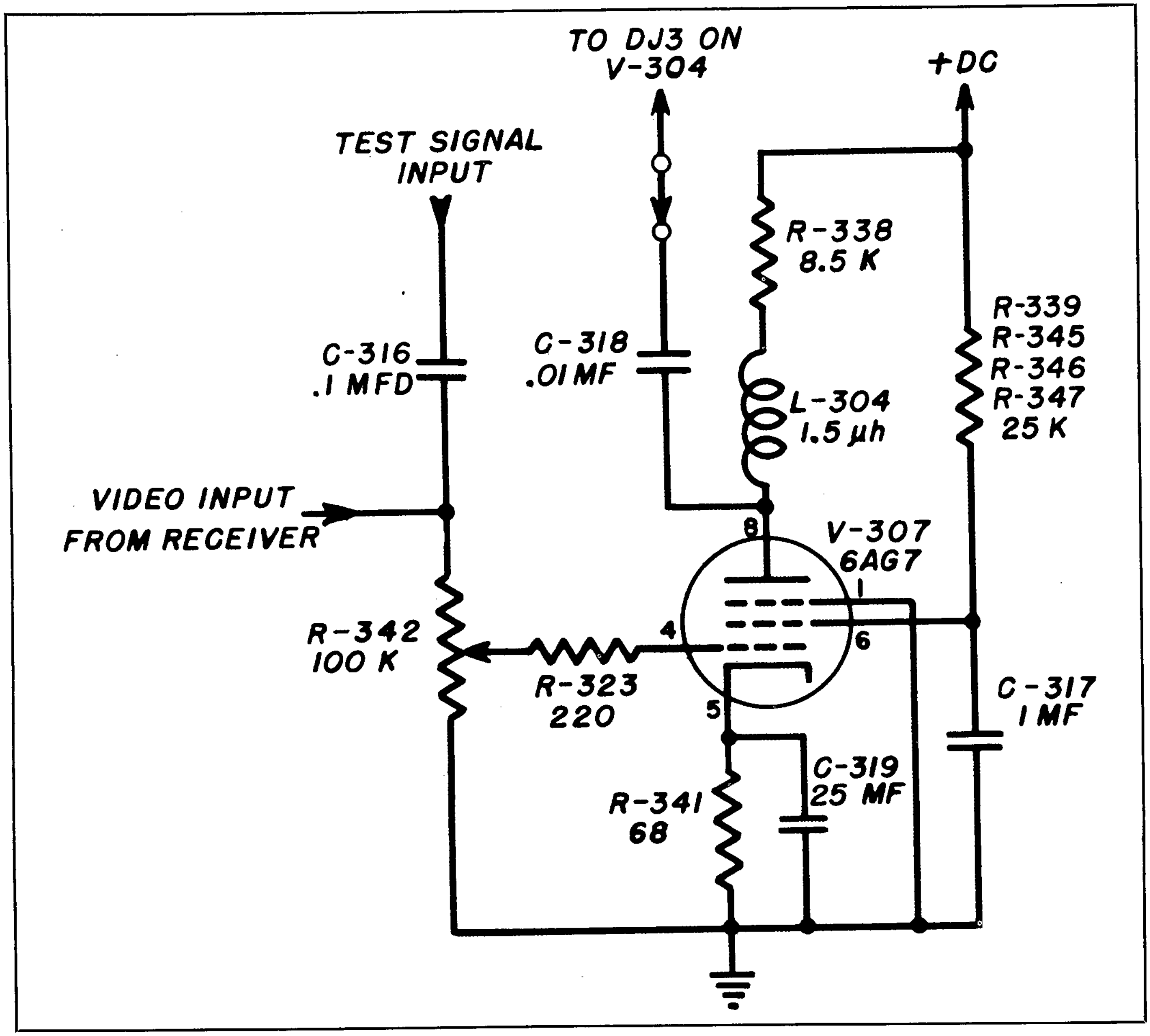


Figure 2-40. Video Amplifier in Monitor Scope

(2) The effect of this action is to produce a part of a sine wave at the plate of the tube. This part of the sine wave is relatively linear, and is used for the sweep circuit. Voltage at the plate is fed to the horizontal deflection plates of the cathode ray tube. Two basic sweep ranges are provided. These are the 20-mile range and the 80-mile range. Ranges are selected by switching C-309 between the plate to ground for the 20-mile range, and C-310 from plate to ground for the 80-mile range. The slope of the sweep voltage is changed by these two capacitors. R-313, the SWEEP AMP control, is used to limit the voltage applied to the tube. The sweep voltage is applied to deflection plate DJ_2 of V-304 through capacitors C-311 and C-326 in parallel. DJ_1 and DJ_2 are supplied d-c centering voltages from R-322, the HORIZONTAL CENTERING control. Adjustment of this control permits moving the start of the sweep until the sweep line starts at the right position on the left-hand side of the tube.

f. VIDEO AMPLIFIER.

(1) This circuit amplifies the video pulses from the Monitor Receiver and applies them to the cathode ray tube. V-307, a Type 6AG7 tube, is the video amplifier. See Fig. 2-40. Voltage from the Monitor Receiver, appearing at REC INPUT terminal, J-317, is applied to the grid of the tube. R-342, the VERTICAL GAIN control, regulates the amplitude of the voltage applied to the grid. When the unit is being used for test purposes, input voltage is applied through

TEST INPUT jack J-319. Capacitor C-316 is connected between this jack and the top of R-342 to prevent any d-c component of the voltage under test from being applied to the grid of the tube. The video amplifier has a shunt peaking inductance L-304 in its plate circuit in order to peak the video signals from the Monitor Receiver. Due to this inductance, the tube will pass harmonic voltage components as high in frequency as 1 megacycle.

(2) The output of the video amplifier is coupled to switch section S-301E of the RANGE switch. Since it is desirable to see the video signals as rising deflections on the tube face, this switch section, while in the 20- and 80-mile positions, connects video pulses to verical plate DJ_3 of V-304. Since video pulses from the Monitor Receiver are negative, this connection is necessary. However, when the unit is being used as a test scope, and it is desired to measure positive pulses and have them appear as rising deflection on the sweep, the switch is in the 3 position. This position of the switch connects the output of the video amplifier to deflection plate DJ_4 of the cathode ray tube. Therefore the positive voltage components in the signal under test will also appear as rising deflections.

(3) The vertical plates DJ_3 and DJ_4 of the cathode ray tube also receive a static centering voltage from R-324, the VERTICAL CENTERING control. By adjustment of this control the vertical position of the sweep base line may be changed.

g. INTERNAL TRIGGER GENERATOR.

(1) When the Monitor Scope is used as a test scope, it becomes necessary to trigger its own sweep circuit, as well as the circuits it is desired to test from a common trigger source having a common repetition rate. V-303A shown in Fig. 2-41, is used to generate the trigger and apply it to V-303B, the trigger output amplifier. A 60-cps synchronizing voltage is applied to the grid of V-303A through coupling capacitor C-312 from one side of the power transformer. V-303A operates with zero bias and is normally conducting. When the synchronizing voltage swings positive the voltage drop across resistor R-317, produced by the flow of grid current, holds the grid to zero potential. When the synchronizing voltage swings negative, the tube is cut off and the plate swings positive.

(2) Because of this action, the voltage at the plate of the tube represents practically a square block of voltage at the 60-cycle frequency. This square block rises and falls very sharply. When the grid is driven in a positive direction, grid current flows to ground through grid resistor R-316. The high value of this resistor prevents burning the grid out. It causes the grid to assume only a small positive bias, rather than the full 300 volts it would have without the resistor R-316. The leading edge of the output pulse from V-303A triggers the output amplifier V-303-B.

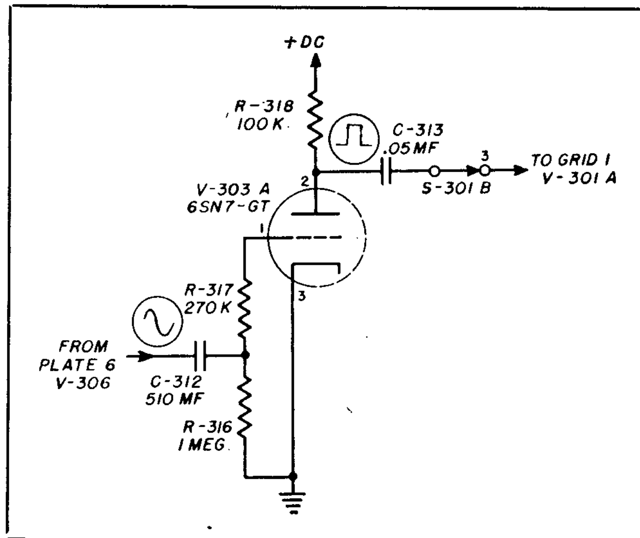


Figure 2-41. Internal Trigger Generator in Monitor Scope

b. TRIGGER OUTPUT AMPLIFIER.

(1) The output of V-303A is coupled to the grid of trigger amplifier V-301A through switch section S-301B when it is in the 3 position. Consequently, the gate multivibrator and sweep circuits are caused to operate. The output from V-301A is applied to the grid of V-303B by coupling capacitor C-314. See Fig. 2-42. Capacitor C-314 with a capacity of only 100 mmf differentiates the leading edge of the block across resistor R-319 and presents a sharp spike of voltage to the grid of V-303B. V-303B is drawing plate current due to the value of its grid resistor. The grid is at a positive potential due to the flow of grid current through it. The sharp spike of negative voltage applied to the grid of V-303B causes a positive sharp spike of voltage to appear in the plate circuit. This sharp spike is coupled by C-315 to jack J-320, the TEST TRIGGER SIGNAL OUT jack on the panel of the unit.

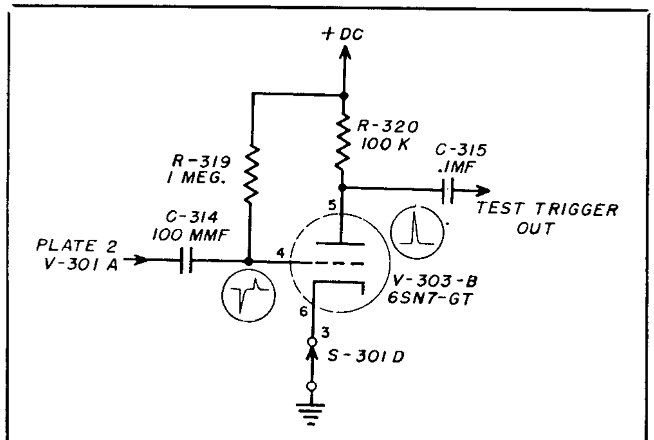


Figure 2-42. Trigger Output Amplifier in Monitor Scope

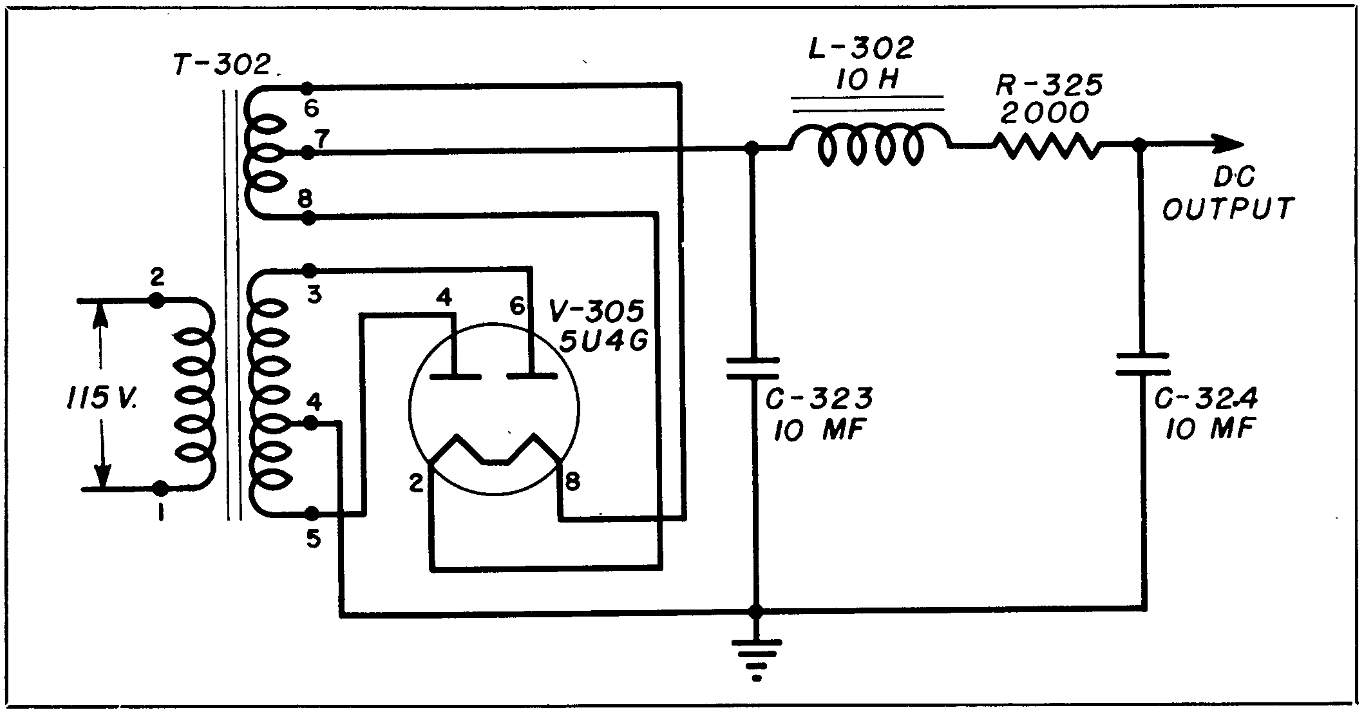


Figure 2-43. Low Voltage Power Supply in Monitor Scope

(2) Tubes V-303A and V-303B are only operative in the number 3, or test position, of the RANGE switch. On the other two positions, their cathodes are uncoupled from ground and allowed to float. Consequently, no current will be drawn through the tubes, and they will not operate.

i. RANGE SWITCH.

(1) The operation of the range switch is summarized as follows. Section S-301F is not used. It may be used as a spare in maintenance. The switch positions considered are those appearing on the panel of the Monitor Scope. Positions 20, 80 and 80 INT refer respectively to positions 1, 2, and 3 of S-301 on the schematic diagram.

(a) POSITION 20—S-301A connects R-309 in parallel with R-308 to speed the flip-back action of the multivibrator. S-301B breaks the connection between the plate of V-303A and grid of V-301A. S-301C connects C-309, the 20-mile sweep capacitor, between the plate of V-302B and ground. S-301D opens the cathode circuit of V-303A and V-303B. S-301E connects the video from the video amplifier to plate DJ_3 of V-304.

(b) POSITION 80—S-301A disconnects R-309. S-301B has the same function as in position 1. S-301C connects capacitor C-310 between the plate of V-302B and ground and disconnects C-309. This develops the sweep for the 80-mile range. S-301D and S-301E have the same functions as in position 1.

(c) POSITION 80 INT.—S-301A has the same function as in position 2. S-301B connects the plate output of V-303A to the grid of V-301A. S-301C has the same function as in position 2. S-301D grounds the cathodes of V-303A and V-303B and permits them to operate. Switch S-301E connects the output of the video circuits to plate DJ_4, disconnecting it from DJ_3.

j. POWER SUPPLIES.

(1) Two rectifier circuits supply power for operation of the equipment. One of these shown in Fig. 2-43, is composed of transformer T-302 and the full-wave rectifier V-305, a type 5U4G tube. The output of this circuit is filtered by inductance L-302 and capacitors C-323 and C-324, connected in the form of a capacitor-input filter. This low voltage circuit provides d-c voltages for the tubes, for the horizontal and vertical centering, and the focus balance voltages of the cathode ray tube. Filament voltages for all the tubes except the cathode ray tube are supplied by windings on T-302.

(2) The high voltage power supply shown in Fig. 2-44 is comprised of transformer T-301 and the half-wave rectifier tube V-306, a Type RKR72 tube. The output of this circuit is filtered by resistor R-344 and capacitor C-321. A voltage divider, composed of resistors R-328 to R-334 inclusive, is connected across this supply. Potentiometer R-328 is the INTENSITY control supplying voltage to the intensity grid of the cathode ray tube. Potentiometer R-331 is the FOCUS control, supplying voltage to the focusing grid of the cathode ray tube.

(3) Line voltage is applied to the power supplies through line switch S-302 which is used when the

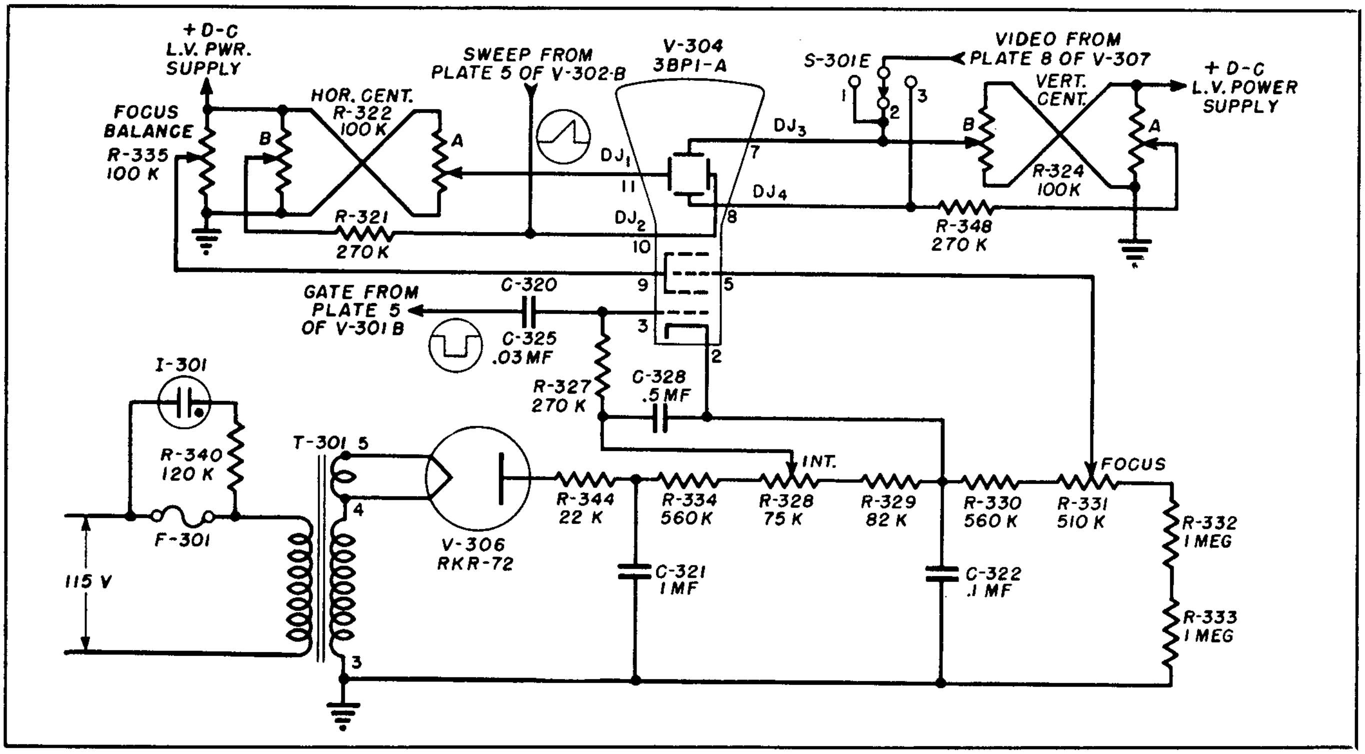


Figure 2-44. High Voltage Power Supply and Cathode Ray Tube in Monitor Scope

equipment is employed as a test scope. On one side of the line is fuse F-302 and across it is fuse warning light I-302. The line then goes through line filter L-303 and is applied to both power transformers. A special fuse is in the line leading to the high voltage supply. This is fuse F-301 which is shunted by fuse warning light I-301. When I-301 lights, it indicates that the high voltage rectifier circuit is open. When I-302 lights, it indicates trouble in either power supply circuit, or in the circuits which they supply.

(4) Positioning voltage for the beam in the cathode ray tube is obtained from the output of the low voltage power supply. This voltage is applied across dual potentiometers R-322 and R-324. The arms of these potentiometers are connected to the deflection plates of V-304 as shown in Fig. 2-46. The d-c potentials thus obtained are used to center the beam in V-304.

12. INDICATOR CONSOLE CAY-46ADJ.

a. GENERAL.

(1) The Indicator Console, Type CAY-46ADJ, is composed of several components which provide indications of range and azimuth for the operator. Since indications are usually desired at the control position of a radar set, the Indicator Console is designed to contain, in addition to the indicating equipment, certain control apparatus necessary to govern operation of the radar set as a whole. The functional diagram in Fig. 2-45 shows the relationship between the various components of the Indicator Console. The following discussion describes the function of each component in the order in which the components are related to each other. In the discussion that follows, the functions of the Console will be traced in a logical sequence.

b. TRIGGER CIRCUIT.

(1) The trigger pulses from the transmitter are received at a terminal board in the top of the left-hand cabinet of the Indicator Console. From this terminal board, the pulse line is connected to a small resistor panel. The panel contains isolating resistors for the line from the transmitter and isolating resistors for the trigger pulse lines which go to the remote PPI Indicators. Also, from this resistor board, a line is connected to the IFF Coordinator which delivers the trigger pulse to the Eccles-Jordan multivibrator or *flip-flop* circuit. This circuit is used to provide alternate blanking pulses for the radar video and for the IFF video. The circuit causes *both* radar and IFF video signals to appear on the Range Scope at the same time. Another cable from the trigger termination point extends to the PPI scope. There it couples to the pulse amplifier which is the input tube in the gate circuit. Terminating resistors are provided in the top section of the PPI cabinet in order to properly terminate the trigger line from the trigger pulse termination.

c. CONSOLE RECEIVER.

(1) GENERAL.—The Console Receiver accepts the 15-megacycle intermediate frequency signal from

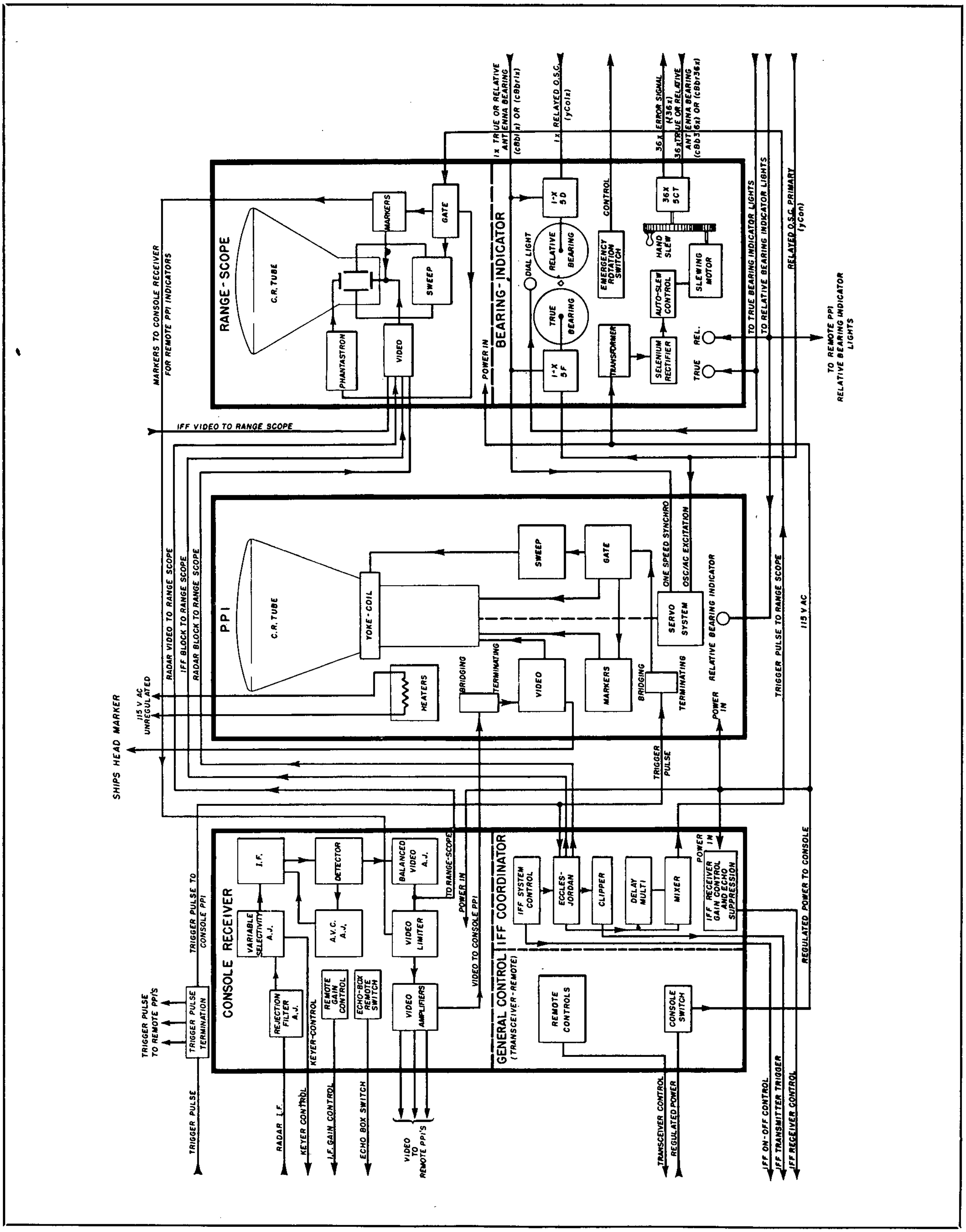


Figure 2-45. Indicator Console Block Diagram

the Monitor Receiver in the SR equipment, or from some other conversion system with an output at the proper frequency. It provides the video signals required for the indicating components by amplifying and demodulating the intermediate frequency signals. The following general division of circuits is shown on the block diagram in Fig. 2-45. Their functions are described in the following paragraphs.

(2) ANTI-JAM REJECTION FILTER.—An i-f signal is applied to the Console Receiver through the anti-jam rejection filter. This filter is comprised of two sharply tuned series type wave-trap circuits across the i-f input line. They are used for the purpose of eliminating jamming signals. Either circuit may be tuned sharply to any particular i-f frequency within the range of the i-f channel. Consequently, by tuning the filters to a sharp jamming signal, it is possible to greatly attenuate it and eliminate jamming effects in receiver circuits. It is possible, by using both of these filters, to literally "cut out" a section of the i-f band without seriously affecting the overall performance of the receiver. These filters are tuned by operating the A.J. TUNING controls inside the small door on the receiver panel.

(3) VARIABLE SELECTIVITY ANTI-JAMMING CIRCUIT.—The output of the anti-jamming filter circuit is fed to the grid of one of two i-f amplifier tubes. The first of these two tubes is an untuned (a periodic) amplifier with a very low plate resistor which provides little gain. Consequently, it serves more as an isolation tube than an i-f amplifier. The second tube has a sharply tuned network in its plate circuit. In general, the function of this network is to select a section of the i-f band in which it is desired to operate the radar equipment. Three band widths may be selected. These are: 100 kc/s, 250 kc/s, and 1.8 mc/s. During jamming, it is often possible, by selecting a narrow band width, to completely eliminate the jamming. The operator may then tune up on the peak of the echoes from his own radar equipment. Choice of band width is made by operating the I.F. BAND WIDTH switch. The operation of this switch also changes the amplification factor of the first of the two tubes in this circuit so that it maintains a relatively constant output level despite the change in band widths.

(4) INTERMEDIATE FREQUENCY AMPLIFIERS.—The output of the variable selectivity anti-jamming circuit is fed to the intermediate frequency amplifiers. Three stages of transformer-coupled intermediate-frequency amplification are provided in the Console Receiver. The 15 mc/s output is fed to the video detector.

(5) DETECTOR STAGE.—The detector stage is a double diode, with one output providing negative video pulses and the other output providing video pulses. One output is fed to one of the balanced video amplifier tubes while the other is fed to the other tube of the balanced video amplifier. The negative output of the detector is also used to control tne AVC tube.

(6) AVC ANTI-JAMMING CIRCUIT.—The AVC circuit receives the negative output of the diode detector. The cathode current of the i-f amplifiers flows to ground through the plate-to-cathode circuit of the AVC tube. When the negative signal from the detector appears at the grid of the AVC tube, the impedance of the tube is increased. The cathodes of the i-f amplifiers are, therefore, raised with relation to their grids. This causes the gain of the i-f amplifiers to decrease which provides the AVC action. Two capacitors are included for controlling the time constant of the AVC circuit. They are so connected that they delay the AVC action of the circuit. Little or no AVC action is obtained against a narrow pulse such as a pulse coming from a target. However, on longer blocks, often used in an attempt to jam the radar system, the AVC control will operate and prevent overloading the receiver and indicator circuits. This is an anti-jam feature. Three different delays may be selected by the operator, in order to most effectively counteract jamming attempts by enemy action.

(7) ANTI-JAMMING BALANCED VIDEO CIRCUIT.—The balanced video receives *both* the negative and positive outputs of the detector stage. The balanced video stage consists of two amplifier tubes with their grids connected effectively in push-pull due to the positive and negative output of the detector, and their plates in parallel across a common load resistor. In such a circuit, if the grid bias conditions of both tubes are the same, and the positive and negative signals are of equal amplitude, the outputs across the common plate resistor will balance out. This leaves an output which is effectively zero. However, in the operating constants of the circuit, one of the amplifier tubes is operated slightly beyond the plate cut-off point. Therefore, the level at which the radar pulse is received is amplified only by one tube. Any signal of an amplitude higher than that expected from the radar signal will cause *both* amplifiers to operate. When the second amplifier of the stage comes on, its output offsets the output of the first amplifier since its output is 180 degrees out of phase with the output of the first amplifier. Consequently, the net output of the stage will only be the desired amplitude for the radar video signal. Any signal which causes amplification above that amplitude will be cancelled out in the common output of both tubes. This system forms an effective discriminator against any jamming signal above the amplitude of the radar echo. In many cases, it will permit the echo video signal to ride through jamming interference.

(8) JAMMING INDICATOR METER.—The jamming indicator meter is in the negative side of

the detector circuit. When an excessive signal is present, this meter will indicate an increase in diode current and warn the operator of the presence of a heavy jamming signal.

(9) VIDEO AMPLIFIER AND CATHODE FOLLOWER.—The resultant output of the balanced video amplifier circuit is applied to the grid of a video amplifier. This stage is a double triode with one section connected as a cathode follower. The output of this section is connected to the Range Scope. This output is not subject to the action of the video limiter but is limited by the action of the balanced video stage. An output from the amplifier section is fed to the second video amplifier which drives the four cathode follower tubes. These tubes provide output video signals for the remote PPI units in use with the radar equipment. This output is subject to action of the video limiter.

(10) VIDEO LIMITER AND MIXER.—The output from the triode video amplifier stage is applied to the video limiter and mixer stage. This stage consists of a double triode with three inputs and a common output. One of these inputs is the negative video pulse from the triode video amplifier. The second input is a positive IFF video signal voltage and the third input, controlled by the PPI MARKER switch on the panel of the receiver, is the PPI marker voltage from the Range Scope. The operating conditions of this stage are such that the tube is operated near cut-off condition. It may be cut off by the negative video signals which are applied to the grid or by the positive marker or IFF signals which are applied to the cathodes. The limiting action of the stage is due to the fact that it is operated near cut-off. Consequently, it will amplify small signals. When larger signals are applied, the tube will cut off and its amplification will be limited to the amount of amplification secured at the cut-off point.

(11) VIDEO CATHODE FOLLOWERS.—Four cathode follower tubes form the output of the video amplifier circuits. They receive the output from the video amplifier and limiter and transform this high impedance output to a low impedance level so that it may be coupled to the remote PPI indicators by a low-impedance coaxial pulse cable. No terminating resistors are provided in the top of the cabinet for the cathode followers not in use. Any of the cathode follower lines which are actually connected to the remote PPI indicators are terminated at the indicators.

(12) POWER SUPPLIES.—Power is supplied for the plate circuits of the receiver by a full-wave rectifier circuit with a capacitor-input filter. A filament winding on the transformer provides filament voltage for all of the tubes in the receiver.

d. RANGE SCOPE.

(1) GENERAL.—The Range Scope shown in Fig. 2-45 receives radar video signals from the Console Receiver, a trigger voltage, a radar block and an IFF block from the IFF Coordinator, and IFF video signals from the IFF equipment associated with the ship's radar installation. It generates a very accurate sweep circuit which is displayed on the face of a cathode ray tube. Video signals from the radar equipment are caused to appear along the sweep line in such a manner that they indicate the distance from the radar equipment to the target. When it is desired to interrogate a target with the IFF equipment, the IFF signals are caused to appear on a sweep line slightly below the radar video sweep line. The sweep repetition rate is so rapid that, to the eye, two sweep lines appear on the face of the Range Scope while a target is being interrogated. The radar targets appear along what appears to be the upper sweep line while the IFF indications appear along the lower line. General functioning of the circuits which accomplish this display of radar and IFF targets are explained in the following paragraphs. A more detailed explanation of these circuits will appear later in this section. Reference should be made to the block diagrams, Fig. 2-5 while reading the discussion.

(2) GATE CIRCUITS.—The trigger pulse from the IFF Coordinator is coupled to the gate circuit. This pulse appears on the grid of a pulse amplifier which is the first stage of the gate circuit. The two following tubes in the gate circuit form a multivibrator which turns over almost instantaneously. Then, following a pre-determined delay period, it turns back very rapidly. The pre-determined delay or gate width period is fixed by the choice of timing resistors. Four gate widths are provided in the unit. These are for a 4, 20, 80 and 200 mile sweep. The gate widths determine the four ranges on which the Range Scope will operate. They are adjustable by the RANGE switch on the front panel of the unit. The output is a positive pulse of voltage to unblank the cathode ray tube and trigger the phantastron delay tube on the 4- 20- and 80-mile ranges, and a negative pulse which triggers the sweep and markers circuit.

(3) SWEEP CIRCUIT.—The gate circuit triggers the sweep circuits of the range scope. A negative pulse of voltage cuts off the sweep tube. The voltage rise at its plate is made to charge a timing capacitor which determines the linear rate of the sweep. A choice of timing capacitors is provided so that four sweep speeds are available to provide a sweep for the four ranges on which the Range Scope operates. In order to provide linearity of the sweep, a cathode follower tube is used to lower the voltage at the lower side of the timing capacitor at the same rate at which the voltage across the capacitor increases. As the voltage across the timing capacitor *increases* the capacitor charges. Without this circuit device, the sawtooth rise at the plate of the tube would become non-linear as the voltage across the plate resistor decreased

due to the voltage rise across the capacitor. Since the voltage across the capacitor is also increased, the nonlinearity of the sweep is minimized. Therefore, linearity of the sweep voltage rise is obtained. A sweep amplifier-inverter provides a push-pull output for the sweep circuits. This output is applied to the horizontal plates of the cathode ray indicator tube in the Range Scope.

(4) PHANTASTRON CIRCUIT.—The phantastron circuit is also triggered by the output of the gate circuits. This circuit is, in effect, a highly accurate, variable delay multivibrator. It has a delay which is linear, and proportional to a voltage applied to the circuit. This makes it possible to secure a delay which is linearly proportional to the position of a potentiometer arm. It is, therefore, possible to attach mechanical indicating devices to the potentiometer arm in such a manner that the position of the arm can be translated into actual range in nautical miles or yards. The output of the phantastron is a pulse of voltage which has a duration that is proportional to the position of the potentiometer arm. This pulse is made to appear as a step in the sweep of the Range Scope. When the potentiometer is adjusted so that the steps or block just touches the target indication, the range of the target may be read from the counters which are geared to the potentiometer. The phantastron circuit is used on the 4, 20 and 80-mile ranges when the operator pulls out the RANGE STEP control. It permits very accurate ranging of targets on the Range Scope.

(5) RANGE MARKER CIRCUITS.—The range marker circuits develop pulses of voltage which are applied to the sweep of the Range Scope to indicate the approximate distance of the target from the radar equipment. These circuits are triggered by the leading edge of the gate circuit pulse and produce a string of pulses. These pulses are a period of time apart equivalent to 1 mile, 5 miles, 20 miles and 50 miles on the 4, 20, 80, and 200 mile ranges, respectively. The pulses are applied when desired by the operator, to the sweep on the face of the cathode ray tube where they appear as vertical spikes at a point equivalent to the number of nautical miles they indicate. By comparing the target with the nearest range marker, an approximate estimate of the distance to the target may be made. The markers are also useful in calibrating the sweep circuit and in adjusting the sweep so that the calibration scales on the screen of the scope will give approximately correct readings of range. The marker voltages are also applied to the video output of the receiver. From this point they are supplied to remote PPI indicators which do not have their own marker generating circuits.

(6) VIDEO CIRCUITS.—The video circuits of the Range Scope employ three tubes. Two of these are mixer tubes and the third is the video output amplifier. Marker pulses from the marker circuits, radar video signals from the Console Receiver, and the radar video blocking pulse from the IFF Coordinator are fed into one of the mixer tubes. The other tube receives the IFF video signal from the IFF equipment, and the IFF video blocking pulse from the IFF Coordinator. The blocking pulses from the IFF Coordinator and IFF video signals from the IFF equipment are only present when the operator manipulates the IFF switch on the IFF Coordinator to interrogate a target. When the IFF equipment is not used, the only input to the video circuit is the radar video signals from the Console Receiver. The plates of the two mixers are connected in parallel and their combined output is applied to the video output amplifier. However, when the IFF circuits are being used, and video and IFF blocks from the IFF Coordinator are present in the circuit, only one of the mixer tubes operates at a time. First, the mixer tube receiving IFF signals is cut off and only the radar video is allowed to pass through to the video output amplifier. Then, on the following pulse, the mixer tube which receives the IFF video is cleared and the mixer receiving the radar video is blocked. Consequently, only the IFF video is applied to the video output amplifier and reaches the cathode ray tube. The effect of this circuit is to apply radar video signals during one sweep of the cathode ray tube and IFF signals on the next sweep. This alternating application of radar and IFF video signals causes the simultaneous appearance of both signals on the face of the indicator.

(7) CATHODE RAY INDICATOR TUBE.—The cathode ray indicator tube is a Type 5CP7 tube, employing electrostatic deflection. Sweep voltages are applied to two deflection plates of the tube in such a manner as to cause the sweep to move horizontally across the face of the tube from left to right. Balancing voltages are employed on the vertical plates to center the sweep line vertically. The output of the video amplifier is applied to the vertical deflection plates to cause the signal to appear on the sweep line. In addition, during operation of the IFF equipment, part of the IFF blocking signal is applied to the vertical plates to cause the IFF sweep line to appear on a different level from the radar sweep line.

(8) POWER SUPPLIES.—Two power supplies are included in the unit. The first of these is a low voltage power supply which provides plate and filament voltages for the receiver type tubes in the unit. The second supplies a high voltage, which is applied to the post-accelerator anode of the cathode ray tube. This second supply also provides filament voltage for the cathode ray tube and filament voltage required for the operation of certain other receiver tubes which have their filaments at a high potential with respect to ground.

e. IFF COORDINATOR.

(1) GENERAL.—The IFF Coordinator shown in Fig. 2-45 is included in the Indicator Console to apply target information received from the radar system with information received from the IFF system. Both indications are made to appear simultaneously on the face of the Range Scope. Trigger pulses to the Range Scope are furnished by this unit. It also provides radar and IFF blocking voltages which were discussed in reference to operation of the Range Scope. The unit is only operative when the operator activates it by pressing the switch to either MOMENTARY or ON positions.

(2) IFF SYSTEM CONTROL.—This control consists of the large switch seen on the upper part of the front panel towards the top of the unit. This switch, when in the OFF position, connects the transmitter trigger through the IFF Coordinator to the Range Scope. Thus, the Range Scope is triggered every time the transmitter is triggered. When the switch is in the MOMENTARY or ON position, the same results are obtained. However, the switch handle will lock in the ON position and will return automatically when released by the operator when it is placed in the MOMENTARY position. Operating this switch in either position brings the IFF system into operation. The IFF transmitter is turned on and its keying pulse is generated by the IFF Coordinator and supplied to the IFF transmitter. At the same time radar and IFF video blocks are generated and supplied to the Range Scope. A special Range Scope trigger, which consists of a trigger pulse for the radar sweep and a delayed trigger pulse for the IFF sweep, is generated and applied to the Range Scope. The regular trigger from the radar transmitter is cut off while the IFF Coordinator is operating and the special triggers substituted.

(3) ECCLES-JORDAN OR FLIP-FLOP CIRCUIT.—This circuit provides radar and IFF video blocking voltages to the Range Scope. It consists of a flip-flop circuit which turns rapidly in one direction when triggered by a pulse. It stays in that condition until the next pulse comes along to trip the circuit and cause it to return to its original condition. The circuit output, which is in the form of rectangular pulses of voltage 180 degrees out of phase is used to permit the application of radar video signals to the Range Scope, following one trigger pulse. The second trigger pulse reverses the phase of the pulses to block the radar video signals and permit the application of the IFF video signals to the Range Scope. This alternating action continues as long as trigger pulses are applied to the circuit. The output voltages are taken from the cathodes of the two tubes forming the circuit.

(4) CLIPPER CIRCUIT.—A positive pulse from the Eccles-Jordan flip-flop circuit is taken from the plate of one of the tubes. This positive pulse is differentiated and applied to the clipper circuit. The clipper circuit is, in effect, two cathode followers in series. The first of these two cathode followers clips the negative-going spike from the integrated wave and applies a positive spike to the second, or clipper output tube. This output tube provides a positive spike of approximately 15 volts across a line to the IFF transmitter. This line is terminated at 50 ohms. Since the clipper is only operative on the positive-going voltage of one of the two flip-flop tubes, it only provides an IFF trigger *every other time* the trigger pulse from the transmitter appears. This trigger, due to the choice of the tube which triggers the clipper circuit, appears when the radar video block is supplied to the Range Scope so that the IFF video appears on the face of the indicator tube.

(5) DELAY MULTIVIBRATOR.—The delay multivibrator circuit provides the delay which is necessary to synchronize the appearance of the IFF targets on the screen with the radar target indications. This delay is necessary because there is some delay inherent in every IFF system. By delaying the trigger to the Range Scope a certain period following the trigger to the IFF transmitter, it is possible to apparently cancel out the delay inherent in the IFF system and allow the IFF video signals to indicate the proper range on the face of the tube. This, of course, has the effect of making them appear directly under the position of the radar target indications which makes it easier for the operator to identify an interrogated target.

(6) MIXER CIRCUIT.—The mixer circuit is provided to mix the radar trigger with the delayed IFF trigger and to supply them on the same cable to the Range Scope. It consists of two cathode followers with their cathodes and plates connected in parallel. The grid of one of the tubes is coupled to one of the plates of the flip flop circuit so that it provides an output which coincides with every second trigger from the radar transmitter. The grid of the other tube connected to the output of the delay multivibrator provides a delay IFF trigger every alternate time the transmitter trigger appears. The output of this mixer circuit is used to trigger the Range Scope when the operator is interrogating a target with the IFF system.

(7) IFF RECEIVER CONTROLS.—Two controls are provided for remotely controlling the volume and echo suppression circuits in the IFF receiver. These are the IFF RECEIVER GAIN control and the ECHO SUPPRESSION SWITCH. The controls apply only to the operation of the IFF equipment. Their use and purpose is explained in the instruction book supplied with that equipment.

(8) POWER SUPPLY.—A single full-wave rectifier circuit provides plate and bias voltages. A winding on the power transformer supplies heater voltages for all tubes in the unit.

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f. PPI INDICATOR.

(1) GENERAL.—The PPI Scope shown in Fig. 2-45 receives a trigger pulse from the transmitter and video pulses from one of the cathode follower output stages in the Console Receiver. It generates a PPI type sweep and applies video pulses to the sweep. This action gives an indication of range on the face of the cathode ray tube. Also, the scope contains a servo system required to rotate the sweep and provide a typical PPI indication of the bearing of the targets. The PPI Scope contains the following circuits:

(2) GATE CIRCUIT.—This circuit receives trigger pulses from the transmitter. Each trigger pulse starts one cycle of operation. The gate circuit *gates* the PPI tube. That is, it determines the length of time that the trace will be visible (unblanked) on the face of the PPI indicator tube. It triggers the sweep trace at the same instant that the transmitter sends out a pulse of radio frequency energy from the antenna. Also, it excites the marker circuits to provide range marker signals which appear on the face of the indicator tube as dots along the sweep line. These dots trace out circles on the face of the tube when the antenna is being rotated.

(3) SWEEP CIRCUITS AND DEFLECTION YOKE.—The sweep circuits develop a sawtooth wave necessary to make the dot travel from the center of the tube radially outward to the edge. These sweep voltages are applied to the tube as varying fields of magnetic force by the yoke coil. A deflection of the electron beam within the tube is produced which causes it to move radially outward from the center to the edge of the tube. The yoke rotates in synchronization with the antenna through the action of the servo system. Consequently, the direction of the trace on the face of the tube is moved electrically in azimuth in a manner to correspond with the motion of the antenna.

(4) RANGE MARKER CIRCUITS.—When triggered by the gate circuit, the range marker circuits produce accurately timed pulses of voltage. These pulses are applied to the PPI tube in such a manner as to cause bright dots to appear equidistant along the sweep trace. Since the space between each dot represents a definite time interval, it is also representative of a definite distance along the line in proportion to the entire sweep length. By comparing targets with these marker dots, the range of the target may be approximated. As the sweep trace rotates, these dots leave rings on the PPI tube which calibrate the face of the tube in miles. Four markers appear on the sweep in each range. On the 4-mile range, they are 1 mile apart. On the 20-mile range they appear 5 miles apart, and on the 80- and 200-mile ranges they are 20 and 50 miles apart, respectively.

(5) VIDEO CIRCUITS.—These circuits receive video signals from the Console Receiver, amplify them and apply them to the PPI tube. They produce a bright dot which appears along the sweep at the instant the video signal arrives from the receiver.

(6) PPI TUBE.—The PPI tube is a Type 7BP7 cathode ray tube. Magnetic deflection of the electron beam is employed to provide proper trace on the screen. Various signals (unblanking, markers and video) are applied to the cathode and grids of the tube. This must be done to intensify the electron stream and cause a bright dot to become visible at the instant these various voltages appear. Focusing of the stream is accomplished by a focus coil placed around the neck of the tube behind the sweep yoke. Ships Head Marker voltage is developed in the bias network to greatly intensify the sweep when it is pointing in the direction the ship is heading.

(7) SERVO SYSTEM.—The servo system positions the deflection yoke coils in such a manner as to make the sweep trace extend in an angular direction. This direction is representative of the angular deflection of the antenna from a fixed reference point. The operator may therefore read, from the face of the tube, the approximate bearing of the target by determining the direction from the center of the tube at which a target appears. As the antenna rotates, the sweep trace rotates, much as the spoke of a wheel. The targets remain on the indicator screen for a length of time following the passing of the trace. Direction of the target with reference to the center of the tube indicate the azimuth of the target, even though the antenna and the sweep continue their rotation.

(8) POWER SUPPLIES.—The unit contains two power sources. One of these is a low-voltage supply which provides bias and regulated and unregulated voltages for the smaller tubes of the unit. The other is a high voltage supply which provides a rectified potential of 5,000 volts d-c for application to the post-accelerating anode of the cathode ray tube.

g. BEARING INDICATOR.

(1) GENERAL.—The Bearing Indicator shown in Fig. 2-45 accurately indicates the angular pointing direction of the antenna, with reference to a fixed reference point. When the radar equipment is being operated on true bearing, this reference point is true North as indicated by the ship's gyro-compass equipment. When the equipment is being operated on relative bearing, the target is shown as being at a point in angular deflection from the ship's heading, or the direction in which the ship is pointed at any given instant. The Bearing Indicator performs two functions. The first is to repeat back at the Indicator Console the true or relative bearing of the antenna. The second is to provide voltages which allow the antenna to rotate and permit it to be pointed in any direction desired by the operator.

(2) INDICATING CIRCUITS.—Bearing indications showing the position of the antenna in azimuth are disclosed on two dials which may be seen together through a window on the front panel of the unit. One of these is the TRUE BEARING indicator and the other is the RELATIVE BEARING indicator. The true bearing indicator is a 5F synchro coupled to a 1-speed 6DG synchro-differential generator on the Antenna Pedestal. The 6DG synchro provides synchro-data voltages which position the 5F synchro in accordance with reference data supplied the 6DG. If true bearing reference voltages are fed to the 6DG synchro, the 5F synchro takes on a position which is representative of the true bearing of the antenna, or its angular deflection from true North. In this case the dial connected to the 5F synchro indicates the true bearing of a target which is at maximum on the Range Scope when the antenna is pointed directly at it. Relative bearing is indicated by a 5D differential synchro fed by the output of the 6DG synchro-differential generator on the Antenna Pedestal. When true bearing voltages are fed to the 6DG and to the 5D, and the O.S.C. voltage subtracted from it, this synchro takes a position which corresponds to the relative bearing of the antenna. Thus, the indicator dial attached to it will indicate the relative bearing of the target when it is at a maximum on the face of the Range Scope.

(3) SLEWING CIRCUITS.—The components of this circuit, located in the Bearing Indicator, are comprised of a 36-speed 5CT synchro, a gear train and an auto-slewing motor. A hand-wheel works into the gear train so that the operator may turn it to move the antenna as desired. The 5CT synchro is interconnected with a 6DG type synchro-differential generator which is geared 36:1 to the antenna. It is excited by either the true or relative bearing voltages supplied by other components of the radar equipment. Consequently, the output of the 5CT synchro is a voltage which exists when there is a difference in angular position between the antenna and the rotor of the 5CT synchro. This difference may be caused either by a movement of the rotor of the 5CT synchro or by a movement of the antenna. The voltage which exists only when such a difference in position takes place, is used to provide an excitation voltage for the antenna drive components. These components rotate the antenna in a manner to eliminate the difference in position. How this is accomplished is a function of the radar set with which the Indicator Console is used. However, the operator, by moving the handwheel causes the antenna to move and take up a position corresponding to the position of the rotor of the 5CT synchro. In this manner, control of the position of the antenna from the console may be obtained.

(4) SLEWING MOTOR SYSTEM.—The d-c slewing motor is mechanically connected to the 5CT synchro through a gear train. Either the handwheel or the slewing motor will make the 5CT rotor move, causing the antenna to move correspondingly. The slewing motor switch, on the front panel, provides two motor speeds in each direction. It may be adjusted by the operator to determine the speed at which it is desired to have the antenna rotate. The voltage supply for the slewing motor is obtained from a dry-disc rectifier which is built into the unit.

(5) EMERGENCY OPERATION SWITCH.—This switch is for use during an emergency when the normal synchro system is not working. It connects the output of an external rectifier directly to the antenna drive motor on the pedestal. Therefore, it permits the antenna to be rotated when the synchro system is not operating.

(6) TRUE AND RELATIVE BEARING LIGHTS.—When one type of bearing indication is in use, a pilot light indicating this type of operation is illuminated on the panel of the unit. Also, the lights which illuminate the bearing indicator dials are switched so that only the dial in use is illuminated. This enables the operator to determine at a glance which type of operation is being employed.

h. GENERAL CONTROL UNIT.

(1) GENERAL.—The General Control Unit is shown in Fig. 2-45. This unit permits the Transceiver to be controlled from the Indicator Console. It also contains a master switch which controls the application of power to the other components in the Indicator Console.

(2) REMOTE CONTROLS.—The remote controls for the Transceiver consist of two pushbuttons for turning the Transceiver on and off from the Indicator Console position; an indicator light on the panel which is illuminated when the transmitter is on; another light, marked LOCAL CONTROL, which shows when control of the Transceiver is transferred from the Transceiver position to the Indicator Console; and two pushbuttons to control the motor-driven voltage regulator. This regulator raises and lowers the voltage to the oscillator tubes in the Transceiver. A kilovolt meter on the front panel provides a relative indication of the voltage being applied to the transmitting tubes by the modulator.

(3) LOCAL CONTROLS.—There is only one control for local operation. This is the master ON-OFF switch for all of the Indicator Console Units.

(4) BLOWER MOTOR.—The blower motor is included in the General Control unit because space is available. Actually it is so mounted that its output is directed upward to the Console Receiver.

(5) SPARE TUBE STORAGE.—Extra dummy sockets and tube clamps are provided in the chassis. Spare tubes may be kept in these sockets for use as replacements in the console. These sockets are not connected and are for tube storage only.

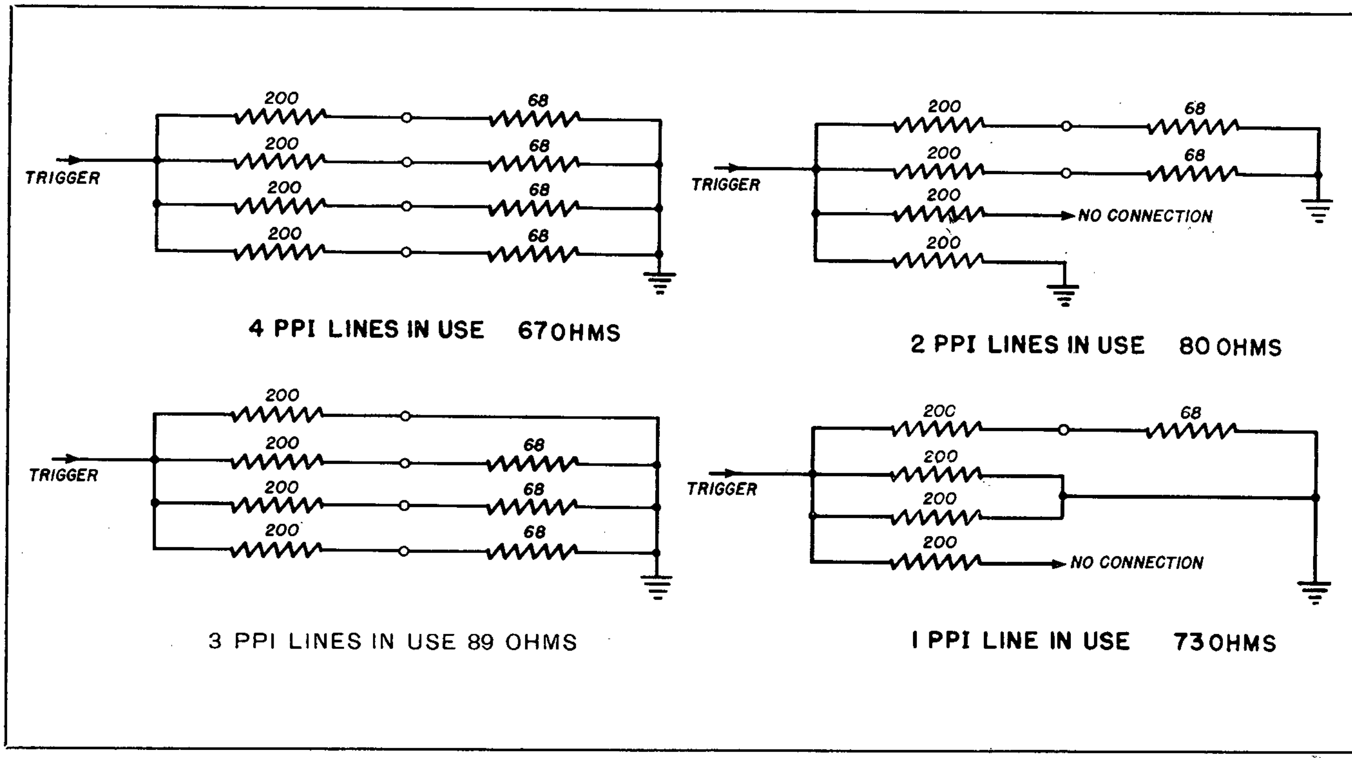


Figure 2-46. Pulse Line Terminations

i. TERMINATION OF PULSE LINES.

(1) GENERAL.—The trigger and video pulse lines used in both the Indicator Console and radar system must be very carefully terminated in order to prevent a mismatch in the line. Failure to do this would result in a serious distortion of the shape of the waveform. The two lines employ different methods of termination, though the net result in both cases is the same.

(2) TRIGGER PULSE LINE.—The trigger pulse line from the transmitter terminates in four series resistors in the top of the Indicator Console cabinet. Fig. 2-46 shows how this network appears. When four remote PPI indicators are in use, a 68-ohm resistor is placed across the line in the last unit on each line. The network will then appear as four 268-ohm resistors in parallel, and present a load resistance of 67 ohms. Taking resistor tolerances into account, this is a good approximation of 70 ohms, the cable impedance of the line from the transceiver. Thus, an approximate match is secured, and the cable presents a matched resistive load rather than a reactive which would distort the shape of the pulses.

(3) If three channels are in use, one of the 68-ohm resistances will be missing. The termination will appear as three 268-ohm resistors and a 200-ohm resistor in parallel, or 89 ohms. In the installation section of this book, proper connections are given for terminating the line in this way. When two channels are used, one left floating and the fourth is grounded. This produces an impedance of approximately 80 ohms. When one channel is used, two of the remaining channels are grounded and one floats. The resulting impedance from the latter circuit is 73 ohms.

(4) Each video channel must be terminated by a 68-ohm resistor across the line. This resistor is connected to the circuit by a switch on the remote indicator units. The resistor used is the one located in the unit on the line which is farthest away from the console. These are the BRIDGE or TERMINATE connections in the remote unit. Consequently, the combination should be adjusted in accordance with the instructions for the remote unit. However, when not in use, these lines may be left open due to the type of cathode follower output tube in use without affecting the other channels in the receiver.

13. CONSOLE RECEIVER.

a. GENERAL.

(1) The Console Receiver is not a complete receiver. It requires the addition of a heterodyne oscillator, mixer and pre-amplifier stages. These units are contained in the Monitor Receiver in the Transceiver

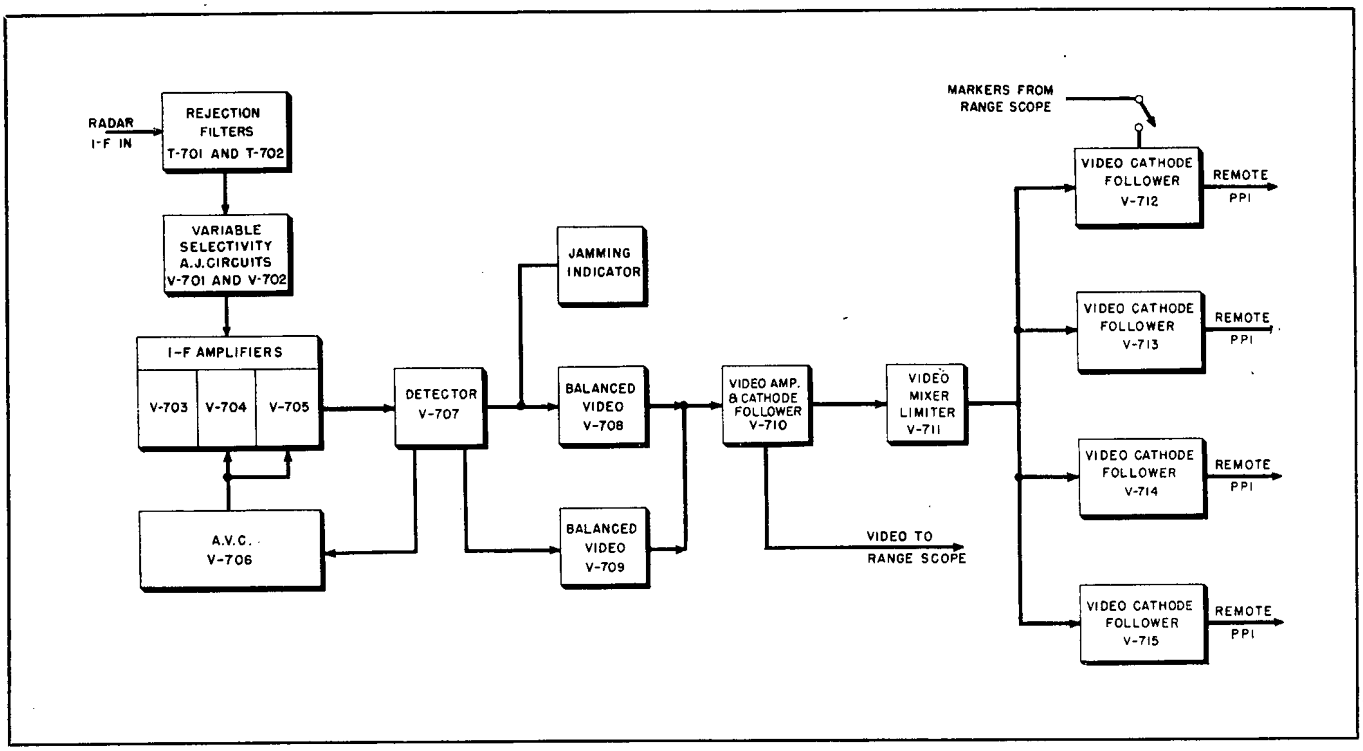


Figure 2-47. Console Receiver Block Diagram

Console. The following paragraphs describe each circuit in detail. The detailed block diagram in Fig. 2-47 is included to provide a general picture of the overall function of the various circuits.

b. ANTI-JAMMING REJECTION FILTERS.

(1) The 15-megacycle input signal is coupled to the Console Receiver at connector J-701. It is applied to the input of two filters of infinite rejection type. These filters are tuned to the undesired signal by the operator when certain types of radar jamming signals are present. The two filters are similar. The various parts of the filter are assembled inside of an aluminum can which looks very much like an i-f transformer. T-701 is Rejector 2 and T-702 is Rejector 1. One of these filters is adjusted to make it tunable over one-half of the bandwidth of the receiver. The other filter is tunable over the other half of the band.

(2) Each of the filters has two tuning adjustments. One of these adjustments is available at the top of the shield can for aligning the filter when the receiver is being aligned. It is set so the filter range covers the proper section of the i-f band-width of the receiver. The other tuning adjustment is brought out to a knob on the front panel of the Console Receiver behind the door in the shock-insulated panel. The tuning knobs turn a shaft on which is mounted a cam arrangement. The cam forces a plunger into the coil to change its inductance. The plunger is held against the cam by a compressed spring. These two filters are useful as anti-jamming controls when a jamming signal occurs on single frequency. Resistors R-701 and R-702 are balancing resistors used to equalize the charges on the filter capacitors. Due to the control from the front panel, the filter may be tuned to the frequency of the jamming signal. The signal will be by-passed to ground and will not reach the amplifier stages of the receiver. In effect, each filter is a series resonant wave trap, adjustable to the unwanted frequencies in the i-f band. These frequencies may be produced by continuous wave, M.C.W., or other sustained types of interference designed to overload the receiver circuits and thus jam the radar set. The method for setting these controls is explained in Section 4.

c. VARIABLE SELECTIVITY ANTI-JAMMING CIRCUIT.

(1) Following the two rejection filters at the input to the receiver, the i-f signal is coupled to the grid of the Type 6AC7 first i-f amplifier tube, V-701. See Fig. 2-49. This tube, and the Type 6AC7 second i-f amplifier tube, V-702, provide very little gain. They function primarily as part of the variable selectivity anti-jamming circuit where very little gain is required. V-701 is a conventional resistance-coupled amplifier. Its plate resistor, R-707, is only 4,700 ohms. The low value of resistance used does not provide much gain but it greatly broadens the response of the amplifier. This feature is necessary in order to provide sufficient band-width to allow the rejection filters to function and still leave enough band-width for the desired signal.

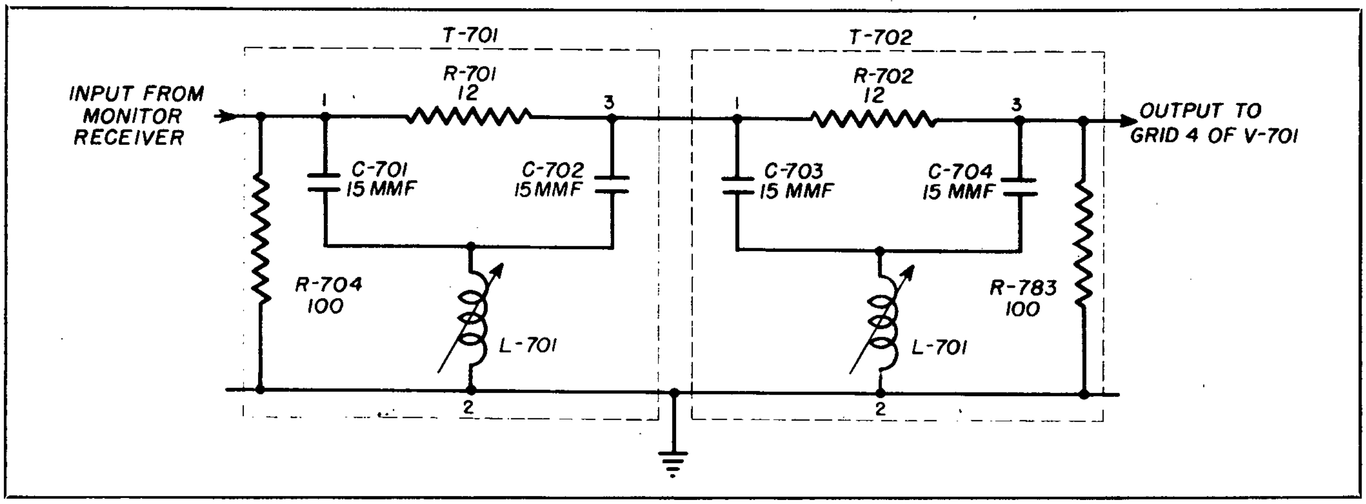


Figure 2-48. Anti Jamming Filters

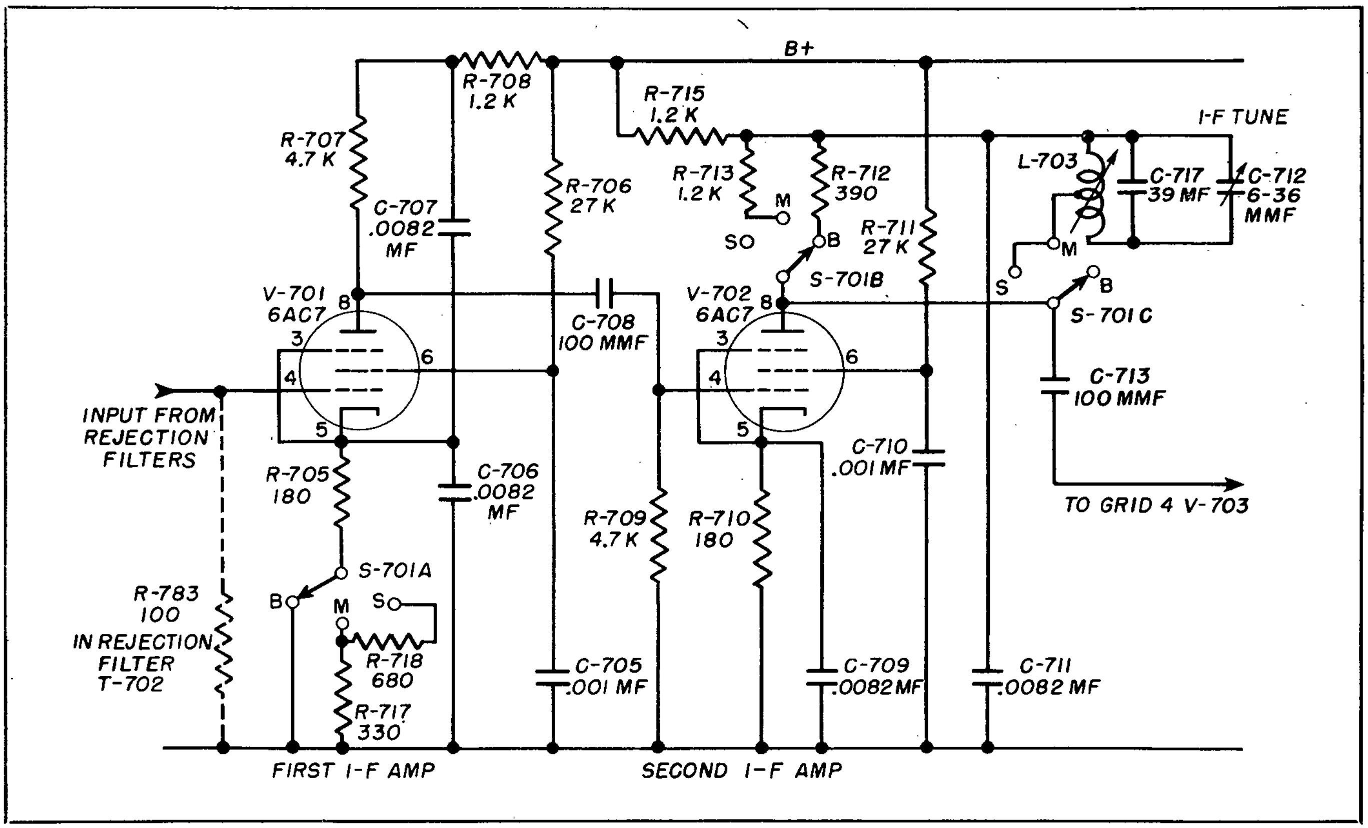


Figure 2-49. Variable Selectivity Anti-Jamming Circuits

(2) The output of the first i-f amplifier is coupled to the grid of V-702. The band-width in the plate circuit of V-702 is made variable in three steps by means of switches S-701B and S-701C. Switch S-701 is the I.F. BAND WIDTH switch located on the front panel of the unit behind the door. When this switch is in the BROAD position, (B), the 390-ohm resistor R-712 is inserted as the plate load of V-702 as shown in Fig. 2-49. Under this condition, the band-pass of the circuit is approximately 1.5 megacycles. When the switch is in the MEDIUM position designated (M) in Fig. 2-49, the 1,200 ohm resistor R-713 is connected across a part of the inductor L-703. The addition of the tuned circuit makes the amplifier more selective than it is in the BROAD position, and results in a band-width of approximately 250 kilocycles. In the SHARP position designated (S) in Fig. 2-49, the plate is connected directly to inductor L-703 and all parallel or series resistance is removed from the circuit. This results, due to the high Q of the tuned circuit, in a

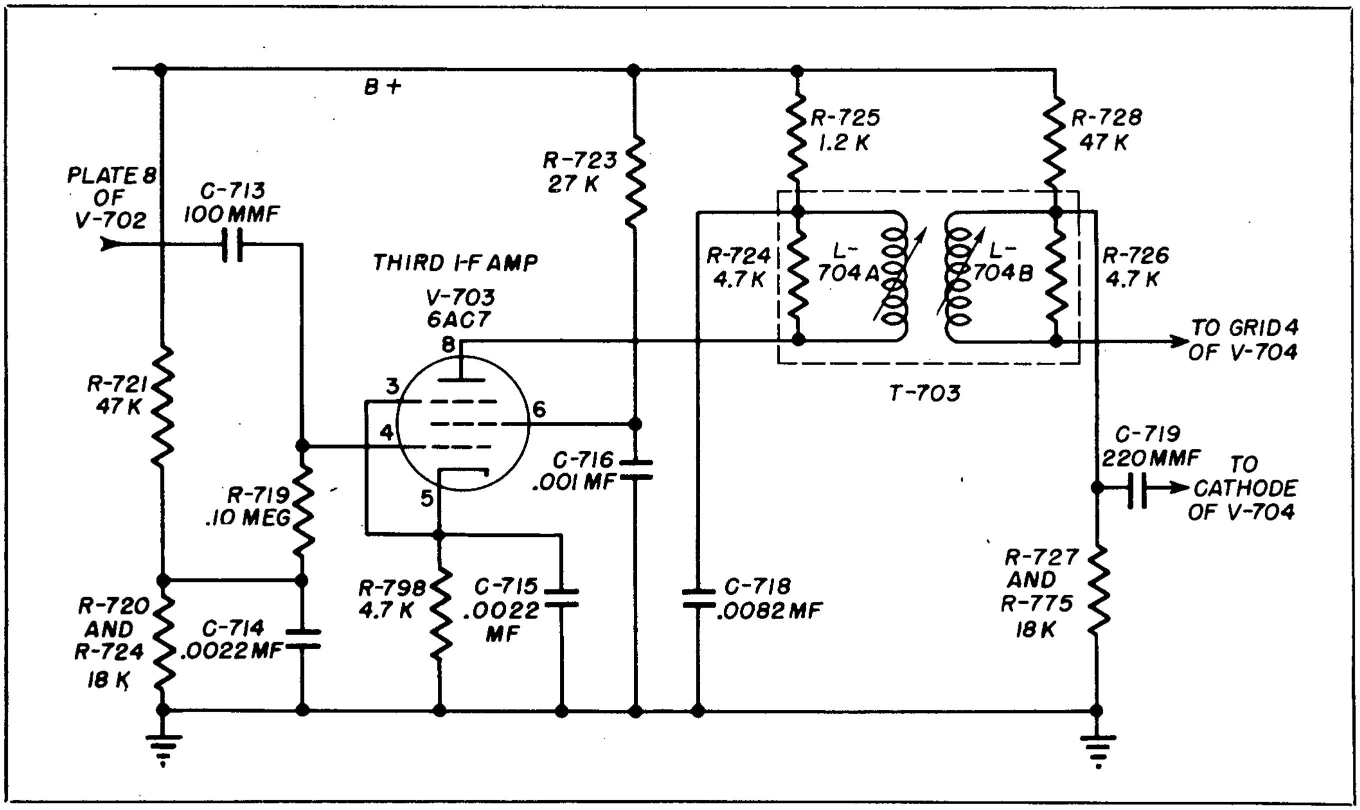


Figure 2-50. Third I-F Amplifier

band-width of approximately 100 kilocycles. The three band-widths available permit the operator to select a band-width that will be the most effective in minimizing or eliminating any jamming signal which is within the wide band-width, but not exactly on the same frequency as the radar transmitting oscillator. C-712, the tuning capacitor for the tuned network, is operated by a control on the front panel of the receiver. By operating this control, when the circuit is adjusted to SHARP or MEDIUM, the narrowed band-width may be moved to any section of the receiver band-width. Capacitor C-717 limits the tuning range to the receiver band-width.

(3) It will also be noticed from the schematic diagram that another section of the I.F. BAND WIDTH switch S-701 is used to change the value of the resistance in the cathode of V-701 as the selectivity of V-702 is varied. This is due to the fact that the gain of V-702 increases as the band-width in the plate circuit of V-702 is decreased. With the switch in BROAD position, the gain of V-702 is low due to the insertion of resistor R-712 in its plate circuit. In this case, the cathode of V-701 is returned to ground through its cathode resistor R-705. Thus, V-701 gives its greatest gain, to compensate for the loss of gain in V-702. When the switch is in the MEDIUM position, the tuned circuit, partly shunted by resistor R-713, provides a higher plate load impedance and the gain of the tube is increased. In this condition, resistor R-717 is switched into series with resistor R-705 in the cathode circuit of V-701. This lowers the gain of V-701 by an amount necessary to compensate for the increased gain in V-702. In the same manner, when the SHARP band-width is used, the gain of V-702 is increased since the tuned circuit is no longer shunted by any resistance. In this switch position, resistors R-718 and R-717 are both added in series with resistor R-705 in the cathode circuit of V-701 to compensate for the increased gain of V-702. This maintains the output to the third i-f amplifier V-703 at a constant level regardless of the position of the I.F. BAND WIDTH switch.

d. THIRD I-F AMPLIFIER.

(1) The output of the variable selectivity anti-jamming circuit is applied to the grid of the type 6AC7 third i-f amplifier tube V-703, by coupling capacitor C-713. See Fig. 2-50. The cathode bias of this tube is very high due to the use of a cathode resistor of 4,700 ohms. Due to the plate potential applied to the stage, the cathode of the tube is from 50 to 55 volts above ground. In order to provide normal Class A operating bias, the grid is tapped to a voltage divider formed by Resistors R-721, R-720, and R-774 between the plate supply bus and ground. A positive bias of about 52.5 volts is applied to the grid. The difference between the grid and cathode potentials provides an effective bias between the grid and cathode. Consequently, tube operation is approximately normal. One

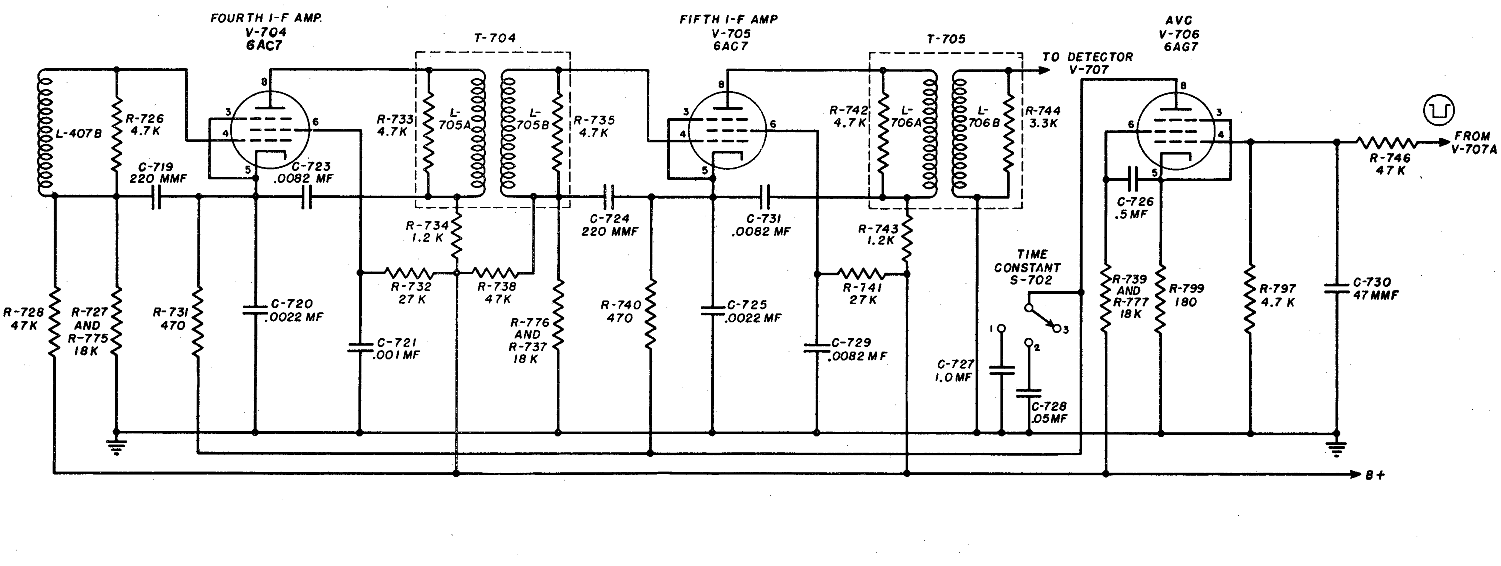


Figure 2-51. Fourth and Fifth I-F Amplifiers and AVC Tube

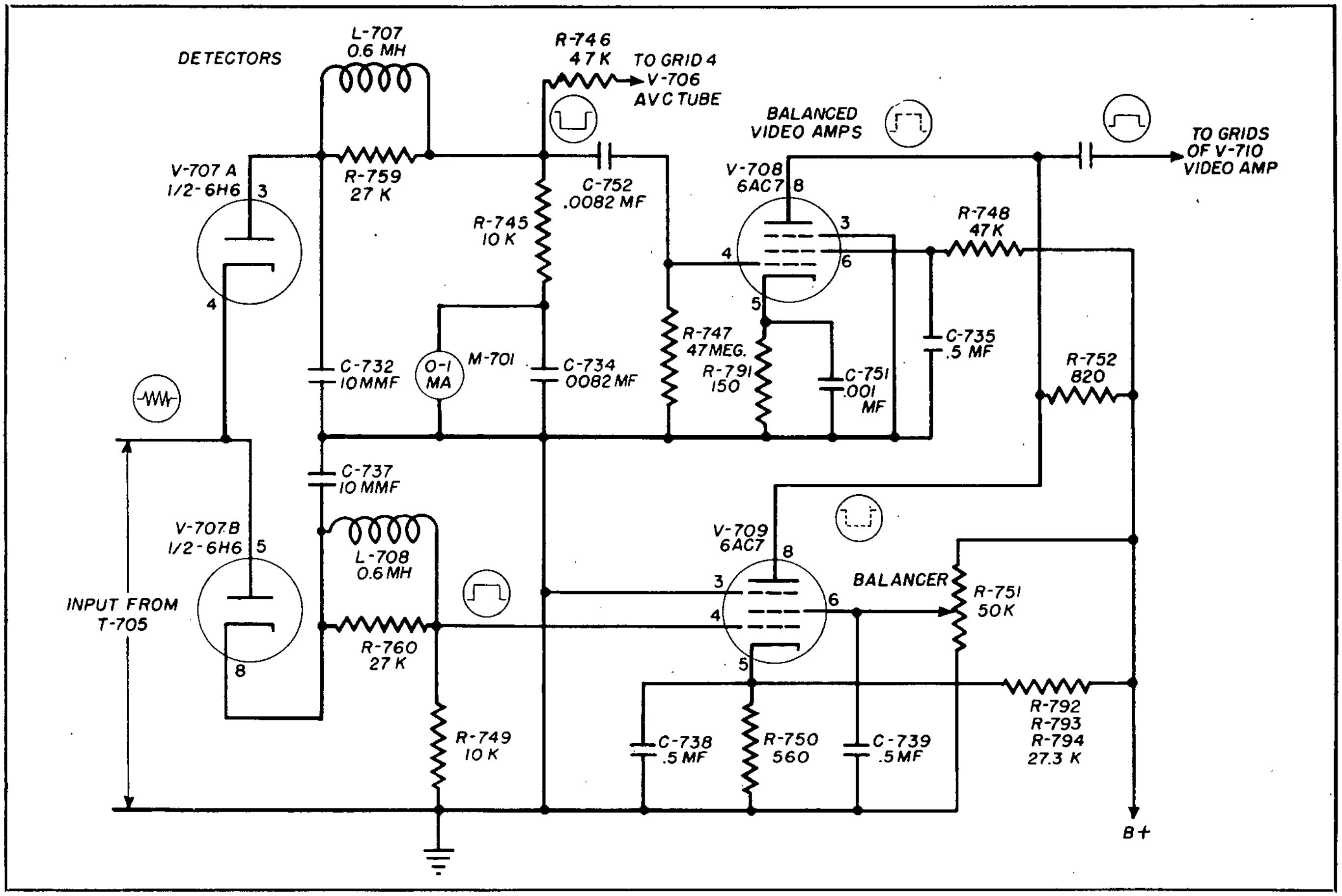


Figure 2-52. Detector and Balanced Video Circuits

effect obtained through the use of this high cathode bias is that when a very strong signal is applied to the grid of the tube, the extra current flowing through the high cathode resistance greatly increases the cathode bias and prevents the tube from being overloaded. The primary reason for operating V-703 at such high potentials above ground is because of the fact that the AVC circuit places V-704 and V-705 at a high potential above ground. The low plate voltages required would cause a potential to exist between the primary and secondary windings of transformer T-703.

(2) The plate circuit of V-703 is tuned to the intermediate frequency by the primary winding of the interstage i-f transformer T-703. The output of the stage is coupled to the grid of the fourth i-f amplifier V-704 by the secondary. This transformer is a permeability-tuned unit. Its tuning controls for both the primary and secondary are available on the top of the shield can for use when aligning the i-f stages.

e. FOURTH AND FIFTH I-F AMPLIFIERS.

(1) The fourth i-f stage is the type 6AC7 tube V-704, and the fifth i-f stage is V-705, a similar type tube. See Fig. 2-51. These two stages are coupled together by i-f transformers T-704. Transformer T-705 serves as an output transformer for the fifth i-f amplifier stage. Like the third i-f amplifier stage, the cathodes of these two tubes are operated approximately 50 volts above ground. A positive grid potential is obtained in a manner similar to the manner in which the grid potential is obtained for V-703. However, the cathodes of the tubes are returned to ground through the AVC control V-706, a type 6AG7 tube. The tube's impedance, under resting conditions, provides a cathode bias which, with the regular cathode bias resistors, sets the cathodes of the tubes approximately 50 volts above ground. The operation of V-704 and V-705 is similar to the operation of V-703 except that their gain is controlled by the AVC voltage from V-706. The AVC action is explained in Par. 5b (6) of this section.

f. DETECTOR.

(1) The Type 6H6 double diode tube V-707 receives amplified i-f signals from the secondary of the i-f transformer T-705 connected in the plate circuit of the fifth i-f amplifier. The i-f signals are connected to the cathode of one diode section and to the plate of the other section of V-707 as shown in Fig. 2-52. Consequently, the output of section V-707A will be negative video pulses while the output of section V-707B will be positive video pulses. The negative pulses secured from V-707A are peaked by inductor

L-707 which is located inside transformer T-708. The current of V-707A flows through jamming indicator meter M-701, R-745, R-759 and peaking inductances L-707, the latter being connected in parallel with R-759. Negative video pulses are directly coupled to the AVC tube V-706 through resistor R-746. They are also coupled to the grid of V-708 through capacitor C-752. V-708 is one of the tubes in the balanced video amplifier stage. Positive video pulses from V-707B are peaked by inductor L-708 located inside transformer T-708 and applied to the grid of V-709, the other tube of the balanced amplifier.

(2) M-701, a 0-1 milliammeter, is located in the diode return circuit of V-707B to indicate the average current through the tube. When a jamming signal is present in the system, the amplitude of the i-f signal will be greatly increased. This larger signal will cause the average diode current to increase. Therefore, the meter indicates the presence of jamming signals and may be used to indicate when the rejection filters are correctly tuned.

g. AVC ANTI-JAMMING CIRCUITS.

(1) The AVC circuit is controlled by the negative video output of the detector, V-707A. The AVC tube is shown in Fig. 2-51. The detector is coupled to the grid of the Type 6AG7 AVC tube, V-706, through resistor R-746. Since no coupling capacitor is used, the d-c voltage developed across the diode return resistor R-747 also appears on grid 4 of V-706. This enables AVC action to continue regardless of the length of the negative pulse from V-707A. This is necessary during the long blocks of voltage usually encountered in various types of jamming conditions. The cathode current of the fourth and fifth i-f amplifiers flows through the AVC tube. A negative voltage applied to the grid of V-706 increases its plate-to-cathode impedance and causes the cathodes of the two i-f amplifier tubes to become more positive. Since the grids of the tubes are at a fixed potential, it has the same effect as reducing the potential on their grids. Therefore, gain of the tubes will be decreased. As the amplitude of the negative pulses varies on grid 4 of V-706, the gain of V-704 and V-705 also varies. This permits maximum signal amplification while at the same time the effect of jamming is held to a minimum.

(2) The action of the AVC is delayed by the inclusion of two capacitors in the system. Capacitor C-730 connected from the grid of V-706 to ground in parallel with resistor R-746, provides a very slight delay. It also tends to smooth out the grid fluctuations so that AVC control does not completely disappear between pulses. Capacitors C-727 and C-728 may be switched into the circuit by the TIME CONSTANT switch S-702 inside the door on the front panel. They function to increase the delay of the system. When one of these capacitors is in the circuit, the voltage at plate 8 of V-706 cannot change materially until the charge on the capacitor has changed. The object of the delay introduced by these capacitors is to slow down the AVC action so that the gain of the i-f amplifiers cannot change while they are receiving a desired radar echo signal. However, any jamming signal such as a blocking signal which is longer than an echo pulse will affect the system and reduce the gain in the i-f stages. In the long time constant position, the picture which appears on the Range Scope is very similar to ordinary radar scope indications. In the short time constant position, a typically large image will build up very quickly to its maximum height. Then it will drop down to approximately half height and remain for the duration of the pulse. In this manner, the pulse is not permitted to saturate the screen during its entire width, but only for a very small instant of time. Consequently, on heavy jamming, it may be possible to transform the jamming blocks into spikes. This will permit the radar signals to appear between the spikes on the scope face.

h. BALANCED VIDEO AMPLIFIER.

(1) This stage is comprised of the Type 6AC7 tubes V-708 and V-709 as shown in Fig. 2-52. The grid of V-708 is fed negative video signals from plate 3 of detector V-707. V-709 is fed positive signals from cathode 8 of V-707. The plates of V-708 and V-709 are connected together with resistor R-752 serving as a common load resistor for both tubes. Since the voltages at the grids are 180 degrees out of phase, the voltages at the plates will also be 180 degrees out of phase. If the voltages at the grids were equal, and the amplification factors of both tubes the same, the voltages at the plates would cancel out across the common load resistor. The net output would be zero, regardless of the amplitude of the voltages at the grids. However, in normal operation of the circuit, the constants of the two tubes are not the same. For low level signals, the gain of V-709 is adjusted to zero by operation of potentiometer R-751, the BALANCER control on the panel of the receiver inside the door marked A.J. controls. Under this condition, V-709 does not function, while V-708 amplifies the negative video signals. These signals appear as positive video signals across the load resistor R-752.

(2) Under the normal conditions, V-709 is operated slightly beyond the plate cut-off value. The BALANCER control is set so that V-709 remains cut off for normal radar video signals. However, when a signal of higher amplitude than the radar video appears, it will appear in equal intensity on the grids of both tubes. The signals will be, of course, 180 degrees out of phase. The setting of the BALANCER permits V-709 to amplify, once the cut-off point is passed and it will reproduce the stronger component of the signal across the plate load resistor. There, it will appear as a voltage pulse 180 degrees out of phase with the stronger component of the same signal from

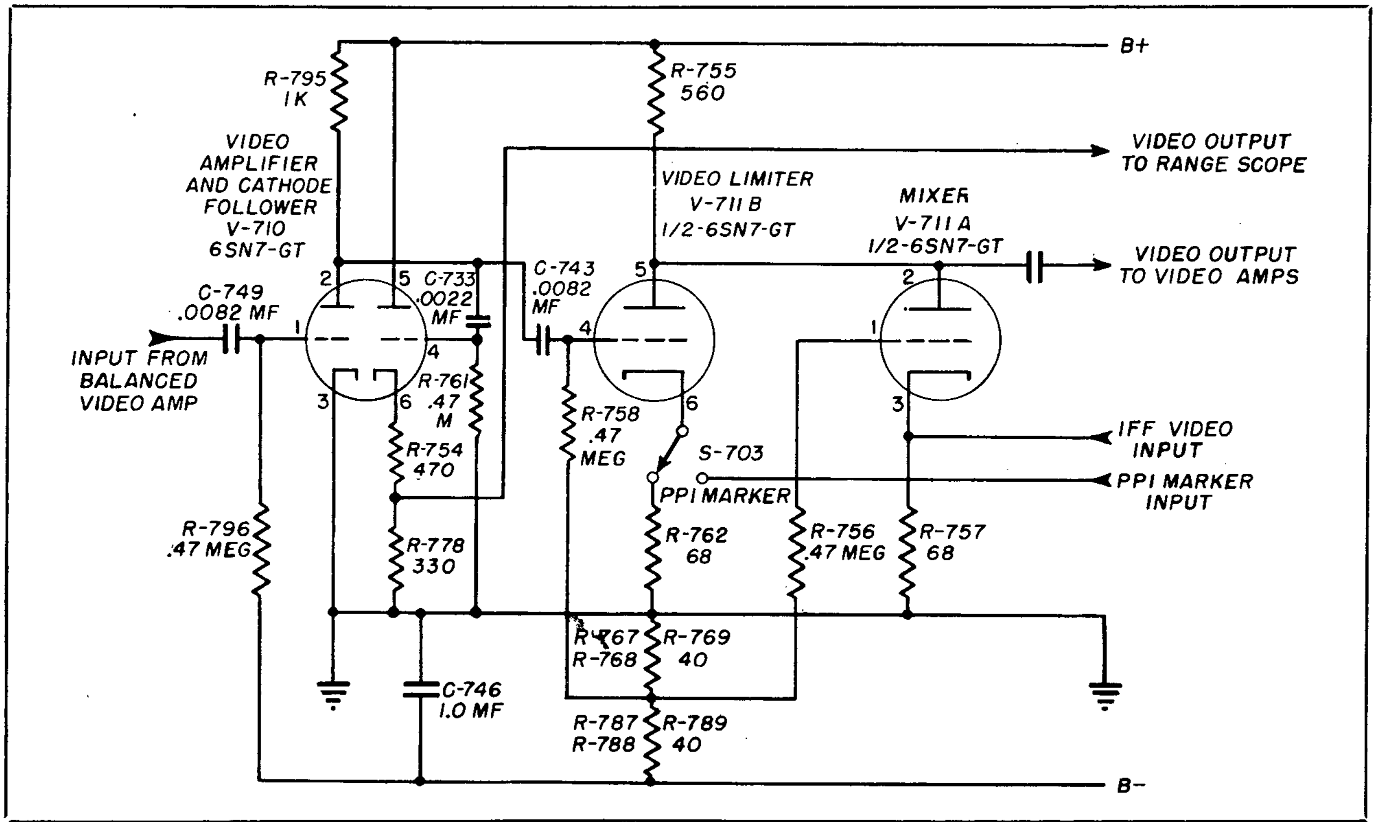


Figure 2-53. Video Amplifier and Cathode Follower

V-708. Due to the different operating conditions of the two tubes, the amplitude of the output of V-709 will always be less than that of V-708. This difference is equal to the amplitude of the normal radar video signal. Therefore, the circuit acts to cancel out heavier jamming signals although it still permits the radar video signals to be reproduced across the common load resistor R-752.

i. VIDEO AMPLIFIER AND CATHODE FOLLOWER.

(1) The output of the balanced video amplifier is coupled to grid 1 of the video amplifier V-710A by the coupling capacitor C-749. See Fig. 2-53. This stage consists of a type 6SN7-GT double triode tube. One section is connected as an amplifier and the other section as a cathode follower. A slight negative bias is applied to grid 1 of V-710A by the bias resistor network in the negative return to the rectifier circuit in the unit. When positive video pulses from the balanced amplifier are applied to the grid of the tube, negative video pulses appear at the plate.

(2) Two negative output voltages are taken from V-710A. These outputs are taken from plate 2 of V-710A and are obtained from the voltage developed across the plate load resistor R-795. One output is applied to grid 4 of the video limiter and mixer V-711, and the other output is coupled to grid 4 of V-710A through capacitor C-733. V-710B functions as a cathode follower. Its output is taken from the junction of resistors R-754 and R-778 which are connected in series between the cathode of V-710B and ground. This provides a low-impedance signal for transmission by cable to the Range Scope.

j. VIDEO LIMITER AND MIXER.

(1) The video limiter and mixer, shown in Fig. 2-53, consists of a type 6SN7-GT tube V-711, and its associated components. The two plates of the double triode sections are connected in parallel. Negative video signals from the triode video amplifier are coupled to grid 4 of the tube by coupling capacitor C-743. Under normal operation, the cathode resistor for this section of the tube is resistor R-762. While the tube tends to act as an amplifier, amplification is limited on strong signals since negative pulses are supplied to the grid. Therefore, amplification of the stage is limited, since no amplification is obtained after the grid is driven to the point where it cuts off the tube. In other words, the stage will amplify low amplitude signals but will be driven to cutoff by strong signals. This limits the output on strong signals. The PPI MARKER switch S-703 in the cathode circuit switches cathode 6 to a 68-ohm resistor in the Range Scope. The PPI marker voltage from the Range Scope appears across this resistor. The PPI markers are positive pulses. Applying these markers to cathode 6 of V-711B raises the cathode potential

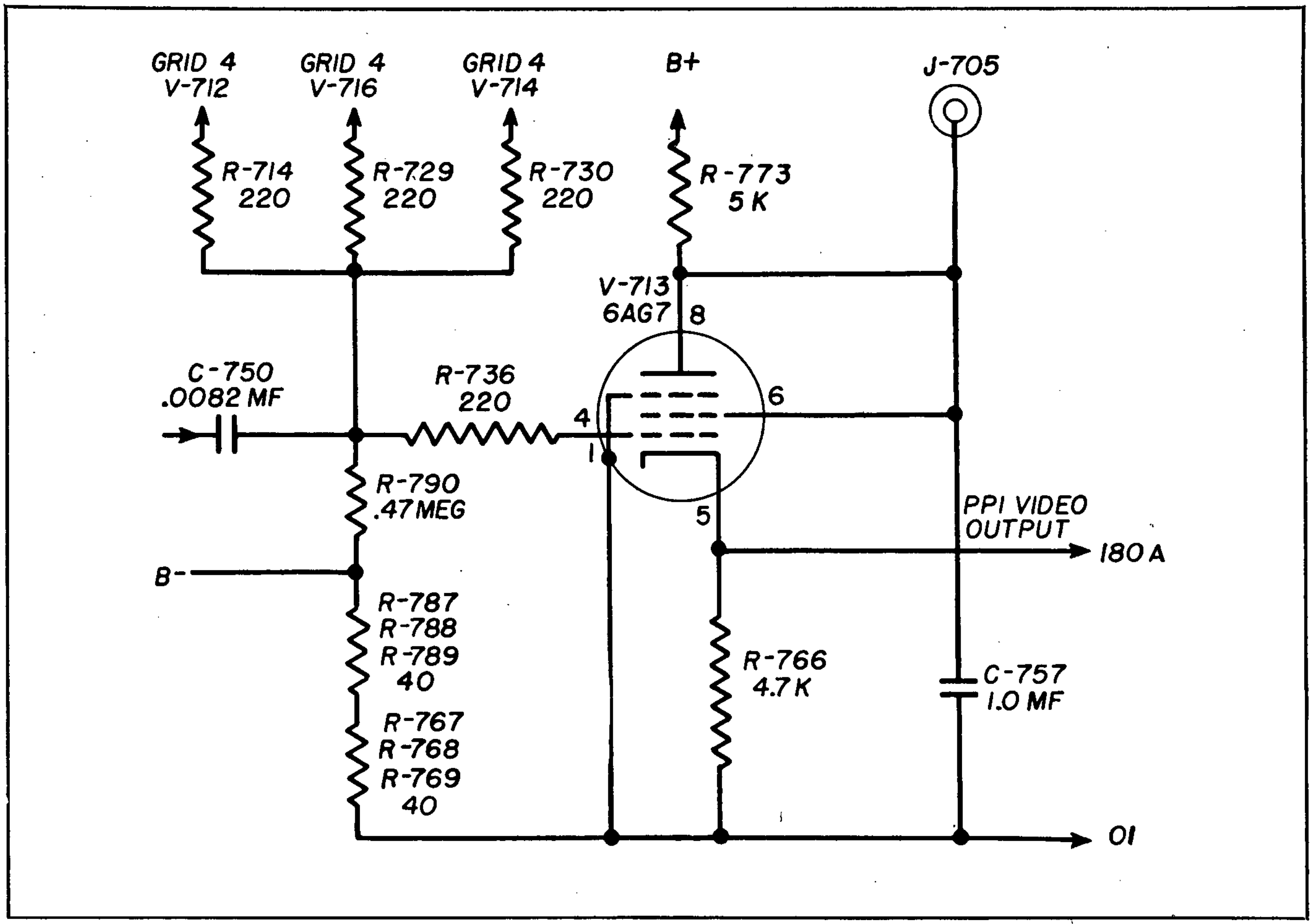


Figure 2-54. Video Output and Cathode Follower

with reference to the grid potential. It produces the same output in the plate circuit of the tube as would be obtained if negative markers were applied to the grid. Thus, this section of the tube serves to amplify and limit the video pulses, to limit the PPI marker pulses, and to mix them both in the plate circuit of the tube.

(2) The section of the tube formed by grid 1, plate 2, and cathode 3 (V-711A) is employed to inject IFF signals into the video output to the PPI unit in the Console and to the remote PPI indicators used with the equipment. The PPI marker signals are positive, and are injected into the circuit across the cathode resistor of V-711B. They appear on plate 5 as positive signals since they increase the negative bias for the duration of each pulse. Since the plates of both sections of the tube are connected in parallel, the common output consists of video signals and IFF signals. When the PPI MARKER switch S-703 is thrown it will also include the PPI markers. The PPI MARKER switch is only used when the remote PPI indicators are not equipped with marker-generating circuits of their own. It is also used when it is desired to calibrate the PPI markers with the range markers from the Range Scope.

k. VIDEO OUTPUT CATHODE FOLLOWERS.

(1) The output of the video limiter and mixer is fed to the grids of four cathode follower tubes. These tubes are the Type 6AG7 tubes, V-712, V-713, V-714 and V-716. Since the circuits of all four tubes are identical, only V-713 is shown in the simplified schematic in Fig. 2-54. These cathode followers have very high cathode resistors, R-763, R-766, R-764 and R-765, each being 4,700 ohms. The high cathode resistors are for the purpose of reducing the gain of the tube practically to zero when output of the cathodes is not connected to a PPI unit. When such a connection is made, a 68-ohm resistor is placed across the line at the remote point. With this resistor being the effective cathode resistor, the tubes operate as normal cathode followers. If the remote PPI unit line is disconnected, the 4,700 ohm resistor raises the cathode potential to about twice its normal potential under load and prevents the tube from running free. This makes it unnecessary to connect a terminating resistor across the cathode resistors of tubes not in use. Four cathode followers are employed so that separate lines may be run to different parts of the ship. With four such lines, if one is damaged, the others are not affected.

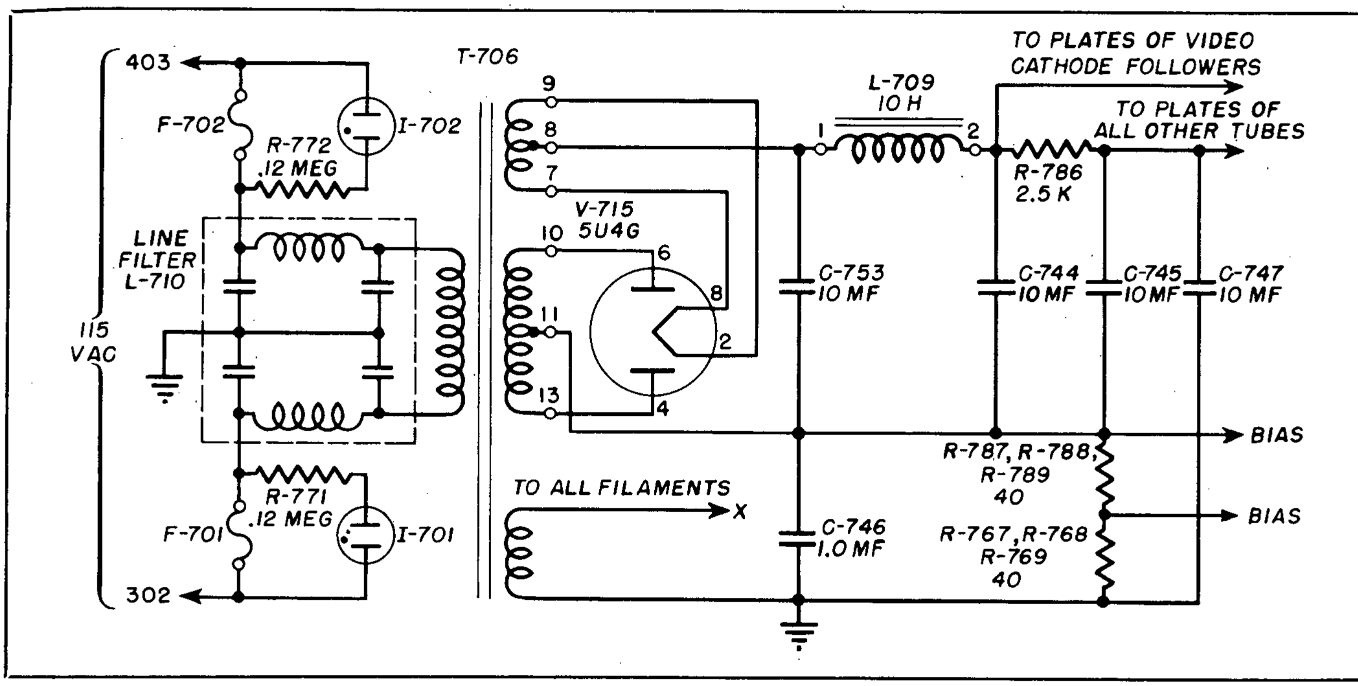


Figure 2-55. Receiver Power Supply

l. POWER SUPPLY.

(1) Plate voltages are supplied for the entire unit by a full-wave rectifier circuit comprised of transformer T-706, the Type 5U4G rectifier tube V-715, and the filter circuit comprised of capacitor C-753, inductor L-709, capacitor C-745, resistor R-786, and capacitors C-744 and C-747. See Fig. 2-55. The negative return to the rectifier circuit is through a resistor network comprised of Resistor R-767, R-768, R-769, R-787, R-788, and R-789. This network provides a negative bias which is supplied to the grids of the video amplifier, the limiter and mixer, and the video output cathode followers. The network is filtered by the 1.0 mfd capacitor, C-746.

(2) Line filter L-710 is provided to filter out line disturbances. Both sides of the a-c input line are fused. The fuses are rated at 2 amperes, and a neon indicator lamp and series resistor is connected across each fuse. When the fuse is not blown, current will not flow through the indicator light circuit. However, when the fuse blows, a small amount of current, limited by the resistor, will flow in this circuit. The indicator light then lights and indicates the fuse which is blown. The amount of current flowing through the series resistor and the light is not sufficient to develop voltage in the power supply.

m. REMOTE CONTROLS.

(1) Two remote controls are provided in the Console Receiver. One of these is the GAIN CONTROL which controls the gain in the Monitor Receiver in the Transceiver. The control is R-703, 2,000 ohm potentiometer. The other remote control is the ECHO BOX switch S-704. This switch applies 110 volts a-c to a relay in the Monitor Receiver which brings the echo box circuits into use. One section of the I.F. BAND WIDTH switch has connections brought out to one of the terminal boards for connection to a keyer or modulator. This section of switch S-701 may be used to control the width of the keying pulse out of a keyer or modulator.

n. INTERCONNECTION CIRCUITS.

(1) Interconnections between the Console Receiver and components of the Indicator Console as well as the balance of the components with which the Console is being used, are made to terminal boards in the top section of the cabinet in which the Console Receiver is located. Also, in the top section of this cabinet is located the trigger pulse terminating strip. Distribution of the trigger pulse is made from this point to the Indicator Console components, as well as to any remote PPI indicators.

14. RANGE SCOPE.

a. GENERAL.

(1) The Range Scope is shown in the block diagram in Fig. 2-56. It is the basic range-determining component in the Indicator Console. It displays radar targets in a Type *A* display on the screen of a cathode ray tube. In this manner, distance from the radar set to the target can be very accurately determined. It is also used to display IFF video signals from the IFF equipment associated with a ship's radar installation on the face of the same tube. Therefore, should an

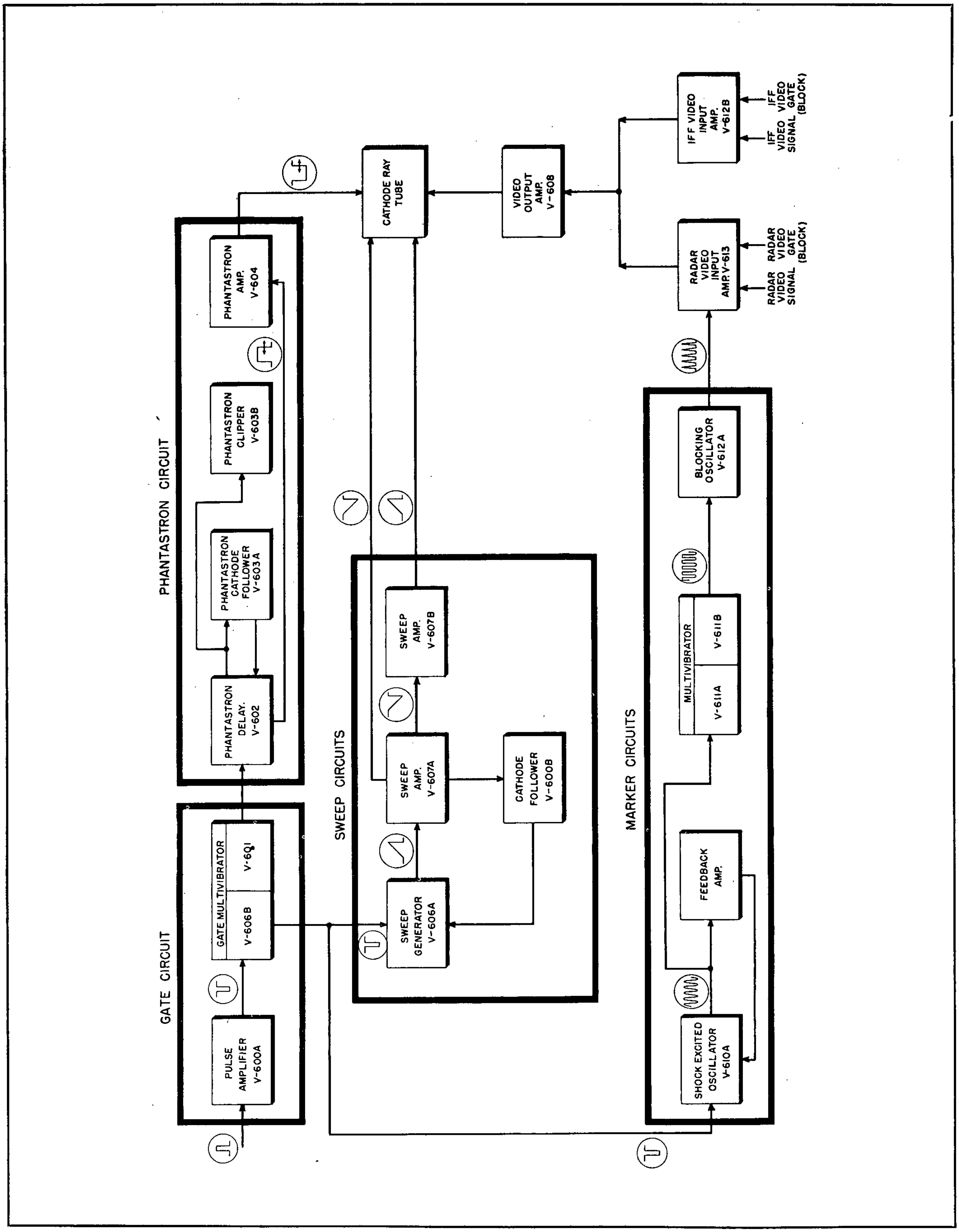


Figure 2-56. Range Scope Block Diagram

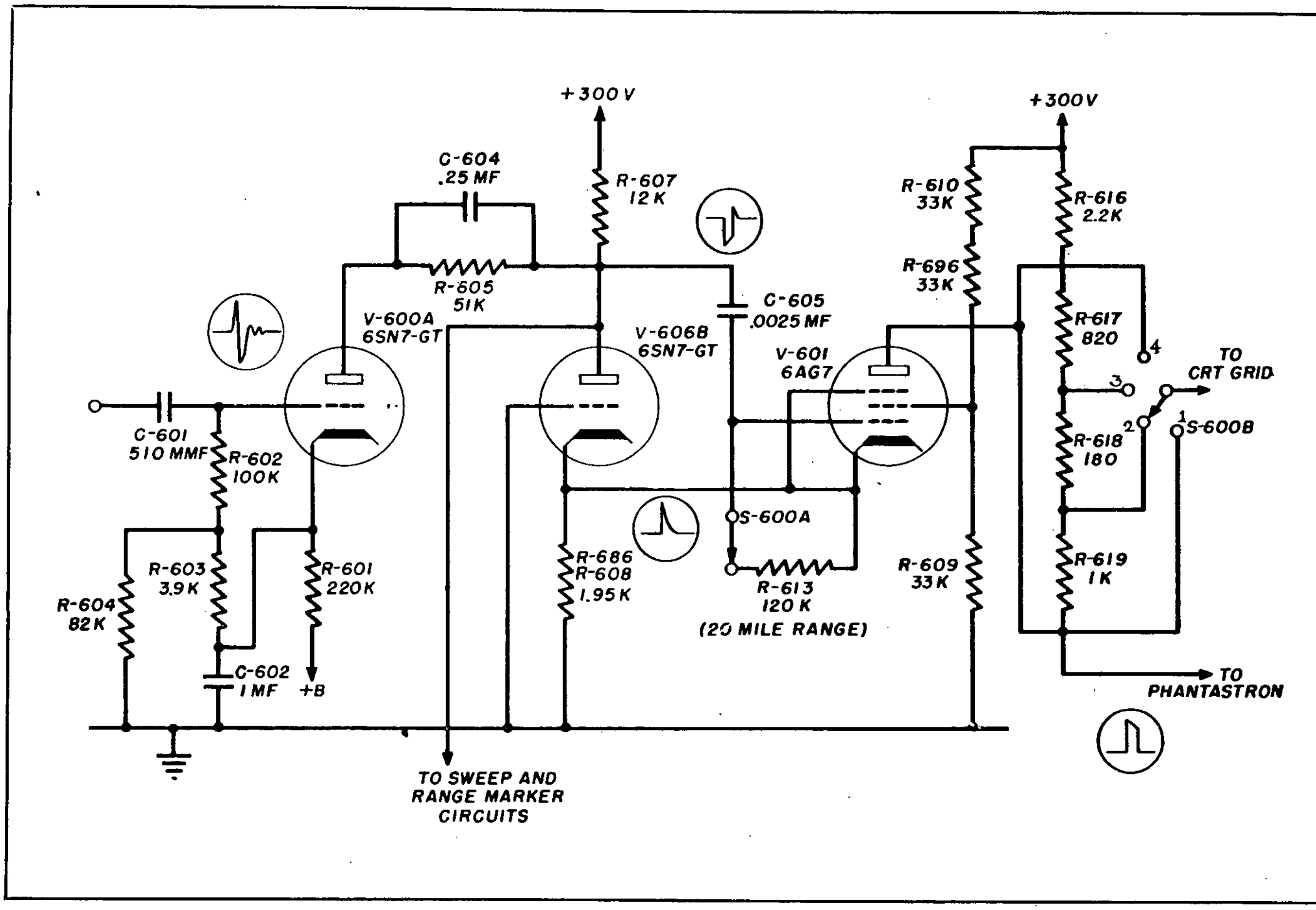


Figure 2-57. Gate Circuit in Range Scope

interrogated target be friendly, it will cause IFF identification signals to be displayed on the scope. Also, when used in conjunction with the Bearing Indicator, it enables the operator to know when the antenna beam is centered on the target. Accurate bearing information may therefore be determined from the dials of the Bearing Indicator.

(2) The accuracy with which the range to a target may be read on the range indicator is ± 100 yards up to 80 miles, when range is read by comparison with the range step. The range step is only available for measurements on the three shorter ranges on which the range scope operates. The scope operates on pulse widths of 0.5 to 20 microseconds, and on trigger repetition rates of 60 to 1,100 cycles per second. It requires a trigger pulse amplitude from 5 to 40 volts, video signals at —2.5 volts and IFF video signals at $+5$ volts. Four ranges are provided, the 4-, 20-, 80-, and 200-mile ranges being available by operation of a switch on the front panel of the unit.

(3) The Range Scope consists of seven separate circuits. The text which follows will be broken down into individual descriptions of these circuits. These circuits are: Gate Circuit, Sweep Circuit, Phantastron Circuit, Range Marker Circuit, Video Circuit, Cathode Ray Indicator Tube Circuit and the Power Supply Circuits. See Fig. 2-56.

b. GATE CIRCUIT.

(1) The gate circuit is triggered by a positive pulse from the IFF Coordinator. It would also be possible to trigger the Range Scope directly from the transmitter or modulator if they provide a positive trigger pulse. However, since the Range Scope is also required to indicate IFF video pulses and there is some delay inherent in the IFF system, it is necessary to delay the trigger of the sweep which carries the IFF indications. This is done to properly range the IFF video signals and locate them under the corresponding radar video signals on the scope face. The IFF Coordinator supplies the delayed trigger necessary for IFF operation. The radar trigger supplied to the Range Scope is applied at the same instant as the trigger from the radar transmitting equipment associated with the Indicator Console.

(2) The gate circuit is shown in the simplified schematic diagram, Fig. 2-57. The tubes in this circuit are: V-600A which is one-half of a Type 6SN7GT tube, V-606B which is also one-half of a Type 6SN7GT tube, and V-601 a Type 6AG7 tube. V-600A is the trigger pulse amplifier while V-606B and V-601 form

a multivibrator circuit which determines the gate width. The output of the circuit consists of both positive and negative going, rectangular pulses of voltage. The positive pulse from plate 8 of V-601 is used to unblank the cathode ray tube. It permits the trace to be seen during the time the positive gate pulse is present. The leading edge of this positive pulse is also differentiated by capacitor C-607 and resistor R-622 and used to trigger the phantastron circuit when the range step is desired on the 4- and 20-mile ranges. A negative pulse of voltage is taken from plate 5 of V-606B and is used to trigger the sweep and range marker circuits.

(3) The positive pulse of voltage from the IFF Coordinator is applied to the grid circuit of V-600A through coupling capacitor C-601. V-600A operates well below plate current cut-off and the positive trigger pulse is amplified and inverted in the plate circuit of the tube. Fig. 2-57 shows that V-600A is connected in an unconventional manner. It employs a common plate resistor (R-607) with V-606B. Its own plate resistor R-605 connected from the plate of V-606B, is by-passed by capacitor C-604 to speed up the action of the circuit. Capacitor C-604 in series with capacitor C-605 couples the negative pulse from plate 2 of V-600A to grid 4 of V-601, the plate circuit of V-606B.

(4) The cathode of V-600A is held at a high positive potential above ground because its cathode resistors, R-603 and R-604, are part of a voltage divider between the plate supply bus and ground. Resistor R-601 connects cathode 3 of V-600A to the plate supply bus to complete the divider. This is done because V-600B, the other half of the tube, is employed in the sweep circuit in such a way that its cathode is driven approximately 200 volts above ground. The design of the tube does not permit a voltage difference in excess of 100 volts between the heater and the cathode. In the case of V-600B, it is necessary to place the filament approximately 100 volts above ground so that the differential between the cathode and filament will never exceed 100 volts. This means it is also necessary to raise the cathode potential of V-600A above ground so as not to exceed the 100 volts differential between its cathode and heater since the heaters of the two sections of the tube are connected in parallel. Consequently, the operating potentials of V-600A are set by resistors R-601, R-603 and R-604 so that the cathode is approximately 150 volts above ground and the grid is approximately 130 volts above ground. The filament of the tube is not grounded. It is permitted to float and attain its own voltage level, which is about 150 volts.

(5) The common plate resistor for V-600A and V-606B, together with capacitor C-604 couples the sharp negative spike appearing in the plate circuit of V-600A to the plate of V-606B. From this point, it is coupled to the grid of V-601 by capacitor C-605. V-606B and V-601 are coupled together to form a one-kick multivibrator. When triggered, such a multivibrator goes through one cycle of operation, and then returns to a static condition. It will remain in this static condition until another trigger pulse is applied to the circuit. As can be seen from the simplified schematic diagram in Fig. 2-57, the cathodes of the tubes are connected together and cathode current flows to ground through a common cathode resistor R-608 paralleled by R-686. In the static condition, V-601 is drawing heavy plate current because its control grid is returned directly to its cathode through one of the resistors selected by the RANGE SWITCH, S-600A. Fig. 2-57 only shows the resistor, R-613, which is used on the 20-mile range. The drop through the plate resistors, R-619, R-618, R-617 and R-616, which are connected in series, places the potential at the plate of V-601 at a low value. Screen voltage is maintained at a relatively high value due to the fact that the screen is connected to the voltage divider formed by resistors R-607, R-696, and R-610.

(6) The control grid of V-601 is at the same level as the cathode due to its connection through resistor R-611, R-612, R-613, or R-614. These four resistors are the gate width resistors used to determine gate width. One of these resistors is selected by S-600A, which is part of the RANGE switch located on the front panel of the unit. The grid of V-606B is at ground potential due to its direct connection to ground and the cathode bias developed across the cathode resistor is sufficient to cut off the tube. Consequently, voltage existing at the plate of V-606B in the static condition is practically the full voltage of the power supply, or +300 volts.

(7) The cycle of operation is started by the appearance of the amplified trigger pulse from V-600A as a sharp negative spike of voltage on the grid of V-601. This negative spike drives the grid of V-601 in a negative direction. When V-601 is triggered, the voltage at its plate rises in a positive direction and the voltage at its cathode drops proportionally. The drop in cathode potential reduces the potential difference between the cathode and grid of V-606B and causes V-606B to draw current. Consequently, the voltage at the plate of V-606B drops. This drop is in turn coupled to the grid of V-601, and added to the drop in the grid potential initially caused by the spike of trigger voltage from V-600A. The action is cumulative and almost instantaneous, and the grid of V-601 is very rapidly driven to a cut-off condition. When V-601 is cut off, the voltage at its plate of V-601 rises almost vertically while the voltage at the plate of V-606B drops almost vertically. The circuit is now in a condition in which V-601 is cut off and V-606B is drawing heavy current. V-601 is a pentode because the change-

over from a conducting to a non-conducting state is more rapid in a pentode than in a triode, since the grid-to-plate capacity in a pentode is much lower because of the presence of the screen and suppressor. Any voltage swing at the plate is coupled through the tube capacity to its control grid. In a triode this coupled voltage tends to partially cancel the effect of the normal driving voltage and retard the action of the tube.

(8) The grid of V-601 is driven considerably below cut-off by the action just described. If the grid of V-601 could remain at cut-off, the circuit would not return to its original condition. Because the grid is connected to the cathode through the timing resistor in use (either R-611, R-612, R-613, or R-614) the circuit will stay at cut-off until the negative charge on the grid side of capacitor C-605 leaks off through the timing resistor. The time required for grid 4 of V-601 to return to zero bias depends upon the value of the timing resistor in use. The voltage on the grid of V-601 will gradually rise in a positive direction as capacitor C-605 charges up in a reverse direction. The length of time is determined by the value of the timing resistor in use. When this voltage has attained a point sufficiently positive for V-601 to pass current, the circuit begins to reverse itself and take on its original, and locked condition. As soon as V-601 begins to draw current, the voltage on its plate begins to fall. The cathode potential of V-606B is therefore increased due to increased cathode current flowing through the cathode resistors. This in turn, allows the cathode of V-606B to increase in voltage, which has the effect of increasing the negative voltage applied to the grid of V-606B. Consequently, V-606B draws less current and the voltage at its plate rises rapidly since less current is being drawn through its plate resistor. The rising voltage on the plate of V-606B is coupled to the grid of V-601 by capacitor C-605. This rising voltage adds to the rising voltage on the grid due to the leakage through the timing resistor. This action is rapid and cumulative. The voltage on the plate or V-601 drops rapidly to its minimum point while the voltage on the plate of V-606B increases rapidly to its maximum points. Since the rise and fall of the voltages on the plates of the two tubes is almost instantaneous, the voltage existing on the plates will take the form of a rectangular wave.

(9) The voltage at the plate of V-601 will represent a positive square wave, while the voltage at the plate of V-606B will be a negative square wave. The duration of the peak of these square waves of voltage will depend upon the length of time it takes for the grid of V-601 to attain the point at which it again begins to draw current. This depends upon the value of the resistance from the cathode of V-601 to its grid, which in turn, depends upon the timing resistor cut into the circuit by S-600A as previously stated. Switch S-600A is the RANGE switch on the front panel of the unit.

(10) The plate resistor of V-601 is made up of four resistors in series. These are resistors R-619, R-618, R-617 and R-616, as shown in Fig. 2-57. Their values are 1,000 ohms, 180 ohms, 820 ohms and 2,200 ohms respectively. These resistors form a voltage divider in the plate circuit of the tube. Taps are brought out from this divider to switch S-600B, which is one of the sections of the RANGE switch on the front panel of the unit. The resistors are connected to the switch in such a manner that the amplitude of the unblanking pulse applied to the intensifying grid of the cathode ray tube, varies with the position of the switch. The values of these resistors have been chosen so that the apparent illumination of the tube screen is held relatively constant, regardless of the length of the gate and rapidity of the sweep. Consequently, it is possible to switch from one range to another without having to adjust the tube's intensity. On the shorter ranges, the sweep is more rapid and the electrons do not impinge on any one point on the screen for as long a time as on the longer ranges. Consequently, it is necessary to apply an unblanking voltage of greater amplitude on these shorter ranges to increase the number of electrons in the beam and compensate for the speed of the sweep. The divider resistors in the plate of V-601 provide nearly constant brilliancy over the four ranges at a repetition rate of 200 cycles for the three shorter ranges and 120 cycles at the 200 mile range. In order to reduce flicker at 120 cycles, the amplitude of the unblanking pulse is the same as it is for the 4-mile sweep at 200 cycles.

c. SWEEP CIRCUIT.

(1) The sweep circuit is triggered by the negative gate pulse from the plate of V-606B. A simplified schematic diagram is shown in Fig. 2-57. The circuit contains the sweep generator tube V-606A, which is one-half of a Type 6SN7-GT (the sweep cathode follower V-600B which serves to increase the linearity of the sweep when it attains a high amplitude) the sweep amplifier V-607A and the sweep inverter V-607B. All of the tubes mentioned are sections of Type 6SN7-GT tubes. The output of the sweep circuit consists of a positive linear sawtooth wave and a negative linear sawtooth wave. These two outputs are applied to the horizontal deflection plates of the cathode ray indicator tube to cause the sweep to travel from left to right across the face of the tube.

(2) V-606A, the sweep generator tube, has its cathode connected to ground. Its grid is returned to the positive voltage supply so that it draws a heavy current. Grid resistor R-6004 limits the current drawn by the tube since the drop across it is applied as bias

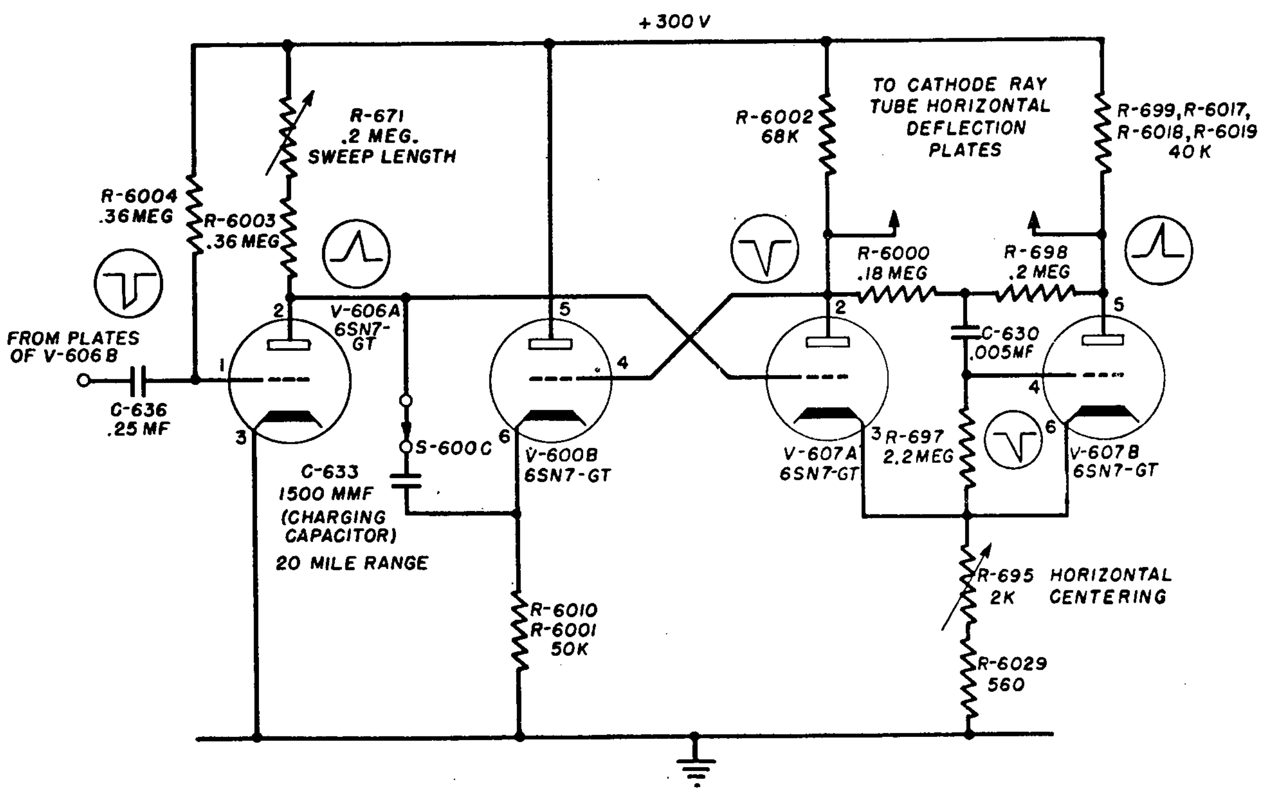


Figure 2-58. Sweep Circuit in Range Scope

to the grid. The grid current flows to ground through resistor R-6004 and the power supply circuits. The direction of flow is such that the drop across resistor R-6004 is negative at the grid connection. This maintains the grid potential at a relatively low value which just permits the tube to draw saturation current. These connections are shown in the simplified schematic in Fig. 2-58. Since the tube is drawing heavy current, the drop across the plate load, consisting of resistor R-6003 and potentiometer R-671 in series, reduces the voltage at the plate to a very low value. A capacitor is connected through RANGE SWITCH S-600C from the plate of V-606A to the cathode of V-600B, as shown in Fig. 2-56. The actual value of capacity used depends upon the position of the RANGE switch S-600C. Four choices of capacity are available. Capacitor C-632, a 300 mmf capacitor is connected into the circuit on the 4-mile range. Capacitor C-633, a 1,500 mmf capacitor is used on the 20-mile range. Capacitor C-634, a 0.0056 mmf capacitor is used for the 80-mile range while the 200-mile range requires three capacitors C-635, C-644, and C-645 in parallel for a total capacity of .015 mf.

(3) When V-606A is drawing heavy current, its plate voltage is very low. When the negative square wave from the gate circuit is applied to the grid of V-606A, it is driven to cut-off almost instantaneously. Resistor R-6004 is large enough to prevent capacitor C-636 from discharging during the time the gating pulse is applied to it. Therefore, the tube is driven to cut-off and held in this condition for the duration of the gate pulse. There is also an immediate tendency for the voltage on the plate of the tube to rise to the full value of the plate voltage applied to the tube through its plate resistors. However, in order for the voltage at the plate to rise, sufficient current must flow through the plate resistors to charge the capacitor connected in the plate circuit by the RANGE SWITCH. Consequently, the voltage at the plate will rise slowly. The time required for it to reach the value of the supply voltage is the length of time it takes for the charging current to flow through the plate resistors and charge the capacitor selected by the switch, to the supply voltage. This causes the voltage to rise in a sawtooth form, and the voltage wave developed at the plate will be a sawtooth wave. A sawtooth wave of voltage may be defined as a voltage which rises or falls slowly at a linear rate and rapidly returns to its original condition.

(4) In order to provide a linear time base for

measuring the distance to a target, the sweep must move across the face of the tube at a constant rate. With a simple sawtooth circuit such as would be obtained if the charging capacitor was returned to ground instead of to the cathode of V-600B, the sawtooth would not be entirely linear. This is due to the fact that as the voltage across the capacitor rises its polarity is such as to oppose the charging voltage and reduce the current flowing through the resistor. The voltage across the resistor decreases as the voltage across the capacitor increases. Consequently, the wave will start out as a relatively linear wave, but will increase exponentially in a curved form instead of linearly as the voltage across the resistor decreases. This curves the upper part of the wave and makes it nonlinear beyond a certain amplitude. In many circuits, only the lower, or approximately linear part is used. This is amplified so that it provides the total sweep amplitude required for operation of the cathode ray tube. However, this is not practical on short ranges especially where the length of the sweep must equal the time duration of the gating pulse producing the sawtooth sweep voltage.

(5) In order to secure a linear wave shape for the full amplitude of the sweep, it is necessary to maintain a constant charging rate to the capacitor through the series resistors. By some circuit device or other, the voltage drop across the resistors must remain constant. Two devices for accomplishing this are often used in radar equipment. The first is to cause the voltage at the *top* of the resistor to rise at a rate proportional to the rise in voltage across the capacitor, maintaining a constant drop across the resistor, and a constant current flow through it. Another method is to lower the potential applied to the *bottom* of the capacitor. This, of course, lowers the potential at the top of the capacitor and maintains a constant voltage drop across the charging resistors. The latter method is the simplest to employ, and is used in this circuit.

(6) Reference to Fig. 2-58 shows that capacitor C-633 is returned to the cathode of V-600B instead of to ground. The cathode is placed at a relatively high potential above ground because its two cathode resistors, R-6010 and R-6001, in parallel, provide approximately 50,000 ohms resistance. The positive sawtooth wave developing at the plate of V-606A is applied to the grid of V-607A, which is one of the two sweep output amplifiers. An inverted sawtooth waveform is secured from the plate of this tube and applied directly to the grid of V-600B. This inverted waveform causes the voltage across cathode resistors R-6001 and R-6010 of V-600B to vary in the form of a negative peaked sawtooth, since the tube acts as a cathode follower. As the voltage rises on the plate of V-606A it drops at the same rate on the cathode of V-600B. Therefore, the potential applied to the lower section of the charging capacitor is *lowered* at the same rate that the voltage at the plate of V-606A is *raised*. As previously explained, this has the effect of maintaining a constant voltage drop across the plate resistors. It maintains the linearity of the sawtooth wave throughout its entire amplitude and the full amplitude may be used and applied to the cathode ray tube horizontal deflection plates.

(7) Potentiometer R-671, with a value of 200,000 ohms, is the SWEEP LENGTH control on the front panel of the unit. It determines the sweep length on the face of the tube by changing the amount of resistance in the plate circuit. This tends to raise the voltage at the plate of the tube and make the drop across the resistors less as resistance is removed from the circuit, or greater as it is added. Since the maximum rise in voltage across the capacitor is the total voltage across the plate resistors, it is possible to limit the total amplitude of the sawtooth sweep wave to its correct value. The *length* of the sweep on the face of the tube is determined by the amplitude of the voltages applied to its deflection plates. This tends to expand or shorten the length of the sweep.

(8) In addition to providing the negative sawtooth wave for operation of the cathode follower, V-607A is one of two tubes which provide a push-pull output for the sweep circuits. The positive sawtooth is amplified and inverted by V-607A and appears at the plate of the tube, across plate resistor, R-6002, as a negative going sawtooth wave. This voltage is applied to one of the plates of the cathode ray tube. It is also coupled to the grid of V-607B by resistor R-6000 and capacitor C-630. Resistor R-698 is used to provide sufficient degeneration to keep the amplitude of the output of V-607B at the level of the output of V-607A. The negative output of V-607A applied to the grid of V-607B is amplified, inverted and appears on the plate of V-607B as a positive voltage. Since the output of both V-607A and V-607B is applied to the grid of V-607B, the effective value of the voltage applied to the grid of V-607B is always proportional to the difference between the output voltages from the plates of the two sections of the tube. The values of resistors R-6000 and R-698 are chosen so that the driving voltage on grid 4 of V-607B is always equal to the driving voltage on grid 1 of V-607A. Therefore, the stage is a self-balanced amplifier. The outputs on the plates have the same amplitude and are 180 degrees out of phase and constitute the push-pull output necessary to control the sweep on the face of the cathode ray tube. The output of V-607B is taken from the plate of the tube at the junction of plate resistors R-699, R-6017, R-6018 and R-6019 in series.

(9) To add to the stability of the circuit, both tubes are degeneratively self-biased by means of the voltage appearing across their common cathode resis-

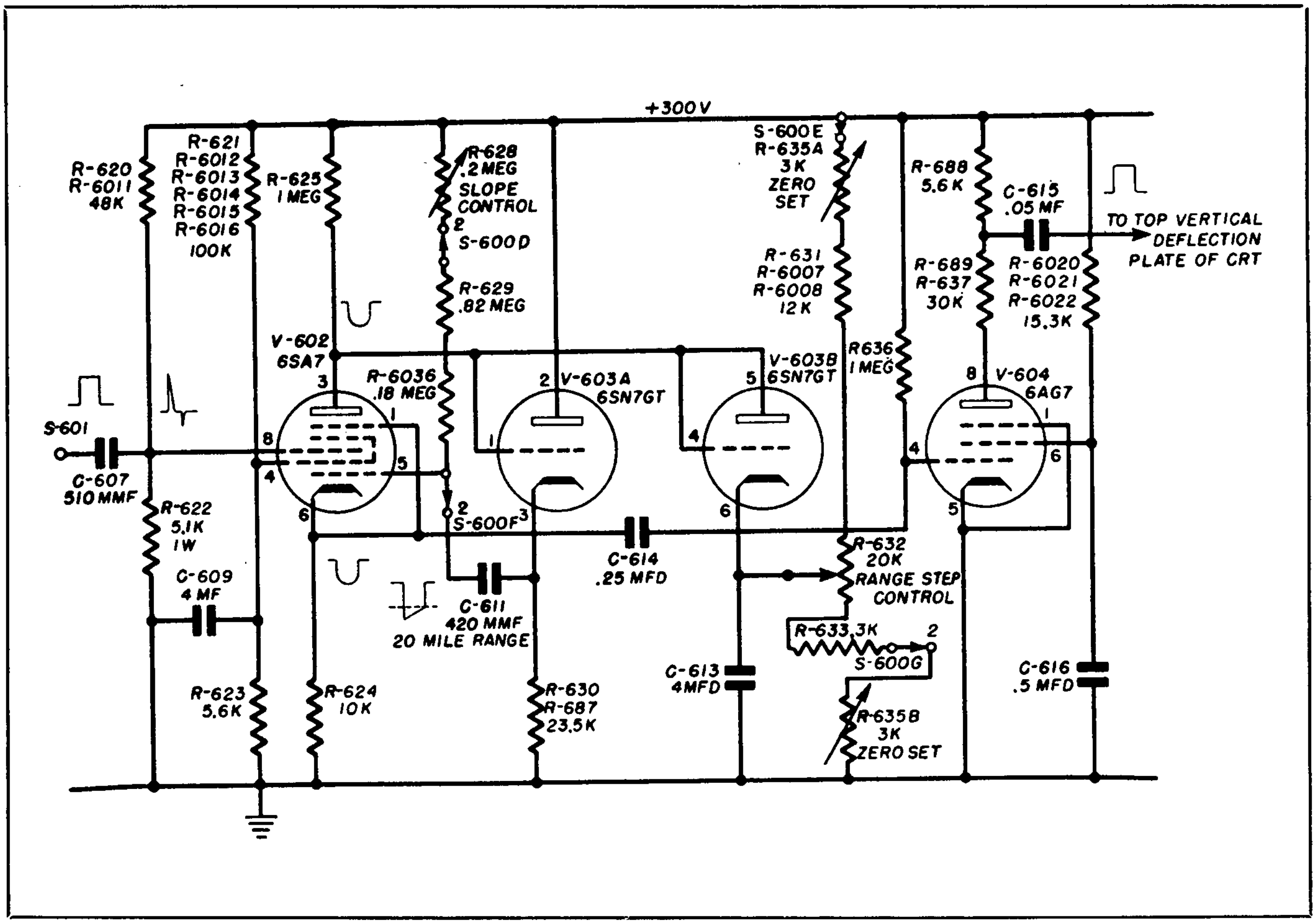


Figure 2-59. Phantastron Circuit in Range Scope

tors, R-695 and R-6029. Since these resistors are not by-passed with a capacitor, the common cathode voltage swings positive and negative in step with the grids. This effectively reduces the gain of the tubes. This feature, together with the self-balancing features of the circuit, causes the tubes to deliver outputs that are equal and constant in amplitude regardless of voltage conditions. The HORIZONTAL CENTERING control is located in the cathode circuit of these tubes. The purpose of this control is to equalize the plate currents flowing through each of the tubes. Since the plate load of V-607A is 68,000 ohms and the plate load of V-607B is 40,000 ohms, lowering the cathode potential causes the d-c voltage at the plate of V-607A to change more than the d-c voltage at the plate of V-607B. Therefore, the starting point of the sweep on the face of the tube can be shifted horizontally by adjusting the control. Since the horizontal deflection plates are directly coupled to the plates of the push-pull amplifier, it is not necessary to use d-c restorers to prevent the plates from swinging too far at the end of the sweep.

d. PHANTASTRON CIRCUIT.

(1) The phantastron circuit shown in Fig. 2-59 is used to produce the range step marker which is movable along the sweep line on the face of the scope. The range step permits a very accurate measurement of the range of targets on the 4-, 20-, and 80-mile ranges. When the range step is moved along the sweep line until its vertical edge touches a target indication, the range is accurately indicated on counters which appear through two windows below the face of the cathode ray tube.

(2) The phantastron is a form of delay multivibrator which is triggered simultaneously with the triggering of the sweep circuits. The delay is variable and highly linear so that the width of the output pulse may be measured in terms of range. The output of the phantastron is applied to the vertical plates of the cathode ray tube. There, it appears on the screen as a step in the sweep. The width of the pulse and, consequently, the step in the sweep is adjustable by regulating the RANGE STEP control on the front panel of the unit. The control is also linear, and is geared to the range counters. When the control is adjusted so that the step coincides with a target echo, the counters will indicate the range to the target. The accuracy of the indication obtained is ±100 yards up

to 20,000 yards on the 4-mile, 20-mile and 80-mile ranges. The phantastron is used on these ranges only.

(3) A simplified schematic diagram of the Phantastron circuit is shown in Fig. 2-59. V-602, a Type 6SA7 tube, is the phantastron delay tube. V-603A, one-half of a Type 6SN7-GT tube, is the phantastron cathode follower. V-603B, one-half of a Type 6SN7-GT tube, connected as a diode, is the phantastron blocking diode, and V-604, a Type 6AG7 tube, is the phantastron squarer and amplifier tube. Since the phantastron circuits are used only when the operator desires to make accurate measurements, the action of the circuit is controlled by a switch on the front panel of the Range Scope. This switch is controlled by the RANGE STEP knob. Pulling out on this knob closes a microswitch on the shaft behind the knob. This switch connects the positive gate pulse to V-602. This switch is shown in Fig. 2-59 as S-601. The rectangular pulse of gate voltage is differentiated by the 510 mmf capacitor C-607 and resistor R-622. The voltage applied to the grid of the phantastron tube is a sharp positive spike that occurs in coincidence with the leading positive going edge of the gate pulse. It is followed by a small negative spike pulse produced by the negative going trailing edge of the gate pulse through the differentiating action of capacitor C-607. The positive pulse is used to trigger V-602.

(4) The operation of the phantastron is similar to the action of a one-kick multivibrator that goes through one complete cycle and rests until the next trigger pulse. The tube that is triggered is V-602. The output is also taken from this tube. The circuit is designed to produce an output pulse with a width that can be varied over three ranges from zero to eighty miles. The width of the pulse within the limit of the range selected is dependent upon the setting of the RANGE STEP potentiometer R-632. The adjustment of this control determines the cathode potential of V-603-B and thus controls the amount of current that this tube draws through the plate resistor, R-625, in the plate circuit of the phantastron tube V-602. The voltage drop across resistor R-625 determines the plate potential of V-602 during the no-trigger period and therefore determines the width of the output pulse as will be explained later. The voltage swing at the plate of V-602 is directly coupled to the grid of the cathode follower, V-603-A, and the output taken from the cathode of this tube is fed back to the control grid of V-602 through the capacitor selected by switch section S-600F. The amount of capacity in the feed back circuit, fixes the time constant in the grid circuit of V-602 and thus determines the maximum width or range of the output pulse and therefore the range of the circuit. The output pulse from the cathode of V-602 is applied to the grid of V-604 which acts as a clipper to provide a pulse with a flat top and straight sides. With this general picture of the circuit as a guide the detailed operation in the following paragraphs can be more clearly understood.

(5) Referring to Fig. 2-59, note that grid 8 of V-602 is connected to a voltage divider made up of resistors R-620, R-6011 and R-622. This divider provides a d-c potential of approximately 28 volts for grid 8. Grid 4 is connected to a similar divider and its normal d-c potential is approximately 69 volts due to the divider current and the screen current flowing in V-602 which flows through the upper portion of the divider. Since grid 8 is less positive than grid 4 no plate current flows in V-602 and a virtual cathode with a potential equal to that of grid 8, exists between grids 4 and 8. The current flowing in the triode section consisting of the cathode 6, control grid 5 and the screen grid 4 produces a voltage drop across the cathode resistor R-624 that places the cathode at approximately 50 volts positive with respect to ground. It is evident from the foregoing description that in addition to the conducting triode just described, *another non-conducting triode also exists in V-602.* This triode consists of the virtual cathode, grid 8, acting as a control grid, and the plate of V-602.

(6) Assume that the RANGE STEP control R-632 has been adjusted to a point that is 187 volts positive with respect to ground. Since the voltage drop across a conducting diode is insignificant, plate 5 of V-603-B may also be considered to be at a potential of approximately 187 volts. Plate 5 of V-603-B and plate 3 of V-602 are connected together and have a common plate resistor and therefore are at the same potential. Since grid 1 of V-603-A is also connected to the plate of V-602, its potential will be 187 volts and V-603-A will be conducting with a correspondingly high voltage drop across its cathode resistance. Since the grid of a cathode follower cannot assume a potential very much higher than the cathode, the potential of cathode 3 in V-603-A may be considered to be the grid potential which is 187 volts. It must be remembered that the points just described have a potential of 187 volts because of the setting of the RANGE STEP control and that this potential may be varied within limits by the adjustment of this control.

(7) Fig. 2-59 shows that grid 5 of V-602 is connected to the 275-volt bus through approximately one megohm of resistance and is coupled to the cathode of V-603-A through a capacitor which in this case is capacitor C-611. The potential of grid 5 of V-602 will be the same as the potential of cathode 6 of V-602 which is approximately 50 volts. This grid potential is obtained by the voltage drop across the one megohm of resistance produced by the flow of grid current. This voltage drop is approximately 225 volts which subtracts from the applied voltage of 275 leaving a net potential of 50 volts on grid 5. Therefore the

potential difference between the cathode and control grid of the conducting triode section in V-602 is approximately zero volts. Referring again to capacitor C-611, note that it is connected to 187 volts at cathode 3 of V-603-A and on the other side to 50 volts at grid 5 of V-602. Therefore, it assumes a charge of 137 volts.

(8) The positive trigger from V-601 is applied through switch S-601 and capacitor C-607 to grid 8 of V-602. The trigger pulse is the gate pulse from the gate multivibrator and varies in width with the range in use. Capacitor C-607 and resistor R-622 constitute a short time constant RC circuit that differentiates the wide pulse to the narrow pulse shown in Fig. 2-59. The positive going portion of this pulse is used to trigger V-602. When grid 8 is driven positive current flows to the plate of V-602 from the virtual cathode. The increased current flow in resistor R-625 causes the potential of plate 3 of V-602 to drop instantaneously to the potential of the virtual cathode which is approximately the same as the potential of grid 4. Under this condition the potential of grid 1 in V-603-A suddenly drops from 187 to 69 volts and the plate and grid of V-603-B also drops to 69 volts. The potentials now applied to V-603-B prevent it from conducting and during this time charging current flows into capacitor C-613. The function of this capacitor is to act as a by-pass or filter to maintain a constant flow of current in the voltage divider containing the RANGE STEP control and thus make the circuit more linear over the adjustment range of the control. If this current was allowed to vary the lengths of successive pulses would not be the same and the range step would be inaccurate.

(9) Returning to V-603-A, it was shown that the trigger pulse produced a negative swing at the plate of V-602 that dropped the grid of V-603-A to an instantaneous potential of 69 volts. This potential does not exist for any appreciable length of time beyond the duration of the trigger pulse as will be explained later. The cathode of V-603-A follows the grid down to the same potential and if it were not for the passage of the trigger pulse and degenerative feedback in the circuit, the potential of grid 5 in V-602 would come to rest at a voltage equal to the sum of the negative 137-volt charge on capacitor C-611 and the instantaneous 69-volt potential of the cathode of V-603-A. This net potential would be 68 volts negative with respect to ground. Since this potential is more than sufficient to cut off the heavy flow of screen current, cathode 6 of V-602 drops to ground potential. Under this condition, grid 5 of V-602 becomes instantaneously 68 volts negative with respect to the cathode. When the cathode potential drops, the potential of the virtual cathode also falls to a point where the potential difference between it and the d-c potential of grid 8 permits plate current to continue to flow after the trigger pulse has passed. Since the virtual cathode alone cannot maintain a large plate current and exist for any appreciable length of time, it is obvious that plate 3 of V-602 cannot be maintained at a potential of 69 volts. As the virtual cathode diminishes, the resistance of the plate triode section of V-602 rises causing a corresponding rise at the plate. Any variation in voltage at the plate of V-602 causes a corresponding change in the plate current through V-603-A. Therefore when plate 3 of V-602 rises, the cathode potential of V-603 also rises and in turn decreases the negative bias on grid 5 of V-602. It is evident that after the passage of the trigger pulse, plate 3 of V-602 can rise until the potential of grid 5 reaches cut-off. At this point any further tendency of plate 3 to rise causes the potential of grid 5 to become more positive and allow cathode current to flow again in V-602. However, any flow of cathode current replenishes the virtual cathode and the increased plate current flow prevents plate 3 from rising. Therefore a state of equilibrium is reached where plate 3 assumes a potential of 119 volts and cannot rise above that point as long as capacitor C-611 remains charged because any tendency to rise is counteracted by the degenerative feedback supplied by V-603-A.

(10) The result is that when the circuit is triggered it instantly assumes a state of equilibrium with the cathode of V-603-A approximately 119 volts positive with respect to ground. The sum of this voltage and the capacitor voltage places grid 5 of V-602 at a potential of approximately 18 volts negative with respect to ground and the cathode of V-602. At this time V-602 is operating under conditions analogous to a class B amplifier with cathode bias where just enough current flows from the cathode to maintain the bias slightly above cut-off. In this case the small amount of cathode current maintains the virtual cathode. This condition exists until the charge on capacitor C-611 has decreased sufficiently due to the flow of discharge current through resistors R-628, R-629, R-6036 and the cathode resistors of V-603-A. When the charge on capacitor C-611 decreases sufficiently to raise the potential of grid 5 of V-602 to a point where it will permit any appreciable current to flow to grid 4 of V-602, the cathode potential of that tube rises and causes a corresponding rise in the potential of the virtual cathode, causing the plate triode section of V-602 to approach cut-off conditions. At the same time the flow of screen current prevents the cathode of V-602 from replenishing the virtual cathode increasing the plate resistance of the tube. The negative increase of bias and the increased plate resistance in the plate triode section of V-602 causes the plate potential to rise and this positive swing is fed back through V-602-A causing a further positive rise at grid 5 of

V-602. This further increases the screen current in V-602. This entire action is cumulative and the plate potential of V-602 rises almost instantaneously to its original potential of 187 volts or to any other potential that may be selected by the adjustment of the RANGE STEP control. When this occurs, the plate triode section of V-602 is cut off and all points in the circuit that were originally at a 187-volt potential also return to that potential. The potential of grid 5 of V-602 is now high enough to cause the grid to again draw current and recharge capacitor C-611 so that the potential of grid 5 to ground is maintained at 50 volts positive. Cathode 6 of V-602 also returns to a potential of 50 volts positive with respect to ground and zero volts with respect to the grid. In this condition the circuit is ready for the next trigger pulse and a repetition of the cycle just described.

(11) The width of the negative pulse obtained from the cathode of V-602 depends upon the length of time required to discharge capacitor C-611. This discharge time depends upon the initial charge on the capacitor. The charge on the capacitor is fixed by the potential of the plate of V-602 which is in turn determined by the setting of the RANGE STEP control. Thus it can be seen that varying the setting of the RANGE STEP control varies the width of the output pulse. The negative output pulse appearing across resistor R-624 is coupled through capacitor C-614 to the grid of the normally conducting tube V-604. The amplitude of this pulse is approximately 50 volts. Since approximately 7 volts cuts off V-604 the pulse is clipped and squared in this stage. The output taken from the junction of plate resistors R-688 and R-689 is coupled to the upper vertical deflection plate of V-605 through capacitor C-615.

(12) The output pulse from the phantastron starts with the leading edge of the gate pulse and therefore the leading edge of the phantastron pulse is coincident with the start of the sweep on the cathode ray tube. Since the phantastron pulse is applied to the vertical deflection plates of the cathode ray tube, the trailing edge of the pulse appears as a vertical line on the sweep. The length of the pulse or range step is variable from zero to the maximum length of the sweep by means of the RANGE STEP control. This control is directly calibrated in miles. When the RANGE STEP control is adjusted until the length of the pulse equals the distance from the start of the sweep to the target being ranged, the vertical line appears coincident with the left-hand side of the target pip. The range of the target is then indicated on the calibrated counters that are driven by the shaft of the RANGE STEP control.

(13) Potentiometer R-628 in the grid circuit of V-602, is the SLOPE control for the 20-mile range and is in series with the resistors R-629 and R-6036 when the RANGE SWITCH S-600D is in the 20-mile position. Potentiometer R-627 is the SLOPE control for the 4-mile range. It is selected by switch S-600D, a section of the RANGE SWITCH. Potentiometer R-6037 is the SLOPE control for the 80-mile range. The purpose of these potentiometers is to fix the discharge rate of the coupling capacitor from the cathode of V-603-A to the control grid of V-602. Three coupling capacitors are provided. The appropriate capacitor is switched into the circuit by S-600F, another section of the RANGE SWITCH. Capacitor C-610 is the charging capacitor for the 4-mile range, capacitor C-611 is used for the 20-mile range and capacitor C-650 is used for the 80-mile range. The value of the capacitor and the adjustment of the SLOPE potentiometer in use determines the slope of the rising voltage on the control grid of the phantastron.

(14) The divider network containing the RANGE STEP control includes a dual potentiometer. This may be potentiometer R-634 or R-635 depending upon the position of sections S-600E and S-600G of the RANGE SWITCH. One section of this potentiometer is included in the upper section of the divider network and the other part is in the lower section of the divider. Both sections are controlled by a single shaft. The potentiometer is constructed so that turning the shaft adds resistance in one section and subtracts an equal amount of resistance in the other. This does not affect the total amount of resistance in the total divider and therefore does not change the amount of current flowing through the potentiometer. It does serve to raise and lower the end voltages of the RANGE STEP potentiometer and to apply a *higher* or *lower* voltage to the potentiometer arm when it is in any given position. Two dual potentiometers are provided. One potentiometer consists of R-634A and R-634B and is switched into the circuit for the 4-mile range. The other potentiometer consists of R-635A and R-635B and is used for the 20-mile and 80-mile ranges. These controls are the ZERO SET controls used to set the phantastron output so the step will accurately measure range to a target.

(15) Both the SLOPE and the ZERO SET controls are used to align the phantastron circuit. The SLOPE control adjusts the width of the phantastron range step. In this manner, the width present on the screen is made to correspond with the reading of the range counters. These counters show through the small windows beneath the range scope tube. The ZERO SET controls align the range step on a time basis with the start of the sweep. In actual practice, the SLOPE control is adjusted until the actual width of the pulse output of the phantastron as measured in yards on the face of the CR tube is the same as the counter reading in yards. This can be performed by plotting a graph similar to the one in Fig. 2-60, show-

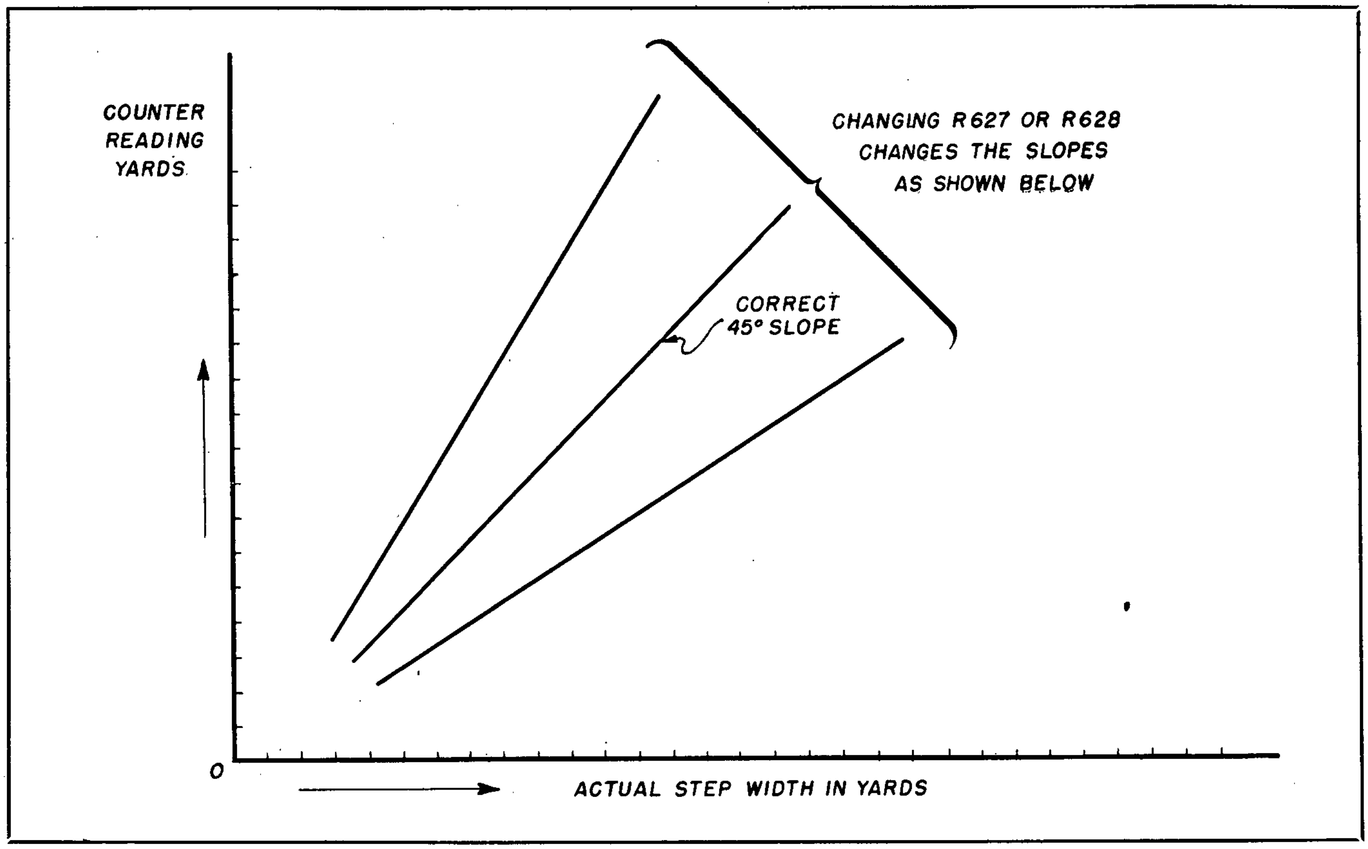


Figure 2-60. Adjustment Plot of Slope Controls

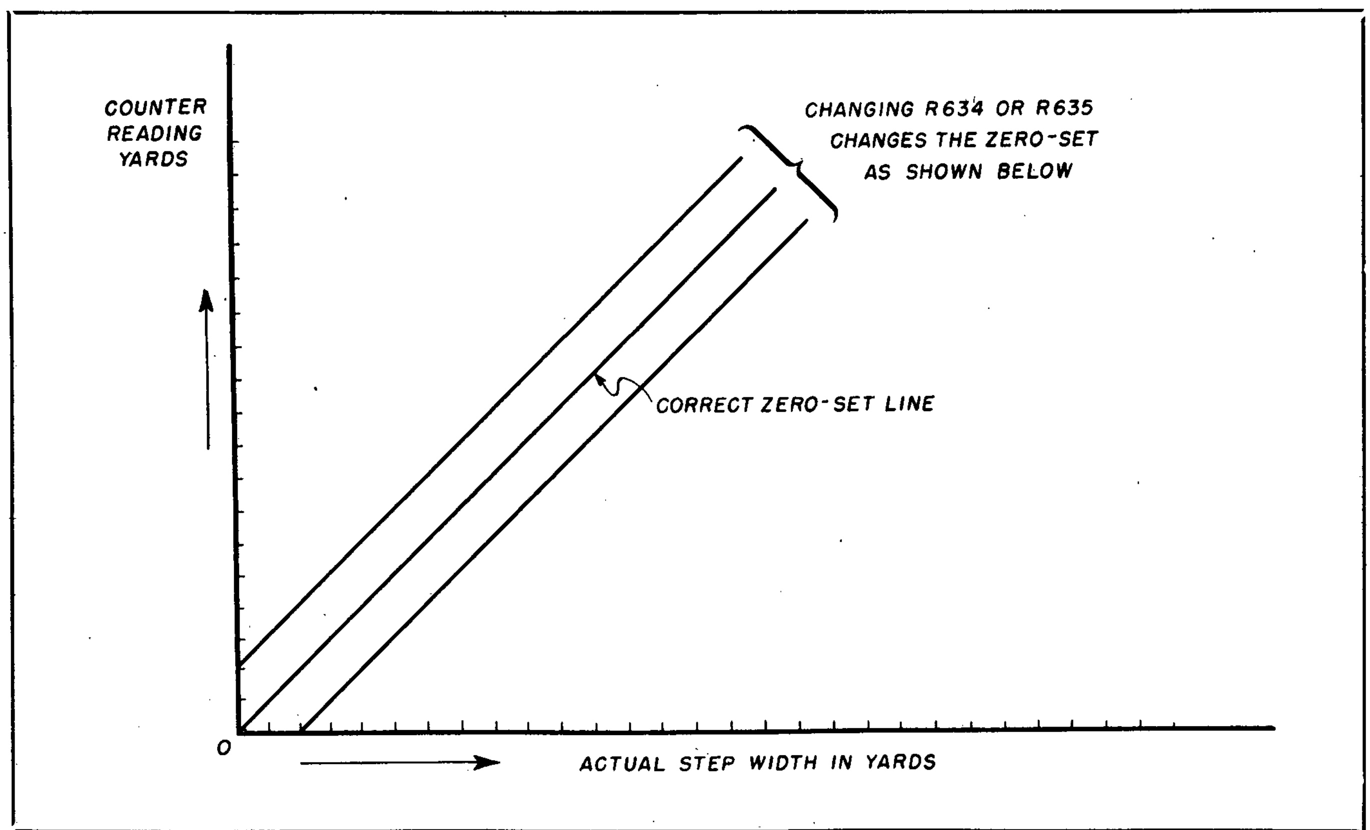


Figure 2-61. Adjustment Plot of ZERO SET Controls

ing how the length of the range step block increases on the face of the tube in comparison with the reading of the range counters. The ideal slope is one which is linear so that any change along one coordinate of the graph produces an identical change along the other coordinate. This will provide a line at an angle of 45 degrees slope equal to 1 when the control is properly adjusted. When the range potentiometer is properly compensated, this line should be linear. The slope should be set to 45 degrees by adjustment of the SLOPE control. If the line is not linear, the taper of the potentiometer is out of adjustment. In this case it is necessary to replace the potentiometer since its adjustment requires precision laboratory equipment that is not readily available in the field.

(16) The plot may show a slope of 45°, but an extension of the slope line may not strike the zero point or origin of both coordinates on the graph. This means that although the range represented by the pulse width is correct, it is not starting at the proper point. Therefore, the trailing edge will not give a proper indication of the range to a target. Knowing that the actual slope of the phantastron is correct, it can be zero set by replotting the graph and adjusting the ZERO SET until the slope line passes through the zero point or origin of both coordinates of the graph, as shown in Fig. 2-61. Another method of obtaining the desired result is by aligning the outside edge of the step with an accurate calibration pip, or a range marker. The ZERO SET and the RANGE STEP controls are then adjusted until the readings of the counters coincides with the known range.

(17) Two typical plots of the adjustment of these two controls, are shown in Figs. 2-60 and 2-61. In order to accurately align the phantastron, plots should be made for each range on which it operates. Since the phantastron is not used on the 200-mile range, the operation of the circuit is stopped by grounding the control grid of V-602. This effectively cuts off the tube and disables the circuit. It prevents the operator from accidentally pulling out the RANGE STEP control and bringing the circuit into action when no SLOPE or ZERO SET resistors are included in the circuit.

e. RANGE MARKER CIRCUITS.

(1) The range marker circuits provide positive pulses which are applied to the video system of the Range Scope. In this manner, indications of range may be placed on the radar sweep trace so that the operator may compare them with a target signal so as to roughly estimate the range to a target. These markers appear on the radar video sweep as sharp pips extending downward from the radar sweep line. The range markers are developed in such a manner that they are a fixed distance apart along the trace. For example, on the 4-mile range the markers appear at 1-mile intervals along the sweep. On the 20-mile range they are 5 miles apart. On the 80-mile range they are 20 miles apart, and on the 200-mile range they are 50 miles apart.

(2) The range marker circuits are triggered by the leading edge of the negative pulse from the plate of V-606B. The circuit consists of the Type 6SN7-GT double triode tubes V-610, V-611, and one-half of V-612 which is also a Type 6SN7-GT. On the simplified schematic diagram in Fig. 2-62, they are shown as five separate triodes. V-610A is the shock excited oscillator, V-610B is the marker feed-back tube, V-611A is the pulse shaping tube, V-611B is the blocking oscillator trigger tube, and V-612A is the blocking oscillator. The other half of V-612, or V-612B, is used in the video circuits of the Range Scope.

(3) The trigger pulse, which is the negative gate pulse, is taken from the plate of V-606B in the gate circuit. This same pulse is also used to trigger the sweep circuits of the range scope. It is applied to the grid of the shock excited oscillator V-610A, by the coupling capacitor C-637. Since the grid of the shock excited oscillator is returned to the +225 volt supply through the 1 megohm resistor R-684, the tube is drawing heavy current in its static condition. This current flows to ground through the range marker coil and the cathode resistor in use. These range marker coils (L-601, L-602, L-603, and L-604) are inductors which determine the frequency of the range marker oscillations. The proper coil is switched into the circuit by S-600H, a section of the RANGE SWITCH which is used to select the operating range of the unit.

(4) The instant before the negative gate pulse appears, V-610A is drawing a heavy plate current. When the pulse appears, the grid is quickly driven negative until the tube is cut off. This action is very rapid due to the straight leading edge of the pulse. Due to the time required to charge capacitor C-637, the grid of V-610A is held below cut-off during the entire gate period. This action cuts off the current flowing through the tube and the marker oscillator inductor which is switched into the circuit by RANGE SWITCH S-600H. This allows the magnetic field surrounding the inductor to collapse. The voltage across the inductor produced by its collapsing field adds to the charge already existing on the capacitor that parallels the inductor. Following this, the capacitor discharges through the inductor and again builds up a field. The collapse of the field charges the capacitor in the opposite direction from its original charge. The energy originally stored in the circuit is sufficient to cause the inductance and capacity of the circuit to oscillate at its natural frequency for approximately six or seven cycles. In a simple shock excited oscillator the oscillations would decay rapidly in amplitude, but V-610B, the marker feedback tube, has its cathode

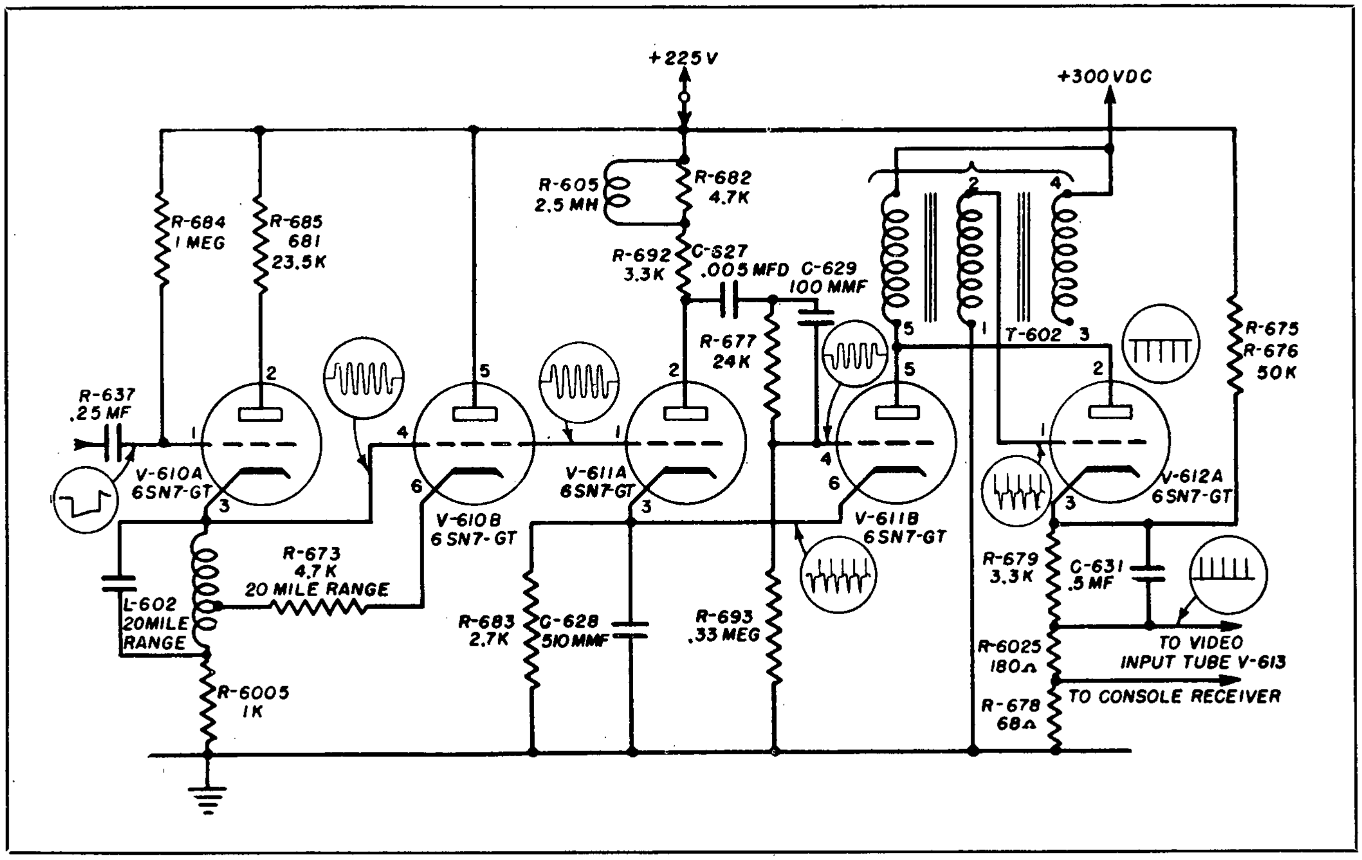


Figure 2-62. Range Marker Circuits in Range Scope

connected to a tap on the inductor selected by RANGE SWITCH S-600J. This provides a sufficient regeneration to prevent the decay of oscillations and maintain six or seven cycles of the oscillation at approximately the same amplitude. In this circuit, the four resistors R-690, R-673, R-691, or R-680 have been selected to introduce the proper amount of regeneration to keep the amplitude of the output voltage approximately equal for all four ranges. Only resistor R-673 has been shown in the simplified schematic. The grid of the feed-back amplifier is coupled directly to the cathode of V-610A which is the high side of the marker coil in use. The range markers are also coupled to the grid of V-611A from the cathode of V-610A. V-611 is the pulse shaper and functions as a cathode coupled multivibrator. The plate load of V-611 consists of resistor R-682 (paralleled by inductor L-605) in series with resistor R-692. When V-611A is triggered the interruption of the current through inductor L-605 causes an induced voltage to appear across it. This voltage adds to the output of V-611A to peak the output pulses which are applied to the grid of V-611B.

(5) The cathodes of the two sections of V-611 are connected together. Resistor R-683 is the common cathode resistor for both sections. For this reason, both tubes operate together to form a multivibrator. V-611A normally draws current at the start of the cycle. The oscillation voltage appearing on its grid tends to drive it through cut-off on the negative peak of every cycle. The input voltage is amplified, and an overshoot is created by the inclusion of inductor L-605 in the plate circuit of V-611A. The circuit produces a narrow pulse with a peak on the leading edge which coincides with the start of the oscillation. These square pulses, or marker blocks, appear in the plate circuit of V-611B across the trigger winding of transformer T-602 in the blocking oscillator circuit.

(6) The blocking oscillator V-612A is in a cut-off condition when no signal is present due to its high cathode bias. The tube is cut off since its grid is returned to the base of the cathode resistor which is part of a voltage divider between the voltage supply and ground. The bias is sufficient to prevent the rectangular pulse from the plate of V-611B from firing the tube. The tube is actually triggered by the sharp peak riding on top of the pulse rather than by the pulse itself. Cathode bias is obtained from the network containing resistors R-675 and R-676 (in parallel) and R-6025 in series with R-678. These resistors form a divider between the +225 volt bus and ground.

(7) The application of a pulse at the grid of V-612A drives the grid positive very rapidly. This creates a negative pulse in the plate circuit and a positive pulse in the cathode circuit. The negative pulse at the plate is inverted by transformer T-602 and applied to the grid of V-612A. It drives the grid

farther in a positive direction, the instant it appears. After the peak of the pulse is reached, the grid rapidly returns to a negative condition due to the fixed cathode bias of the tube. This cuts off the tube and the circuit remains cut off until another pulse appears to again start the cycle of operation. Since the grid is connected to ground through the transformer and no effective capacity exists in the circuit, this action is almost instantaneous. Consequently, the voltage in the cathode circuit of the tube will be a sharp positive spike. The width of this spike is approximately three-quarters of a microsecond, when measured at one-quarter of the height of the spike.

(8) Positive spikes are required for downward deflections on the cathode ray tube. This is because the signal passes through two amplifiers to get to the deflection plates of the cathode ray tube. Since each amplifier inverts the signal, a positive input is taken from the cathode of V-612A. The plate circuit would supply negative marker pulses. Two amplitudes of marker signals are provided in the output of the circuit. The amplitude of the marker signal, which is taken from the junction of resistors R-679 and R-6025, is about 20 volts. This is the marker signal for the video circuits. A marker voltage at a lower potential, about 5 volts, is taken from the junction between resistors R-678 and R-6025. This 5-volt marker signal is supplied to the video circuits in the Console Receiver. It is also applied to the video amplifier in the remote PPI Indicator if the PPI MARKER switch in the Receiver is in the ON position. Resistor R-679 is by-passed with capacitor C-631 in order to maintain a constant potential between the cathode of V-612A and the junction of resistors R-679 and R-6025. The range marker circuits may be turned on and off by means of the MARKER switch S-602 on the front panel of the unit. This switch supplies plate voltage to the circuit when markers are desired and removes it when they are not.

f. VIDEO CIRCUITS.

(1) The video circuit accepts the radar video and the IFF video signals. It applies them to the cathode ray indicator tube, V-605, in such a way that the radar signals appear as vertical spikes above the radar sweep line and the IFF signals appear as vertical spikes below the IFF sweep line. The IFF sweep line appears beneath the radar sweep line when the operator places the IFF switch on the IFF Coordinator in the MOMENTARY or ON positions. The video circuit also accepts the output of the range marker circuit to produce range markers on the radar sweep. These markers are applied as spikes on the radar sweep which point downward, or in the opposite direction from the radar target indications. The various ways in which these signals appear on the Range Scope are shown in Fig. 2-63. All of the indications, except the range step or phantastron block, are applied by the video circuits.

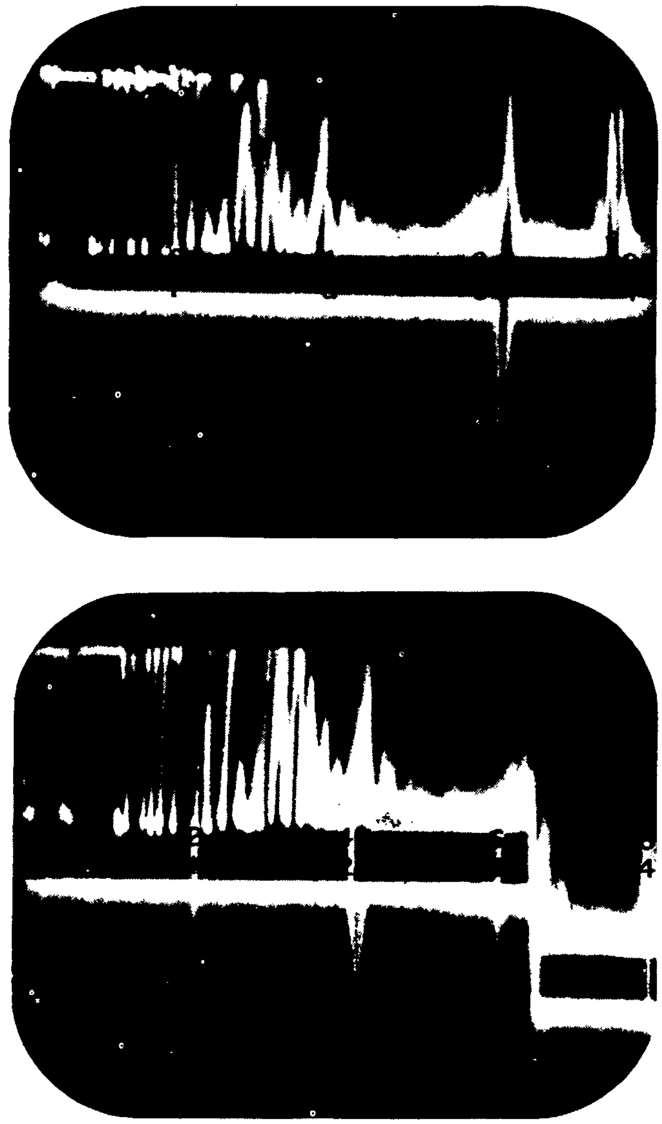


Figure 2-63. Typical Range Scope Presentations

(2) The circuit, as shown on the simplified schematic diagram Fig. 2-64 consists of a type 6AC7 radar video amplifier, V-613, the IFF video amplifier V-612B which is one-half of a type 6SN7-GT tube, and the Type 6AG7 video output tube, V-608. V-613 and V-612B have their plates connected in parallel and their combined output is applied to the grid of V-608. The radar video blocking voltage from the IFF Coordinator is applied to the cathode of the radar video amplifier, V-613 and the IFF video blocking voltage is applied to the cathode of the IFF video amplifier, V-612B. The purpose of the radar and IFF blocking voltage is to make it possible for the radar and IFF signals to appear on the screen of the same cathode ray tube. A radar video signal or echo is returned for every single pulse in the repetition frequency of the radar transmitter. The IFF transmitter is triggered by the IFF Coordinator or on each alternate pulse from

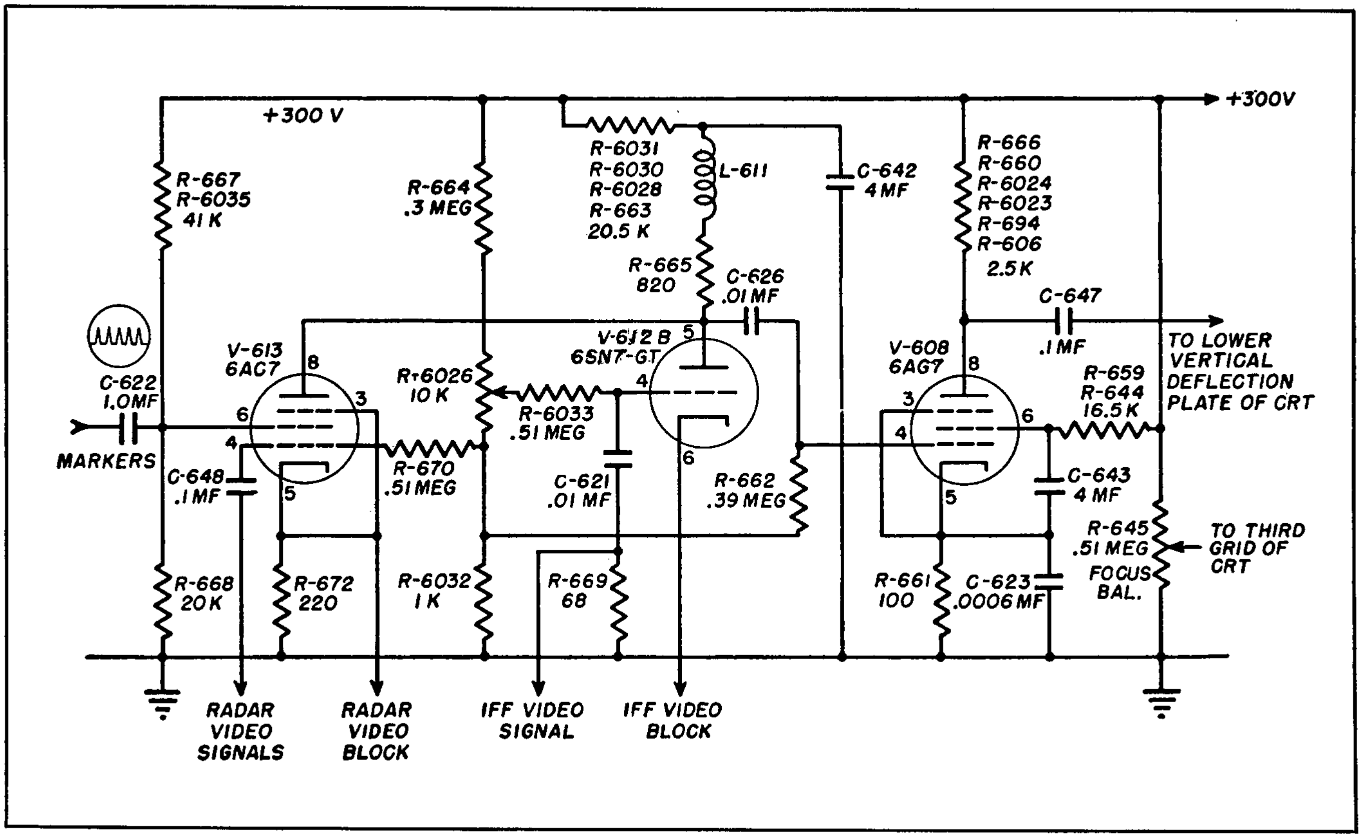


Figure 2-64. Video Circuits in Range Scope

the radar transmitter. The IFF video blocking voltage disables the IFF sweep tube, V-612B, so that noise and signal voltages from the IFF Receiver will not appear on the radar sweep. This sweep is supposed to show only radar and marker signals. On the following sweep, when IFF signals are desired, the radar amplifier tube is cut off by the radar video blocking voltage and only the IFF signals appear on the cathode ray tube. The video circuits also provide a vertical positioning voltage for the sweep on the cathode ray tube. During the radar sweep, this output makes the lower vertical plate of the cathode ray tube more negative and the entire radar sweep is shifted upward about three-sixteenths of an inch. During the IFF sweep the d-c potential of the lower vertical plate shifts in a positive direction and the sweep line shifts downward three-sixteenths of an inch. Due to the persistence of the screen, two sweep lines, three-eighths of an inch apart, appear to exist simultaneously on the cathode ray tube.

(3) In order to provide this type of display, the IFF Coordinator applies a negative rectangular pulse of voltage to the cathode of the radar video amplifier V-613 and a positive rectangular pulse of voltage to the cathode of the IFF video amplifier V-612B on the same cycle. See Fig. 2-65. The negative pulse of voltage applied to the cathode of the radar video amplifier permits it to amplify and pass radar and marker signals to the vertical deflection plates of the cathode ray tube through V-608. On the following sweep, a positive voltage is applied to the cathode of the radar video amplifier V-613, and a negative voltage is applied to the cathode of the IFF amplifier V-612B. This cuts off the radar video amplifier, and permits the IFF video amplifier to pass IFF signals on to the video output tube and thence to the cathode ray indicator tube. Grid 4 of V-613 is biased to a d-c potential that is more positive than the d-c potential of grid 4 of V-612B. When V-613 is amplifying, the d-c potential of the common plate circuit is more negative than it is when V-612B is amplifying. This alternate shift is rectangular in form as shown by the waveforms in Fig. 2-65 and is amplified and inverted by V-608 and applied to the lower deflection plate of V-605 to determine the position of the sweep on the face of the tube. The bias on grid 4 of V-612B is adjustable by means of potentiometer R-6026. This permits the separation between the two sweep lines to be adjusted to widths up to approximately one inch. A peaking inductance L-611 is included in the common plate circuit of V-613 and V-612B to peak video signals before they are applied to the mixer.

(4) V-608 is a conventional amplifier driven by the output from the common plate circuit of V-613 and V-612B. Its purpose is to provide an alternating vertical positioning voltage and to amplify the video and marker signals. The output appears across its plate resistors (R-666, R-660, R-6024, R-6023, R-694,

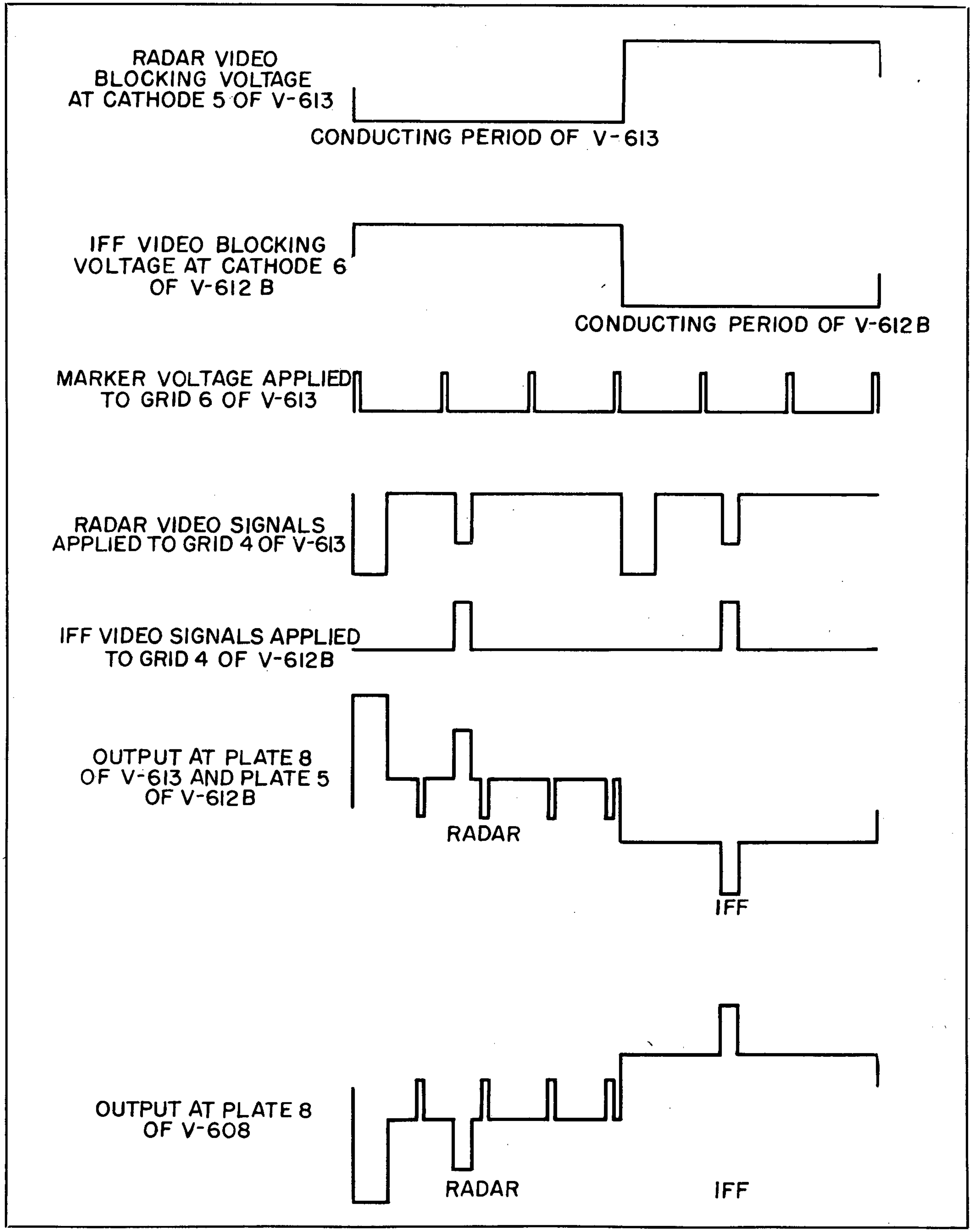


Figure 2-65. Radar and IFF Blocking Action in Video Circuits

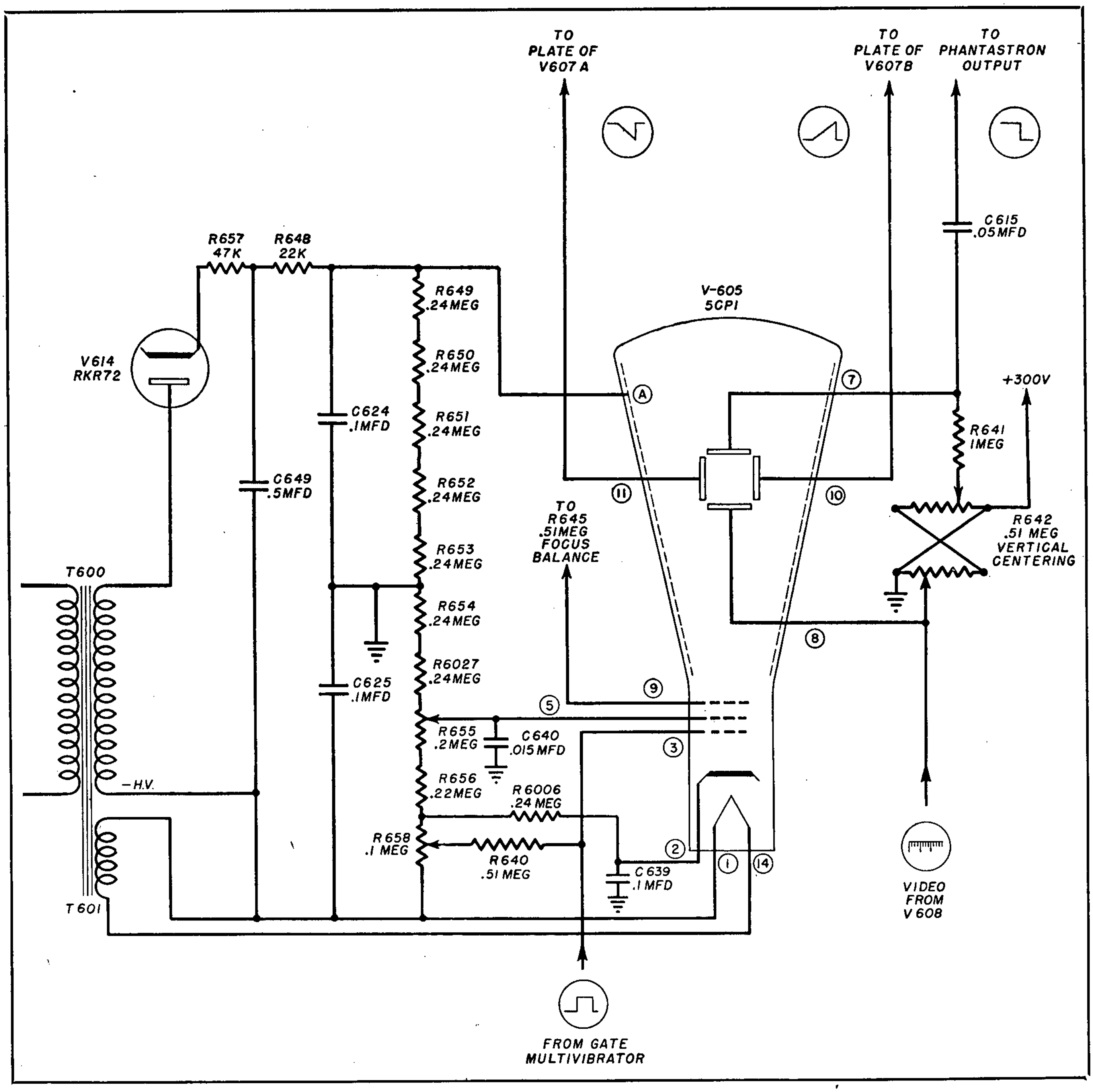


Figure 2-66. Cathode Ray Tube and High Voltage Supply Circuits

and R-606 in parallel) and is coupled to the lower vertical deflection plate through capacitor C-647. The output of V-608 is shown in Fig. 2-65. Note that the d-c level is swinging alternately positive and negative. This causes the sweep on the Scope to be shifted upward on the radar sweep and downward on the IFF sweep. The radar signals are negative and consequently produce an upward deflection in the sweep. The marker signals are positive and produce a downward deflection. The IFF signals are positive and also produce a downward deflection.

g. CATHODE RAY TUBE CIRCUITS.

(1) The cathode ray tube is a type 5CP1 tube. Its circuits are shown in Fig. 2-66. The output of the phantastron is applied to the top vertical deflection plate 7 and the radar, marker, and IFF signals are applied to the bottom deflection plate 8. The sweep is vertically centered on the screen by means of the VERTICAL CENTERING control on the front panel. This control is a dual 510,000-ohm potentiometer which is connected to the vertical deflection plates so that the voltage on one plate is increased while the

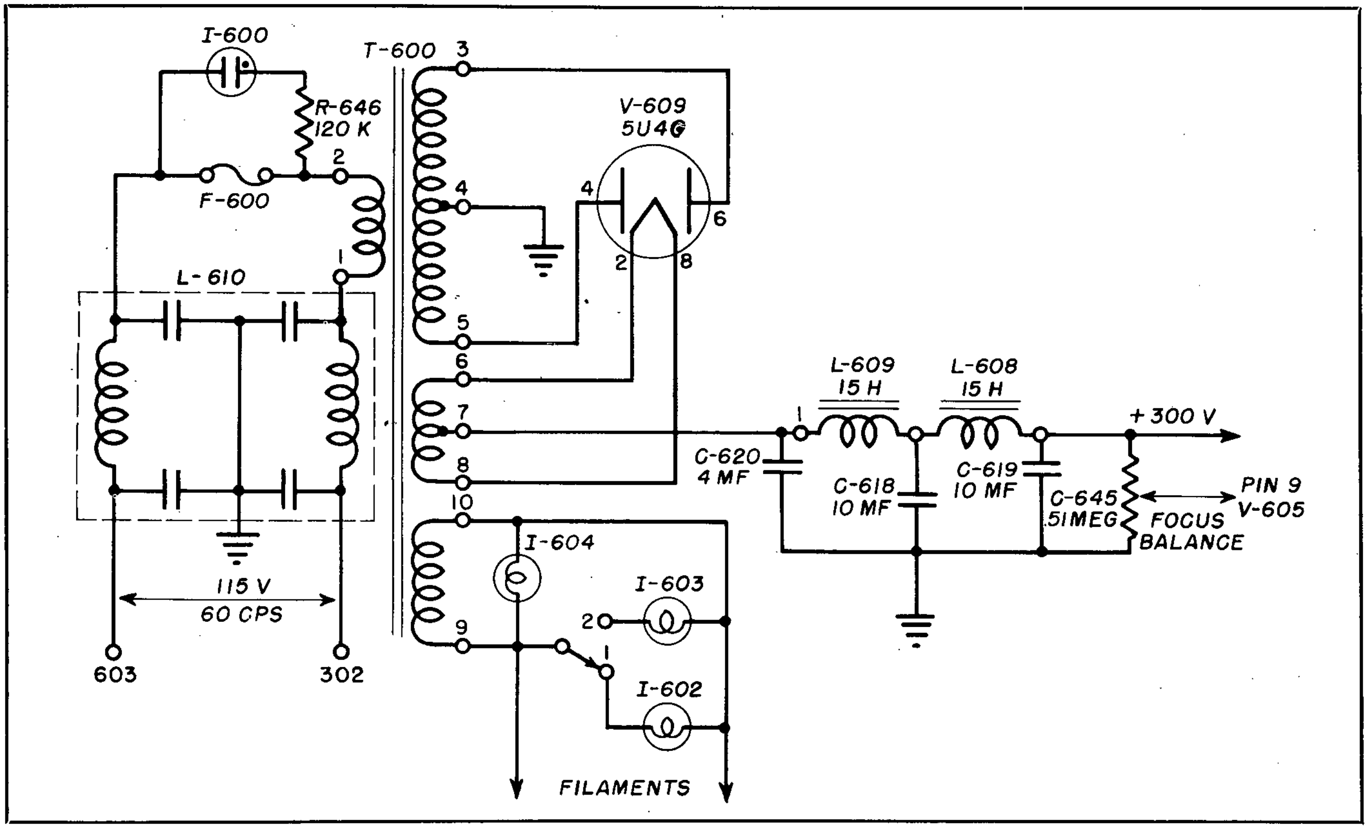


Figure 2-67. Low Voltage Power Supply Circuit

voltage on the other is decreased. The centering potential is secured from the 300 volt d-c supply. The d-c potentials of the horizontal deflection plates are obtained by directly connecting them to the plates of the balanced sweep amplifier V-607. These potentials can be adjusted with potentiometer R-695, the HORIZONTAL CENTERING control on the front panel of the unit. The high positive potential required for the post-accelerating anode of the cathode ray tube is supplied by the high voltage power supply.

(2) Filament voltage is supplied to the filament of the cathode ray tube by a special winding on transformer T-601 in the high voltage supply. The filament is returned to the junction of resistors R-656 and R-658 in the voltage divider across the high voltage power supply. This point is negative with respect to ground. The cathode of V-605 is returned to the filament through resistor R-6006. The cathode current flowing through this resistor causes the cathode to be slightly positive with respect to the filament. The intensifying grid 3 is connected to the arm of potentiometer R-658 and is slightly negative with respect to the cathode. The positive unblanking pulse from the gate circuit is coupled to grid 3 through the paralleled capacitors C-617 and C-641. This unblanking or gate voltage drives the grid positive with respect to the cathode, so that the electron stream is intensified to the point of visibility for the duration of the pulse.

(3) The focusing grid 5 of V-605 is returned to the arm of the FOCUS control R-655. This control is a potentiometer in a system of resistors forming a bleeder across the high voltage supply. Grid 5 is positive with respect to cathode 2 as shown in Fig. 2-66. Grid 9 of V-605 is returned to the potentiometer R-645, in the low voltage power supply. This potentiometer is connected across a positive potential of approximately 300 volts. It is the FOCUS BALANCE control used in focusing the tube.

(4) The voltage divider across the high voltage power supply is grounded at the junction of resistors R-653 and R-654. This causes the high voltage to be divided into the positive potential between the post-accelerator and ground and the negative potential between the cathode and ground. The post-accelerator potential is +1700 volts, and the cathode potential is —1300 volts. This arrangement places the lines feeding the post-accelerator and the cathode at approximately half the total high voltage above, and below ground respectively. This reduces the possibility of arc-overs and short circuits.

b. POWER SUPPLIES.

(1) Two power supplies are provided in the unit. One of these is the low voltage, full-wave +300 volt supply shown in simplified form in Fig. 2-67. It supplies the d-c voltages for the plates and screens of the receiving type tubes in the unit. This supply consists of transformer T-600, the type 5U4G full-wave

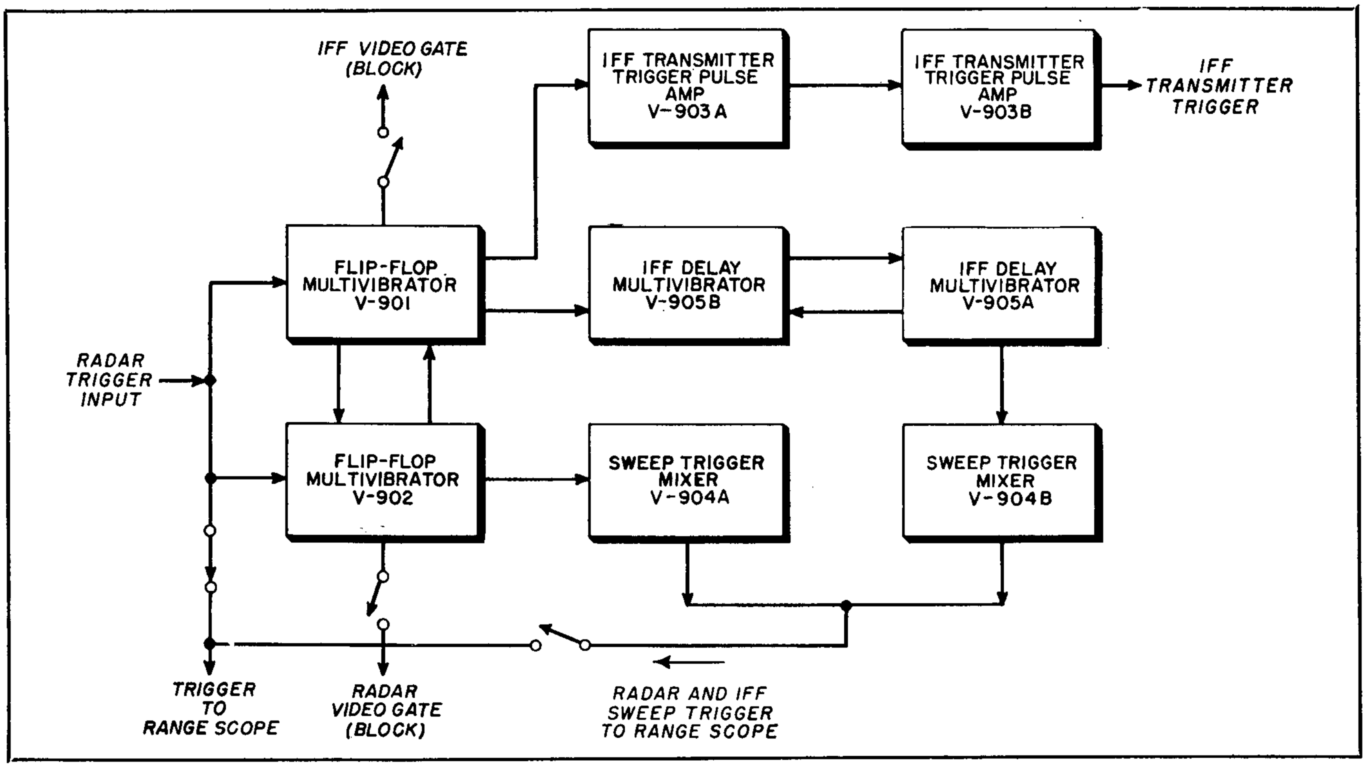


Figure 2-68. IFF Coordinator, Block Diagram

rectifier tube V-609, and the filter system. The output is filtered by the three-stage capacitor input filter comprised of capacitors C-618, C-619, and C-620 and inductors L-608 and L-609. Transformer T-600 supplies power for the pilot lamps and filament voltage for the receiver type tubes which have their cathodes at ground potential.

(2) The high voltage power supply shown in Fig. 2-66 consists of transformer T-601 and the half-wave rectifier tube V-614, a type RKR-72 tube. The output is filtered by an RC filter consisting of capacitors C-624, C-625, and C-649 and resistors, R-648 and R-657. The output of approximately 3,000 volts appears across a voltage divider. The voltage divider is grounded at the junction of resistors R-653 and R-654 as shown in Fig. 2-28. The various voltages required to operate V-605 are taken from the taps and potentiometer arms as shown in Fig. 2-28. Transformer T-601 has a special ungrounded filament winding to heat V-600 and V-603. A special insulated winding on transformer T-601 supplies filament voltage for the cathode ray tube V-605.

(3) The a-c line voltage to both power supplies is controlled by a switch on the General Control Unit in the Indicator Console. Both sides of the a-c line to the primaries of the power transformers are filtered by line filter L-610 to prevent line noise from affecting the performance of the unit. A separate fuse and fuse warning lamp is used in the lead to each of the transformers so that each transformer is fused separately. See Fig. 2-67. The warning lamps are illuminated when the fuse is blown to indicate which circuit has blown a fuse.

15. IFF COORDINATOR.

a. GENERAL.

(1) The IFF Coordinator is used in the Indicator Console to provide a means of presenting the video signals from the radar system and the video signals from the IFF system as one pattern on the face of the Range Scope. The IFF Coordinator supplies a trigger for the IFF transmitter, a gate and sweep circuit trigger to the Range Scope, a delayed IFF sweep trigger, an IFF video gate and a radar video gate to the Range Scope. The unit is triggered by the positive trigger pulse from the radar transmitter or its modulator, which is associated with the Indicator Console.

(2) The outputs from the IFF Coordinator are listed and described in the following paragraphs. Refer also to Fig. 2-68.

(a) IFF TRIGGER.—This output triggers the IFF transmitter every other time the radar transmitter fires. In other words, the radar transmitter fires on one cycle and the IFF transmitter is silent. On the next cycle, both the radar transmitter and the IFF transmitter fire. The cycle of operation takes place as long as the operator desires to interrogate a target, which is done by adjusting the IFF switch on the IFF Coordinator to either the MOMENTARY or ON positions.

(*b*) RADAR TRIGGER TO RANGE SCOPE.—This trigger is generated by the IFF Coordinator and is applied to the Range Scope at the same instant the radar transmitter transmits a pulse of radio frequency energy. It is used to trigger the gate and sweep circuits in the Range Scope to produce the base line on the cathode ray tube on which radar video signals appear. The way this trigger is used in the Range Scope has been previously described.

(*c*) IFF TRIGGER TO RANGE SCOPE.—This trigger is generated by the IFF Coordinator by the action of the pulse from the transmitter. It occurs in a periodic time relationship with respect to the radar trigger described in the above paragraph but it does not appear at the same time. The IFF trigger to the Range Scope is delayed slightly by the action of the IFF Coordinator to compensate for the delay that is inherent in the response from an interrogated IFF system. This delay is compensated for by adjustment of a control which places the IFF Range Scope trigger a fixed period of time behind the IFF transmitter trigger. This is necessary to make the IFF video signal from an interrogated target fall directly below its radar signal on the face of the Range Scope Indicator tube.

(*d*) IFF VIDEO BLOCKING PULSE.—The sequence of operation of the IFF and radar transmitter is such that, when radar video signals are desired on the scope, only the radar transmitter fires on the first cycle. On the following cycle, both the radar and the IFF transmitter fire. While no IFF video signals are being received during the cycle in which radar information is desired on the range scope, noise from the IFF receiver will be present. The purpose of the IFF video blocking pulse is to prevent this noise from appearing on the face of the indicator tube during the radar cycle.

(*e*) RADAR VIDEO BLOCKING PULSE.—This pulse appears during the cycle in which the IFF information is desired on the face of the indicator tube. Since the radar transmitter fires at the same time as the IFF transmitter, radar video signals also will be received during the silent period of the cycle following the action of the transmitters. The radar video blocking pulse serves to prevent the radar video signals from appearing on the Range Scope during the IFF cycle of operation.

b. SEQUENCE OF IFF OPERATION.

(1) The sequence of the functions performed in the IFF coordinator is shown on the waveform drawing in Fig. 2-69. Line 1 of this figure, shows the trigger pulse from the radar transmitter which is used to time and trigger the IFF Coordinator as well as the other components of the radar set. When the radar equipment is operating on the 200 cycle pulse repetition frequency, the transmitter fires 200 times per second but the IFF transmitter only fires 100 times per second. This firing sequence takes place only when the CHALLENGE switch on the IFF Coordinator is moved to the MOMENTARY or ON position.

(2) Lines 2 and 3 in Fig. 2-69 are the radar video blocking pulse and the IFF video blocking pulse respectively. The first trigger pulse shown on line 1 starts a negative rectangular pulse, shown on line 2, which is the radar video blocking pulse. This pulse continues until the next radar transmitter pulse appears. The first radar transmitter pulse also triggers circuits in the IFF Coordinator to produce a positive rectangular pulse of voltage which also lasts until the next trigger arrives. This voltage is the IFF video block on line 3 of Fig. 2-69. The positive IFF video blocking pulses prevent the output from the IFF receiver from appearing on the Range Scope during the first cycle of operation, and the negative radar video blocking pulse allows the radar video signals to be amplified by the video circuits in the Range Scope. When the second radar transmitter pulse appears, the polarities of the two video blocking pulses are reversed and the IFF video signals appear on the Range Scope while the radar video signals are blocked.

(3) The IFF transmitter trigger is shown on line 4 of Fig. 2-69. An IFF transmitter trigger pulse is produced by every second radar transmitter pulse. Therefore, the IFF transmitter operates on every other pulse from the radar transmitter. Line 5 in Fig. 2-69 shows the time relationship of the gate and sweep trigger pulses sent to the Range Scope. The first sweep trigger occurs in time coincidence with the radar transmitter trigger. Therefore the first trigger on line 5 produces the radar sweep on the Range Scope. The first trigger, which is the trigger for the IFF sweep cycle, does not appear at the same instant as the trigger from the radar transmitter or the trigger to the IFF transmitter. It is delayed slightly. This delay can be adjusted between 3 and 50 microseconds. The purpose of this delay is to compensate for the delay in the IFF equipment as previously described. Fig. 2-69 shows that the IFF sweep trigger occurs shortly after the IFF video blocking pulse removes the disabling bias from the IFF video amplifier in the Range Scope. The first pulse on line 5 is the radar sweep trigger and it occurs at the same instant that the radar blocking pulse removes the disabling bias from the radar video amplifier in the Range Scope.

(4) Line 6 of Fig. 2-69 shows the time at which the sawtooth sweep voltages appear in the Range Scope. The radar sweep starts with the appearance of the radar sweep trigger and the IFF sweep starts with the appearance of the IFF sweep trigger. Line 7 shows the Range Scope unblanking pulses which coincide with the sweep voltages. Line 8 shows a typical radar presentation of targets on the face of the tube. The

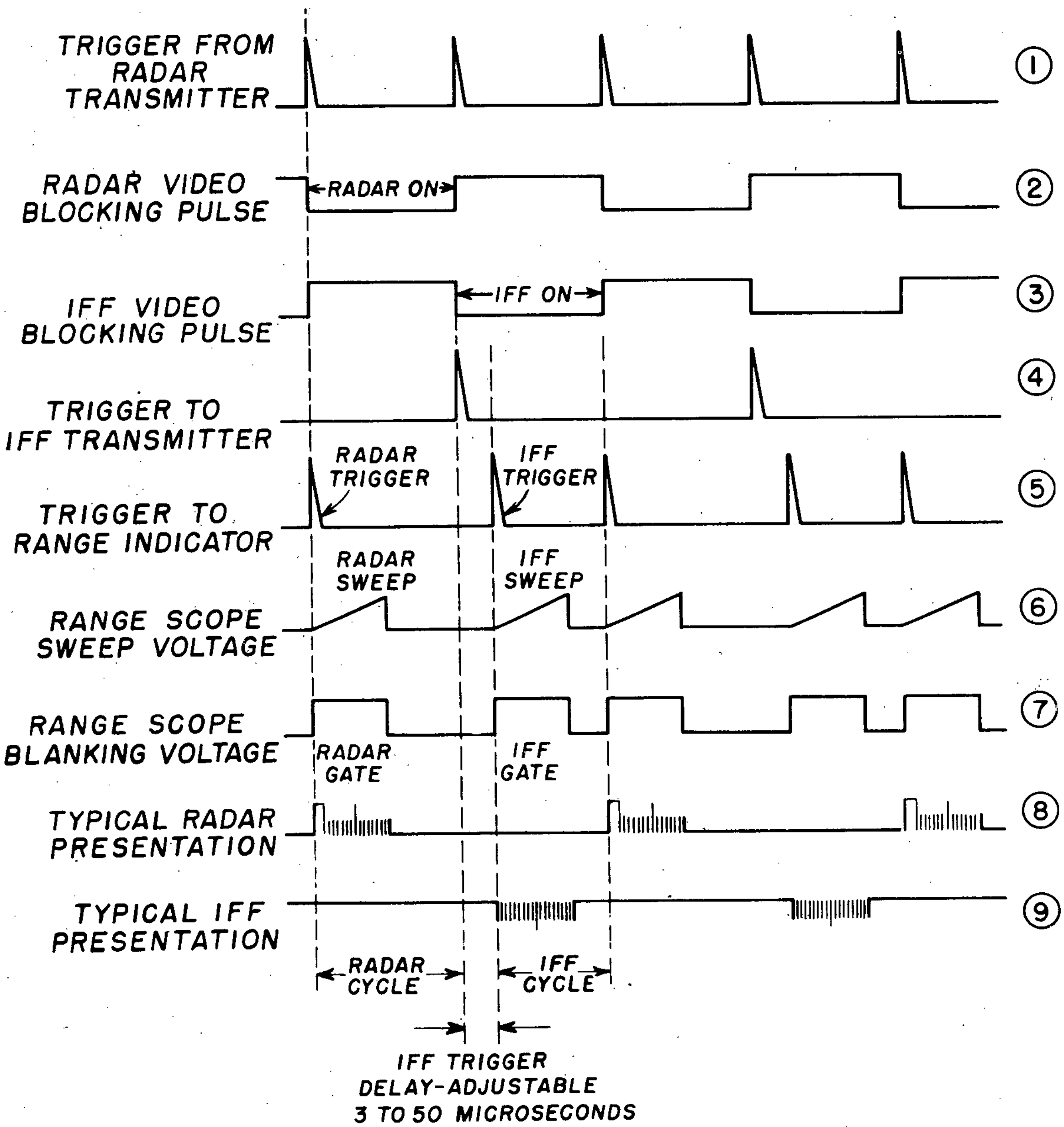


Figure 2-69. Waveforms of IFF Operation With a Radar System

start of this presentation coincides exactly with the first radar transmitter trigger in line 1. Thus, a target which is exactly half the total range on which the equipment is operating, would appear at the exact center of the sweep.

(5) Line 9 shows how the IFF presentation appears when the delay is properly adjusted. Assume the target is at a distance equal to half the length of the sweep, as shown on line 8, and that the delay in the IFF equipment is equal to a range of approximately one-eighth of the total length of the sweep. The target, which should appear in the center of the sweep, would then appear five-eighths of the length of the sweep away from the starting point. This would give a false indication of range, and cause the IFF indication to appear farther out on the sweep than the corresponding radar indication from the target. It is necessary for the IFF response pip to appear directly beneath the radar target pip that is being interrogated, in order to establish an identity between the two. Therefore, it is necessary to delay the starting time of the IFF sweep by an interval of time equal to the delay in the IFF equipment. The result is shown in Line 10 of Fig. 2-69. This shows that the start of the IFF sweep is delayed until the IFF indication from the target now falls in the exact center of the sweep. Consequently, it will appear directly below the radar target indication in the center of the range indicator tube.

c. CIRCUITS IN THE IFF COORDINATOR.

(1) The circuits of the IFF Coordinator required to develop the timing sequence and outputs, shown in Fig. 2-69 and to accomplish certain control functions for the IFF equipment associated with the radar installation, may be divided into the following contributing circuits which are shown in the block diagram in Fig. 2-68.

(a) MULTIVIBRATOR.—This circuit is triggered by the radar transmitter trigger and develops the radar and IFF video blocking voltages. It also provides timing and trigger voltages for the other circuits in the component.

(b) IFF TRANSMITTER TRIGGER CIRCUITS.—These circuits develop the trigger for the IFF transmitter.

(c) IFF DELAY MULTIVIBRATOR.—This circuit acts to delay the sweep trigger to the Range Scope on the IFF sweep cycle.

(d) MIXER CIRCUIT.—This circuit mixes the trigger for the radar sweep and the IFF sweep in the Range Scope into one common output. This output is applied to the gate circuit of the Range Scope by a low impedance line.

(e) SWITCHING CIRCUIT.—This circuit accomplishes the switching and control operations. The operator need only operate one switch on the front panel of the unit in order to interrogate a target.

(f) IFF RECEIVER CONTROLS.—This circuit provides remote control of certain IFF receiver functions by the Indicator Console operator.

(g) POWER SUPPLY.—This circuit supplies all d-c and filament voltages for the operation of the IFF Coordinator.

d. MULTIVIBRATOR.

(1) This circuit, shown in Fig. 2-70 is sometimes called a flip-flop circuit, and consists of the two tubes, V-901 and V-902. These tubes are type 6AG7 tubes. Their cathodes, control grids and screens form the two triode sections necessary in an Eccles-Jordan type of circuit. The output, used to trigger other circuits in the unit, is taken from the plates of the two tubes. The plate is electron-coupled to the other elements of the tube through the electron stream from the cathode to the plate. The IFF and radar video blocks are taken from the cathodes of the tubes and the outputs that produce the IFF and Range Scope triggers are taken from the plates.

(2) The simplified schematic diagram in Fig. 2-70 shows the components of the circuit which make up the Eccles-Jordan multivibrator. When the IFF switch is in the OFF position, the trigger from the radar transmitter is connected to the CHALLENGE switch section S-901A which is not shown in the figure, and fed directly to the Range Scope. The Eccles-Jordan circuit also receives the trigger through capacitors C-901 and C-904 but does not function due to the fact that V-902 has a very high cathode resistor, R-911. The value of this resistor is 56,000 ohms and maintains the bias voltage at cut-off. When CHALLENGE switch S-901 is switched to either the MOMENTARY or ON position, the cathode of V-902 is connected to ground through switch section S-901D and resistor R-672 which is in the Range Scope. This resistor has a value of 220 ohms and when it is connected in parallel with the 56,000-ohm resistor R-911, the cathode bias of V-902 drops, causing the tube to conduct and causing V-901 to be cut off.

(3) Assume that the CHALLENGE switch, S-901 is in its ON position. The synchronizing trigger from the radar transmitter is applied to grid 4 of both V-901 and V-902. Since V-902 is conducting, the positive trigger has no effect on it and the voltage at its screen grid 6 will be low because of the heavy current being drawn through the series resistors connecting it to the high voltage supply line. Since grid 4 of V-901 is coupled to grid 6 of V-902 by the two resistors R-905 and R-937, its potential is determined by grid 6 of V-902 and V-901 is cut off. This causes the potential on grid 6 of V-901 to be high. The voltage on plate 8 of V-901 is also high due to the cut-off condition of the tube. Plate 8 of V-902 will be at a low potential since the tube is conducting heavily.

(4) The trigger from the radar transmitter ap-

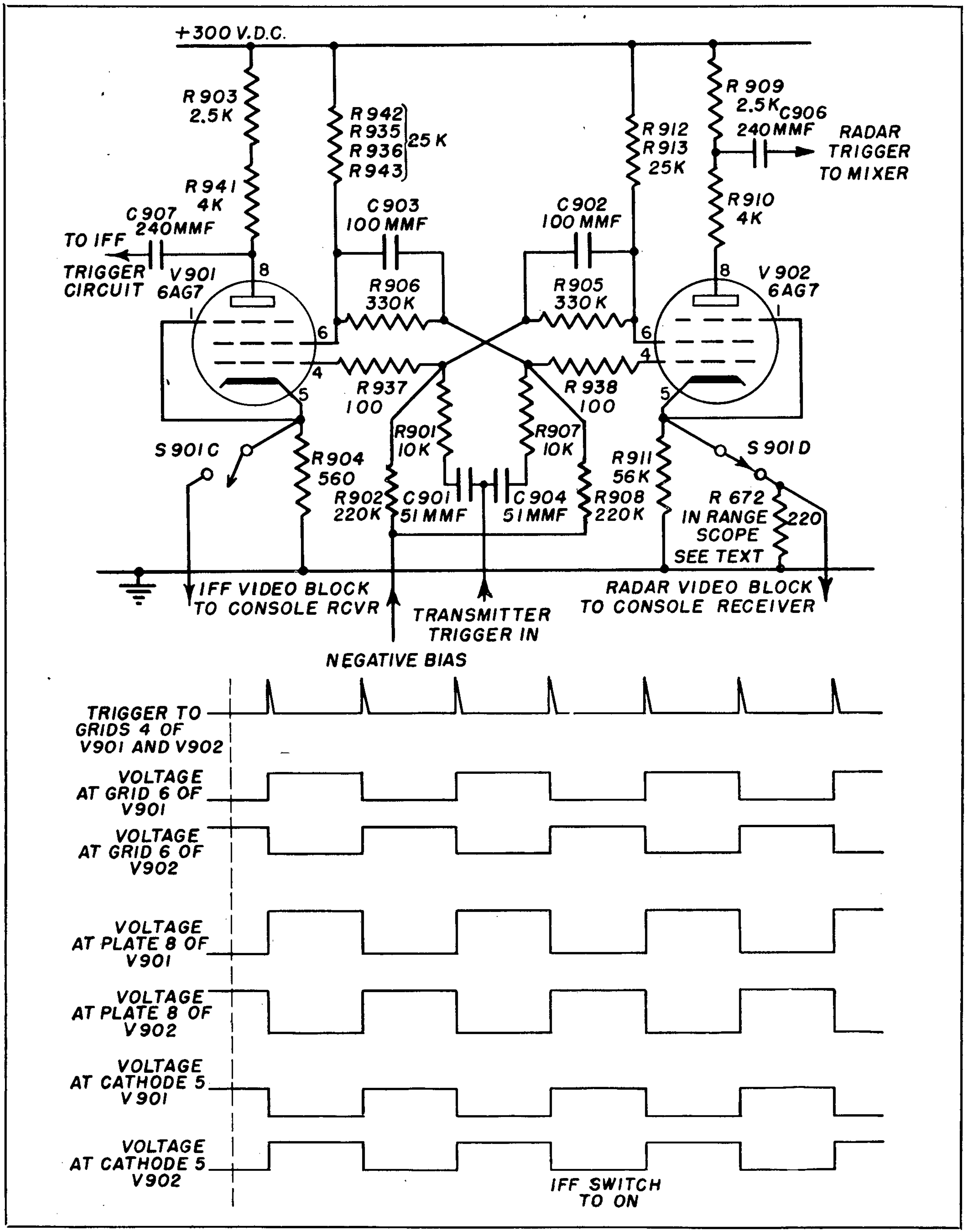


Figure 2-70. Flip Flop Multivibrator in IFF Coordinator

pears on both grids simultaneously. Since the trigger is positive, and V-902 is already drawing saturation current, it will have no effect on V-902. The positive trigger applied to grid 4 of V-901 will drive the tube into conduction and the voltage on grid 6 of V-901 will drop due to the increased current flowing through resistors R-935 and R-936. This drop will be conducted to grid 4 of V-902. Capacitor C-903 is connected across resistor R-906 to conduct the drop rapidly across the resistor and thus steepen the front of the wave as it appears on grid 4 of V-902. The decrease in the potential on grid 4 of V-902 results in a decrease in the plate and screen current through the tube. The voltage at grid 6 rises and this rise is coupled to grid 4 of V-901 by resistors R-905 and R-937. Capacitor C-902 by-passes R-905 to speed up the action. As the potential on grid 4 of V-901 rises, the coupled back voltage adds to the positive voltage from the trigger and the conduction through V-901 is increased. Grid 4 of V-901 rises very rapidly due to the cumulative effect of the circuit. Grid 4 of V-902 continues to go farther negative for the same reason. This continues at a very fast rate until grid 4 of V-901 has risen in a positive direction up to the limits permitted by the constants of the circuit while grid 4 of V-902 is driven negative beyond the cut-off point. In this condition, V-901 draws maximum current and V-902 is cut-off.

(5) At this point in the operation, the circuit will rest until another trigger comes along. The grid potential of V-902 will remain low due to the fact that the voltage of grid 6 of V-901 is held to a low value by the relatively large amount of current being drawn through the resistors connecting it to the d-c supply. Grid 4 of V-901 will remain high in potential since it is connected to grid 6 of V-902 which is at a high potential because no current is being drawn through the resistors connecting it to the d-c supply. When the next trigger pulse arrives, it is also applied to both grids 4 of V-901 and V-902. However, since V-901 is already drawing saturation current, it will have no effect on this tube. Driving its grid to a higher potential will not increase the current through the tube. V-902, on the other hand, has been cut off. The application of a positive voltage to its grid causes the grid to begin to rise and the tube starts drawing current. This starts the *flip back* cycle of operation. When V-902 starts to draw current, its screen potential starts to drop. The drop is coupled to grid 4 of V-901 causing it to drop. The potential of grid 6 will start to rise, and this rise will be coupled back to grid 4 of V-902 adding to the positive trigger voltage. The action is cumulative, and very rapid and the circuit returns to its original condition.

(6) The circuit rests in this condition until another trigger pulse arrives. From the foregoing description, it can be seen that one tube draws current following one trigger and the other tube draws current following the succeeding trigger. This cycling of the circuit will continue as long as triggers are applied to it and it is not cut off by the action of the CHALLENGE switch on the panel of the unit.

(7) The voltages at the plates are amplified reproductions of voltages at the screen grids. This is due to the fact that electron coupling exists between these two elements in each tube. Pentodes are used in this circuit because if inter-electrode capacity should exist between the plate and control grid, the grid potential would be adversely influenced by the plate potential and the rise and fall of the voltages would be slowed down and there would be a delay in the flipping action of the circuit. The use of pentodes permits the circuit to turn over very rapidly and the leading and trailing edges of the square pulse at the plates and cathodes are effectively vertical.

(8) The IFF video blocking pulse is the voltage across the cathode resistor of V-901. The radar blocking pulse is the voltage across the cathode resistors of V-902. These voltages are taken from the cathodes in order to obtain a low impedance output for connection to the Range Scope through low impedance cables. Switch S-901C connects the IFF video blocking pulse to its cable and switch S-901D connects the radar blocking pulse to its cable. These two switches are parts of the CHALLENGE switch on the front panel of the unit and are shown schematically in Fig. 2-74. Contact is made whenever this switch is in either the MOMENTARY or ON positions. Bias voltage for the grids of both tubes is obtained from a voltage divider which includes potentiometer R-944. This potentiometer is also connected in the negative return circuit of the rectifier in the power supply. This bias is adjusted by the BIAS ADJUST control R-944 on the deck of the unit towards the rear. It is normally adjusted to a point where the proper voltage relationship exists between the grid and cathode potential to secure proper synchronization from the trigger pulses.

(9) Three other outputs are taken from the circuit. The IFF trigger circuits receive a pulse of voltage from the plate of V-901. One tube of the mixer circuit receives a pulse of voltage from the junction of the plate resistors R-909 and R-910 in the plate circuit of V-902. An output for the trigger delay multivibrator is taken from a potentiometer, R-917, in a voltage divider between the plate of V-901 and the connection to the negative bias supply to the grids of V-901 and V-902.

e. IFF TRIGGER CIRCUITS.

(1) The IFF trigger circuit is comprised of the two cathode follower tubes V-903A and V-903B. These are the two halves of a type 6SN7-GT tube and are designated as pulse amplifiers in Fig. 2-68. These tubes

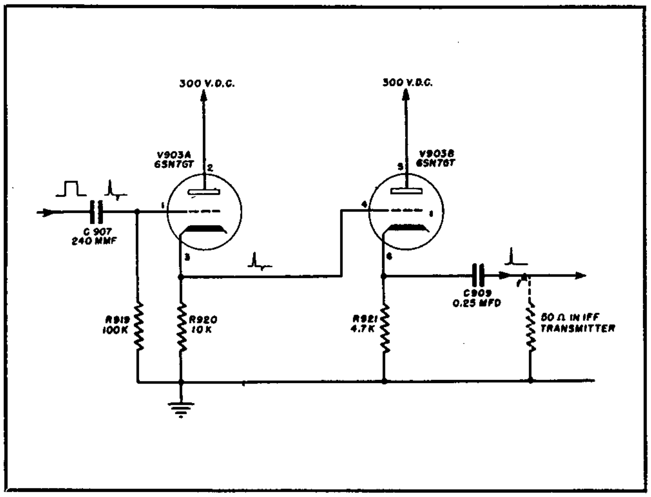


Figure 2-71. IFF Trigger Circuit in IFF Coordinator

are shown in the simplified schematic in Fig. 2-71. A positive rectangular pulse of voltage from the plate of V-901 is coupled to the grid of the first cathode follower V-903A through the differentiating network comprised of capacitor C-907 and resistor R-919. This causes the pulse to appear at the grid of the tube as a tall, sharp spike of voltage as shown in Fig. 2-72. This spike occurs with the leading edge of the pulse from the plate of V-901, and is followed by a small negative pulse produced by the trailing edge of the rectangular pulse. The positive pulse acts on the circuit.

(2) V-903A has a 10,000-ohm cathode resistor, R-920. This high resistance places the tube practically at cut-off. Consequently, a large positive pulse will appear across the cathode resistor followed by a very small negative spike. The small size of the negative spike is due to the fact that the grid is slightly above cut-off. Only a small negative voltage will drive it to cut-off. Any voltage on the grid beyond that will have no effect on the cathode current of the tube. Therefore, the small negative pulse on the grid is clipped to a very low amplitude in the cathode circuit. It is necessary to have the trigger generated from the positive pulse so as to time the IFF transmitter properly. Since the flip-flop circuit delivers a positive pulse for every second radar transmitter pulse, the differentiated positive pulse appears only on every second transmitter trigger. See Line 4 of Fig. 2-69. V-903B is the output tube and it feeds the low-impedance line to the IFF transmitter. Its grid is coupled to the cathode of the first cathode follower V-903A. This second cathode follower, according to the schematic diagram, has a cathode resistor of 4,700 ohms. However, at the termination of the line in the IFF transmitter, another resistor is placed across the line in parallel with resistor R-921 in the IFF Coordinator. This resistor is only 50 ohms, so that when the unit is connected to the IFF transmitter, the effective cathode *load* the tube must work into, is only 50 ohms. Blocking capacitor C-909 prevents the actual current from flowing through this resistor. The output of the cathode circuit is, therefore, a sharp positive 10 to 15 volt pulse of voltage across an impedance of 50 ohms. The use of two cathode followers in cascade is made necessary because the circuit must deliver considerable power to build up the 10 to 15 volt signal across such a low impedance.

f. IFF DELAY MULTIVIBRATOR.

(1) The IFF delay multivibrator provides the delayed trigger for the IFF sweep in the Range Scope. It consists of two halves of a type 6SN7-GT tube connected in a delay multivibrator circuit. These tubes are shown as V-905A and V-905B on the simplified schematic in Fig. 2-72. The trigger voltage for this multivibrator is secured from a voltage divider formed of resistors R-916, R-917, R-918 between the plate of V-901 and the negative bias network in the rectifier negative return circuit. R-917 is a 200,000 ohm potentiometer which is the TRIGGER DELAY control used to adjust the amount of delay in the circuit. By operating the TRIGGER DELAY control, the resting potential on the grid of V-905B may be varied over a range sufficient to provide the required delay periods necessary with the different types of IFF equipment with which the radar equipment may be used. The positive pulse of voltage is applied to the multivibrator circuit where it appears on the grid of V-905B through series resistor R-930. Before the trigger voltage appears, V-905A is drawing a heavy current due to the connection of its control grid to the high voltage supply through resistor R-928. Due to the high cathode bias of 11,000 ohms used in the circuit (R-927 and R-940 in parallel) cathode 6 is raised to a point where it is more positive than grid 4 of V-905B and consequently the tube is cut off. The vertical leading edge of the positive block is applied to grid 4 of V-905B through the 56,000-ohm series resistor, R-930.

(2) The resting or d-c potential of the grid has been established by the position of the arm of the potentiometer R-917, which is the TRIGGER DELAY control. This control is used to set the grid a certain value below the point at which the tube will pass current. Adjusting this control will vary the resting potential of the grid over a relatively wide range. It will also establish a positive potential across capacitor C-912 which is coupled from the plate of V-905A to the grid of V-905B. When the positive pulse from the divider appears at the grid through the series resistor R-930, the voltage on grid 4 does not rise vertically, for it is necessary to charge capacitor C-912 to the potential at which the tube fires. The rate of this charge will depend upon the time constant of R-930 and the capacitor C-912, as well as the voltage

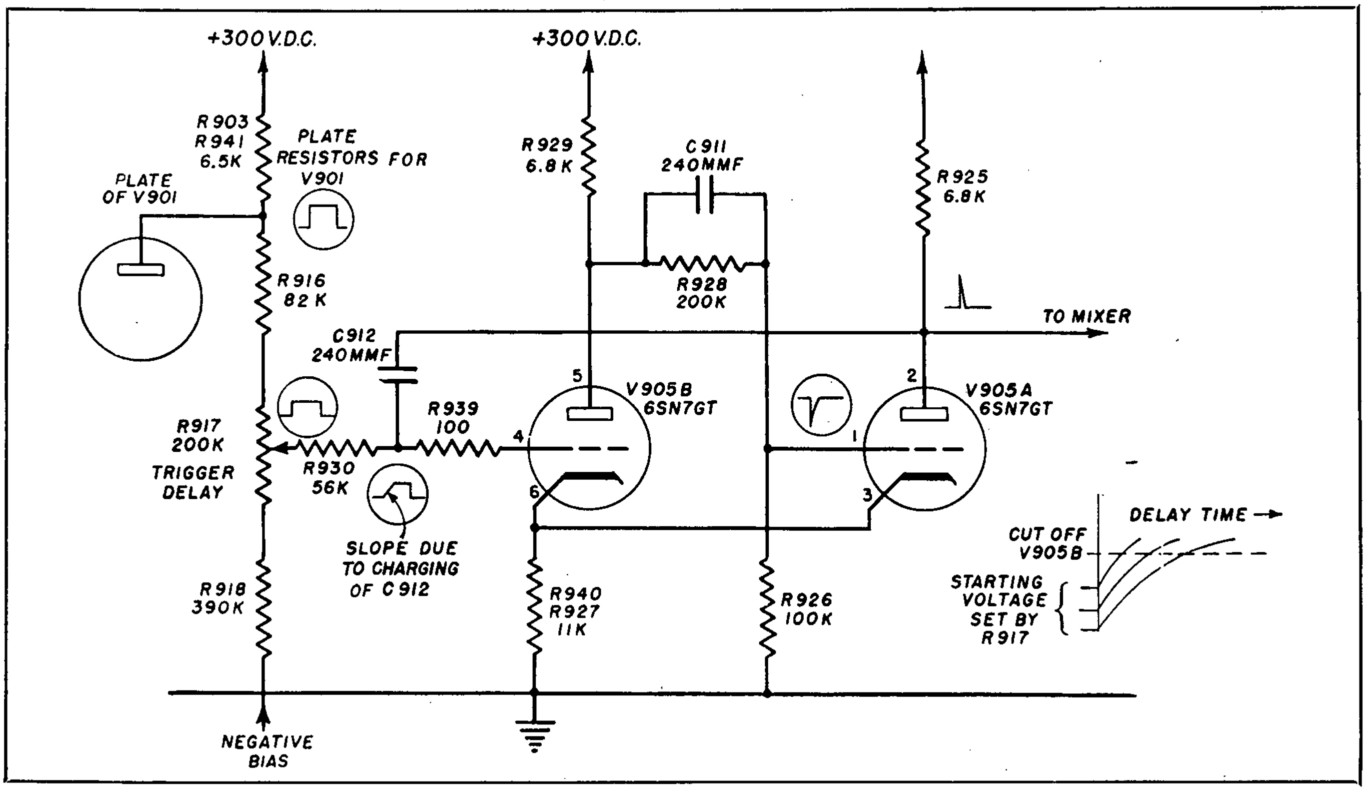


Figure 2-72. IFF Trigger Delay Multivibrator in IFF Coordinator

initially existing across the capacitor which is determined by the setting of potentiometer R-917. Consequently, the grid voltage will rise with a slope instead of vertically, and it is this slope and the voltage at which the grid was resting before the voltage from the divider appeared which determines the amount of delay present. This action is illustrated by the curves in Fig. 2-72. The dotted line represents the point at which conduction can take place in V-905B. The curved lines represent the rise in grid voltage for three different settings of the TRIGGER DELAY control. Time moves from left to right. It can be seen that the more negative grid 4 is made, the more time elapses before the tube begins to conduct.

(3) The voltage on the grid of V-905B rises at a relatively slow rate as compared with the vertical rise at the plate of V-901. When the voltage has risen to the cut-off point, or the point at which the tube begins to draw current, the delay multivibrator will turn over. This action takes place because V-905B will begin to draw current, and this will cause an increase in the plate current through the plate resistor R-929. This creates a drop in the voltage existing at the plate of the tube. The voltage drop thus produced is coupled to grid 1 of V-905A by the coupling capacitor C-911 and the resistor R-928. The grid will become more negative and this will reduce the current through V-905A, causing the voltage across its plate resistor to rise. It will also cause the voltage at the cathode of the tube to drop and this will lower the cathode of V-905B since both cathodes are connected across a common cathode resistor. Decreasing the cathode voltage has the same effect as increasing the grid voltage. This causes more plate current to flow through V-905B. This operation is very rapid, with each voltage change contributing to the action of the circuit and C-905A cuts off rapidly and V-905B is left drawing full current.

(4) V-905A cuts off almost instantaneously, and the voltage at its plate rises almost vertically until it equals the total voltage delivered by the d-c supply. At this point, V-905A is cut off and V-905B is drawing current. Since there is a minimum of capacity in the grid circuit of V-905A, the circuit will begin to flip back to its initial condition almost as soon as the circuit has turned over. The only delay present will be due to the capacity of the tube section comprised of the grid, cathode and plate of V-905A, and the distributed circuit capacity. The grid of V-905A becomes positive very rapidly due to its connection to the high voltage supply through R-928. As it charges up, V-905A again begins to conduct, the cathode voltage of the two tubes goes up and V-905B begins to cut off. The rise in the plate voltage on V-905B is coupled to the grid of V-905A and adds to the charge on capacitor C-911 which is produced by the high voltage supply. The circuit very quickly flips back to its initial resting state with V-905A drawing current and V-905B cut off. This causes a narrow pulse of positive voltage to appear on the plate of V-905B.

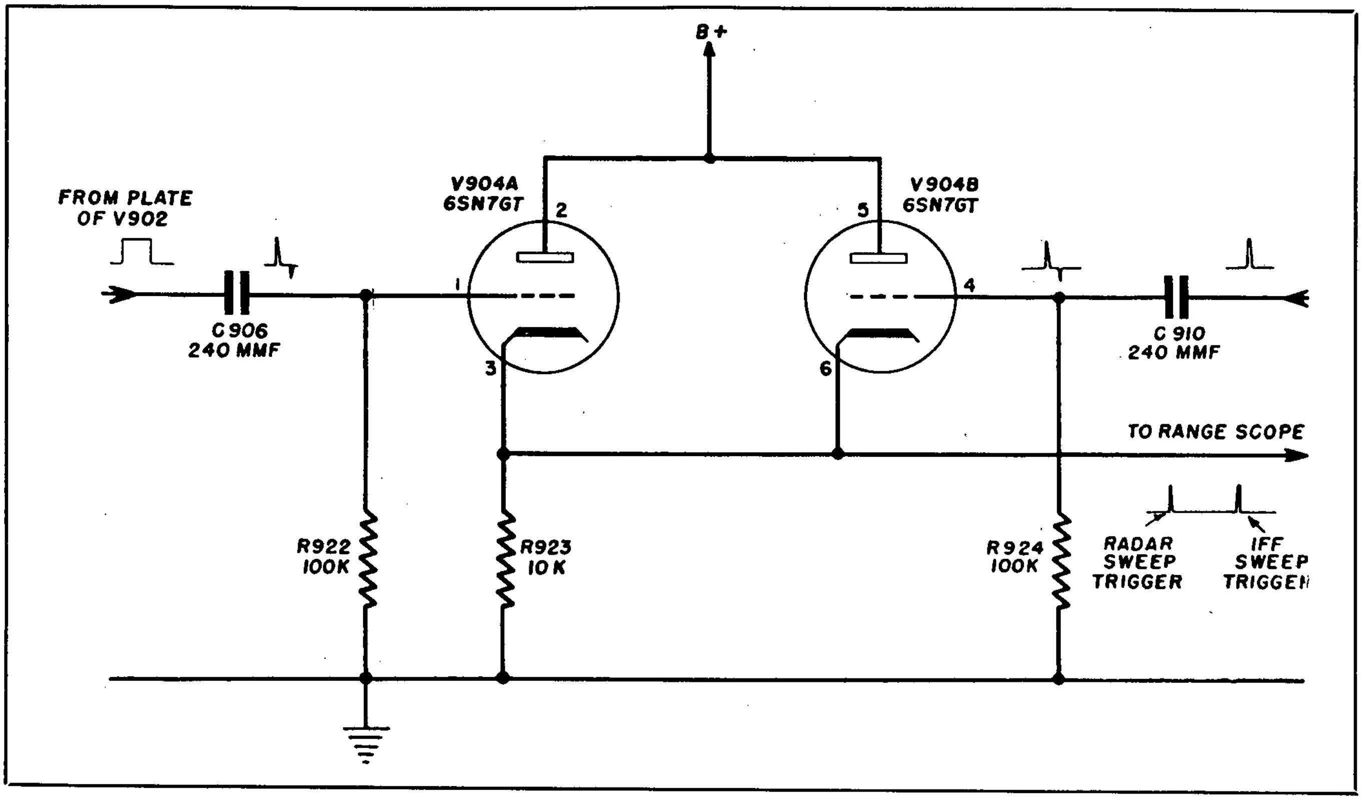


Figure 2-73. Mixer Circuit in IFF Coordinator

(5) The length of time this block appears after the circuit has been triggered by the positive leading edge of the pulse from the plate of V-901, depends upon the delay set into the circuit by potentiometer R-917. R-917 is the TRIGGER DELAY control located near the center of the main deck. The delay is caused by two factors. The first of these is the resting bias applied to the grid of V-905B by the adjustment of the TRIGGER DELAY control. The second is the value of the potential existing across the capacitor C-912 which is established also by the same control and which determines the leading slope of the wave. Potentiometer R-917 causes very little change in the slope of the wave as it appears on the grid of the tube. However, as shown by the curves in Fig. 2-72, the delay will be varied due to the difference in voltage between the resting bias of the grid and the point at which the grid potential reaches the firing point of the tube. Since adjusting the control will cause resting bias to be raised or lowered, this same action will cause more or less delay before the circuit turns over and causes the positive pulse to appear at the plate of V-905A.

(6) Because of the fast return action of the circuit, the output is a narrow positive pulse of voltage which appears at the plate of V-905A at a pre-determined period of time following the appearance of the rectangular pulse at the plate of V-901. Since the delay control is not calibrated, the delay is set by observing the Range Scope and lining up a typical IFF response underneath the radar signal from the interrogated target.

g. MIXER CIRCUIT.

(1) The mixer circuit receives the positive-going square pulse from the plate circuit of V-902, reduced in amplitude since it has been taken from the junction of the two plate resistors R-910 and R-909. It also receives the positive-going pulse from the plate of V-905A. Both of these outputs, which appear alternately, as can be seen by reference to the waveform diagram Fig. 2-69, are applied to the line which is coupled to the input of the gate circuit in the Range Scope.

(2) The circuit shown in Fig. 2-73 consists of two sections of a type 6SN7-GT tube, V-904, with the plates and cathodes connected in parallel. Grid 4 of V-904B is driven by the output of the delay multivibrator while grid 1 of V-904A is driven by the positive square pulse from the plate of V-902. The tubes are connected as cathode followers as shown on Fig. 2-73. The 10,000 ohm resistor R-923 is of sufficient value to operate both tubes near cut-off. This is necessary so that the small negative pulse of voltage which comes from the differentiation of the voltages applied to the grids will not appear in the output. The positive pulse from the plate circuit of V-902 is differentiated by the network consisting of capacitor C-906 and resistor R-922. It causes a sharp pulse of voltage to

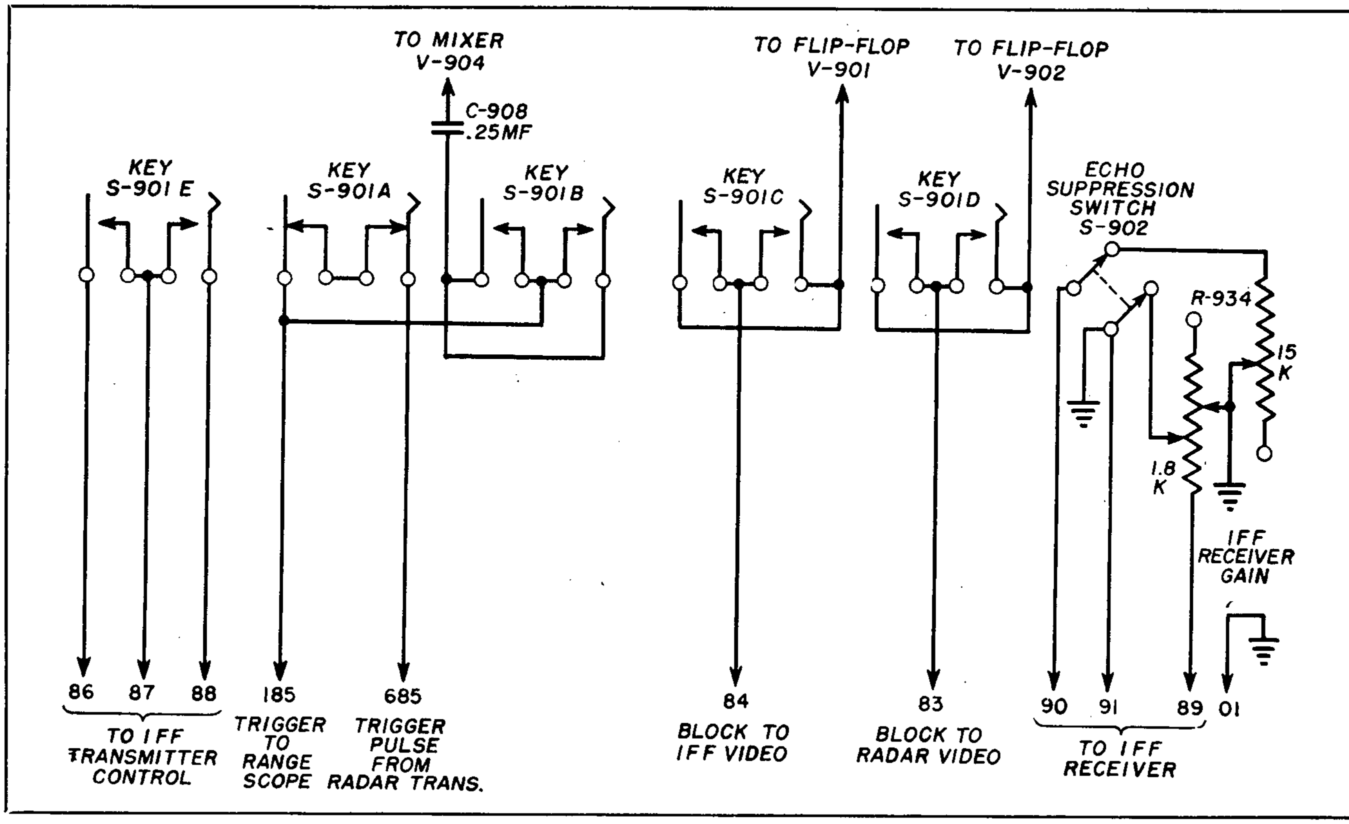


Figure 2-74. Switching Circuits in IFF Coordinator

appear on the grid of V-904A followed by a negative pulse. See Fig. 2-69. The positive pulse causes the tube to draw a heavy current and the voltage at the cathode of the tube is a positive pulse of slightly less amplitude. The output of V-904A will be a sharp pulse of voltage which appears simultaneously with the trigger from the radar transmitter, which starts the cycle of Range Scope operation in which radar targets appear on the indicator tube screen. The positive voltage appearing at the plate of V-905A is also integrated and appears on grid 4 of V-904B. This is a delayed trigger, appearing a pre-determined length of time after the IFF transmitter trigger. The delayed trigger produces a positive pulse at the cathode of V-904B which starts the IFF sweep on the Range Scope. The delay is the amount of delay inherent in the IFF equipment and is adjustable by the TRIGGER DELAY control, R-917. The two pulses of voltage are the ones shown on Line 5 of Fig. 2-69. They are supplied to the Range Scope when switch S-901B, a section of CHALLENGE switch S-901, is in either the MOMENTARY or the ON positions.

h. SWITCHING CIRCUITS.

(1) The IFF Coordinator is the basic control point for the IFF equipment associated with the Indicator Console. The switching circuits that accomplish this control are shown in Fig. 2-74. When the CHALLENGE switch, S-901, is in the OFF position, the transmitter trigger comes into the unit on terminal 685 in the top of the cabinet in which the unit is contained. It is applied to the Eccles-Jordan or flip-flop circuit, which is blocked as previously explained. It is also connected to the line to the Range Scope by switch section S-901A, which is closed. All other switch sections are open.

(2) When the CHALLENGE switch is in the MOMENTARY or ON position, switch section S-901A is open and the transmitter trigger is disconnected from the line to the Range Scope and the output of the mixer circuit is connected to this line through switch section S-901B. Switch section S-901E turns on the power to the IFF transmitter in either position of the switch. Switch section S-901C connects the radar video block to the Range Scope video circuits. Switch section S-901D connects the IFF circuits to the Range Scope video circuits and also, by doing this, parallels the high cathode resistor R-911 in the flip-flop circuit with a low value resistor in the Range Scope and thereby permits this circuit to respond to the transmitter trigger. The IFF trigger line is connected to the IFF transmitter at all times, although no trigger is supplied, except when the flip-flop or Eccles-Jordan circuit is operating.

i. IFF RECEIVER REMOTE CONTROLS.

(1) Two controls are supplied on the IFF Coordinator for remote control of the IFF Receiver. These

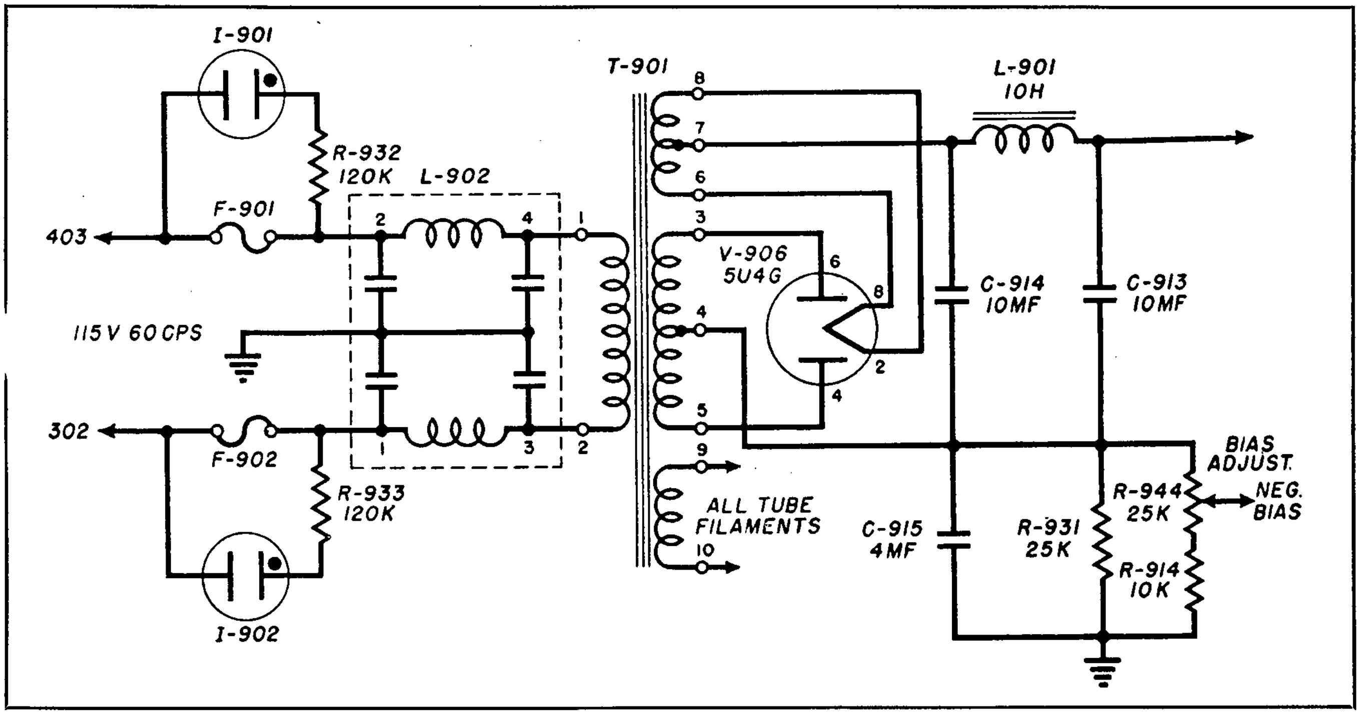


Figure 2-75. Power Supply in IFF Coordinator

are the ECHO SUPPRESS switch, S-902, which is used to control certain IFF receiver functions. These controls are shown in Fig. 2-74. The other control is the IFF RECEIVER GAIN control. The use and purpose of these two controls will be explained in the instruction book supplied with the IFF equipment.

j. POWER SUPPLY.

(1) The power supply for the unit is a full-wave rectifier circuit. It is shown in simplified form in Fig. 2-75. V-906 is a type 5U4G full-wave rectifier tube. The positive output of the circuit is filtered by a capacitor input filter comprised of capacitor C-914, inductor L-901 and capacitor C-913. The negative return to the center-tap of the high voltage winding on transformer T-901 is through a resistance network composed of resistors R-931, R-914 and potentiometer R-944. The potentiometer is the BIAS ADJUST control which is used to adjust the negative bias of the grids of the Eccles-Jordan multivibrator so that proper cycling will be obtained. The negative bias network is filtered by capacitor C-915. Filament voltages are obtained from two filament windings on T-901.

(2) The 115 volt a-c input line to the primary of transformer T-901 is fused at the input to the unit by fuses F-901 and F-902. Indicator lamps I-901 and I-902 are neon type bulbs and, in series with resistors R-932 and R-933, respectively, are connected across the fuses. When a fuse blows, the lamp associated with it will light up, thus indicating which fuse has opened. The line voltage is filtered with a line filter, L-902, which filters line noise and small line disturbances from the input line.

16. PPI INDICATOR.

a. FUNCTIONS OF A PPI INDICATOR.

(1) A PPI Indicator must perform two functions. One is to measure the time interval required for a pulse of micro-wave radio frequency energy to reach a target, to be reflected by it, and for some portion of this reflected original pulse energy to return to the radar equipment. This time measurement is recorded visibly on the face of the PPI tube. From this visual indication the range (distance) from the main radar equipment to the target can be quickly approximated. The other function is to record the target's position on the face of the tube in such a way that the PPI unit will also indicate in degrees of azimuth, the direction of the target from the main radar equipment.

(2) The way the PPI unit indicates the range to the target may be understood by reference to Fig. 2-76. A short pulse of ultra high radio frequency energy is generated by the transmitter of the main radar equipment with which the PPI unit is associated. This pulse is radiated by the radar antenna *A* in Fig. 2-76 and strikes a target A_1. A certain portion of the radio frequency energy is reflected by the target (re-radiated) in the direction of the radar antenna where it is received by the radar equipment's rotating antenna. The reflected *echo* signal is translated by the radar receiving equipment into an electrical pulse of video voltage which occurs at a *definite time interval* following the transmission of the radio frequency pulse.

(3) The difference in time between the transmission of the pulse of radio frequency energy by the radar transmitter, and the reception of the reflected

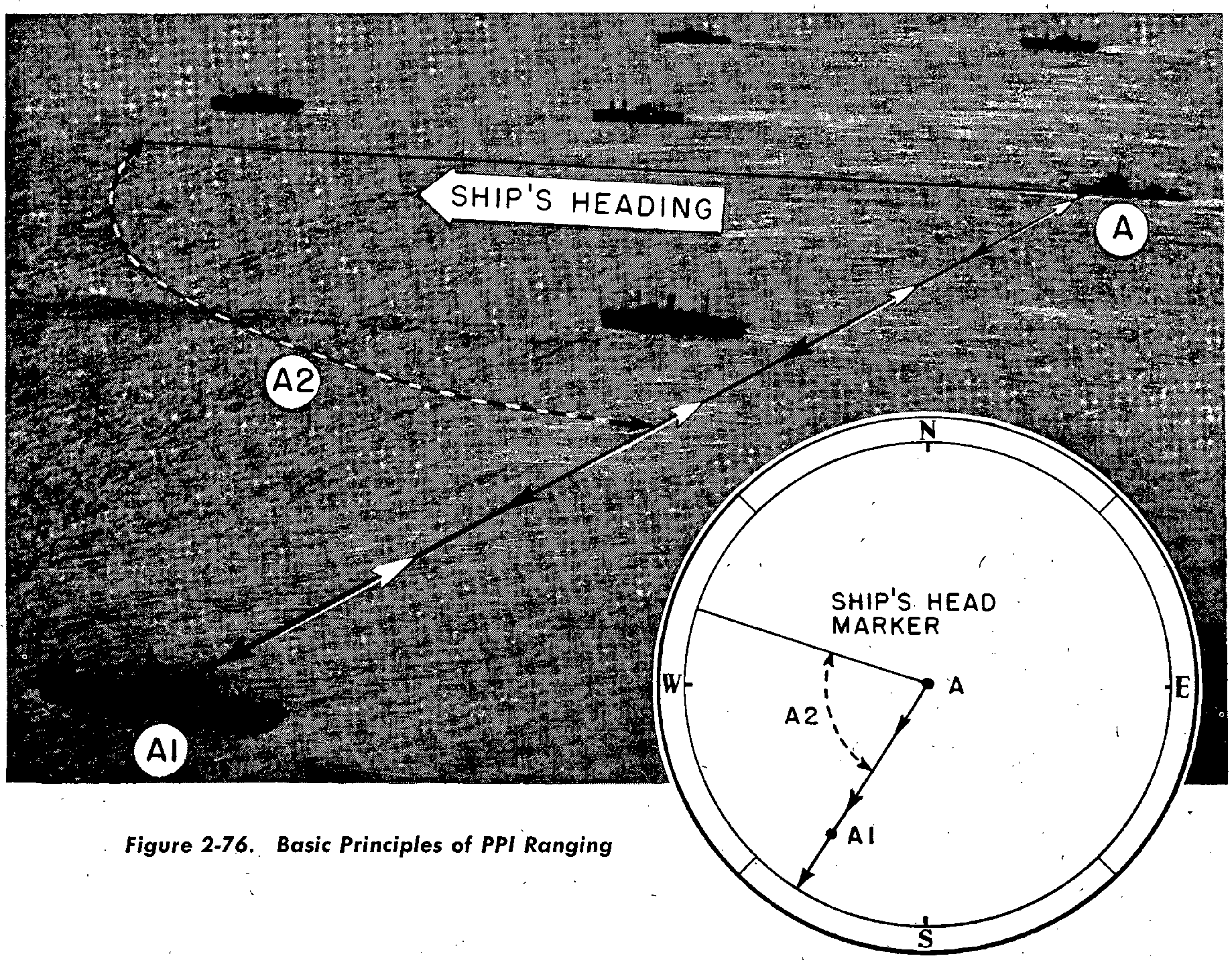


Figure 2-76. Basic Principles of PPI Ranging

echo signal is used by the PPI unit to show the distance (range) of the target on the PPI tube screen. Since the speed of radio waves in space is *constant* at approximately 162,000 nautical miles per second, the distance traveled by the pulse of r-f energy is always *directly* proportional to the time interval between the transmission of a pulse and the reception of an echo signal from a target. The PPI unit receives, from the main radar equipment, two different electrical pulses of voltage. One is received at the instant that the transmitter *sends out* its radio frequency pulse of energy. The other is received the instant that an echo signal is *received* from a target. At the instant the radar antenna *A* radiates a pulse of ultra high radio frequency energy, a pulse of voltage is supplied to the PPI unit, which releases the spot at *A* on the face of the tube and starts it on its way outward to the rim of the tube. The spot travels at a constant speed, which is much slower than the speed of radio frequency pulse in space. The pulse of radio frequency energy travels to, strikes the target and returns from it, while the spot travels from *A* to A_1. At the instant the echo returns to the radar equipment, the second or video pulse of voltage is supplied to the PPI unit. This voltage is applied so as to *intensify* the spot at the instant the target echo returns. After this intensifying pulse, the dot returns to its original brilliancy and continues to the edge of the tube to complete its electrical sweep. While the dot is intensified, a bright spot (A_1) is formed on the cathode ray tube. Due to the *persistency* of the cathode ray tube screen, this bright dot remains on the screen for a short time so that it may be observed by the operator. The path of the dot also appears as a relatively bright line extending outward from the center of the tube.

(4) Since the speed of the radio frequency energy in space is constant, and the speed of the dot in its travel across the face of the tube is also *constant,* the position of the target indication (the point at which the dot is intensified) *will* ALWAYS *be proportional to the distance between the radar antenna and the target.* Therefore, the bright line may be calibrated so that the distance may be read directly from the face of the tube. Actually, the distance the dot travels is propor-

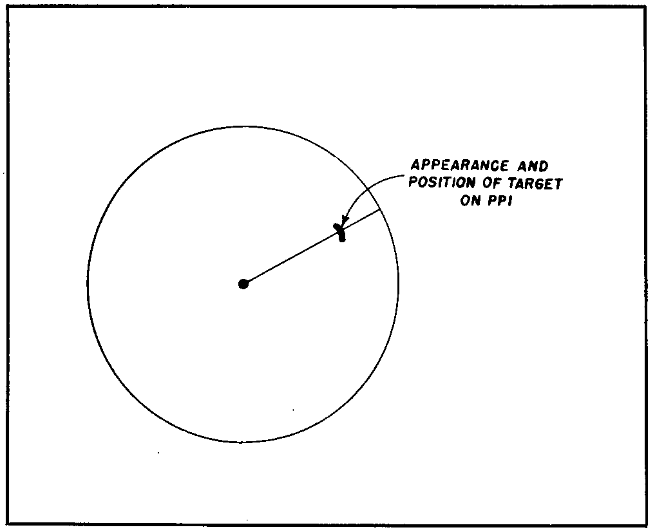


Figure 2-77. Effect of Beam Width on Appearance of PPI Target

tional to *twice* the distance between the target and the radar set; that is, the dot moves from A to A_1 in the time required for the radio frequency energy to travel to the target and back. However, to find the actual range of the target, it is only necessary to divide the distance (or time interval) by two. This is done by the range marker circles on the face of the tube, which will be explained later. The calibration is such that the actual range is easily approximated from the indication on the screen of the tube.

(5) The directional data derived from the PPI tube is obtained by the use of a highly directional rotating antenna on the radar equipment. The only echoes which can be received are echoes from targets which are within a narrow sector in the direction in which the antenna is pointed at a given instant. The antenna rotates continuously in azimuth while searching and the beam on the face of the tube travels outward in the same direction as the antenna is pointing. Thus, when the antenna is pointing at 45 degrees in azimuth, the direction of the trace on the face of the PPI tube is positioned so that the dot travels from the center of the tube to a point on the azimuth scale on the bezel which is indicated as 45 degrees in azimuth. When a target appears at, say a direction of 66 degrees in azimuth, it will only appear on the face of the tube while the antenna is pointed approximately the same direction. For example, the relative bearing of the target A_1 is 315 degrees with reference to the ship's heading. In other words, the target is 45 degrees off the port bow as shown by the dotted line A_2 in Fig. 2-76. It will not appear while the antenna is pointed in any other direction, not even in 180 degrees reversal. By rotating the direction of the trace on the tube in synchronism with the antenna, the directional effects required of the PPI type indicator are obtained. The electrical means by which this is accomplished are described later in this section.

(6) Fig. 2-77 shows the relation between the position of the radar antenna and the direction of the sweep trace at any given instant. The two lines radiating from the antenna represent the area of the antenna field pattern that contains sufficient r-f energy to cause an echo signal from a target. Thus, an echo will appear on the face of the tube during 10 degrees of rotation of the antenna. The signal will be strongest when the antenna is pointed *directly at* the target. The rotation of the antenna causes the shape of the PPI targets to appear very much like small cucumbers, with the true direction of the target indicated by the point of greatest intensity. When the antenna is not rotating, the signals received from targets within the relatively narrow area of the beam appear as dots along the trace line.

b. DESCRIPTION OF CIRCUIT FUNCTIONS.

(1) The PPI Unit contains the following circuits which are shown in the function diagram in Fig. 2-78.

(a) GATE CIRCUIT.—This circuit *gates* the PPI tube. That is, it determines the length of time that the trace on the face of the tube will be visible or unblanked during each cycle of operation. It *triggers* or starts the sweep trace at the same instant that the transmitter sends out a pulse of radio frequency energy. It also excites the Range Marker Circuit.

(b) SWEEP CIRCUITS AND DEFLECTION YOKE.—The sweep circuits develop the modified sawtooth wave necessary to cause the dot to travel from the center of the tube outward when triggered by the gate circuit. The deflection yoke receives the sawtooth output of the Sweep Circuits. The intensity of the magnetic field produced by the deflection yoke increases linearly. This causes the electron beam within the tube to be deflected radially outward from the center to the edge of the tube. The yoke rotates in synchronism with the radar antenna through a system of synchronous transmitters and receivers. Consequently the *direction* of the deflection on the face of the tube is moved electrically in azimuth to correspond to the position of the antenna.

(c) RANGE MARKER CIRCUITS.—These circuits, when triggered by the gate circuit, produce accurately timed pulses of voltage which are so applied to the PPI tube that they cause bright dots to appear spaced equidistantly along the sweep trace. Since these dots represent definite time intervals, they also represent a definite distance along the sweep line and are used to calibrate the sweep trace in miles. The distance between dots is equivalent to five miles. By comparing the targets with these marker signals, the range distance of the targets may be approximated. As the sweep trace rotates, these marker dots leave illuminated rings around the face of the tube. These rings are called *range marker circles* and they calibrate the face of the tube in miles.

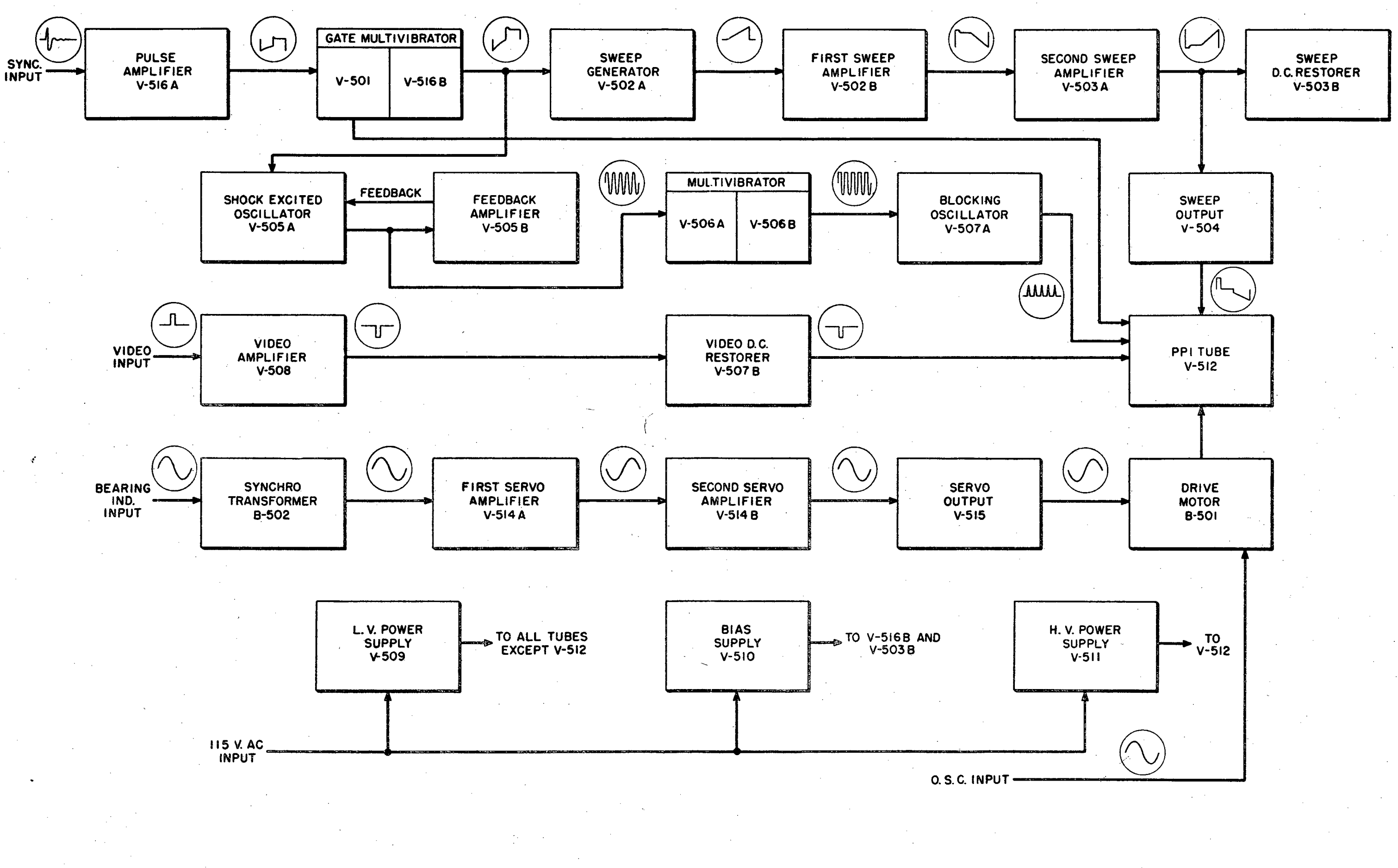


Figure 2-78. PPI Indicator, Block Diagram

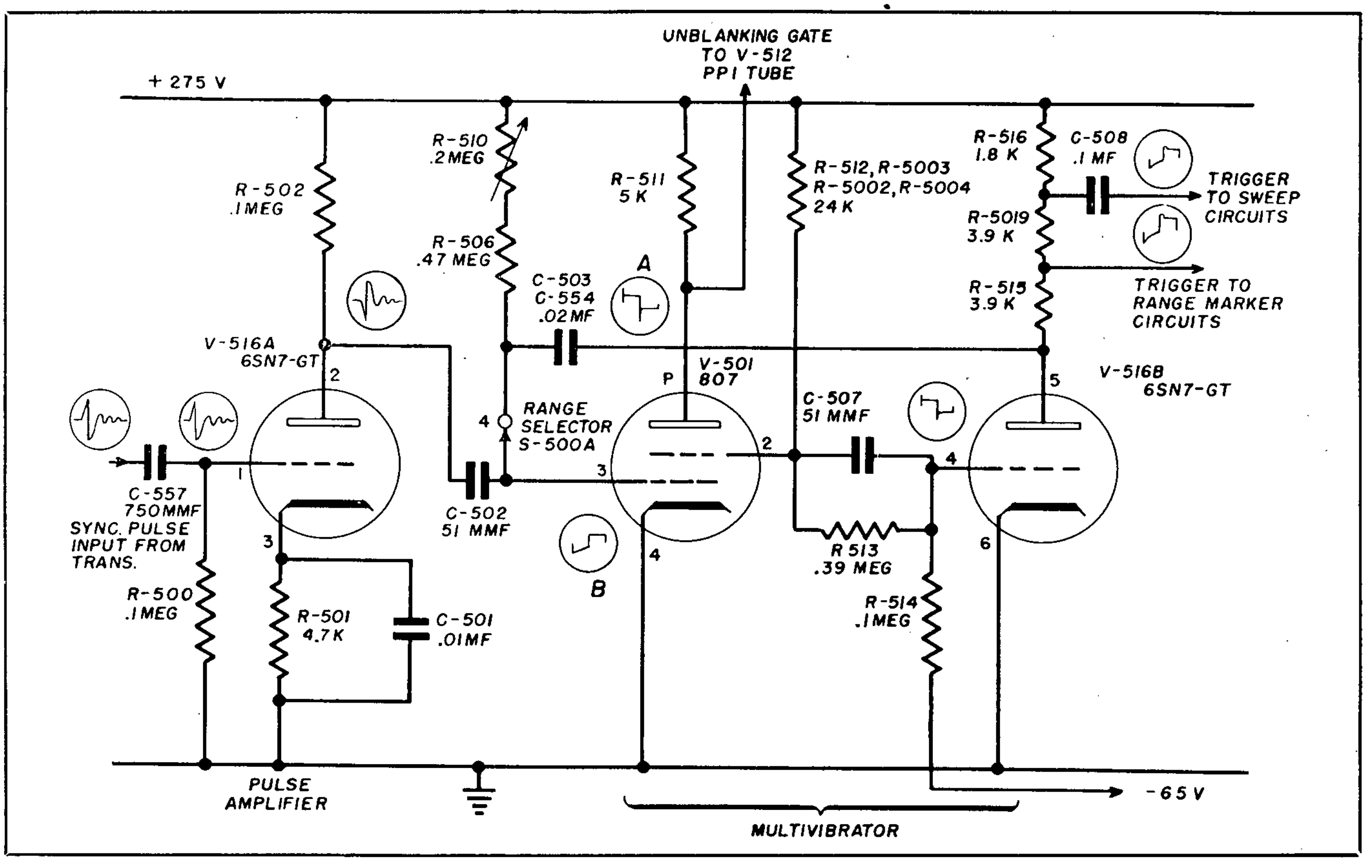


Figure 2-79. Gate Circuit in PPI Indicator

(*d*) VIDEO CIRCUITS.—These circuits receive the video signals from the main radar receiver of the equipment, amplify them and apply them to the PPI tube so that they appear as bright dots along the sweep trace. These bright dots indicate targets. The position of the targets on the face of the tube enables the operator to judge the *distance* and the *direction* of the target from the ship.

(*e*) SERVO SYSTEM.—The servo system mechanically positions the deflection yoke of the PPI tube in accordance with the position of the antenna of the ship's main radar equipment. When the antenna rotates, the deflection yoke also rotates, due to the electrical response from the synchro transmitters. The rotation of the deflection yoke causes the direction of the trace on the PPI tube to point in azimuth so that it always corresponds to the direction in which the antenna is pointing.

(*f*) LOW VOLTAGE POWER SUPPLY.—This circuit supplies the power for all of the tubes in the equipment, except the high voltage required by the PPI tube.

(*g*) HIGH VOLTAGE POWER SUPPLY.—This circuit supplies the high voltage (5,000 volts) required as the accelerating potential of the PPI tube.

c. GATE CIRCUIT.

(1) The gate circuit is comprised of one section of the Type 6SN7-GT double triode vacuum tube, V-516, and the Type 807 tube, V-501. See Fig. 2-79. V-516 is shown as two separate triodes, V-516A and V-516B in this figure. V-516A functions as a trigger amplifier, while V-501 and V-516B serve as the gating tubes of the circuit.

(2) The positive trigger, or synchronizing pulse, from the transmitter of the radar equipment, is applied to the grid of V-516A through the 750 mmf capacitor C-557. The output of V-516A is an amplified negative pulse with a shape roughly corresponding to the input pulse and this is coupled to the grid of V-501, through capacitor C-502. V-516A uses a large plate load resistor, R-502, to obtain a voltage gain of 12.

(3) V-501 and V-516B are connected to form a multivibrator circuit. It will be noted, however, that the grid of V-516B is coupled to the screen of V-501, instead of to the plate, as in the conventional multivibrator circuit. Consequently, the screen of V-501 serves as the plate of one triode in the multivibrator circuit. Since the plate of V-501 is electronically coupled to the screen, the waveform at the plate is an amplified reproduction of the waveform on the screen. This electron coupling also reduces capacity present in the plate circuit which would, if present, serve to distort the output wave. The grid of V-501 is returned to the positive d-c voltage supply so that V-501

is drawing current in the absence of a signal at its grid, while the grid of V-516B is connected to —65 volts negative, so that V-516B is cut off. Consequently, the voltage at the plate of V-501 is low, due to the drop through its plate resistor R-511, whereas the plate voltage at the plate of V-516B is high, due to the fact that no current is being drawn through its plate load, which is formed by resistors R-515, R-516 and R-5019.

(4) In the early models of the PPI units, the 80-mile sweep would shorten to about 65 miles when the repetition rate was increased above 800 cps. The later models incorporate an improvement that maintains the 80-mile sweep at full length at frequencies of 800 cps or higher. In order to accomplish this, the gate tube V-516B has been unloaded from the sweep tube V-502A, to lower points on the plate load of the gate tube. The plate circuit of V-516B is now formed of three resistors instead of two. These resistors are, respectively, R-515, R-516, and R-5019, with resistor R-515 connected directly to the plate and resistor R-516 to the +275 volt supply. These resistors are connected in series, and the input to the marker tube V-505A, is taken off between the junction of resistors R-515 and R-5019. The input for the sweep tube, V-502A, is taken off at the junction of resistor R-5019 and R-516. Sufficient voltage is still available to drive both tubes, but the loading reflected back upon V-516B has been reduced so that the flyback time of the gate circuit is increased. The circuit change just described tends to make the —65 volt bias adjustment more critical. In order to counteract this to some extent, resistor R-515 has been made 3900 ohms, to equal resistor R-5019.

(5) Due to the negative potential on the grid of V-516B, the circuit is locked and will not oscillate as a free-running multivibrator. It requires a negative voltage on the grid of V-501, such as is supplied by V-516A when it is triggered, to start the multivibrator. When such a voltage is applied, the multivibrator will produce one cycle of oscillation, and then return to a locked condition until triggered again. The operation of this circuit when a trigger is applied to the grid of V-516B is shown in Fig. 2-79. During the locked condition of the multivibrator, as shown in Fig. 2-79, the voltage at the plate of V-501 is low and the voltage at the plate of V-516B is high. At the instant the trigger voltage from the radar equipment of the ship appears at the grid of V-516A, a large negative voltage wave is generated in the plate circuit of this section of the tube and is applied to the grid of V-501. V-501 has been drawing heavy current, but with the appearance of a large negative pulse, it is cut off. The voltage at the plate of V-501 rises instantly as shown by waveform "A" in Fig. 2-79. Since the cut-off of the current through V-501 results in an instantaneous rise in the voltage at the plate, it also results in a rise in voltage at the screen of V-501. This voltage rise is coupled to the grid of V-516B, causing it to swing in a positive direction. The change of potential on the grid causes V-516B to start conducting. The voltage at the plate will drop immediately from its high potential to a new low potential, due to the drop through its plate resistors R-515, R-516, R-5019 in series.

(6) The drop in the plate voltage at the plate of V-516B is coupled back to the grid of V-501, by the timing capacitor in use (see Fig. 2-79), driving the grid of V-501 still further negative. This condition in the circuit is shown by waveform "B" in Fig. 2-79. At this point in time, V-501 is cut off and V-516B is conducting heavily. The grid of V-501 has been driven well below cut-off and will continue to stay below cut-off until the coupling capacitor selected by switch S-500A charges through its associated resistors to the point at which the tube again conducts. Fig. 2-79 shows C-503 and C-554 in use. The time that elapses before V-501 again draws current will depend upon the time constant of the capacitance and resistance in its grid circuit. Four possible combinations of resistance and capacitance may be selected and connected into the grid circuit by means of switch S-500A, the RANGE SWITCH on the front panel of the unit. Assume, as shown in Fig. 2-79, that the resistance in the grid circuit is resistors R-506 and R-510 and the capacitance is C-503 and C-554. The time constant of this combination will determine the length of time that will elapse before the grid of V-501 again is sufficiently positive for the tube to draw current.

(7) As soon as the grid of V-501 again permits the tube to draw current, the voltage at the plate of V-501 will fall rapidly due to the drop of voltage across resistor R-511. In the case of the circuit, as connected in Fig. 2-79, this time will be approximately 48 microseconds, or about four radar miles. Consequently, the circuit as shown in Fig. 2-79 is such as will develop at the plate of V-501, square pulse of voltage of approximately 250 volts amplitude and 48 microseconds, or about four radar miles as shown in waveform A on the figure. The width of this pulse, of course, depends upon the range for which the circuit is adjusted by operation of switch S-500A.

(8) Fig. 2-79 shows how a square wave pulse of voltage is formed in the plate circuit of V-501 following the appearance of the timing pulse from the ship's radar. This square wave is applied to the second grid of the PPI tube V-512, and raises the potential of this grid during the positive part of the waveform. The electron stream will then be strong enough to produce a visible indication on the face of the tube for the duration of the square wave or gating pulse. Following the drop at the trailing edge of the gating pulse, the voltage at the grid of the PPI tube will again drop so that the electron stream will not be sufficiently

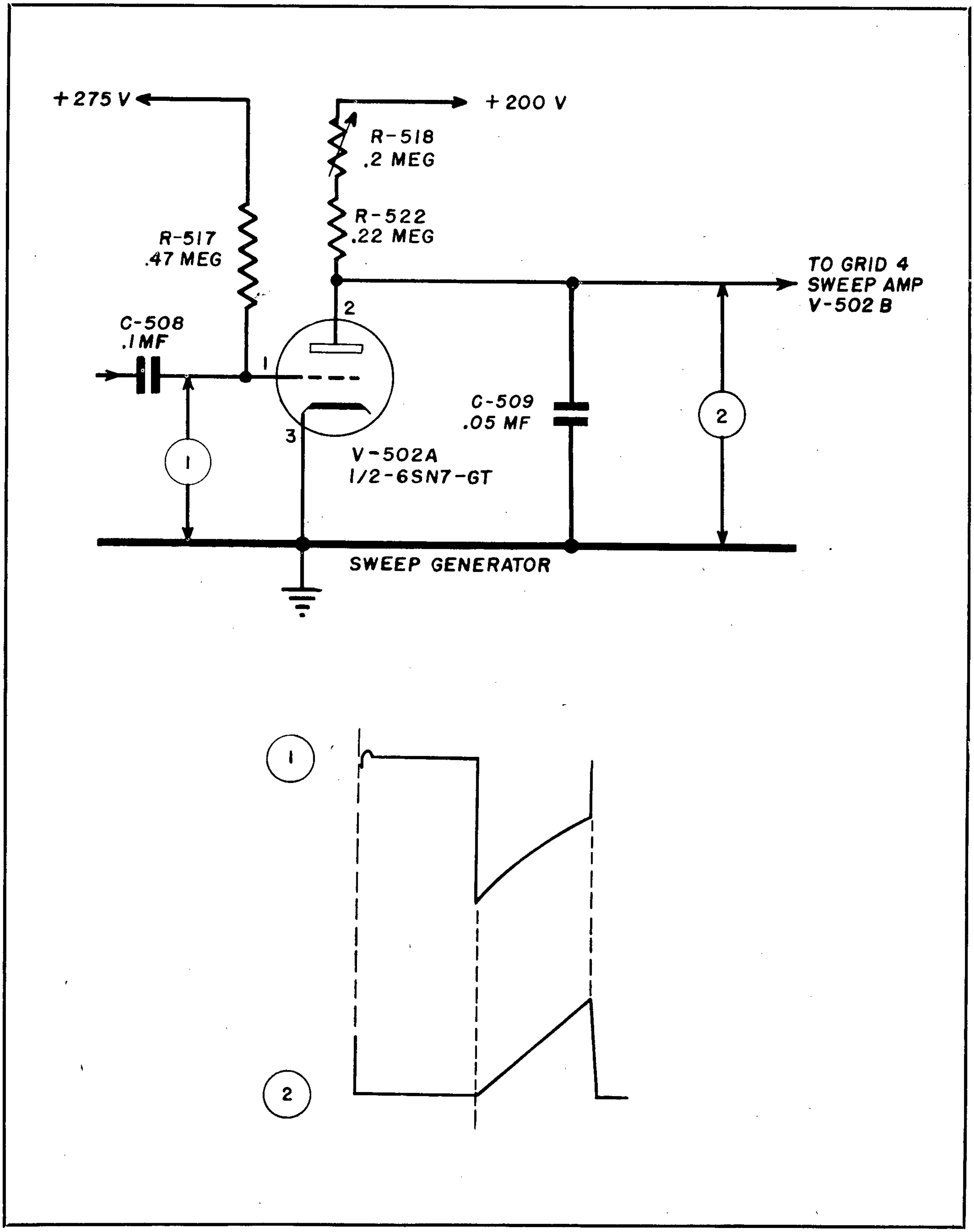


Figure 2-80. Sweep Generator in PPI Indicator

strong to produce a visible indication on the tube, and the tube will be blanked out. The pulse at the plate of V-501 starts at the same instant that the electron beam starts to leave the center of the tube. The time duration of the gating pulse is equal to the time required for the electron beam to move from the center of the PPI tube to its outer edge. Consequently, the tube will be illuminated during the time the trace is moving *outward* and blanked during the time that the trace is *returning* to the center of the tube preparatory to starting another sweep outward.

(9) The output from the plate of V-516B is similar to the square wave at the plate V-501, although it is of opposite polarity, and the positive portion slopes instead of being flat topped. Since only the negative leading edge and flat peak of the wave are used to control the sawtooth generator and the range marker circuits, the shape of the positive portion of the wave is of little or no importance since it occurs after the desired actions by the other circuits have been completed. This negative square wave is applied at two different places. One of these is the grid of V-502A in the sweep circuit and the other is V-505A in the range marker circuits.

(10) To summarize the action of the gating circuits, the trigger pulse from the radar equipment controls the production of the following outputs:

(a) A *positive* square pulse of voltage in the plate circuit of V-501. This pulse is used to unblank the PPI tube during the outward path of the trace.

(b) A *negative* pulse of voltage in the plate circuit of V-516A. This pulse triggers the switch tube, V-502A, of the sweep circuits in order to produce the sweep voltages required for the PPI tube.

(c) A *negative* pulse of voltage in the plate circuit of V-516B. The negative pulse of voltage excites the shock excited oscillator V-505A in the range marker circuit and causes it to produce the frequency from which the range markers that appear on the face of the PPI tube are obtained.

d. SWEEP GENERATOR.

(1) The sweep generator shown in Fig. 2-80, consists of one-half of the Type 6SN7-GT double triode tube V-502. V-502A and its associated components form a sawtooth sweep generator circuit. See Fig. 2-80. The grid of V-502A is returned to +275 volts through resistor R-517. The flow of grid current keeps capacitor C-508 charged to a potential of approximately zero volts with respect to ground during the no signal periods. Since the cathode of V-502A is grounded, the bias is zero volts. During no signal periods, the tube draws enough current through its plate load resistors to drop the plate voltage from 200 volts down to about three volts. When the negative square wave generated in the plate circuit of V-516B is applied to the grid of V-502A, the tube is cut off, and draws no current. When the tube is cut off by a negative signal at its grid, the voltage rises at the plate of the tube at a rate *determined* by the time constant of the plate resistors and the capacitor and resistor connected between the plate and ground. Four such resistor-capacitor combinations are shown on the schematic diagram. The proper one for operation of the set at the desired range is selected by means of switch section S-500D, one of the sections of the RANGE SELECTOR switch on the front panel. Notice that this switch section is ganged with section S-500A, which selects the width of the gate. In this manner, the gate width and the time constants in the plate circuit of the switch tube are switched simultaneously whenever the operator desires to switch the range of the indicator.

(2) One of the plate resistors in each timing circuit is made variable so that the exact time constant can be obtained by adjustment of the screw-driver-operated controls located inside of the unit. The time constant in the plate circuit of V-502A determines the distance the trace travels during the time the PPI tube is unblanked. These controls are normally adjusted to make the trace long enough to include four range marker pips. Fig. 2-80 shows the simplified schematic of this circuit. Only the components for the 80-mile range are shown. The pulse formation appearing on the grid of the tube is shown in waveform (1). Since the negative amplitude is sufficiently great to keep V-502A cut off during each gate cycle, the fact that the positive portion of this waveform has a sloping top makes no difference in the output. When the negative pulse strikes the grid of V-502A, it drives the grid far below cut-off. The grid remains below cut-off for the time determined by the width of the square wave on the grid, or until after one trace has been completed on the face of the PPI tube.

(3) At the instant the tube is cut off, the voltage across capacitors C-555 and C-510 starts to rise because it is necessary to charge the capacitors before the plate of the tube can rise to the maximum voltage of +275 volts. The rate of the rise will be determined by the size of the capacitors and the plate resistor. The voltage rise across the capacitor is shown by waveform (2) in Fig. 2-80.

e. SWEEP AMPLIFIER CIRCUITS.

(1) The output of V-502A is coupled directly to the grid of V-502B, the first feed-back amplifier tube. See Fig. 2-81. This tube, in conjunction with V-503A and V-504, acts as a feedback amplifier circuit with the feed-back coupling existing between the cathode of V-504 and the cathode of V-502B. About 60 db of degenerative feed-back is introduced in this way in order to produce the distorted waveforms on the grid of V-504 that is required to cause a sawtooth rise of current in the yoke coil. These circuits are shown in Fig. 2-81.

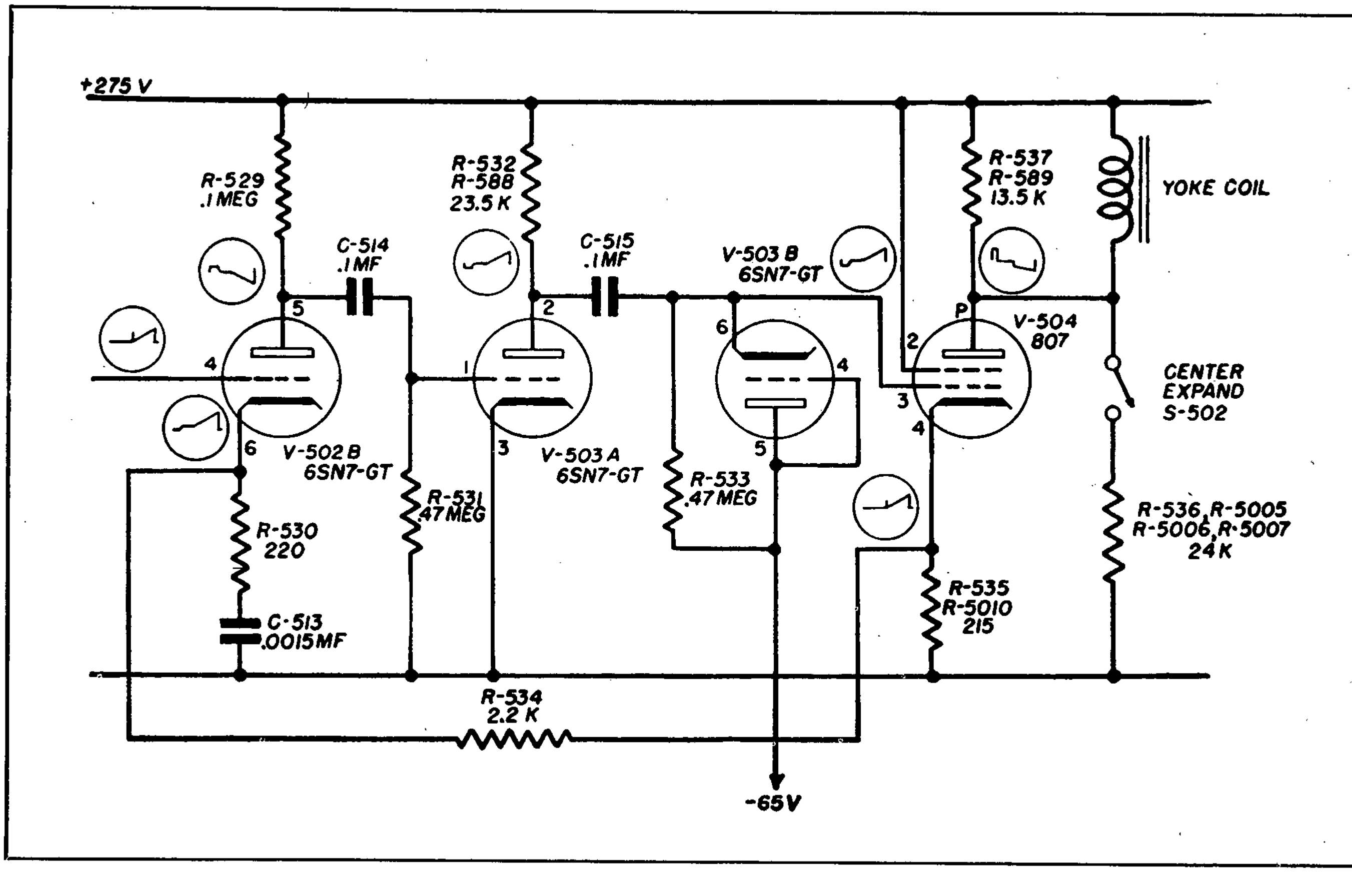


Figure 2-81. Sweep Amplifiers in PPI Indicator

(2) Inasmuch as the yoke coil, into which V-504 operates, has considerable capacity to ground, the current in the cathode of V-504 and, therefore, the feedback current will not be of the exact form desired. That is, it will not be regenerative at the higher frequencies. To correct this condition, a small high frequency compensating circuit, comprised of capacitor C-513 and resistors R-530 and R-534 is introduced into the cathode circuit of V-502B. This network by-passes some of the feedback current at the higher frequencies, and therefore permits an increase in the gain through V-502B at these frequencies. The use of regenerative feedback in this circuit provides a combination of a rectangular pulse and sawtooth wave on the grid of V-504. Note that the current from V-502B does not flow through resistor R-530, but flows through resistors R-535 and R-5010 in parallel which form a common cathode resistor for V-502B and V-504.

(3) The output of V-503A is a positive peaked wave which is applied to the grid of V-504 by capacitor C-515. The sweep d-c restorer tube V-503B is connected from the grid of V-504 to ground. The negative grid potential of —65 volts applied to the grid of V-504 maintains this tube at cut-off except when a positive pulse is being applied to its grid. The grid bias resistor, R-533, is 470,000 ohms and this high value is used to prevent distorting the pulse at the grid of the tube. The high grid resistance makes the use of the d-c restorer necessary. In the intervals between positive pulses, the grid of V-504 is considerably below cut-off due to the —65 volt potential and the low potentials applied to the plate and screen. The grid and plate of V-503B are connected together and the tube is operated as a diode. At the instant *before* the appearance of a positive going pulse at the grid of V-504, the cathode and plate of V-503B are at approximately the same potential, or about —65 volts. However, when the pulse appears, the cathode of V-503B is raised to a potential higher than the plate and grid. The tube will not pass current when the cathode is positive with respect to the plate, and therefore the tube is blocked against the *positive* pulse. However, following the positive pulse, the grid of V-504 must be restored to —65 volts and any tendency to oscillate must be quenched. The sweep d-c restorer does this instantly. When the grid is *more negative* on the swingback than the —65 volts of the bias potential, the cathode of the diode is *negative with respect to the plate.* Under this condition, current will flow through the tube and instantly restore the grid potential to —65 volts. In effect, the d-c restorer serves to short out grid resistor R-533 and prevent the grid from ever being *more negative* than —65 volts, the proper starting point for each cycle of operation.

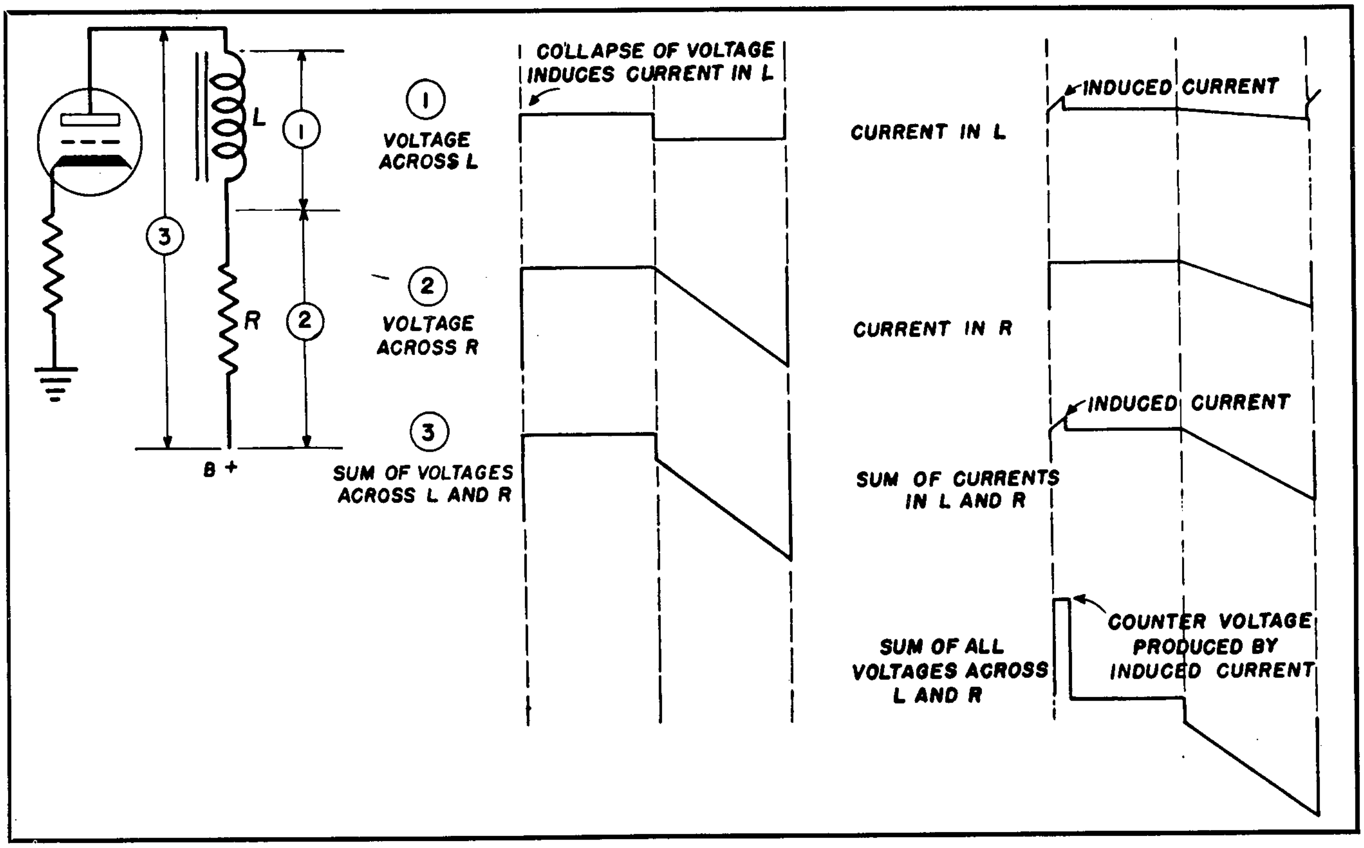


Figure 2-82. Development of Peaked Sawtooth Voltage

(4) The voltage reproduced in the plate circuit of the sweep yoke driver V-504 is a negative going combination of pulse and sawtooth wave which has essentially the same form as the positive going waveform developed in the plate of V-503A. The cathode resistors for V-504, R-535 in parallel with R-5010, serve an additional purpose which is not obvious from a study of the schematic diagrams. As explained in the previous paragraphs, V-504 is normally at cut-off when no pulse is present at its grid and draws full current (approx. 110 ma.) when the pulse appears. This rapid swing would normally tend to affect the regulation of the power supply and consequently the operation of the other tubes in the equipment. However, as explained in the description of the gate circuits, V-501, V-502A and V-503A also swing from a cut-off condition to a point where they draw current heavily. When V-504 is drawing current, these three tubes are cut off. When these three tubes begin to draw current, V-504 goes to cut-off. Consequently, by careful selection of the values of resistors R-535 and R-5010, it has been found possible to approximately balance these two current drains and provide a relatively even drain on the power supply despite the wide swings of the tubes.

(5) In order to start the cathode ray electron stream at the center of the tube, it is necessary to start the sweep with no current flowing through the deflection yoke coil. This condition is obtained when the Type 807 tube, V-504, is biased to cut-off. It is also necessary, following the start of the sweep, to secure a *linear increase* in current through the yoke coil, and consequently a magnetic field which increases linearly, in order to move the electron beam across the face of the PPI tube at a *constant rate of speed.* It would seem that all these requirements would be satisfied if a linear sawtooth wave of voltage was applied across the deflection yoke coil, but such is not the case. A square wave of voltage in the plate circuit of V-504 would produce a linear increase of current through the coil if it could be wound without having any resistance. However, no coil can be wound without some resistance. In the type of coil required in the deflection yoke, this resistance is appreciable. Therefore, it is necessary to consider the effect of the *resistance* of the coil when considering the shape of the input voltage to the driver tube V-504. The inductance and resistance are effectively in series as shown in Fig. 2-82. If the current in an inductance rises linearly, the voltage across the inductance will have a constant amplitude. Therefore, a perfectly rectangular pulse of voltage will produce a sawtooth shaped pulse of current in an inductance. The voltage across a resistance will produce a current in the resistance that has exactly the same shape the voltage has. It is obvious that if a rectangular pulse is applied across an inductance and resistance in series, the current that flows will be a combination of a rectangular pulse and a sawtooth.

(6) Assuming that the current flowing through the coil has the desired linear sawtooth form similar to current waveform 2 on Fig. 2-82, a similar current waveform would of necessity be flowing through the series resistance in the coil. Waveform 2 is also similar to the voltage drop which would be necessary at the plate of the tube to produce the desired current if the coil resistance alone is considered. Waveform 1 would be the voltage necessary to produce a linear sawtooth rise alone. However, since the *rate of change* of current flowing through an inductance determines the voltage across it, and the value of the *current* flowing through a resistor determines the voltage drop across it, it is obvious that two different waveforms would be developed, one across the inductance and one across the resistance. Referring to Fig. 2-82, the voltage drop across the inductance during the linear increase in current would take the form shown in waveform 1 while the voltage drop across the resistor would take the form shown in waveform 2. Since the total effect of the deflection coil in the plate circuit of the tube includes both the inductance and the resistance, the voltage drop across the two would produce an overall voltage drop which would combine *both* waveforms 2 and 3. The abrupt return of the deflection voltage from its most negative value to zero causes a sudden collapse of the magnetic field surrounding the coil. This produces a counter e.m.f. that causes a small sawtooth rise of current in a positive direction. This current produces a narrow pulse of voltage across the coil and a sawtooth shaped voltage across the resistance. The result would be waveform 4 on Fig. 2-82. Waveform 4 is, therefore, the voltage drop *across* the deflection coil when the desired linear sawtooth current form is flowing *through* the coil. Therefore, to produce the desired current through the coil, the voltage drop *across* the coil must be the same as shown in waveform 4. The linear current increase produces an effectively linear increase in the magnetic field developed by the coil. The direction of this field is such that the electron stream, and consequently the dot on the face of the tube caused by the electron stream, moves radially outward from the center of the edge of the tube. This produces the sweep trace on the face of the PPI tube. The targets are produced on the tube face by intensifying the electron stream at the proper points on its outward course. Resistors R-537 and R-589 are placed across the deflection coil to dampen the oscillations which would normally occur during the return trace, due to the inductance of the coil and its inherent capacity to ground.

(7) Switch S-502 and resistors R-536, R-5005, R-5006, and R-5007 form a circuit which, when the switch is closed, allows a small amount of current to be drawn through the PPI deflection yoke coil. The purpose of this is to move the start of the trace a slight distance outward from the center of the tube in order to spread out the signals which are located close to the ship and which might otherwise appear as an indistinguishable mass around the center dot. Switch S-502 is the CENTER EXPAND switch on the front panel. The employment of this feature is described under the instructions on Operation.

(8) The cathode ray tube, V-512, is a type 7BP7. It is shown with the high voltage power supply in Fig. 2-83. It has a long-persistent (persistency, 7) screen which causes the target indications to remain on the face of the tube for a short time after the sweep has passed. The electron stream is focused by the focus coil L-514, which creates a magnetic field within the stem of the tube. This tends to bunch the electrons into a thin stream so that they will cause a sharp dot on the face of the tube where they strike the fluorescent coating. Resistor R-576 is a 15,000 ohm, variable resistor operated by the FOCUS control on the front panel. This control permits adjustment of the current flowing through the focus coil so that the different focusing adjustments may be made. The focus coil itself has a high resistance, and consequently its resistance is affected to some extent by temperature changes in the air around it. Therefore, as the unit warms up, or the outside air temperature around it changes, it may be necessary to re-focus the cathode ray beam. The PPI gate voltage (unblanking voltage) is a square wave, applied to the second grid of the cathode ray tube. This method of gating requires a higher voltage than would be necessary if the unblanking voltage was applied to the first grid or cathode. It is necessary to apply the unblanking voltage to the second grid since the range marker pips are applied to the first grid and the video pulses are applied to the cathode. The large pulse, necessary to unblank V-512 is secured from the plate circuit of V-501. Note that the different signals which appear on the PPI tube are all applied to different elements of the tube, instead of being mixed and all applied at one element. This simplifies adjustments and also provides a simpler circuit by eliminating the customary mixing stages. High voltage (5,000 volts d-c) is supplied to the accelerating coating in the tube by the high voltage power supply.

f. HIGH VOLTAGE POWER SUPPLY.

(1) The high voltage supply is shown in Fig. 2-83. It consists of the power transformer, T-501, and the Type RKR-72 high voltage rectifier tube V-511. The output is filtered by a resistor-capacitor network, comprised of resistors R-5001, R-569, and capacitors C-543 and C-544. Resistors R-570 and R-571 form a bleeder to improve the regulation of the supply. The output of the supply is 5,000 volts and this is applied to the second anode of the cathode ray PPI tube, V-512.

(2) The inputs to both the high voltage rectifier and the low voltage rectifier are filtered by a line filter,

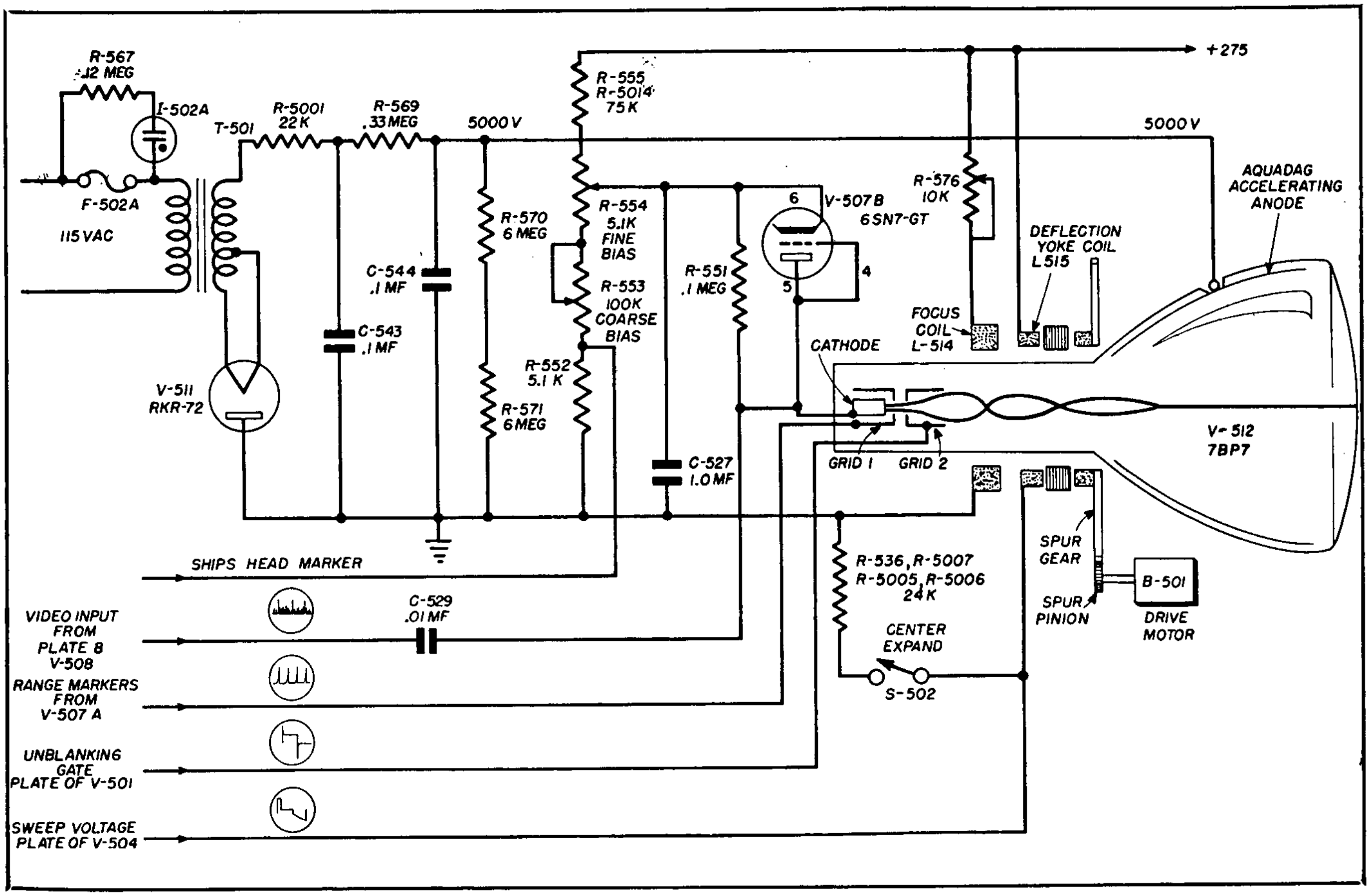


Figure 2-83. Cathode Ray Tube and High Voltage Power Supply

L-510, which contains two inductors and four capacitors. This filter is tuned so that high frequency voltage existing in the line will not pass into the unit; and also that high frequency voltages, developed within the equipment, will not pass to the line and upset the functioning of other equipment drawing power from the same line.

(3) Two fuses are included to protect the power circuits in case of part failure within the equipment. F-500A is a line fuse located between switch S-501A and the line filter L-510. F-500A opens when an overload occurs in either the high or low voltage power supply. A current limiting resistor in series with a neon indicator bulb shunts fuse F-500A. When the fuse is not blown, this neon bulb does not glow. However, when the fuse opens, a small amount of current, limited by the limiting resistor, will pass through the neon bulb. This will light the neon bulb and thus indicate which fuse has blown. A similar fuse, F-501A, and neon indicator system is placed in the input from the O.S.C. line of the ship in case of a short circuit in the servo drive motor, B-501, or its leads. Switch S-501B, together with S-501A is part of the OFF-ON switch on the front panel. Switch S-501B controls the input voltage to the servo drive motor. Fuse F-502A protects T-501.

(4) Switch S-503 is a disc type thermostatic switch, which operates when the temperature inside the unit drops below 1° to 9° C. This switch connects a heater resistor, R-5018 across the a-c supply line. These strip heaters are located near the rotating yoke mechanism. Inasmuch as this circuit draws considerable current, this switch is not fused but is connected directly to the line through the circuit breaker which is located in the top of the case. The circuit breaker receives its power from any convenient 115 volt a-c outlets (not necessarily the same one supplying the other circuits of the equipment). The heaters will operate whether the rest of the set is on or off. An auxiliary outlet for connecting a soldering iron is provided in the top of the case. This outlet is also wired directly to the circuit breaker. Blower motor B-503 is provided to maintain air circulation within the unit. It is a split phase, capacitor-start-run motor which operates at a normal speed of 3300 r.p.m. The 5.0 mf capacitor C-553 is the phase-splitting capacitor for the motor.

g. RANGE MARKER CIRCUITS.

(1) The range marker circuits are shown in Fig. 2-84. They are triggered by a negative square wave from the gate circuit. They produce positive range marker pulses, and apply them to the first grid of the

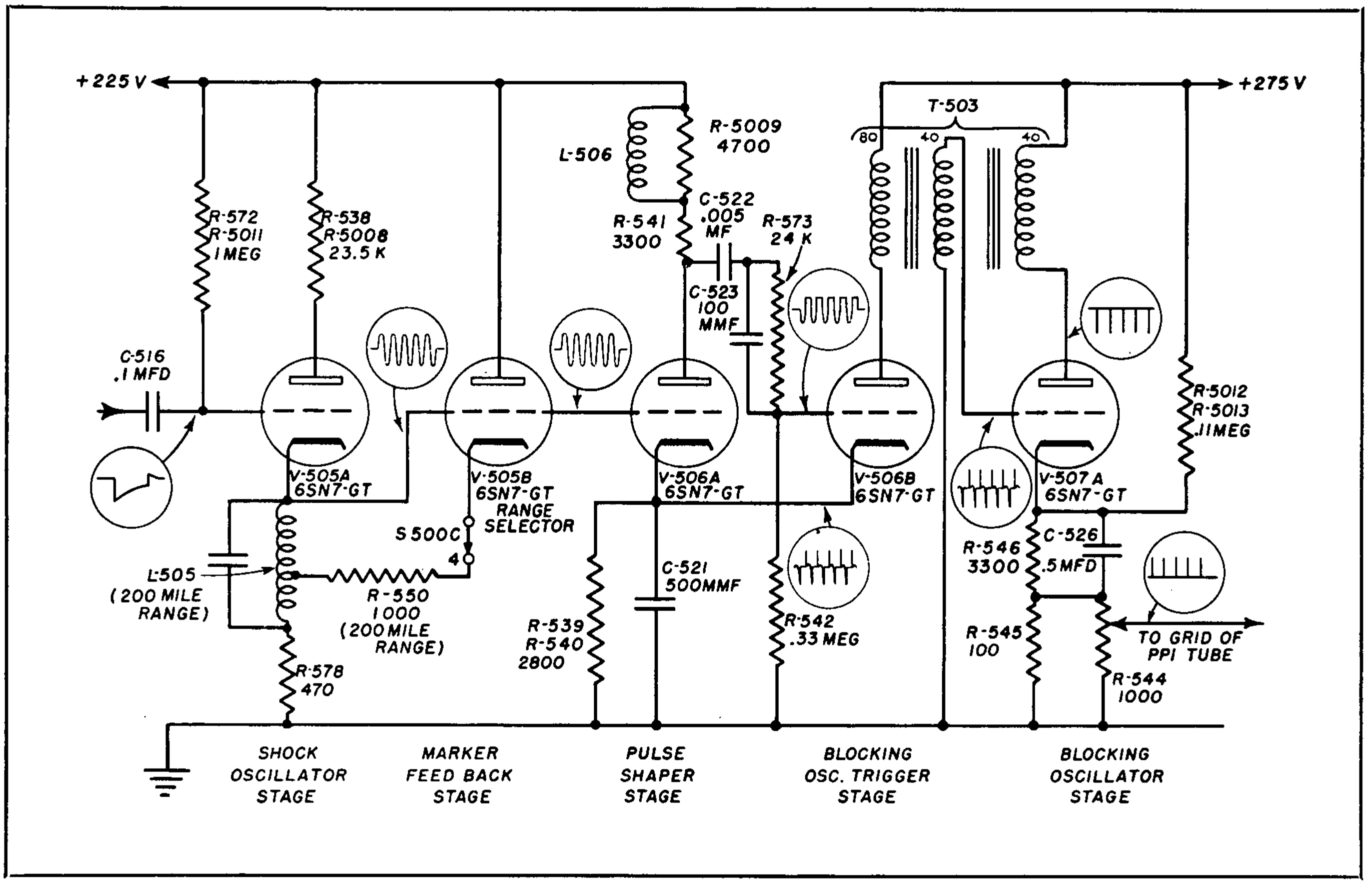


Figure 2-84. Range Marker Circuits in PPI Indicator

PPI tube V-512. The circuits are comprised of the Type 6SN7-GT double triode tubes V-505, V-506 and one of the triode sections of V-507. V-505A is the shock oscillator, V-505B is the feedback amplifier, V-506A is the pulse shaper, V-506B is the blocking oscillator trigger and V-507A is the blocking oscillator. The other half of V-507 is used in the video circuits and its function will be explained separately under the discussion of these circuits. The trigger voltage for the range marker circuits is taken from the junction of resistor R-515 and R-5019, which are in the plate circuit of V-516B. This pulse is applied to the grid of the shock oscillator, V-505A, by C-516. See Fig. 2-84. Since the grid of V-505A is returned to the positive 225-volt supply through grid resistors R-572 and R-5011 in parallel, the tube normally draws full current in the absence of the negative trigger pulse. This current flows through inductors L-502, L-503, L-504, or L-505, whichever is switched into the circuit by switch S-500B. These are the range marker oscillator inductors, and one inductor is provided for each of the four ranges on which the equipment operates. Resistor R-543 serves as a cathode resistor in the 4 and 20 mile ranges and resistor R-578 is the cathode resistor for the 80 and 200 mile ranges. The two different resistors are required to keep the output of the circuit at approximately the same amplitude for all four ranges.

(2) At the instant before the trigger voltage appears, the tube is drawing full current. When the negative trigger pulse appears, the tube is instantly cut off due to the straight leading edge of the pulse. The grid is held below cut-off for the duration of the negative pulse. During the time that V-505A draws current, the capacitor across the inductor in the cathode circuit becomes charged. The cathode side of the capacitor is charged positive with respect to ground. When the negative trigger pulse cuts off V-505A, the stoppage of current causes the magnetic field surrounding the inductor to collapse, inducing a voltage that further increases the positive charge on the capacitor. When the inductor has delivered up its reactive energy to the capacitor, the capacitor discharges back through the inductor. This process continues at the natural frequency of the LC combination for about six cycles. Normally, this oscillation would rapidly decay in amplitude. However, V-505B, the feedback tube, has its cathode connected to a tap on the inductor in use by selector switch section S-500C. This provides the proper amount of regeneration to prevent the decay, and consequently, the five or six cycles are all of approximately the same amplitude. In this feedback circuit, resistors R-547, R-548, R-549, and R-550 have been selected to introduce the proper amount of regeneration to keep the amplitudes of the marker pulses approximately the same for all four ranges.

(3) V-505B is the feedback amplifier. See Fig. 2-84. Its grid is coupled directly to the cathode of V-505A, and its cathode is returned to ground through the feedback circuit described in the preceding paragraph. The range marker oscillations are also coupled directly from the cathode of V-505A to the grid of V-506A, the pulse shaper. V-506A amplifies these oscillations, which are applied to the grid of V-506B. However, the cathodes of V-506A and V-506B are directly coupled together across a common cathode resistance (R-539 and R-540 in parallel) and the two tubes tend to act together as a multivibrator. V-506A normally draws current and the start of the oscillation tends to drive it through cut-off on each cycle. This drive is amplified, and an overshoot is created by the inclusion of the inductor L-506 in the plate circuit of V-506A. The circuit creates a narrow flat topped wave with a peak on the leading edge which coincides with the start of each oscillation. These marker pulses appear in the plate circuit of V-506B across the trigger winding of the blocking oscillator transformer T-503.

(4) The blocking oscillator, V-507A, is cut off by its high positive cathode bias voltage when no signal is present. Bias is obtained by connecting the cathode of V-507A to tap on a voltage divider between the +275 volt bus and ground. The combined bleeder current and the cathode current of V-507A charge capacitor C-526 to a potential that keeps V-507A at cut-off. This bias is such that the overshoot on the square wave V-506B is required to start the oscillator. Consequently the blocking oscillator is not triggered by the square block but by the narrow overshoot which appears on it. The application of a pulse to the grid of the blocking oscillator (which is cut off at the time the pulse appears) drives the grid instantaneously positive. This creates a negative pulse in the plate circuit and a positive pulse in the cathode circuit. The negative pulse created in the plate circuit of the tube is inverted by transformer T-503 which coupled the output at the plate back to the grid. The positive feedback voltage from transformer T-503 drives the grid still further positive the instant it appears. When plate current saturation is reached and the plate current assumes a steady d-c state, the feedback voltage disappears. The grid then returns rapidly to a negative condition; the tube is cut off and remains in this condition until another pulse appears in the plate circuit of V-506B. Since the grid is coupled to ground only by the grid resistor, this action is very rapid and the pulse of voltage in the cathode circuit of V-507A will be a very narrow spike of voltage. The width of the marker pulses thus developed is approximately three-fourths of a microsecond measured at 70% of the height. Since positive pulses are required to brighten the cathode ray tube V-512, the output from V-507A is taken from the cathode circuit of the tube across resistor R-544, which is the MARKERS control on the panel of the unit. This control provides for adjusting the marker intensity to the proper level for viewing on the face of the tube. The markers are applied to the first grid of the cathode ray PPI tube V-512 so that they brighten the sweep at the instant the marker pulses appear, and thus serve to provide range calibration indications on the face of the PPI tube.

h. VIDEO CIRCUITS.

(1) The video circuits receive the target pulses from the interconnected radar installation, amplify them, and apply them to PPI cathode ray tube as negative pulses of voltage which appear as target indications on the face of the PPI tube. The video circuits shown in Fig. 2-85 of the Type 6AG7 amplifier tube V-508 and one-half of the dual triode tube 6SN7-GT V-507. The other half of this dual triode tube is the blocking oscillator V-507A which was described in the section on the range marker circuits. V-507B is the video d-c restorer and V-508 is the video amplifier tube. The video input signal is a positive pulse of voltage from the interconnected radar installation. It is coupled to the unit across resistor R-559. The input across resistor R-559 is applied between the VIDEO INPUT connection and ground, which is the chassis of the unit. Since a number of remote PPI indicators may be connected across the video line from the Indicator Console, a small switch marked BRIDGE—TERMINATE is included in the top of the case of the unit. This switch cuts in or out a 68 ohm resistor which may be placed across the video input of the unit. If *more than one* indicator is used on one source, this switch may be thrown to the BRIDGE position. This leaves the 68 ohm resistors out of the circuit. Two resistors are connected to this switch. One is to *terminate* the video input circuit, and the other to *terminate* the synchronizing pulse circuit. Thirteen Indicator units may be connected to the Indicator Console. The BRIDGE-TERMINATE switch may be thrown to BRIDGE, if the unit is one of many on the line, or it may be thrown to TERMINATE, if it is the only one on the line or the end unit on the line.

(2) The video input is fed directly across potentiometer R-559, a 2,000 ohm carbon resistor, adjustable from the front panel of the unit by moving the VIDEO GAIN control. This gain control is essentially loaded across the 68 ohms BRIDGE-TERMINATE resistor in the top of the unit. Capacitor C-531 is a small, 40 mmf capacitor which is the video high frequency compensating capacitor. When the slider of the VIDEO GAIN control is turned away from its maximum position, capacitor C-531 shunts the higher frequencies, present in the video pulse, around the potentiometer so that they are not attenuated. This capacitor passes more high frequency voltage when the

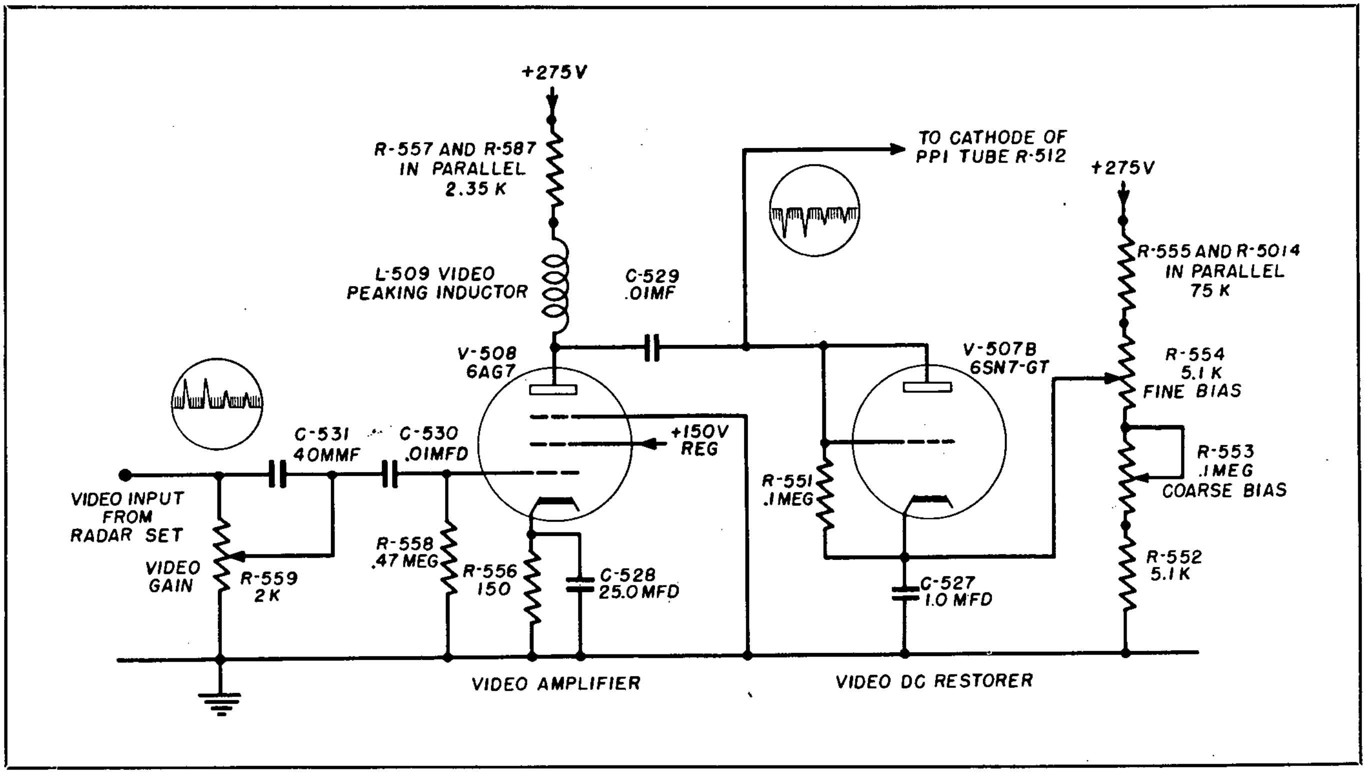


Figure 2-85. Video Circuits in PPI Indicator

gain control is in some position other than maximum. In normal practice it is set so that, when the gain control is half-way down, this capacitor serves to compensate very accurately. The video input signal is coupled to the grid of V-508 by the .01 mf capacitor, C-530. The cathode resistor, R-556, is by-passed by the 25.0 mf electrolytic capacitor C-528. Inductor L-509, in the plate circuit of V-508, is a peaking inductor used to compensate for the loss of high frequencies due to the output capacity of V-508 and the input capacity of the cathode ray tube. These appear in parallel across the plate circuit of the tube. The value of the inductor is chosen to resonate with the output capacity of the tube at a frequency which closely approximates the frequency at which the response of the circuit begins to drop off. This provides a peaking of the frequencies which would normally be attenuated and results in an overall improvement in the response of the circuit. By careful choice of the inductance of the peaking choke and by maintaining the capacity in the plate circuit at a low value, the response of the circuit is maintained at a point where it is only 3 db down at a frequency of 2.5 megacycles.

(3) The plate of V-508 is coupled by coupling capacitor C-529 directly to the cathode of V-512, the PPI cathode ray tube. Since the input pulse to V-508 is positive, its output is negative, and consequently tends to brighten up the indication on the cathode ray tube when video signals are present. Note that *positive* pulses applied to the grid of the tube serve to brighten the PPI tube indications, whereas *negative* pulses applied to the cathode serve the same purpose. Actually, it is the *difference in voltage* between the cathode and the grid which serves to accelerate the electrons of the electron stream and to brighten the indications. Either the grid may be *raised* in voltage with reference to the cathode, or the cathode voltage may be *lowered* with reference to the grid in order to intensify the electron stream and consequently brighten the images on the screen. This characteristic of the cathode ray tube makes it possible for three different signals (range markers, unblanking gate and video signals) to be connected to different elements of the tube to secure the same result. The cathode level is maintained at approximately the right brightness by means of the two intensity controls, R-553 and R-554. Potentiometer R-553 is a screw-driver-operated control located on the side of the chassis, which is not available from the front panel. The unit must be slid forward in its case to adjust this control. Potentiometer R-554 is the FINE INTENSITY control and is located on the front panel of the unit. When first setting up the equipment, the coarse bias control is adjusted to the approximate range desired for operation. Then the chassis is pushed into place, and during operation fine adjustments are made with the FINE INTENSITY control located on the front panel. Instructions for adjusting this control are contained in Section 4.

(4) V-507B is the video d-c restorer which serves to return the cathode of the PPI tube, V-512, to the proper bias following the appearance of a video signal on its cathode. The grid and plate of the tube are

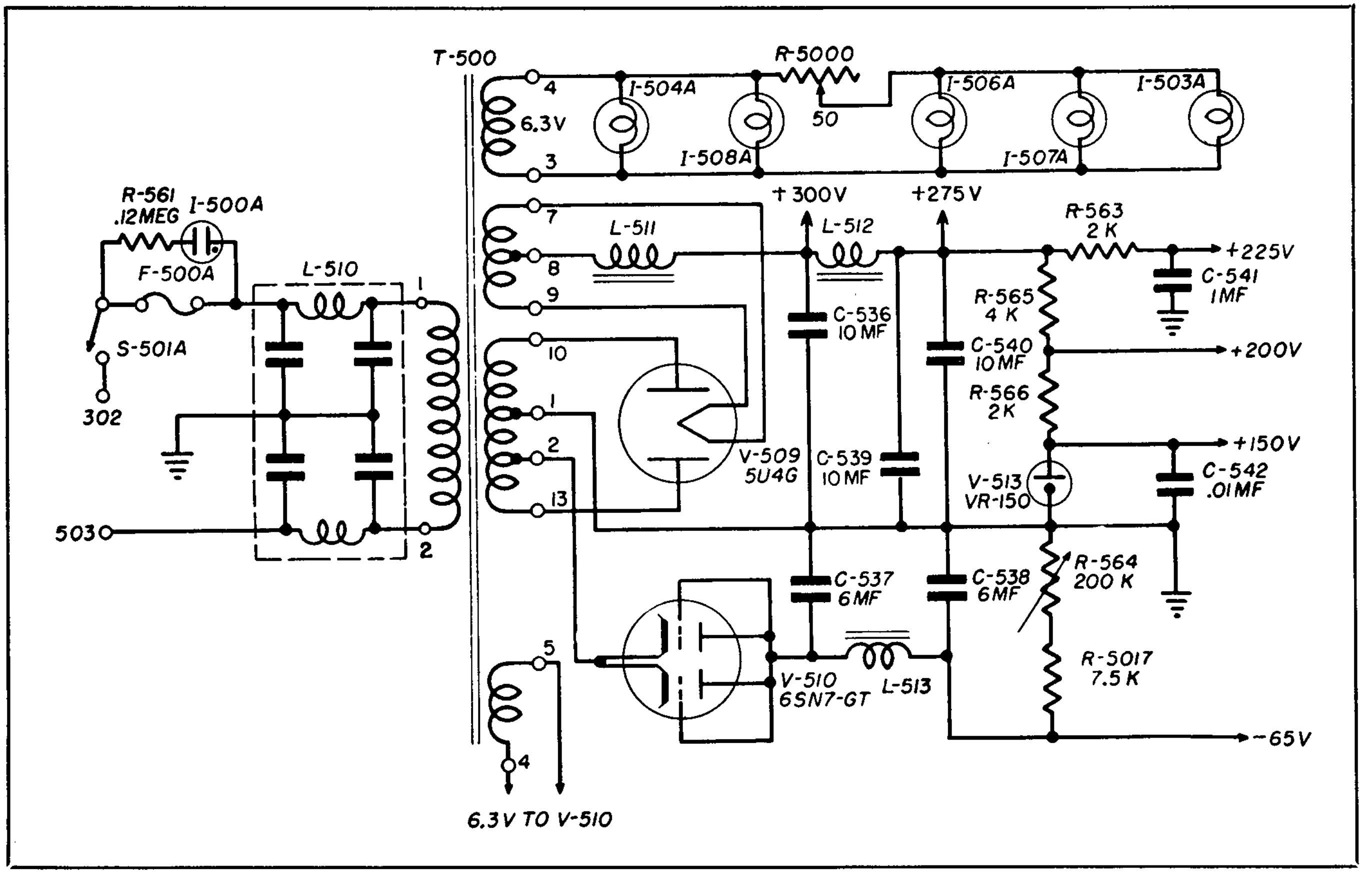


Figure 2-86. Low Voltage Power Supply in PPI Indicator

connected together and the tube operates essentially as a diode. The plate and cathode are both placed at the same potential by FINE INTENSITY control R-554. The adjustment of Potentiometer R-554 will serve to place the plate and cathode of V-507, as well as the cathode of the cathode ray PPI tube, V-512, at the positive potential selected by potentiometer R-554 along the voltage divider formed by resistors R-552, R-553, R-554 together with R-555 and R-5014, the latter two resistors being in parallel. At the instant before a video signal appears, the cathode of V-512 is at the resting potential determined by the adjustment of potentiometer R-554. The plate and cathode of V-507B are also at the same potential. The video signals appear, and being negative, drive the cathode of the PPI tube negative. The plate of the video d-c restorer is also driven negative inasmuch as it is directly coupled to the cathode of the PPI tube V-512. In this condition, the plate of V-507B is negative with respect to its cathode due to the voltage developed across the 100,000 ohm resistor R-551 by the video signals. In this condition, the diode *will not* conduct current, and consequently the negative pulse will not pass through the diode, but will be applied fully to the cathode of the PPI tube. However, following the passage of the video signal, there is a tendency for the cathode of the PPI tube to fly too far positive, due to the inductances existing in the tube and the connections to it. When this occurs, the plate of the diode will then be *positive* with respect to the cathode, and the tube will conduct. The positive charge will thus be removed instantly from the cathode of the PPI tube. This prevents the cathode from ever attaining a positive potential with respect to the pre-determined bias secured by adjustment of the FINE INTENSITY control R-554. Resistor R-551 is also included in the circuit to prevent dissipation of the negative pulse through the bias circuits. When a negative pulse is present, the video d-c restorer is ineffective, on the fly-back, when the cathode tends to go positive with respect to the pre-determined bias adjustment, the triode instantly shorts out the resistor and permits dissipation of the positive charge. This tends to eliminate any oscillation in the circuit.

i. LOW VOLTAGE POWER SUPPLY.

(1) The low voltage power supply circuit is shown in simplified form in Fig. 2-86. It is comprised of transformer T-500, which supplies high voltage to the +275 volt d-c rectifier circuit, to the —65 volt bias rectifier circuits, and filament voltages for all the operating tubes of the unit except the high voltage rectifier tube. The Type 5U4G full-wave rectifier tube, V-509, is the low voltage +275 volt d-c rectifier and its output is filtered by an inductance-input net-

work, consisting of inductors L-511 and L-512 and capacitors C-536, C-539 and C-540. Two voltage regulator tubes are provided in this supply. The Type VR-150 tube, V-513, has two regulated outputs, one at 150 volts and the other at 200 volts d-c. The VR-150 tube, V-517, supplies 150 volts of regulated d-c for use by the servo circuits of the units. An unregulated output of +225 volts, which is supplied to the marker generating and amplifier circuits, is produced by the drop through the 2,000-ohm dropping resistor, R-575.

(2) The —65 volt d-c bias supply is comprised of the Type 6SN7-GT bias rectifier tube, V-510, and the output is filtered by the capacitor input filter, comprised of inductor L-513 and capacitors C-537 and C-538. Potentiometer R-564 is a variable 200,000 ohm resistor used to load the bias supply and thus to vary its voltage output. Accurate adjustment of this bias voltage is necessary because the bias on the gate circuit is quite critical. Adjustment of this resistor provides a control of the bias voltage over the necessary range.

(3) The outputs of the low voltage supply are:

(a) +275 volts and —65 volts to the gate circuit.

(b) +200 volts, regulated, to the sweep generating circuits.

(c) +275 volts, unregulated, to the plate of the sweep tubes.

(d) +275 volts to the focus coil of the PPI tube.

(e) +225 volts to the range marker circuits.

(f) +275 volts and +150 volts, regulated, to the video circuits.

(g) +275 volts and +150 volts, regulated to the servo amplifier.

(h) Also provided by transformer T-500 are 6.3 volts a-c for filament supply for all the operating tubes, the bias rectifier, and the PPI tube. A special center-tapped winding supplies the filament voltage for the low voltage rectifier V-509 while another winding supplies power for the pilot lights around the bezel of the unit and on the panel.

(4) The voltage regulator tube V-513, which provides one of the regulated outputs of the low voltage power supply, serves a very useful function. It has been proved that the sensitivity of a cathode ray tube is inversely proportional to the square root of the second anode voltage. In other words, the value of the voltage applied to the second anode determines the *resistance* of the electron beam to the effort of the magnetic field to move it across the screen. The *stiffness* of the electron stream thus *increases* as the square root of the high voltage. This high voltage is obtained from the high voltage transformer, which is connected directly to the supply line. The normal value of this voltage is about 5,000 volts. However, if the line voltage is increased by 10%, the high voltage applied to the second anode would be increased by 10%, or would rise 500 volts. Consequently, the deflection sensitivity would be decreased by 4%. Similarly, if the line voltage were to fall 10%, the sensitivity would be increased by 5%. Referring to Fig. 2-86, it is seen that the voltage regulator tube V-513 is connected across the +275-volt output of the low voltage power supply. The voltage output of this supply will increase or decrease with the line voltage changes. The voltage regulator tube V-513, will maintain a drop of 148 to 152 volts across it. To do this, it will draw *more or less current* through resistors R-565 and R-566. Assume the line voltage, and consequently the output of the low voltage power supply, has increased 10%. At some point along the divider, the voltage will have increased by 4%. This point on the divider may be calculated, or it may be determined by experiment. In the case of this unit, this voltage is 192 volts, measured when the set is operating on a normal line voltage of 115 volts a-c. This 192 volt point which increases by 4% or decreases by 5% as the line voltage varies, is supplied to V-502A as its plate supply.

(5) Assume that the line voltage supply has increased by 10%. The second anode voltage of the cathode ray tube has *increased* by 10% and the deflection sensitivity of the cathode ray tube has *decreased* by approximately 4%. But due to the connection of the switch tube V-502-A to the 192 volt tap on the voltage divider supplying V-513, the input voltage to the plate of V-502A has also increased by 4%. Therefore, the output voltage of V-502A will be increased by 4% and the current through the cathode ray tube deflection yoke will be increased by 4%. This increase in current through the cathode ray tube deflection yoke balances the decrease in sensitivity in the tube due to the higher second anode potential, and the overall deflection sensitivity of the tube remains unchanged over a wide range of line voltage fluctuations.

j. SERVO SYSTEM.

(1) A block diagram of the servo system in the PPI Indicator is shown in Fig. 2-87. The function of this system is to position the sweep on the PPI tube so that its position corresponds to the direction in which the radar antenna is pointing. The radar antenna is geared to a 6DG differential synchro generator located in the Antenna Pedestal. The three-wire output from this generator is connected to the three winding stator of a 5CT synchro control transformer in the PPI Indicator. For an explanation of the theory of operation of synchro units, refer to Par. 18 of this section which describes the general theory of the antenna positioning system of which the PPI servo system is a part. When the position of the antenna differs from the position of the PPI sweep, an error voltage appears across the output terminals of the 5CT rotor. This voltage is applied through the filter and anti-hunt circuits to the first servo amplifier.

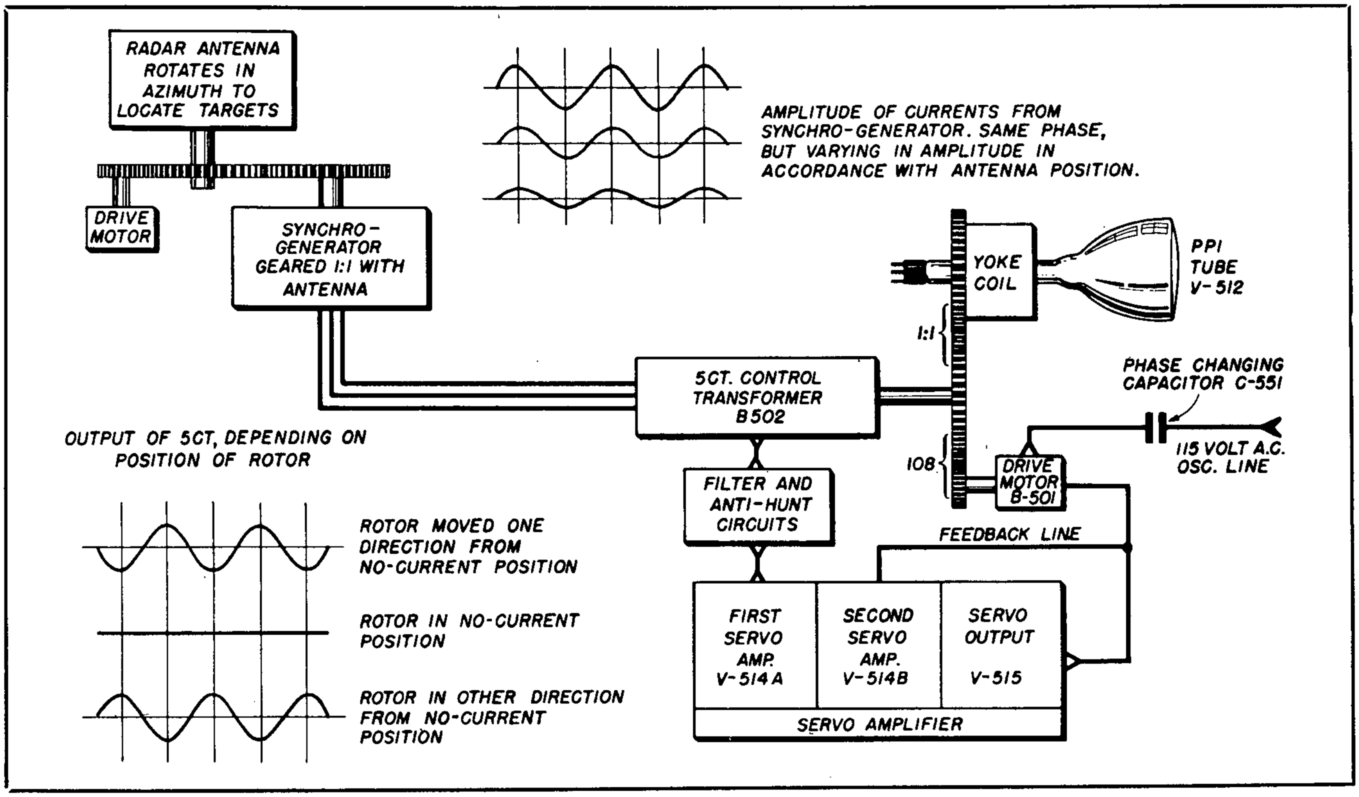


Figure 2-87. PPI Servo System, Block Diagram

(2) The 60-cycle output from the 5CT is applied to the grid of V-514A, the first servo amplifier. It is further amplified by V-514B and the servo output tube V-515, and applied to one field of the low inertia motor B-501. B-501 is a two-phase motor with two windings which are geometrically 90 degrees apart. The other phase of this motor is fed by the ship's 115-volt O.S.C. line through phase shifting capacitor C-551, so that the second winding receives a voltage that is out of phase with either of the two possible voltages which might be provided by the 5CT control transformer. If the phase from the 5CT leads or lags the phase in the O.S.C. line, the motor will run either in one direction or another. When the shaft of the 5CT is displaced in one direction with reference to the position of the antenna, a voltage is applied to the field of the motor which will cause it to run in the direction required to reduce the error. When the antenna reverses, the difference in position between the antenna and the rotor of the 5CT is in the other direction, and voltage is supplied to the drive motor which will cause it to turn in the opposite direction. When the relative positions of the rotor of the 5CT and the antenna coincide, no current is supplied to the motor and it will stop. In this manner, the system can be made to position the shaft of the 5CT in the same position as the antenna. Since the deflection yoke coil is driven by the 5CT also, the deflection yoke coil has also been made to take on a position corresponding to that of the antenna.

(3) It is obvious that for the system to operate, it is necessary for a difference in position to exist. Consequently, when the antenna is rotating continuously, it is necessary for a slight difference in position to exist in order for the amplifier to receive a driving voltage and deliver an output to the drive motor. The amount of lag required is determined by the attenuation factor of the anti-hunt network and the gain of the servo amplifier. This angle is small, being approximately one-half of one degree for all antenna speeds. Since this angle is small with respect to the beam width of the antenna, it has no effect upon bearing accuracy.

(4) A simplified schematic diagram of the PPI servo system is shown in Fig. 2-88. When an error exists in the system, the rotor of the 5CT synchro control transformer is displaced from the no-current or minimum coupling position of the magnetic field and an output voltage appears across the input circuits of the servo amplifier. Capacitor C-552 is placed across the coils of the 5CT to correct its power factor. The voltage across the rotor of the 5CT appears across resistor R-579 and capacitor C-534. These components are connected in series to ground and act as a voltage divider so that the voltage actually applied to the anti-hunt network is the voltage that appears across capacitor C-534. The anti-hunt network is a derivative network. More specifically, it is a bridged-T null network. An examination of its circuit in Fig. 2-88 shows that it does not respond equally well to all

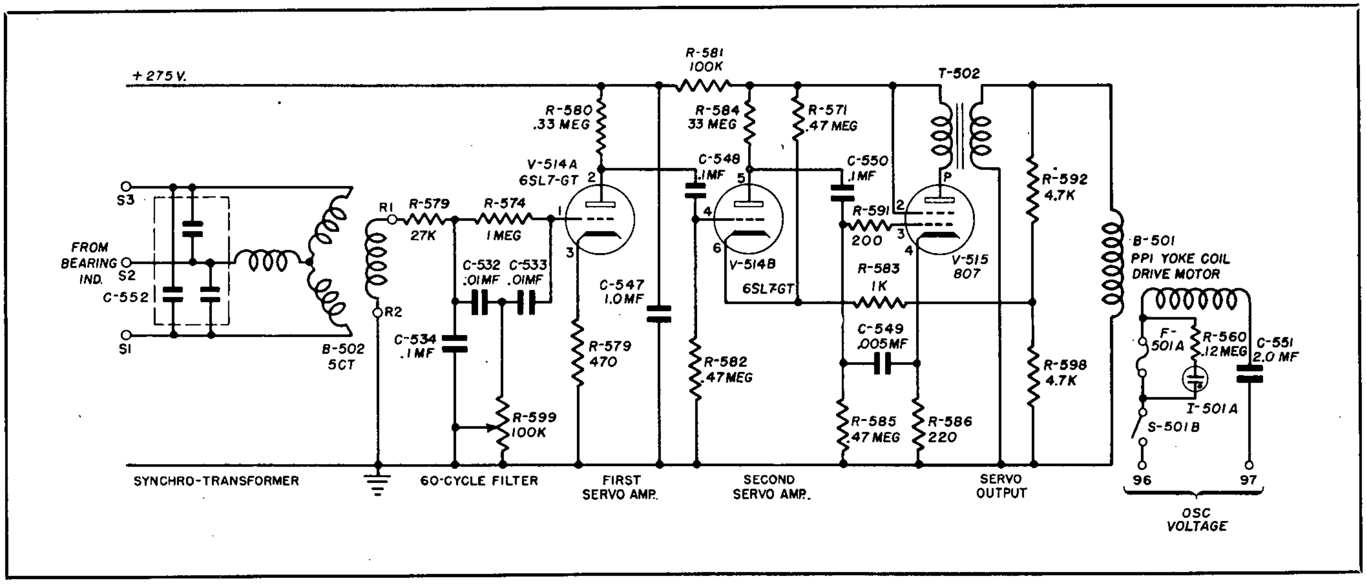


Figure 2-88. PPI Servo System

frequencies. At some frequency, the reactance of the series capacitors is equal to the resistance of resistor R-574. At frequencies below this frequency, the current through resistor R-574 has a slight tendency to rise, and the capacitor current drops. At higher frequencies, the capacitor current rises and the resistor current has a slight tendency to drop. Therefore it is evident that at some frequency a minimum output is obtained. In this circuit, minimum output occurs when the applied frequency is 60 cps. The circuit constants are chosen to attenuate the applied 60-cps voltage by approximately eight to one.

(5) As long as a constant error exists between the angular positions of the synchro differential generator in the Antenna Pedestal and the 5CT control transformer in the PPI Indicator, a constant output voltage at a frequency of 60 cps will be obtained from the 5CT synchro unit. As long as the rotation speed of the Antenna Pedestal does not vary, the amplitude of this voltage will remain constant and as long as the direction of rotation remains unchanged, the polarity of the 5CT voltage will remain unchanged. The anti-hunt circuit has no effect upon this single-frequency voltage other than to attenuate it by a factor of approximately eight to one. Therefore in order for the servo system to follow the antenna, it is only necessary for the error in degrees to be great enough to generate a voltage that will be great enough to drive the first servo amplifier after it has been attenuated by the anti-hunt network. When the amplifier is driven by an error voltage, a driving voltage for the servo drive motor is produced that rotates the system in a direction tending to reduce the error angle to zero. In this way the yoke coil on the PPI tube is rotated by the servo system so that the PPI sweep always follows closely behind the antenna as it rotates.

(6) If the antenna is suddenly brought to rest, the 5CT synchro control transformer continues to deliver an output voltage to the servo amplifier until the drive motor positions the rotor of the 5CT so that it is zeroed with the synchro unit in the Antenna Pedestal. The mechanical inertia of the PPI servo system presents a problem when the zero point is reached. When zero is reached, the 5CT synchro unit has enough momentum to cause it to continue to rotate and pass on through the zero point and thus generate an error voltage that is opposite in polarity to the original error voltage. If corrective measures were not employed, this output voltage would reverse the drive causing it to build up speed in the opposite direction. The motor would then drive the system back to zero and momentum would make the system continue on through causing another error voltage to appear. This oscillation would continue until the friction and power losses in the system overcame it.

(7) The purpose of the anti-hunt network is to provide a large voltage with a polarity the same as the error voltage that would be produced if the system passed through the zero point. To prevent oscillation or hunting this voltage must appear instantly upon the slightest tendency of the system to pass through zero and it must disappear just as rapidly when the system is brought to rest. Otherwise it would act as an error voltage and drive the system backward. The anti-hunt network is shown in Fig. 2-88. It consists of capacitors C-532 and C-533 and resistors R-574 and R-599. This circuit is a bridge-T null network as previously explained. Potentiometer R-599 is used to adjust the circuit so that it delivers enough driving voltage for the amplifier when the antenna is rotating and to establish the null point of the circuit. The nominal setting of this potentiometer is approximately 70,000

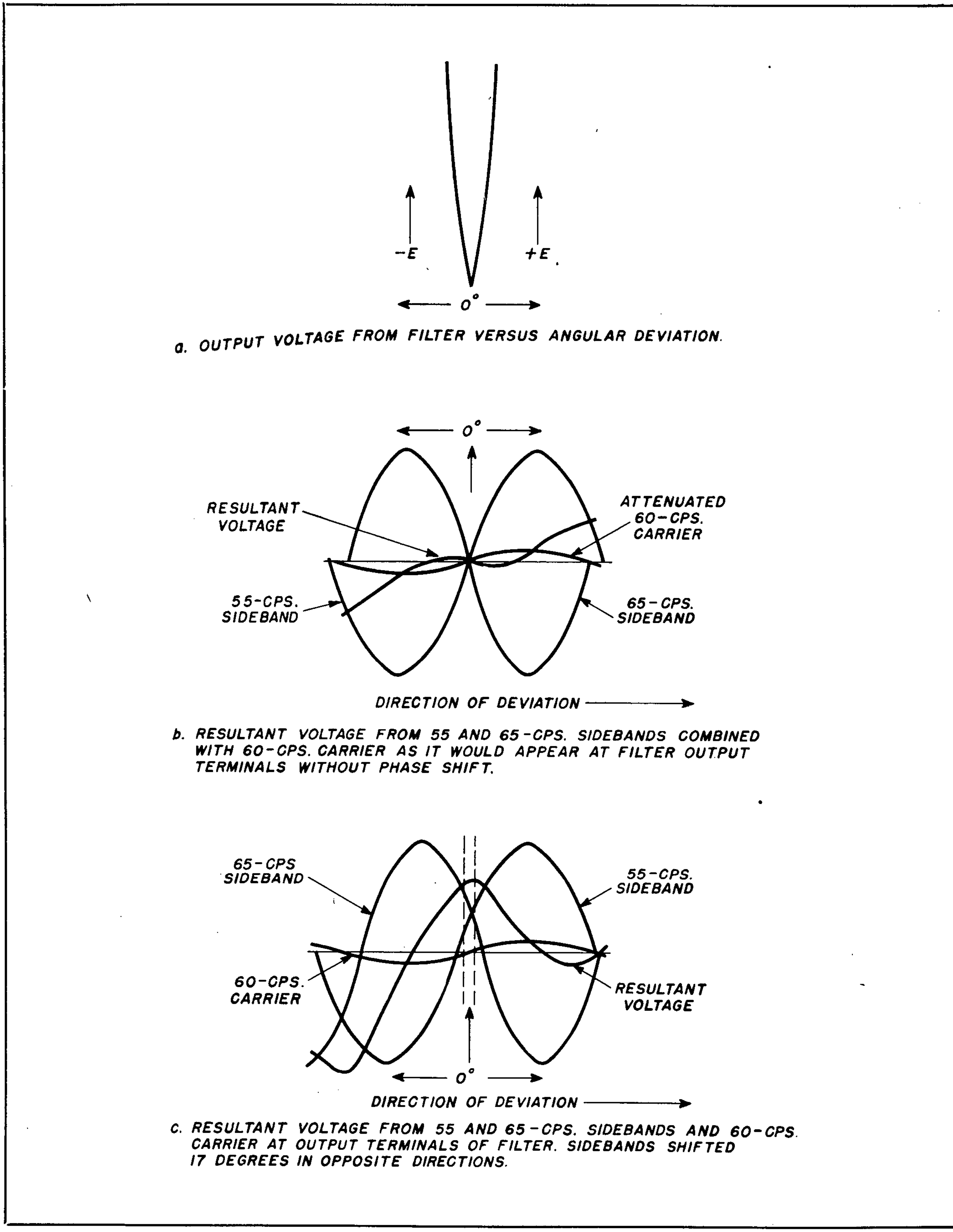


Figure 2-89. Phase Relationships in Anti-Hunt Network

ohms. Actually, a true null point is not obtained with this circuit but any 60-cps voltage present when the system attempts to hunt, is attenuated to such a low amplitude that its effect is negligible. It is evident that any attempt on the part of the 5CT synchro will produce an increase in the amplitude of its 60-cps output. The rate of increase represents a modulating frequency. At the zero position, the carrier amplitude is zero and therefore the hunting voltage delivered to the network is a 60-cps carrier, 100 per cent modulated with the hunting frequency. Assume that the initial hunting frequency is 5 cps. Any attempt to hunt produces a 60-cps carrier with 55- and 65-cps sidebands. The function of the anti-hunt network is to suppress the 60-cps carrier and shift the phases of its sidebands in opposite directions so that their amplitudes add up to a resultant voltage with a polarity that will drive the servo motor in a direction opposite to the direction in which the momentum of the system is driving it. Actually this voltage acts as a brake on the system since it disappears the instant the system comes to rest where the rate of amplitude change is zero. For this voltage to be effective, it must appear immediately upon the slightest deviation from zero. A plot of this voltage versus degrees of deviation from zero is shown in part *a.* of Fig. 2-89. This curve shows that the polarity of the voltage must reverse with the direction of the deviation. The voltage builds up rapidly and theoretically it could reach infinity if the hunting angle could become great enough to cause a resonant effect to appear in the network. The overall effect of the network is to make a very small deviation appear as a very large angle to the servo amplifier.

(8) A plot of the attenuated carrier and its unattenuated sideband frequencies are shown in part *b* of Fig. 2-89. This is the output that would be obtained from the filter if the sidebands were not shifted in phase. The resultant voltage shown is the sum of the three voltages and it is this resultant voltage that acts on the grid of the first servo amplifier. Note that the amplitude of the resultant voltage in Fig. 2-89b is less than the amplitude of the 60-cps carrier and opposite in phase. It is not great enough to drive the amplifier and would drive it in the wrong direction if it could drive it at all. The direction of rotation is to the right. If the direction reverses, the polarities reverse. It is evident from the low amplitude of the resultant voltage that the system could coast until the amplitude of the 60-cps voltage increased sufficiently to drive the amplifier. However, the sideband frequencies suffer a phase shift as they pass through the network. The 55-cps sideband lags the suppressed carrier and the 65-cps sideband leads the carrier. At a hunting frequency of 5 cps, the phase shift is approximately 17 degrees as shown in Fig. 2-89*c*. This phase shift causes the resultant voltage to shift in phase so that its polarity is the same as the polarity of the 60-cps carrier that would eventually reach an amplitude sufficient to drive the system back to zero. Note in Fig. 2-89*c* that the amplitude of the resultant voltage reaches a peak just slightly off the zero position. If the direction of deviation is reversed, the polarities shown are reversed and a negative peak is obtained with the same relative position with respect to zero. Therefore the maximum angle through which the system can hunt is the angle represented by the vertical dotted lines in Fig. 2-89*c*. This angle is a very small fraction of a degree. The effect of the resultant voltage is to apply a voltage that opposes the rotation of the drive motor through very small angles. This voltage quickly disappears when a relatively large error angle appears in the system. The anti-hunt voltage disappears in this case because the rate of follow-up is constant and therefore the amplitude of the 60-cps error voltage applied to the anti-hunt network is constant. When the error voltage is constant, there are no sidebands present.

(9) The output voltage from the anti-hunt circuit is amplified by V-514A and applied to the grid of V-514B through coupling capacitor C-548. V-514A employs cathode degeneration to improve its response characteristics. Resistor R-561 and capacitor C-547 are included to de-couple the plate circuits V-514A and V-514B to prevent feedback through the B+ circuits which would cause motor boating and other undesirable effects. Resistors R-592 and R-598 form a voltage divider across the plate circuit of the output tube, and a degenerative feedback voltage is taken from the junction of the two resistors. When the 5CT is zeroed, the voltage induced in the rotor of the drive motor, when it continues to coast, is fed back to the cathode of V-514B to provide a small reversing voltage to stop the motor. This voltage is coupled to the cathode of the second servo amplifier through the cathode resistor R-583. The result of this negative feedback is to provide a constant input voltage to the motor when the antenna is rotating and to brake the motor to a sudden stop when the system reaches zero position.

(10) The plate voltage of the servo output tube is supplied by a special voltage regulator circuit which was mentioned in the description of the low voltage power supply. The regulator is designed to provide an output of 150 volts d-c and is comprised of the regulator dropping resistor R-575 and the type VR-150 regulator tube V-517. In addition to supplying regulated plate voltage, this tube also serves to present an even load on the power supply despite the fact that the plate current of the servo output tube varies over a reasonably wide range. When reversing the motor drive suddenly, or when sudden acceleration is desired, a larger-than-usual amount of current is required.

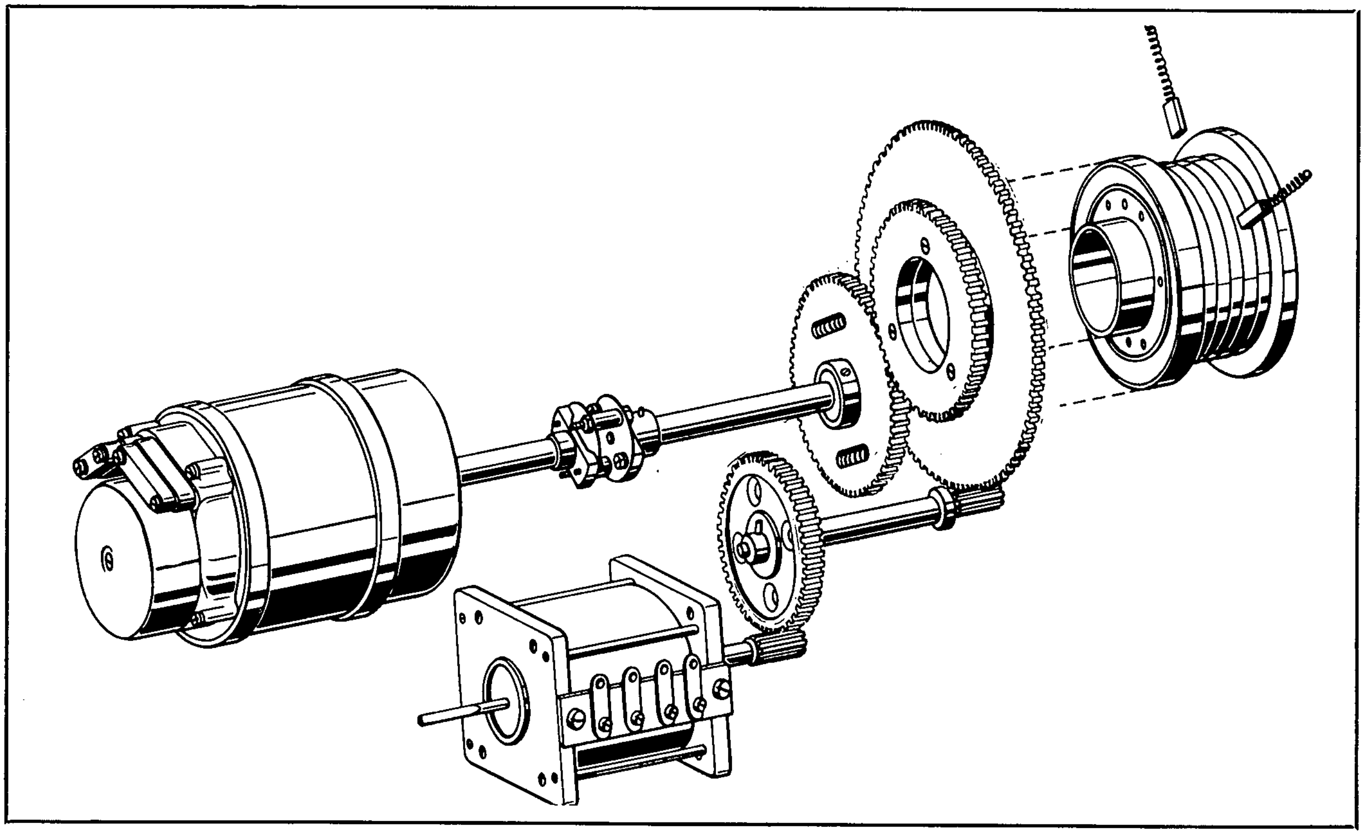


Figure 2-90. PPI Servo System, Mechanical Diagram

When the servo output tube is drawing more current, the voltage regulator will draw less. And when the requirements of the servo tube are less, the voltage regulator tube will absorb the excess of current. Thus the amount of current required from the power supply will be constant, and the regulation of the power supply will not be affected by the varying plate current requirements of the servo output tube.

k. YOKE COIL.

(1) The yoke coil consists of a coil mounted in a cylindrical form that fits over the neck of the PPI tube near the bell of the PPI envelope. See Fig. 2-90. Connections to the yoke coil are made by means of carbon brushes that ride on two slip rings that are mounted on the circumference on the coil form. The field of the yoke coil passes diametrically through the neck of the PPI tube. When the electron beam passes through this field, the beam is deflected at right angles to the direction of the magnetic field and the direction of the beam. The amount of deflection depends upon the intensity of the magnetic field. Since the field intensity varies directly with the amplitude of the current in the coil and the current is varying linearly (sawtooth), the beam will be deflected outward at a constant rate of speed and abruptly returned to the center of the tube where it begins its outward motion again. The PPI servo system rotates the yoke coil around the neck of the tube in a fixed relationship to the position of the radar antenna, and the position of the sweep is used to indicate the direction of the target. The yoke coil is mounted in the aluminum casting and is borne by two special ball bearings. The races of these bearings are constructed of non-ferrous metal and the balls are Pyrex glass.

l. DRIVE GEAR TRAIN.

(1) The yoke coil is rotated by a large spur gear with 180 teeth as shown in Fig. 2-90. This gear is assembled to the yoke coil with three screws. The motion of this gear is obtained from drive motor B-501, which obtains power from the output of V-515 in the servo amplifier. The pinion on the shaft of motor V-501 has 12 teeth and it mates with a spur gear with 79 teeth. The larger gear is mounted on a shaft that drives an 11 tooth pinion. This shaft turns in two ball bearings. The pinion on the shaft mates with the large 180-tooth spur gear that drives the yoke coil. The over-all speed reduction from the drive motor to the yoke coil is approximately 108 to 1. The reason that odd numbers of teeth are used on the gears is to reduce wear and simplify reassembling the gear train when it is disassembled for any reason. The odd numbers of teeth preclude the possibility of the same teeth meshing too often and the wear is thus equalized. Therefore, it is not necessary to mark the teeth when the gears are disassembled. The gear ratio is chosen to permit the motor to run at a speed of approximately 3200 rpm that can be easily controlled by the servo system which reduces the possibility of hunting. Hunt-

ing is a condition where the control is inaccurate enough to cause the motor armature to mechanically oscillate when the radar antenna stops rotating.

m. SERVO GEAR TRAIN.

(1) A smaller spur gear with 104 teeth is assembled to the large yoke spur gear to form a cluster assembly as shown in Fig. 2-90. This gear mates with a split gear with 104 teeth to provide a 1 to 1 ratio. The split gear consists of two gears mounted side by side on the same shaft. An opening is cut into the web of each gear, and a helical spring is inserted in the opening. One end of the spring rests against one gear at one end of the opening and the other end of the spring rests against the other gear at the other end of the opening. The compressed spring forces the gears in opposite directions. Therefore, the adjacent teeth of the split gear are out of line. One of the split gears is firmly keyed to the drive shaft and the other split gear is free to rotate a small amount on the shaft. The teeth of the split gear completely fill the space between the teeth of the gear in the cluster on the yoke coil, and backlash is eliminated.

(2) The shaft driven by the split gear turns in two ball bearings as shown in Fig. 2-90. A universal coupling connects the split gear shaft to the armature shaft of the 5CT synchro-transformer B-502. The 1 to 1 gear ratio causes the armature of the synchro-transformer to rotate through one complete revolution each time the yoke coil completes one revolution.

n. SERVO OPERATION.

(1) Whenever the field of the synchro-transformer is displaced by the movement of the radar antenna, an output is obtained from the servo amplifier. The servo output energizes drive motor B-501 and it rotates the yoke coil through the drive gear train. The phase of the voltages applied to the motor depends upon the direction in which the radar antenna is rotating. Consequently, the drive motor rotates the yoke coil in the same direction in which the radar antenna rotates. The drive motor also rotates the armature of the synchro-transformer B-502 until it occupies a position where the field is no longer displaced. At this point the servo amplifier no longer delivers an output to the drive motor and it stops running. If the radar antenna rotates continuously, the armature of the synchro-transformer never catches up with the field and the motor drives the yoke coil continuously.

(2) The synchro-transformer B-502 is held in place with three clamps. When these clamps are loosened, the synchro-transformer can be rotated in its mounting. The armature does not turn because of the mechanical rotation of the synchro-transformer by hand. Rotation by hand moves the field to produce an output voltage from the servo amplifier to the drive motor, which in turn rotates the yoke coil and the armature of the synchro-transformer until the hand rotation is discontinued. This feature permits the direction of the PPI sweep to be oriented with the direction of the radar antenna. In practice, the synchro-transformer is never rotated more than a few degrees. If the PPI sweep and the radar antenna are as much as 180 degrees apart, the relayed O.S.C. connections are reversed.

17. GENERAL CONTROL UNIT.

a. GENERAL.

(1) The General Control Unit shown in Fig. 2-91 consists mainly of switches for remotely controlling the radar transmitter associated with the Indicator Console. It also contains devices which indicate the operating conditions in the transmitter. A switch is included for turning the components of the Indicator Console on and off as a group. A blower motor is also included in the unit and ventilates the Console Receiver. A number of storage sockets are mounted in the back of the unit. They are used for storing spare tubes for the components of the Indicator Console.

b. TRANSMITTER CONTROLS.

(1) The key type switch on the front panel of the unit is S-406. This switch is used for turning the radar transmitter on and off when the REMOTE-LOCAL switch at the transmitter is in the REMOTE position. Transmitter pilot light I-402, marked TRANSMITTER ON, is illuminated whenever the radar transmitter is operating. The LOCAL CONTROL pilot light, I-401, is illuminated to show when the control of the transmitter is turned over to the Indicator Console position.

(2) The PLATE VOLTAGE kilovoltmeter M-401 is used to read the plate voltage applied to the oscillator tubes in the transmitter. C-402 is a capacitor to by-pass radio frequency voltage around the meter. The multiplier resistor for this meter is in the transmitter, and consequently the lines to the meter are at a relatively low potential.

(3) Switches S-401 and S-402 are the OFF and ON push-buttons for the a-c power to the equipment. Switches S-403 and S-404, the LOWER and RAISE buttons respectively, remotely operate the motor-driven control which raises or lowers the plate voltages applied to the oscillator tubes.

c. INDICATOR CONSOLE SWITCH.

(1) This is switch S-405. It turns on and off all a-c supply voltages to the various components in the Indicator Console. If this switch is in the ON position, the components of the Console may be turned on and off with the rest of the equipment by the ON-OFF buttons on the unit. If the operator wishes to turn off the Indicator Console and leave the rest of the equipment on, the INDICATOR CONSOLE switch must be used. Care must be taken when working around this switch. The 115 volt a-c power is on the terminals of this switch even though the interlocks on the Console are open.

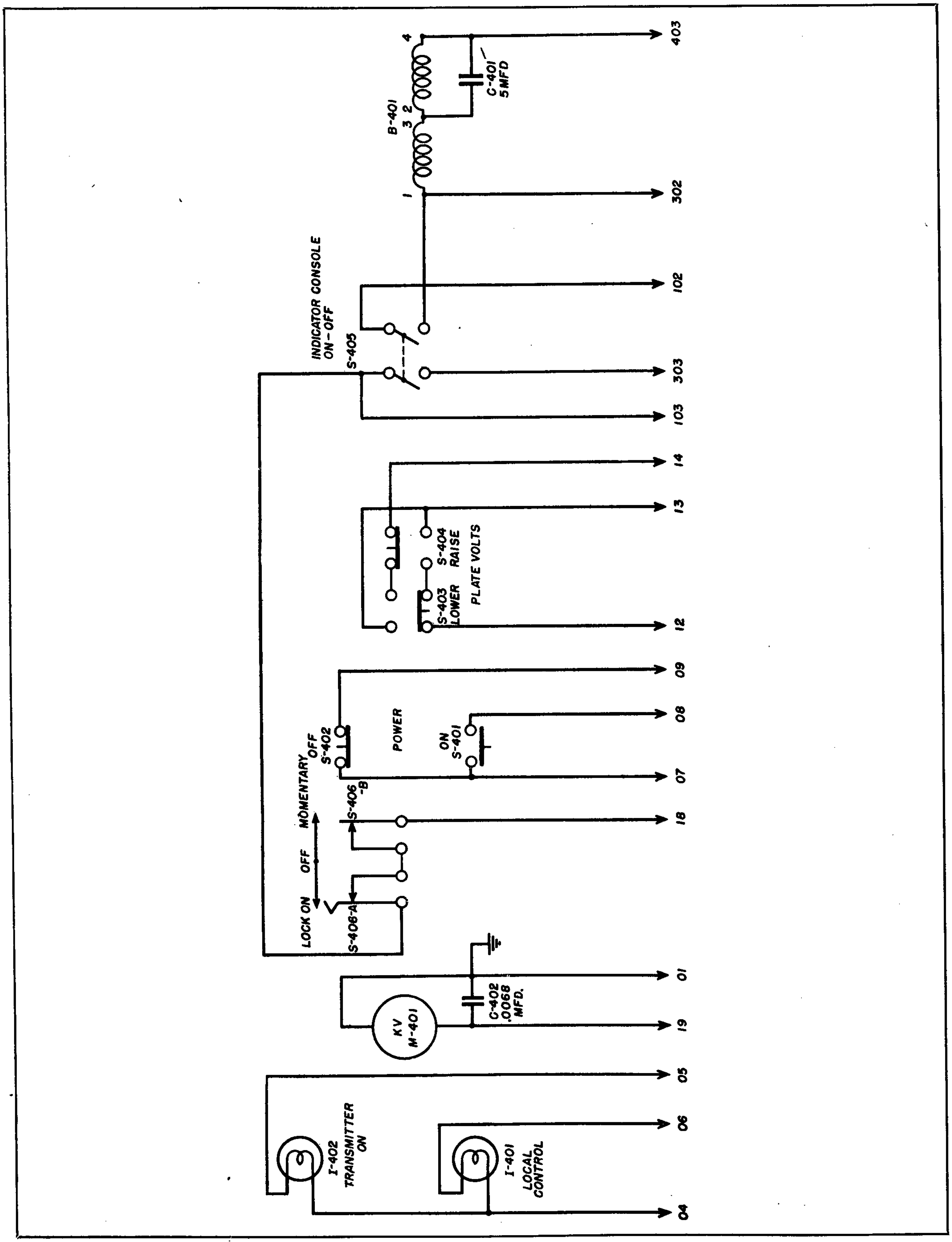


Figure 2-91. General Control Unit, Schematic Diagram

d. BLOWER MOTOR.

(1) The blower motor, B-401, is a capacitor-start-split-phase motor operating from the 115 volt line. Its primary purpose is to cool the Console Receiver above it rather than the General Control unit itself.

18. ANTENNA POSITIONING SYSTEM.

a. GENERAL.

(1) The Bearing Indicator is the main antenna positioning control and indicating unit and is located in the Indicator Console. A block diagram of the Bearing Indicator is shown in Fig. 2-92. By operating a handwheel on the front panel, the operator may move the antenna of the radar set in azimuth to any position desired. In addition, the operator may cause the antenna to be automatically rotated in azimuth for searching operations. A switch on the front panel of the unit can be operated to energize a d-c motor, which in turn, will rotate the handwheel. Thus, the antenna will rotate continuously while the switch is in one of its ON positions. Two speeds in either direction are available by the operation of this switch.

(2) The Bearing Indicator also indicates the position of the antenna in azimuth. Two types of indications are provided. One of these is the *true bearing* indication, which indicates the position of the antenna with reference to true North. The other indication is relative bearing which is the bearing of the antenna with respect to the ships bow. The Bearing Indicator is only one part of the antenna positioning system. Consequently, to understand the electrical functioning of the unit, the description of its operation is combined with a description of the antenna positioning components. Fig. 2-92 is a simplified block diagram of the antenna positioning system of the SR Equipment. Refer to this diagram during the following discussion.

b. FUNCTIONAL DESCRIPTION.

(1) The complete antenna positioning system obtains basic positioning data voltages for true bearing indications from the ship's gyro-compass system. These voltages are applied to the Synchro Amplifier, which is part of the Antenna position system. The voltages are termed *O.S.C.* meaning *own ship's course.* The output of the Synchro Amplifier varies in accordance with the deviation of the heading of the ship from true North as established by the gyro-compass equipment. The three-wire output voltage obtained from the synchro amplifier is combined with relative data voltages to provide true bearing indications on the Bearing Indicator and PPI Indicator. The compass voltage also acts to maintain the position of the antenna with respect to true North. For example, if the Antenna be trained to 45° in azimuth, it will continue to point in that direction regardless of any change in the ship's course. The Synchro-Amplifier receives a 1-speed data voltage, a 36-speed data voltage, and a compass excitation voltage from the ship's compass circuits. From these voltages, a set of *relayed* voltages are produced by the Synchro Amplifier which have the same phase and amplitude as the voltages supplied by the compass system. The primary purpose of the Synchro Amplifier is to prevent loading the compass equipment and to isolate the antenna positioning equipment from the compass circuits.

(2) Further reference to Fig. 2-92 shows that the antenna has two 6DG synchro-differential generators geared to it. The gear ratio is such that the shaft of one of the synchro-differential generators rotates 36 times while the antenna rotates once. When the 36-speed relayed compass data voltages are applied to the stator of the unit, a second set of voltages will appear across the rotor. These voltages will be proportional to the difference between the rotor position of the 6DG in the Antenna Pedestal and the position of the rotor of the 36-speed compass synchro generator. The voltages are connected to the stator of the 36-speed 5CT synchro transformer which is geared to the handwheel on the front of the bearing indicator. If the rotor of the 5CT is displaced from its zero voltage position, it delivers an output voltage. The output of the 5CT synchro transformer is connected to an electronic servo amplifier. The output of the electronic amplifier is applied to a servo generator and the output of the servo generator drives the antenna drive motor to reposition the antenna in accordance with the position of the 5CT rotor in the Bearing Indicator. The above combination forms what is termed a closed servo loop or servo system. This is the basic antenna positioning system of the equipment. Its operation will be explained in the following paragraphs. When the stator of the 5CT is in a certain angular position, determined by the voltages from the 6DG on the antenna pedestal, no output will be applied by the 5CT to the servo amplifier. When the angular relationship of the rotors of the 6DG and 5CT changes, or when the 36-speed compass voltages change, as they do when the ship changes course, an output will appear from the 5CT which will be applied to the servo amplifier.

(3) It can be seen that it is possible to secure an output from the 5CT in three ways. The first is to physically move the antenna, which will move the rotor of the 6DG. The second is to rotate the handwheel and move the rotor of the 5CT. The third is for the ship to change course and thus change the voltages applied to the rotor of the 6DG. The amplitude of the output from the 5CT will reflect the magnitude of the displacement or the change in the 36-times compass voltage. It will also reflect the direction in which the positional difference exists by means of the polarity of the output. The output from the servo amplifier is applied to the servo generator. This is an a-c motor-driven two-stage d-c generator. When no

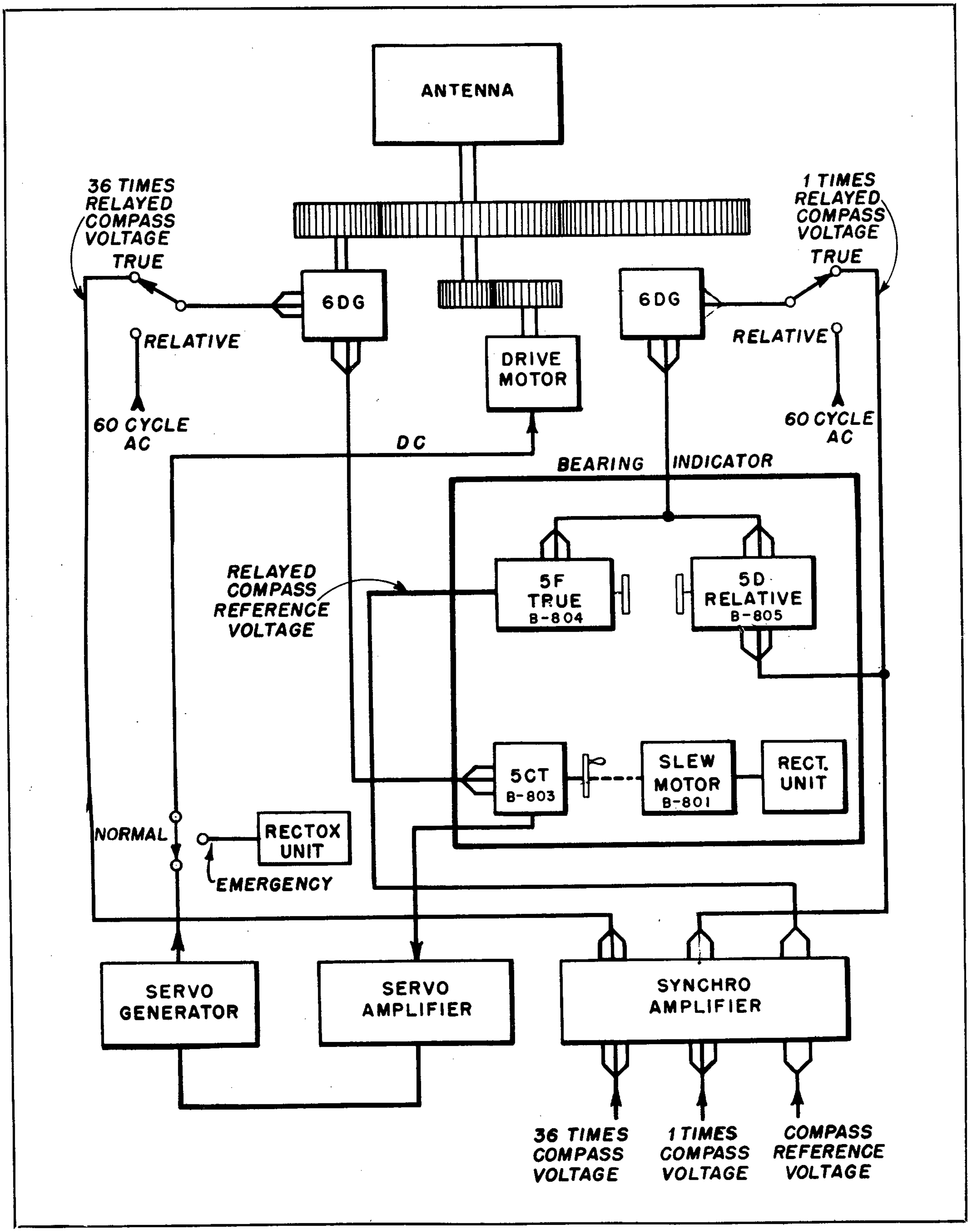


Figure 2-92. Antenna Positioning System, Block Diagram

voltage is applied to the servo generator, it is running without field voltage and consequently not delivering an output to the antenna drive motor. The moment an output voltage appears across the rotor of the 5CT synchro transformer, the servo amplifier supplies field current to the servo generator, the servo generator supplies a d-c voltage to the antenna drive motor, and the motor drives the antenna in azimuth. The direction of this rotation is determined by the polarity of the 5CT output so that the antenna moves in a direction which drives the shaft of the 6DG to correct any angular difference between the position of its rotor and the rotor of the 5CT in the Bearing Indicator. When the antenna reaches the proper position, the output from the 5CT becomes zero. Therefore, no more current is supplied to the d-c drive motor and the Antenna stops.

(4) The operator, by moving the handwheel, creates an output from the 5CT which will reposition the antenna to a position which corresponds to the handwheel movement. If the ship changes course, and the compass voltages used as a reference change, the same net result is obtained and the antenna is moved. Should the antenna be physically displaced, the 5CT will produce an output which will move the antenna back to the position determined by the handwheel. This latter action is usually caused by antenna momentum after the handwheel has stopped. Since the antenna is then displaced from the corresponding position of the handwheel, the action of the servo system serves to bring it back to the proper position. When the system is being operated on relative bearing, the reference voltage is a source of constant a-c from the ship's a-c lines. It is applied to the 6DG so that the reference will be to the bow of the ship rather than to true North.

(5) The position of the antenna appears on dials in the Bearing Indicator due to the action of three synchro units. Two of these are in the Bearing Indicator and one is geared to the antenna. Referring to the simplified block diagram in Fig. 2-92, it will be seen that a 6DG synchro-differential generator is geared in a 1:1 ratio to the antenna. This generator is excited by the 1-speed compass voltage from the Synchro Amplifier when the equipment is operated on true bearing. The output voltage from the 6DG is a three-wire synchro signal. When excited by the true bearing compass voltage, it represents the deviation of the antenna from true North. This voltage is applied to two other synchro units in the Bearing Indicator. These synchros have dials coupled to their shafts. The 5F synchro repeater unit drives the true bearing indicator dial. Voltages from the 6DG on the antenna, position its shaft and dial in such a manner that it indicates the deflection of the antenna in degrees from true North when the system is operating on true bearing. When the system is operating on relative bearing, the 5F synchro indicates relative bearing. The reference voltage for the rotor of this indicator is the compass excitation from the synchro amplifier. The 5D synchro-differential generator, always indicates relative bearing. The output from the one-speed 6DG in the Antenna Pedestal is applied to one of the windings of the 5D. The other winding receives a fixed one-speed three-wire compass reference voltage from the Synchro Amplifier when the equipment is operating on relative bearing. The 5D synchro unit subtracts these voltages to obtain a difference voltage that represents the position of the antenna with respect to the bow of the ship. The indication is, therefore, the direction of the antenna with relation to the bow of the ship. When the radar set is operating on relative bearing, excitation voltage to the 6DG on the antenna pedestal is a constant voltage from the ship's a-c lines.

(6) When the operator desires to have the antenna rotate continuously, a small d-c drive motor in the Bearing Indicator is used to drive the hand control. This small d-c motor, called a slewing motor, is coupled to the handwheel by a reduction gear. When it is running, it rotates the 5CT to supply a continuous error voltage to the servo amplifier.

(7) From the foregoing explanation it can be seen that in true bearing operation excitation voltage from the compass is relayed by the Synchro Amplifier to the synchro units in the Antenna Pedestal and compass reference voltage from the Synchro Amplifier is relayed to the Bearing Indicator. The output from the Bearing Indicator, drives the Servo Amplifier, and its output is used to excite the Servo Generator. The output of the Servo Generator drives the Antenna Drive Motor. The detailed discussion of the antenna positioning system takes up each component in the order in which its function appears in the sequence of operation.

19. SYNCHRO UNITS.

a. GENERAL.

(1) In order to understand the functioning of the antenna positioning system, it is necessary to have a general understanding of the operating principles of synchro units. A synchro unit is a single-phase transformer, constructed like a motor. There are two types of synchro units used in the SR Equipment. One type has a primary winding consisting of a single coil which is wound on the armature or rotor. The field consists of three windings and is generally called the stator. The coupling coefficient between the windings is approximately 0.45. The stator windings are connected together in a star or Y arrangement as shown in Fig. 2-93. The other ends of these windings form a three-wire output circuit. The other type of synchro unit used in the SR Equipment is a differential generator

and its primary consists of three coils which are star-connected, similar to the stator arrangement. The stator coils of both types are physically placed 120 geometrical degrees apart in the synchro unit. From this it may be deduced that when the rotor is positioned so that close coupling exists between it and one of the stator windings, the coefficient of coupling between it and the other two stator windings is considerably less. Therefore equal voltages will not be obtained from each of the stator windings. As the rotor is turned, its magnetic field rotates with it and as the coupling with each individual coil changes with rotation of the rotor, the potentials at the stator terminals also change.

b. MOTORS AND GENERATORS.

(1) When two synchro units are connected together as shown in Fig. 2-93 a, the rotors assume the same position with respect to each other. When the two rotors are in the same position, the voltages induced in the stator windings are identical and since the windings are connected so that the flow of current in one coil is opposed by the flow of current in the corresponding coil, no current flows in any of the stator circuits. In this case there is no torque on the rotor. If the rotor of the synchro generator is rotated 30 degrees, the voltage across stator winding S1 rises from 26 to 45 volts. Since this voltage exceeds the 26 volts across the S1 winding in the synchro motor, a current flows in the circuit and a magnetic field exists at S1 with a polarity opposite to the polarity of the rotor field at the point. The same conditions exist in the S2 windings. The voltage across the S3 winding in the synchro generator drops to zero since the axis of the rotor is perpendicular to the axis of the S3 winding and the coupling is reduced to zero. The voltage in the S3 winding to the synchro motor causes a current to flow in the S3 circuit that is opposite in polarity to the currents flowing in the other two windings. Consequently a magnetic field exists at S3 in the synchro motor that is opposite to the field of the rotor at that point. The attraction that now exists between the rotor and the stator field in the synchro motor produces a torque that tends to turn the rotor in the same direction in which the rotor of the synchro generator was turned. This torque exists until the positions of the rotors are the same and current ceases to flow. Thus it can be seen that when the rotor of the synchro generator is rotated, the rotor of the synchro motor follows closely.

c. CONTROL TRANSFORMERS.

(1) If the rotor of the synchro motor is not connected to the rotor of the synchro generator as shown in Fig. 2-93*b,* there is no tendency for it to turn and a different situation exists. When the positions of the two rotors are 90 degrees apart, the rotor of the second synchro unit, which now becomes a transformer, is closely coupled to two opposing fields and the currents induced by them cancel each other. At the same time the rotor axis is perpendicular to the magnetic field of the other stator winding and the coupling between these two windings is zero. Except for a very small voltage induced in the rotor by eddy currents the output voltage taken from the rotor will be zero. In this arrangement, the stator windings of the synchro transformer become the primary and the rotor winding is the secondary. If the rotor of the synchro generator is rotated 30 degrees as shown, the stator voltages change. The voltage across S1 rises to 45 degrees, the voltage across S2 drops to approximately 45 volts and the voltage across S3 drops to zero. This shifts the resultant magnetic fields and increases the coupling to the rotor as shown and an output voltage appears across it. The application of control transformers is described in connection with the components in which they are used.

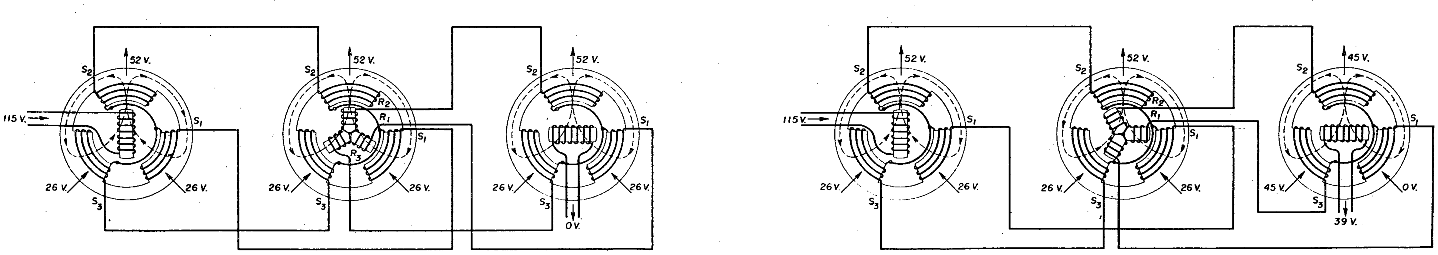
d. DIFFERENTIAL GENERATORS.

(1) Fig. 2-93*c* shows a synchro differential generator. The basic principles involved are the same as for the two preceding cases. The only difference is that the differential synchro generator acts as a one-to-one ratio coupling transformer between two synchro units with single winding rotors. When the three-winding rotor is aligned with the stator coils, close coupling exists between the rotor and stator windings and the output voltage is equal to the input voltage. If the rotor of the differential generator is rotated slightly, the coupling changes and produces a corresponding change in output voltage. For example, in the right-hand portion of Fig. 2-93*c,* the voltage across R1 is zero volts and the voltage across the S1 winding connected to it is also zero volts. The voltages across the other two rotor windings is 45 volts and this voltage also appears across the stator windings connected to them.

(2) To determine the voltage relationships in a synchro differential generator, consider the left-hand portion of Fig. 2-93*c.* In this figure, R1 is closely coupled to S1 and similar coupling exists between the other corresponding coils. The angular deviation of the rotor is zero. In this case the rotor voltages are equal to the product of the cosine of zero degrees and the stator voltages. For example, the voltage across R1 is equal to 52 cos O° (52 x 1) which is 52 volts. The voltage across R2 is 26 cos O° (26 x 1) which is equal to 26 volts. In the right-hand portion of Fig. 2-93*c,* the rotor of the differential synchro is displaced 30 degrees in a counterclockwise direction. The polarity arrows show that in this position, the voltages induced in R1 by S1 and S3 will be opposite in phase. Since the axis of R1 is perpendicular to the axis of S2, no coupling exists between these coils. Therefore, the voltage across R1 is the sum of the voltages induced

a. SYNCHRO GENERATOR AND MOTOR

b. SYNCHRO GENERATOR AND CONTROL TRANSFORMER



c. DIFFERENTIAL GENERATOR

Figure 2-93. Synchro Units, Basic Principles

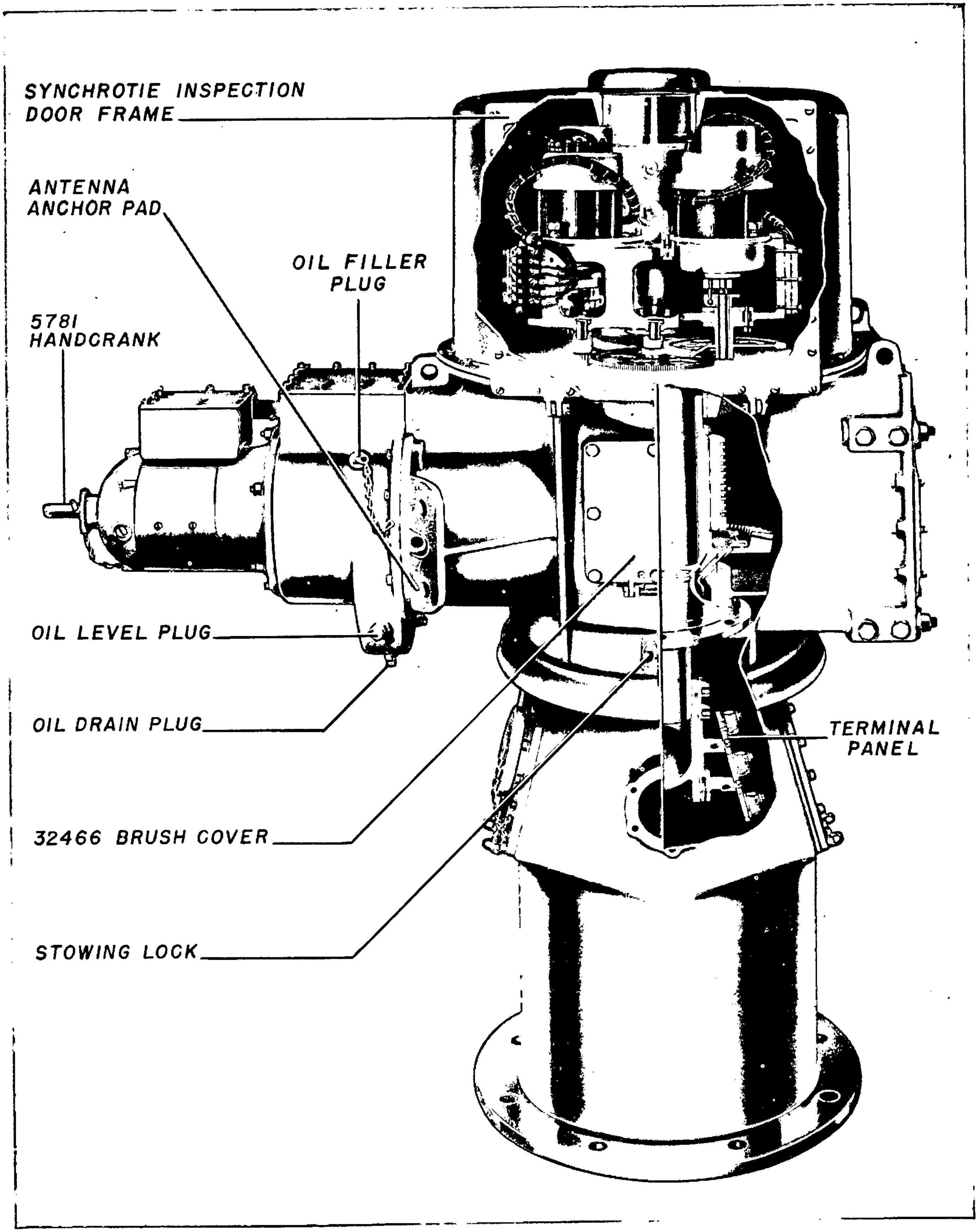


Figure 2-94. Antenna Pedestal

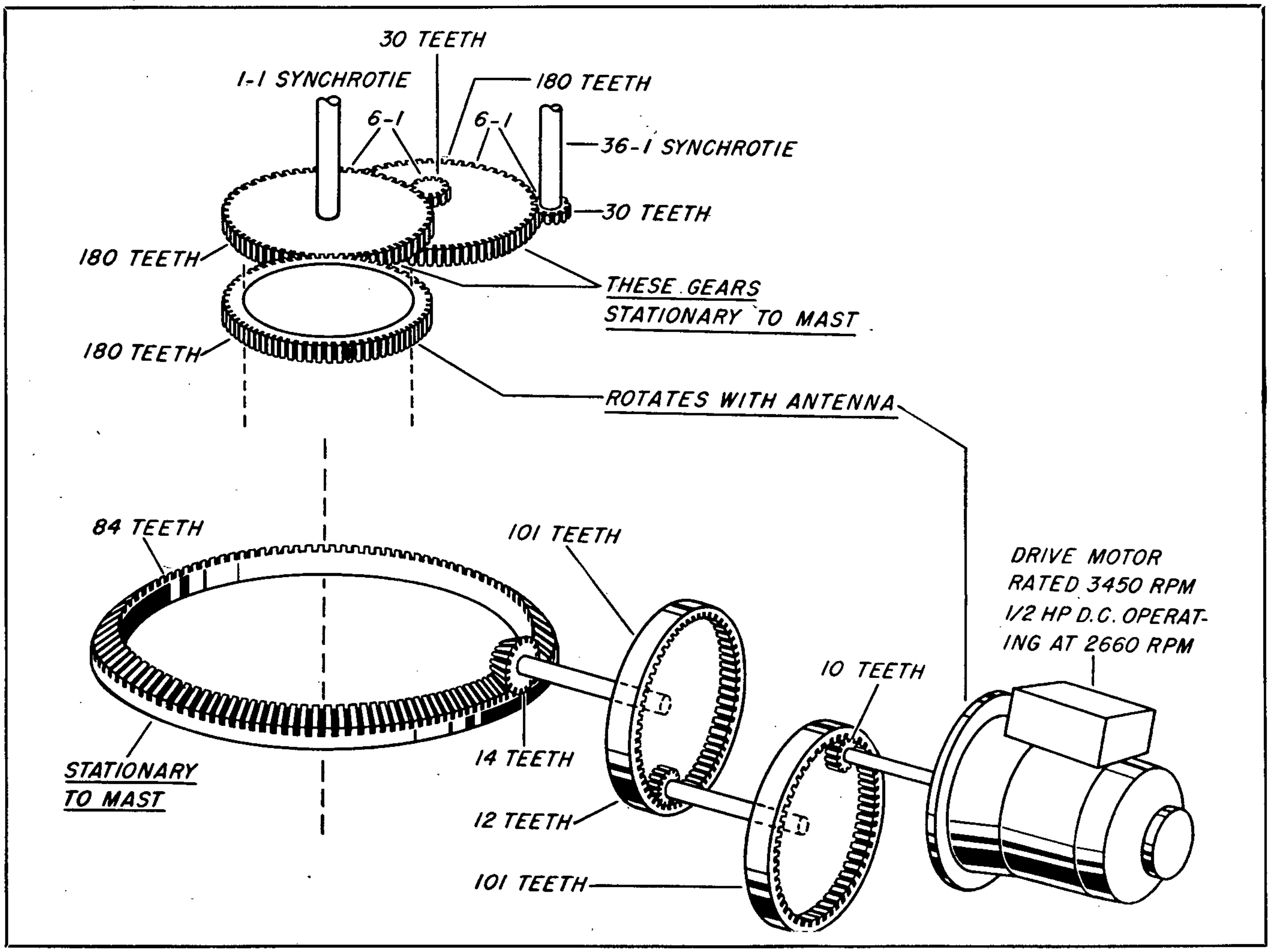


Figure 2-95. Antenna Pedestal Gear Schematic

by S1 and S3. This voltage is 26 cos 30° — 26 cos 30° which is equal to zero. The voltage across R2 is induced by the fields of S2 and S1. Since the field of S1 links S2, it is obvious that the two component fields acting on R2 are S1 and one-half of the S2 field. Note that this field links S3. Therefore the voltage across R2 is 26 cos 30° +26 cos 30° which is 45 volts. Similarly, the voltage across R3 is —26 cos 30° — 26 cos 30° which is —45 volts. Thus it can be seen that as the angle changes, the voltages change directly with the product of its cosine function and the stator voltages.

20. ANTENNA PEDESTAL.

a. GENERAL.

(1) The Antenna Pedestal supports the antennas and contains the rotating mechanism and the position data synchro units necessary to provide an indication of the direction of the antenna and to control its rotation. The Antenna Pedestal also contains the r-f transmission lines. The r-f lines pass through rotating joints in the upper portion of the Antenna Pedestal to permit the antennas to rotate. The r-f lines in the Antenna Pedestal have been discussed in connection with the r-f transmission system and therefore require no detailed treatment here.

b. SYNCHRO ASSEMBLY.

(1) There are two 6DG synchro differential generators located in the dome of the Antenna Pedestal. See Fig. 2-94. One of these units transmits one-speed data to the Bearing Indicator to position its dials on which true and relative bearings are indicated. The other 6DG transmits data to the positioning circuits in the antenna positioning system. The 6DG synchro units are mounted in a casting that clamps to the center post of the Antenna Pedestal around which the dome rotates. A schematic diagram of the gears in the Antenna Pedestal is shown in Fig. 2-95. A spur gear, fastened to the rotating dome, rotates around the center post and meshes with a spur gear mounted on the shaft of the one-speed 6DG. Each of these gears have 180 teeth and the 6DG rotates at the same speed with which the dome rotates but in the opposite direction. The gear on the one-speed 6DG also meshes with a

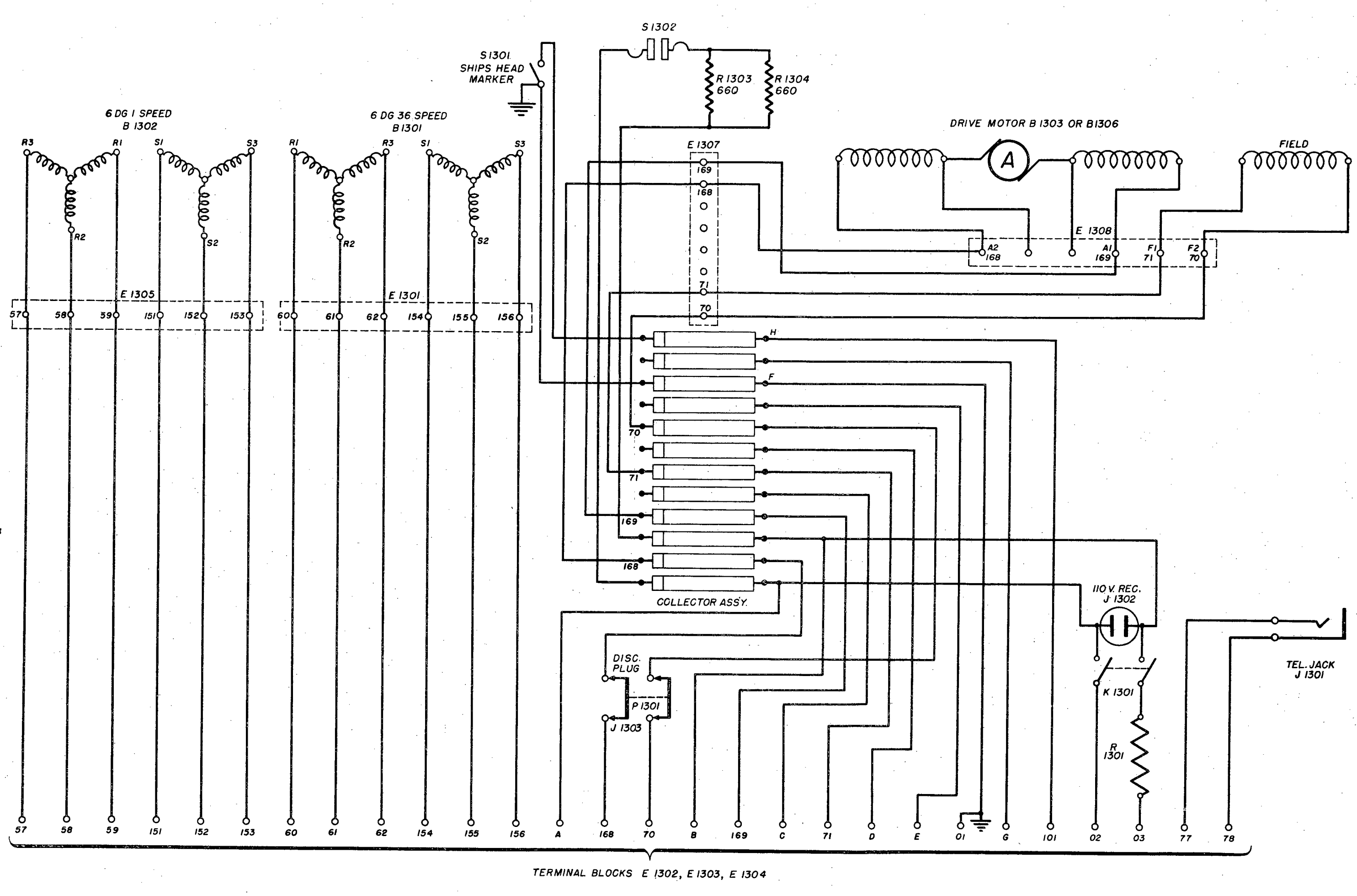


Figure 2-96. Antenna Pedestal, Schematic

30-tooth pinion in a cluster gear. The cluster rotates around a shaft mounted on the synchro casting. The other gear in the cluster has 180 teeth and meshes with a 30-tooth pinion mounted on the rotor shaft of the 36-speed 6DG. Thus the rotation speed of the dome is increased 36 times in two 6-to-1 stages.

c. ROTATING ASSEMBLY.

(1) The rotating mechanism is shown in Fig. 2-95. The lower portion of the Antenna Pedestal does not rotate. It consists of the base, center post, ring gear and collector ring assembly. The upper portion of the dome rests on graphite-impregnated bronze bearings mounted on the center post. There are two of these bearings. The drive motor shown in Fig. 2-95 has a 10-tooth pinion mounted on its drive shaft. This pinion meshes with a 101-tooth annular gear which drives a shaft on which is mounted a 12-tooth pinion. This pinion meshes with another 101-tooth annular gear. The shaft driven by the second annular gear has a 14-tooth bevel gear pinion mounted on it. This pinion meshes with the bevel ring gear which is mounted on the stationary center post. When the armature of the motor rotates, the bevel gear pinion rolls along on the bevel ring gear and carries the dome with it. A crank is provided which can be attached to the motor shaft so that the Pedestal can be rotated manually.

d. COLLECTOR RING ASSEMBLY.

(1) Power for the drive motor and other circuits is brought into the base through multi-conductor cables which connect to leads that pass up through the lower portion of the center post to the collector ring assembly. The collector ring assembly has twelve silver rings. Six are in use and six are spares. The brushes are phosphor bronze and are mounted on brush blocks that are in turn mounted on the dome. The brush blocks are mounted on access plates that are mounted over holes in the side of the dome with mounting studs. The removal of these plates permits the brush assemblies and the collector rings to be inspected, cleaned and repaired. The brushes connect to leads that go to the various components.

e. CIRCUITS.

(1) A schematic diagram of the Antenna Pedestal is shown in Fig. 2-96. The leads from the synchro units are brought down to terminal blocks in the base of the Antenna Pedestal. The stator windings of the 6DG synchro units are excited by either of two output voltages obtained from the Synchro Amplifier. One of these voltages is the relayed compass voltage which is a function of the angle between the ship's heading and true North. The position of the rotor always represents the angular position of the antenna with respect to the bow of the ship. The subtraction of one of these angles from the other is obtained by the degree of coupling between the rotor and stator as previously explained. Since the degree of coupling is determined by the position of the rotor, an output voltage is obtained that is proportional to the deviation of the antenna from true North. The other voltage is a fixed reference voltage obtained from a transformer in the Synchro Amplifier. When this voltage is used to excite the 6DG stators, the output voltage is proportional to the angular deviation of the antenna from the bow of the ship and is used for relative bearing indications. The output of the 36-speed synchro changes 36 times for each revolution of the Antenna Pedestal. The 36-speed output is used to control the servo system that rotates the Antenna Pedestal. The output from the one-speed synchro unit is used to position the dials on the Bearing Indicator.

(2) A telephone jack, J-1301 is used to provide a telephone circuit to the rest of the radar equipment below deck. The circuits to this jack are brought out to one of the terminal blocks in the base. An a-c circuit is connected to a convenience outlet through circuit breaker K-1301. This circuit breaker has a thermal overload element R-1301 which opens the circuit breaker in case of overloads. From the convenience outlet, the a-c circuit is connected through the collector ring assembly and switch S-1302 to two heater resistors R-1303 and R-1304. The drive motor has separate armature and field circuits. These circuits are brought up through the collector ring assembly. Fig. 2-96 shows two windings in series with the armature. The function of these windings is to produce a field, in addition to the regular field, that improves the speed regulation of the motor at slow speeds. The armature circuit passes through a disconnect plug P-1301 and J-1303. The purpose of this plug is to permit maintenance personnel to disconnect the motor when servicing the Antenna Pedestal. The excitation to the field is continuous. The armature is excited with a d-c output from the Servo Amplifier that appears only when an error exists in the antenna positioning system. The polarity of this voltage is reversible and its magnitude is also variable. Thus the direction and speed of the motor is variable and is controlled by the servo system. Switch S-1301 is a microswitch which is actuated by a small depression in the circumference of the bevel ring gear. The switch is mounted on the dome and moves around the bevel gear when the dome is rotating. This switch is so positioned that it sends an impulse to the PPI Indicator each time the antenna is trained directly over the bow of the ship.

21. SYNCHRO AMPLIFIER.

a. GENERAL.

(1) The Synchro Amplifier, sometimes known as the O.S.C. or "own ship's course" amplifier, comprises the apparatus needed to isolate the true bearing synchros of the SR equipment from the synchros of the ship's master gyro-compass. The master gyro-compass synchro generators must be isolated from the SR An-

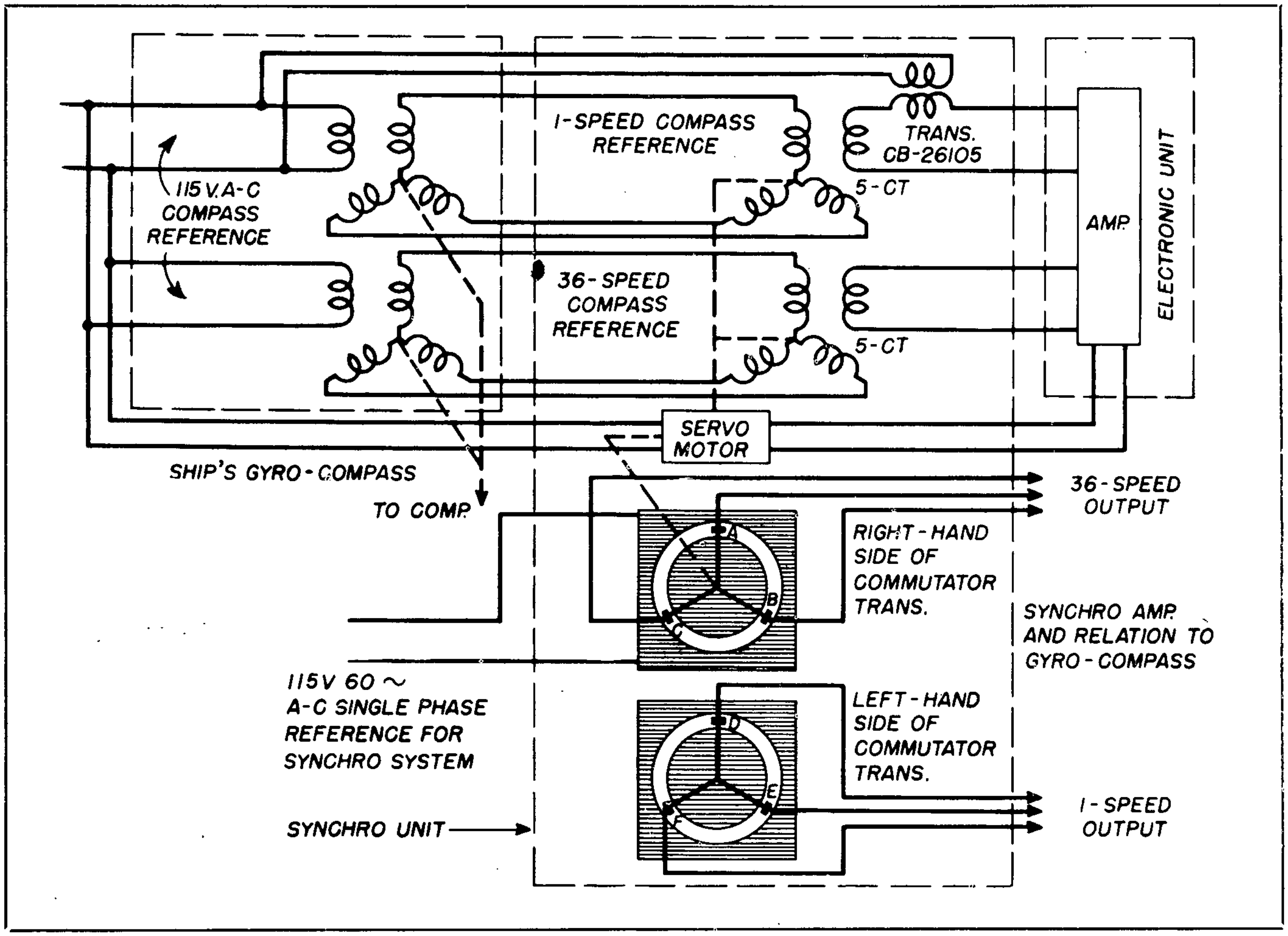


Figure 2-97. Relayed Compass Voltage Circuits, Simplified Diagram

tenna positioning circuits in order to prevent the inaccuracies that would be introduced into the position of the master synchros by a directly connected circuit. When the Synchro Amplifier is used in conjunction with the ship's gyro-compass system, the only load upon the two synchro generators of the compass is the power losses in the two synchro control transformers and the input circuits in the Synchro Amplifier. The Synchro Amplifier consists of two units. One of these, the Synchro Unit contains the control transformers. The other unit is an electronic amplifier. A schematic diagram of the Synchro Amplifier and ship's gyro-compass system is shown in Fig. 2-97. The synchro generators of the ship's gyro-compass transmit voltages to the control synchros of the Synchro Unit. A voltage is generated in the rotors of the repeaters proportional to their displacement from synchronism with the rotors of their respective generators. This voltage is fed into the Electronic Unit where it is amplified sufficiently to control a servo motor which drives the control synchros and a commutator transformer from which reproductions of the original synchro voltages are sent to the various Synchro Units. As shown in Fig. 2-97, data is supplied to the Synchro Amplifier by two synchro generators in the ship's gyro-compass. The 1-speed compass synchro produces one complete cycle of voltage for each complete rotation of the compass. The 36-speed compass synchro makes 36 complete voltage cycles for each complete rotation of the compass. The two synchro generators are identical; their rotational differences are accomplished by means of a gear train. Because of the speed difference between the two synchros, the 36-speed unit delivers the same voltage output for 1/36 of one degree of compass rotation as the 1-speed unit delivers in a full degree of compass rotation. It would be possible to operate the Synchro Amplifier on only the 1-speed system. However, in such a system a small displacement of the synchro generator would induce only a small voltage in the rotor of the synchro generator. In the 36-speed system a small displacement of the 1-speed synchro generator causes the 36-speed generator to turn through an angle 36 times as large. The one-speed and 36-speed voltages are combined in the Electronic Unit of the Synchro Amplifier to produce a torque in the servo motor which changes the position of the brush assemblies on the commutator transformer to correspond to the displaced position of the synchro generator of the compass. The use of the 36-speed system therefore increases the sensitivity of response of the Synchro Amplifier by approximately a factor of 36. Since the output of the 36-speed system is zero at each 10 degrees compass rotation, the 1-speed system must be added in order to eliminate these false zero points.

b. SYNCHRO UNIT.

(1) The schematic diagram of the Synchro Unit is shown in Fig. 2-97. As shown, the 1-speed and the 36-speed voltages from the synchro generators of the gyro-compass are applied to corresponding 1-speed and 36-speed 5CT control transformers. When the rotors of the control synchros in the Synchro Amplifier are zeroed with the rotors of the synchro generators of the compass, no voltage is induced in the rotor of either the 1-speed 5CT or the 36-speed 5CT, the system is in equilibrium and the amplifier output to the servo motor is zero. When the compass rotates in such a way as to create an instantaneous 1° displacement between the rotors of the generator synchros and the control synchros, an output voltage appears across their rotors. A 5CT synchro has approximately one volt induced in its rotor for each degree of displacement between its rotor and that of its corresponding generator, for small displacement angles. The displacement of one degree causes a potential of one volt to be induced in the rotor of the 1-speed unit and a potential of 36-volts to be induced in that of the 36-speed unit. The total of 37 volts is amplified by the Electronic Unit and the output obtained is used to drive the servo motor of the Synchro Unit. The servo motor is geared to the 5CT control synchros, and turns them in a direction that eliminates the angular displacement between their rotors and the rotors of the synchro generators of the compass. When the rotor of a 5CT control transformer is zeroed with the generator supplying it, there is no voltage induced in the rotor. If the rotor is turned from the zero-voltage point, the polarity of the induced voltage will either be the same as the compass reference voltage which induces it, or opposite in polarity, depending upon the direction in which the rotor is turned. This property of the synchro is used in conjunction with the Electronic Unit to cause the servo motor to turn in the correct direction to eliminate the displacement error in its rotor.

(2) If the rotor of a 5CT control transformer is in angular correspondence with the rotor of its generator, its output, as has been mentioned, is zero. If the rotor be turned mechanically through an angle of 180 degrees, without changing the position of the rotor of the generator supplying it, the output of the control transformer rotor would again be zero. It appears therefore, that the system will be in equilibrium for each 180 degrees of rotation. This is undesirable because if the indicating components are to read correctly, there can be only one zero point in 360 degrees of rotation. The combination of the one-speed and 36-speed voltages in the electronic amplifier is accomplished in such a way as to eliminate this undesirable feature.

(3) The servo motor, as was previously mentioned, is geared to the 5CT control synchros, and turns them in such a way as to bring their rotors into alignment with the rotors of the synchro generators in the compass. The servo motor is also geared to a *commutator transformer,* the rotor of which is also positioned in accordance with the position of the rotor of the synchro generator. It is this commutator transformer which supplies the 1-speed and 36-speed voltages which are replicas of those fed into the Synchro Amplifier by the compass, and which are used throughout the SR system. The commutator transmitter consists of a coil of flat copper ribbon wound edgewise on a laminated core which has two flat parallel faces. Part of the insulation of the winding is removed, on each of the windings, in such a manner as to form a circular concentric track on each of the flat surfaces. A brush arrangement is mounted on the common center to operate against each face. Each brush assembly is made up of three brushes which are electrically insulated from each other and set 120 geometrical degrees apart. An a-c voltage of 115 volts, single phase, 60 cycles, is connected to the coil of the transformer. The brush assemblies are connected by means of a gear train so that the ratio of the speed of rotation of the two brush assemblies is 36:1. Referring to Fig. 2-97, the 1-speed brush assembly is designated by contact points D, E, and F, while the 36-speed assembly is designated by the contact points A, B, and C. Considering either of the assemblies, a 360° rotation will cause the magnitude of the a-c voltage between any two of the contact points to vary sinusoidally through a complete cycle. This is precisely what occurs between any two of the output leads of a synchro generator, and it is evident that the 1-speed and the 36-speed compass voltages are faithfully reproduced or relayed by this arrangement. The reference voltage which is used in the positioning system of the SR equipment is applied to the coil of the commutator transformer, and the positioning voltages are the 1-speed and the 36-speed outputs of the commutator transformer. The compass reference and positioning voltages are therefore used only to position the components of the Synchro Amplifier, resulting in a load upon the compass synchros which is well beneath their rating. The commutator transformer and connections are sufficiently heavy to carry the entire synchro load of the SR equipment with a wide margin of safety.

c. ELECTRONIC AMPLIFIER.

(1) The function of the Electronic Unit is to accept the 1-speed and the 36-speed signals from the

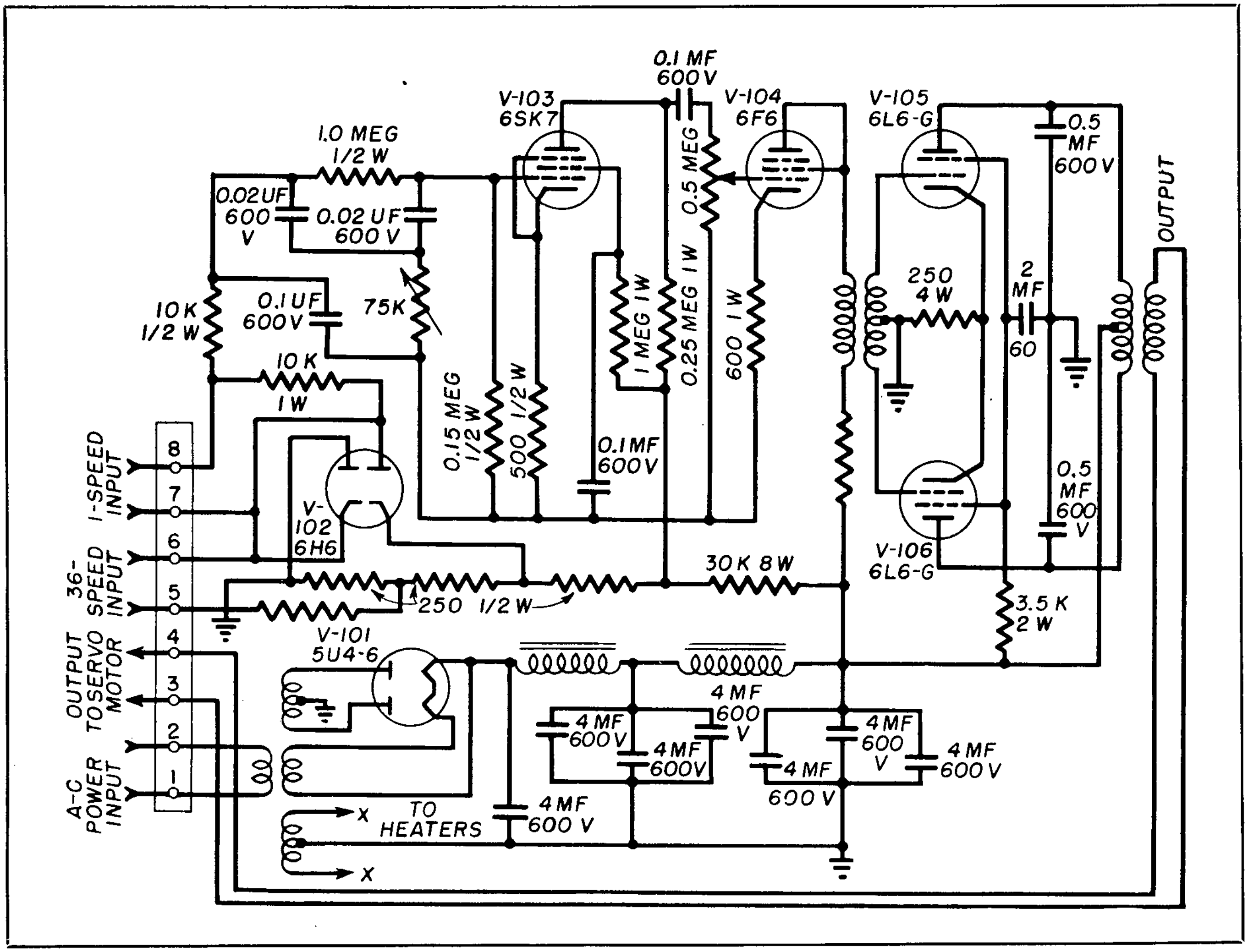


Figure 2-98. Servo Amplifier in Synchro Amplifier, Simplified Diagram

synchro generators of the compass, mix them properly, amplify the result and from them supply a voltage to the servo motor of the Synchro Unit. This voltage must be of correct magnitude and polarity to drive the servo motor in the proper direction to eliminate the positional error between the rotor of the synchro generator in the compass and that of the 5CT control transformer in the Synchro Unit. The schematic diagram of the Electronic Unit is shown in Fig. 2-98. The Electronic Unit, with the exception of its input circuit, is a conventional two-stage audio amplifier followed by a push-pull power amplifier stage. The input circuit will be considered in detail, since it is this circuit which combines the 1-speed and 36-speed input voltages, and which provides the anti-hunt features of the Synchro Amplifier.

(2) The simplified equivalent input circuit is shown in Fig. 2-99. It contains all components of the input and anti-hunt circuits which drive the 6SK7 tube V-103, which is the input stage of the conventional amplifier. The 1-speed and the 36-speed input voltages are represented by e_1 and e_2 respectively, in series with the internal impedance of the synchro, Z_g. The two sections of the 6H6 rectifier tube V-102, are represented as T_1 and T_2. For the purpose of analysis of the 1-speed and 36-speed mixing circuit, the impedance presented to it by the anti-hunt and amplifier input circuit is represented by Z_0. It is the voltage e_0, developed across the input impedance Z_0, which determines the relative effect of the 1-speed and 36-speed voltages on the positioning output of the Synchro Amplifier.

(3) The way in which the input circuit accepts the input synchro voltages depends upon whether the instantaneous polarity of these input voltages is negative or positive with respect to the side of the input which is common to both synchros. The effective circuits for voltages of either polarity, either 1-speed or 36-speed, are shown in Figs. 2-100 and 2-101. Consider first the impedance presented to the 1-speed voltage referring to Fig. 2-100. When its polarity is positive with respect to the common junction of the synchros, T_1 conducts, and presents a low resistance, so that the synchro voltage e_1 is applied directly to Z_0.

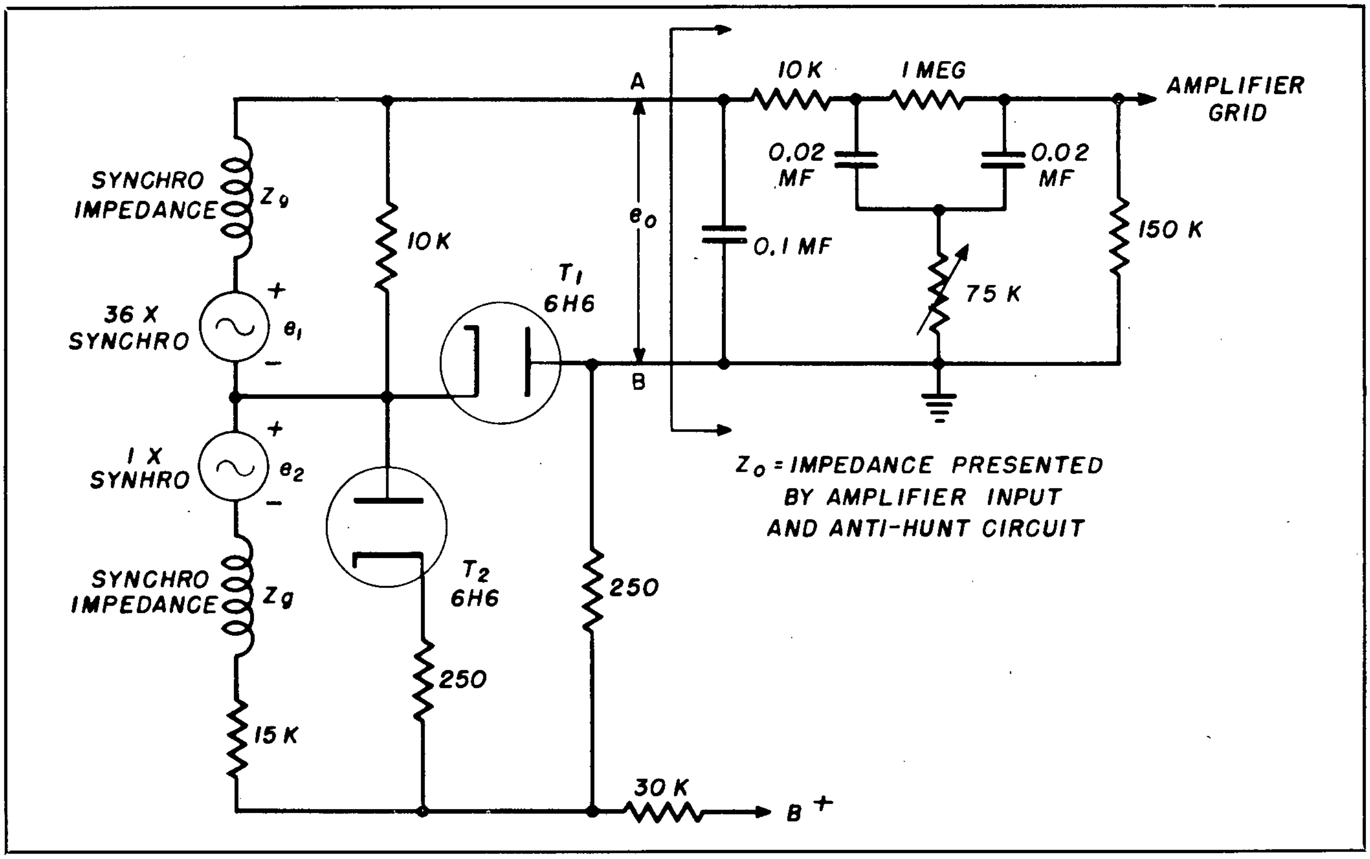


Figure 2-99. Equivalent Input Circuit of Synchro Amplifier

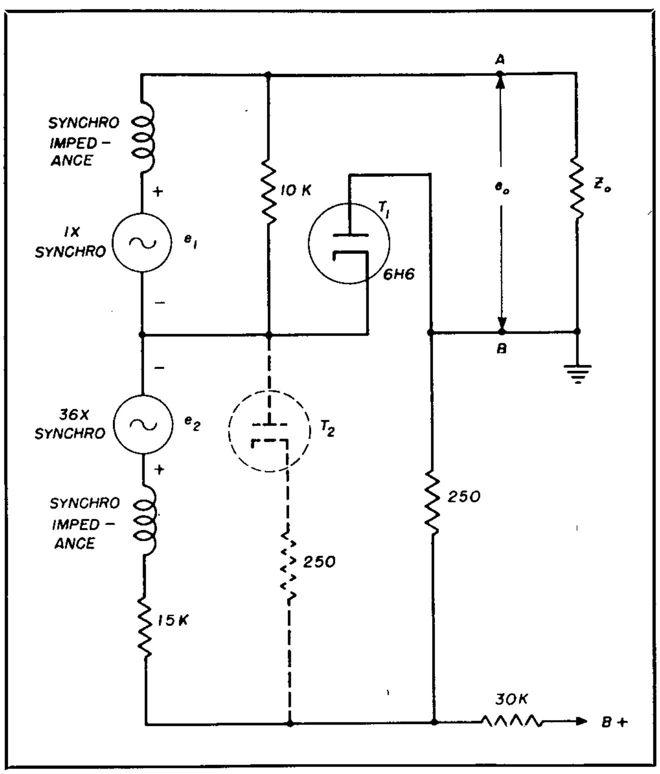


Figure 2-100. Equivalent Circuit for Positive One-Speed or 36-Speed Voltages

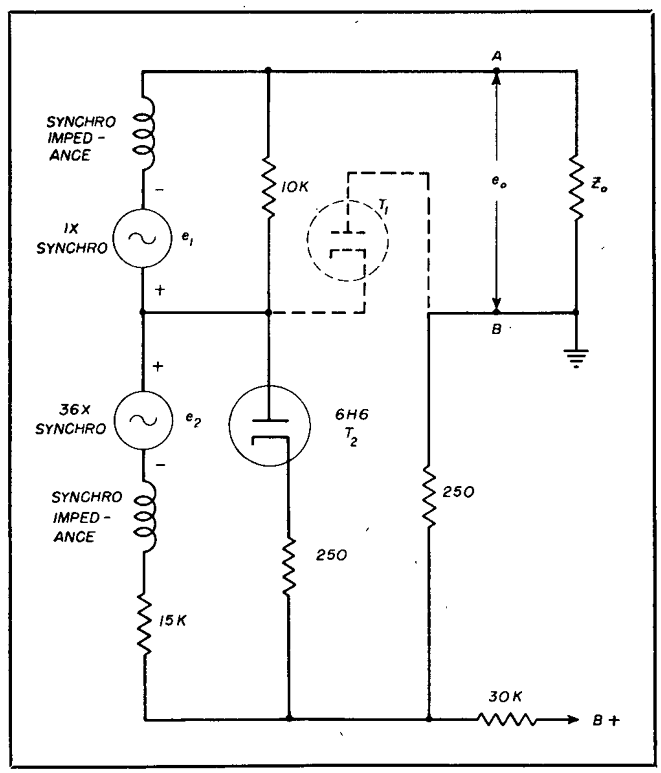


Figure 2-101. Equivalent Circuit for Negative 36-Speed or One-Speed Voltages

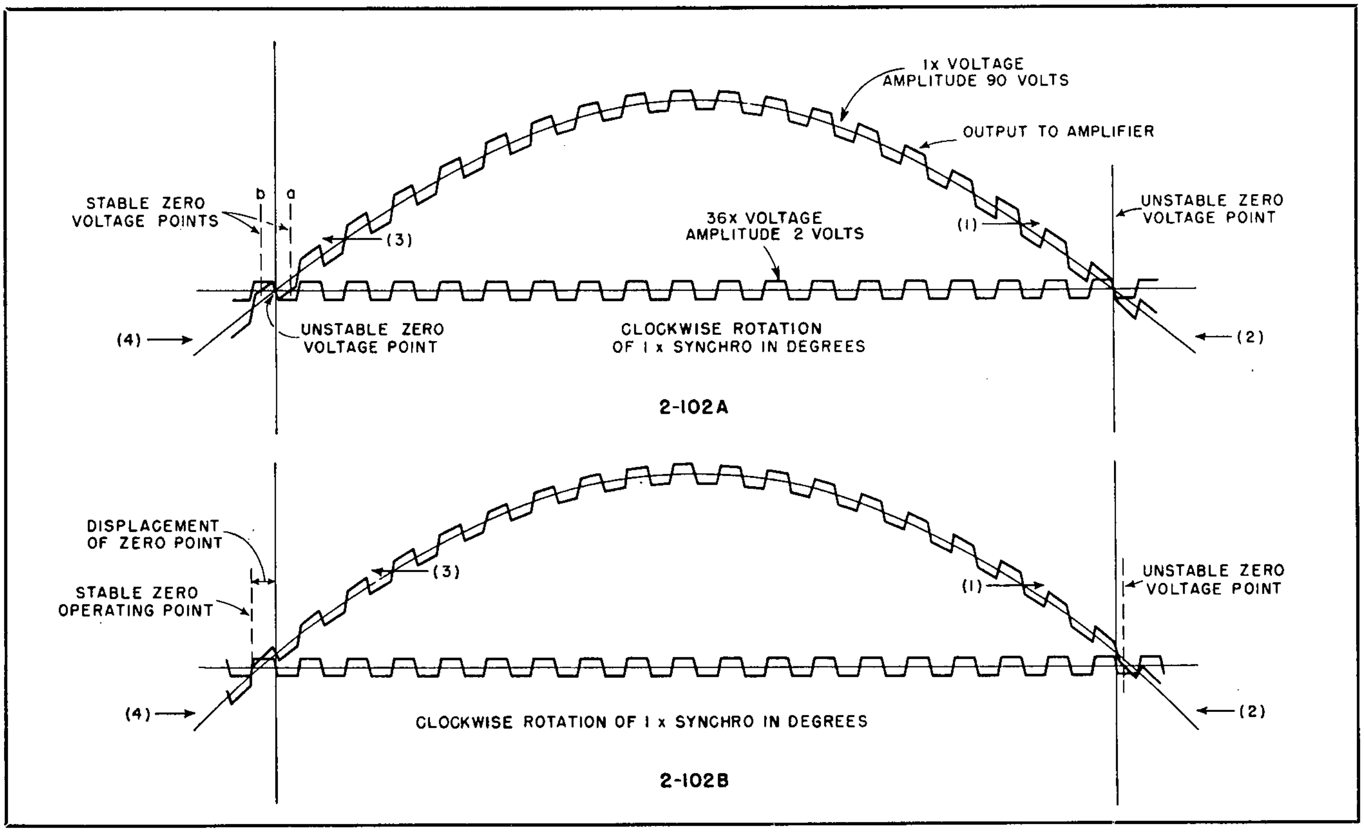


Figure 2-102. Voltage Relationships in Input Circuit of Synchro Amplifier

A diode passes an appreciable plate current even with no voltage applied to the plate, because of what is known as the *Edison effect.* This means the potential of the plate with respect to the cathode must be made a specific negative value in order to cut the tube off. Referring to Fig. 2-100, it may be seen that until e_1 at the plate of T_2 becomes sufficiently negative to overcome the Edison effect in T_2, this diode will also conduct. This makes no appreciable difference in the output, however, since the resistance presented by T_1 is very low, and a conducting T_2 only shunts another low impedance in parallel with T_1. When the polarity of e_1 is negative as shown in Fig. 2-101, the plate of T_2 is positive and it conducts, presenting a low resistance to the passage of current, so that e_1 is again applied directly to Z_0. Until e_1 reaches a value sufficiently negative to overcome the Edison effect, T_1 will also conduct, but as has been mentioned in the case of positive values of e_1, this does not appreciably affect the appearance of e_1 across Z_0. It must be remembered that e_1 and e_2 are 60 cycle voltages whose amplitude is determined by the angle of rotation of the shaft of the synchro, and whose polarity with respect to the reference voltage which induces them depends upon the direction in which the synchro was rotated from the point of zero voltage. Therefore, since either polarity of the 60 cycle e_1 is applied to Z_0 with no appreciable decrease in amplitude, it follows that e_1 is reproduced with no attenuation.

(4) The 36-speed voltage is not reproduced at Z_0 in the same manner as e_1. When e_2 is positive with respect to the common junction of the synchros, T_1 conducts and presents a low resistance to the current flowing in the circuit of e_2, as shown in Fig. 2-100. Since the only portion of e_2 which can be applied to Z_0 is that developed across the low resistance of the conducting T_1, practically none of e_2 appears in the output under this condition. If it were not for the bias applied to T_1, this situation would hold at all times, and e_2 would have no effect on the operation of the circuit. This bias is obtained from the circuit from B+ through the synchro units to ground. The connection of the cathode of T_1 to this circuit places it at a potential approximately equal to the drop across the 250-ohm resistor that is in series with ground, the 30 K resistor, and B+. However, because of the bias, T_1 does not begin conducting until the value of e_2 has reached a definite positive value. T_1 does not, therefore, begin to conduct until the potential of e_2 reaches approximately two volts positive. On the negative portions of the e_2 cycle, as shown in Fig. 2-101, T_1 is non-conducting, but T_2 conducts to effectively short-circuit the output of e_2 as far as the negative portion of this voltage applied to Z_0 is concerned. The effect of eliminating the negative half of the 60 cycle e_2 wave is to reduce its rms value. However, this action has no material effect upon the operation of the circuit.

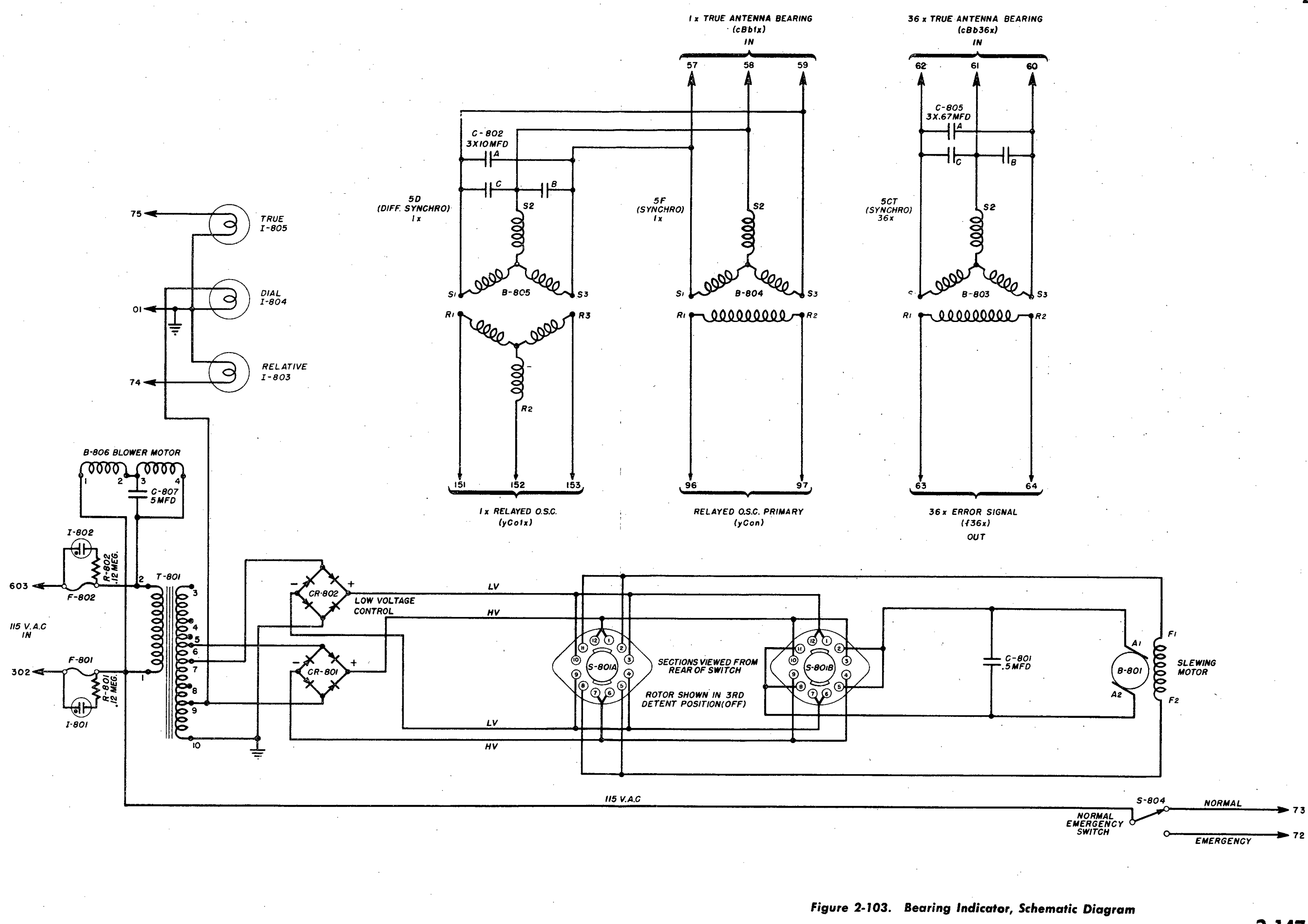


Figure 2-103. Bearing Indicator, Schematic Diagram

(5) Before the potential of e_2 reaches the two-volt value necessary for the limiting action of the diode to take effect, the 36-speed voltage is applied in series with the 1-speed voltage across Z_0. The voltage wave applied to the amplifier input circuit Z_0 is therefore the sum of the 1-speed and the 36-speed voltages. This output voltage is shown in Fig. 2-102. In Fig. 2-102 the horizontal distance represents degrees of rotation of the 1-speed system. The vertical distance represents the rms amplitude of a 60-cps voltage. Both the one-speed and 36-speed amplitudes are plotted on the vertical distance. The positive vertical distance represents a 60-cps voltage that has the same polarity as the reference voltage that produced it. The negative vertical distance represents a 60-cps voltage with a polarity opposite to the reference voltage. As shown in Fig. 2-100, the polarity of the induced voltage reverses for each 180 degrees of rotation of the synchro unit producing it. The polarity with respect to a zero voltage point depends upon whether the synchro rotates in a clockwise or counterclockwise direction from the zero point. The voltage waveform in Fig. 2-102 is the voltage obtained at the input terminals of the bridged-T filter in the input circuit of V-103 in Fig. 2-97 when the one-speed synchro rotates 360 degrees and the 36-speed synchro generator rotates through 36 times 360 degrees. This voltage is applied through the amplifiers to one of the windings in a two-phase servo motor. The other phase for this motor is obtained from the reference voltage circuit through a phase-shifting capacitor. The motor turns in one direction when the voltage shown in Fig. 2-102 is in phase with the reference voltage and turns in the opposite direction when the voltage in Fig. 2-102 is out of phase with the reference voltage.

(6) Consider the zero voltage position of the rotor, designated by the 180° angle of rotation in Fig. 2-102, as the point of equilibrium of the system. When the amplifier output is in phase with the reference voltage, the motor rotates the rotors of the synchro control transformers in a direction that reduces their output to zero. The direction of motor rotation is represented by arrow (1) in Fig. 2-102. If the compass synchro moved in the opposite direction, the voltage output of the amplifier would reverse its phase and the motor would turn in the opposite direction as represented by arrow (2) of Fig. 2-102. These directions of rotation are such as to reduce the output of the rotor to zero. When this occurs, the motor no longer turns and the system is in equilibrium.

(7) The system operates satisfactorily at the 180 degree point, but it is apparent from Fig. 2-102 that the same polarities of voltage exist at the zero degree point so that the system will also be in equilibrium at this point. In order to operate satisfactorily, the system can be in equilibrium, or "lock in" at only one point. Otherwise the calibrations of the indicator dials would be meaningless. In order to correct this difficulty, suppose the connections to the motor be reversed, so that the direction of rotation is as shown by arrows (3) and (4) on Curve A of Fig. 2-102. The system will now be unstable at both the zero point and the 180° point, but will be in equilibrium at points (a) and (b), since the direction of rotation of the motor at small displacement angles from these points will be such as to cause the rotor to return to the zero output position. Zero voltage points (a) and (b) occur because at these points the 36-speed voltage is equal and of opposite polarity to the 1-speed voltage, causing a cancellation. The system remains unsatisfactory, however, since the curve of total output voltage has two stable points of zero output. If the axis of the 1-speed voltage could be displaced with respect to the zero voltage axis, the curve of total voltage would be raised with respect to the zero axis, and one of the zero points would be eliminated. This is accomplished by transformer CB-26105 shown in Fig. 2-97. By means of this transformer a constant a-c voltage of approximately two volts peak is added in series with the 1-speed voltage. This voltage is derived from the reference voltage and therefore is in phase with it regardless of the rotation of the synchro control transformers. The resulting output voltage curve is shown as Curve B in Fig. 2-102. It has only one stable zero voltage point, which is the condition required for satisfactory operation. This voltage is applied to the servo motor, and permits the system to lock in at only one point, so that the position of the synchro control transformers with respect to the generator synchros in the gyro-compass is always the same.

(8) The anti-hunt circuit incorporated into the Electronic Unit is that portion of the circuit between the points "A-B" and the amplifier grid of Fig. 2-99. The function of this circuit is to cause the rotors of the synchros to stop when the voltage to the servo motor is zero, and not to overshoot this point because of their mechanical inertia. This overshooting is referred to as "hunting." The anti-hunt circuit is of the same type as used in the servo system of the PPI Unit, and has been described in conjunction with that unit in Par. 17*j*.

22. BEARING INDICATOR.

a. GENERAL.

(1) The Bearing Indicator is located for convenience in the Indicator Console. It has two primary functions. One is to display the bearing of the antenna and the other is to provide an artificial error voltage to permit the antenna to be rotated continuously or to permit the antenna to be trained on a particular target. In the original SR Equipments, the voltage for continuous rotation was normally supplied by a small d-c slewing motor which rotated a synchro generator

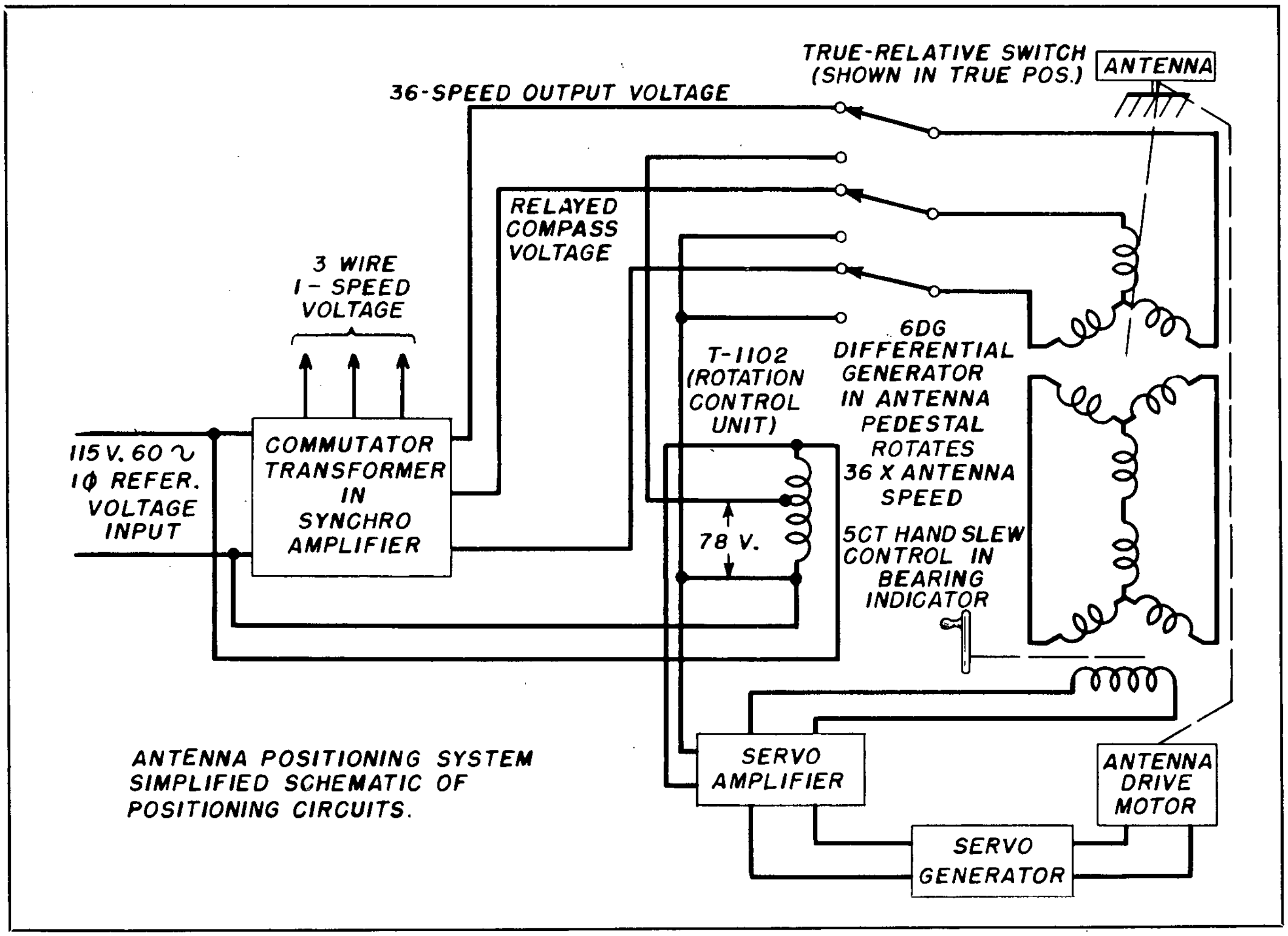


Figure 2-104. Bearing Indicator Antenna Positioning Circuits

that delivered an output voltage to the Servo Amplifier. For emergency operation a d-c rectifier in the Rotation Control Unit was used to continuously rotate the antenna. For manually positioning the antenna, a small handwheel is used to drive the synchro generator that excites the Servo Amplifier.

(2) Experience has shown that combat conditions require continuous rotation of the antenna practically all the time. In order to relieve the servo system of the burden of continuous operation, Navy Field Change No. 28 changed the circuits so that for continuous operation, power for the antenna drive motor is normally obtained from the rectifier in the Rotation Control Unit. The servo system is used continuously only in case of emergencies. Manual operation is still controlled by the servo system.

b. ANTENNA POSITIONING CIRCUITS.

(1) The Bearing Indicator consists of a power supply, a 5D differential synchro unit, a 5F synchro motor, a 5CT synchro generator, and a d-c drive motor for the 5CT. The complete circuit is shown in Fig. 2-103. The output of the 5CT synchro B-803 is coupled to the input circuit of the Servo Amplifier in the Rotation Control Unit. The stator voltages for B-803 are taken from the rotor of 36-speed differential synchro in the Antenna Pedestal as shown in Fig. 2-104. The position of the rotor of B-803 is determined by the handwheel or by the rotation of the slewing motor B-801 shown in Fig. 2-103. The slewing motor may be operated at two speeds and its direction of rotation is reversible. The speed and direction of rotation are selected by switch S-801, which is the SLEWING MOTOR switch on the front panel of the unit. The switch has five positions. The center position is the off position, while the two right-hand positions cause the antenna to slew in a clockwise direction at either 1¼ or 5 rpm. The two left-hand positions cause the antenna to slew in a counterclockwise direction at the same rates.

(2) The rectifier circuit is connected so as to have two output voltages. One is higher than the other. The switch applies high voltage to the field and low voltage to the armature for one speed, and low voltage to the field and high voltage to the armature for another. The polarity of one voltage is reversed to reverse the motor. The primary of transformer

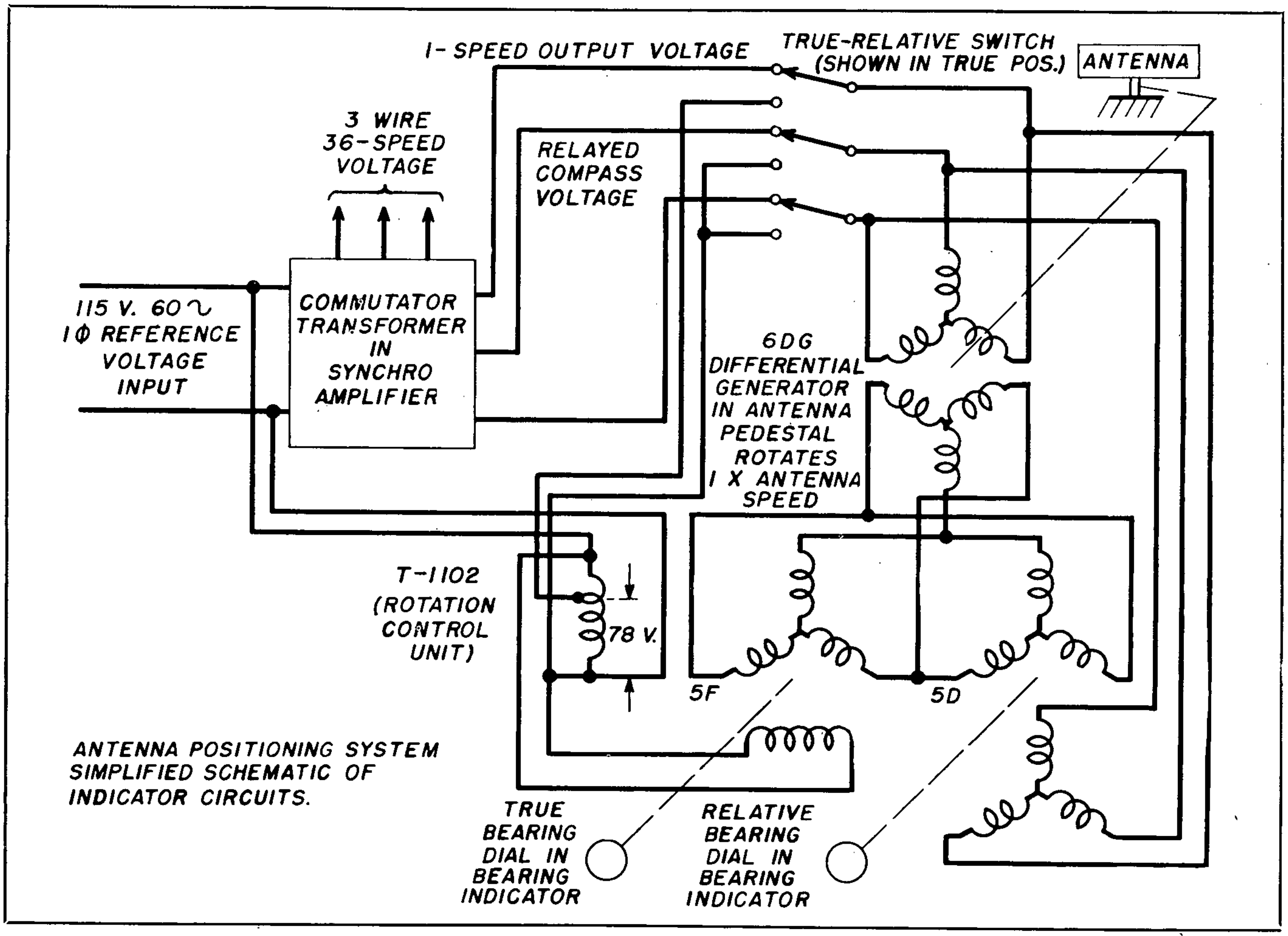


Figure 2-105. Bearing Indicator, Antenna Bearing Repeater Circuits

T-801 is fused by fuses F-801 and F-802. Indicator lights are connected across these fuses to indicate when a fuse blows. The blower motor is connected across the a-c line. This motor is mounted so that its air stream is directed upward to the bottom of the Range Scope chassis in the right-hand cabinet. The output from transformer T-801 is obtained from variable taps and is rectified by the dry disc rectifiers CR-801 and CR-802. Low slewing motor speeds are obtained by connecting the low voltage output of CR-802 to the armature of B-801 and the high voltage output of CR-801 to its field. This is done by means of switch S-801. The 5-rpm speed is obtained by connecting CR-802 to the field and CR-801 to the armature.

(3) Two bearing indicator lamps are provided in the unit. One of these lamps is illuminated when the set is on true bearing, and the other when it is on relative bearing to indicate to the operator which bearing system is in use. There is also a pilot light behind both dials which lights up when true bearing is in use. This light is extinguished when the set is on relative bearing. At that time, the true bearing dial does not indicate true bearing due to the fact that compass voltages are not supplied to the 6DG in the Antenna Pedestal. Instead, a fixed reference voltage is used as shown in Fig. 2-104.

c. BEARING REPEATER CIRCUITS.

(1) The bearing repeater circuits consist of the 5F synchro motor B-804 and the 5D synchro differential motor B-805. A simplified diagram of these circuits is shown in Fig. 2-105. In true bearing operation the TRUE-REL switch on the Rotation Control Unit connects the relayed compass voltage to the stator windings of the one-speed 6DG in the Antenna Pedestal. The output of the 6DG rotor is proportional to the true bearing of the antenna and is connected to the stator windings of the 5D and 5F synchro motors in the Bearing Indicator. The single winding rotor of the 5F synchro B-804 is connected to the reference voltage and the dial on the shaft of this unit indicates true bearing. The three-winding rotor of B-805 is connected to the relayed compass voltage and the compass component present in the stator of the 5D is subtracted out leaving the relative component which is displayed on the dial. The shaft of the 5D always rotates through an angle proportional to the angle

between the heading of the ship and the direction of the antenna.

(2) In relative bearing operation a fixed 78-volt reference voltage is connected through the switch to the stator of the 6DG and the rotor of the 5D. A 115-volt potential from the same source is connected to the rotor of the 5F synchro. These voltages are obtained from transformer T-1102 in the Rotation Control Unit. With this type of connection, both dials indicate relative bearing. See Fig. 2-105.

23. ROTATION CONTROL UNIT.

a. GENERAL.

(1) The Rotation Control Unit is the principal component in the antenna positioning system. It supplies voltage to the antenna drive motor for both types of operation described in this paragraph. The Rotation Control Unit consists of a case containing the Servo Amplifier and the Rectifier Power Unit. The top of the Rotation Control Unit case contains the terminal boards to which the external connections of the Servo Amplifier and the Rectifier Power Unit are connected. It also contains two switches. One of the switches is the SYNCHRO SYSTEM switch. In its O.S.C. position, the equipment operates on true bearing. In the A-C position, the equipment operates on relative bearing. The other switch is the REMOTE INDICATORS switch. In its ON position, antenna positioning data is supplied to the Indicator Console and to any other remote indicators connected to the SR system.

b. SERVO AMPLIFIER.

(1) The function of the Servo Amplifier is to amplify any error voltage that may appear in the system and apply a d-c voltage to the exciter of the Servo Generator to enable it to deliver an output to the antenna drive motor. The polarity of this voltage is such as to rotate the drive motor in a direction to reduce the error. The circuits of the Servo Amplifier are shown in Fig. 2-106.

NOTE

THESE CIRCUITS ARE MODIFIED BY NAVY FIELD CHANGE No. 31-SR WHICH ADDS ANTI-HUNT NETWORKS IN THE GRID CIRCUITS OF V-1101.

V-1101 is a type 6SL7-GT and it functions as an amplifier for the error voltage obtained from the output of the 5CT synchro generator in the Bearing Indicator and a bias rectifier for V-1102 and V-1103. V-1102 and V-1103 are type 807 tubes and they function as rectifiers to produce a d-c voltage across the field of the exciter in the Servo Generator. The a-c voltage that is rectified for the excitation voltage is obtained from transformer T-1101.

(2) The operation of the Servo Amplifier is rather complex because all voltages applied to the tube elements are a-c voltages and because the circuit is not grounded at any point and therefore there is no natural reference point. In order to properly visualize the functions of the circuit, it is necessary to arbitrarily select a reference point to which all voltages can be measured. This point may be taken at any point in the circuit. In this discussion the reference point is terminal 5 of transformer T-1101 unless stated otherwise. Fig. 2-106 shows wave forms such as would appear on an oscilloscope synchronized so that the beginning of the sweep is on the peak of the cycle. The total output of the transformer is 300 volts at a frequency of 60 cps. This voltage is applied across a series circuit consisting of the exciter field in the servo generator, the RC circuits in the plate circuits of V-1102 and V-1103, the tubes themselves, and the balancing potentiometer R-1112. Transformer T-1101 is tapped at a 35-volt point with respect to terminal 3 and the voltage from this point is applied to the plates of V-1101 through plate loads consisting of parallel RC circuits.

(3) When the system is in a state of equilibrium, there is no output from the 5CT synchro generator in the Bearing Indicator. Since the 5CT is connected to transformer T-1103, there is no output from the secondary winding of this transformer to be applied to the grids of V-1101. The cathodes of V-1101 are connected together and returned to terminal 3 of transformer T-1101 through resistor R-1116. This arrangement provides coupling between the two sections, degeneration for each section and a certain amount of cathode bias. From Fig. 2-106 it can be seen that the plates of V-1102 and V-1103 are alternately positive and negative with respect to their cathodes. Therefore V-1102 and V-1103 act as grid controlled half-wave rectifiers, each tube drawing current through one-half of the exciter field in the Servo Generator. Note that the currents in the exciter field flow in opposite directions and the magnetic fields produced by them cancel each other when the amplitudes of the currents are equal. The grids of V-1102 and V-1103 are connected to terminal 4 on transformer T-1101 through the parallel RC combinations in the plate circuits of V-1101A and V-1101B as shown in Fig. 2-106.

(4) Assume that no error exists in the system and that the plates of V-1102 and V-1103 are passing through zero potential and beginning their positive excursion. At this instant, the plates of V-1101 are starting their negative excursion. As time continues, the grids and plates of V-1102 and V-1103 have a positive going sinusoidal voltage applied to them and plate current flows in both tubes. Since equal voltages are applied to both tubes, there is a tendency for the plate currents to equal each other. As the potential applied to the grids increases, they draw more and more current. The grid current charges capacitors C-1103 and C-1104 to provide a negative bias. The time required for the bias to build up is determined by the grid-

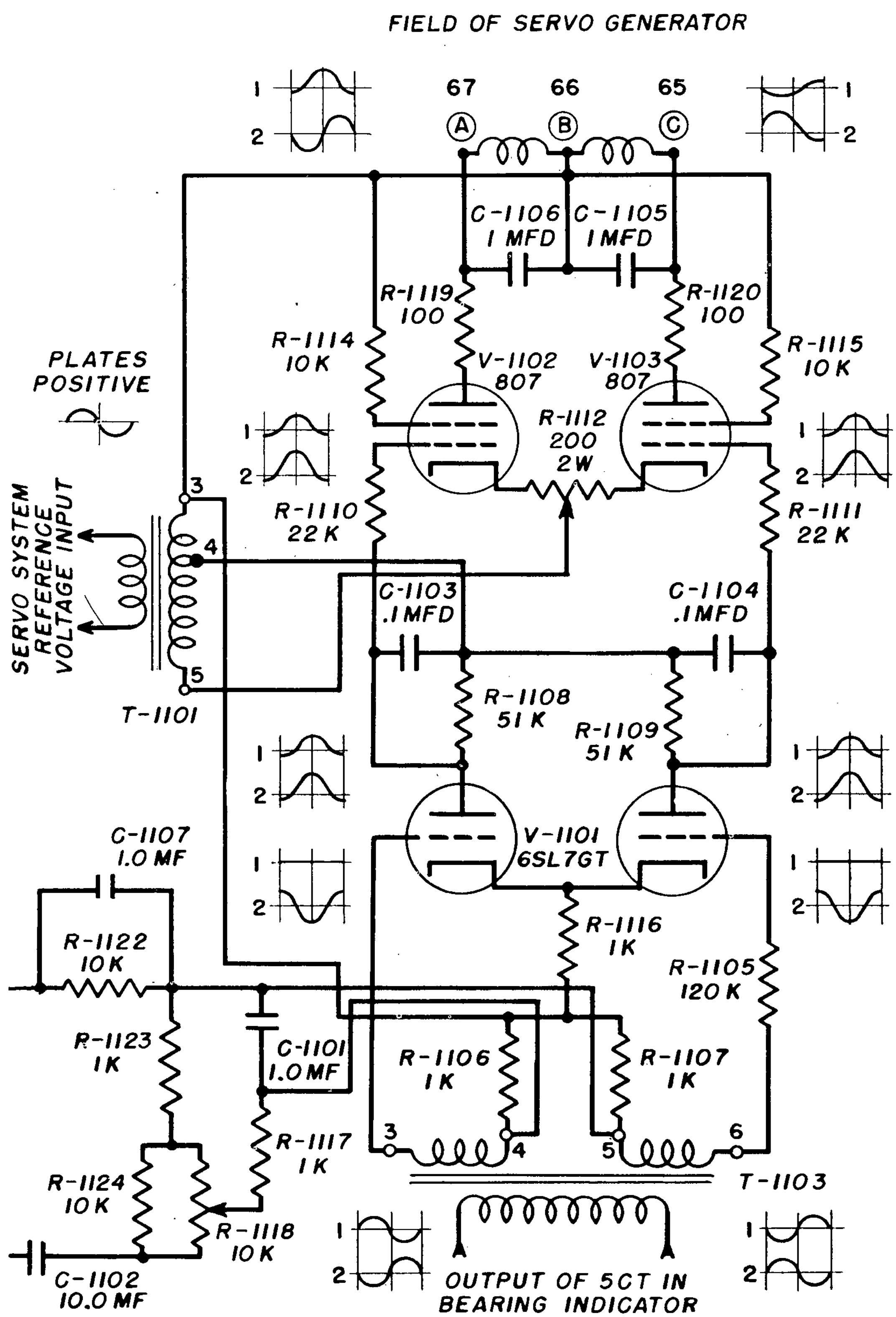


Figure 2-106. Servo Amplifier, Simplified Diagram

cathode resistance of the tubes and by the series resistors in the grid circuit and the parallel resistors associated with capacitors C-1103 and C-1104. For example, R-1110 delays the bias sufficiently to allow the average value of plate current in V-1102 to equal the maximum value of current required to energize the exciter field. R-1108 which shunts C-1103 determines the amount of bias applied to the grid of V-1102. R-1108 therefore functions as a grid leak resistor for V-1102.

(5) During the time when V-1102 and V-1103 are conducting, their plate current, flowing through the exciter field, lags the applied voltage because the current through the secondary winding of transformer T-1101 cannot be in phase with the voltage across the transformer. The capacitors shunting the capacitor field reduce this phase angle to approximately 45 degrees during the period of conduction. The voltage on the grids of V-1102 and V-1103 lags the transformer voltage by approximately 42 degrees. When the voltage on the plates of V-1102 and V-1103 is going from zero through 300 volts and back to zero, the voltage on the grids of the tubes is leading it 3 degrees and is going through zero to —34 volts and back to zero. This —34 volts is the sum of the —299 volt rectified charge on capacitor C-1103 and the ±265-volt rise across the transformer which is applied to the grid. Under this condition, the d-c value of the current flowing in each half of the exciter field is approximately 30 ma. V-1101 has no effect upon the grid bias of V-1102 and V-1103 as long as there is no error in the system. The cathode bias developed by the minute amount of plate current flowing in V-1101 reaches an rms value of approximately 0.4 volt which biases both sections of the tube near cut-off. The voltage across V-1101 is in phase opposition to the voltage across V-1102 and V-1103. Consequently V-1101 is non-conducting because its plates are negative with respect to its cathode when V-1102 and V-1103 are conducting. When the plates of V-1102 and V-1103 are negative with respect to their cathodes, the plates of V-1101 are positive with respect to their cathodes but the tube cannot conduct because its grids are biased at cut-off.

(6) The conditions described above exist during each positive excursion of the voltage across transformer T-1101. During the time when this voltage is going negative, the rectified voltage on capacitors C-1103 and C-1104 discharges through their respective parallel resistors and when the next positive excursion starts the charge on the capacitors is zero.

(7) When the 5CT synchro unit in the Bearing Indicator delivers an output voltage to transformer T-1103, the grid bias conditions described above are altered. The error voltage across the secondary windings of T-1103 will be exactly in phase with the output from transformer T-1101 at grid 1 of V-1101A or else it will be exactly out of phase in which case it would be in phase at grid 4 of V-1101B. The polarity depends upon the direction in which the rotor of the 5CT synchro has been rotated and the amplitude depends upon the size of the displacement angle. Assuming that the maximum displacement error in the system is one-half of one degree, the amplitude of the 5CT is 0.5 volt for maximum error. The output from each secondary winding of T-1103 is 1 volt for an input of 0.5 volt. The step-up ratio is necessary because of the necessity for the 120K ohm series limiting resistors R-1104 and R-1105 in the grid circuits of V-1101. These resistors are required to prevent the possibility of overdriving V-1101 each time the equipment is placed in operation when there is a possibility of large errors existing in the antenna positions system.

(8) Consider the instant at which power is first applied to the circuit and assume that grid 1 of V-1101A is excited with an error voltage that is in phase opposition to the applied voltage on the plates of V-1102 and V-1103. The excitation on grid 4 of V-1101B will be in phase with the applied voltage on the plates of V-1102 and V-1103. Under this condition the plate of V-1101A is negative with respect to its grid and cathode when the plate of V-1102 is going positive. The plate of V-1101B is also negative with respect to its cathode but the grid of V-1101B is swinging in a positive direction. Since the plates of both sections of V-1101 are going negative, they cannot conduct during the period when V-1102 and V-1103 are conducting. During the first half of the initial cycle, V-1102 and V-1103 conduct and rectify a grid bias of approximately —24 volts. While the amplitude of the rectified bias reaches a point much greater than —24 volts, the short time constant of the grid leak permits part of this bias voltage to be discharged before the cycle ends. Also, the series resistors delay the charging of the grid capacitor as previously explained. The end result is to permit the flow of an average current that is equal to the current that would flow if the applied plate voltage were a d-c voltage and the bias a d-c potential of —24 volts. The conditions just described permit V-1102 and V-1103 to both draw 28 to 30 ma through their portions of the exciter field during the first half of the initial cycle. Since the field currents are equal and in opposite directions, the flux intensity is zero and the output of the exciter is zero. In order to allow for differences in tube characteristics, resistor values and capacitor values, the balancing potentiometer R-1112 is placed in the cathode circuits of V-1102 and V-1103 as shown in Fig. 2-106. By means of this control, the bias of the two tubes can be adjusted until their plate currents are equal.

(9) After the passage of the first half of the initial cycle, the plates of V-1102 and V-1103 swing negative and the tubes are cut off. At the same time

the plates of V-1101 swing in a positive direction. The grid of V-1101A which is excited in phase opposition to the plates of V-1102 and V-1103 is also swinging in a positive direction. Therefore, V-1101A conducts. The grid of V-1101B is going negative however, and this section remains cut off. V-1101A is permitted to conduct because the short time constant in its plate circuit discharges capacitor C-1103 before the plate of V-1101A reaches the peak of its positive excursion. The current drawn by V-1101A places an initial charge of approximately —13 volts on capacitor C-1103. Since the only resistance in series with capacitor C-1103 and the charging current is the plate resistance of the tube this charging action is much faster than the charging action due to grid current in the opposite half of the cycle. It is evident that capacitor C-1103 cannot begin to discharge until the voltage applied to the plate of V-1101A has decreased to a point where the charging voltage applied to the capacitor is less than 13 volts. This point occurs at a period in time where the negative swing of the transformer voltage is nearly completed and the voltage will soon start its second positive excursion. There is just sufficient time for the capacitor to discharge from —13 volts to a potential of approximately —8 volts when the transformer voltage passes through zero and starts its positive swing. During this time V-1101B has remained in a non-conducting condition and capacitor C-1104 is completely discharged when the voltage begins to swing positive.

(10) The positive half of the second cycle causes the grid of V-1102 to begin to draw current as soon as its potential passes zero and immediately a charging voltage with the same polarity as the remaining charge on capacitor C-1103 is applied to the capacitor. The potential of the capacitor at this time has decreased to approximately —5 volts. It has been previously shown that the flow of grid current produces a net grid voltage of —24 volts which is the sum of the total capacitor charge and the applied voltage. Since the same amount of grid current flows during each cycle, it is evident that the total charge on the capacitor will be raised from its previous value of —299 volts to —304 volts because it had a charge of —5 volts when the charging action started. With an average bias of —29 volts, the plate current of V-1102 drops to approximately 15 ma. During this same time, however, V-1103 has functioned in exactly the same way that it functioned with no error voltage. It has rectified the same bias and therefore is drawing an average current of approximately 30 ma.

(11) The currents in the exciter field are now unbalanced. The half of the field supplied by V-1102 has a potential of approximately 35 volts across it and 15 ma flowing in it. The other half of the field associated with V-1103 has the normal voltage approximately 70 volts across it and a current of 30 ma flowing through it. Since the polarities of the voltages and currents are opposing, a magnetic field exists that is equivalent to the field that would be produced by applying 35 volts in one direction across the entire field winding. Under this condition, the exciter delivers a voltage to the field of the generator in the Servo Generator and the Servo Generator delivers a driving voltage to the d-c motor in the Antenna Pedestal.

(12) If the phase of the error voltage is reversed, the conditions described above are reversed and the current through V-1103 is reduced to 15 ma. This reverses the polarity of the output to the antenna drive motor and it runs in the opposite direction. For intermediate values of error voltage, the charge placed on capacitor C-1103 or C-1104 is correspondingly less and the reduction of the plate current of V-1102 and V-1103 is also correspondingly less. Thus a small displacement angle produces less torque at the antenna drive motor than a large displacement angle produces. However, when the displacement angle exceeds a critical size, the current drops almost abruptly to 15 ma. and the motor torque is constant for all displacement angles greater than the critical angle.

(13) When the equipment is turned off, large errors can appear in the system due to an accidental movement of the Antenna Pedestal, rotation of the 5CT in the Bearing Indicator or a change in ship's course that produces a large error in the Synchro Amplifier. It is possible under extreme conditions to have an input error voltage of 55 volts to transformer T-1103. In this case the output across each secondary winding is 110 volts. This voltage exceeds the limitations imposed by the resistors in the grid circuits of V-1101 to the extent that the minute amount of plate current required to produce the cathode bias in the non-conducting section now flows to the grid instead of the plate. This prevents the capacitor in the plate circuit from receiving the small charge that it customarily receives when the plates of V-1101 are swinging positive. This charge is so small that ordinarily its effect is negligible and it has been considered as zero previously. However, the disappearance of this charge raises the bias slightly and the gain of the type 807 tubes is sufficiently high to permit the slight change in bias to cause the plate current to rise to 40 ma. In the other 807 which has its current reduced by the error voltage, the bias can increase to a point where the plate current of the type 807 tube is reduced to 5 ma. This condition is a transient condition, however, since the system quickly returns to a state of equilibrium.

(14) Anti-hunt control of the system between the Servo Amplifier and the antenna drive motor is obtained by connecting the armature of the drive motor across the input terminals of the network shown in

Fig. 2-106. If the system has a tendency to hunt, an alternating voltage will be induced in the armature of the antenna drive motor. This voltage appears across the network and the component of this voltage that appears across capacitor C-1101 is applied in series with the error voltage across the two secondary windings of transformer T-1103. The phase of the feedback voltage is such as to always be in phase opposition to the error voltage applied to the grids of V-1101. This form of degenerative feedback discourages any tendency of the system to hunt. The amplitude of the anti-hunt feedback is controlled by the adjustment of potentiometer R-1118. The frequency response of the anti-hunt network determines the actual amplitude of feedback voltage applied to the input of V-1101. The feedback voltage suffers a phase shift as it passes through the anti-hunt network, the phase angle between voltage and current being a function of frequency. Thus the feedback voltage may or may not be exactly 180 degrees out of phase with the error voltage at the grid of V-1101. The sum of the instantaneous voltages on the grid determines the effective grid voltage. Once the balancing potentiometer has been adjusted, the phase shifting characteristics of the network act to always apply the proper amplitude of anti-hunt voltage to V-1101.

(15) The Servo Amplifier chassis also contains the power supply for the field of the antenna drive motor. The field supply voltage is constant, only the armature voltage is variable as a result of the action of the Servo Amplifier just described. The field power supply consists of transformer T-1105 and the full-wave rectifier V-1104. V-1104 is a type 5U4G tube and its rectified output is delivered directly to the field of the antenna drive motor without passing through a filter. The field of the motor supplies enough inductance to remove any objectionable ripple voltage.

(16) Transformer T-1102 is shown in Fig. 2-107. The purpose of this transformer is to supply a 78-volt reference voltage to the various synchro units in the antenna positioning system during relative bearing operation. Power is applied to auto-transformer T-1102 whenever relay K-1106A is in its closed contact position. When relative data is being supplied, the contacts of relay K-1105 are open and the compass reference voltage from the synchro amplifier is not applied to the primary of the transformer T-1101 in the Servo Amplifier. It is this voltage that is rectified and used to produce a field current in the exciter of the Servo Generator, during servo operation. During relative operation, relay K-1106 applies the a-c supply voltage to the Servo Amplifier.

c. RECTIFIER POWER UNIT.

(1) The Rectifier Power Unit shown in Fig. 2-108 consists of two dry disc rectifiers which are excited by separate windings on transformer T-1104. In the original SR Equipments the Rectifier Power Unit was normally de-energized. When the Rectifier Power Unit is in use, relays K-1101 and K-1102 are in their closed contact positions and power is supplied to the armature and field of the antenna drive motor from the outputs of the dry disc rectifiers. When the equipment is controlled by the Servo Amplifier and the Servo Generator relays K-1101 and K-1102 are in their open contact positions and relays K-1103 and K-1104 are in their closed contact positions. The latter two relays apply a-c power to the a-c motor in the Servo Generator, connect the output of V-1104 to the field of the antenna drive motor and connect the output from the Servo Generator to the armature of the antenna drive motor. When the unmodified equipment is in servo operation, the antenna speeds are two and one-half rpm and five rpm in either direction. When the unmodified equipment is operating from the Rectifier Power Unit in emergency operation, the antenna rotates in only one direction at a speed of 7 rpm. In equipments modified by Navy Field Change No. 28, the normal method of operation is with the Rectifier Power Unit. The circuits have been modified to permit the antenna to be rotated at two speeds in either direction. Servo operation is still retained, but the Servo switch is normally in its OFF position.

(2) The two switches S-1105 and S-1104 are located in the top of the Rotation Control cabinet. They are operated from the front of the cabinet. S-1105 is the Synchro System switch. When it is in the O.S.C. position, relayed compass voltages are supplied to the synchro system so that true bearing operation is obtained. When it is in the AC position, the bearing indications secured are for relative bearing. In relative bearing, the normal phase of the a-c line is used as a reference voltage for the synchro units. S-1104, is the REMOTE INDICATORS switch. In its ON position, it connects one-speed, 36-speed and reference voltages to the Indicator Console and any remote indicators in use. In the OFF position, these voltages are disconnected.

(3) K-1109 and K-1110 are overload relays for protection of the antenna drive motor and Rectifier Power Unit. The primaries of the two power transformers are both protected by fuses. F-1101 protects the primary of T-1101 while F-1103 protects the primary of the Rectox transformer T-1104. F-1102 serves to protect the relative bearing transformer T-1102. T-1102 is an autotransformer which provides the 78-volt supply for the synchro system while it is operating on relative bearing.

24. SERVO GENERATOR.

a. GENERAL.

(1) The purpose of the Servo Generator is to accept the d-c output of the Servo Amplifier and amplify it to 250 volts which is used to drive the antenna

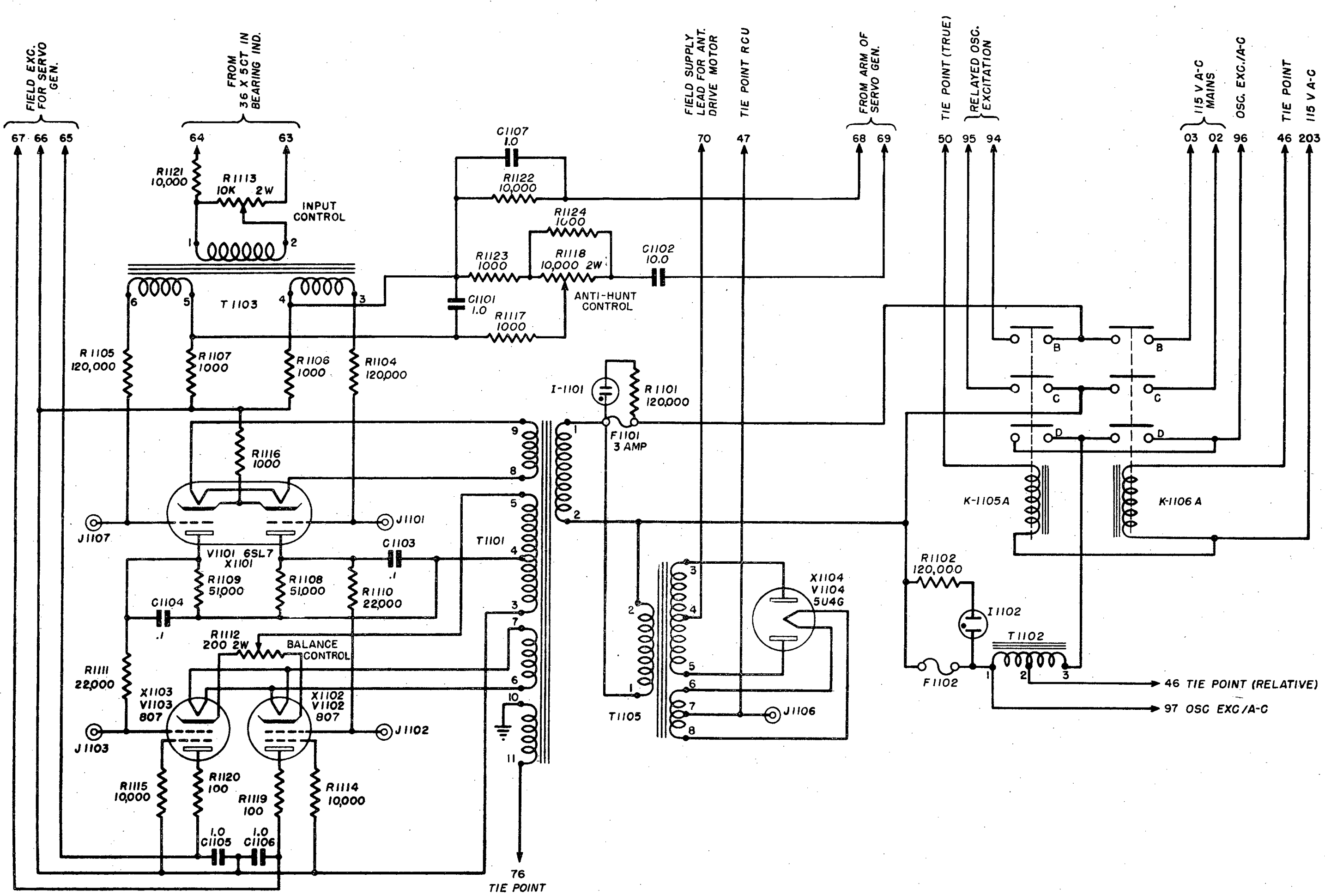


Figure 2-107. Servo Amplifier, Complete Schematic Diagram

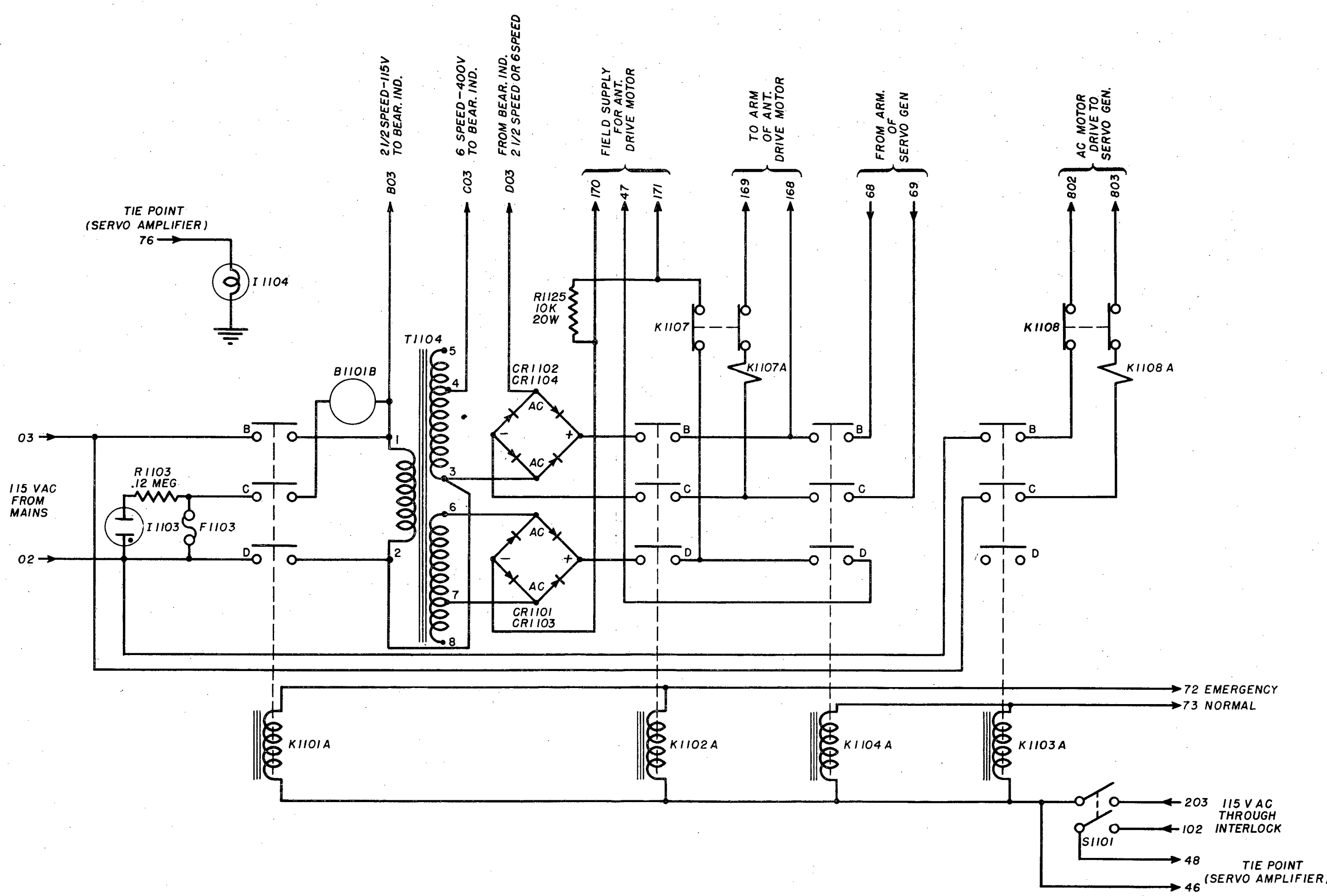


Figure 2-108. Rectifier Power Unit, Complete Schematic Diagram

drive motor in the Antenna Pedestal. The Servo Generator runs continuously during servo operation but delivers an output only when the antenna is to be rotated.

b. DESCRIPTION.

(1) The Servo Generator is a cascade generator. The output from the Servo Amplifier is applied to the field of an exciter generator. The output taken from the armature of the exciter is applied to the field of a d-c generator and the output from the armature of this generator is applied to the armature of the antenna drive motor. The simplicity of the circuit makes it unnecessary to include it here for purposes of explanation. The circuits may be found in Section 7. The exciter has a four-pole field. The exciter field is center tapped as previously noted in the discussion of the Servo Amplifier. The d-c generator field is also a four-pole field. The a-c drive motor is operated with 115 volts obtained from the main power circuits.

25. POWER SUPPLY SYSTEM (NXsr-30306).

a. GENERAL.

(1) The power supply circuits are shown in Fig. 2-109. The function of these circuits is to convert the ship's d-c power into a-c power for the SR Equipment. Two types of primary power equipment are available for the SR Equipment on Contract NXsr-30306 and are listed and described in Section 1. The principles of operation are the same for both types. The difference between the two types is that one is designed to convert 115 volts d-c to 115 volts a-c and the other is designed to convert 230 volts d-c to 115 volts a-c. Since the two types are very similar in principle, only the 115 volt system will be completely described. The discussion of the 230 volt system will be limited to the magnetic controller.

b. MAGNETIC CONTROLLER CAY-211181.

(1) The 115-volt power supply system consists of a Motor Generator set CAY-211182 and three control units. One of the control units is the Push Button Station CAY-211186 which is used to start and stop the system. Another control unit is the Magnetic Controller CAY-211181 which actually applies starting and running voltages to the d-c motor in the Motor Generator. The third control unit is the Voltage Regulator CAY-211185 which regulates the a-c output of the a-c generator in the Motor Generator. The following discussion refers to Fig. 2-109 and it is suggested that the reader follow the circuits in this figure closely, when reading the description of their operation. Power from the ship's 115-volt d-c lines is applied to input terminals L_1 and L_2 in the Magnetic Controller. The circuit goes from terminal L_1 to thermal relay K-1446. The contacts of this relay are normally closed. The circuit passes through the fuse and contacts in this relay, and goes out on terminal 4 to the Motor Generator where it enters on terminal 4 and goes through the contacts of a centrifugally operated over-speed switch. The circuit then comes out of the Motor Generator on terminal 3 and reenters the Magnetic Controller on terminal 3. From here the circuit passes out again to terminal 3 on the Pushbutton Station, goes through the front contacts of the STOP switch, which are normally closed, and then connects to one of the back contacts of the START switch and terminal 2. From terminal 2, the circuit goes through terminal 2 in the Magnetic Controller to one of the D contacts on relay K-1441. Since these contacts are normally open in the de-energized position of the relay, and since the back contacts of the START switch are normally open, the circuit is incomplete at this point.

(2) When the START button is pressed, 115 volts d-c appear on terminal 1 in the Pushbutton Station and go through terminal 1 in the Magnetic Controller to contacts K-1442-D. These contacts are normally closed when the relay is de-energized and the circuit through them is completed to the other side of the d-c line L_2, through relay coil K-1443-A. This energizes the relay, opening its B contacts and closing its C and D contacts. The opening of contacts K-1443-B removes the short circuit from resistor R-1441, placing it in series with the armature of the d-c motor in the motor generator. When contacts K-1443-C close, 115 volts d-c from terminal 1 are connected through relay coil K-1444-A to line terminal L_2, energizing the relay. Contacts K-1443-C also apply voltage to contacts K-1443-D and since these contacts close at the same time, the circuit from terminal 1 is also completed to line terminal L_2 through relay coil K-1445-A.

(3) When relay K-1444 is energized, its B contacts open to remove the short circuit from resistor R-1441 and part of resistor R-1442. See Fig. 2-109. Contacts K-1444-C close, applying 115 volts to the delay windings of relays K-1443, K-1444, and K-1445 through resistor R-1443. When relay K-1445 is energized, its B contacts open and remove the short circuit from resistors R-1441 and R-1442. Contacts K-1445-C close and apply 115 volts from terminal 1 through relays K-1441 and K-1442 to line terminal L_2. The circuit to these relays is connected to their C contacts as shown in Fig. 2-109. In the de-energized position, the contacts are normally closed and short circuit half of the relay windings. Therefore the voltage is applied across only half of the relay coils, resulting in a high current and a strong field. Once the relays are energized, the amount of current required to keep their armatures pulled in is considerably less than that required to pull them in. In order to prevent the unnecessary consumption of power, relay contacts K-1441-C and K-1442-C open to remove the short circuit across half of the relay coils. At the same time

contacts K-1441-D and K-1442-D close and connect the complete coils to the 115 volts present at terminal 2. This voltage comes from line terminal L_1, through relay K-1446, the centrifugal over-speed switch in the Motor Generator, and the STOP switch in the Push-button Station. Consequently, the D contacts of relay K-1441 lock both it and relay K-1442 in the energized position until the circuit is interrupted by one of the three components just mentioned.

(4) When relay K-1441 is energized, its B contacts close, connecting line L_1 through the thermal element of relay K-1446 and terminals F_1 to the field of the d-c motor in the Motor Generator. These contacts also connect line L_1 to one side of the armature of the d-c motor through resistors R-1441 and R-1442. Relay K-1442 operates simultaneously with relay K-1441. Its B contacts close, connecting line L_2 through the S_2 terminals to the other side of the field and armature of the d-c motor in the Motor Generator, starting the motor. Contacts K-1442-C open, reducing the current in the relay coil K-1442-A, and contacts K-1442-D open, breaking the circuit to relay K-1443-A. These contacts are in series with the back contacts of the START switch to eliminate the possibility of resistors R-1441 and R-1442 remaining in the circuit too long if the START switch is held closed. However, relay K-1443 does not return to the de-energized position immediately because there is sufficient current flowing in its delay winding to cause the magnetic field to decay gradually. When the flux intensity decreases sufficiently, the relay drops open. The delay time is determined by the setting of one section of the dual potentiometer R-1445 which fixes the values of voltage applied across the holding coil. When the delay time of relay K-1443 has elapsed, it drops open and contacts K-1443-B close, short circuiting resistor R-1441 to remove it from the armature circuit and increase the armature current. At the same time contacts K-1443-C and K-1443-D open. Contacts K-1443-C break the circuit to relay coil K-1444-A and after a delay time determined by the amount of current flowing in its delay or holding coil, it drops open. Relay K-1445 is not immediately affected by the opening of contacts K-1443-D since it is also connected to 115 volts through its own C contacts, the C contacts of relay K-1444, and the D contacts of relay K-1441. When the delay time of relay K-1444 has elapsed, it drops to the de-energized position and its B contacts close, short circuiting resistor R-1441 and part of R-1442. This further increases the armature current in the d-c motor. Note in Fig. 2-109 that when contacts K-1444-B close they parallel contacts K-1443-B through part of resistor R-1442. This arrangement permits the current increase to be carried by contacts K-1444-B alone. If the B contacts were in series, the current carried by each set of contacts would be much greater and the possibility of sticking contacts would be greatly increased.

(5) Contacts K-1444-C open when the relay is de-energized but have no effect on the holding coils since they are now connected to 115 volts through the C contacts of relay K-1445. However, contacts K-1444-C break the circuit to relay K-1445 when they open. When this occurs, relay K-1445 starts its time cycle and when its flux density has decayed sufficiently, it drops out, closing its B contacts and opening its C contacts. The B contacts short circuit resistors R-1441 and R-1442 to remove the remaining portion of resistor R-1442 from the armature circuit. This connects the armature of the d-c motor directly to the line and maximum current flows. When contacts K-1445-C open, they break the circuit to the relay holding coils, completely de-energizing the three relays. The time required for relays K-1443, K-1444 and K-1445 to drop to the de-energized position is determined by the setting of potentiometer R-1445 and it is set to cut out the last resistance from the armature circuit at the instant the motor reaches full speed. In order to stop the Motor Generator, the STOP switch is pressed, breaking the circuit to the holding contacts K-1441-D which de-energizes both relays K-1441 and K-1442. This opens the B contacts of these relays disconnecting the motor from the line. If the line current to the motor becomes excessive due to overload or mechanical difficulties, the thermal relay K-1446 opens its contacts and removes both the motor and the relays from across the power line.

c. MAGNETIC CONTROLLER CAY-211187.

(1) The Magnetic Controller used in the 230-volt supply is much simpler than the one used in the 115-volt supply because it does not have to be designed to handle as much current. The schematic diagram of the 230-volt Magnetic Controller is shown in Fig. 2-110. The circuit from terminal L_1 goes through thermal relay K-1454, the over-speed switch in the Motor Generator, and the STOP switch just as it did in the 115-volt system. Since the rest of the equipment is the same in the two circuits, only the Magnetic Controller is shown in Fig. 2-110. When the START switch is closed, 230 volts are applied through the normally closed K contacts of relay K-1451 to relay coil K-1452A. The other side of relay coil K-1452A connects to the other line terminal L_2. When this relay is energized, its B contacts open, removing the short circuit from resistor R-1453. At the same time, the normally open contacts K-1452E and K-1452F close. When the E contacts close, they connect 230 volts from L_1 to relay coil K-1453A and through this coil to terminal L_2 which is the other side of the line. The E contacts are also connected to the F contacts and the closing of the E and F contacts applies 230 volts to the holding coil circuit and to the E contacts of relay K-1453.

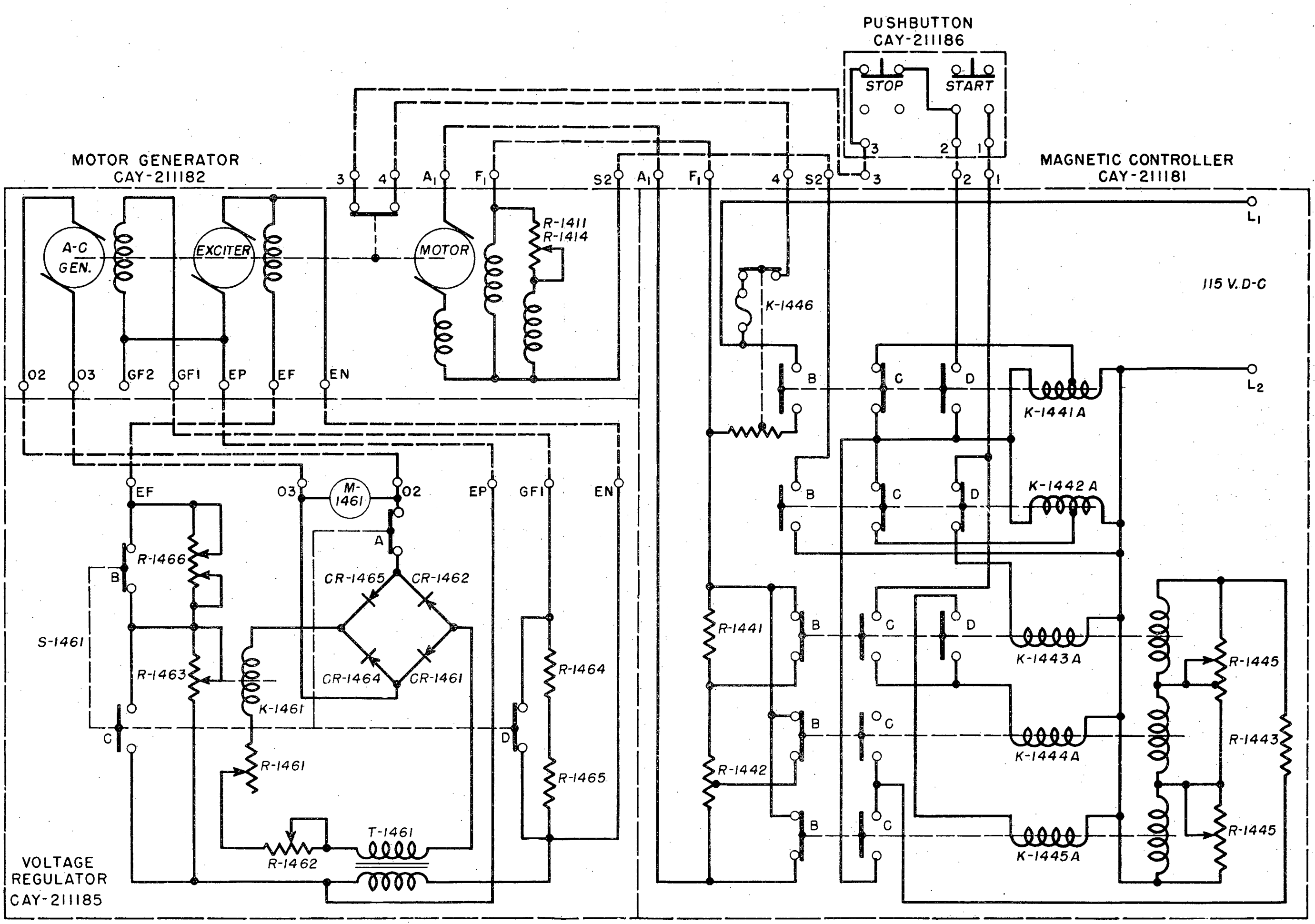


Figure 2-109. Primary Power Circuits (115 V.D.C.)

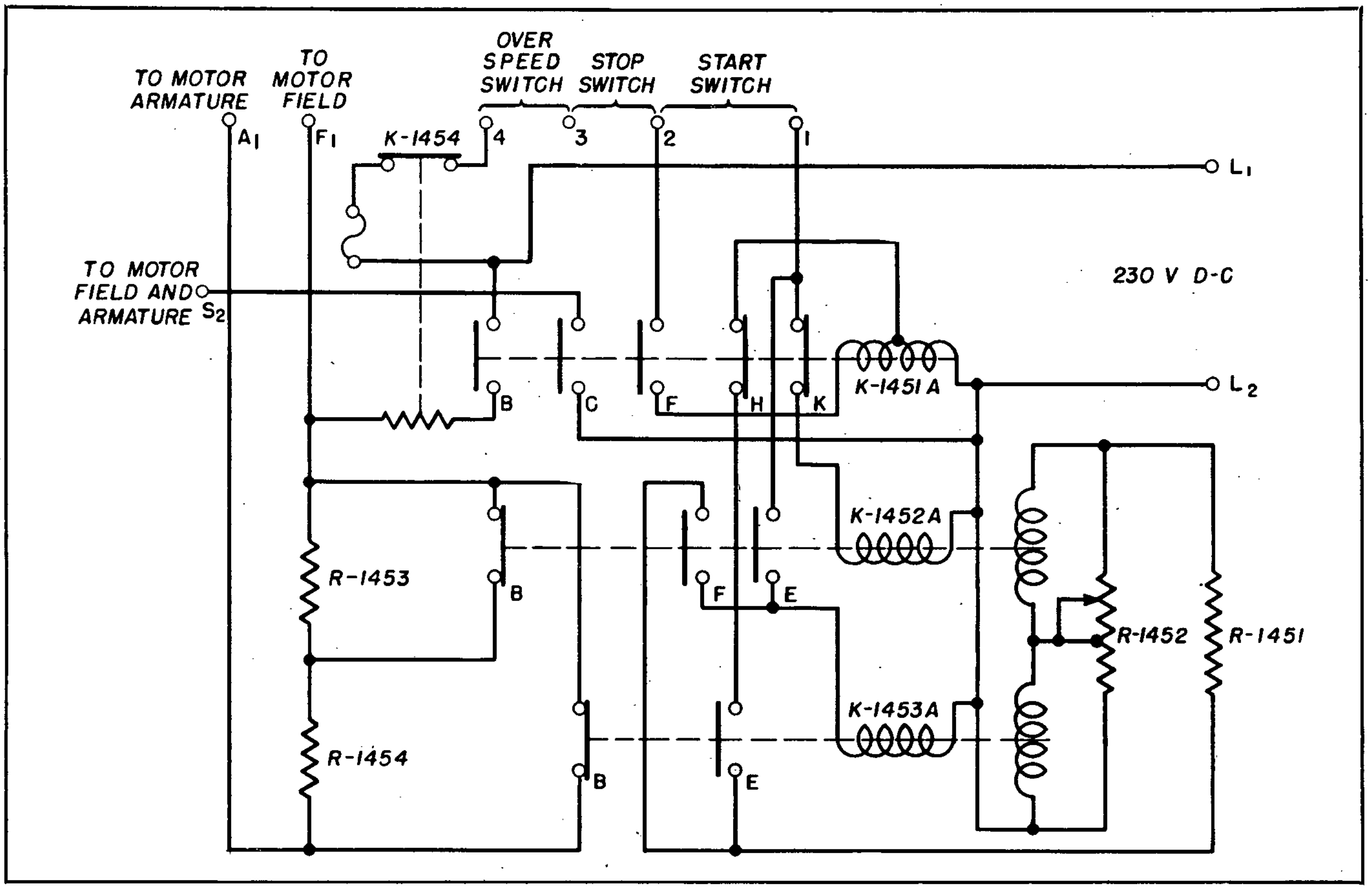


Figure 2-110. Magnetic Controller CAY-211187 (230 V.D.C.)

(2) When relay K-1453 is energized, its normally closed B contacts open, removing the short circuit from resistors R-1453 and R-1454. This places the two resistors in series with the armature of the d-c motor in the Motor Generator. Contacts K-1453E close and apply 230 volts to a portion of the relay coil K-1451A energizing the relay. When relay K-1451 is energized, its B contacts close and connect line terminal L_1 to the A_1 and F_1 terminals of the motor armature and field respectively. The C contacts close, connecting the common armature and field terminal S_2 to line terminal L_2 and the motor starts to run. Contacts F close and apply 230 volts across the entire coil K-1451A, reducing the amount of current flowing in it. This is possible because the current required to hold a relay is not as great as the current required to pick up the armature. A short time after contacts K-1451F close, contacts K-1451H open breaking this part of the circuit since it is no longer needed. Contacts K-1451K open breaking the circuit to relay K-1452A. This relay does not de-energize immediately because of the current flowing in its holding coil. This current is not sufficiently great to hold the relay, but it does cause the relay field to decay slowly. The time required for the field to decay sufficiently for the relay to return to its de-energized position is a function of the current flowing in the holding coil. The current in the holding coil is fixed by the adjustment of potentiometer R-1452. After the time delay relay K-1452 drops out and its B contacts close, short circuiting resistor R-1453 and increasing the armature current in the d-c motor. The E and F contacts open breaking the circuit to relay coil K-1453A and to the holding coil circuit. However, the holding coil circuit is still connected through the E contacts of relay K-1453 to the tap on relay coil K-1451A. Relay K-1453 remains energized until the time delay fixed by its holding coil has elapsed. When this occurs, the relay returns to its former position and its B contacts close, short circuiting resistors R-1453 and R-1454. This removes all series resistance from the armature circuit and the motor reaches its average speed. The E contacts close, breaking the circuit to the holding coils. At this point only relay K-1451 is energized and the circuit remains in this condition until the STOP switch is opened, or the over-speed switch operates breaking the circuit to terminal L_1.

d. VOLTAGE REGULATOR CAY-211185.

(1) The over-speed switch in the Motor Generator opens if the load is removed from the motor generator. When this switch opens, it disconnects the d-c motor and the relays from across the power line

since it is in series with relay K-1446. The d-c motor is mounted on the same shaft with a d-c exciter and an a-c generator. The exciter is shunt wound and its output is connected to the field of the a-c generator. The field of the exciter is in series with a variable resistor R-1463 in the Voltage Regulator. The position of a four section switch in the Voltage Regulator determines whether voltage regulation is to be accomplished by manual or automatic means. Fig. 2-109 shows this switch in the automatic position with contacts C open and contacts A, B and D closed. The dry disc bridge rectifier shown in Fig. 2-109 is connected directly across the output of the armature of the a-c generator. The armature voltage is indicated by Voltmeter M-1461. The d-c output of the bridge rectifier appears across the coil of K-1461, through potentiometers R-1461 and R-1462 and transformer T-1461. These potentiometers are adjusted so that the pull on the armature of K-1461 adjusts the spring contacts on resistor R-1463 to a point where the field current of the exciter is just sufficient to maintain an output of 115 volts from the armature of the a-c generator. If the armature voltage increases, the increased output of the bridge rectifier causes the current in coil K-1461 to increase, increasing the pull on its armature and thus increasing the amount of resistance in series with the field of the exciter. This causes a decrease in the exciting voltage applied to the field of the a-c generator and the output voltage drops to the point where the circuit balances and remains there unless otherwise disturbed. The point of balance can be changed at will by adjusting potentiometers R-1461 and R-1462.

(2) Any sharp change in voltage output would start the electro-mechanical voltage regulating system to oscillating and produce a continuous alternating swing in output voltage if some type of degenerative feedback were not provided. In order to obtain degenerative feedback, the primary of transformer T-1461 is shunted across the exciter field. The secondary of this transformer is connected, in series with potentiometers R-1461 and R-1462 and the Silverstat coil K-1461, across the output of the bridge rectifier. The polarity of the transformer windings is such that when an increase in rectifier output causes a decrease in exciter output voltage, the output of the transformer bucks the output of the rectifier. Consequently, the armature in the Silverstat K-1461 comes to rest almost immediately. Potentiometer R-1462 is adjusted so that the Silverstat can only respond to rates of changes in voltage output that are too slow to produce any appreciable output from transformer T-1461.

(3) In manual operation, switch sections A, B, and D are open and section C is closed. Section C short circuits the Silverstat resistor and section B removes the short circuit from the manually operated rheostat R-1466 which replaces the Silverstat. Section A opens to remove the bridge rectifier from across the output of the generator armature, and section D opens to place resistors R-1464 and R-1465 in series with the anti-hunt transformer T-1461 so that it cannot produce a current flow in the rectifier when manual adjustments are being made.

e. VOLTAGE STABILIZER.

(1) The output of the Motor Generator is connected to the main power input terminals 02 and 03 in the Transceiver Console. After passing through the MAIN POWER ON switch S-101, part of the power is connected through terminals 1202 and 1203 to the input terminals 1 and 2 of the Voltage Stabilizer. The Voltage Stabilizer is shown in Fig. 2-111. The line from terminal 2 connects through the primary winding of transformer A to a tap on parallel LC circuit B. This circuit is resonant at 63 cps, and the inductor is near saturation in the range of 103-127 volts. The impedance point of the tap on the inductor is chosen to match the impedance of the input power line. One side of transformer A is connected to a tap on the parallel circuit B and the other side is connected through the series resonant circuit C to one side of the primary winding of transformer D. The other side of transformer D is connected to the side of the parallel circuit C that connects to the input line 1. Any increase in line voltage tends to increase the line current into circuit B, but the drop in voltage across the primary of transformer A increases and subtracts from the line voltage to maintain a fairly constant input to circuit B. Since the inductor in circuit B is near saturation, a given increase in input voltage produces a relatively small increase in the voltage across the entire circuit. The polarity of the output of transformer A is such that it always partially cancels the voltage across the parallel circuit B. Consequently, while an increase or decrease in input voltage causes a small increase or decrease across the parallel circuit, the voltage output from transformer B also increases or decreases in phase opposition and the amplitude of the sum of these voltages remains the same as it was before the initial change occurred. The circuit constants are chosen so that the output voltage remains fairly constant over a range of 103 to 127 volts. The circuit is also compensated for shifts in line frequency which would produce an appreciable drop in the voltage across the parallel circuit B. This is accomplished by adding the series circuit C in series with the input circuit to the primary winding of transformer D. Circuit B is resonant at 63 cps and circuit C is resonant at 57 cps. If the line frequency increases, the voltage across circuit B increases, but at the same time the voltage drop across circuit C decreases a like amount since the line frequency has shifted further away from its resonant frequency. If the line frequency decreases,

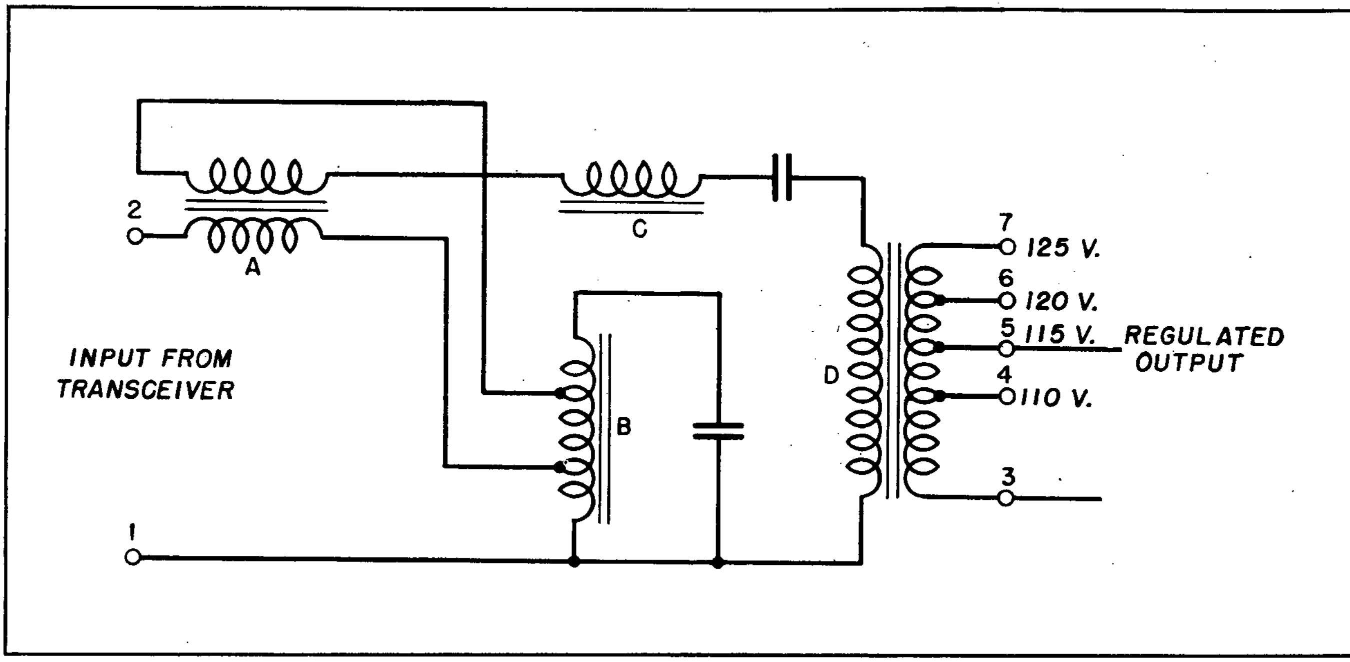


Figure 2-111. Voltage Stabilizer, Simplified Diagram

the voltage across circuit B decreases and the voltage drop across circuit C also decreases a like amount. Thus, it can be seen that in the range between the limits represented by the resonant frequencies of the tuned circuits, the voltage output is constant. If the frequency is held constant, the output voltage varies $\pm 1\%$ for an input voltage variation of 103 to 127 volts. If the voltage is held constant, the output voltage varies $\pm 3\%$ for a frequency variation of 57 to 63 cps. If both voltage and frequency shift, the output voltage varies $\pm 4\%$ within the limits given.

26. POWER SUPPLY SYSTEM (NXsr-46032).

a. GENERAL.

(1) The power supply system used with SR Equipments purchased on the above contract is very similar to the 230-volt system in use with equipments purchased on contract NXsr-30306 which is described in detail in the preceding paragraph. The principle differences may be seen in the complete schematic diagrams of the equipments in section 7. The Motor-Generator operates from 230 volts d-c only. It has a built-in over-speed regulator to improve voltage and frequency regulation. The input and output leads pass through r-f filters to prevent radiation from the transmitter from affecting the efficiency of operation. The Voltage Regulator is an improved type with r-f shielding for its components. It is identical electrically to the Voltage Regulator supplied on the other contract except for a few minor changes in part numbers. The Magnetic Starter is slightly different from the CAY-211187. It contains automatic reset circuits to eliminate the necessity of pressing a manual reset button each time an overload stops the operation of the Motor Generator. The Pushbutton Stations have separate contacts for the reset circuit and when the START-EMERGENCY button is pressed, the reset circuit operates automatically. The reset contacts short-circuit relay contacts K-1584 to accomplish this. Since the general theory of this type of equipment is discussed in Paragraph 25, the discussion in this paragraph is confined to a description of the operation of the equipment. Refer to Figs. 7-183 and 7-185 in Section 7 during the following discussion.

b. MAGNETIC STARTER.

(1) Pressing the START-EMERGENCY RUN button on any one of the Remote Pushbutton Stations or on the Magnetic Controller cabinet door energizes magnetic reset coil K-1584A on the overload relay which closes contact K-1584E. Successively, the main and neutralizing coils of timetactors K-1582A and K-1583A are energized. This action inserts starting resistors R-1583 and R-1584 in series with the armature. Contactor K-1581A is energized and the motor starts. Interlock K-1581F closes and provides a holding circuit around the push buttons. Also, with this action, interlock K-1581K opens and de-energizes reset coil K-1584A and the main coil K-1582A. After a definite time delay, the normally open contacts K-1582E and K-1582F open and the normally closed contact K-1482B closes. This shorts out the first step of starting resistance R-1583. Main coil K-1583A is now de-energized. After a second time delay, resistor R-1584 is shorted out and the motor is connected across the line.

(2) Low voltage, overload, overspeed or depressing the STOP pushbutton will de-energize the con-

troller and stop the motor. The motor must again be started in the usual manner. In an emergency, the motor may be run with overload by simply holding down the START-EMERGENCY RUN pushbutton. The accelerating time may be varied by adjusting the potentiometer resistor R-1582 connected between terminals 12 and L-2. Coil K-1581A has two windings. Normally, winding FT is short-circuited by interlock K-1581H. However, after contactor K-1581 picks up, K-1581H opens and both coils are used in series. If the voltage should fail and is again restored, the motor must be started by depressing the START button.

c. VOLTAGE REGULATOR.

(1) The Voltage Regulator is used to control the voltage of the a-c generator by means of variable resistor R-1463. This resistor is built into the Voltage Regulator and is connected in series with the shunt field of the exciter. Control element K-1461 consists of a pivoted arm which is controlled by the D.C. operated electro-magnet. A spring is attached to this arm for use in opposing the electromagnet's pull. The position of the moving arm is determined by the balance between the magnetic pull and the spring pull. Coil K-1461A, of control element K-1461 receives its energy from the single phase Rectox rectifier CR-1461 to CR-1464. The input to the rectifier is supplied by single phase a-c from the output terminals of the Type CAY-211328 a-c generator. Thus, the d-c voltage which is applied to the terminals of coil K-1461A varies in the same proportion as the a-c generator voltage.

(2) The moving arm of the regulating element carries an insulated pusher pin to bear against an assembly of spring mounted silver buttons which connect to steps on the regulating resistor R-1463. This arm closes the buttons together to short out resistance when the coil spring tension overcomes the magnetic pull on the armature. Conversely, when the pull on the armature is greater than the pull of the spring, the arm moves in the opposite direction. Therefore, the silver buttons separate to insert resistance into the exciter field circuit. Voltage adjusting rheostat R-1467 is connected in the circuit of coil K-1461A. This rheostat is used to raise or lower the a-c output voltage. The control knob for this resistor is accessible from the front panel in the regulator cabinet. R-1461, an adjustable resistor, is placed in the same circuit with R-1467. It is used to set the voltage so that adjustments can be made to the desired range.

(3) Damping transformer T-1461 is used to stabilize the action of the regulator moving arm. For example, when the a-c generator voltage rises above the regulated value, regulator K-1461 operates to insert resistor R-1463 in the exciter field circuit. This reduces the voltage across the exciter field, which in turn reduces the voltage across the armature of the exciter. The primary of damping transformer T-1461, being connected across the exciter armature, is subject to this change in voltage. The resulting change in current in the primary winding, induces a voltage in the secondary winding in opposition to the flow of current in coil K-1461A. Thus, the magnetic pull is temporarily reduced by this impulse from damping transformer T-1461 and the regulator is restrained from making an excessive correction in the exciter field circuit. When the a-c voltage falls below the regulated value, K-1461 operates to cut out resistance in the exciter field circuit. The impulse from the damping transformer T-1461 aids the current in the voltage coil. Regulator K-1461 is thus restrained from making an excessive increase in the exciter field current.

(4) Transfer switch S-1461 enables the operator to control the voltage by automatic operation of the regulator or by manual operation of exciter field rheostat R-1466. When the switch is in the AUTOMATIC position, the contacts of the switch short out the fixed resistors R-1464 and R-1465 in series with the a-c generator field. It also shorts out rheostat R-1466. When the switch is turned to the MANUAL position, these contacts open and reinsert the above mentioned resistors back in their circuit. However, in the MANUAL position of the switch, a contact shorts out variable resistor R-1463.

(5) Exciter field rheostat R-1466 has a MAIN and VERNIER control to obtain fine adjustment of the a-c voltage when the voltage is manually controlled by means of the exciter field rheostat R-1466. The large handwheel controls the coarse adjustment and the smaller handwheel controls the fine adjustment. An a-c voltmeter M-1461, 0-150 volts scale, is supplied to indicate the voltage on the terminals of the a-c generator.

SECTION 3

INSTALLATION AND INITIAL ADJUSTMENT

1. GENERAL.

a. This section contains the instructions and diagrams necessary for the installation of the SR Radar Equipment. Considerable time will be saved if these instructions are carefully studied before any attempt is made to install the equipment. Comparable information is included in blueprint form with each equipment.

2. UNPACKING.

a. The weights and dimensions of the equipment and its various components are given on the outline drawings in this section. These weights and dimensions should be noted and sufficient personnel should be assigned to the installation crew to handle the units and secure them in position. Hoisting gear should be available to handle the unit before and after it is uncrated. The hoisting should be supervised by an experienced rigger. The units are delivered with all delicate adjustments made at the factory and with all vacuum tubes in their sockets.

b. The boxes and crates containing the equipment should be kept in an upright position at all times. The upright position is indicated by an arrow stenciled on each box or crate. Use a nail-puller for removing nails and remove at least three sides of the crate before attempting to remove the equipment. *Do not use a hammer or pinch bar* for opening crates containing delicate apparatus. The crates should not be opened until after the units have been placed in the approximate position they will occupy when installed. After the equipment has been unpacked it should be thoroughly inspected for damage in transit. Tubes and control knobs should be inspected for breakage. Wires which may have become loosened should be tightened or replaced. Any unusual amount of damage to the case or its components should be reported to the proper authorities. Proper forms should be used in reporting excessive damage.

3. INSTALLATION OF MODULATOR.

a. GENERAL.

(1) The Navy Type CAY-50AGU Modulator is supplied as part of a modification kit for changing Navy Model SR Equipments over to Navy Model SR-a Equipments. When the modulator is shipped as part of a Navy Model SR-a Equipment by the contractor, it is installed simultaneously with the SR-a Equipment.

b. INSTALLED AS A MODIFICATION.

(1) When the Modulator is installed as a modification of SR Equipment, certain changes must be made in Transceiver CAY-43ACM in order to convert it to Transceiver CAY-43ADK before the Modulator may be connected with it. These changes are covered by Field Engineering Bulletin SR Radar Navy Field Change No. 20, Conversion of SR to SR-a Equipment. A copy of this field change is included in Section 7. The Navy Type CAY-67AAD Keyer Unit is removed from its compartment in the lower bay of the Transceiver and an interconnection panel, supplied as part of the modification kit, is installed in its place. Certain other modifications are made on the Transceiver which are covered in the Field Service Bulletin mentioned above. These changes are discussed generally in Section 1 and may be seen in detail by comparing the schematic diagram of Transceiver CAY-43ACM with the schematic diagram of Transceiver CAY-43ADK. The interconnection panel which is installed in the space formerly occupied by the Keyer unit is shown in Fig. 3-1.

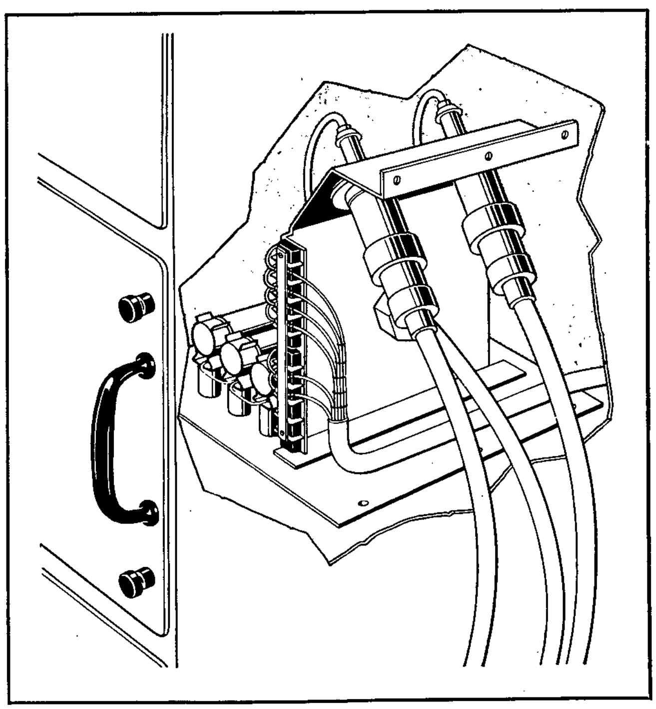


Figure 3-1. Interconnection Panel in Transceiver CAY-43ADK

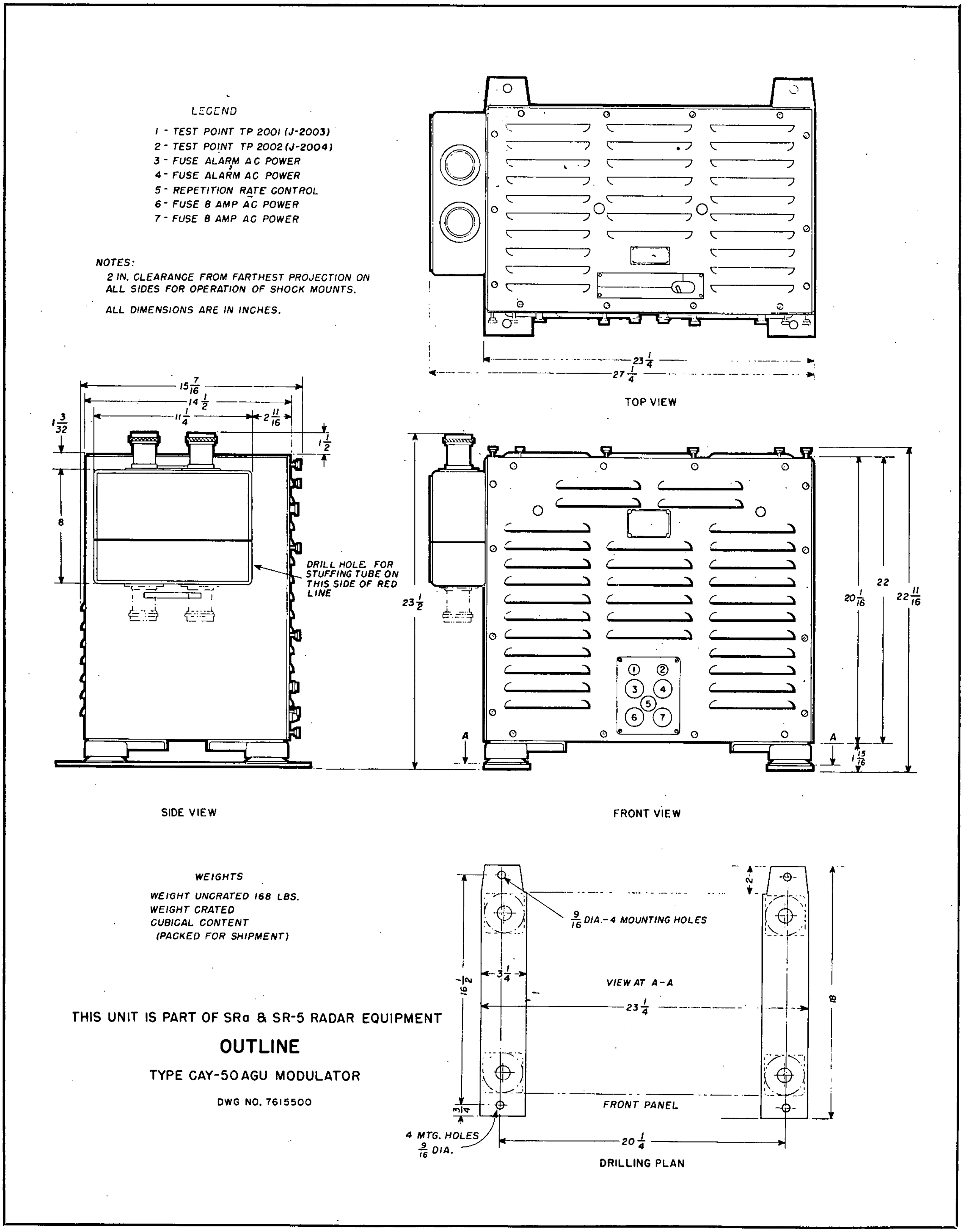


Figure 3-2. Modulator CAY-50AGU, Outline and Mounting Dimensions

(2) The Modulator should be installed adjacent to the Transceiver if at all possible. If it is not possible to place the two side by side, the least possible separation should be made to keep the length of the pulse cable at a minimum. When the Modulator is installed as a modification, it may be necessary to install the Modulator in the place formerly occupied by the Auto-Dehydrator in order to have it located close to the Transceiver. The mounting dimensions of this unit are the same as the Auto-Dehydrator, and the Modulator may therefore be mounted in essentially the same space as the former unit. These mounting dimensions are shown in Fig. 3-2. If it is necessary to mount the Modulator in the space formerly occupied by the Auto-Dehydrator, the Auto-Dehydrator may then be mounted at any available point near the Antenna or else not used at all. When installing the Modulator, a space of 2 inches must be provided at the sides and rear of the unit, in order that the shockmounts have space in which to operate. About 30 inches of space should be left in front to permit the Unit to be serviced. The uncrated weight of the unit is 168 pounds. It may therefore be handled without difficulty by two men. The Modulator is fastened in place by four bolts. These bolts may be held either by drilling and tapping holes in the deck to receive them, or by drilling clearance holes and securing the bolts with lockwashers and nuts. The drilling plan for the holes is shown in Fig. 3-2.

c. INSTALLED AS PART OF SR-a EQUIPMENT.

(1) When the Modulator is supplied as part of a Model SR-a Equipment, the installation is much the same as when it is installed as part of a modification except for the fact that the modifications to the Transceiver have already been made before the Equipment was shipped.

4. INSTALLATION OF TRANSCEIVER.

a. The Transceiver shown in Fig. 3-3 should be located as near as possible to the Antenna, in order to reduce the losses in the r-f transmission line. It should be positioned so that there is enough clearance at the sides and rear to permit removing the shields for maintenance and cleaning. At least 30 inches should be allowed in front of the Transceiver to permit space for the operator to stand in front of the unit while operating the controls and to permit removal of the components. The cabinet is mounted upon four plunger type shockmounts which raise it about 4 inches clear of the deck. Place the approved Navy template on the deck so as to allow for the proper clearance. Proceed to drill the mounting holes. After the mounting holes have been drilled, place the unit in position. If no template is available, refer to Fig. 3-3 which gives dimensions for a template. Sufficient personnel and hoisting gear should be present to handle the unit which weighs approximately 1,150 pounds. The unit may be lightened slightly by removing the Monitor Scope and the Monitor Receiver. If these units are removed, follow the procedure outlined for removing the units of the Indicator Console. Across each of the four shockmounts connect a 6 inch length of 1 inch wide copper braid, ending in a suitable terminal for fastening beneath a shockmount bolt.

5. INSTALLATION OF INDICATOR CONSOLE.

a. GENERAL.

(1) The Indicator Console should be installed in a location where the average temperature is always within moderate limits. There should be free air circulation since the equipment dissipates about 580 watts of the input power. It should be mounted on a firm support, preferably at some point in the ship which is not subject to excessive vibration or direct shock. In normal use, the equipment is mounted with the three cases assembled side by side on a common cradle. However, in special installations, two cases may be mounted on a common cradle and the third case mounted separately. Where space is limited, the equipment may be mounted with each case on a separate cradle. Special installations of this type require extra equipment. Since the equipment is normally supplied with only a three-case cradle and individual cradles for each unit will be required.

(2) Space must be allotted around the Indicator Console to allow for its movement on the shockmount. A two-inch clearance should be allowed between all points on the console and adjacent bulkheads, pipes, wiring, or other stationary objects. A clearance of at least 30 inches in front of the Console should be given to allow for the operation of the units and for the removal of the individual chassis. If more than 30 inches of space is available, it will make the removal of the components easier and provide a more comfortable operating space for the operator. Terminal boxes may be located on the back or on either side of the Console, as required. The location of these boxes is discussed in the paragraph of this section concerning the interconnection of the units. Fig. 3-4 is an outline drawing with all of the dimensions necessary to indicate the size of the space required for installation. Figs. 3-5 to 3-10 inclusive show the dimensions of each component. This information is valuable when the components have to be taken through small openings. The Indicator Console is shipped with all three cases bolted to the cradle. A drilling template is shown in Fig. 3-4 to indicate where the mounting holes should be located so as to mount the cradle permanently in the ship. A similar template is also supplied with each cradle. The dimensions and clearances indicated in Fig. 3-4 should be followed when locating the template and drilling the mounting holes.

b. PLACING THE INDICATOR CONSOLE.

(1) If adequate hoisting equipment is available, it may be possible to lift the entire Console, with the units and cradle in place onto the position where it is to be installed. The complete Indicator Console weighs over 500 pounds and this method of installation should not be attempted unless sufficient personnel and lifting gear are available to handle it without jarring or dropping it.

(2) Generally, it will be necessary to remove the various components from the Console, and then remove the cases from the cradle. All of the chassis in the Console are removed from their place in the same manner. Loosen the captive screws around the front edge of the panels. Then pull the unit two-thirds of the way out of the cabinet. At this point, it will be stopped by the automatic stops which are built into the cabinet. The panel screws are shown in Figs. 3-5 to 3-10 inclusive. Unscrew the small cable clamps above the point where the cables connect to the component. These clamps are shown in Fig. 3-5 to 3-10 inclusive. Unfasten the screws in the terminal boards and disconnect the wires. Each wire is tagged and numbered to correspond to the numbers on the terminal boards. This is done to insure that it will be reconnected properly when the component is replaced in the cabinet. In order for the chassis of a unit to clear the connection cable when the unit is removed from the case of the Indicator Console, a small recessed area has been provided in the case adjacent to the cable on each unit. This area is covered by a small plate held by two captive screws. Before removing the chassis from the case, remove the plate covering the recessed area and place the connection cable in the space thus provided. After interference by the connection cable has been eliminated in this way, press the lock buttons in the case adjacent to the bottom of the chassis. This will release the locks which have been holding the chassis in the two-thirds forward position. On the larger units, two locks are employed, while on the smaller units, only one lock is used. Once these latch mechanisms have been released, the units may be removed from their chassis.

(3) The PPI Scope and the Range Scope are comparatively heavy units. They weigh about 125 and 75 pounds, respectively. Sufficient personnel should be available when removing these units to make certain that they are not dropped or jarred. Following the removal of the electrical components, the case will be light enough to be handled easily by three or four men. If it is desired to remove the three cases separately from the cradle, it will be necessary to remove the bolts which hold the three cases together. The assembly bolts are located in the top of the cases, and may be reached by removing the tops of the three cases. The tops are secured to the cases by four Dzus fasteners, which need only be turned a quarter of a turn to remove the tops. When the tops are removed the assembly bolts may be removed. The cases may be removed from the cradle by removing the bolts in the bottom that secure the cases to the cradle.

(4) If mounting holes have not already been provided, secure the template and locate it so that sufficient clearance around the unit is assured. Drill only the holes specified on the template. The proper drill size is indicated on the template and on the outline drawing, Fig. 3-4. The cradle may now be bolted into place. If the cases have been removed from the cradle they should now be reassembled to the cradle with the original hardware, and the bolts holding the cases together should be replaced if the cases have been separated. Slide the chassis into their respective positions until they are about one-third the way in and the lock has been engaged. Make certain that the chassis cannot be pushed in or pulled out. By reference to the outline drawing, Fig. 3-4, be certain that the chassis are in their proper position in the cases. It is possible to interchange the Console Receiver and Range Scope as well as the IFF Coordinator and General Control unit. The two components of each pair mentioned above are the same size and shape.

(5) Replace the wiring on the terminal boards, making certain that the connections are correct. Match the numbers on the wires with the numbers on the terminal boards on the side of the unit. Replace the cable clamps and tighten their thumbscrews. Replace the covers on the recessed cable openings. Push the lock release buttons and push the chassis into the case until the panels meet the flanges on the cabinets. Fasten them temporarily with the captive screws. Most of the chassis will have to be pulled forward later during the alignment procedure.

6. INSTALLATION OF ANTENNA AND ANTENNA PEDESTAL.

a. GENERAL.

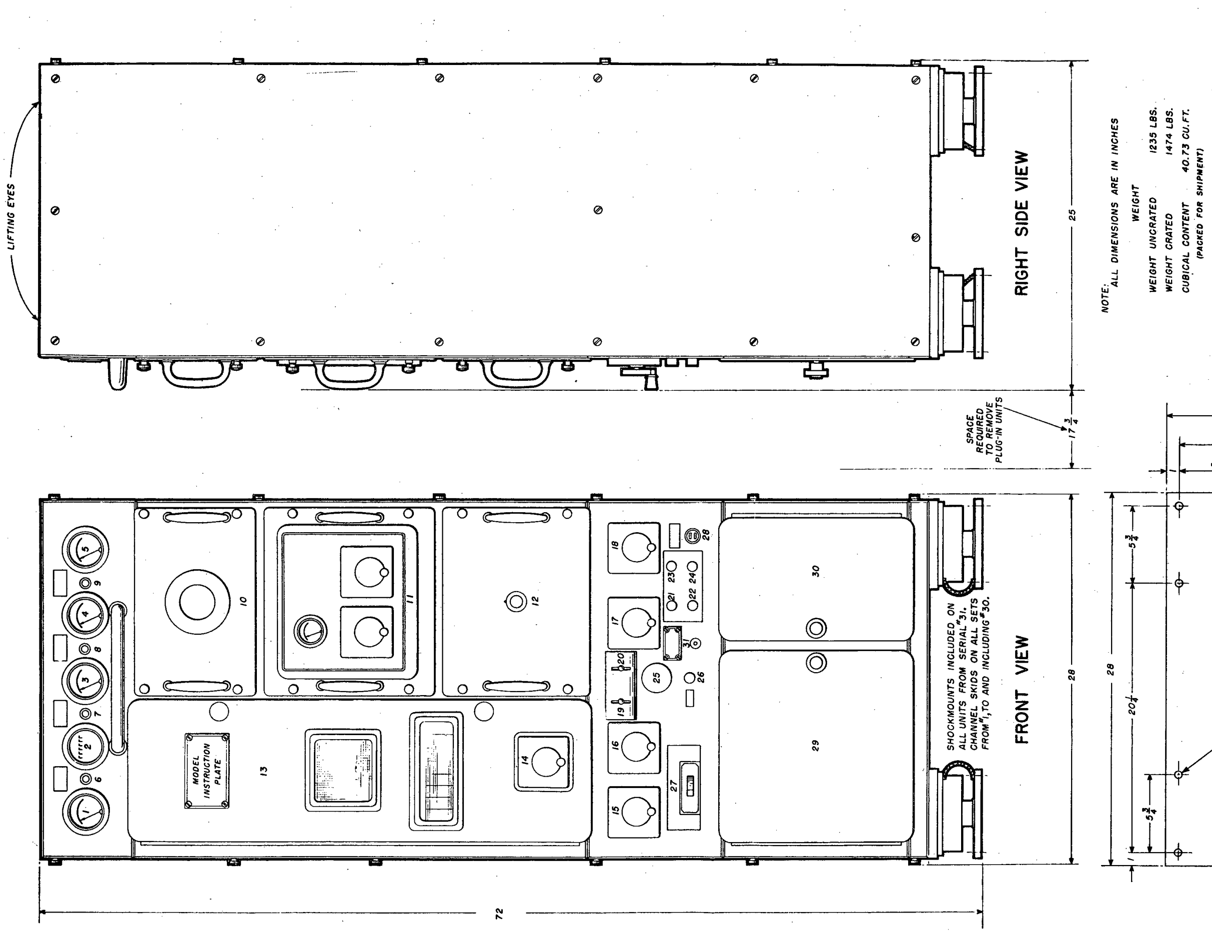
(1) If a crane or boom is available, the easiest way to install the Antenna and Antenna Pedestal is to assemble the two together on the top deck and with the stowing lock on the Pedestal engaged, hoist them into place on the mast. Anchor the Pedestal base securely to prevent any possibility of tipping due to the added weight of the Antenna.

b. ASSEMBLY OF ANTENNA TO ANTENNA PEDESTAL.

(1) Remove the protective shipping cover from the entrance to the concentric lines at the top of the dome of the Pedestal. Pull the slotted connector until the end of the fingers project slightly above the top of the dome of the Pedestal. Wrap one turn of a piece of string around the fingers to compress them so that when the concentric line is lowered the fingers will fit within it easily. Anchor the ends of the string at convenient places, such as two of the bolts holding the

LEGEND

1 METER-FILAMENT VOLTAGE
2 METER-SERVICE HOURS
3 METER-PLATE VOLTAGE
4 METER-PLATE CURRENT
5 METER-GRID CURRENT
6 INDICATOR LIGHT-MAIN POWER
7 INDICATOR LIGHT-LOCAL CONTROL
8 INDICATOR LIGHT-FILAMENTS
9 INDICATOR LIGHT-PLATE VOLTS
10 MONITOR SCOPE-DWG. 7611725
11 MONITOR RECEIVER-DWG. 7611455
12 KEYER UNIT-DWG. 7611223
13 ACCESS DOOR-OSCILLATOR
14 DIAL-OSCILLATOR TUNING
15 DIAL-#1 TUNING STUB
16 DIAL-#2 TUNING STUB
17 DIAL-#1 DUPLEXER
18 DIAL-#2 DUPLEXER
19 SWITCH-LOCAL TO REMOTE CONTROL
20 SWITCH-R. F. OSCILLATOR KEYING
21 SWITCH-POWER ON
22 SWITCH-POWER OFF
23 SWITCH-PLATE VOLTAGE INCREASE
24 SWITCH-PLATE VOLTAGE DECREASE
25 FILAMENT VOLTAGE REGULATOR
26 REGULATOR SHAFT LOCK
27 SWITCH-MAIN POWER & EMERGENCY OFF
28 RECEPTACLE-115 V A. C. CONVENIENCE OUTLET
29 ACCESS DOOR-WIRING & FUSES
30 ACCESS DOOR-RECTIFIER TUBES
31 GRID JACK AND INSTRUCTION PLATE



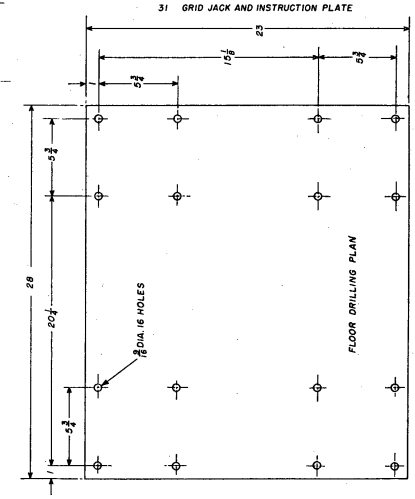


Figure 3-3. Transceiver CAY-43ACM, CAY-43ADK, Outline Diagram

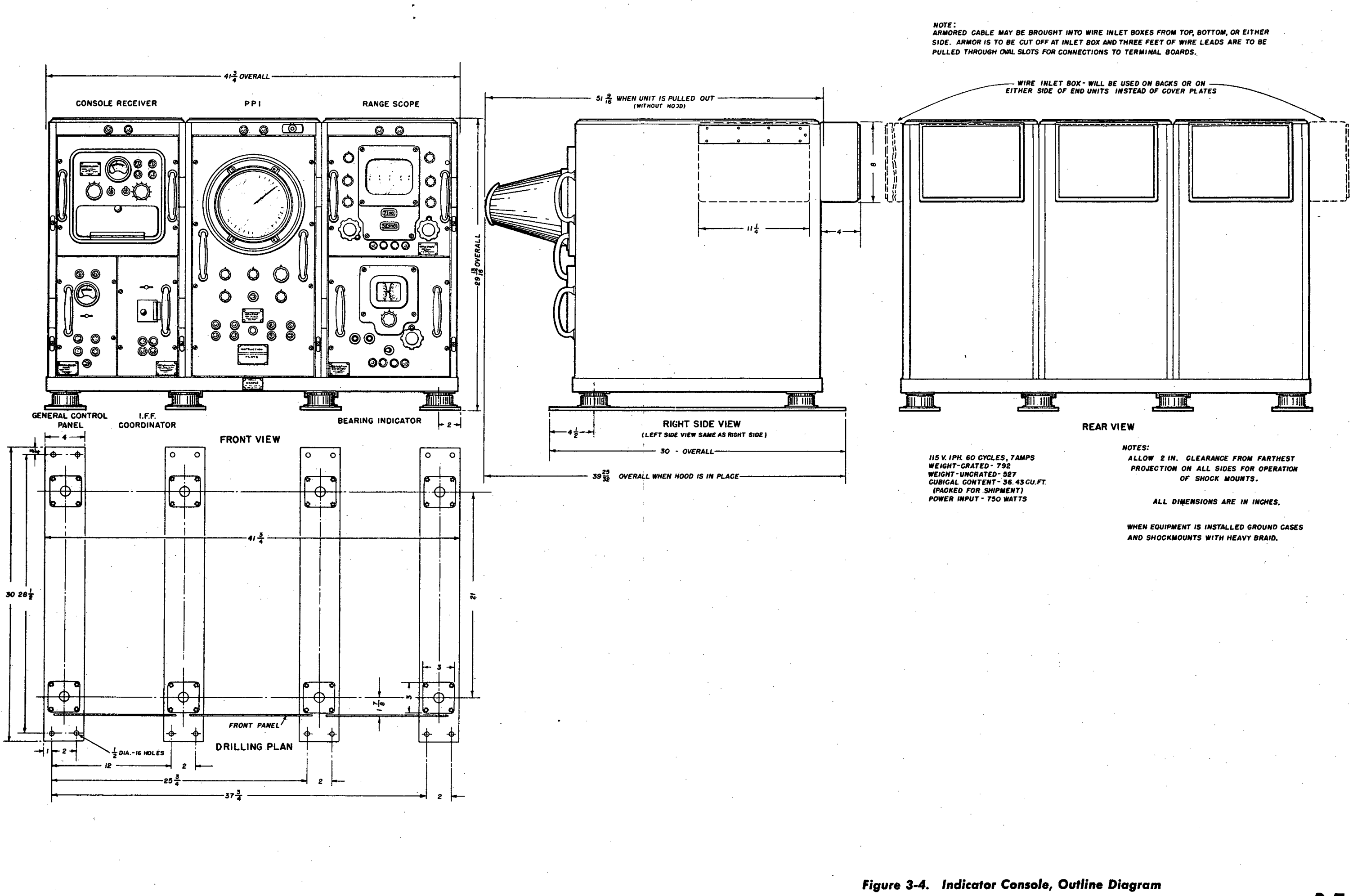
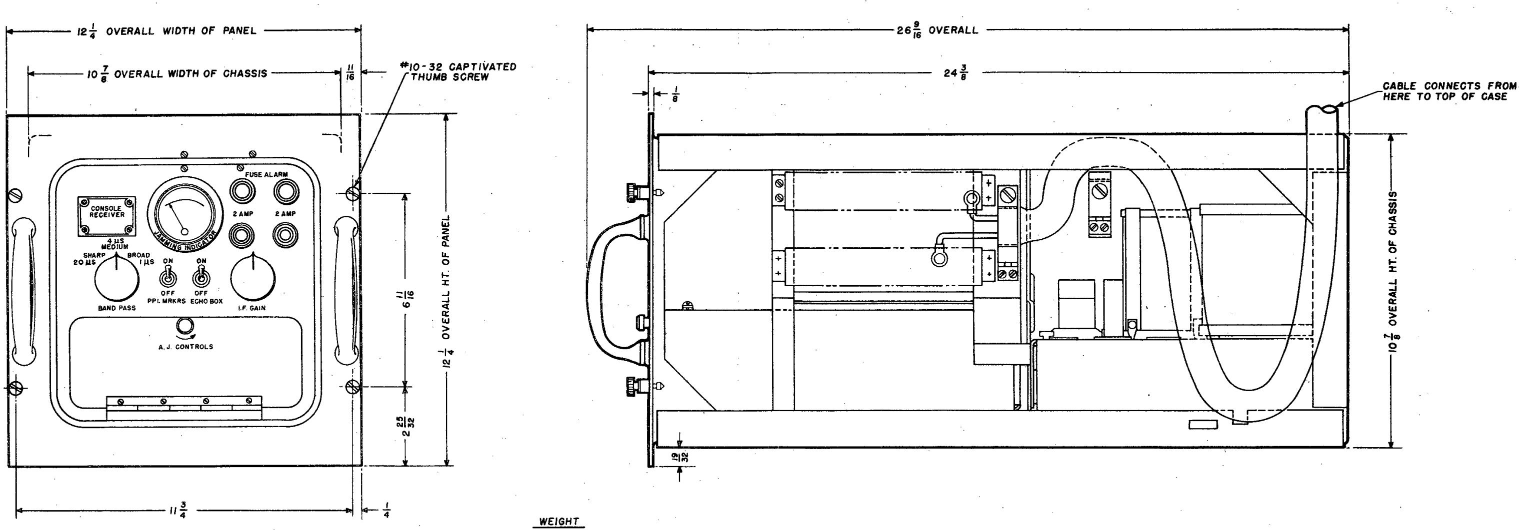


Figure 3-4. Indicator Console, Outline Diagram

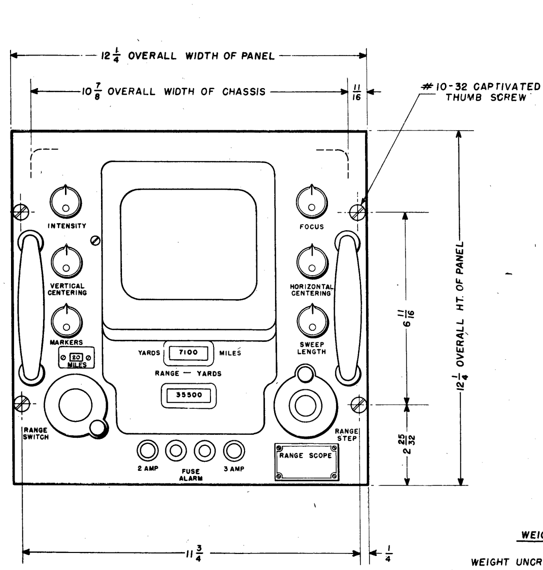


WEIGHT

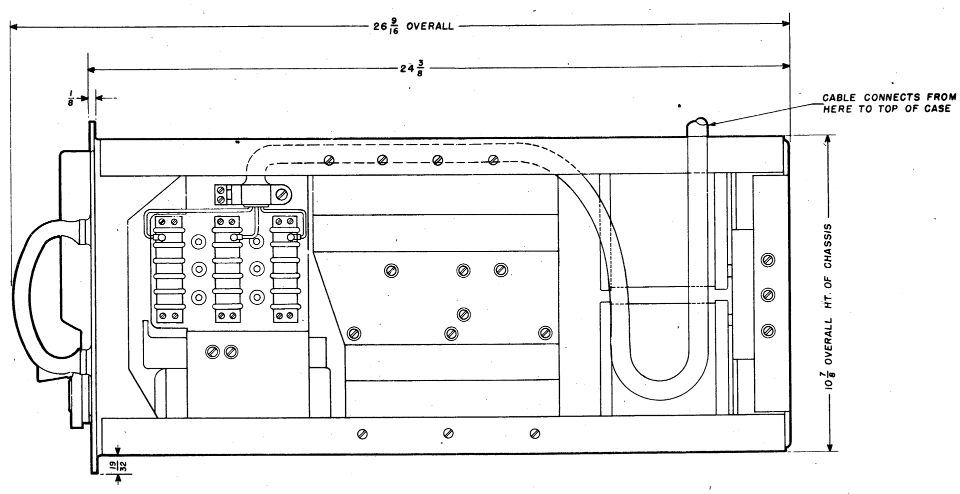
WEIGHT UNCRATED - 63 LBS.
PACKED WITH INDICATOR CONSOLE
(SEE DWG. 7611717 OR DWG. 7614742)

NOTE:
ALL DIMENSIONS ARE IN INCHES.

Figure 3-5. Console Receiver, Outline Diagram



FRONT VIEW



RIGHT SIDE

WEIGHT

WEIGHT UNCRATED 77 LBS
PACKED WITH INDICATOR CONSOLE

NOTE:
ALL DIMENSIONS ARE
IN INCHES

Figure 3-6. Range Scope, Outline Diagram

Figure 3-6. Range Scope, Outline Diagram

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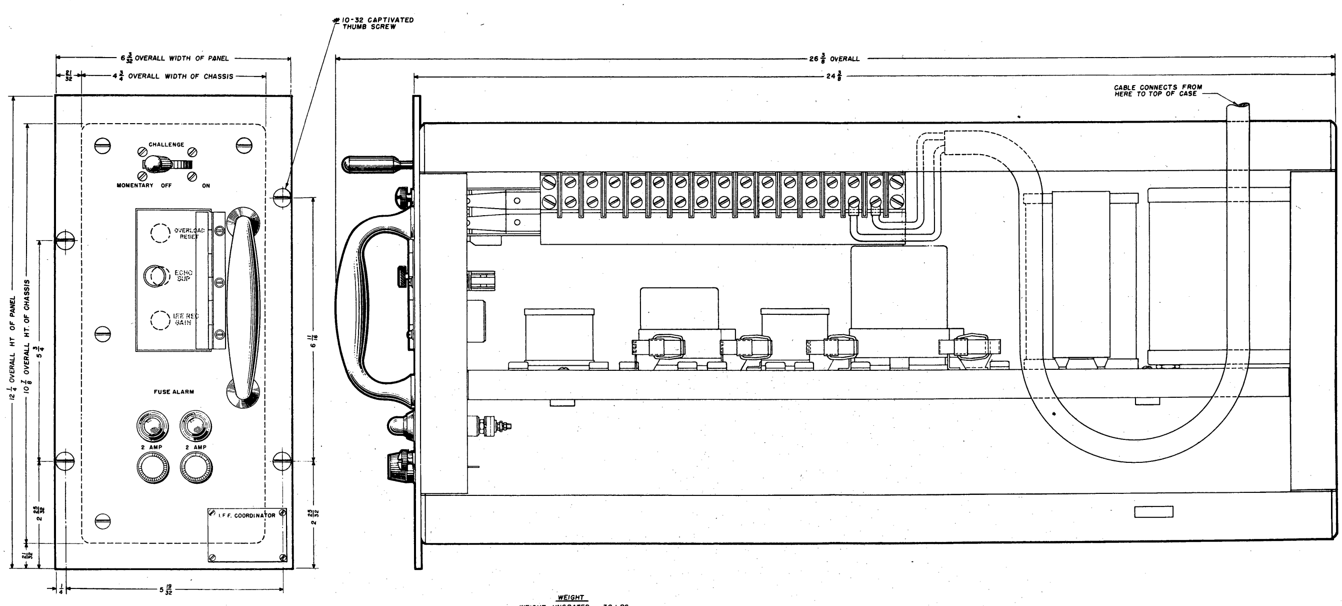

WEIGHT
WEIGHT UNCRATED 30 LBS.
PACKED WITH INDICATOR CONSOLE

NOTE:
ALL DIMENSIONS ARE IN INCHES

Figure 3-7. IFF Coordinator, Outline Diagram

Figure 3-7. IFF Coordinator, Outline Diagram

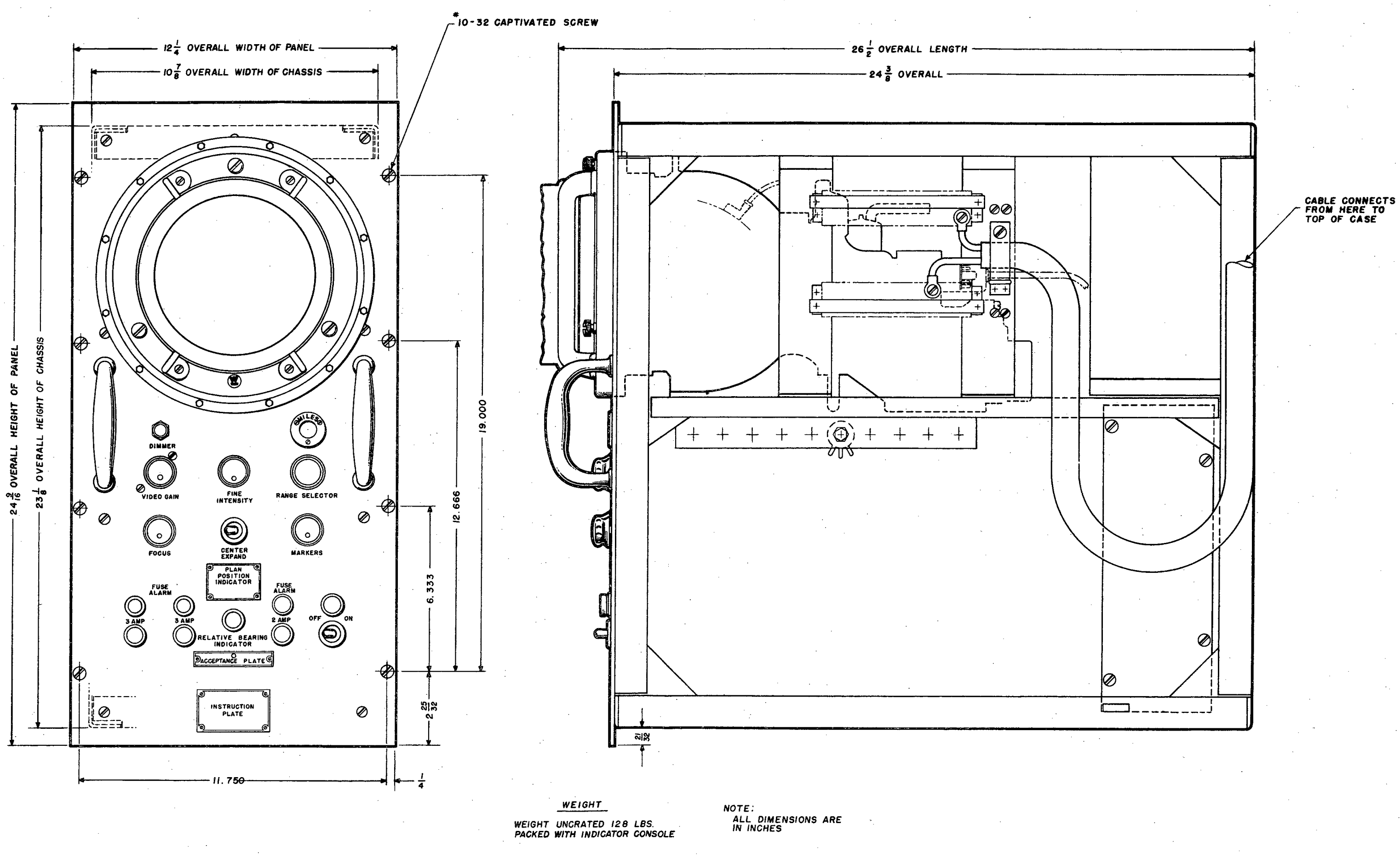

Figure 3-8. PPI Indicator, Outline Diagram

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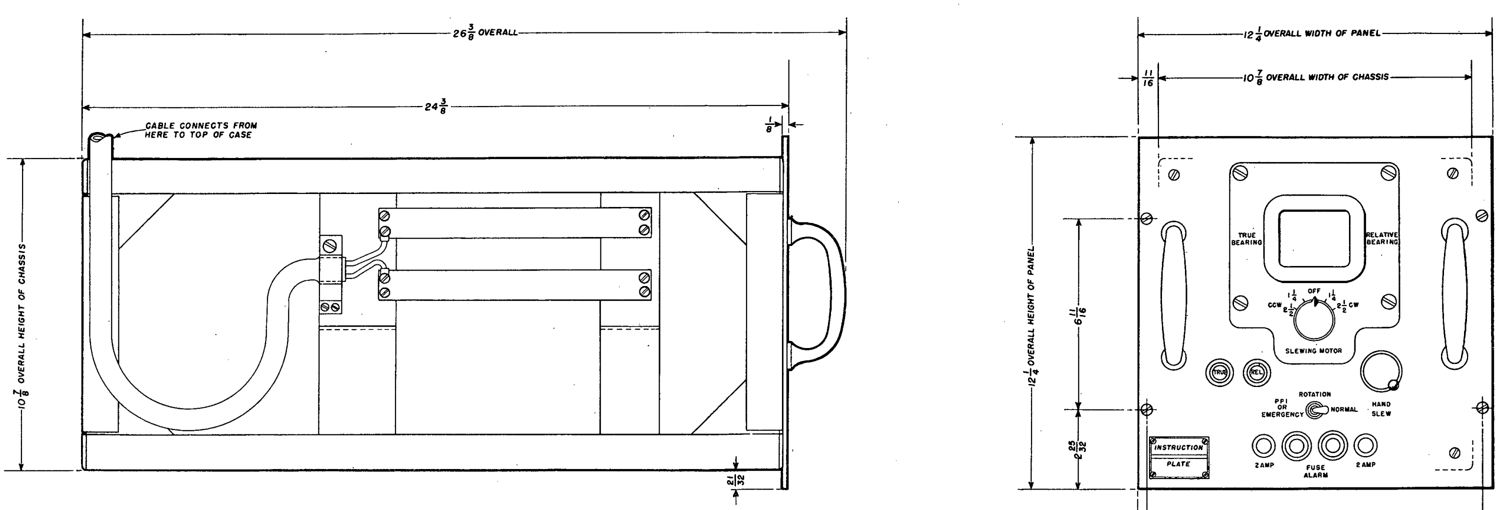

LEFT SIDE VIEW

FRONT VIEW

NOTES:
ALL DIMENSIONS ARE IN INCHES.

WEIGHTS
WEIGHT UNCRATED — 70 LBS.

PACKED WITH INDICATOR CONSOLE
(SEE DWG 7611717)

Figure 3-9. Bearing Indicator, Outline Diagram

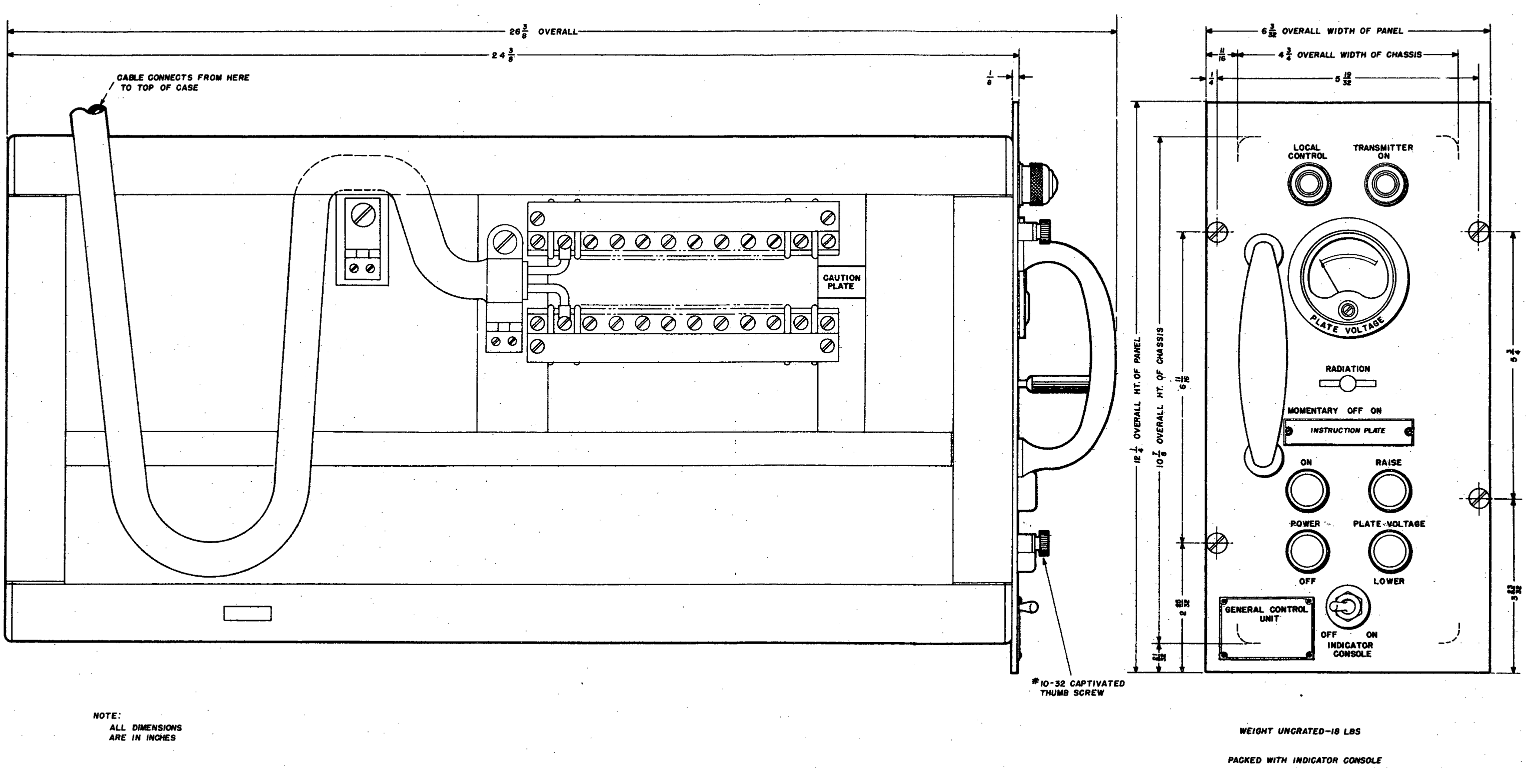

Figure 3-10. General Control Unit, Outline Diagram

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access cover at one side of the dome. Place a small block of wood or equivalent material on the flange at the top of the Pedestal to hold the flange on the concentric line above the flange face on the Pedestal during assembly until the string can be removed. The wooden spacer should not be thick enough to prevent the inner concentric lines from partially coming together. Four bolts project through the Antenna mounting face of the Pedestal. Insert these bolts until their ends are flush with the Pedestal face. The Antenna is shipped with all components assembled, leaving only the connections to the Pedestal to be made. See Fig. 3-11. When placing the Antenna framework on the Pedestal it is essential that sufficient personnel or proper crane facilities be available in order to prevent damage to the concentric line when lowering it upon the Pedestal. Place the gasket on the flange on the top of the Pedestal and lower the Antenna assembly carefully, making certain that at all times the axis of the concentric line on the Antenna is in alignment with the axis of the concentric line of the Pedestal.

(2) Make certain that the fingers of the slotted connector enter the concentric line of the Antenna. With the flange of the Antenna concentric line separated from the flange on the top of the Pedestal by the block of wood placed there, remove the string which was used to compress the fingers of the slotted conductor. Remove the block of wood, and permit the flange Antenna concentric line to come into position with the flange on the top of the Pedestal. Simultaneously, the braces which support the antenna to the face of the Pedestal must assume their final position against the face of the Pedestal. In this final position, the four bolt holes on the face of the Pedestal must be in alignment with the corresponding four holes in the Antenna supporting braces.

NOTE

WHEN LOWERING THE CONCENTRIC LINE OF THE ANTENNA INTO POSITION WITH THE CONCENTRIC LINE OF THE PEDESTAL, BE EXTREMELY CAREFUL TO PREVENT BINDING OF THE SLIDING SURFACES, AND CONSEQUENT DAMAGE TO THE LINES.

(3) Push into position the four bolts which hold the Antenna braces to the face of the Pedestal. Apply lockwashers and nuts, and tighten until the two holes drilled laterally through each bolt are in alignment with the two corresponding holes in the bracket supporting the antenna, and with the corresponding tapped holes in the Pedestal casting. Use a centerpunch or similar tool to secure alignment of the holes. Insert the two stud bolts with appropriate lockwashers in the side of each bracket, and tighten them. Tighten the nuts on the four bolts which pass through the front face of the Pedestal. The function of these bolts is to lock the eight bolts which pass through the side of the brackets. Insert stud bolts and lockwashers to hold the flange of the Antenna concentric line to the flange on the top of the Pedestal, and tighten. Mount the four arms or struts which act as braces between the Antenna and the Pedestal. The ends of the struts that should be bolted to the Pedestal may be identified by the small pipe plug in them. Bolt the Pedestal lug of each of the struts to the Antenna anchor pad located on the motor housing near the main body of the Pedestal. Place the lug of the strut beneath the lug of the junction point or anchor pad. The framework braces of the Antenna terminate at four places in small hemispherical junction points. The flat surfaces of these junction points have lugs welded to them. The other ends of the bracing struts from the Pedestal are bolted to these lugs.

c. ASSEMBLY OF ANTENNA AND PEDESTAL TO MAST.

(1) The Antenna Pedestal is rigidly bolted to the mast by means of eight bolts. The location of these bolts is indicated on the templates shown in Fig. 3-12. Care should be exercised to make certain that the location of the bolt holes is in proper relation to the heading of the ship. To facilitate alignment of the Antenna and Antenna Pedestal with the bow of the ship, the stowing lock on the Pedestal should be engaged. In securing the Antenna Pedestal to the mast, lockwashers must be used under the securing nuts. Hardware should preferably be of stainless steel. As in the case of other units, adequate hoisting gear and sufficient personnel should be available to handle the Antenna Pedestal. When installing the Antenna to the mast, care must be taken in lifting the assembly. Three eyeholes are provided on the top of the Pedestal. All three of these holes must be used. The Antenna may be lifted by utilizing the two front eyeholes, but it will not balance properly. Be careful that none of the supporting cables lean against the concentric lines as they are fragile and can be crushed. In case the proper size chains for the hoisting operation are not available, a sling under the Pedestal may be used.

CAUTION

CARE MUST BE EXERCISED TO SEE THAT NO PORTION OF THE SLING TOUCHES ANY TRANSMISSION LINES.

d. ASSEMBLY OF V.H.F. IFF ANTENNA.

(1) Remove the H.F. system dipole elements and install V.H.F. system dipole elements. Cut the safety wire which binds the dipole to the lock nut and unscrew the dipole elements from the threaded stud.

(2) Screw the V.H.F. dipole element over the stud until it is tightly seated against the lock nut.

(3) Insert new safety wires and twist them tight with pliers.

e. ASSEMBLY OF U.H.F. IFF ANTENNA.

(1) Detach the H.F. or the V.H.F. system, whichever is in use at the time. To do this, remove the four bolts holding each of the four IFF Antennas to

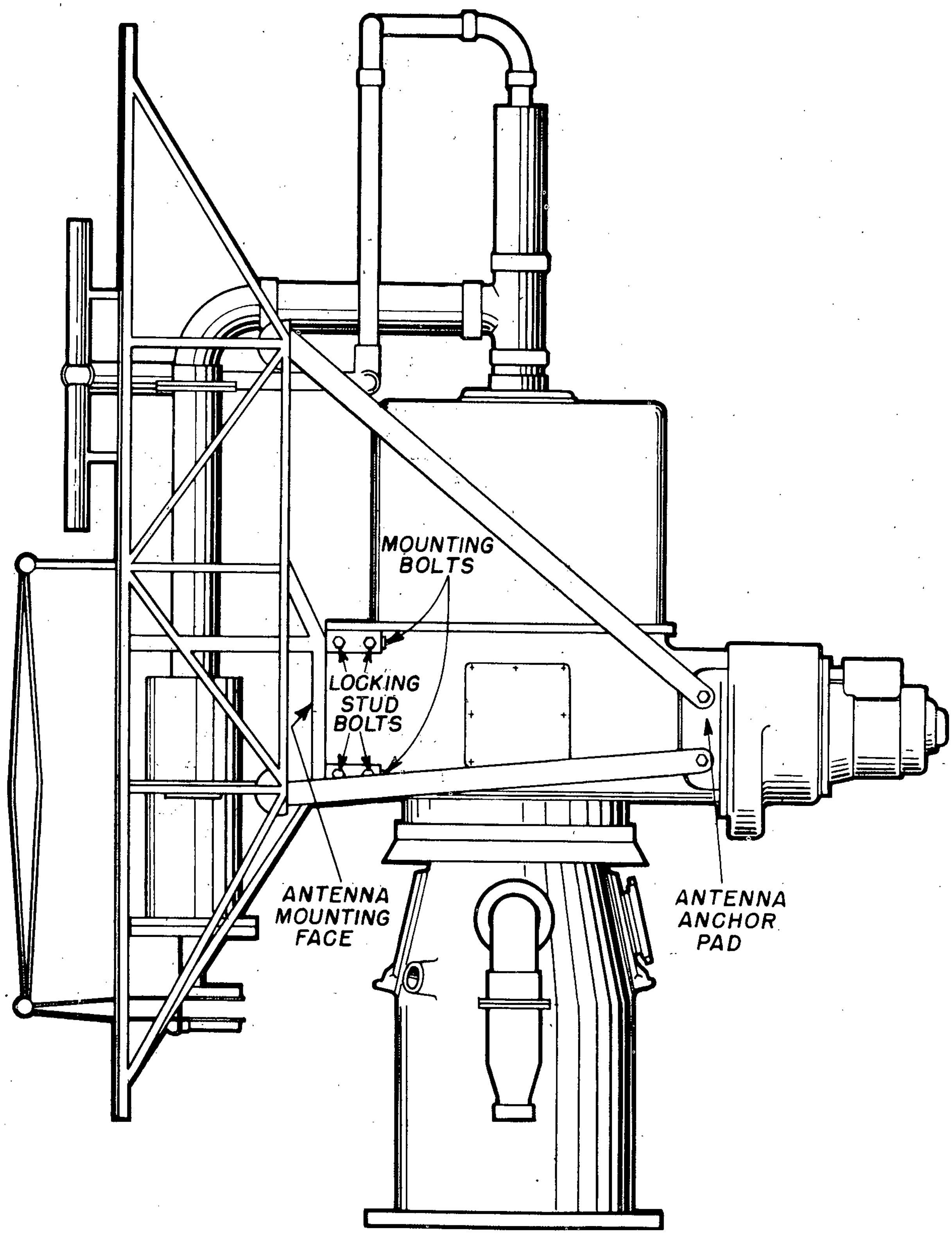
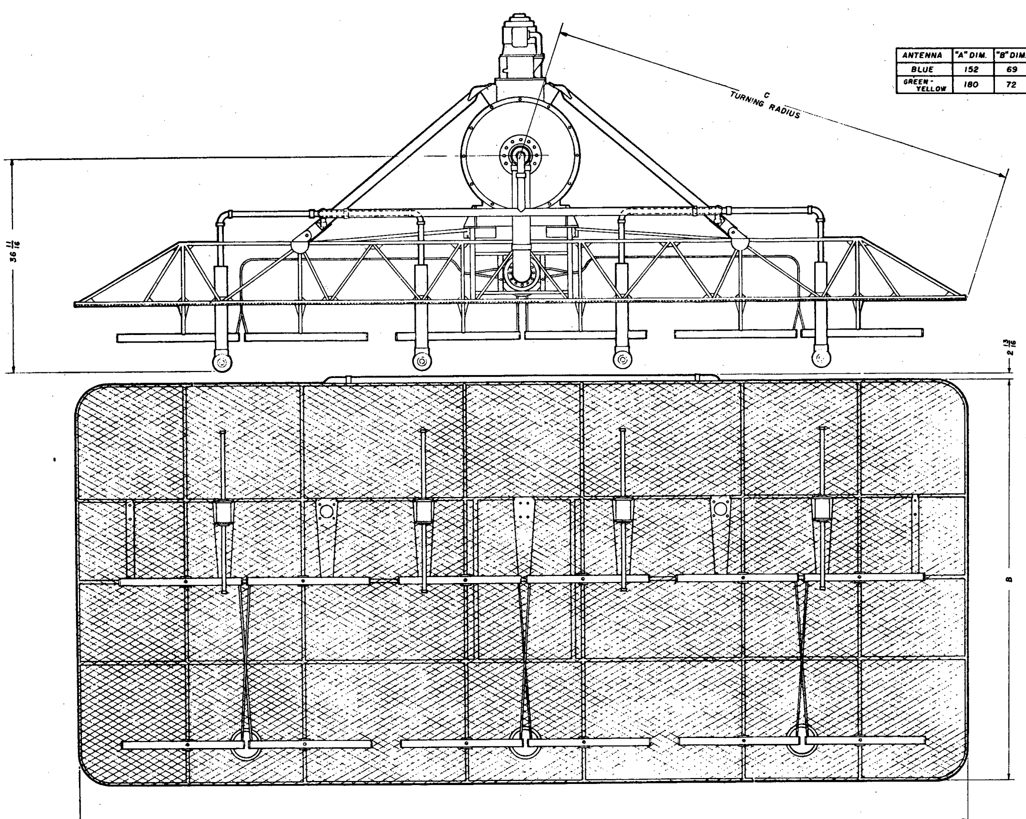


Figure 3-11. Assembly of Antenna to Antenna Pedestal

ANTENNA	"A" DIM.	"B" DIM.	"C" DIM.
BLUE	152	69	$80\frac{1}{8}$
GREEN-YELLOW	180	72	$93\frac{1}{2}$



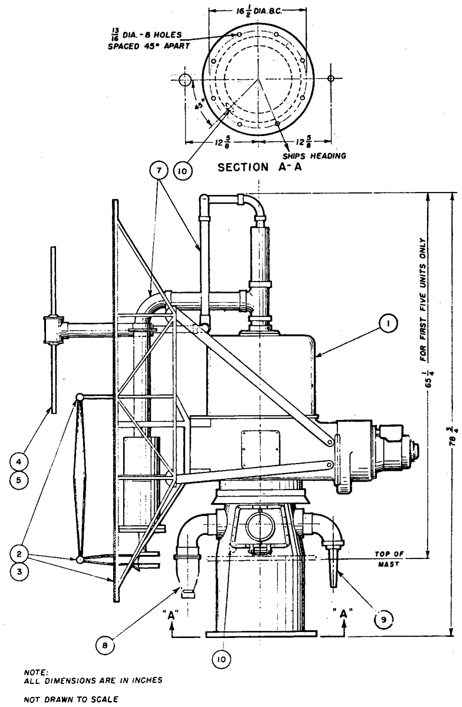
WEIGHT

BLUE ANTENNA CRATED 760 LBS.
ANTENNA UNCRATED 251 LBS.
CUBICAL CONTENT 324.02 CU. FT
(PACKED FOR SHIPMENT)
PEDESTAL CRATED 582 LBS.
PEDESTAL UNCRATED 428 LBS.
CUBICAL CONTENT 33.2 CU. FT.
(PACKED FOR SHIPMENT)

YELLOW GREEN ANTENNA CRATED 760 LBS.
ANTENNA UNCRATED 272 LBS.
CUBICAL CONTENT 324.02 CU. FT.
(PACKED FOR SHIPMENT)

LEGEND		SR	SR-5
PART	DESCRIPTION	NAVY TYPE	NAVY TYPE
1	ANTENNA PEDESTAL	CAJS-21ACP	CAJS-21ADD
2	BLUE ANTENNA ASSEMBLY	-66AHE	-66AHE
3	GREEN-YELLOW ANTENNA ASSEMBLY	-66AHF	-66AHF
4	MARK 3 DIPOLE - PURPLE - HF	-66AHG	-66AHG
5	MARK 3 DIPOLE - ORANGE - VHF	-66AHH	-66AHH
6	MARK 4 DIPOLE GROUP (SEE NOTE) - UHF	-66AHJ	-66AHJ
7	CONCENTRIC LINES		
8	COAXIAL CONNECTOR - RADAR ANTENNA		
9	COAXIAL CONNECTOR - I.F.F. ANTENNA		
10	POWER INLET - 1.90 DIA. (THREADED)		

NOTE: PART 6 IS ASSEMBLED ON 7611791.



NOTE:
ALL DIMENSIONS ARE IN INCHES

NOT DRAWN TO SCALE

Figure 3-12. Antenna and Pedestal, Outline Diagram the main radar Antenna frame. Unscrew each of the couplings of the feed line tees with a spanner wrench. Hold the feed line tee firmly and pull the dipole concentric line away from the tee to disengage the inner line plug. This procedure will permit each of the dipoles and its associated transmission line to be removed.

(2) Install the two impedance matching converters, one opposite each of the IFF line tees. Place the converter through the hole in the radar Antenna framework, holding it in such a position that the terminal screws are in vertical alignment with the off-set screw on top. Connect the inner line plug into the feed line tee being sure that the inner conductors join together properly. Check the seating of the gasket and tighten the coupling on the outer line with the spanner wrench provided.

(3) Install the four dipole arrays, making certain that each is in its correct position (right end, right center, left center, left end) as designated on the nameplate. The connecting lugs located at the joining ends of each of the two pairs of dipole arrays mesh so that the terminal lugs line up to receive the terminal screws on the converters. Fasten these terminals securely; then apply mounting hardware.

(4) Screw the caps on the open ends of the feed line tees with the spanner wrench provided.

f. ECHO BOX ANTENNA.

(1) The Echo Box Antenna shown in Fig. 3-13, is mounted six inches below the main radar Antenna and in the same plane with the radar dipole above it. It should be clamped to some firm support. This support may be the mast or any available rigid surface located six inches from the bottom of the Antenna. The clamps used should be fashioned in such a form as to hold the Echo Box Antenna by passing around the shield which forms its largest diameter. The clamps may be made of either a metal or a non-conductor. If desired, the six-inch dimension may be varied in order to change the maximum indication which may be obtained from the echo box indicating meter. The amount of variation required may be determined by experiment.

7. INSTALLATION OF SYNCHRO AMPLIFIER.

a. GENERAL.

(1) Both units comprising the Synchro-Amplifier are designed for bulkhead mounting and should be so installed that the Electronic Unit cover hinge is at the bottom and the Synchro Unit switch and terminal compartment is at the top with the Electronic Unit above the Synchro Unit. Suitable shockmounts are provided with these units, and installation is made by bolting these shockmounts to the bulkhead. It is desirable that the Synchro Amplifier be installed as near as possible to the Antenna, since the output from the Synchro-Amplifier must be connected to the Antenna Pedestal. Sufficient space must be allowed to permit the cover of the Electronic Unit to be swung open, so that the Synchro Unit may be removed. Six inches must be allowed on all sides of the Synchro Unit. The mounting dimensions are shown in Fig. 3-14.

b. MOUNTING THE UNITS.

(1) The units are mounted by means of metal blocks welded to the bulkhead and drilled and tapped to receive the mounting bolts. Instead of small metal blocks, metal strips may be more conveniently welded, in the case of the Synchro Unit. The method of bulkhead mounting is as follows:

(a) Determine the location of the unit, and mark the position of the mounting holes on the bulkhead.

(b) Over the position of each hole, weld a steel block to the bulkhead. The dimensions of this block should be approximately two inches square and three-quarters of an inch thick.

(c) Mark the position of each mounting hole on the steel blocks. Drill and tap each block to take the mounting screw. The 4 holes to hold the Electronic Unit should be drilled and tapped for ½-13 stud bolts. The 8 holes for the screws holding the Synchro Unit should be drilled and tapped for ⅜-16 studs.

(d) Place the Units in position against the bulkhead and assemble them to the mounting blocks with the proper studs.

8. INSTALLATION OF ROTATION CONTROL UNIT.

a. GENERAL.

(1) The Rotation Control Unit should be mounted as near as possible to the Indicator Console, since the type of bearing indication—true or relative—is controlled from the Rotation Control Unit. A clearance of two and one-half inches is required on all sides of the Rotation Control Unit in order that the shockmounts have sufficient space in which to function. The junction box may be mounted on the back or on either side of the unit as required, for ease in connecting the unit to the other components of the system. The shockmount clearance must be determined by the location of the junction box. At least 30 inches must be allowed at the front of the unit for proper operation of the controls. See Fig. 3-15.

b. MOUNTING INSTRUCTIONS.

(1) Instructions for mounting the unit are shown in Fig. 3-15. The shockmounts of the unit are mounted on two sliders, one on each side of the unit. These sliders are in turn bolted to the deck. The size of the holes required for mounting and the drilling plan are shown in Fig. 3-15. The Rotation Control Unit should be mounted to the deck by means of tapped holes if the deck is sufficiently thick to permit tapping. Otherwise, clearance holes should be drilled and the bolts secured by means of nuts and lockwashers on the opposite side of the deck. When installing the Rotation

Control Unit, ground the case by connecting a heavy copper braid between a bolt holding one of the shockmounts to the case and a bolt holding the shockmount to the deck. Suitable terminals must be used on the braid.

9. INSTALLATION OF SERVO GENERATOR.

a. GENERAL.

(1) The Servo Generator may be located any convenient place with its axis pointing fore and aft. Since its crated weight is only 206 pounds, it may be handled without difficulty either crated or uncrated. Two lifting eyes are provided to permit the use of a crane to lift the uncrated unit.

b. MOUNTING INSTRUCTIONS.

(1) The unit is fastened to the deck by means of ⅜-16 bolts inserted through eight slotted holes in the mounting surface at the base of the unit. These bolts should be of stainless steel or cadmium plated to resist corrosion. The mounting dimensions for the unit are shown in Fig. 3-16. The center line of the holes should be coincident with those of the slots.

10. INSTALLATION OF VOLTAGE STABILIZER.

a. The Voltage Stabilizer may be located at any convenient place. The unit is not mounted on shockmounts, and therefore does not require special clearance to bulkheads or other units. It should be mounted where a free circulation of air will be available for cooling. After the unit is uncrated, it may be lifted by use of two lifting brackets one on each end of the unit. These brackets may be removed if desired for installation in available space. The unit should be fastened to the deck by means of four bolts. The drilling plan for these bolts is shown in Fig. 3-17. The bolts may be fastened by drilling and tapping appropriate holes in plates welded to the deck. The bolts should be secured with lockwashers.

11. INSTALLATION OF MOTOR GENERATOR.

a. The Motor Generator should be mounted as near as possible to the main bus, since this unit requires the greatest amount of power, and the line voltage drop must be reduced to a minimum. The requisite information for mounting the unit is shown in Figs. 3-18 and 3-19. The unit is shipped assembled to the bedplate, and includes the motor, the generator, the exciter, and the coupling. The total uncrated weight of unit CAY-211182 and CAY-211188 is 2870 pounds, and that of unit CAY-211326 is 3020 pounds. A crane will be required to move the unit, which should be uncrated before attempting to place it in position. Two lifting eyes are provided; one on the top of the motor and the other on the top of the generator. The Motor Generator must be mounted so that its long axis points fore and aft to minimize wear on the bearings due to gyroscopic action.

b. Sufficient space should be allowed at the location to permit the use of a crane. If this is not possible the Motor Generator must be moved into position on rollers. The use of a crane is much more desirable and is recommended wherever possible. The amount of space around the Motor Generator should be large enough to permit the removal of any of the components from the bedplate. The dimensions which must be maintained in installation are shown in Figs. 3-18 and 3-19. As shown, 40 inches must be allowed between the motor end of the bed plate and any obstructions; 48 inches must be allowed at the generator end, and 30 inches must be allowed in front of the bed plate. The Motor-Generator assembly is fastened to the deck by means of four 1-inch bolts, preferably of stainless steel or cadmium plated to resist corrosion and rust. The drilling plan for these bolts is shown in Figs. 3-18 and 3-19. The bolts should be secured by means of lockwashers and nuts.

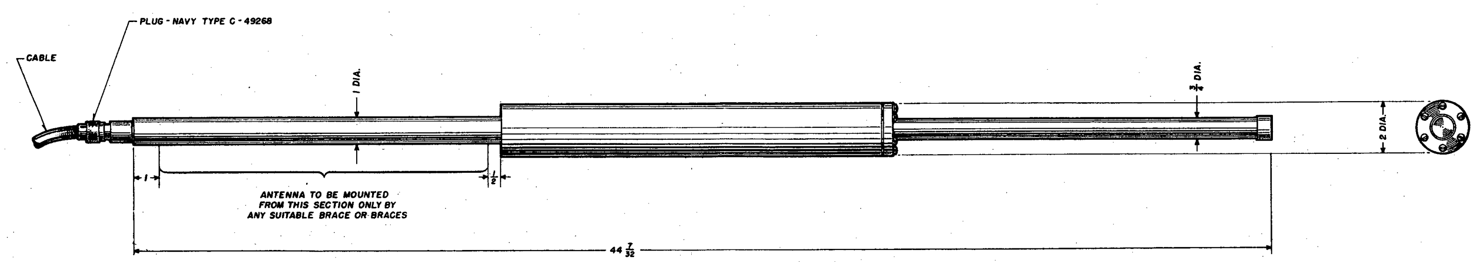
12. INSTALLATION OF VOLTAGE REGULATOR.

a. The Voltage Regulator, as part of the power equipment, should be mounted as near as possible to the Motor-Generator. The uncrated weight of the unit is 232 pounds. It may be handled easily by three men. Bulkhead mounting is used, and sufficient space must be allowed in order that the door will have sufficient clearance in opening. The amount of this clearance is shown in Fig. 3-20. The unit is mounted on a bulkhead through four mounting holes drilled in the back of the case. Bulkhead mounting is accomplished by means of metal blocks welded to the bulkhead, drilled and tapped to receive the mounting bolts, as in the case of the Synchro Amplifier.

13. INSTALLATION OF MAGNETIC CONTROLLER.

a. The Magnetic Controller is also part of the power supply, and should be mounted as near as possible to the Motor-Generator. The uncrated weight of the 230-volt unit is 76 pounds, and that of the 115-volt unit is 130 pounds. Either unit may be handled easily by two men. As in the case of the Voltage Regulator, bulkhead mounting is used. Proper clearance must be allowed so that the door of the unit may have space in which to swing.

b. The Magnetic Controller should be mounted to the bulkhead by means of drilled and tapped metal blocks welded to the bulkhead, as in the case of the Voltage Regulator. The drilling plan and dimensional clearances for the unit are shown in Figs. 3-21 and 3-22. The metal blocks should be drilled and tapped for ⅜-16 machine screws, in the case of the 230-volt unit, and for ¾-10 volts in the case of the 115-volt unit. Mounting is accomplished in the same manner as in the case of the Voltage Regulator. The cable connections are shown in Fig. 3-25.



NOTE:
ALL DIMENSIONS ARE IN INCHES

WEIGHT

UNCRATED	5 1/2 LBS.
CRATED	LBS.
CUBICAL CONTENT (PACKED FOR SHIPMENT)	CU. IN.

Figure 3-13. Echo Box Antenna, Outline Diagram

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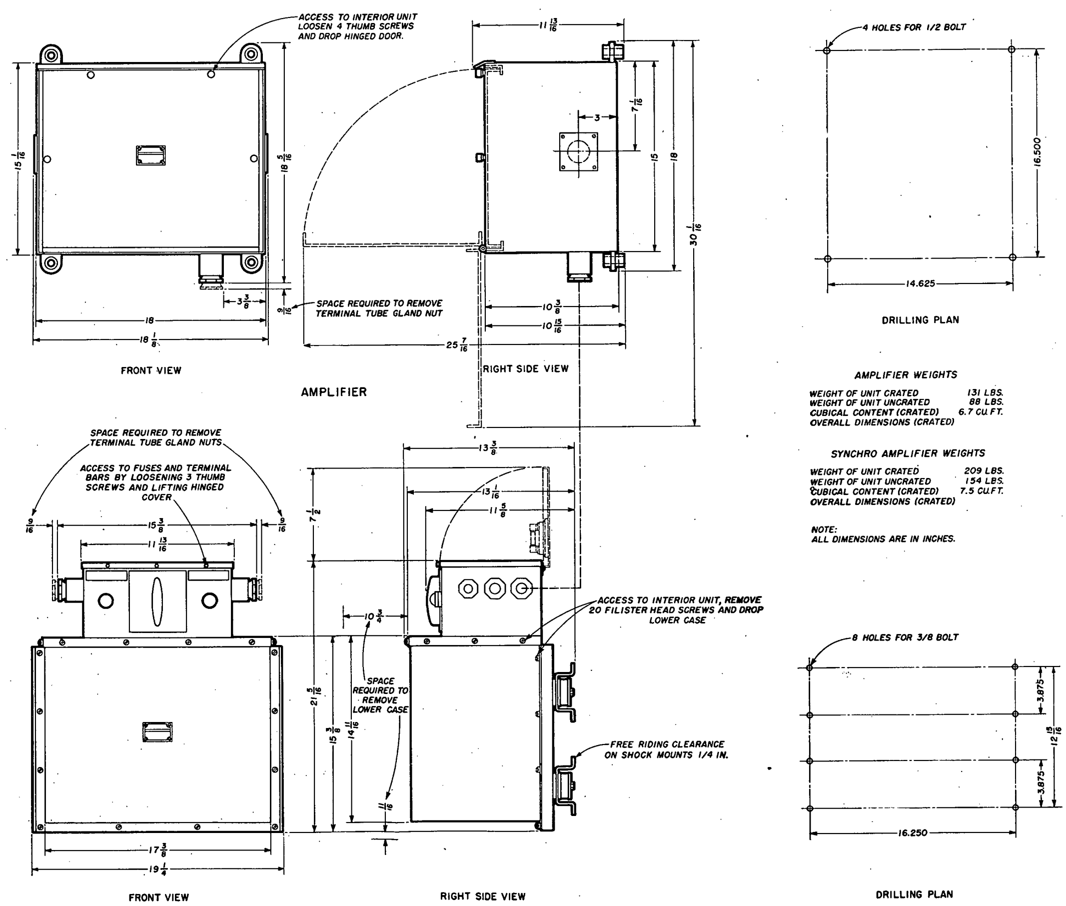


Figure 3-14. Synchro Amplifier, Outline Diagram

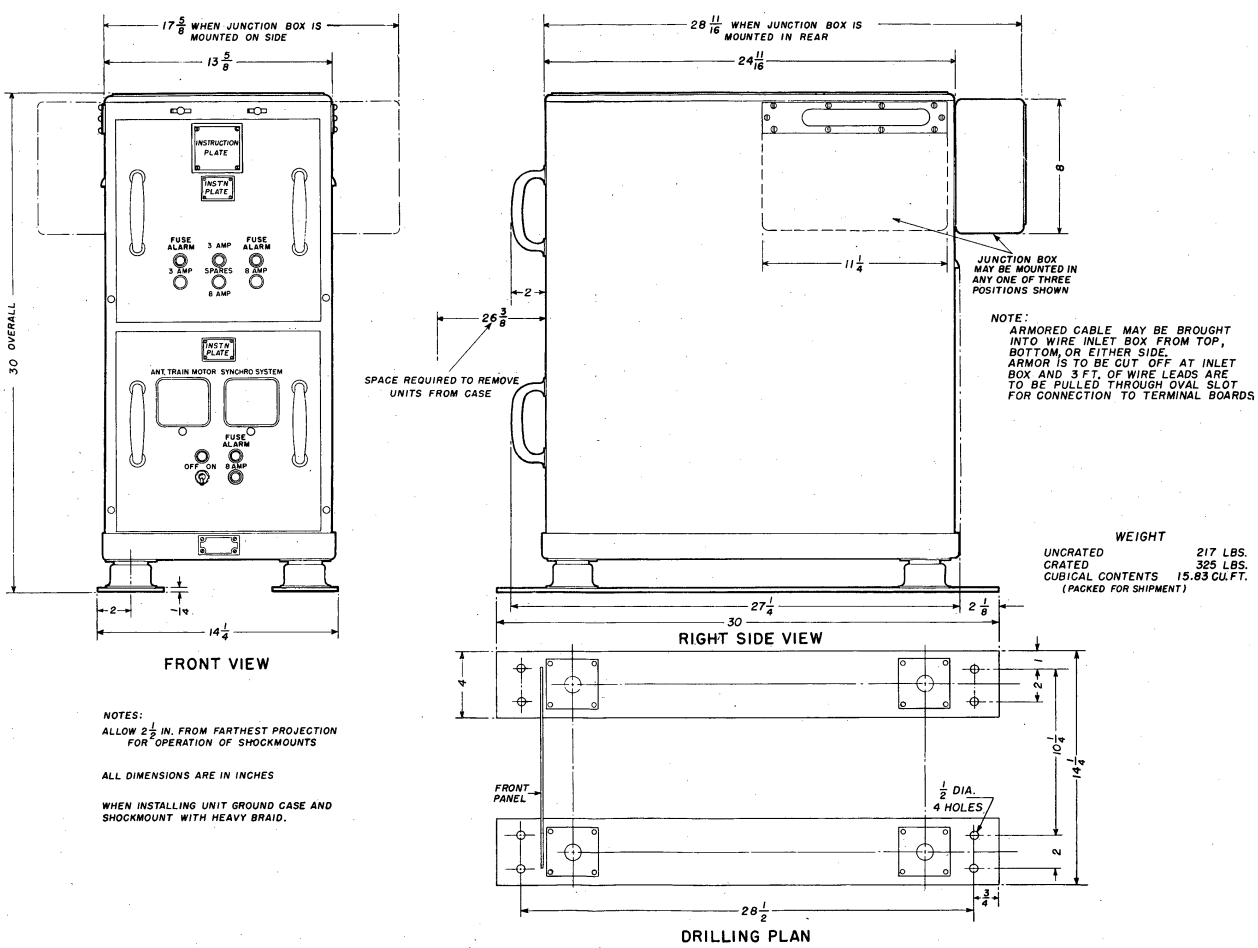
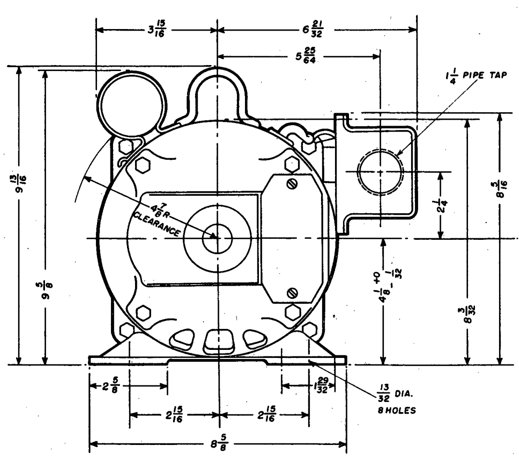
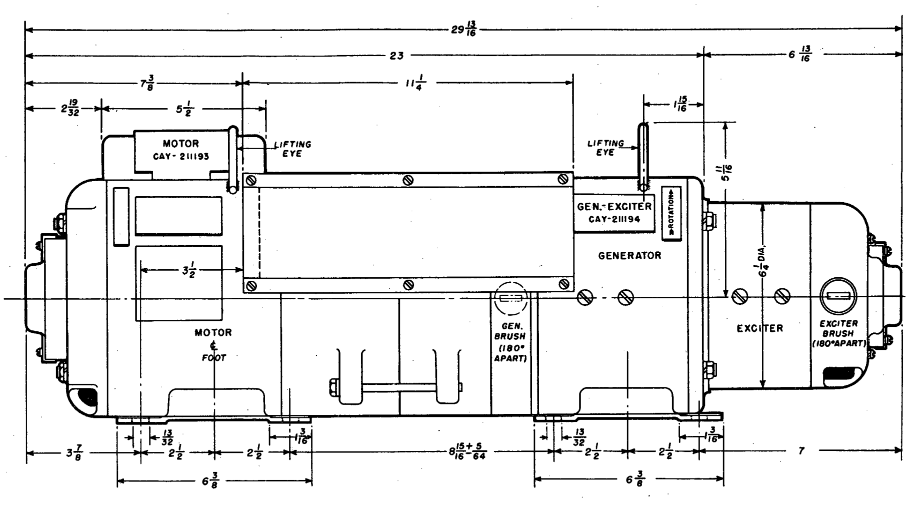


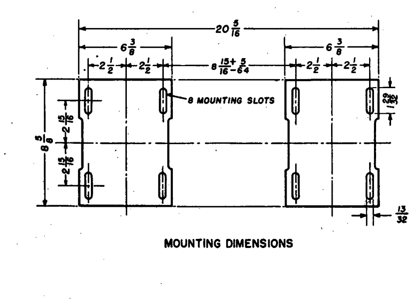
Figure 3-15. Rotation Control Unit, Outline Diagram



VIEW OF MOTOR END



RIGHT SIDE VIEW



MOUNTING DIMENSIONS

NOTE:
ALL DIMENSIONS ARE IN INCHES

WEIGHT	
UNCRATED	*170 LBS.*
CRATED	*206 LBS.*
CUBICAL CONTENT (PACKED FOR SHIPMENT)	*3.66 CU. FT.*

Figure 3-16. Servo Generator, Outline Diagram

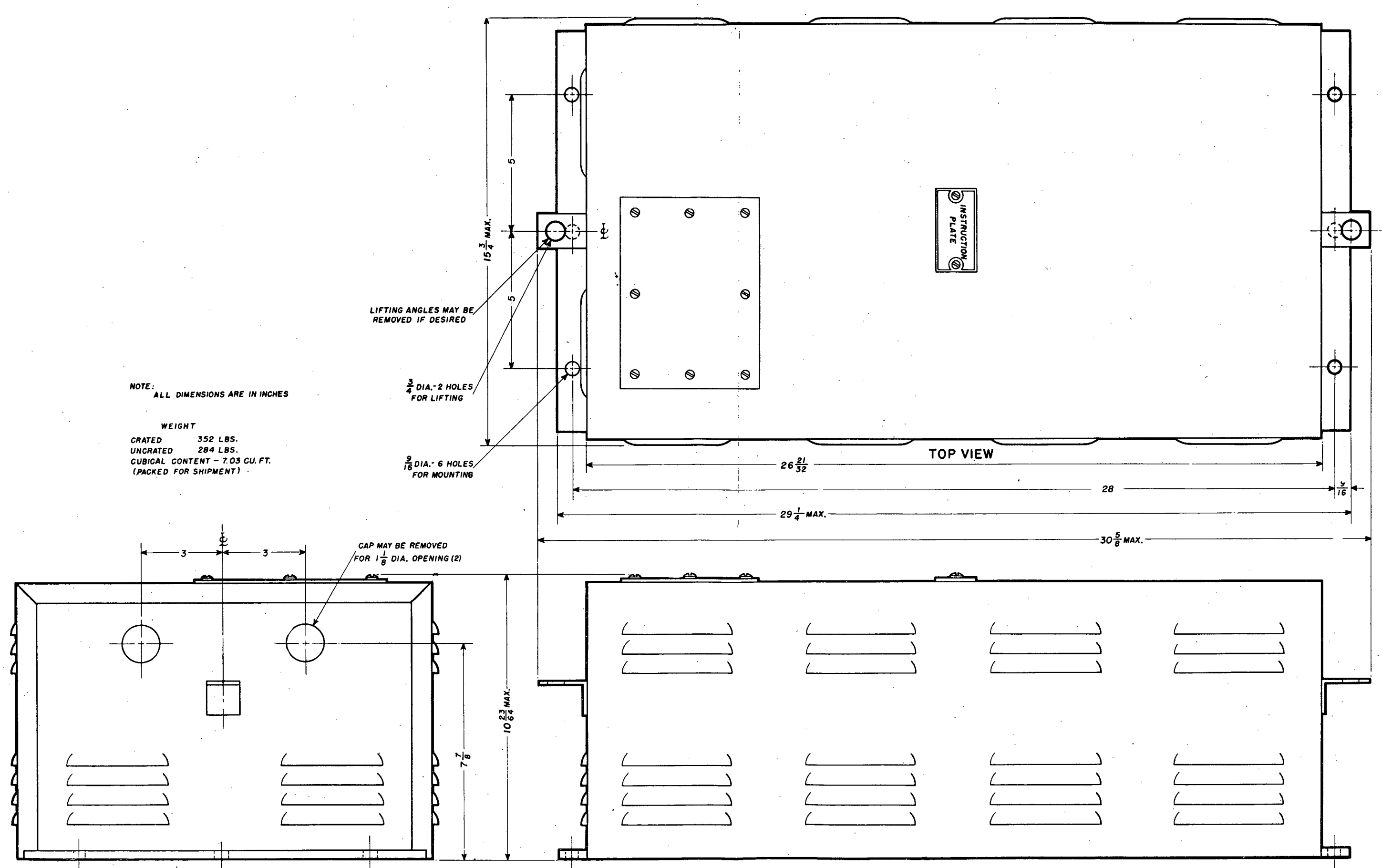


Figure 3-17. Voltage Stabilizer, Outline Diagram

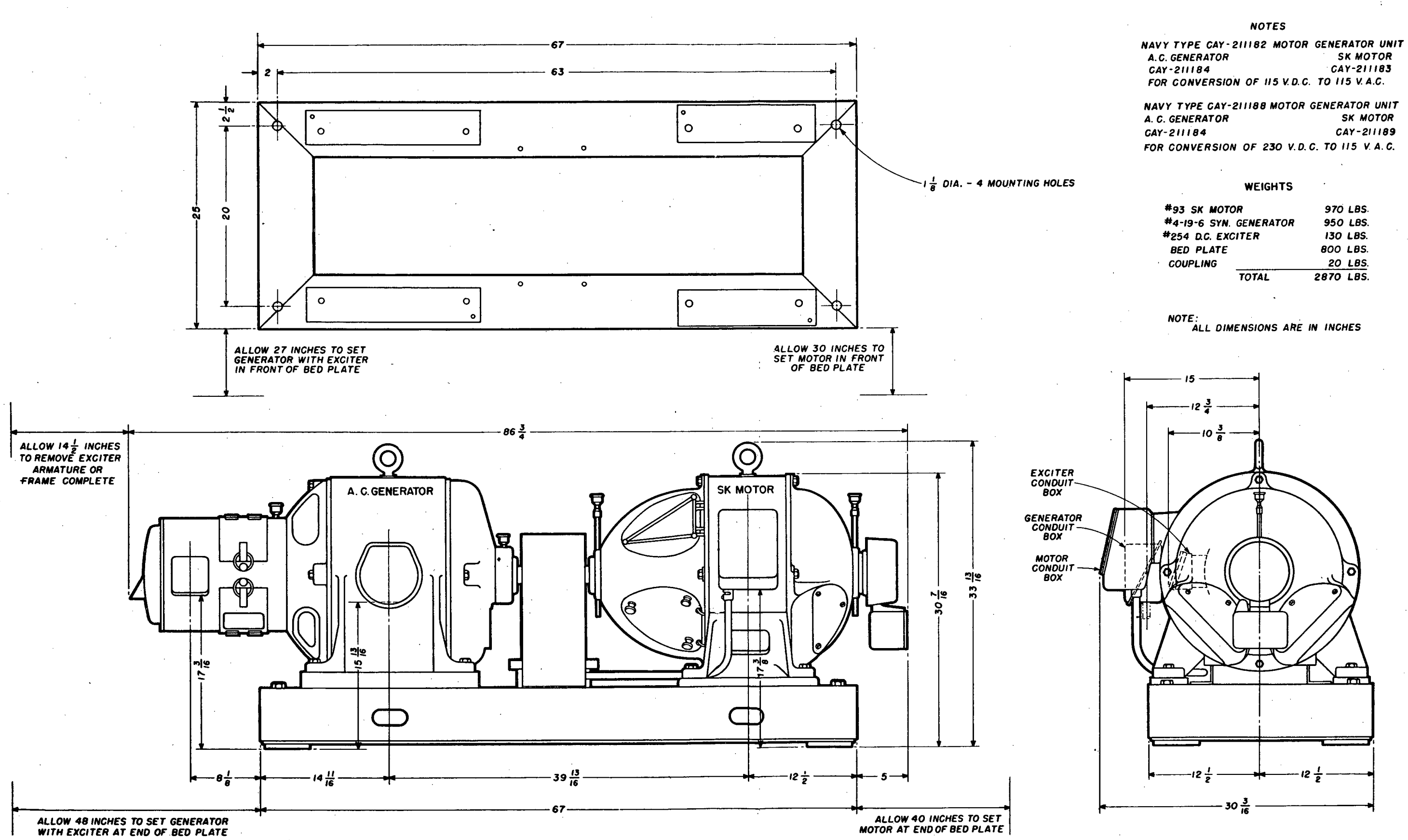


Figure 3-18. Motor Generator CAY-211182 and CAY-211188, Outline Diagram

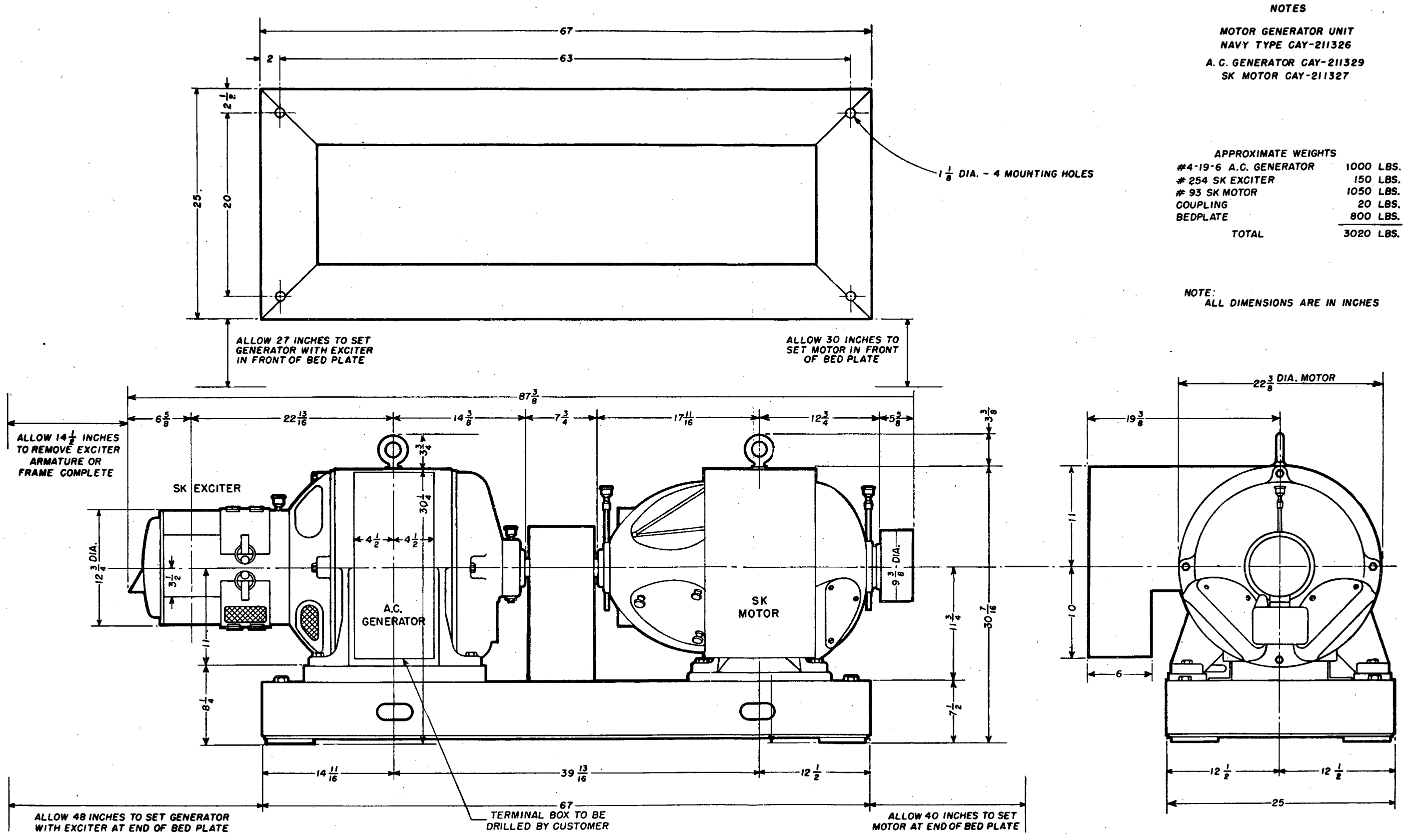


Figure 3-19. Motor Generator CAY-211326, Outline Diagram

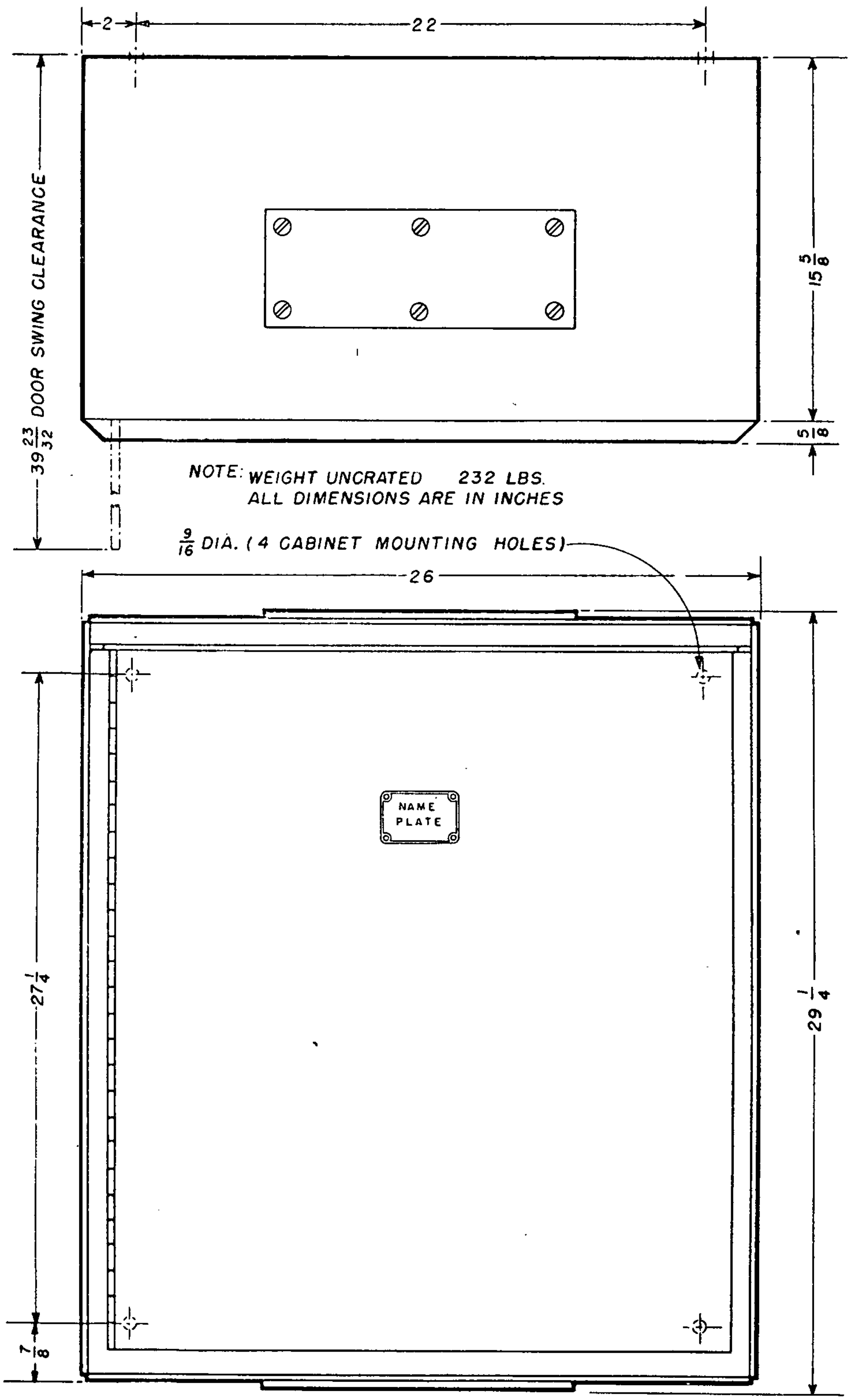


Figure 3-20. Voltage Regulators CAY-211185 and CAY-211185A, Outline Diagrams

Figure 3-20. Voltage Regulators CAY-211185 and CAY-211185A, Outline Diagrams

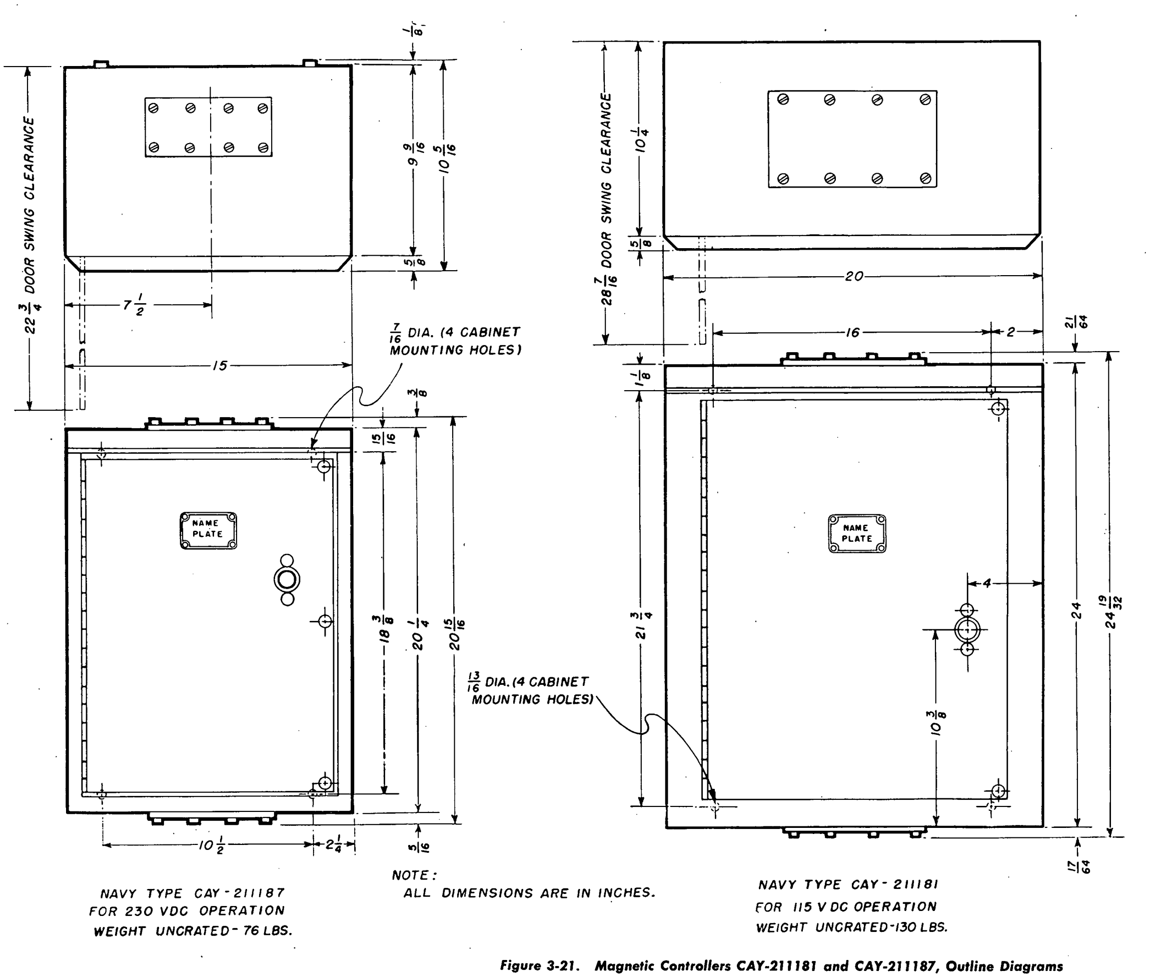


Figure 3-21. Magnetic Controllers CAY-211181 and CAY-211187, Outline Diagrams

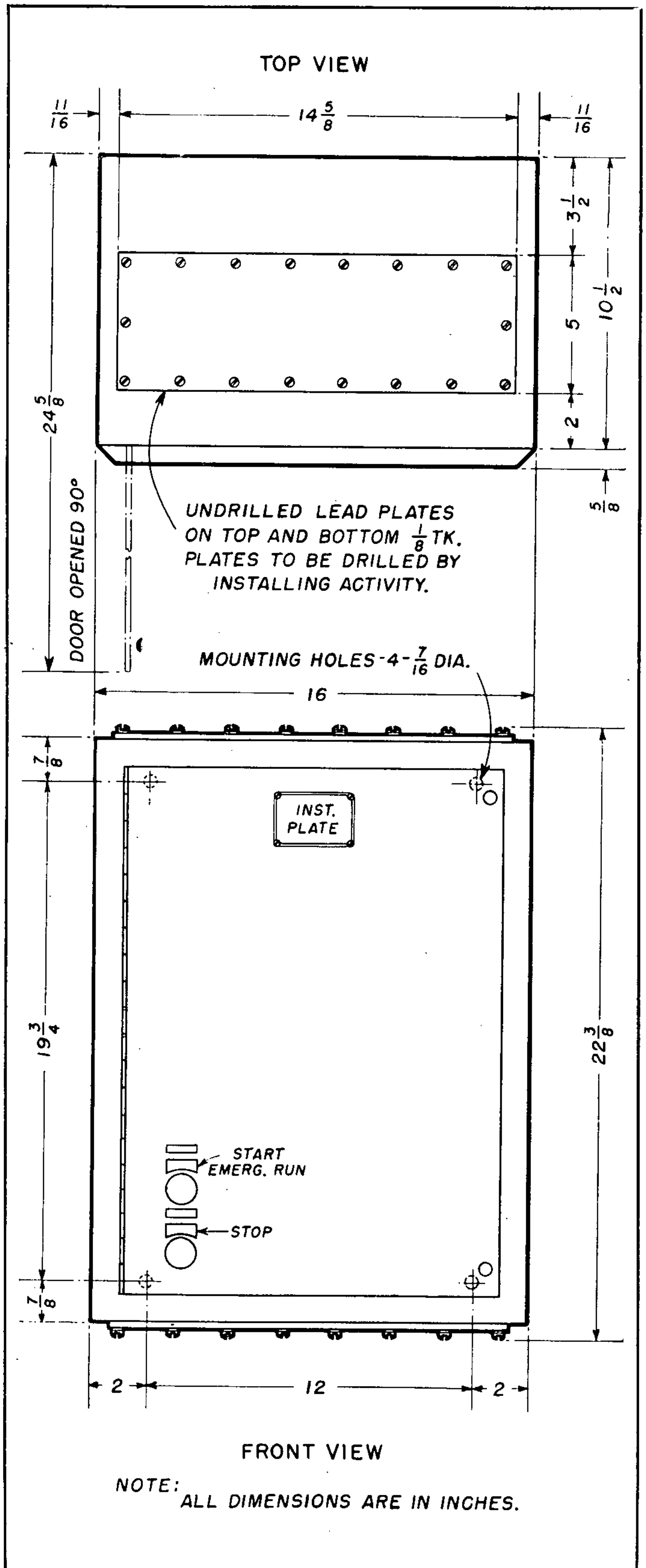


Figure 3-22. Magnetic Controllers CAY-211325, Outline Diagram

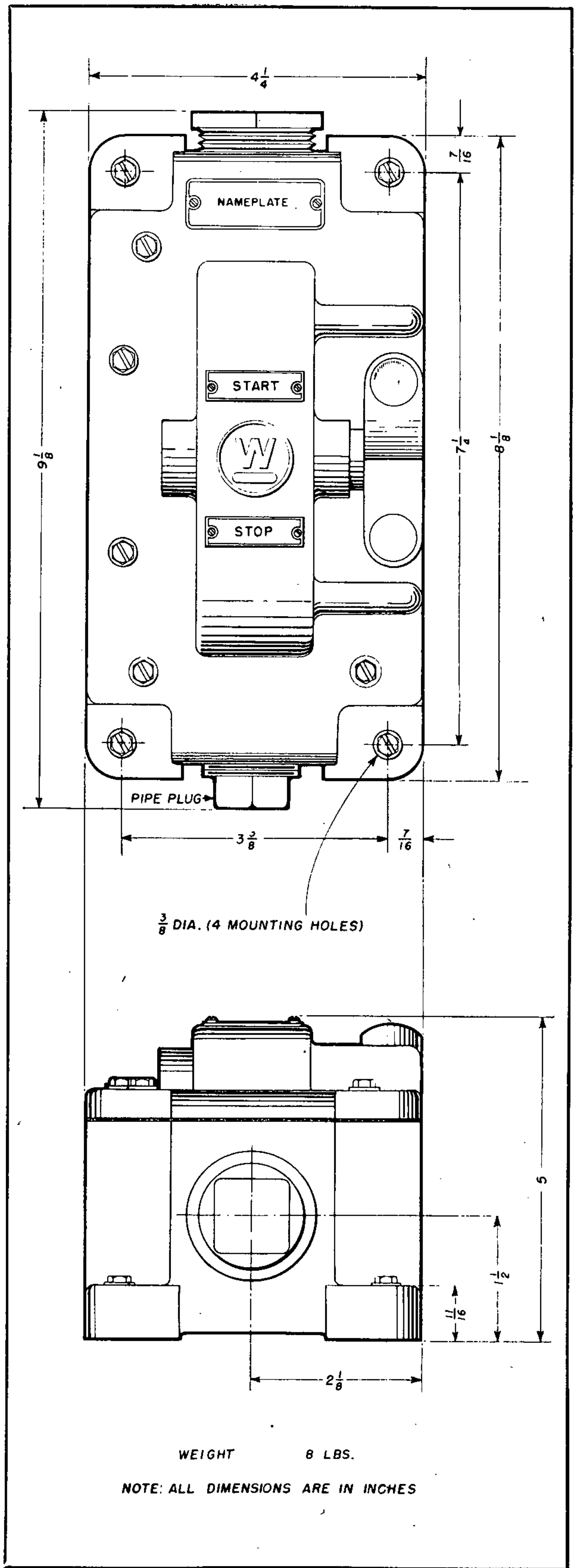


Figure 3-23. Push Button Station CAY-211186 and CAY-24299, Outline Diagram

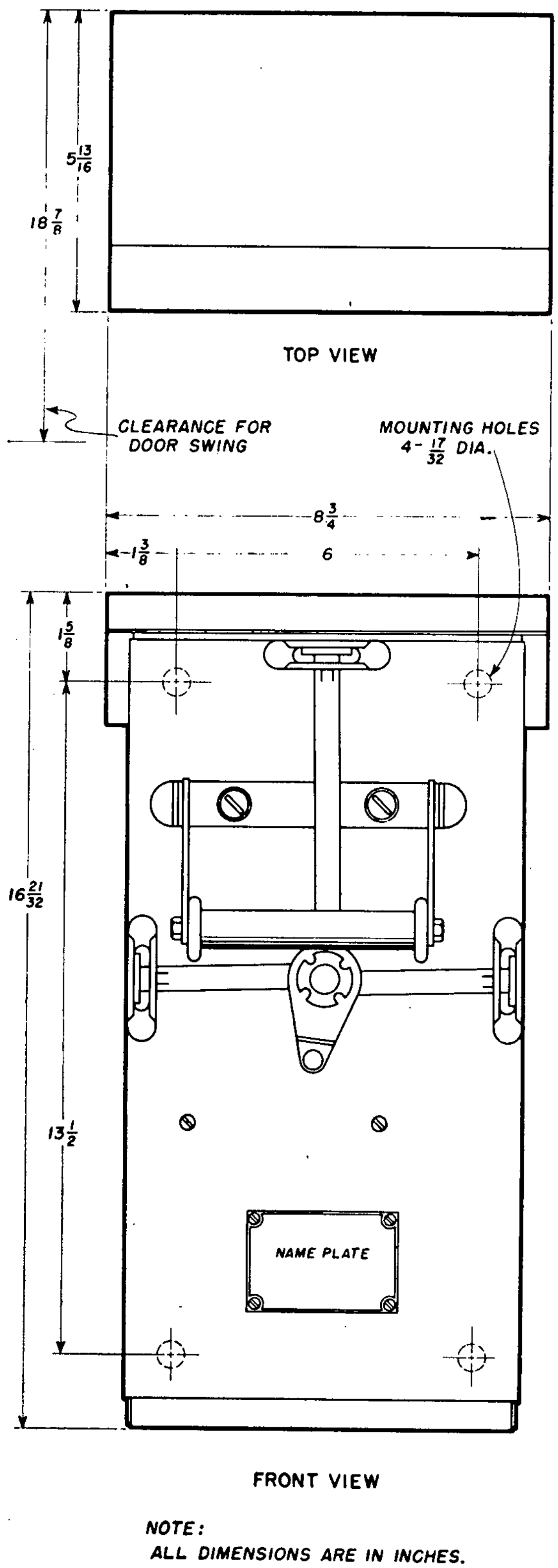


Fig. 3-24. Controller Disconnect Line Switch, Outline Diagram

14. INSTALLATION OF PUSHBUTTON STATION.

a. The Pushbutton Station should be mounted as near as possible to the Transceiver. It is bulkhead-mounted by means of four mounting screws. The drilling plan for these screws is shown in Fig. 3-23. The same method of mounting should be used as in the case of the Voltage Regulator and the Magnetic Controller. Instead of metal blocks, however, a piece of metal of the same dimensions as the base of the pushbutton station may in this case be used. It should be drilled and tapped for 5/16-18 machine screws. The unit should be mounted with studs retained by means of lockwashers.

15. INSTALLATION OF CONTROLLER DISCONNECT LINE SWITCH.

a. The Controller Disconnect Line Switch should be mounted in the same area as the other units of the power supply. It is bulkhead-mounted with four mounting screws in the same manner as the other bulkhead-mounted units previously described. The drilling plan for the unit is shown in Fig. 3-24. The holes drilled and tapped in the metal blocks welded to the bulkhead should be made to take ½-13 machine screws.

16. INTERCONNECTION OF MAJOR UNITS.

a. GENERAL.

(1) The method of interconnection between the various units of the SR system is shown schematically in Fig. 3-25. This master interconnection diagram shows the path to be followed by each connection between the individual units, and the type of cable to be used. The method of entering the individual units with the cable, and the method of connecting terminals to the cables will be discussed in these paragraphs.

b. TRANSCEIVER.

(1) Four types of cable connections are made to the Transceiver. The high power r-f cable is used to conduct the output pulse from the Transceiver to the radar Antenna, and to return the received pulse to the receiving units. This cable is a Type RG-20/U. The method of terminating this cable is shown in Fig. 3-26. The same type of connector is used at each end of the cable. At the Transceiver, the cable is brought into the unit through an opening provided in the rear shield of the Transceiver, near the duplexer. The connector on the end of the cable is fastened to the duplexer by means of the two machine screws, which fit into tapped holes in the duplexer assembly. At the Antenna Pedestal, the connector on the cable fits into a connector at the base of the Pedestal. This connector is of the same type as that used on the duplexer, and is shown in Fig. 3-30. Throughout its run, the cable should be firmly clamped to rigid supports at frequent intervals in order to prevent movement of the cable and consequent damage.