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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

AZIMUTH-ELEVATION RANGE RECORDER

RD-54/TP

AND

AZIMUTH-ELEVATION RANGE RECORDER

RO-3/MPQ

DEPARTMENT OF THE ARMY • AUGUST 1954

TECHNICAL MANUAL
No. 11-5534

DEPARTMENT OF THE ARMY
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AZIMUTH-ELEVATION RANGE RECORDER RD-54/TP
AND
AZIMUTH-ELEVATION RANGE RECORDER RO-3/MPQ

	Paragraphs	*Page*
CHAPTER 1. INTRODUCTION		
Section I. General	1, 2	5
II. Description and data	3–6	5
III. Description of components	7–11	7
CHAPTER 2. OPERATING INSTRUCTIONS		
Section I. Service upon receipt of equipment	12–16	15
II. Controls and instruments	17, 18	22
III. Operation under usual conditions	19–29	29
IV. Operation under unusual conditions	30–33	36
CHAPTER 3. ORGANIZATIONAL MAINTENANCE INSTRUCTIONS		
Section I. Organizational tools and equipment	34, 35	38
II. Preventive maintenance services	36–39	38
III. Lubrication and weatherproofing	40–42	42
IV. Troubleshooting at organizational maintenance level	43–46	43
CHAPTER 4. THEORY		
Section I. Overall theory of Azimuth-Elevation-Range Recorder RD-54/TP and Azimuth-Elevation-Range Recorder RO-3/MPQ	47–50	46
II. Theory of Electronic Control Amplifier AM-489/TP (Servo Amplifier)	51–58	52
III. Theory of synchro transmission	59–63	57
CHAPTER 5. FIELD MAINTENANCE INSTRUCTIONS		
Section I. Troubleshooting at field maintenance level	64–70	60
II. Repairs	71–74	68
CHAPTER 6. MECHANICAL OVERHAUL OF THE RECORDER ASSEMBLY		
Section I. General	75, 76	70
II. Removal of major parts and assemblies	77–87	70
III. Cleaning disassembled parts	88, 89	82
IV. Overhaul of major components	90–98	82
V. Reassembly of major parts	99–110	95
CHAPTER 7. SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE		
Section I. Shipment and limited storage	111, 112	98
II. Demolition of materiel to prevent enemy use	113, 114	98
INDEX		105

ARTIFICIAL RESPIRATION

GENERAL PRINCIPLES

1. Seconds count! Begin at once! Don't take time to move the victim unless you must. Don't loosen clothes, apply stimulants or try to warm the victim. Start resuscitation! Get air in the lungs! You may save a life!

2. Place the victim's body in a prone position, so that any fluids will drain from the respiratory passages. The head should be extended and turned sideward *never flexed forward;* the chin shouldn't sag, since obstruction of the respiratory passages may occur.

3. Remove any froth or debris from the mouth with your fingers. Draw the victim's tongue forward.

4. Begin artificial respiration. Continue it rhythmically and without any interruption until natural breathing starts or the victim is pronounced dead. Try to keep the rhythm smooth. Split-second timing is not absolutely essential.

5. When the victim starts breathing, or when additional help is available loosen the clothing; remove it, if it's wet; keep the victim warm. Shock should receive adequate attention. Don't interrupt the rhythmical artificial technique for these measures. Do them only when you have help or when natural breathing has started.

6. When the victim is breathing, adjust your timing to assist him. Don't fight his efforts to breathe. Synchronize your efforts with his. After resuscitation, keep him lying down until seen by a physician or until recovery seems certain.

7. Don't wait for mechanical resuscitation! If an approved model is available, use it, but, since mechanical resuscitators are only slightly more effective than properly performed "push-pull" manual technique, *never* delay manual resuscitation for it.

BACK-PRESSURE ARM LIFT METHOD

1. *Position of Victim.* Place the victim in the prone (face-down) position. Bend his elbows; place one hand upon the other. Turn his face to one side, placing his cheek upon his hands.

2. *Position of Operator.* Kneel on your left or right knee, at the victim's head, facing him. Your knee should be at the side of the victim's head close to his forearm, your foot should be near his elbow. Kneel on both knees if you find it more comfortable, with one knee on each side of the head. Place your hands on the flat of the victim's back so that their heels are just below the lower tip of his shoulder blades. With the tip of your thumbs touching spread your fingers downward and outward. (See A)

3. *Compression Phase.* Rock forward until your arms are approximately vertical and allow the weight of the upper part of your body to exert a slow, steady, even, downward pressure upon your hands. This forces air out of the lungs. Keep your elbows straight and press almost directly downward on the back. (See B)

4. *Expansion Phase.* Release the pressure, avoid any finish thrust, and commence to rock backward slowly. Place your arms upon the victim's arms just above the elbows, and draw his arms upward and toward you. Apply just enough lift to feel resistance and tension at the victim's shoulders. Don't bend your elbows. As you rock backward, the victim's arms will be drawn toward you. (The arm lift expands the chest by pulling on the chest muscles, arching the back and relieving the weight on the chest.) Drop the arms gently to the ground or floor. This completes the cycle. (See C and D). Now. repeat the cycle.

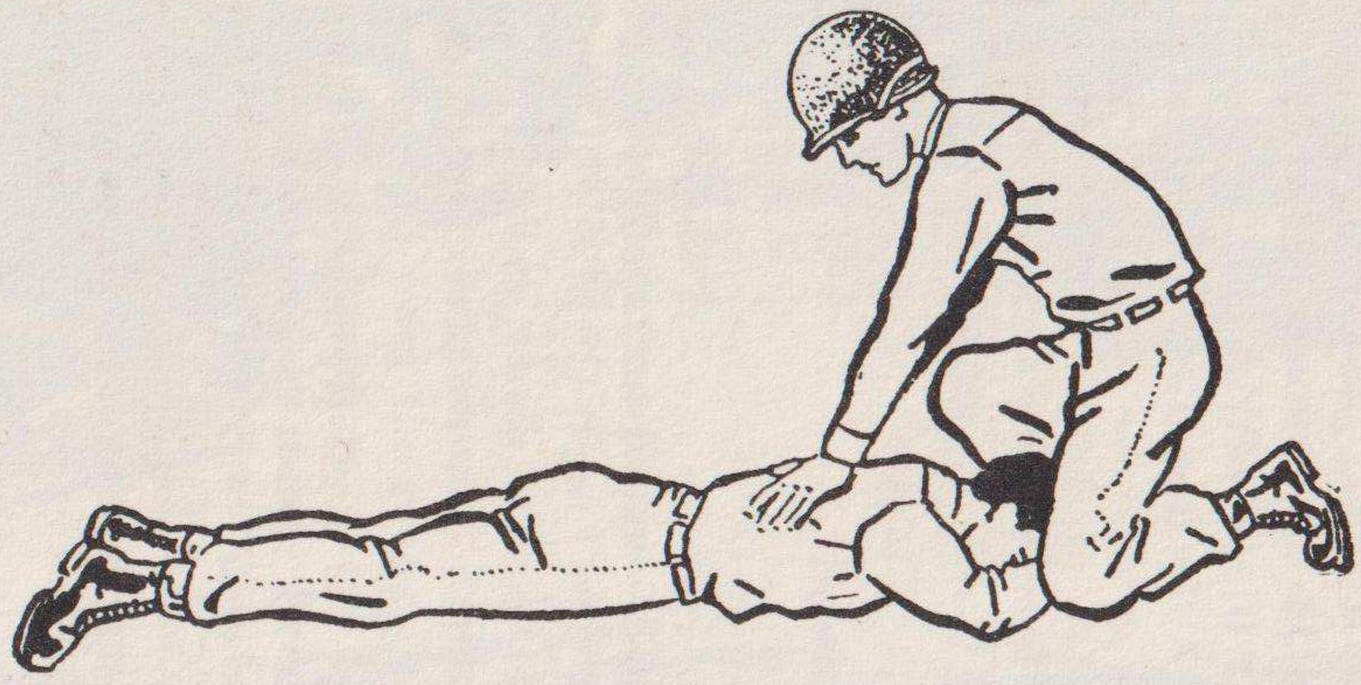
5. *Cycle Timing and Rhythm.* Repeat the cycle 10 to 12 times per minute. Use a steady uniform rate of Press, Release, Lift, Release. Longer counts of about equal length should be given to the "Press" and "Lift" steps of the compression and expansion phases. Make the "Release" periods of minimum duration.

6. *Changing Position or Operator.*

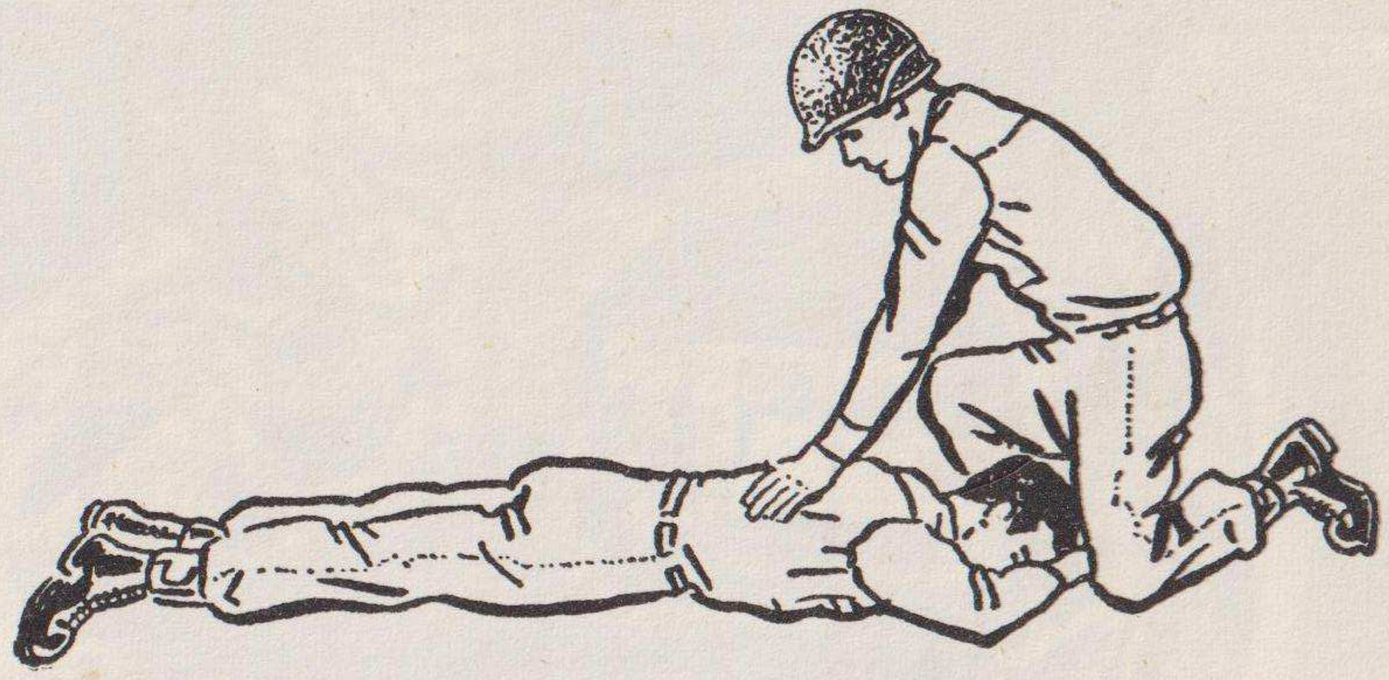
(*a*) Remember that you can use either or both knees or can shift knees during the procedure, provided you don't break the rhythm. Observe how you rock forward with the back-pressure and backward with the arm-lift. The rocking motion helps to sustain the rhythm and adds to the ease of operation.

(*b*) If you tire and another person is available, you can "take turns." Be careful not to break the rhythm in changing. Move to one side and let your replacement come in from the other side. Your replacement begins the "Press-Release" after one of the "Lift-Release" phases, as you move away.

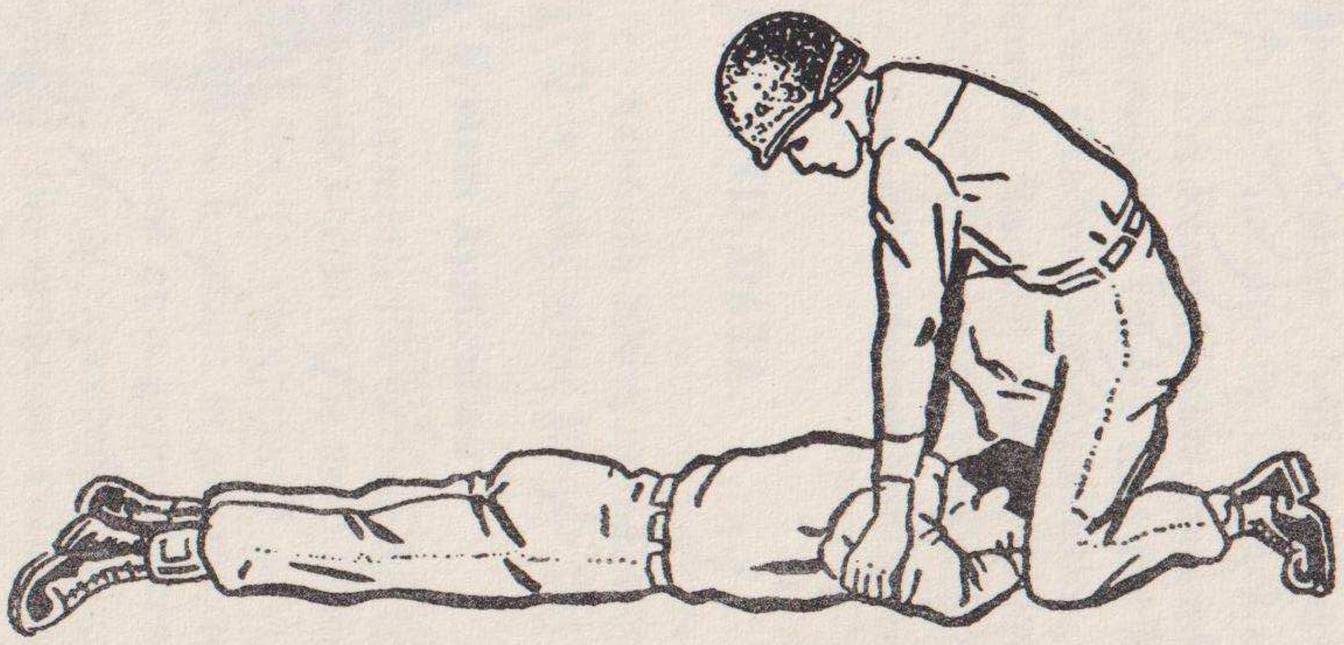
TM AR-3



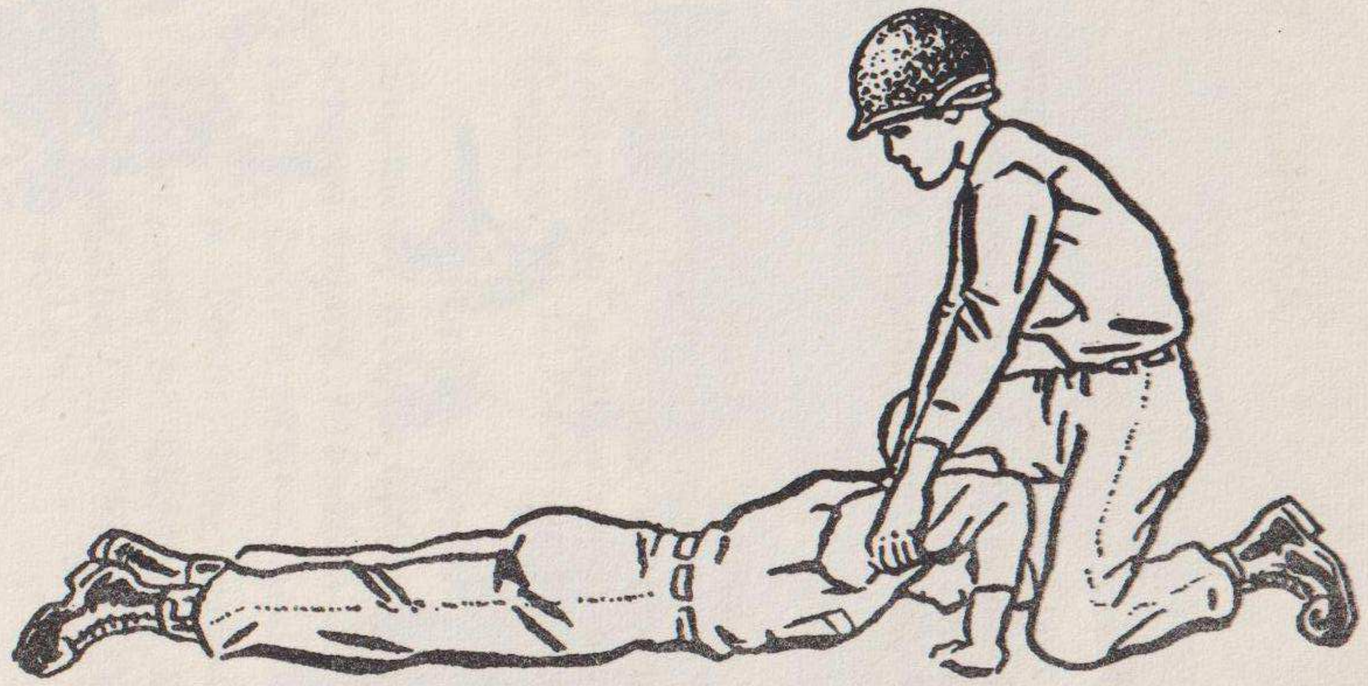
A Position of operator and victim



B Compression phase



C Expansion phase (arm lift)



D Expansion phase (arm release)

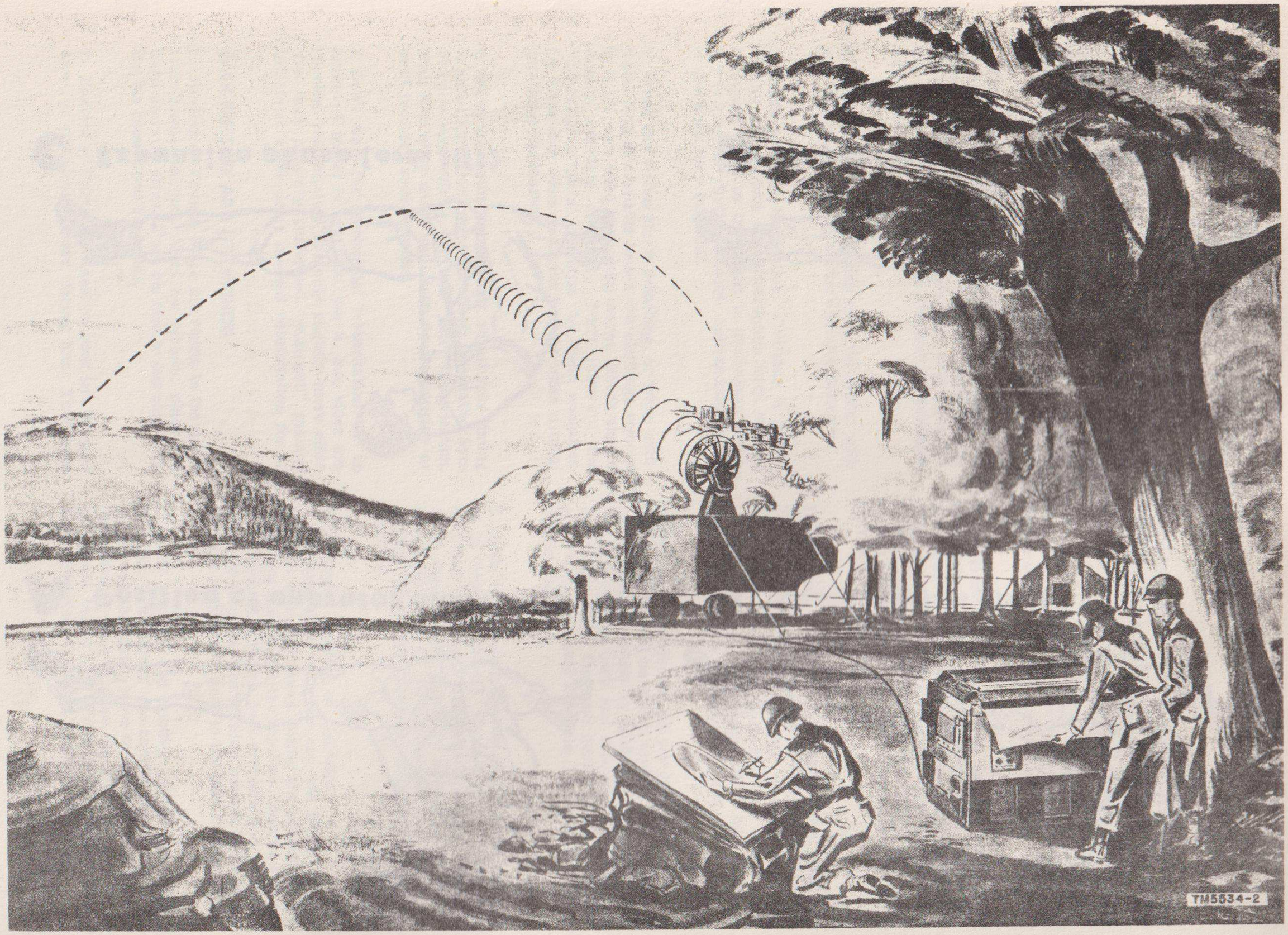


Figure 1. Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ with associated radar set.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual provides information on the installation, theory of operation, operation, maintenance, and repair of Azimuth-Elevation-Range Recorder RD–54/TP and Azimuth-Elevation-Range Recorder RO–3/MPQ (figs. 1 and 2).

b. The material contained in this technical manual is for Azimuth-Elevation-Range Recorder RD–54/TP and Azimuth-Elevation-Range Recorder RO–3/MPQ only and does not include any instructions concerning the radar set used in conjunction with the equipment.

c. Official nomenclature followed by (*) is used to indicate all models of the item of equipment included in this manual. Thus Radio Set SCR–584–(*) represents Radio Sets SCR–584–A and –B, and Radar Set AN/MPQ–10 (*) represents Radar Sets AN/MPQ–10 and –10A.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army materiel and equipment and in performing preventive maintenance:

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

b. DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700–45–4.

c. DA Form 11–238, Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 21).

d. DA Form 11–239, Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form (fig. 22).

e. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. Purpose and Use

a. Azimuth-Elevation-Range Recorders RD–54/TP and RO–3/MPQ (figs. 1 and 2) are electromechanical devices which will record simultaneously on paper the azimuth, height, and range data transmitted from the radar set used in conjunction with the recorders.

b. Azimuth-Elevation-Range Recorder RD–54/TP may be used with the following radar sets after they have been modified for mortar tracking:

(1) Radio Sets SCR–584–A and SCR–584–B.
(2) Radio Set SCR–784.
(3) Radar Sets AN/MPQ–10 and AN/MPQ–10A.

c. Azimuth-Elevation-Range Recorder RO–3/MPQ is used with Radar Set AN/MPQ–22.

4. System Application

a. Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ is used with a properly modified radar set to comprise a system that accurately plots the location of enemy mortars. The radar set is aimed at a general area from which enemy mortar fire is expected. When the enemy mortar is fired, the radar operator will *pick up* the shell in flight. By the time the shell is *picked up* by the radar set, it probably has traveled at least one-third of its flight. As the subsequent trajec-

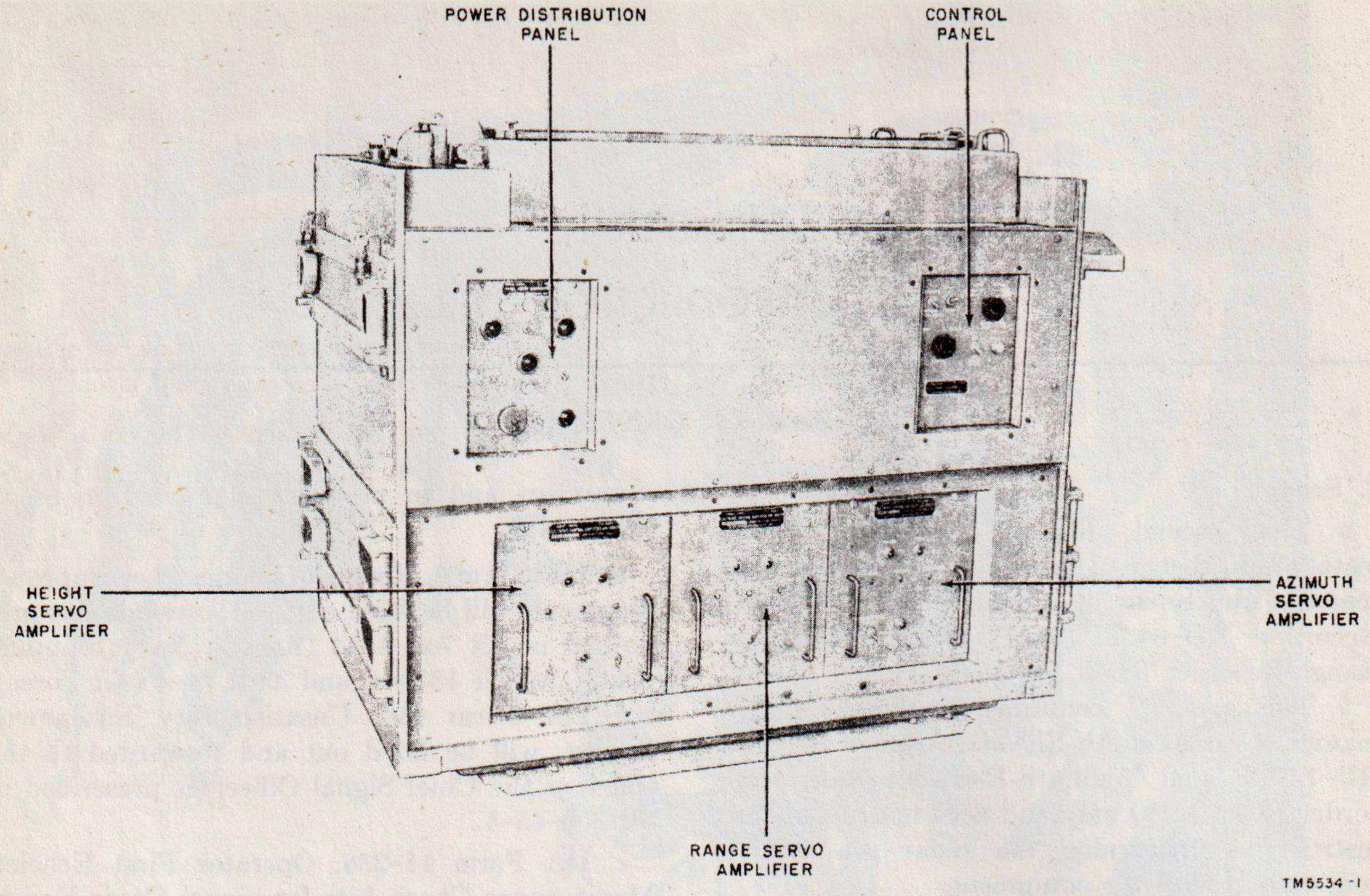


Figure 2. Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ.

tory of the shell is being tracked, the signal data supplied by the snychro generators in the radar set is fed directly to Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ for plotting the azimuth, height, and range of the shell's trajectory. The range and azimuth of the trajectory origin (mortar battery), is extrapolated from these recordings by means of a parabolic template called a trajectory curve and a tricalibrated scale called a plotting aid.

b. Figure 1 illustrates the use of the equipment when solving a typical enemy mortar location problem.

c. Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ also is used to *zero in* friendly mortar fire on predetermined enemy mortar locations.

5. Technical Characteristics

Power supply	115-volt, 60-cycle, three-phase, delta-connected power source.
Accuracy (relative to input data):	
Azimuth-Elevation-Range Recorder RD–54/TP.	Maximum errors of 3 mils in azimuth, 15 yards in range, and 30 feet in height.
Azimuth-Elevation-Range Recorder RO–3/MPQ.	Maximum errors of 3 mils in azimuth, 22.5 yards in range, and 30 feet in height.
Recording System	Three servo-driven styluses record azimuth, range, and height data on a moving strip of paper; one fixed pen records the reference line.
Slewing rate:	
Azimuth	1,000 mils per second.
Range	5,000 yards per second.
Height	7,500 feet per second.
Tracking rate:	
Azimuth	400 mils per second maximum.
Range	3,000 yards per second maximum.
Height	3,000 feet per second maximum

Tracking rate—Continued
Paper speed ..... ⅜ inch per second, or 22.5 inches per minute.

Paper capacity:
Length ..... 150 feet.
Width ..... 29⅝ inches.
Weight ..... 430 pounds.

6. Packaging Data

a. When packaged for export shipment, the components of Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ are placed in moisture-vaporproof containers and are packed in three wooden export crates. The size, weight, and volume of each crate are indicated in the chart.

Number of crates	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Unit weight (lb)
1	56	53	42	72. 2	985
1	26½	27¾	27¾	11. 8	225
1	19	36	17	6. 73	150
Total weight (lb)					1, 360

Note. Items may be packaged in a manner different from that shown, depending on the supply channel.

b. The following list indicates the contents of each case. See the packing list attached to each case for exact contents.

Case dimensions (in.)	Contents	Notes
56 x 53 x 42	1 Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ.	All tubes, lamps, and internal components are installed.
	1 Test cable	Packed inside equipment.
	2 Trajectory curves (7,500-foot)	Packed inside cover of equipment.
	2 Trajectory curves (30,000-foot)	Packed inside cover of equipment.
	1 Plotting aid	Packed inside cover of equipment.
26½ x 27¾–27¾	1 Data cable.	
	1 Reel.	
	2 Technical manuals.	
19 x 36 x 17	1 Set of vacuum tube spares.	
	7 Paper rolls.	
	2 Trajectory curves (7,500-foot).	
	2 Trajectory curves (30,000-foot).	
	1 Plotting aid.	

Note. Trajectory curves (7,500-foot) are not supplied with Azimuth-Elevation-Range Recorder RO–3/MPQ.

Section III. DESCRIPTION OF COMPONENTS

7. Table of Components

Component	Required No.	Height (in.)	Depth (in.)	Length (in.)	Volume (cu ft)	Unit weight (lb)
Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ.	1	43	30	42½	31. 3	430
Data cable	1			225 ft		
Paper roll	7		6 in. dia	30¼	. 49	15
Plotting aids	2	8	3/16	29⅜		
Trajectory curve (30,000-foot)	4	27	3/16	32. 388		
Trajectory curve (7,500-foot)	4	27	⅛	16. 194		
Test cable	1		1 in. dia	96		
Reel	1		21 in. dia	24½		
Technical manual	2					
Total					31. 79	445

Note. The table above is for general information only. See appropriate supply publications for information pertaining to requisition of spare parts. Trajectory curves (7,500-foot) are not supplied with Azimuth-Elevation-Range Recorder RO–3/MPQ.

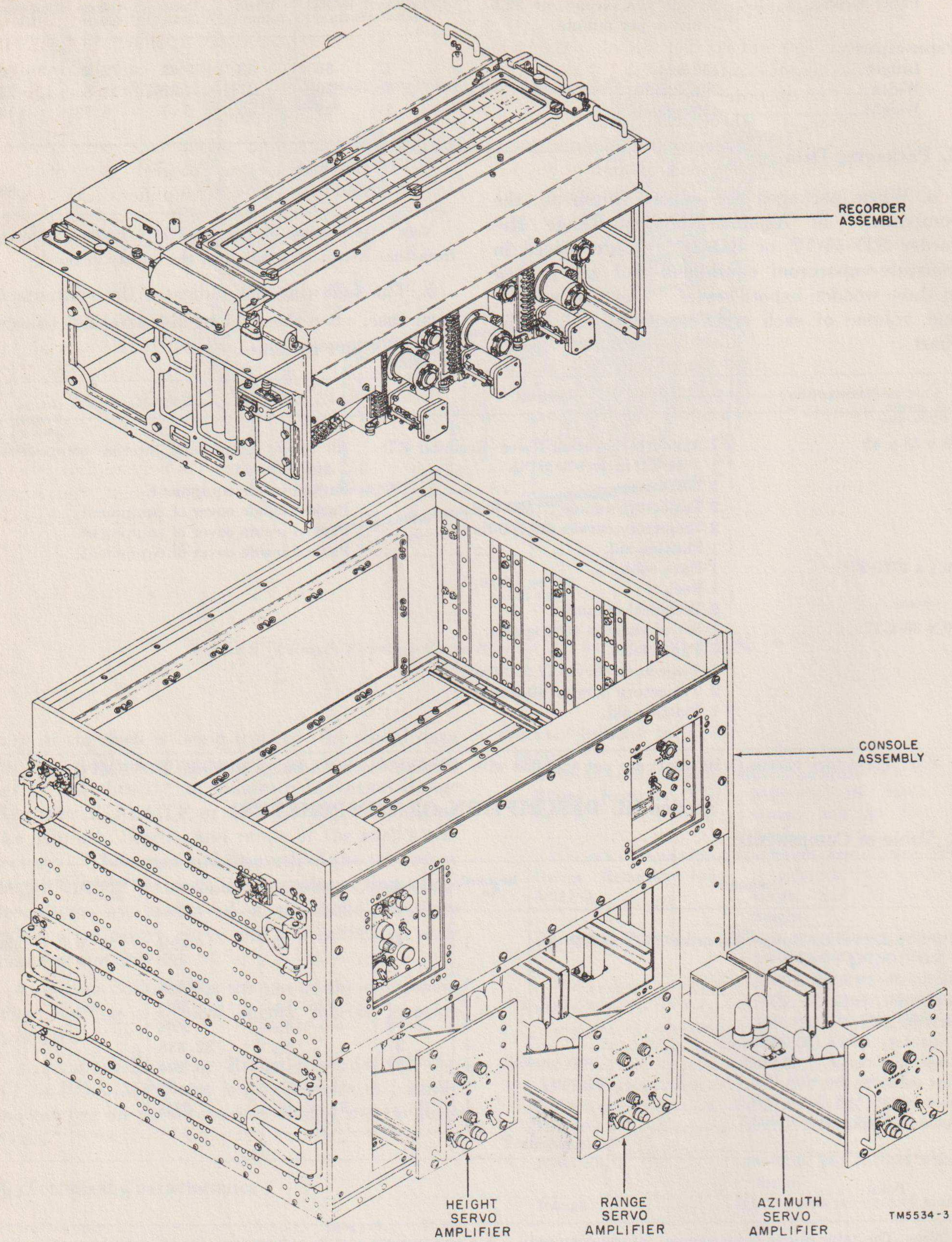


Figure 3. Azimuth-Elevation-Range Recorder RD-54/TP or RO-3/MPQ, exploded view of main assemblies.

8. Description of Azimuth-Elevation-Range Recorder RD–54/TP and RO–3/MPQ

The major assemblies (fig. 3) of Azimuth-Elevation-Range Recorder RD–54/TP and RO–3/MPQ are the recorder assembly, the console assembly, and the three Electronic Control Amplifiers AM–489/TP (servo amplifiers). All of the servo amplifiers are identical and, therefore, interchangeable within the three channels used.

a. Electronic Control Amplifier AM–489/TP (Servo Amplifier).

(1) Each channel (azimuth, height, and range) of Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ contains a servo amplifier, designated Electronic Control Amplifier AM–489/TP (fig. 4). The function of the servo amplifier is to amplify the error voltage generated in the synchro control transformer of its channel. The amplified error voltage then is used to control the associated servo motor which positions the stylus carriage.

(2) The locations of the chassis-mounted components are shown in figure 41, and an under-chassis view is shown in figure 42. The servo amplifiers can be removed easily from the console assembly to facilitate repair.

(3) A coarse-fine switching circuit is incorporated as an integral part of Electronic Control Amplifier AM–489/TP (servo amplifier). The purpose, application, and theory of this circuit is described in chapter 4.

b. Recorder Assembly.

(1) The recorder assembly (fig. 3) is the main functional or operating part of Azimuth-Elevation-Range Recorders RD–54/TP and RO–3/MPQ. Through its three servo loops, electrical signal data is transformed into mechanical shaft movement. By means of a system of pulleys and wire rope, this shaft movement drives three stylus carriage assemblies (fig. 5) over the plotting paper.

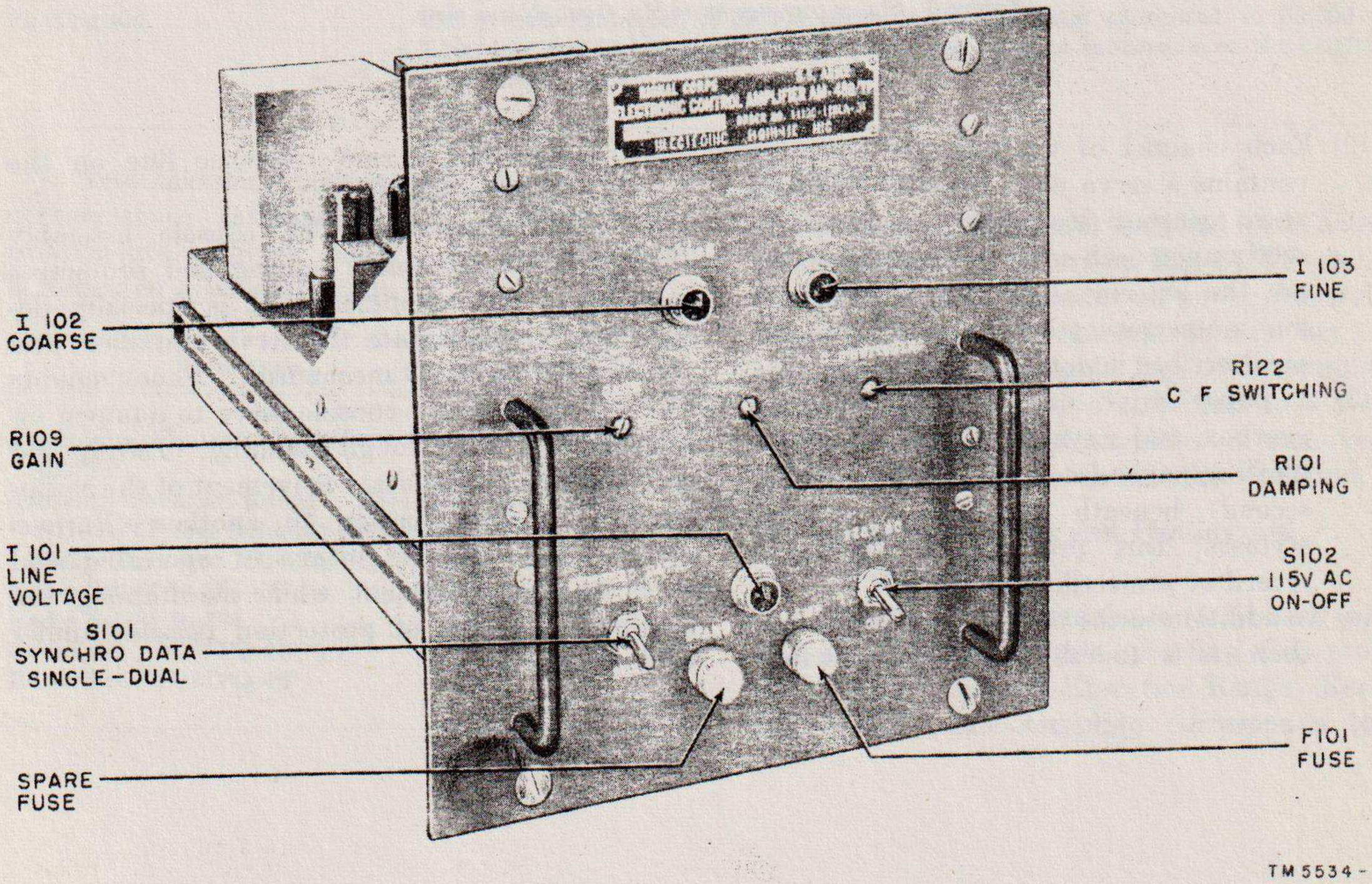


Figure 4. Electrical Control Amplifier AM–489/TP (servo amplifier), location of panel controls.

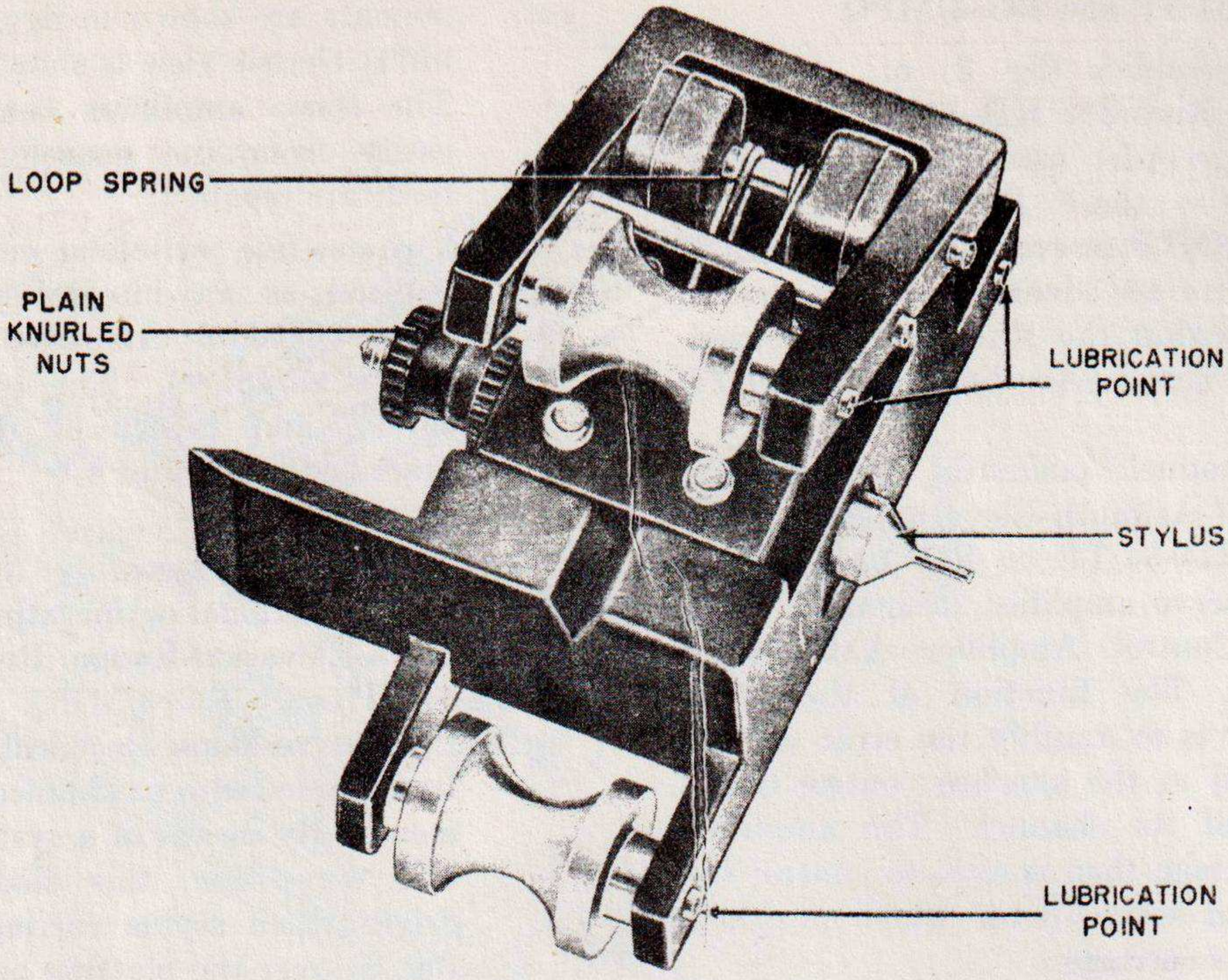


Figure 5. Stylus carriage assembly, front oblique view.

(2) Each channel of the recorder assembly contains a servo unit, hereafter called a servo gearbox assembly. Mounted directly upon each servo gearbox assembly are the associated control transformers and motor generator. These components are described in detail in chapter 4.

(3) A paper drive motor, a paper drive gearbox, and a system of rollers feed the plotting paper (at a speed of ⅜-inch per second) beneath the three marking styluses; this provides a permanent record of projectile trajectory.

(4) In addition to the three movable styluses, there is a fourth fixed stylus, which inscribes a zero reference line on the plotting paper.

c. Console Assembly. The console assembly (fig. 3) forms the main housing and protective member of the equipment. It is specially designed to accommodate the servo amplifiers and the recorder assembly mechanism. Shock mounts at the bottom of the console serve to dampen vibrations caused by rough handling. Lifting and carrying handles facilitate movement of the equipment from one location to another. Various access panels provide means of operating and servicing the equipment while maintaining the maximum amount of protection possible under field conditions.

d. Fuse Chart.

Fuse	Location	Rating	Function
F101	Servo amplifier panel (fig. 4)	1 amp	Prevents overload of input circuit by the power supply of the servo amplifier.
F201	Control panel (fig. 18)	⅛ amp	Protects input circuit to PANEL LIGHTS.
F301	Power distribution panel (fig. 16)	10 amp	Protects 115V AC SUPPLY circuit.
F302	Power distribution panel (fig. 16)	10 amp	Protects 115V AC SUPPLY circuit.
F303	Power distribution panel (fig. 16)	10 amp	Protects 115V AC SUPPLY circuit.
F304	Power distribution panel (fig. 16)	5 amp	Protects the input circuit to the PAPER DRIVE MOTOR.
F305	Power distribution panel (fig. 16)	10 amp	Protects 115 V AC SUPPLY circuit.

e. Differences in Equipment. The differences between Azimuth-Elevation-Range Recorder RD–54/TP and Azimuth-Elevation-Range Recorder RO–3/MPQ are listed below.

Item	Azimuth-Elevation-Range Recorder RD-54/TP	Azimuth-Elevation-Range Recorder RO-3/MPQ
Associated radar set	Radio Sets SCR–584–A and –B Radio Set SCR–784. Radar Sets AN/MPQ–10 and –10A.	Radar Set AN/MPQ–22.
Full travel of height stylus	Represents 7,500 feet or 30,000 feet	Represents 30,000 feet.
Control panel	SLEW switch S202	None.
	HEIGHT FEET switch S203	None.
Height fine control transformer B605 and height coarse control transformer B604.	Height fine control transformer B605 is nearer the servo drive motor than height coarse control transformer B604.	Height coarse control transformer B604 is nearer the servo drive motor than height fine control transformer B605.
Trajectory curves	7,500-foot and 30,000-foot trajectory curves.	30,000-foot trajectory curve.
Plotting aid	Range scale calibrated to 20,000 yards 7,500-foot and 30,000-foot calibrations on the height scale.	Range scale calibrated to 30,000 yards. 30,000-foot calibration on the height scale.

f. Nomenclature Assignments. A list of the nomenclature assignments for equipment and components is given below. A common name is indicated after each item.

Nomenclature	Common Name
Electronic Control Amplifier AM–489/TP	Servo amplifier
Azimuth-Elevation-Range Recorder RD–54/TP and Azimuth-Elevation-Range Recorder RO–3/MPQ	Recorder
Radio Set SCR–584–(*)	Radar set
Radio Set SCR–784	
Radar Set AN/MPQ–10(*)	
Radar Set AN/MPQ–22	

9. Cables

The data cable (fig. 6) supplied with Azimuth-Elevation-Range Recorders RD–54/TP and RO–3/MPQ is used to transmit all power, control, and signal data from the associated radar set to the equipment. A test cable (fig. 7) is supplied to connect any of the servo amplifiers to the equipment when the servo amplifier is removed for repair. This cable serves no other function.

10. Trajectory Curves and Plotting Aid
(figs. 8 and 9)

a. Two parabolic templates (trajectory curves) and a tricalibrated scale (plotting aid) are supplied with Azimuth-Elevation-Range Recorder RD–54/TP. One template corresponds to the

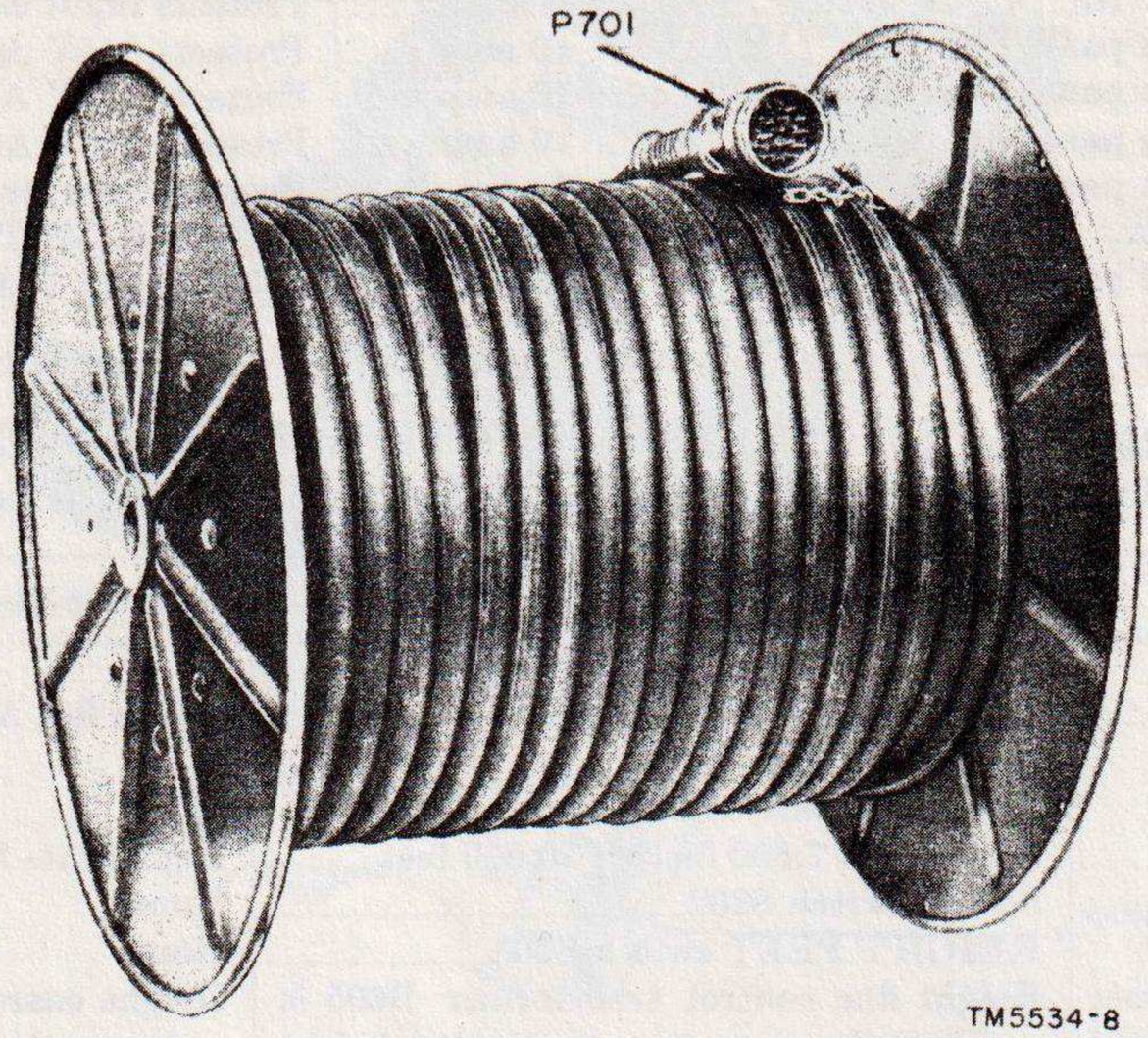


Figure 6. Data cable.

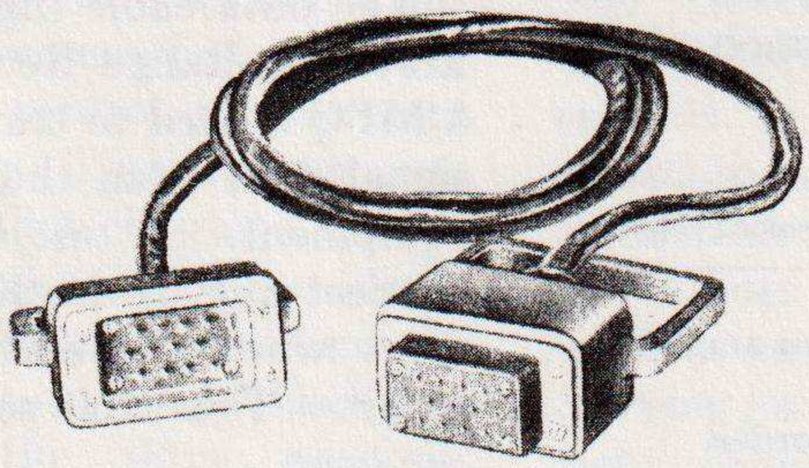


Figure 7. Test cable.

7,500-foot height scale and the other to the 30,000-foot height scale. Although the recorder does not trace an actual shell trajectory on a moving strip of paper, the trajectory can be interpolated from the height, range, and azimuth traces. Interpolation of the parabolic height trace requires the use of the trajectory curve corresponding to the preselected height scale. Range (in yards) and azimuth (in mils) can be determined, with the plotting aid, from the range and azimuth traces on the moving strip of paper.

b. The 7,500-foot trajectory curve is not supplied with Azimuth-Elevation-Range Recorder RO–3/MPQ. The plotting aid supplied with this recorder has a range scale calibrated to 30,000 yards, and has no 7,500-foot calibration on the height scale.

11. Additional Equipment Required

The additional equipment needed for the operation of Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ is a radar set to supply data and power. The radar sets that can be used are given in paragraph 3*b* and *c*.

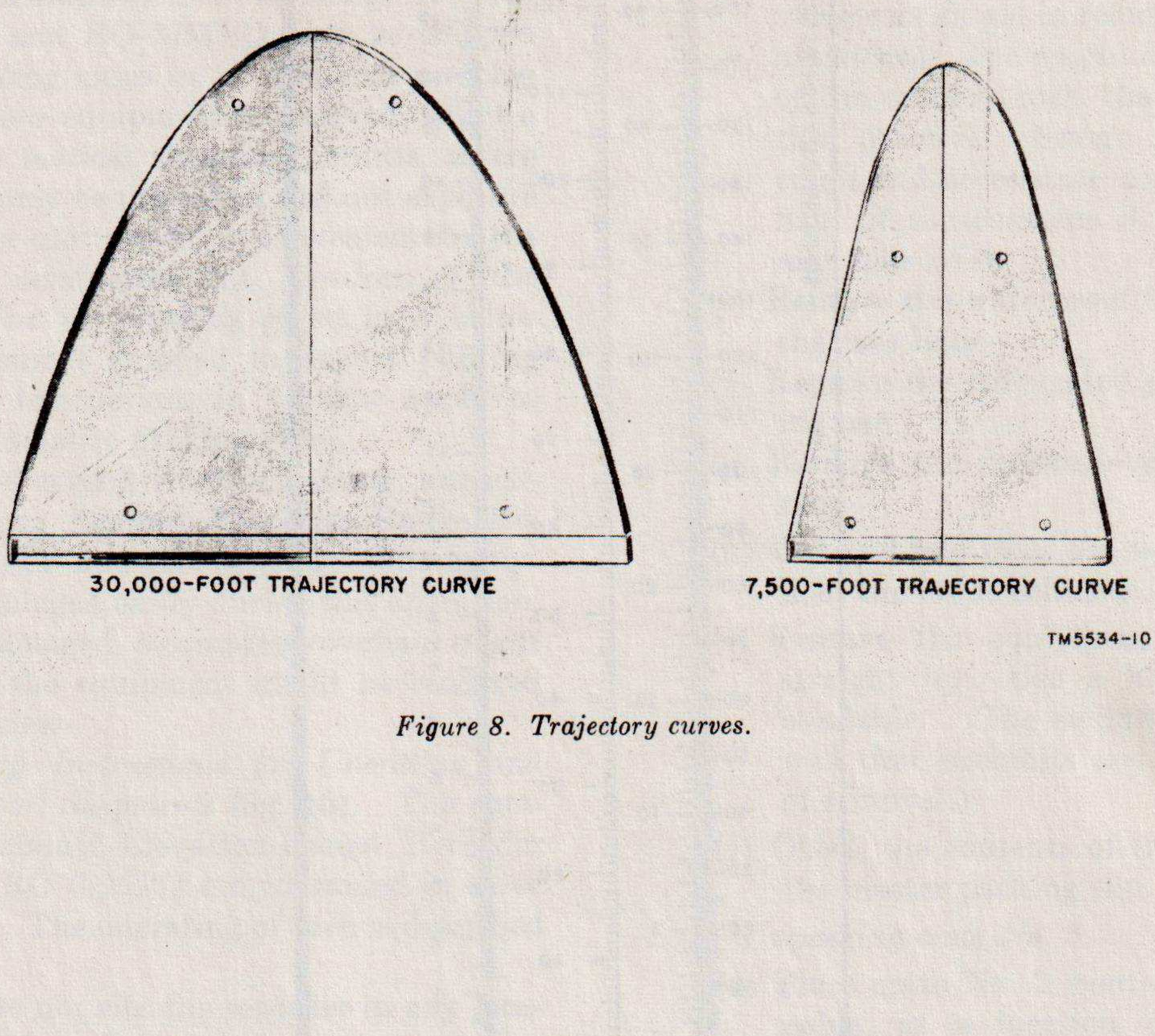


Figure 8. Trajectory curves.

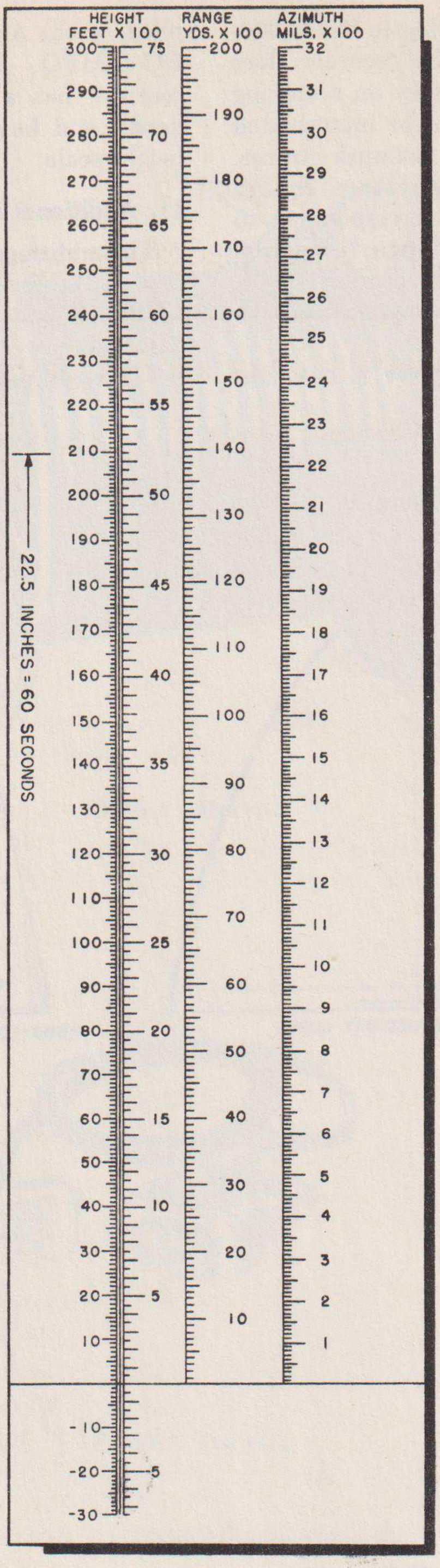


Figure 9. Plotting aid.

CHAPTER 2

OPERATING INSTRUCTIONS

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

12. Uncrating, Unpacking, and Checking New Equipment

Note. For used or reconditioned equipment, refer to paragraph 16.

a. General. Azimuth-Elevation-Range Recorders RD–54/TP and RO–3/MPQ may be shipped in oversea packing cases or in domestic packing cases. When new equipment is received, select a location, if the tactical situation permits, where the equipment may be unpacked without exposure to the elements and which is convenient to the permanent or semipermanent location of the equipment. The instructions given in *b* below apply to equipment shipped in export packing cases, and the instructions in *f* below apply to equipment in domestic packing cases.

Caution: Be careful when uncrating, unpacking, and handling Azimuth-Elevation-Range Recorders RD–54/TP and RO–3/MPQ. The equipment can be damaged easily during this operation. If it becomes damaged, a complete overhaul might be required or the equipment might be rendered temporarily useless.

b. Step-by-step Instructions for Uncrating and Unpacking Export Shipments (fig. 10). The components of Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ are contained in three packing crates. The uncrating of each is described below.

Caution: Do not site the recorder in any location that would hinder proper inspection after removal from the case.

(1) *Unpacking crate No. 1.*

(*a*) Place the packing case as near the operating position as is convenient.

(*b*) Remove all staples.

(*c*) Cut and fold back the steel straps.

(*d*) Remove the nails with a nailpuller. Remove the top and all sides of the packing case. Do not attempt to pry off the sides and top; the equipment may become damaged.

Caution: Do not tip or lean the crate against any structure, tree, or vehicle as an aid in removing the sides of the case. The weight of the contents of the crate is such that it prohibits this practice. Severe damage may result and necessitate a complete overhaul of the contents if the crate tips and falls over.

(*e*) Remove the waterproof barrier used as the case liner.

(*f*) Remove the corrugated paper cushioning pad.

(*g*) Remove the moisture-vaporproof barrier.

(*h*) Cut and fold back the steel straps that hold the crepe cellulose blanket.

(*i*) Remove the equipment by lifting it straight up. Use a hoist, if one is available. (The equipment is set in a well that prohibits any other method of removal.)

(*j*) Check the contents of the case against the master packing slip.

(2) *Unpacking crate No. 2.*

(*a*) Place crate No. 2, containing the data cable, at a location convenient for unpacking.

(*b*) Follow the procedures outlined in (1)(*b*) through (*d*) above.

(*c*) Rip or peel off the tape covering the seams of the corrugated box and cut and bend back the strapping wrapped around the box.

(*d*) Remove the case liner.

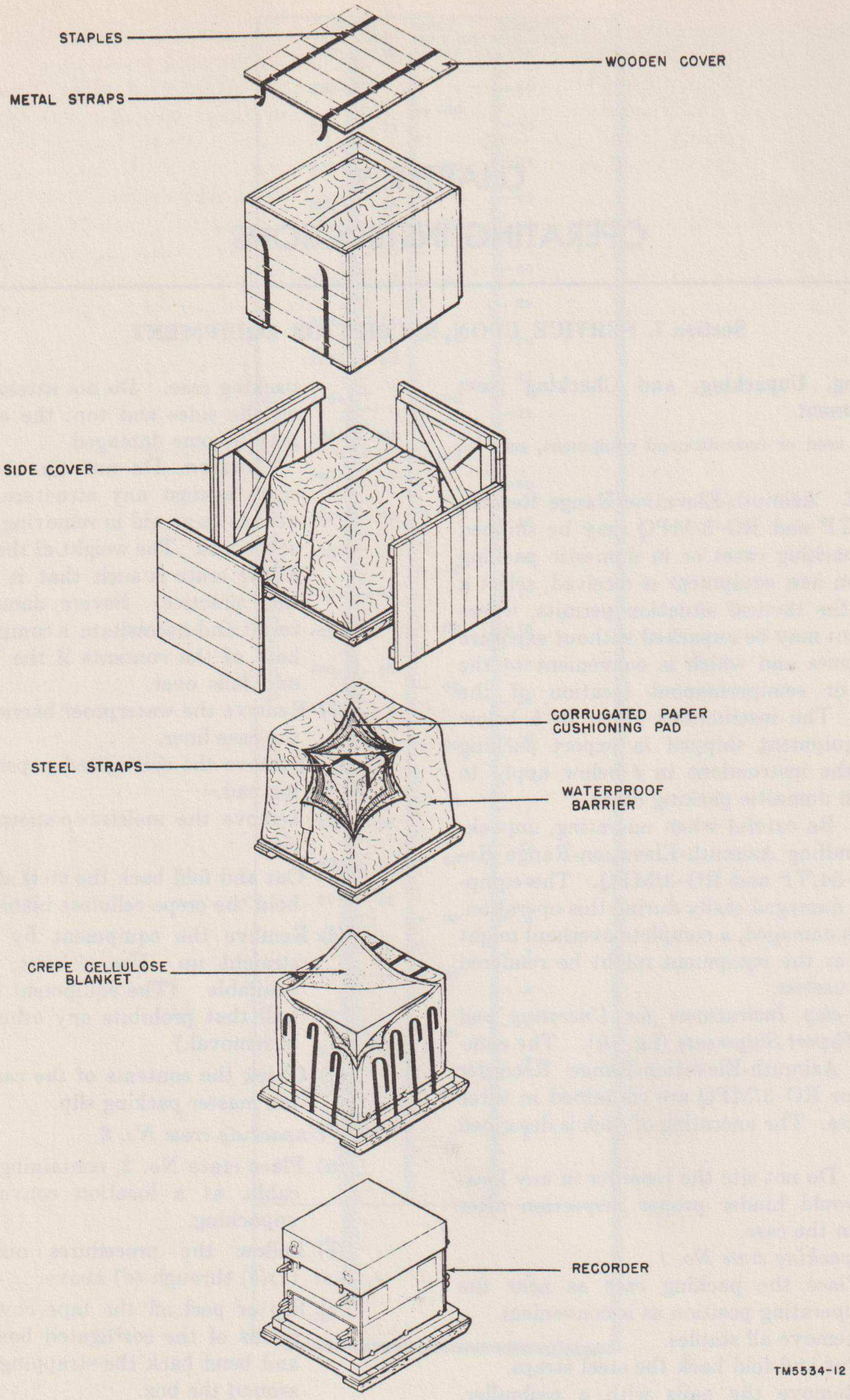


Figure 10. Packing and packaging of Azimuth-Elevation-Range Recorder RD–54/TP or RO–3/MPQ

(*e*) Remove the protective coverings that are on the data input connector plugs.

Caution: Do not use a knife or any sharp instrument when removing the protective coating from the plugs. This may cause severe damage to the plugs.

(*f*) Check the contents of the packing case against the master packing slip.

(3) *Unpacking crate No. 3.*

(*a*) Follow the procedure outlined in (1)(*b*) through (*d*) above.

(*b*) Remove the individually wrapped corrugated cartons containing the vacuum tubes, plotting aids, and trajectory curves.

Caution: Be very careful when handling the vacuum tubes, the plotting aid, and trajectory curves, since they are broken easily. The curves and the plotting aid chip and scratch easily. Never put any object on top of the packaged curves. Always lay the curves on a flat surface.

(*c*) Remove the paper rolls.

Caution: Be careful when handling the paper rolls. The core of the paper rolls can be damaged easily if the roll is mishandled; thus the paper would be rendered unusable.

(*d*) Check the contents of the packing case against the master packing slip.

c. Opening Cardboard Carton and Waterproof Barrier. No special instructions are needed for opening the waterproof paper barriers. Be very careful when removing the equipment or components from the cardboard cartons.

d. Instructions for Opening Metal Containers. Metal containers may be used instead of cardboard cartons. The top of the metal container is soldered to the sides. To open, break the soldered seam by prying the side of the container away from the soldered seam as follows:

(1) Wipe off the excess solder with a heavy-duty soldering iron. Never use a torch, because the contents of the container are inflammable.

(2) With a wooden block or a screwdriver, pry the sides from the soldered seam.

(3) When the seam is completely open, pry off the cover.

(4) Remove the bags of desiccant.

e. Checking. Check the contents of all packing cases against the master packing slip.

f. Unpacking Domestic Packing Cases. Azimuth-Elevation-Range Recorder RD–54/TP also may be received in domestic packing cases. The instructions given in *b* above apply also to unpacking domestic shipments. Cut all metal bands. Open the cartons that protect the components; or, if heavy wrapping paper has been used, remove it carefully and take out the components. Check the contents of the packing case against the master packing slip.

Note. Save the original packing cases and containers. They can be used again when the equipment is repacked for storage or shipment.

13. Installation of the Recorder

a. The recorder has been designed to work in conjunction with a tracking radar set. Since the unit receives its power and signal data from the radar set, the actual location will depend (within the limits of the length of the interconnecting data cable assembly) on the location of the radar set.

b. Locate the recorder in a position that is reasonably level, sheltered, and accessible to all sides for operating and maintenance personnel. Prepare a smooth, flat surface, close to the recorder, for interpolation of the plotted data.

c. Turn the fasteners located on the power and control panel cover assemblies, located on the upper front access panel assembly (fig. 11), one-fourth turn counterclockwise (ccw) and remove the panels.

d. Turn the fasteners along the sides of the lower front access panel assembly one-fourth turn ccw and remove the panel.

e. Loosen the four fasteners on the front panels of the servo amplifiers (fig. 3) and remove the amplifiers from their bays.

f. Place each servo amplifier on a smooth surface and remove the corrugated shielding around each tube. Check all tubes to see that they are seated firmly in their proper sockets (fig. 41).

g. Reinstall the servo amplifiers in their bays.

h. Unfasten the top cover latches on all sides of the equipment and remove the recorder cover (fig. 12).

Caution: Remove the recorder cover carefully. The size and weight of the assembly is such that damage may occur to the stylus frame assembly.

i. Turn the fasteners on the upper rear access panel assembly (fig. 12) one-fourth turn ccw and

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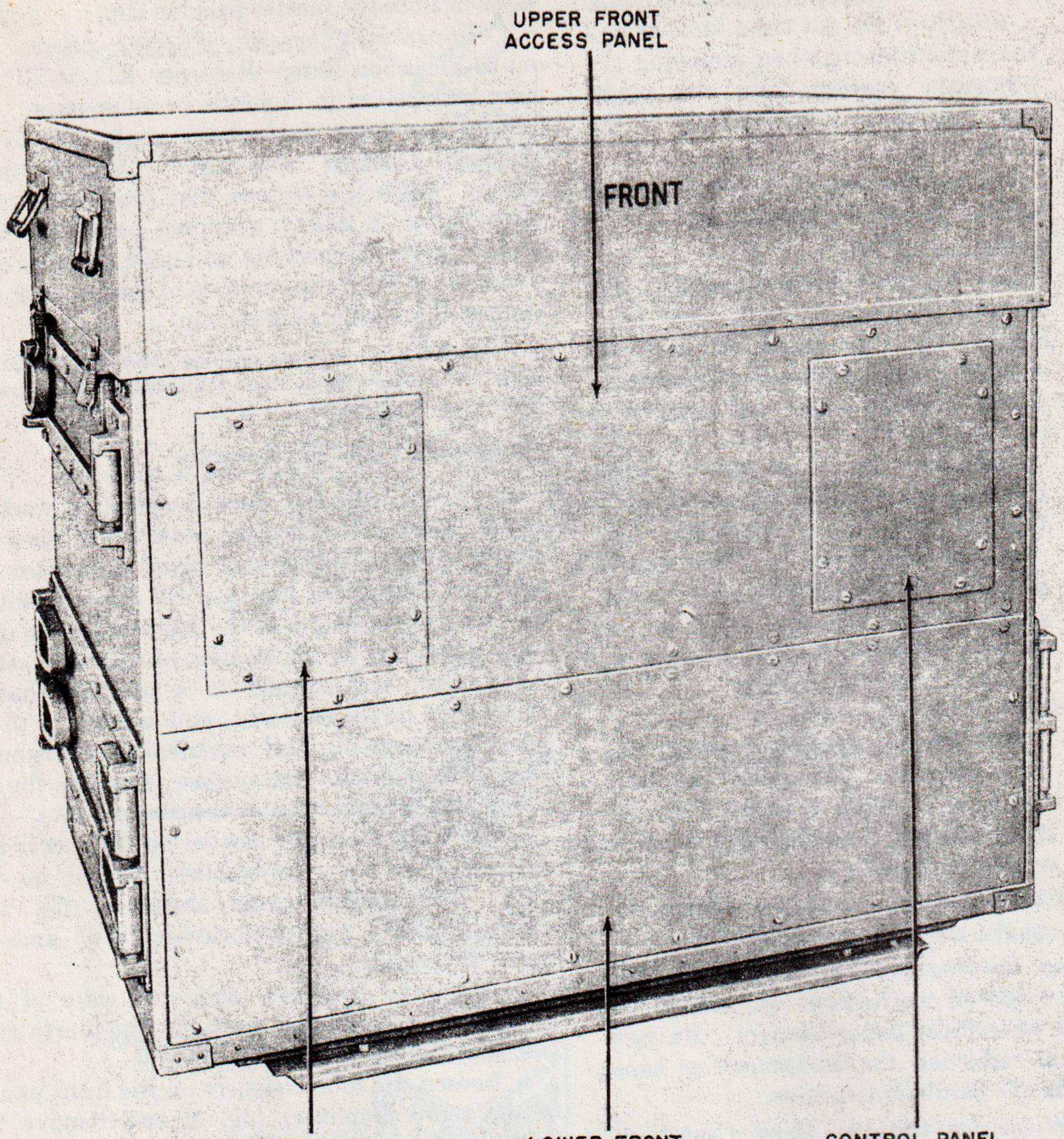


Figure 11. Azimuth-Elevation-Range Recorder RD-54/TP or RO-3/MPQ, front oblique view, with access panels and top cover on.

remove the panel. Remove the test cable that is secured at the rear of the recorder assembly.

Caution: Do not use a knife or sharp instrument to remove the cellulose wrapping taped to the supporting members of the recorder assembly; the test cable may be damaged.

j. Replace the test cable.

k. Remove all tapes from each pulley assembly of the pulley drive mechanism; work from the rear to the front. Remove any other protective coverings, such as corrugated paper and cellulose.

l. Replace the upper rear access panel assembly.

m. Loosen the three captive screws (fig. 13) located on the stylus cover frame and open the

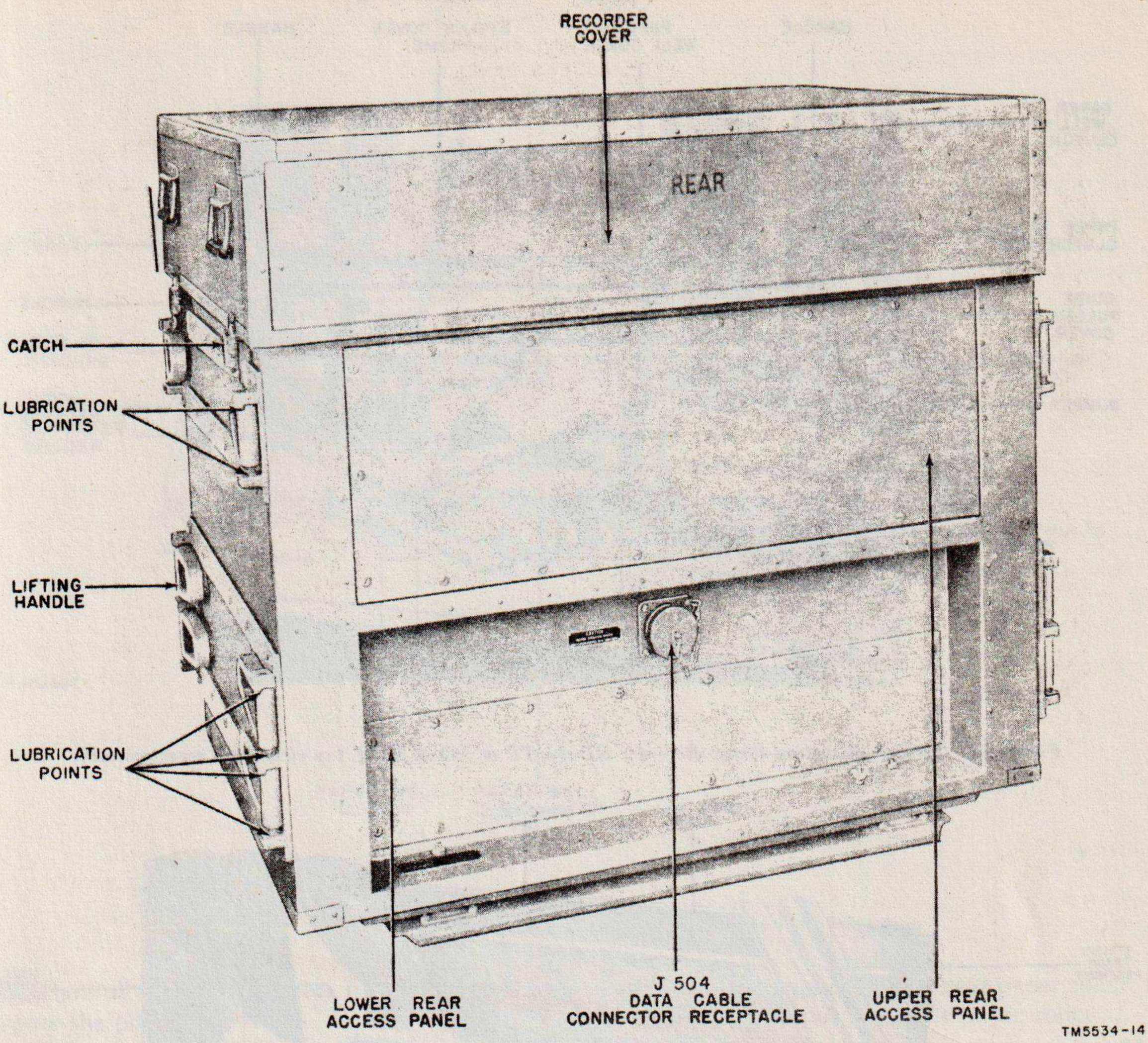


Figure 12. Azimuth-Elevation-Range Recorder RD-54/TP or RO-3/MPQ rear oblique view, with access panels and top cover on.

cover so that the stylus carriage assemblies may be reached easily.

Note. When packed, each stylus carriage assembly is positioned at the end of the guide rods.

(1) Remove the tape that secures the cushioning at the end of each guide rod.

(2) Remove the cullulose wadding that cushions the three stylus carriage assemblies at the end of the guide rods.

Caution: Be careful when removing the protective coverings from the stylus carriage assemblies. Only authorized personnel should attempt to remove them.

(3) Remove the stylus rod damper from its shipping position and place it in its stored position (fig. 50).

(4) Close the stylus cover frame and tighten the captive screws.

14. Installation of Paper Roll

Follow the procedure outlined below when in stalling a roll of paper in the recorder assembly. Refer frequently to figures 14 and 15.

a. Loosen the captive nuts that hold the front paper roll cover to the recorder housing and open the cover. Similarly, open the paper well cover.

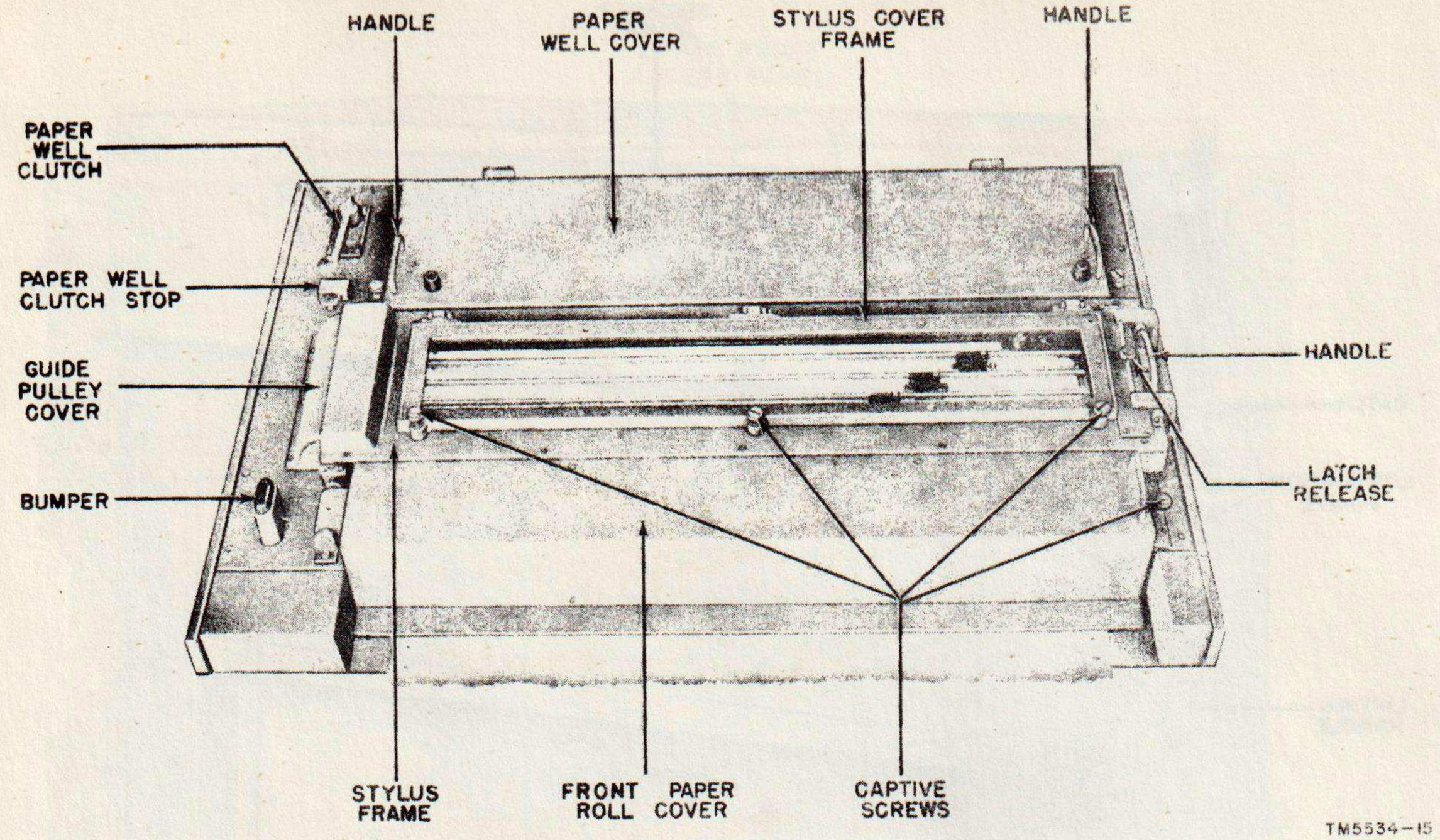


Figure 13. Azimuth-Elevation-Range Recorder RD-54/TP or RO-3/MPQ, top view, with cover removed.

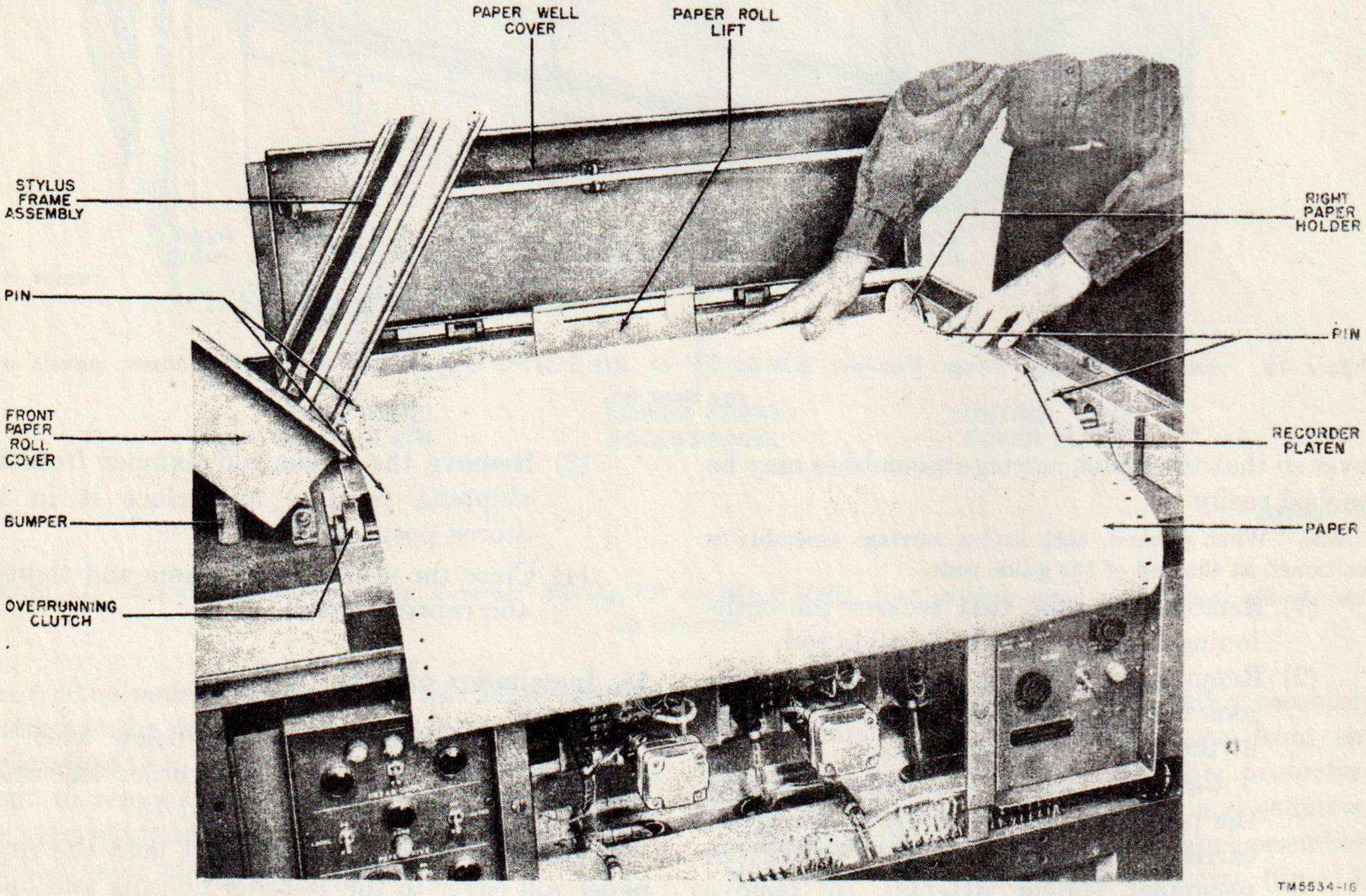
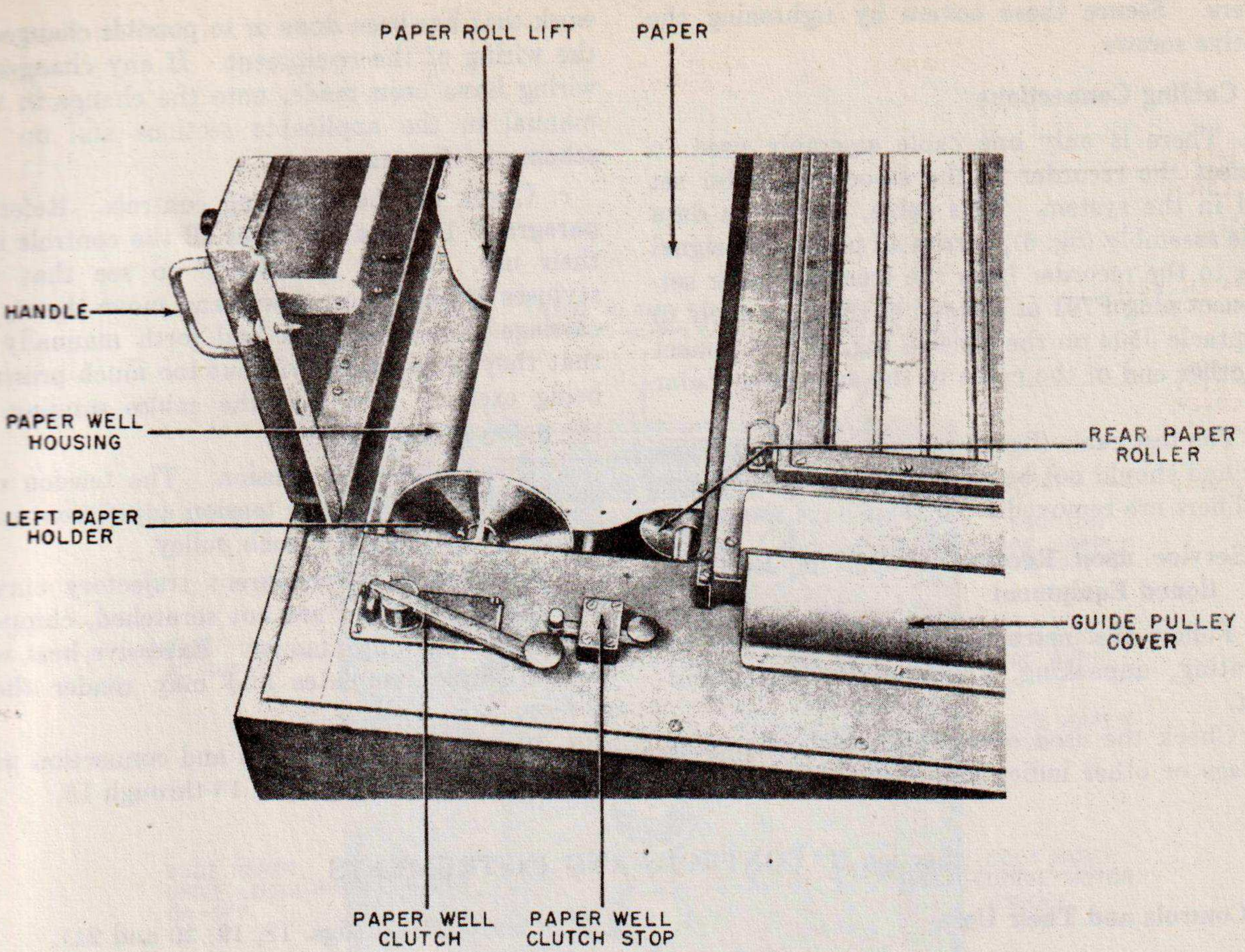


Figure 14. Installation of paper.



TM5534-17

Figure 15. Paper well clutch assembly mechanism.

b. Carefully raise the stylus frame assembly to expose the platen.

c. Trip the paper well clutch stop and, at the same time, move the paper well clutch handle to the left.

d. Lay the paper roll in the paper well housing with its coated side up (feeding from the top of the roll).

Note. The coated side of the paper is treated so that the movement of the brass stylus of each stylus carriage assembly across the face of the paper produces a visible etched line.

e. Use the paper roll lift to raise the roll into position directly between the two paper holders. Engage the paper holders with the core of the paper roll. Move the paper roll clutch handle back to its locked position.

f. Unroll a sufficient length of paper to allow at least 1 foot to overlap the front end of the recorder assembly.

g. Draw the paper over the rear paper roller, the recorder platen, and the front paper roller.

Note. The overrunning clutch attached to the left side of the front paper roller permits free rotation of the roller in a forward direction to enable the paper to be drawn through.

h. Loosen the setscrews in the four pinwheels (two in front, two in rear). Position the pinwheels until the paper drive pins fit correctly into the drive holes of the paper. During this adjustment, hold the paper taut against the paper roll. Tighten the setscrews.

Caution: Be extremely careful when engaging the paper with the roller pins. Keep the paper taut at all times to avoid bunching and wrinkling. Be sure that the pins on both sides of both rollers are engaged.

i. Carefully close the stylus frame assembly.

j. Close the paper well and front paper roll

covers. Secure these covers by tightening the captive screws.

15. Cabling Connections

a. There is only one cable assembly used to connect the recorder to the associated radar set used in the system. This cable, called the data cable assembly (fig. 6), carries all power and signal data to the recorder from the tracking radar set. Connect plug P701 at the end of the data cable to receptacle J504 on the console (fig. 12). Connect the other end of the cable to the associated radar set.

b. The test cable (fig. 7) is used for test purposes only and should not be connected unless the servo amplifiers are removed from their bays for repair.

16. Service upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 12 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for tags or other indications pertaining to repair work that has been done or to possible changes in the wiring of the equipment. If any changes in wiring have been made, note the change in this manual in the applicable sections and on the schematic diagrams.

c. Check all the operating controls. Refer to paragraph 17 for a listing of all the controls and their use. Check specifically to see that the styluses are not worn down, and move the stylus carriage assemblies back and forth manually so that they move freely without too much pressure being exerted. See that the cables running on the pulleys are not frayed.

d. Check the cable tension. The tension can be controlled by the two tension adjustment nuts located on one spoke of each pulley.

e. See that the transparent trajectory curves and the plotting aid are not scratched, chipped, or deformed in any manner. Excessive heat will deform these templates and may render them useless.

f. Perform the installation and connection procedures given in paragraphs 13 through 15.

Section II. CONTROLS AND INSTRUMENTS

17. Controls and Their Uses

The following charts list the controls and functions of the recorder. The controls appear in various locations as indicated by the paragraph headings below.

a. Power Distribution Panel (figs. 16 and 17).

Control	Function
115V AC SUPPLY ON-OFF switch S301.	In the ON position, connects the unit to the power source.
PAPER DRIVE MOTOR ON-OFF switch S303.	In the ON position, starts the paper drive motor.
PAPER DRIVE LOCAL ON-OFF switch S302.	Local control, in the ON position the paper starts to move.
115V AC SERVICE ON-OFF switch S304.	In the ON position, provides 115 volts ac to the service outlet.

b. Control Panel (figs. 18, 19, 20 and 21).

Control	Function
PANEL LIGHTS ON-OFF switch S204.	In the ON position, illuminates the plotting surface.
DIMMER DIM-BRIGHT R201.	Controls the intensity of illumination of the plotting surface.
PAPER DRIVE AUTOMATIC-MANUAL switch S201.	When in the AUTOMATIC position, the operator at the associated radar set can turn the paper drive on or off. In the MANUAL position, operation is local.
SLEW switch S202	When depressed, slews the height gearbox.
HEIGHT FEET switch S203 MPQ 10–30000–7500-SCR 584–7500–30000.	Determines range of the height stylus.

Note. There is neither a SLEW switch (S202) nor a HEIGHT FEET switch (S203) on Azimuth-Elevation-Range Recorder RO–3/MPQ.

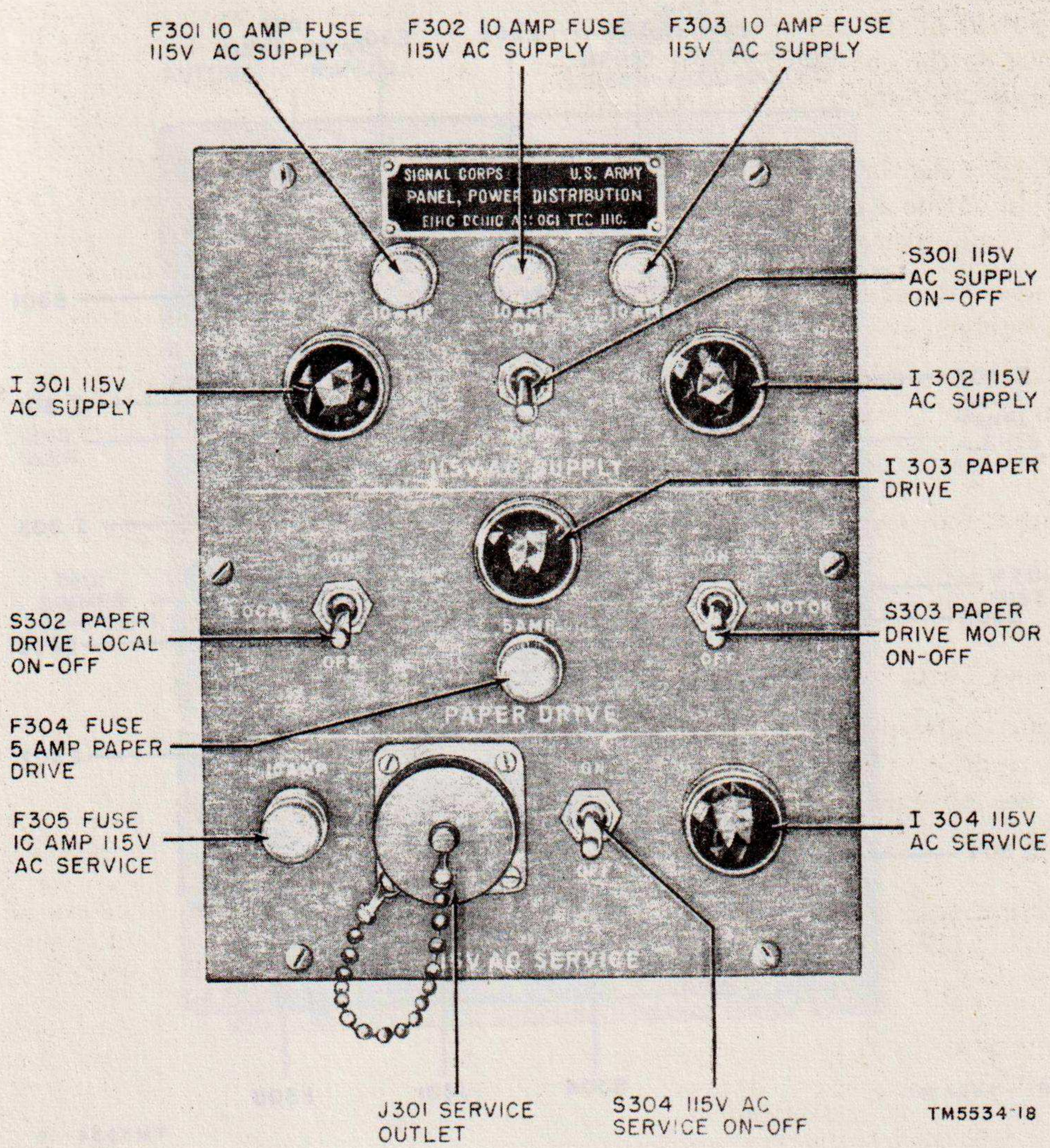


Figure 16. Power distribution panel, loaction of controls.

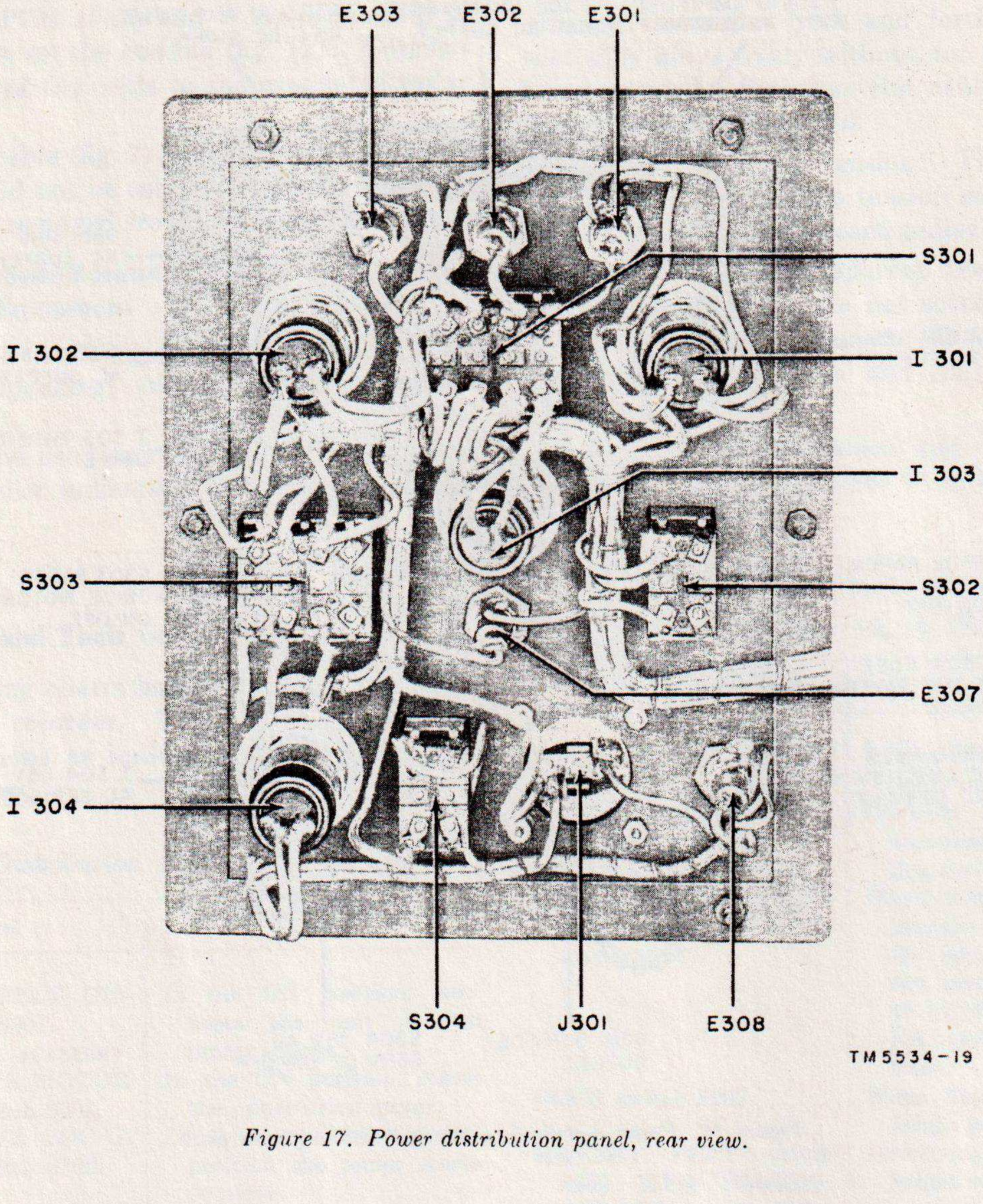
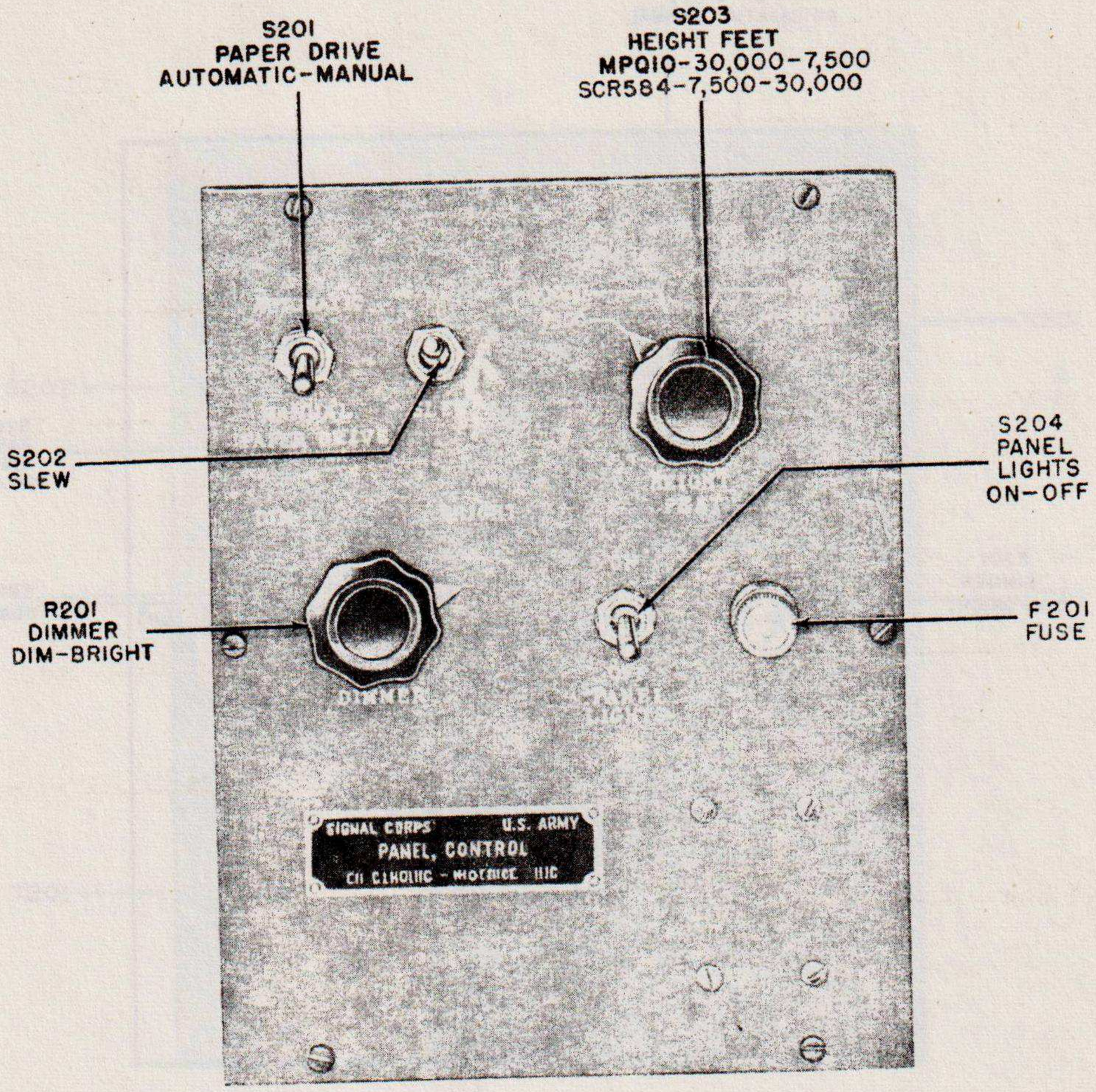


Figure 17. Power distribution panel, rear view.



TM 5534-20

Figure 18. Control panel of Azimuth-Elevation-Range Recorder RD-54/TP, location of controls.

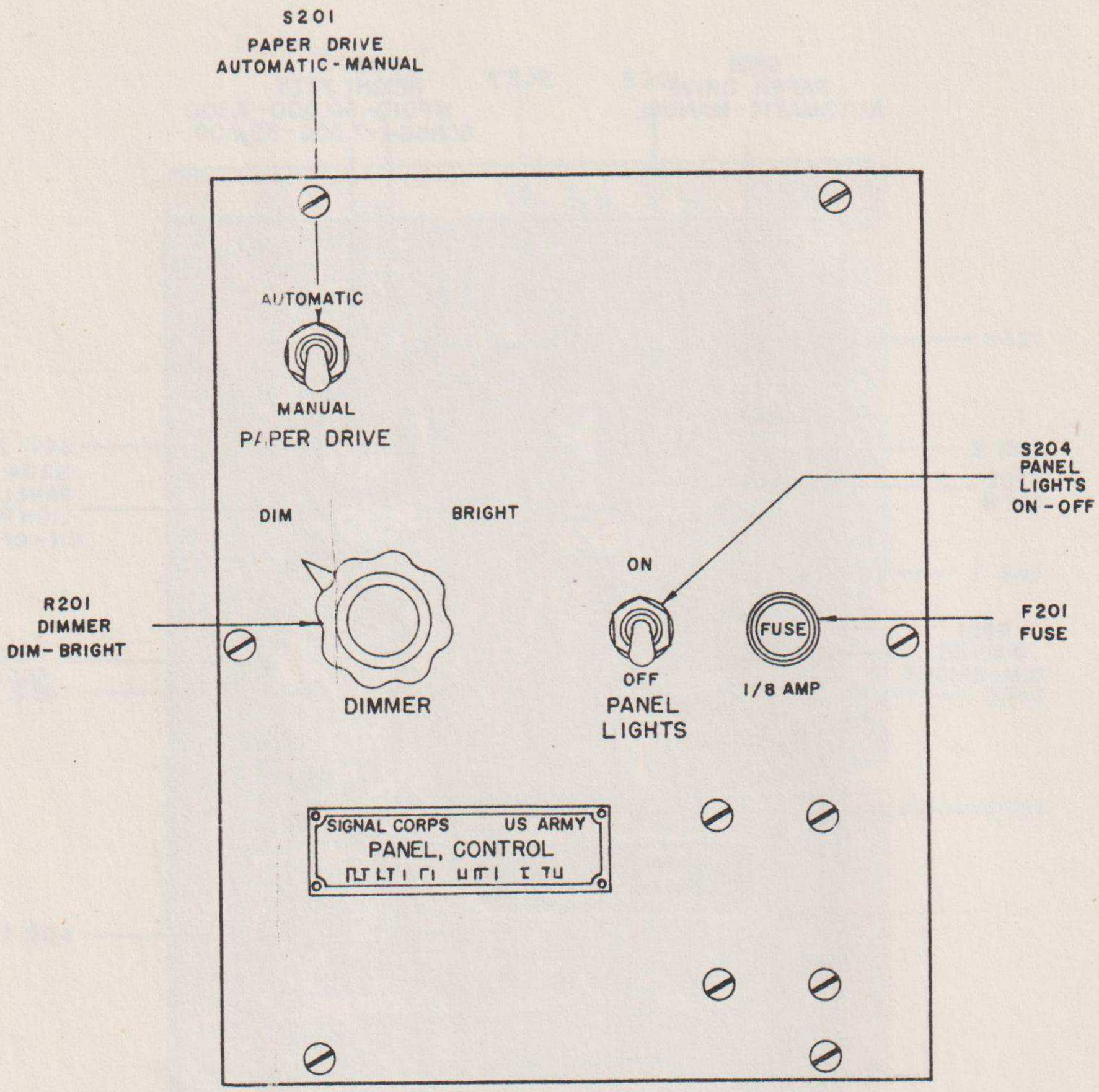


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Figure 19. Control panel of Azimuth-Elevation-Range Recorder RO–3/MPQ.

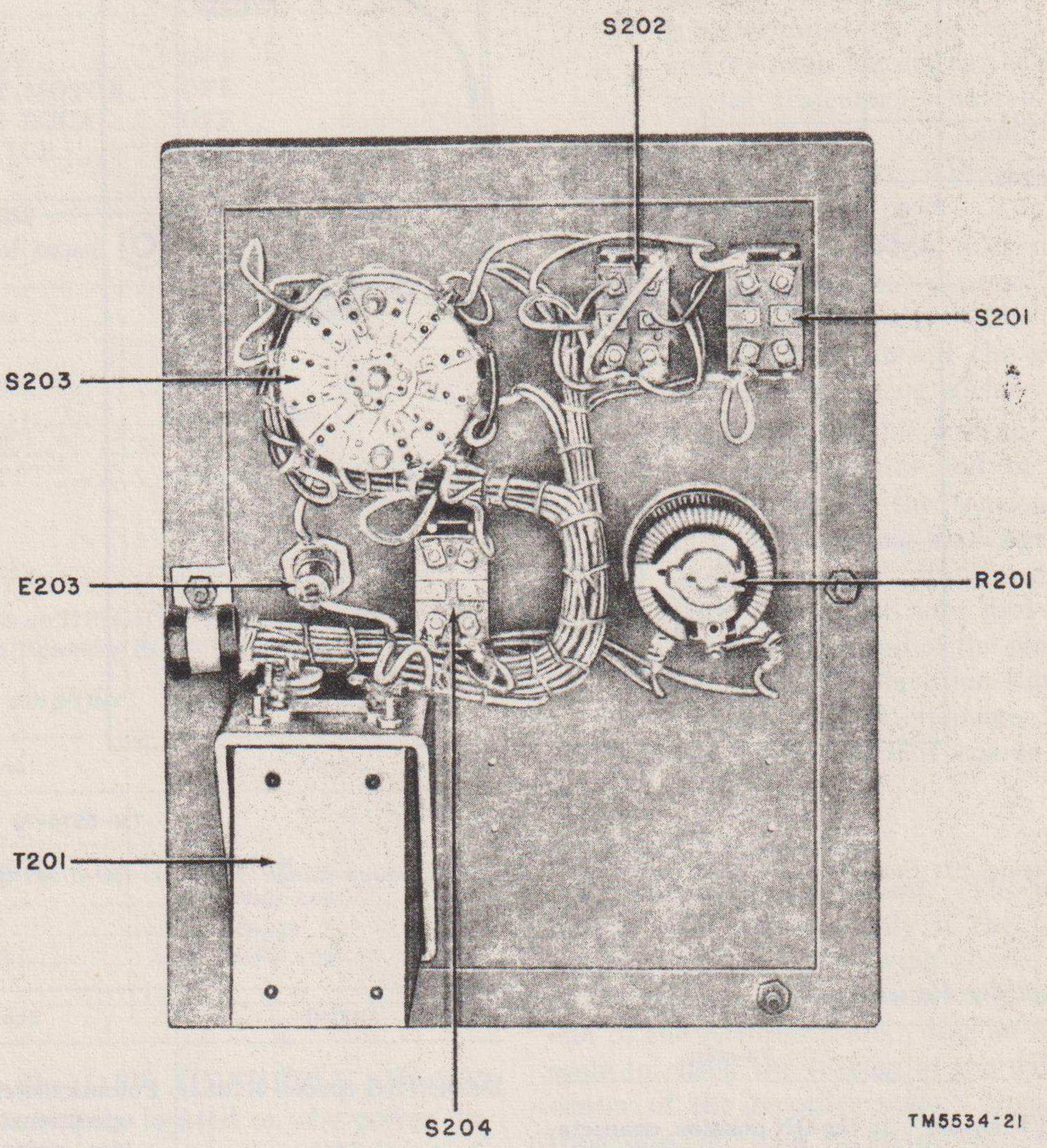
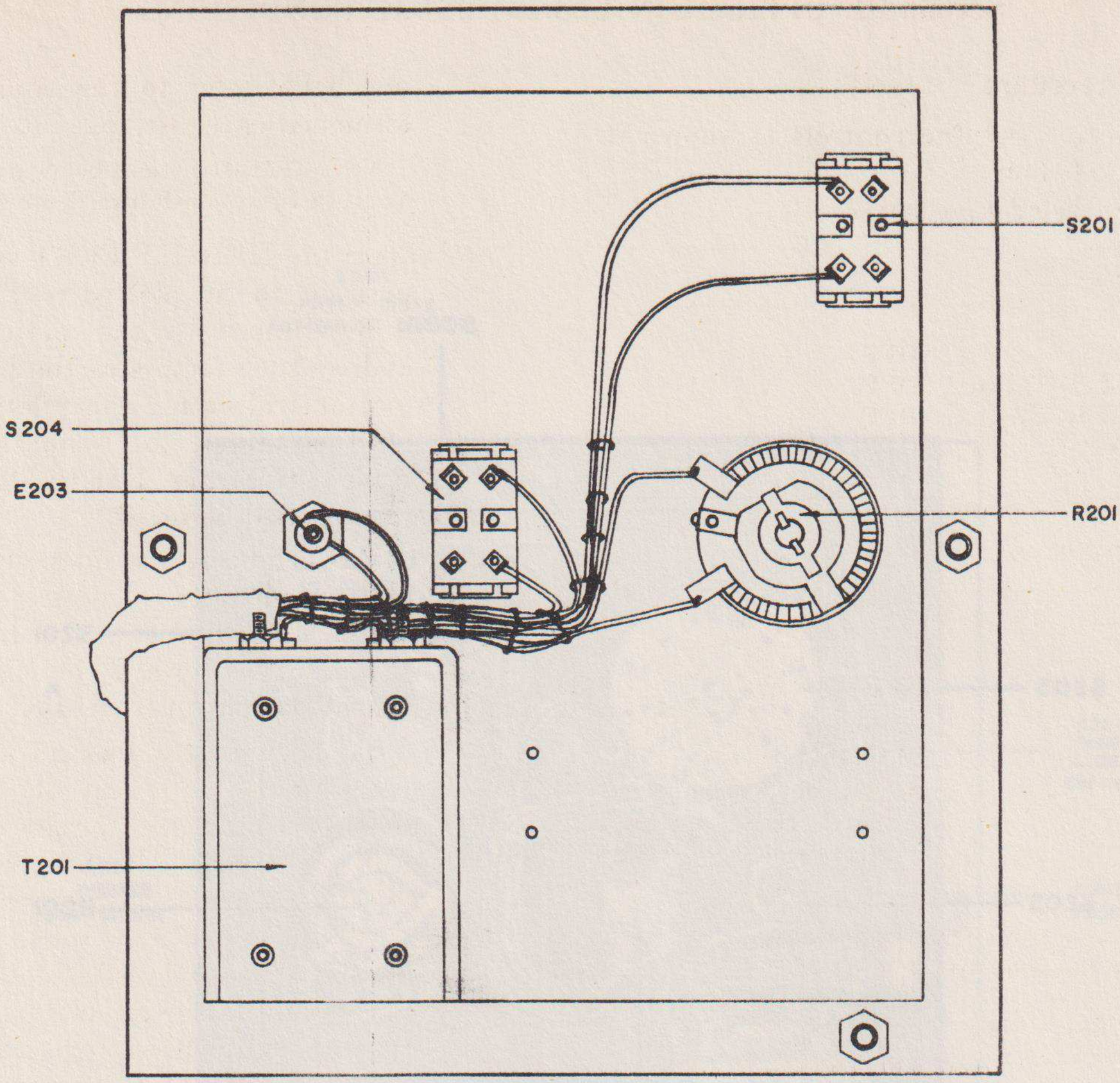


Figure 20. Control panel of Azimuth-Elevation-Range Recorder RD–54/TP, rear view.



TM-5534-72

Figure 21. Control panel (rear view) of Azimuth-Elevation-Range Recorder RO-3/MPQ.

c. Servo Amplifier Panel (fig. 4).

Control	Function
115V AC ON-OFF switch S102.	In the ON position, connects the servo amplifier to the 115-volt a-c power source.
SYNCHRO DATA SINGLE-DUAL switch S101.	In the SINGLE position, disables the coarse-fine switching circuit in the servo amplifier. When in the DUAL position, the coarse-fine switching circuit is in operation.
C F SWITCHING control R122.	Varies operational point of the coarse-fine switching circuit.
GAIN control R109	Potentiometer, controls the gain in the servo amplifier.
DAMPING control R101	Potentiometer, controls the operational point of the loss compensation network.

Note. Haphazard operation or improper setting of the controls can cause damage to this equipment. For this reason, it is important to know the function or every control. The actual operation of the equipment is described in paragraphs 19 through 29.

18. Instruments

There are no instruments incorporated in Azimuth-Elevation-Range Recorder RD–54/TP and RO–3/MPQ.

Section III. OPERATION UNDER USUAL CONDITIONS

19. Starting Procedure

a. Preliminary. Set the controls as shown in (1) through (3) below.

(1) *Power distribution panel.*

Control	Position
115V AC SUPPLY	OFF
PAPER DRIVE MOTOR	OFF
PAPER DRIVE LOCAL	OFF
115V AC SERVICE	OFF

(2) *Control panel.*

Control	Position
PANEL LIGHTS	OFF
DIMMER	Midposition
PAPER DRIVE	MANUAL
HEIGHT FEET	Setting depends on associated radar set and height scale used.

Note. There is no HEIGHT FEET switch on Azimuth-Elevation-Range Recorder RO–3/MPQ.

(3) *Servo amplifier.*

Control	Position
115V AC	OFF
SYNCHRO DATA	SINGLE
GAIN	Extreme ccw
DAMPING	Midrange
C F SWITCHING	Extreme ccw

b. Starting.

(1) Place the 115V AC SUPPLY ON-OFF power switch, located on the power distribution panel, to the ON position.

(2) Set the PANEL LIGHTS ON-OFF switch, on the control panel, to the ON position.

(3) Rotate the DIMMER control, located directly below the PANEL LIGHTS switch, to the intensity level desired for the plotting surface lighting.

(4) Turn each servo amplifier (azimuth, height, and range) 115V AC ON-OFF switch to the ON position. (If the indicator or illuminating lights do not go on, or if the tubes in the servo amplifier do not light, refer to the equipment performance checklist, par. 46.)

Note. The instructions below do not apply to Azimuth-Elevation-Range Recorder RO–3/MPQ.

(5) Place the HEIGHT FEET switch in the position to be plotted. (This position is determined by the tactical situation and by such factors as the height of the mortar trajectory, the relative location of the target to Azimuth-Elevation-Range Recorder RD–54/TP, and the radar set to be used.

(6) If the height stylus does not enter the plotting length, depress the SLEW switch momentarily. The height stylus should move toward the zero reference end of the plotting surface.

(7) If the height stylus does not move toward the zero reference end of the plotting surface, loosen the tension screws and turn the adjusting knob to rotate the applicable control transformer (fig. 22), until the stylus does move toward the zero reference end of the plotting surface. For Azimuth-Elevation-Range Recorder RO–3/MPQ, interchange the captions B605–fine and B604–coarse on the height servo channel.

20. Initial Adjustments

a. Wire Rope Adjustment. The wire rope tension need be adjusted only if the tension proves incorrect after the following check: Displace the stylus carriage assembly manually to the extreme end of the recorder scale. Use an 8-ounce spring scale to check the tension of the wire rope at the center of the recorder scale. Displace the wire rope one-half inch in an upward direction, and observe the value indicated on the spring scale. This value should be approximately 4 ounces. If the scale reads more or less than the 4 ounces required for the correct wire rope tension, the following adjustment must be made—

(1) Loosen the wire rope tension adjusting screw located on the drive pulley (7, fig. 28), using the wire rope tension adjusting nuts, if the wire rope tension is above the nominal value.

(2) Tighten the wire rope tension adjusting screw located on the drive pulley (7, fig.

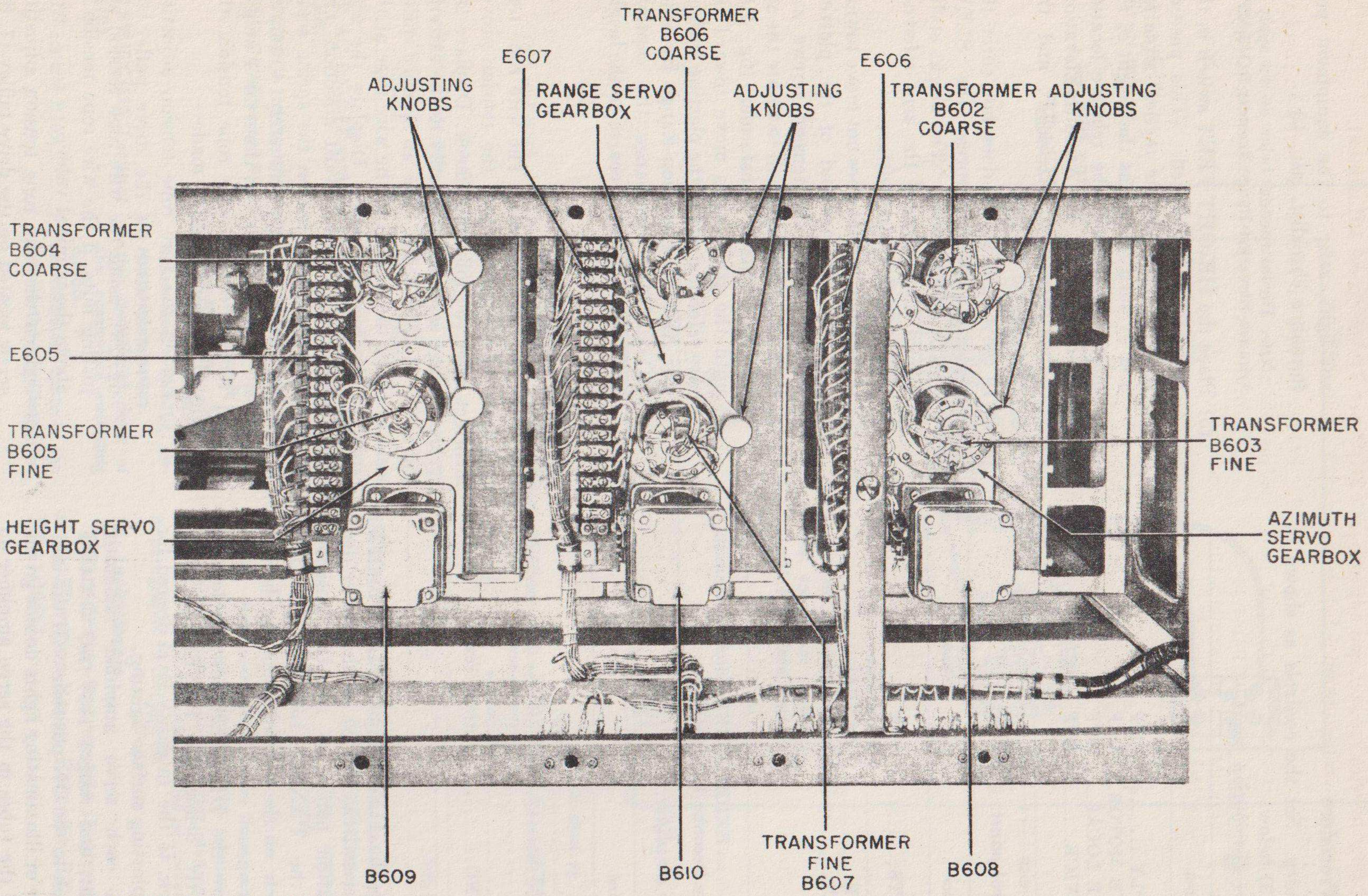


Figure 22. Height, range, and azimuth gearboxes.

28), using the wire rope tension adjusting nuts, if the wire rope tension is below the nominal value.

b. Stylus Pressure Adjustment. If the plot produced by the stylus on the plotting paper proves to be too light in definition, an adjustment that will intensify the plot line can be made in the following manner:

(1) Remove the stylus carriage assembly (31, fig. 51) from between the guide shafting (33).
(2) Remove the two plain knurled nuts (35); this will allow the stylus (11) and the helical compression spring (12) to be removed from the stylus carriage assembly.
(3) To increase the stylus plotting pressure, stretch the helical compression spring (12) slightly.
(4) To reassemble, reverse the order of the procedures listed in (1), (2), and (3) above.
(5) If the plot still proves to be too light, repeat the steps outlined in *b*(1) through (4) above.

c. Servo Amplifier Sensitivity Adjustment. The purpose of this adjustment is to put the styluses (azimuth, height, and range) at positions of optimum plotting efficiency.

Note. Adjust one channel at a time. The adjustment s the same for each one.

(1) Advance the servo amplifier GAIN control to the halfway point to provide some power for the initial motion of the stylus.
(2) Set the SINGLE-DUAL switch in the DUAL position and rotate the C F SWITCHING control to the extreme ccw position. See that the green lamp is lighted to indicate fine operation.
(3) Displace the stylus by giving it a slight push along the plotting surface.
(4) Observe the reaction of the stylus. If the stylus starts to hunt, adjust the DAMPING control until the stylus stops.
(5) Advance the servo amplifier GAIN control and again displace the stylus with a slight push. Further adjust the DAMPING control if it is necessary.

Caution: Do not advance the GAIN control to a point where the stylus will start to jitter.

21. Paper Travel Speed Adjustment
(fig. 52)

Follow the procedure outlined below to check or adjust the paper travel speed.

a. Turn the PAPER DRIVE MOTOR ON-OFF switch located on the power panel to the ON position.

b. Place the paper in motion by putting the PAPER DRIVE LOCAL ON-OFF switch in the ON position.

c. Use any fixed portion of the stylus frame to mark the paper at the start and finish of a 60-second interval.

d. Stop the paper movement. Pull out and tear off the marked section.

e. Use the plotting aid (fig. 9) to see that the two marks are 22.5 inches apart to within one-sixteenth inch.

f. If the two marks made on the paper are more than 22.5 inches apart, reduce the paper travel speed by slowing down the paper drive governor. This can be done by loosening the four self-locking nuts (63, fig. 52) an equal amount.

g. If the two marks made on the paper are less than 22.5 inches apart, increase the paper travel speed by speeding up the paper drive governor. This can be done by tightening the four self-locking nuts (63, fig. 52) an equal amount.

Caution: Be sure that the four nuts are loosened or tightened equally.

h. Repeat the procedures given in *a* through *g* above, and recheck the paper speed. Repeat the adjustment until the two marks are within one-sixteenth inch of the 22.5 INCHES=60 SECS line.

22. Zeroing Procedure

The purpose of zeroing in the recorder with its associated radar set is to orient the styluses so that their readings will correspond to the azimuth, height, and range data being transmitted from the radar set. Before carrying out the procedure outlined below, be sure that the radar set is transmitting the following:

Radar range	zero yards.
Radar elevation	zero mils.
Radar azimuth	zero mils or reference azimuth.

Note. In order that the azimuth sector, through which the radar set is to operate, will be included between the low end and the high end of the recorder azimuth scale, it may be necessary to select an azimuth other than zero mils as the value for the low or zero end of the recorder azimuth

scale. The azimuth selected is the reference azimuth. For example: The center azimuth of the sector to be scanned by the radar set is 3,815 mils. The recorder azimuth scale and plotting aid are calibrated from 0 to 3,200 mils; thus, the center azimuth of the sector to be scanned is off the scale. To bring the center azimuth of the sector to be scanned to the center of the azimuth scale of the recorder and the plotting aid, proceed as follows:

(1) At the 1,600-mil division (center point) of the recorder azimuth scale and of the plotting aid azimuth scale, inscribe 3 800 mils by means of a china marking pencil. This is the center azimuth (3,815 mils) to the nearest 100 mils. Change the other azimuth divisions on the recorder scale and plotting aid accordingly. The zero reference line of the scale now represents 1,200 mils (3,800 mils—1,600 mils=1,200 mils).

(2) The radar set must be positioned to an azimuth of 1,200 mils (new reference azimuth) when the zeroing procedure for the azimuth channel is performed.

a. Perform the zeroing procedure for the azimuth channel as follows:

(1) Throw the SYNCHRO DATA SINGLE-DUAL switch to the SINGLE position.

(2) Use the zero stylus to inscribe a zero reference line by moving the paper manually along the plotting surface.

(3) Loosen the tension screws on the coarse control transformer clamps and adjust coarse control transformer B602 (fig. 22) by turning the adjusting knob until the stylus comes to zero. Use the zero reference line inscribed with the zero stylus.

(4) Throw the SYNCHRO DATA SINGLE-DUAL switch in the DUAL position.

(5) Adjust the fine control transformer B603 by turning the adjusting knob until the azimuth stylus comes exactly down to the zero reference line. This fine adjustment is a very critical setting and should be exactly on the zero reference line.

(6) If there is any backlash present in the setting of the azimuth stylus, manipulate this setting to divide the backlash in half; this diminishes the possible error by that amount.

b. Perform the zeroing procedure for the range channel by using range coarse and fine control transformers B606 and B607 and following the instructions given in *a* above.

c. Perform the zeroing procedure for the height channel of Azimuth-Elevation-Range Recorder RD–54/TP as follows:

(1) Place the HEIGHT FEET switch in the required position.

(2) Place the SINGLE-DUAL switch in the SINGLE position.

(3) Repeat the procedures given for the azimuth channel (*a*, above). If the 7,500-foot height scale is used, adjust coarse control transformer B604; if the 30,000-foot height scale is used, adjust fine control transformer B605.

d. Perform the zeroing procedure for the height channel of Azimuth-Elevation-Range Recorder RO–3/MPQ, using height coarse and fine control transformers B604 and B605. Follow the procedures given in *a* above.

Note. The positions of the coarse and fine control transformers (B604 and B605) for the height servo unit are reversed in this recorder; the positions of the transformers in the range and servo units are the same in both recorders (fig. 22).

e. Adjust the scale so that the pointers on the styluses rest on the zero line.

23. Coarse-Fine Switching Adjustment

For Azimuth-Elevation-Range Recorder RD–54/TP, only the coarse-fine switching circuits of the range and azimuth channels require adjustment. Since the height channel is not adjusted, SYNCHRO DATA SINGLE-DUAL switch of that channel always should remain in the SINGLE position. Follow exactly the procedure described in paragraphs 24 and 25 for adjusting the coarse-fine switching circuits. All channels of Azimuth-Elevation-Range Recorder RO–3/MPQ require the coarse-fine switching adjustment.

24. Range Coarse-Fine Adjustment

Note. The GAIN and DAMPING controls for this channel should be adjusted before performing the following operations. If they have not been adjusted, refer to paragraph 20 before proceeding.

a. See that the C F SWITCHING control is in the ccw position.

b. Throw the SYNCHRO DATA SINGLE DUAL switch to the DUAL position.

c. Turn off the range servo amplifier by putting the 115V AC ON-OFF switch in the OFF position.

d. Displace the range stylus carriage assembly approximately 2½ inches up or down scale.

Note. The above operation can be performed at any position along the plotting surface and need not necessarily be done at the zero point.

e. Turn on the servo amplifier by placing the 115V AC ON-OFF switch in the ON position. The stylus carriage assembly should now sit 2.6 inches (2,000 yards) from its original position.

f. Advance the C F SWITCHING control until the red indicator lamp lights. This causes the stylus carriage assembly to move toward its original position. When the assembly reaches its original position, the green indicator lamp lights and remains lighted, indicating that the circuit has returned to fine operation.

g. Advance the C F SWITCHING control slightly further (in the clockwise (cw) direction) to provide a safety factor. The coarse-fine switching circuit for the range channel is now adjusted.

25. Azimuth Coarse-Fine Adjustment

a. See that the C F SWITCHING control is in the ccw position.

b. Put the SYNCHRO DATA SINGLE-DUAL switch in the DUAL position.

c. Return the GAIN control to zero.

Note. Mark the original setting of this control before returning it to zero. The setting will be returned to its adjusted gain position.

d. Displace the azimuth stylus carriage assembly exactly one-eight inch from its original position in either direction. This operation may be accomplished along any position on the plotting surface. The displacement of this stylus carriage assembly should be as exact as possible.

Note. A very careful check should be made when displacing the azimuth stylus carriage assembly one-eighth of an inch. This setting is extremely critical and should be checked before proceeding with the remainder of the adjustment.

e. Advance C F SWITCHING control until the red indicator lamp lights.

f. Return the GAIN control to its original position. The stylus carriage assembly will return to its original position and the green indicator lamp will light and remain lighted. The coarse-fine switching circuit for the azimuth channel is now adjusted.

Note. If the azimuth system oscillates between the coarse position and the fine position, it is an indication that the coarse and fine control transformers are not accurately alined. To correct this condition, refer to paragraph 22.

26. Height Coarse-Fine Adjustment

To adjust the coarse-fine switching on the height channel of Azimuth-Elevation-Range Recorder RO–3/MPQ use the appropriate C F SWITCHING control and SYNCHRO DATA SINGLE-DUAL switch on the height servo amplifier, as described in paragraph 24. The displacement noted in paragraph 24*d* will, in this instance, be approximately 6½ inches up or down scale. The stable point described in paragraph 24*e* will be 6.5 inches (7,500 feet) from its original position.

27. Operation

The operation of the recorder depends solely on the operation of the associated tracking radar set. This equipment, therefore, cannot be operated independently of the radar set. There are no instructions contained in this manual regarding the operation of the radar set used in the system. Since the recorder receives its signal data and power from the tracking radar, erratic operation of the equipment may sometimes be traced directly to the radar set itself, rather than to the recorder. The operator at the tracking radar can start the paper drive on the recorder only when the PAPER DRIVE AUTOMATIC-MANUAL switch is in the AUTOMATIC position. The recorder always should be in a plotting condition when the operator at the radar set starts the paper in motion along the plotting surface. The theory of operation of the components that make up Azimuth-Elevation-Range Recorder RD–54/TP and RO–3/MPQ is covered in chapter 4.

28. Stopping Procedure

When instructions are received from the operations officer, turn off the equipment in the following sequence:

a. Turn the three servo amplifier 115V AC ON-OFF switches to the OFF position.

b. Turn the main power 115V AC SUPPLY ON-OFF switch to the OFF position.

c. If the recorder is to be moved, disconnect the data cable by removing the connector plug of the data cable from the receptacle connector (fig. 12). Replace the plug caps.

d. Mount the stylus rod damper in its shipping position. Remove the damper from its stored position (fig. 50) and mount it in place beneath the stylus guide rods.

29. Interpretation and Extrapolation of the Height, Range, and Azimuth Plots

a. Need for Extrapolation. Only data above certain height limits are available to the recorder because of radar ground clutter effects. The

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minimum height varies considerably with the type of terrain and the radar site. For present applications of radar in the field artillery, two positions of the projectile are of interest. One is the point at which the projectile leaves the firing piece and the other is at the point of impact. The first is necessary for directing counter-battery fire, and the second is necessary for the adjustment of friendly fire.

b. Theory of Extrapolation. The two positions of interest are at ground height; therefore, the plot must be extended to include them. The plotted curves of the projectile's position will be relatively smooth and continuous. There will be no sudden changes in data. Therefore, the cuves may be extended in the same general trend until the ground height positions are determined. This is called extrapolation. It is necessary to know which part of the plot is used for the gun location and which part for the burst location. Since the paper is driven through the plotter in the same direction at all times, the following holds true regardless of the direction of fire:

(1) *Gun* data at *left* of plot.

(2) *Burst* data at *right* of plot.

c. Pickup Effect. The pickup point is the point at which the radar set is directed when locking on a projectile. When the radar set tracks the first few rounds from a gun, the pickup point may not be the best obtainable. This causes the radar data plots to jump in azimuth or elevation, or both, when locking on the projectile (A and B, fig. 23). These jumps in the plot should not be considered as part of the plot for extrapolation purposes since they do not represent true projectile data.

d. Extrapolation of Height Plot. The first step in the extrapolation procedure is to label the data traces height, range, and azimuth by observing the order in which their starting points appear from left to right. The solid traces on figure 23 represent the data traces made by the styluses in the recorder; the broken lines represent the extrapolated portion of the data traces. The displacement of the starting points of the solid traces occurs because the styluses are displaced laterally from each other by a fixed distance (fig. 50), permitting the proper association of each curve with its stylus. The starting point of each solid trace occurs in this order; height, range, and azimuth. When the gun height (or burst height) is the same as the radar height, the height plot is brought to the zero or ground height by fitting the trajectory curve (plexiglas parabola) to the curve to suit the general trend of that portion of the plot. Extend the height plot until it intersects the ground or zero reference line. The extrapolation procedure to be used when there is a height difference between the radar and the gun is given in *g*(3) below. Since the ground line represents the altitude of the radar, intersection point C, figure 23, represents ground height of the gun. Two adverse conditions of the plot encountered in extrapolating height plots are—

(1) *Height plot not smooth.* If the radar does not track smoothly in range or elevation, the height plot may be erratic or contain oscillations. This may be caused by an improper adjustment of the radar, a poor pickup point, the effect of clouds or ground clutter on the tracking radar, or the effect of the radar's tracking of multiple rounds. If the plot is not smooth, the parabola is fitted so that the variations in the plot lie equally inside and outside the parabola. If variations exist in only a small portion of the plot (fig. 23), as occurs at a poor pickup point, the parabola is fitted to the plot to suit the general trend of that portion of the plot.

(2) *Height plot of shape different from parabola.* The height plot may be of a shape different from the trajectory curve for several reasons:

(*a*) The height-time plot is parabolic only when the effect of air resistance is neglected. For the high velocity projectiles, the influence of air resistance on the projectile's flight is great enough to change the plot considerably.

(*b*) If the paper speed is too fast or too slow, the parabola will be expanded or contracted.

(*c*) If the height curve has a shape different from the parabola, it still can be extrapolated accurately. Keep in mind that the trajectory curve is used only as an extrapolating aid to facilitate the extending of the height plot in a manner that best fits what acutally has been plotted. Therefore, do not attempt to fit the trajectory curve to the height plot as a whole; fit it to either the ascending or descending leg of the plot. The height plot always will conform closely enough to the

parabolic curve to permit using the trajectory curve for this job.

e. Extrapolation of the Azimuth Plot. The azimuth plot can assume different forms depending on the path of the projectile. If the projectile moves directly toward the radar or directly away from the radar, the azimuth plot is a straight line because the azimuth remains the same. An azimuth plot of this type can be extended by means of a straightedge. All azimuth plots, except those for projectiles moving directly toward or away from the radar have some curvature. The azimuth plot of figure 23 is that of a projectile moving from left to right in front of the radar. To extrapolate a curve of this type, fit a portion of the trajectory curve to the plot so that it best fits the curve, and extend the plot as shown by the broken line, BE, figure 23. If the plot is erratic or contains oscillations, it should be extrapolated so that the plot lies equally on either side of the straightedge or trajectory curve.

f. Extrapolation of Range Plot. The range plot is a plot of range from the tracking radar to the projectile. The plot may have a number of different shapes, depending on the path of the projectile relative to the position of the radar. The plot is extrapolated in the same manner as the azimuth plot by using a trajectory curve or a straightedge.

g. Data Reading from Plots.

(1) *Scales.* A plotting aid (plexiglas rectangle) (fig. 9) engraved with height, range, and azimuth scales is used to read data from the plots. The scales are calibrated vertically from a reference line that corresponds to the ground line on the plot and permits the reading of data directly from the plot. Since the scale covers only a 3,200-mil sector in azimuth, occasionally a reference other than zero must be selected (par. 22). After the correct reference has been selected, the scale is renumbered with a china marking pencil for direct reading.

(2) *Reading data to gun or burst.* When the gun, burst, and radar are at the same height, the position of the projectile at zero height is also the position of the gun (or burst). Therefore, the data for the projectile at zero height is also valid for the gun because the projectile is in the gun. To determine the location of the gun, proceed as follows:

(*a*) Extrapolate the height plot, as indicated by the broken line, AC, figure 23, until it crosses the zero reference line.

(*b*) Extrapolate the azimuth and range plots, as indicated by the broken lines through E and D, until the plots extend beyond the point at which the height plot crosses the zero reference line (ground line).

(*c*) Place the zero position of the height scale of the plotting aid over the intersection of the extrapolated height plot and zero reference line or ground line (C, fig. 23).

(*d*) Read the data at the points where the extrapolated range and azimuth plots intersect their respective scales on the plotting aid; point D for range and point E for azimuth. This data indicates the ground range and azimuth from the radar set to the firing piece or burst.

(*e*) To determine the location of the burst, the plots are extrapolated to the right-hand side of the chart (fig. 23) and the data read in the same manner described above.

(3) *Height difference between radar, gun, and burst.* For purposes of computing firing data, the elevation of the control points, observation posts, and radar positions are determined with reference to sea level or an assumed datum plane. This vertical control is then extended into the target area. For a detailed discussion of vertical control refer to the field manual on field artillery observation. To determine the position of the gun or burst not at radar altitude proceed as follows: Extrapolate the height, azimuth, and range plots of the projectile to the zero reference line as though no difference in altitude exists (*g* above) and read the data. Determine from this apparent location of the gun the height difference between the gun (or burst) and radar from the vertical control data. Mark this difference at the proper place on the height scale of the plotting aid. Thus, if the gun position is 10 feet higher than the radar, a mark is made at the height-scale division representing 10 feet. Then, keeping the

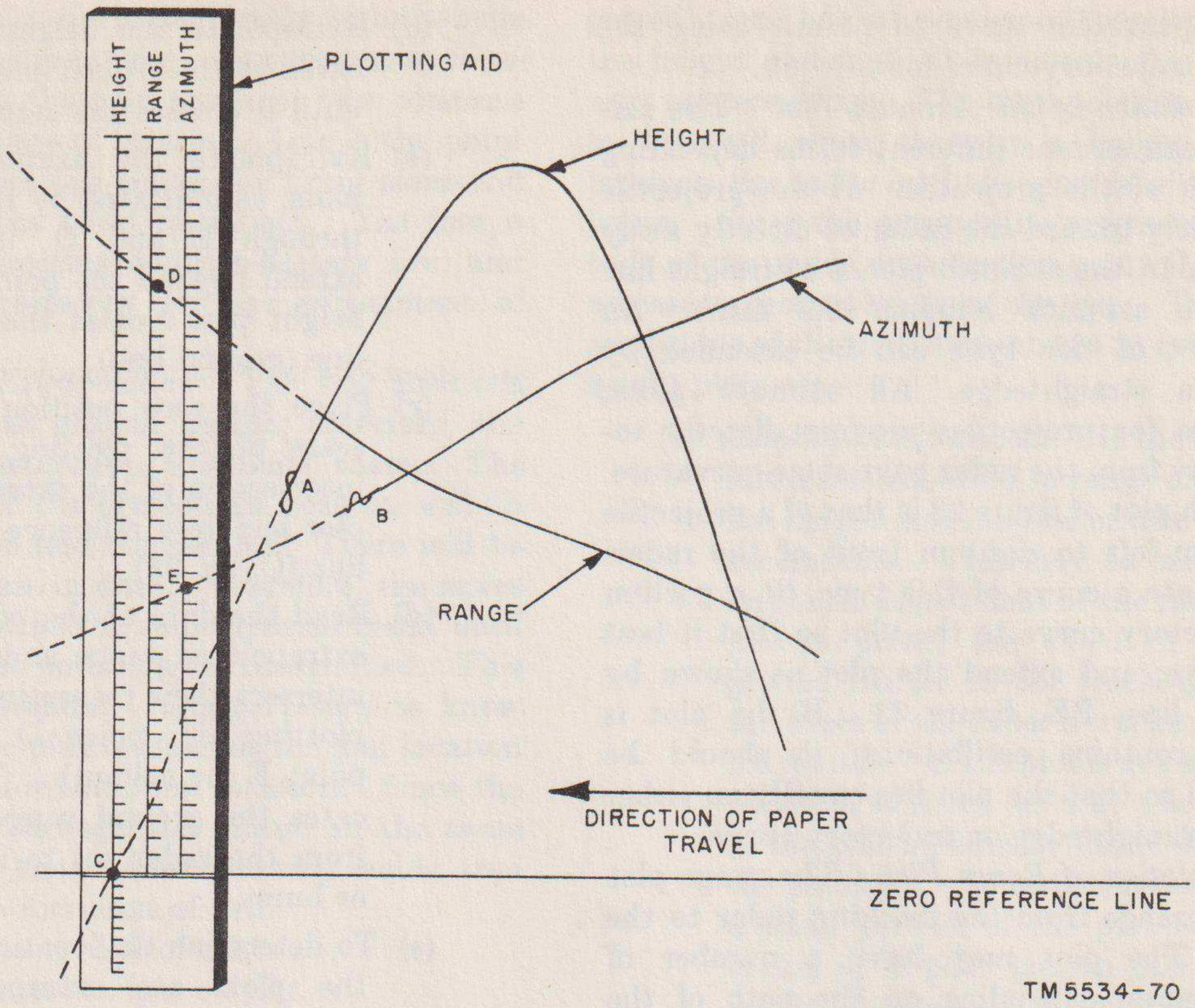

Figure 23. Location of firing point from recorder plots.

plotting aid zero line coinciding with the plotted ground or zero reference line, slide the scale along the zero reference line until the extrapolated height plot intersects the height scale at the newly marked point. The new values of range and azimuth now are read directly from the appropriate scale on the plotting aid. If the location sought is at a lower altitude than the radar set, the height plot must be extrapolated below the zero reference line as determined by the vertical control data.

h. Summary of Plot Interpretation. The following steps are performed to obtain data to a gun or to a point of impact:

(1) Label the height, range, and azimuth plots.
(2) Extrapolate the height, range, and azimuth plots.
(3) Read the data to the gun or to the burst at zero reference level.
(4) Plot the data to the gun or burst and determine the height difference (if vertical control is available).
(5) Reread the data from the plot using the height difference to replot the new values of range and azimuth.

Section IV. OPERATION UNDER UNUSUAL CONDITIONS

30. General

The operation of the recorder may be difficult in regions where extreme cold, heat, humidity and moisture, and sand conditions prevail. In the following paragraphs (31 through 33), instructions are given on procedures for minimizing the effect of these unusual operating conditions.

31. Operation in Arctic Climates

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

a. Be extremely careful when handling the equipment.

b. Keep the equipment warm and dry. If the recorder, when in operation, is not located in a heated inclosure, construct a partial inclosure to help minimize the adverse conditions prevalent in arctic regions. Keep the filaments of the vacuum tubes in each servo amplifier lighted constantly, unless this precaution overtaxes the power supply.

c. Locate the equipment inside a heated inclosure where there is danger of a cold draft striking the vacuum tubes when the servo amplifiers are pulled out of the equipment for test or repair purposes. A sudden draft of cold air can shatter the glass envelope of a heated tube. If a heated inclosure is not available, or if the inclosure is so constructed that this precaution is impossible, place a blanket or some barrier between the source of the draft and the equipment.

d. When equipment which has been exposed to the cold is brought into a warm room, it will sweat until it reaches room temperature. When the equipment has reached room temperature, dry it thoroughly. This condition also arises when equipment warms up during the day after exposure during a cold night.

e. Use any improvised means to protect the interconnecting data cable between the recorder and the radar set, or to protect the test cable when repairing or testing the servo amplifiers.

32. Operation in Tropical Climates

When operated in tropical climates, the recorder may be installed in tents, huts, temporary shelters, or, when necessary for tactical reasons, in underground dugouts. When the equipment is installed below ground and when it is set up in swampy areas, moisture is a serious problem. Ventilation is usually very poor, and the high relative humidity causes condensation on the equipment whenever its temperature becomes lower than that of the surrounding air. To minimize the effects of this condition, place lighted electric bulbs, if possible, under the equipment.

33. Operation in Desert Climates

a. The main problem which arises with equipment operation in desert areas is the large amount of sand or dust and dirt which enters the moving parts of the equipment. Therefore, always keep the access panels mounted on the equipment. The ideal preventive precaution is to house the equipment in a dustproof shelter. Since, however, such a shelter is seldom available, the next best precaution is to make the shelter in which the equipment is located as dustproof as possible with available materials and with regard to the tactical situation. If tents are used, secure the side walls with sand to prevent the canvas from flapping in the wind.

b. Never tie the data cable to either the inside or the outside of improvised shelters. Desert areas are subject to sudden wind squalls which may jerk the data cable connections loose.

c. Be careful to keep the equipment as free from dust as possible. Make frequent preventive maintenance checks (ch. 3). Excessive amounts of dust, sand, or dirt that come into contact with parts that have been lubricated result in grit, which will damage the equipment.

CHAPTER 3

ORGANIZATIONAL MAINTENANCE INSTRUCTIONS

Section I. ORGANIZATIONAL TOOLS AND EQUIPMENT

34. Tools and Materials Supplied

There are no tools or materials supplied with the recorder.

35. Organizational Tools and Materials

The associated radar set, either Radio Set SCR–584–A or –B or Radar Set AN/MPQ–10 or –10A, will stock a complete set of tools and materials needed for maintenance. If it becomes necessary, the tools and material supplied with the associated radar set may be used for the recorder.

Section II. PREVENTIVE MAINTENANCE SERVICES

36. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from troubleshooting and repair since its object is to prevent certain troubles from occuring. (See AR 750–5.)

37. General Preventive Maintenance Techniques

a. Use No. 00 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

(1) If necessary, except for electrical contacts, moisten the cloth or brush with Solvent, Dry Cleaning (SD); then wipe the parts dry with a cloth.

(2) Clean electrical contacts with a cloth moistened with carbon tetrachloride; then wipe them dry with a cloth.

Caution: Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Make sure adequate ventilation is provided.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from inaccessible places; be extremely careful however, or mechanical damage from the air blast may result.

d. For further information on preventive maintenance techniques, refer to TB SIG 178.

38. Use of Preventive Maintenance Forms (figs. 24 and 25)

a. The information in paragraph 39 is presented as a guide to the individual making an inspection of equipment in accordance with instructions on DA Forms 11–238 and 11–239. The decision as to which items on the forms are applicable to this equipment is a tactical decision to be made in the case of first echelon maintenance by the communications officer/chief or his designated representative, and, in the case of second and third echelon maintenance, by the individual making the inspection. Instructions for the use of each form appear on the reverse side of the form.

b. Circled items in figures 24 and 25 are partially or totally applicable to Azimuth-Elevation-Range Recorder RD–54/TP and Azimuth-Elevation-Range Recorder RO–3/MPQ. References in the ITEM block refer to paragraphs in text which contain additional maintenance information.

39. Performing Preventive Maintenance

a. Performing Exterior Preventive Maintenance.

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken. Do not use any solvents or cleaning agents on the

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
(1)	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (*receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories*). PAR. 39 a (1)							
(2)	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 39 a (2)							
(3)	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 39 a (3)							
(4)	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 39 a (4)							
(5)	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 39 a (5)							
(6)	CHECK FOR NORMAL OPERATION. PAR. 39 a (6)							

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.		13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
(8)	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 39 a (7)		14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.	
(9)	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 39 a (8)		15	INSPECT METERS FOR DAMAGED GLASS AND CASES.	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		(16)	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING. PAR. 39 a (10)	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
(12)	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 39 a (9)		18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM5534-80

Figure 24. DA Form 11–238.

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

NO	ITEM	CONDITION
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR. 39 a (1)	
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 39 a (2)	
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 39 a (3)	
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 39 a (4)	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 39 a (5)	
6	CHECK FOR NORMAL OPERATION. PAR. 39 a (6)	
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.	
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 39 a (7)	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 39 a (8)	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES. PAR. 39 a (9)	
13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.	
15	INSPECT METERS FOR DAMAGED GLASS AND CASES.	
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING. PAR 39 a (10)	
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	

NO.	ITEM	CONDITION
19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS: INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES. PAR. 39 b (1)	
20	INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.	
21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION. PAR. 39 b (2)	
22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS. PAR. 39 b (3)	
23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS. PAR. 39 b (4)	
24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE. PAR. 39 b (5)	
25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS. PAR. 39 b (6)	
26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR. 39 b (7)	
27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS. PAR. 39 b (8)	
28	CHECK SETTINGS OF ADJUSTABLE RELAYS. PAR. 39 b (9)	
29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.	
30	INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.	
31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS. PAR. 39 b (10)	
32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE. PAR. 39 b (11)	
33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.	
34	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.	
35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.	
36	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.	
37	MOISTURE AND FUNGIPROOF.	

38 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM 5534-81

Figure 25. DA Form 11–239.

recorder scale. Most cleaning agents will harm the plastic.

(1) Check for completeness and general condition of the equipment (console and recorder assembly, data cable, trajectory curves, plotting aid, and spare parts) (par. 72*a*).

(2) Check the suitability of the installation for normal operation.

(3) Clean dirt and moisture from the exterior of the console and recorder assembly, the data cable connector plug, and the recorder scale.

(4) Inspect the seating of readily accessible *pluck-out* items: tubes, lamps under the recorder scale, fuses, connectors, plug-in coils, and resistors.

(5) Inspect the controls for binding, scraping, excessive looseness, worn or chipped gears, misalinement, and positive action.

(6) Check for normal operation (par. 46). Check the zero adjustments of all control transformers (par. 22). Inspect all wire ropes for evidence of slack.

(7) Inspect cases, mountings, drive pulley grooves, and exposed metal surfaces for rust, corrosion, and moisture.

(8) Inspect the data cable, the data connector, and wire ropes for cuts, breaks, fraying, deterioration, kinks, and strain.

(9) Inspect the looseness of accessible items: toggle and rotary switches, connectors, electrical transformers, relays, motors, the blower, capacitors, and lamps under the recorder scale.

(10) Inspect covers for adequacy of weatherproofing.

b. Performing Interior Preventive Maintenance.

(1) Inspect the electron tubes in the servo amplifiers for loose envelopes, loose cap connectors, cracked sockets, and insufficient socket spring tension; clean dust and dirt carefully; check emission of receiver type tubes.

(2) Inspect electrolytic capacitors foı leaks, bulges, and discoloration (par. 73*b*).

(3) Inspect relays for loose mountings and burned, pitted, or corroded contacts; misalinement of contacts and springs; insufficient spring tension; and binding of plungers and hinge parts. Check the speed of the paper (⅜ inch per second or 22.5 inches per minute). Check the stylus lift for sufficient holding power. Adjust the counterbalance by turning the screws until the stylus is supported fully when in a raised position. Inspect the microswitches under the azimuth drive pulleys for free-running rollers.

Caution: When power has been disconnected to make internal checks, make sure that the stylus assemblies do not bang against their stops when the power is reconnected.

(4) Inspect variable capacitors for dirt, moisture, misalinement of plates, and loose mountings.

(5) Inspect resistors, bushings, and insulators, for cracks, blistering, discoloration, and moisture (par. 73*c*).

(6) Inspect terminals of large fixed capacitors and resistors for corrosion, dirt, and loose contacts.

(7) Clean and tighten switches, terminal blocks, the blower, and relay cases; clean the interior portions of the chassis and the cabinet (pars. 37 and 72*d*).

(8) Inspect the terminal blocks for loose connections, cracks, and breaks (par. 72*c*).

(9) Check the settings of adjustable relays.

(10) Clean and tighten the connections and the mountings for transformers, chokes, and potentiometers.

(11) Inspect transformer T102, chokes, and potentiometers for overheating and oil leakage.

(12) Inspect fuses and fuseholders for corrosion, cracks, and insufficient tension for good contact.

(13) Inspect wires for cracked, cut, and frayed insulation.

Section III. LUBRICATION AND WEATHERPROOFING

40. Lubrication

a. The recorder is designed to operate indefinitely without lubrication other than that provided during manufacture. Several parts that should be lubricated periodically for preservation purposes, however, are listed in the following chart:

Component	Part lubricated	Signal Corps lubricant
Lifting handles	All shafts	AN–G–25
Lifting eyes	All shafts	AN–G–25
Stylus carriage assembly	Roller shafts	AN–G–25

Caution: In many cases, additional lubrication may prove harmful. Lubrication of servo gearbox assemblies, for instance, may cause gears to become sticky and destroy the accuracy and sensitivity of the recorder assembly. If a moving component sticks or otherwise appears to require lubrication, the entire recorder should be turned over to qualified overhaul personnel.

b. The paper drive gearbox assembly should be lubricated with Oil, Low Temperature, Lubricating, Gear (OGR), or an equivalent, only during mechanical overhaul as described in chapter 6. The following chart lists the parts of the equipment lubricated by the manufacturer that do not require subsequent lubrication.

Component	Part lubricated	Lubricant used	Reason subsequent lubrication is not required
Left paper holder	Double-seal bearings	AN–G–25	Sealed bearings.
Right paper holder	Double-seal bearings	AN–G–25	Sealed bearings.
Front paper roller	Double-seal bearings	AN–G–25	Sealed bearings.
Rear paper roller	Double-seal bearings	AN–G–25	Sealed bearings.
Recorder assembly	Drive pulley double-seal bearings	AN–G–25	Sealed bearings.
Governor assembly	Double row bearing	AN–G–25	Not accessible for servicing.
Motor	Shaft bearings	AN–G–25	Not accessible for servicing.
Paper drive clutch	Double-seal bearings	AN–G–25	Sealed bearings.
Paper drive gearboxes	Double-seal bearings	AN–G–25	Sealed bearings.
Rope return pulleys	Double-seal bearings	AN–G–25	Sealed bearings.
Guide pulley assembly	Double-seal bearings	AN–G–25	Sealed bearings.
Guide pulley assembly	Double-seal bearings	AN–G–25	Sealed bearings.
Paper roller assembly	Double-seal bearings	AN–G–25	Sealed bearings.
Paper roller assembly	Double-seal bearings	AN–G–25	Sealed bearings.
Azimuth servo unit	Double-seal bearings	AN–G–25	Sealed bearings.
Range servo unit	Double-seal bearings	AN–G–25	Sealed bearings.
Elevation servo unit	Double-seal bearings	AN–G–25	Sealed bearings.

41. Weatherproofing

a. General. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungi, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moisture-proofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13 and TB SIG 72.

c. Winter Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66 and TB SIG 219.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75.

e. Lubrication. The effects of extreme cold and heat on materials and lubricants are explained in TB SIG 69. Observe all precautions outlined in TB SIG 69.

42. Rustproofing and Painting

a. When the finish on the case or panel has been badly scarred or damaged, rust and corrosion can

be prevented by touching up bared surfaces. Use No. 00 or No. 000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish. Instructions for refinishing badly marred panels and cases are given in TM 9–2851.

Caution: Do not use steel wool. Minute particles can enter the console and cause harmful internal shorting or grounding of circuits.

b. When a touch-up job is necessary, apply paint with a small brush. Remove rust from the panels by cleaning corroded material with solvent (SD). In severe cases, it may be necessary to use solvent (SD) to soften the rust and to use sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section IV. TROUBLESHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

43. General

a. The troubleshooting and repair that can be performed at the organizational maintenance level (operators and repairmen) is necessarily limited in scope by the tools, test equipment, and replaceable parts issued, and by the existing tactical situation. Accordingly, troubleshooting is based on the performance of the equipment and the use of the senses in determining such troubles as burned-out tubes and cracked insulators.

b. This section helps in determining which of the components is at fault and in localizing the fault in that component to the defective stage or item, such as a tube or a fuse.

44. Visual Inspection

a. Failure of this equipment to operate properly will be caused by one or more of the following faults:

(1) Lack of paper in the paper roll.
(2) Jammed-up paper in the recorder assembly.
(3) Incorrect setting of the pinwheels that engage the paper, causing the paper to come out at an angle.
(4) Overrunning clutch jammed.
(5) Improperly connected data cable.
(6) Worn, broken, or shorted leads in the data cable.
(7) Burned-out fuses.
(8) Defective tubes in the servo amplifiers.
(9) Wires broken because of excessive vibration.
(10) Frayed, broken, or kinked ropes on the drive pulleys.
(11) Badly damaged or corroded pulleys.
(12) Servo amplifiers improperly seated.
(13) Stylus worn down.
(14) HEIGHT-FEET switch in wrong position (Azimuth-Elevation-Range Recorder RD–54/TP only).
(15) Incandescent lamps out of position and jamming the paper.
(16 Wires loose or disconnected on terminal boards.
(17) Microswitches slipping out of adjustment.
(18) Control transformers slipping out of adjustment.
(19) Paper drive clutch not operating properly.

b. When failure is encountered and the cause is not immediately apparent, check as many of the above items as is practicable before starting a detailed examination of the component parts of the system. If possible, obtain information from the operator of the equipment regarding performance at the time trouble occurred.

45. Troubleshooting by Using Equipment Performance Checklist

a. General. The equipment performance checklist (par. 46) will help the operator to locate trouble in the equipment. The list gives the item to be checked, the conditions under which the item is checked, the normal indications and tolerances of correct operation, and the corrective measures the operator can take. *When using this list, follow the items in numerical sequence.*

b. Action or Condition. For some items, the information given in the *Action or condition* column consists of various switch and control settings under which the item is to be checked. For other items, it represents an action that must be taken to check the normal indications given in the *Normal indications* column.

c. Normal Indications. The normal indications listed include the visible signs that the operator should perceive when he checks the items. If the indications are not normal, the operator should apply the recommended corrective measures.

d. Corrective Measures. The corrective meas-

ures listed are those the operator can make without turning in the equipment for repairs. If the set is completely inoperative or if the recommended corrective measures do not yield results, trouble shooting or mechanical overhaul is necessary. However, if the tactical situation requires that the overall system be maintained, and if the equipment is not completely inoperative, the operator must maintain the set in operation as long as it is possible to do so.

46. Equipment Performance Checklist

	Item No.	Item	Action or condition	Normal indications	Corrective measures
PREPARATORY	1	Data cable	Plug of data cable connected to J504.		
	2	115V AC ON-OFF switch	Set at OFF position.		
	3	115V AC servo amplifier switches.	Set at OFF position.		
	4	PAPER DRIVE MOTOR switch.	Set at OFF position.		
	5	PAPER DRIVE AUTOMATIC-MANUAL switch.	Set at MANUAL position.		
	6	115V AC SERVICE switch.	Set at OFF position.		
	7	PANEL LIGHTS switch	Set at OFF position.		
	8	DIMMER control	Set at DIM position.		
	9	GAIN control	Set at extreme ccw position.		
	10	DAMPING control	Set at midposition.		
	11	C F SWITCHING control.	Set at extreme ccw position.		
	12[a]	SLEW switch	Keep at normal position.		
	13[a]	HEIGHT FEET switch S203.	Set at height position to be plotted.		
START	14	115V AC SUPPLY switch.	Turn to ON position	Indicators I 301 and I 302 will light.	Check fuses F301, F302, and F303. Check wiring to switch S301.
	15	115V AC servo amplifier switches.	Turn to ON position	Indicator I 101 will light.	Check fuse F101. Check wiring to switch S102.
	16	PANEL LIGHTS switch	Turn to ON position	Illuminates the plotting surface.	Check fuse F201. Check wiring to switch S204.
	17	DIMMER	Turn to BRIGHT position.	Plotting surface illumination increases.	Check rheostat R201.

CHAPTER 4

THEORY

Section I. OVERALL THEORY OF AZIMUTH-ELEVATION-RANGE RECORDER RD–54/TP AND AZIMUTH-ELEVATION-RANGE RECORDER RO–3/MPQ

47. Block Diagram

Figure 26 is a functional block diagram of Azimuth-Elevation-Range Recorder RD–54/TP as a part of an overall system in which Radar Set AN/MPQ–10 (*) is used. Although the theory discussion is based on Azimuth-Elevation-Range Recorder RD–54/TP, it is applicable to Azimuth-Elevation-Range Recorder RO–3/MPQ. Where differences between the two recorders exist they are pointed out in the discussion.

a. Radar Set AN/MPQ–10 (*) is equipped with three pairs of synchro data generators (fig. 26). One pair of synchro data generators supplies the fine and coarse azimuth information; the second pair supplies the fine and coarse range information; and the third pair supplies the height information. This information is transmitted in the form of electrical signals through cable W702 to the recorder.

b. At the recorder, the azimuth, range, and height signals are applied to their respective control transformers. The azimuth coarse signal is applied to the azimuth coarse control transformer and the azimuth fine signal is applied to the azimuth fine control transformer. Each control transformer generates a voltage, called an error voltage. The magnitude of the error voltage is related to the difference between the control transformer's rotor position and the rotor shaft position of the corresponding synchro generator in the radar set. (The theory of synchro transmission is discussed in detail in paragraphs 59 through 63.) The azimuth coarse and fine error voltages are transmitted to a servo amplifier. A switching circuit in the servo amplifier determines which of the error voltages is to be amplified. The servo amplifier output then is fed to the servo motor. The servo motor rotates a shaft that drives the azimuth stylus and turns the rotors of the azimuth control transformers. When the rotors reach a position of zero error voltage output, the servo motor stops rotating. The azimuth stylus will be at a position corresponding to the azimuth information received from the radar set. When the azimuth signal from Radar Set AN/MPQ–10 (*) changes, there is again an error voltage output from the azimuth control transformer. The rotors of the control transformers are turned to the new zero error-voltage output position; the azimuth stylus will move to a new position corresponding to the change in azimuth information. The functioning of the range channel is similar to that of the azimuth channel.

c. The operation of the height channel in the recorder is different from the operation of the range and azimuth channels. There are two height synchro generators in Radar Set AN/MPQ–10 (*). These are shown in figure 26 as solid line blocks. The broken line block around the height coarse synchro generator is used to indicate that only one synchro generator is found in Radio Set SCR–584–(*). Notice that only one control transformer is energized when the recorder is used in conjunction with Radar Set AN/MPQ–10 (*). When in the MPQ 10 30000 position, the HEIGHT FEET switch connects the height coarse synchro generator to the height fine control transformer. When in the MPQ 10 7500 position, the HEIGHT FEET switch connects the height fine synchro generator to the height fine control transformer. The output of the height fine control transformer is fed to the servo amplifier. The servo amplifier output is fed to the servo motor. The servo motor rotates a shaft that drives the height stylus to a position corresponding to the height information received. The rotors of the fine and coarse con-

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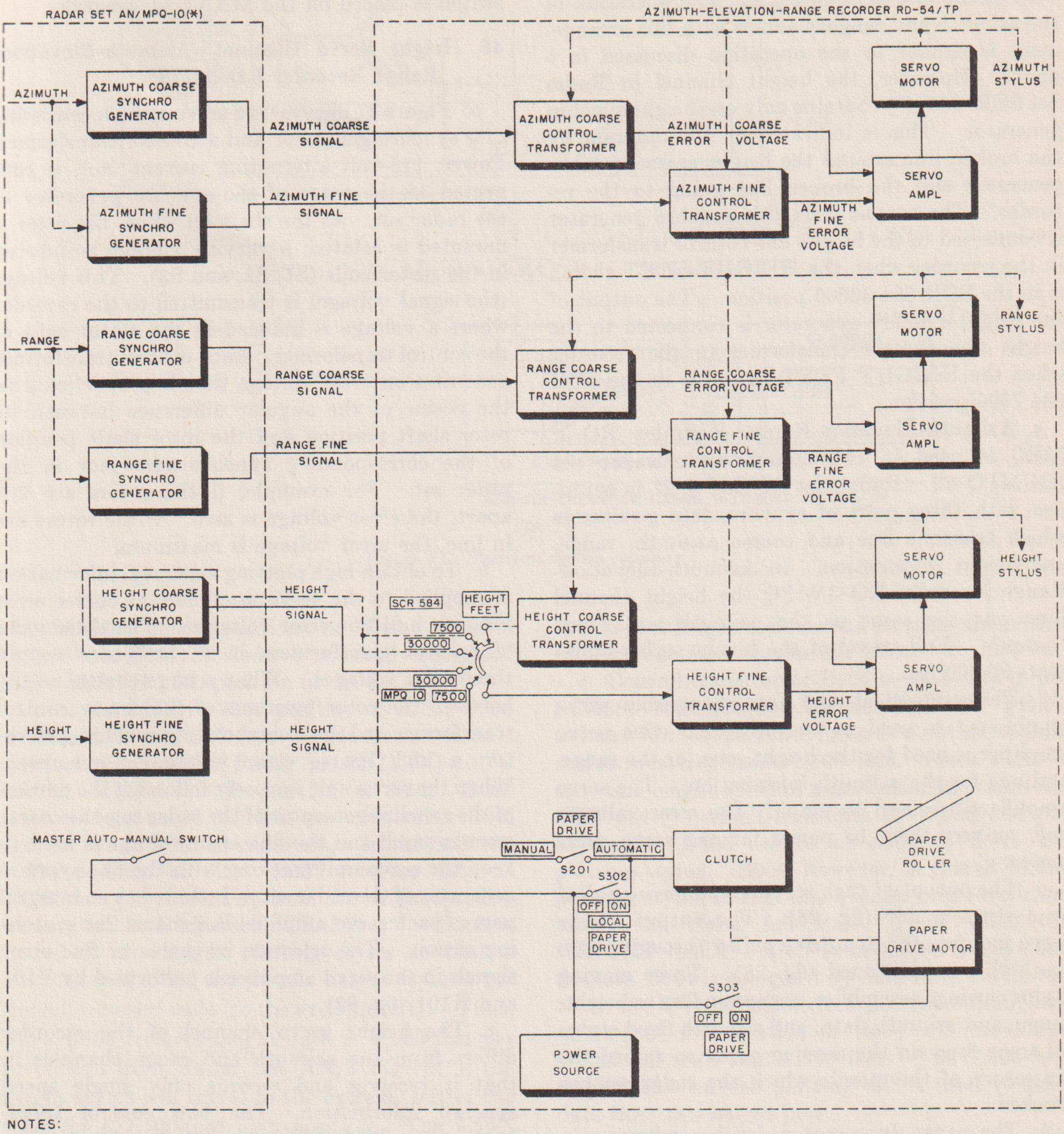

NOTES:

1. HEIGHT COURSE CONTROL TRANSFORMER IS NOT ENERGIZED WHEN RADAR SET AN/MPQ-10(*) IS EMPLOYED.
2. RADIO SET SCR-584-(*) HAS ONLY ONE HEIGHT SYNCHRO GENERATOR (SHOWN BY THE BROKEN LINE BLOCK). WHICH IS CONNECTED TO CONTROL TRANSFORMER THROUGH HEIGHT FEET SWITCH CONTACTS.
3. PAPER DRIVE AUTOMATIC-MANUAL SWITCH S201 IS SHOWN IN THE MANUAL POSITION.

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Figure 26. Azimuth-Elevation-Range Recorder RD-54/TP and/or RO-3/MPQ complete block diagram.

trol transformers are turned until they are in a position of zero error voltage output.

d. The recorder also can be used in conjunction with Radio Set SCR–584–(*). The operation of the azimuth and range channels with this arrangement is similar to the operation discussed in *b* above. However, the height channel in Radio Set SCR–584–(*) contains only one height synchro generator. This is indicated on the diagram by the broken line around the height coarse synchro generator and the broken line going to the recorder. The output from this synchro generator is connected to the height fine control transformer in the recorder when the HEIGHT FEET switch is in the SCR 584 30000 position. The output of the height synchro generator is connected to the height fine control transformer in the recorder when the HEIGHT FEET switch is in the SCR 584 7500 position.

e. Azimuth-Elevation-Range Recorder RO–3/MPQ is used in conjunction with Radar Set AN/MPQ–22. Radar Set AN/MPQ–22 is equipped with three pairs of synchro data generators which transmit fine and coarse azimuth, range, and height information. In Azimuth-Elevation-Range Recorder RO–3/MPQ the height channel functions the same as the azimuth and range channels. Full travel of the height stylus represents 30,000 feet.

f. Three identical and interchangeable servo amplifiers are used in the recorder. One servo amplifier is used for the height, one for the range, and one for the azimuth information. The servo amplifiers are used to amplify the error voltages and convert them to power for the servo drive motor.

g. The output of each servo amplifier is applied to a servo motor (fig. 26). The output of the servo motor is fed to a drive pulley through which the stylus is positioned (fig. 28). Three moving stylus carriage assemblies, corresponding to height, range, and azimuth data, and a fourth fixed stylus all trace lines on the moving paper to record the trajectory of the missile which the radar set has tracked.

h. The paper drive motor clutch mechanism in the recorder unit may be controlled remotely at the associated radar set, or locally by an operator at the recorder unit. For remote control operation, the PAPER DRIVE LOCAL switch, located on the power distribution panel (fig. 16), is placed in the OFF position, and the PAPER DRIVE switch, located on the control panel (fig. 18), is placed on the AUTOMATIC position. For local operation, the PAPER DRIVE LOCAL switch is placed on the ON position, and the PAPER DRIVE switch is placed on the MANUAL position.

48. Height Servo Channel (Azimuth-Elevation-Range Recorder RD–54/TP)

a. Figure 27 illustrates a servo system consisting of a synchro generator and a control transformer. Power, 115-volt alternating current (ac), is connected to the rotor of the synchro generator in the radar set. As the shaft on which the rotor is mounted is rotated, a varying voltage is induced in the stator coils (S1, S2, and S3). This voltage (the signal voltage) is transmitted to the recorder where a voltage is induced in the stator coils of the control transformer. Each control transformer generates an error voltage that is proportional to the cosine of the angular difference between its rotor shaft position and the rotor shaft position of the corresponding synchro generator in the radar set. For example, if the rotors are 90° apart, the error voltage is zero. If the rotors are in line, the error voltage is maximum.

b. To obtain high plotting accuracy, information is supplied to the servo amplifiers as coarse error voltages and fine error voltages. The three pairs of control transformers in the recorder supply these error voltages. When a large change occurs between the rotor positions of the coarse control transformer and the corresponding synchro generator, a high coarse error voltage is generated. When the servo unit is closely following the motion of the synchro generator of the radar set, the coarse error is small and the fine error voltage is used to keep the servo unit tracking with the fine synchro generator of the radar set. Included as an integral part of each servo amplifier is a coarse fine switching circuit. The selection of coarse or fine error signals in the servo amplifier is performed by V101 and K101 (fig. 62).

c. The height servo channel of the recorder differs from the azimuth and range channels in that it receives and records only single speed synchro information. The two control transformers on the height servo gearbox function to permit the change of the recorder plotting scale; they do not function as fine and coarse synchro data inputs to the servo amplifiers. The selection of control transformer B604 or B605 (fig. 58) to be energized is made by HEIGHT FEET switch S203. Control transformer B605, labeled *fine*, is energized in the MPQ10 7500, MPQ10 30000,

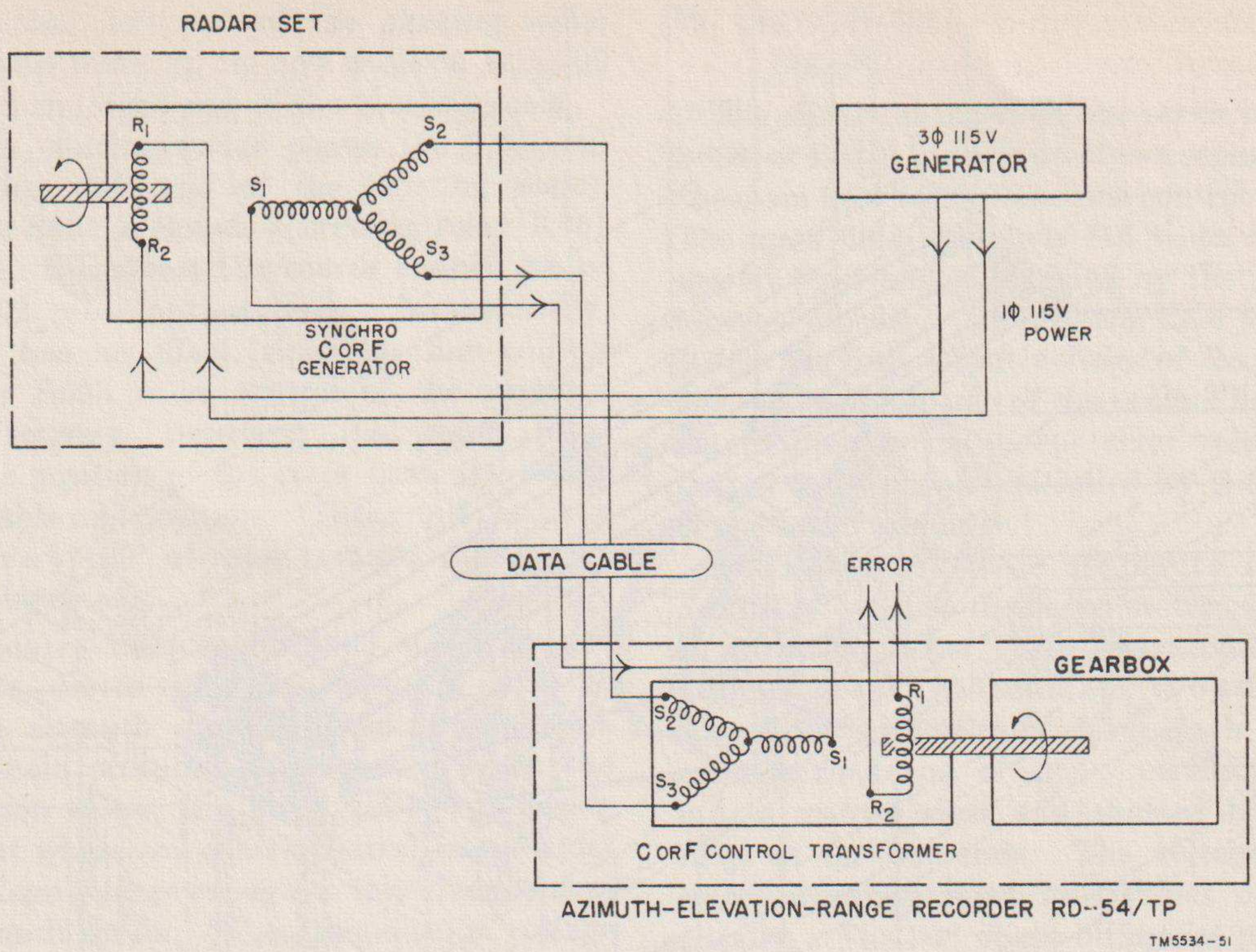

Figure 27. Electrical system coupling.

and SCR584 30000 positions of S203. Control transformer B604, labeled *coarse*, is only energized in the SCR584 7500 position of S203.

d. In the MPQ10 7500 position of S203, B605 receives data at 7,500 feet per revolution from a synchro transmitter in Radar Set AN/MPQ–10(*). In the MPQ10 30000 position of S203, B605 receives data at 30,000 feet per revolution from another synchro in the radar set. In the SCR584 30000 position of S203, B605 receives data at 30,000 feet per revolution from the height synchro transmitter in Radio Set SCR–584–(*). B605 is geared to the height plotting stylus so that 1 revolution of B605 moves the height stylus over the full recorder scale (to the extreme left). Thus, when B605 receives height data at 7,500 feet per revolution from Radar Set AN/MPQ–10(*), the height stylus will travel to the extreme left of the scale for a 7,500-foot high position. The 7,500-foot height scale on the plotting aid is used to read data from this height plot. However, when B605 receives data at 30,000 feet per revolution from Radar Set AN/MPQ–10(*) or Radio Set SCR–584–(*), B605 turns only one quarter of a revolution, causing the height stylus to cover only one quarter of its full travel toward the left. The 30,000-foot height scale on the plotting aid is used to read data from this height plot.

e. Control transformer B604 is used only in the SCR584 7500 position of the HEIGHT FEET switch. In this position, full travel of the plotting stylus must represent 7,500 feet. Since there is only one height synchro transmitter in Radio Set SCR–584–(*) which transmits at 30,000 feet per revolution, B605 cannot be used to drive the plotting stylus. B604, however, is geared to the plotting stylus so that one quarter of a revolution moves the stylus full scale. Thus, when the HEIGHT-FEET switch is in the SCR–584 7500 position B604 is energized by data from Radio Set SCR–584–(*) at 30,000 feet per revolution, one quarter of a revolution of B604 will move the stylus full scale and 7,500 feet. The 7,500-foot height scale on the plotting aid is used to read data from this height plot.

f. SLEW switch S202 disconnects the height servo amplifier from its control transformer and applies a constant 6.3 volts from the secondary of T201 (fig. 58). The 6.3 volts is phased to drive the plotting stylus to the zero reference line and is used to slew the stylus to true position when changing the plotting from a 7,500-foot to a 30,000-foot scale.

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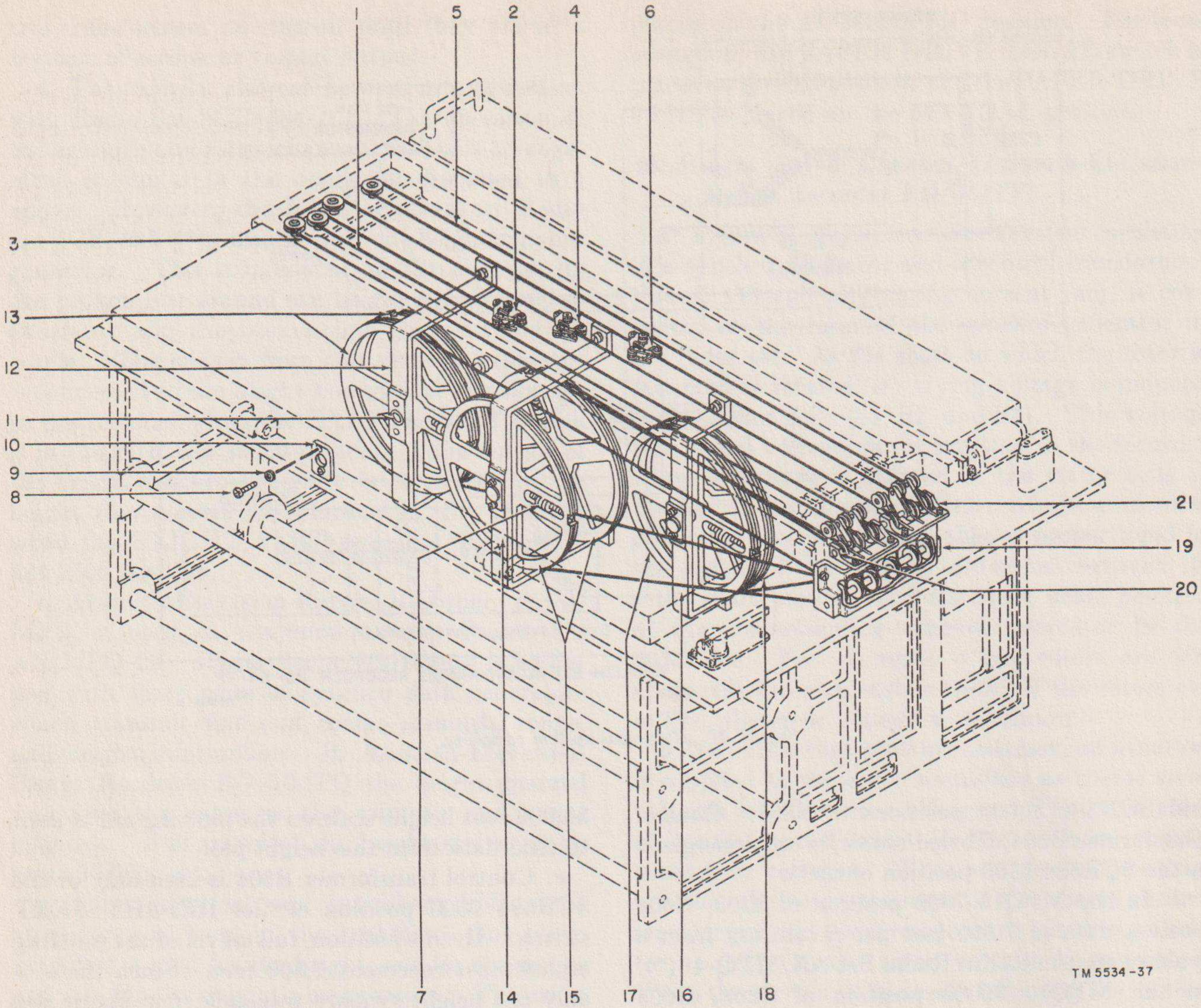


1 Azimuth carriage drive wire rope (W601)
2 Azimuth stylus carriage
3 Range carriage drive wire rope (W601)
4 Range stylus carriage
5 Height carriage drive wire rope (W601)
6 Height stylus carriage
7 Wire rope tension adjusting nuts
8 Fillister-head machine screw, No. 8–32 by ¼ inch long.
9 Split lock washer, No. 8 by .047 inch wide by .031 inch thick
10 Bearing cover
11 Self-alining roller bearing (O604)
12 Azimuth drive pulley bearing support (A605)
13 Azimuth drive pulley
14 Range drive pulley bearing support (A606)
15 Range drive pulley
16 Height drive pulley bearing support (A604)
17 Rear height drive pulley
18 Front height drive pulley
19 Pulley bracket assembly
20 Pulley assembly
21 Pulley assembly

Figure 28. Stylus assembly drive system.

49. Azimuth Sector Switching Circuit

The azimuth sector switching circuit, consisting of microswitches S601 and S602 (fig. 48) and relay K401 (fig. 58), is designed to permit the plotting of 6,400 mils of azimuth variation on the plotting scale, which is 3,200 mils wide. To plot 6,400 mils, the variation from 0 to 3,200 mils is plotted from right to left starting at the zero reference line. When the stylus reaches the 3,200-mil position, the azimuth sector switching circuit acts to slew the stylus back toward the zero reference line where the plot from 3,200 plus mils is continued, again from right to left, to 6,400 mils. If the sector switching circuit is adjusted properly, no more than 45 mils of azimuth plot will be lost between the time the circuit is actuated at the

3,200-mil point (left end of the plotting scale) and the stylus takes up its new position at 3,200 plus mils on the right end of the plotting scale.

a. As the plotting stylus passes the 3,200-mil scale position (left end of the plotting scale), microswitch S601 is closed, energizing relay K401 (fig. 58) which reverses the coarse control transformer B602 rotor output leads. Momentarily, this action has no effect, since the fine control transformer B603 is in control of the azimuth servo. Effectively reversing the rotor leads changes the position of the rotor from the stable to the unstable null position. These null positions occur for every 180° of rotor rotation (3,200 mils of pen displacement).

b. Fine control transformer B603, still in control of the servo, drives the azimuth stylus until the mechanical azimuth stop (1/32 inch beyond the 3,200-mil scale position) is reached. When the stylus motion stops, the error voltage increases to the point where the coarse control transformer output voltage is large enough to take over control of the azimuth servo. When this output voltage takes control of the servo, it drives the servo away from its unstable null position to the stable null position, driving the stylus back across the plotting scale to the 3,200 plus mil point of stable null, where the fine control transformer once again takes control of the servo. The fine error voltage continues to drive the stylus to the 6,400-mil point.

c. Microswitches S601 and S602, located below the azimuth drive pulley (fig. 48), are positioned so that they are closed whenever the azimuth stylus reaches either end of the recorder scale. When they close, they energize K401, a sequential type relay which, when momentarily energized, changes its contact positions and maintains the new position until it is again energized. If the stylus sticks at the end of its travel, limit switch S601 or S602 would remain closed, thus causing relay K401 to remain energized. Heavy current would result which would damage the relay. To prevent this, voltage-dropping resistor R401 is placed in series with the relay by a switch contact whenever the relay becomes energized.

50. Servo Motor

(fig. 58)

The electrical input to the servo motor (B608, B609, or B610) is made up of two separate voltages: one main field voltage and one control field voltage. The main field voltage is 115 volts, 60 cycles per second (cps) and is supplied by the power source for the recorder. The control field voltage is the 60-cps varying output voltage of the servo amplifier. The amplitude of the control field voltage is determined by the 60-cps error voltage input to the servo amplifier multiplied by the overall gain of the servo amplifier.

a. The dual voltage supply to the motor is necessary because the servo motor is a two-phase ac induction motor. The servo motor consists of a squirrel-cage type rotor and two stator windings spaced 90° electrically from each other. The rotor is made up of heavy conducting bars set into armature slots and shorted by conducting rings at the bar ends. The voltages fed to the stator windings must be 90° out of phase electrically. The 90° phase difference plus the effect of the 90° spacing of the windings results in a rotating magnetic field. The rotating field induces a voltage in the rotor by transformer action. The low resistance of the heavy rotor conducting bars permits large currents to circulate in the bars, and the large currents produce magnetic fields around the rotor. The interaction of the rotating magnetic field of the stator and the magnetic field around the rotor causes the rotor to turn.

b. This type of motor is used because it has fast starting and stopping characteristics and develops maximum torque when the rotor is stationary. These properties are desirable as a source of driving power for the stylus drive system.

c. The mechanical output of the servo motor is divided into two components. The first component provides the motive power to the stylus assembly. The second component, called the servo follow-up, is coupled to its associated control transformer and drives the control transformer to a position of zero error volts output. At this point, the radar shaft position is duplicated by the stylus position.

Section II. THEORY OF ELECTRONIC CONTROL AMPLIFIER AM–489/TP (SERVO AMPLIFIER)

While reading the theory of the Electronic Control Amplifier AM–489/TP (servo amplifier), refer frequently to the complete schematic diagram (fig. 62), the block diagrams (figs. 29 and 31), and the functional diagrams (figs. 30, 32, 33, and 34).

51. General

The servo amplifier has two signal inputs: fine error voltage and coarse error voltage. The selection of the error voltage to be amplified is performed by V101, K101, and S101 (fig. 33); the setting of C F SWITCHING control R–22 determines which voltage controls the servo amplifier at any instant. The servo amplifier also has a notched network (fig. 32) at the input to the first amplification stage. This network provides increased amplifier gain when the servo motor tends to lead or lag the radar synchro data generator by an excessive amount. A 115-volt 60-cps power source is applied to the primary of the power transformer (fig. 34). The secondary of the power transformer has three secondary windings; one supplies the filament power for the amplifier tubes; a second supplies filament power to the full-wave rectifier; and the third supplies plate voltage for the full-wave rectifier. Plate voltages for the tubes in the servo amplifier are supplied by the full-wave rectifier. The servo-amplifier output drives the servo motor.

52. Fine Error Input

A fine error voltage is produced by a difference in angular shaft position between the fine control transformer on the servo unit and the fine synchro generator at the radar set. This fine error voltage is applied to terminals 3 and 10 (fig. 62) of the servo amplifier. Terminal 10 is connected to the B minus ground in the servo amplifier. Terminal 3 is connected to fixed contact 4 of relay K101. With the relay in the de-energized position as shown in figure 62, terminal 5 of the relay is connected to relay terminal 4.

53. Notch Network

The notch network (fig. 32), a stabilization circuit, minimizes overshooting or lagging by the servo motor as it follows the radar synchro data generator.

a. The ac error voltage input, from relay K101 (terminal 5), is coupled through C102, appears across R102, and is applied to the notch network made up of R103, C103, R101, and C112. The notch network produces an increased signal voltage to the grid of V102A when the servo motor tends to lead or lag the radar synchro data generator by an increasing or decreasing shaft angle. When the servo motor shaft angular error is constant (the normal condition when the servo motor shaft is tracking accurately the radar synchro data), only the normal 60-cps output voltage is developed by the synchro control transformer and applied as input signals to the servo amplifier. This 60-cps error signal is attenuated by the notch network. When the servo motor shaft tends to lead or lag the radar synchro data generator shaft because of an instantaneou

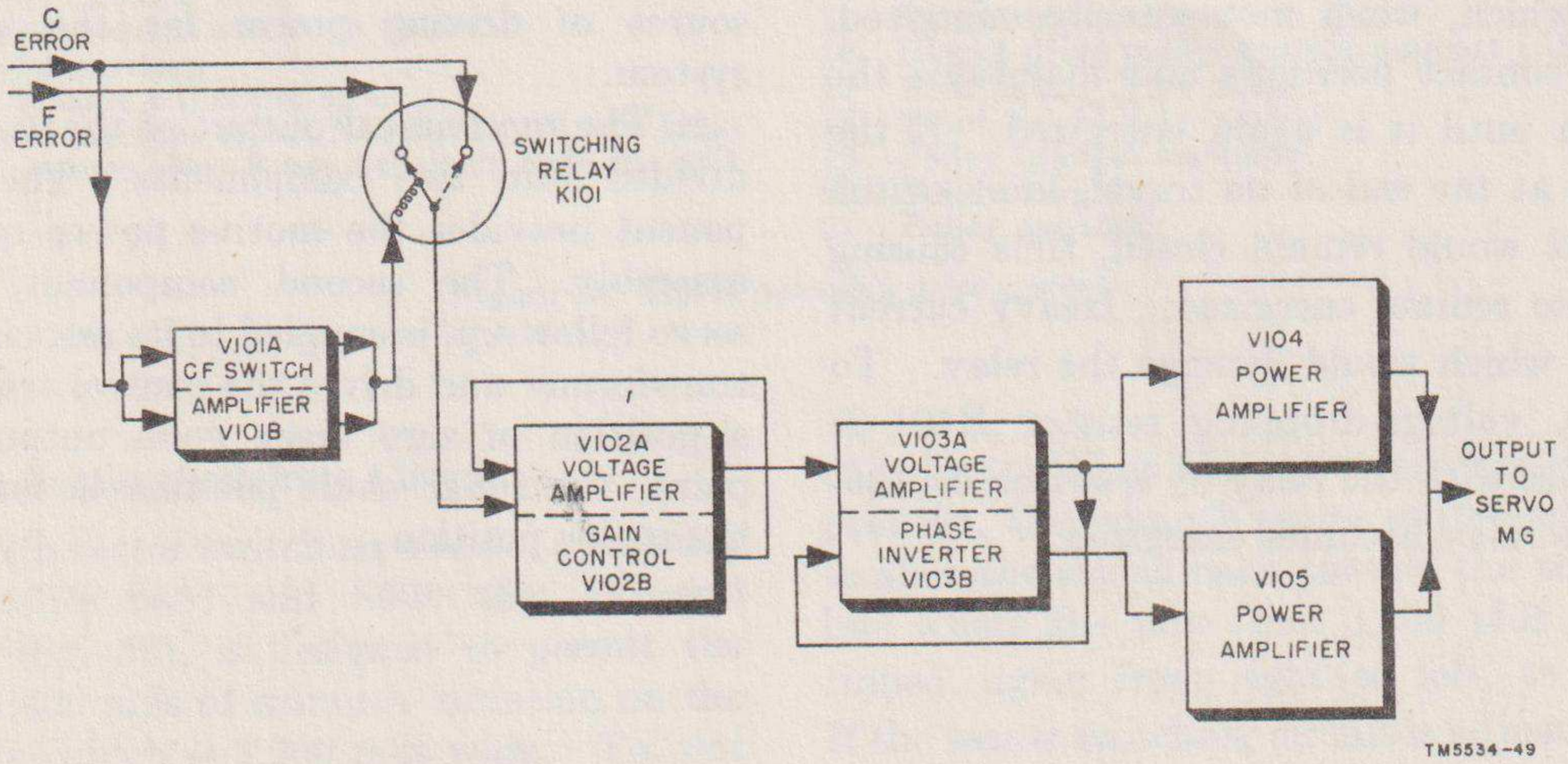


Figure 29. Electronic Control Amplifier AM–489/TP (servo amplifier), block diagram.

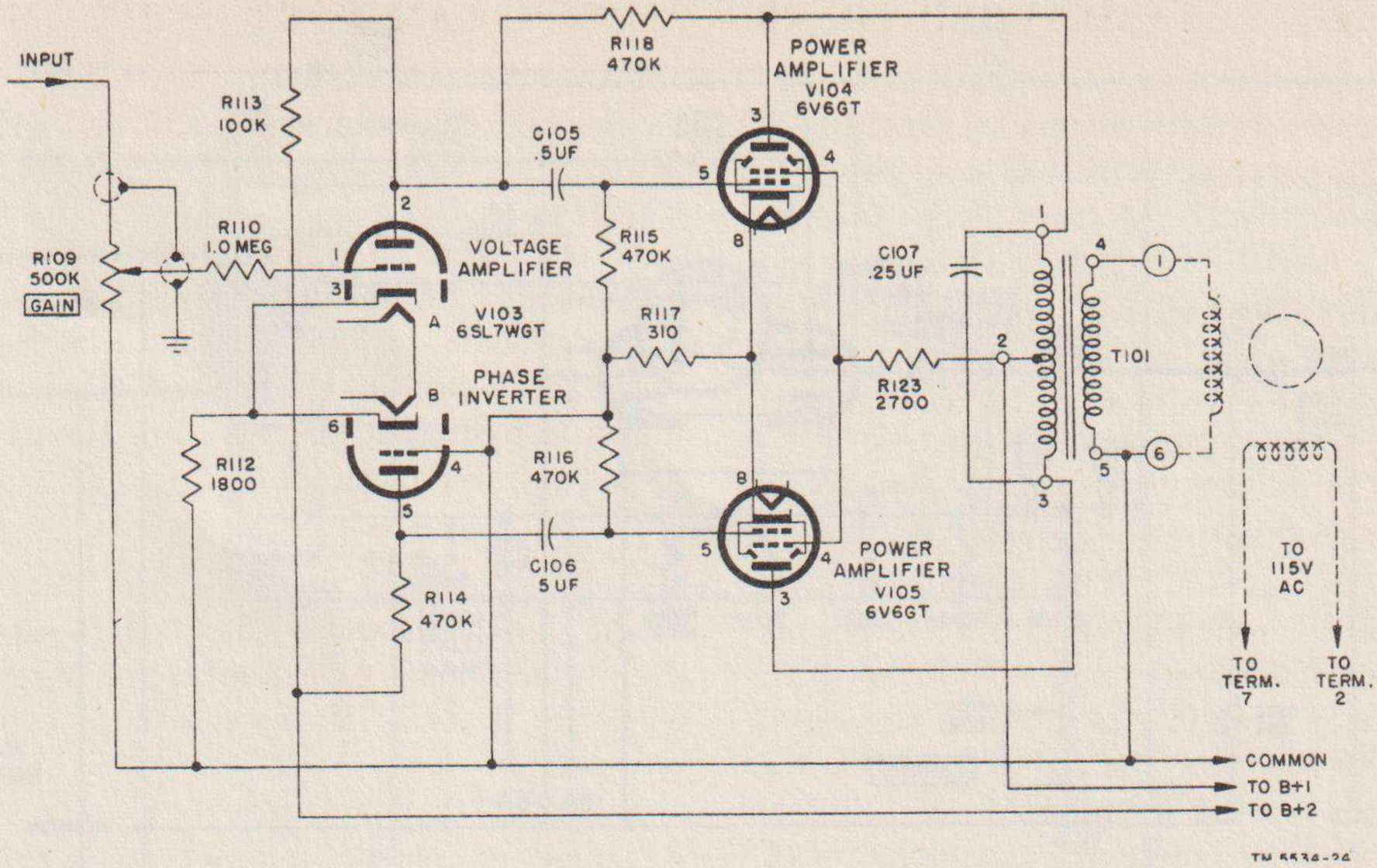


Figure 30. Power amplifier, functional diagram.

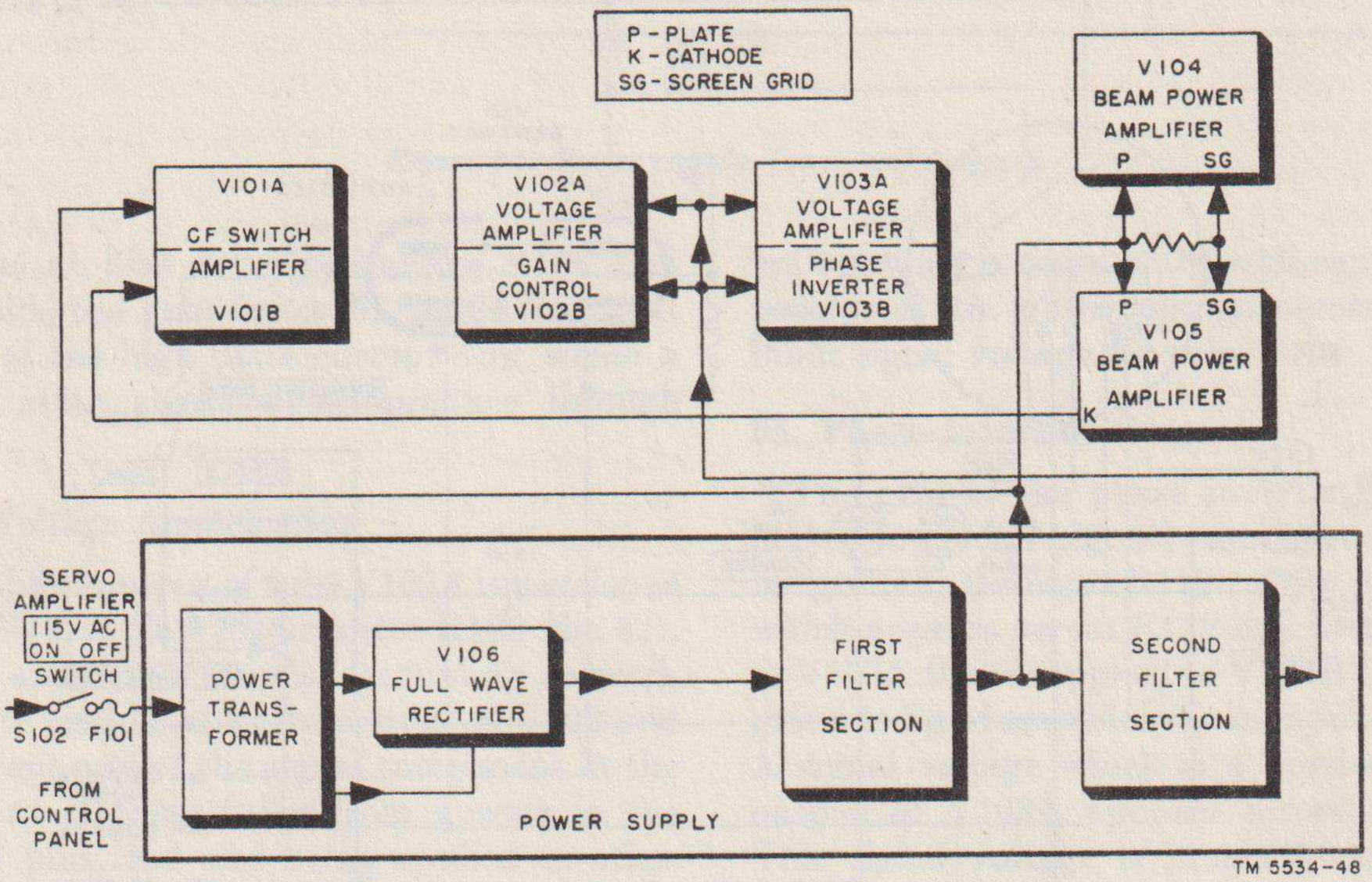


Figure 31. D-c power distribution, block diagram.

change in the rate of tracking, an abnormal shaft angle error exists between the servo motor and the radar synchro data generator shafts. At this time, the normal 60-cps control transformer output is modulated by error variations so that the control transformer output now contains error voltage side bands. The side bands are amplified to a greater extent than the normal 60-cps voltage because the notch network attenuates them to a lesser degree than it does a 60-cps signal. This boosted amplifier output is applied to the servo motor to accelerate or decelerate its normal shaft rotation, whichever is required to track accurately the rotation of the radar synchro generator shaft again.

b. The notch network values of the resistance and capacitance are chosen so that error variation components of the control transformer output will

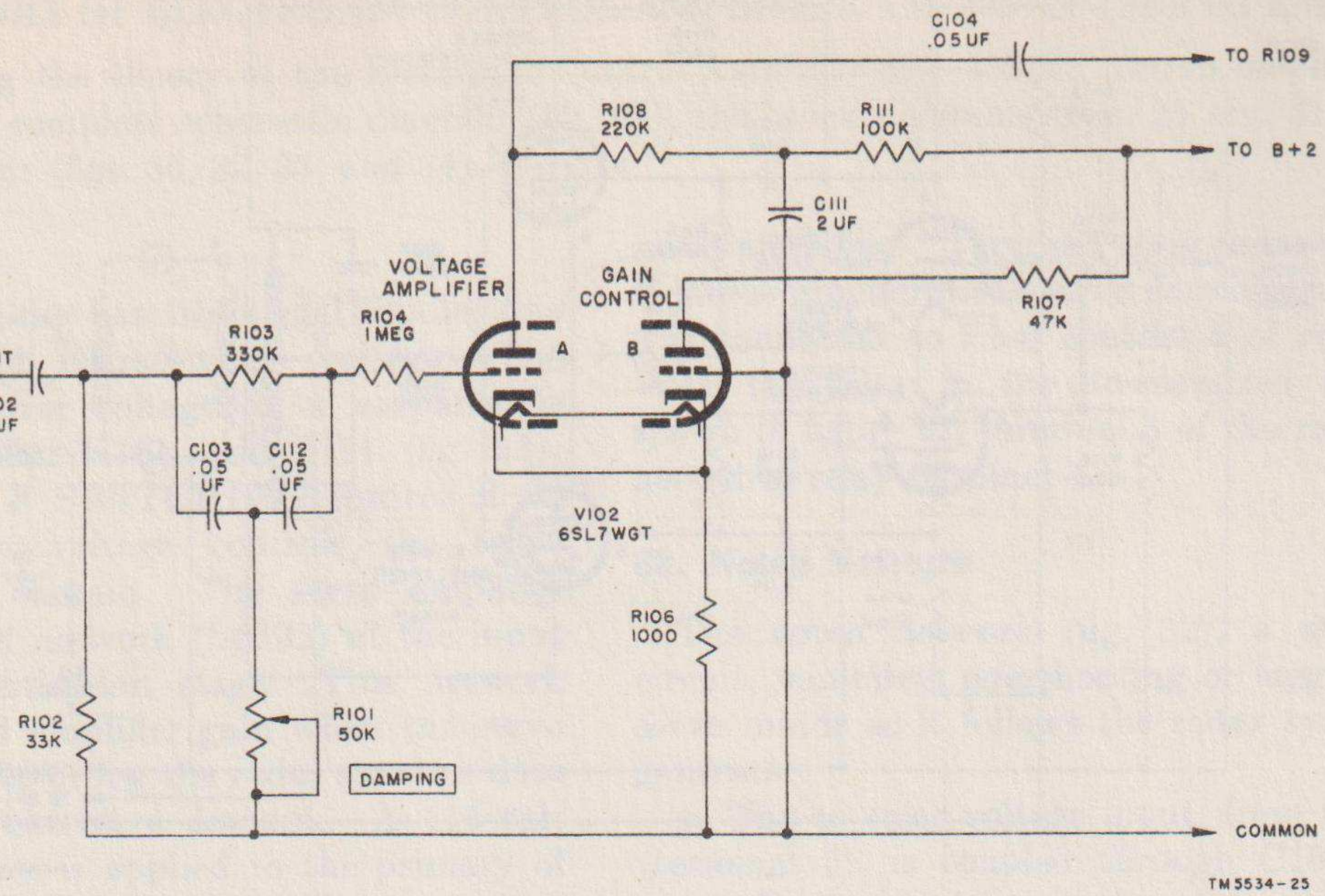


Figure 32. Voltage amplifier, functional diagram.

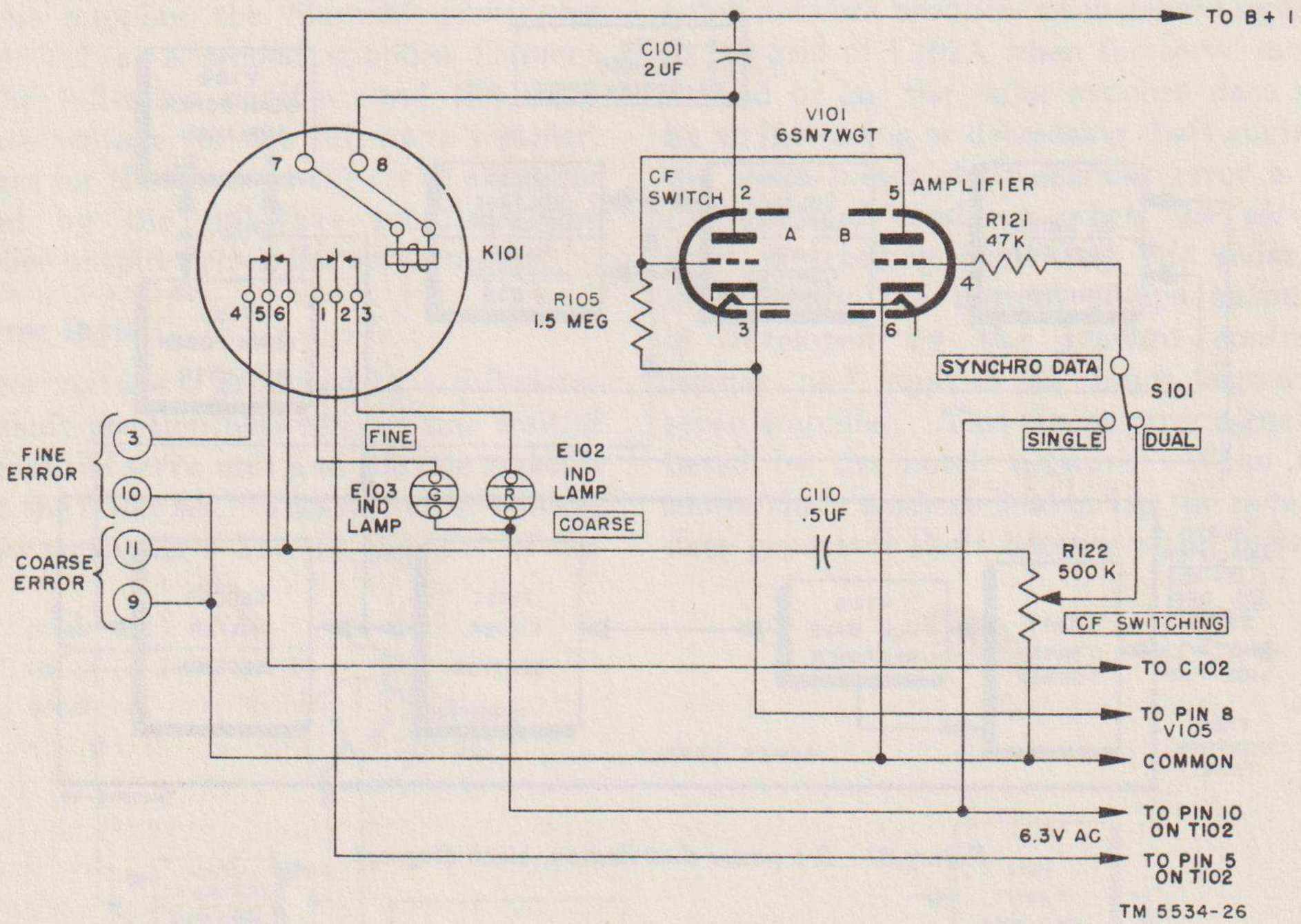


Figure 33. Coarse-fine switching, functional diagram.

be attenuated less than the normal 60-cps component. Potentiometer R101 is connected as a rheostat to tune the notch network to 60 cps; this will provide the full effect of the notch network on error variation components both above and below 60-cps. Potentiometer R101 is called the DAMPING control, and it controls the sensitivity of the entire servo loop to instantaneous changes in the rate of tracking. Resistor R104 limits the flow of grid current to a safe value on the positive half-cycles of a high-value input signal. Resistor R106 is a cathode-biasing resistor to provide operating bias for V102A and V102B. The V102B triode has its grid grounded and serves to

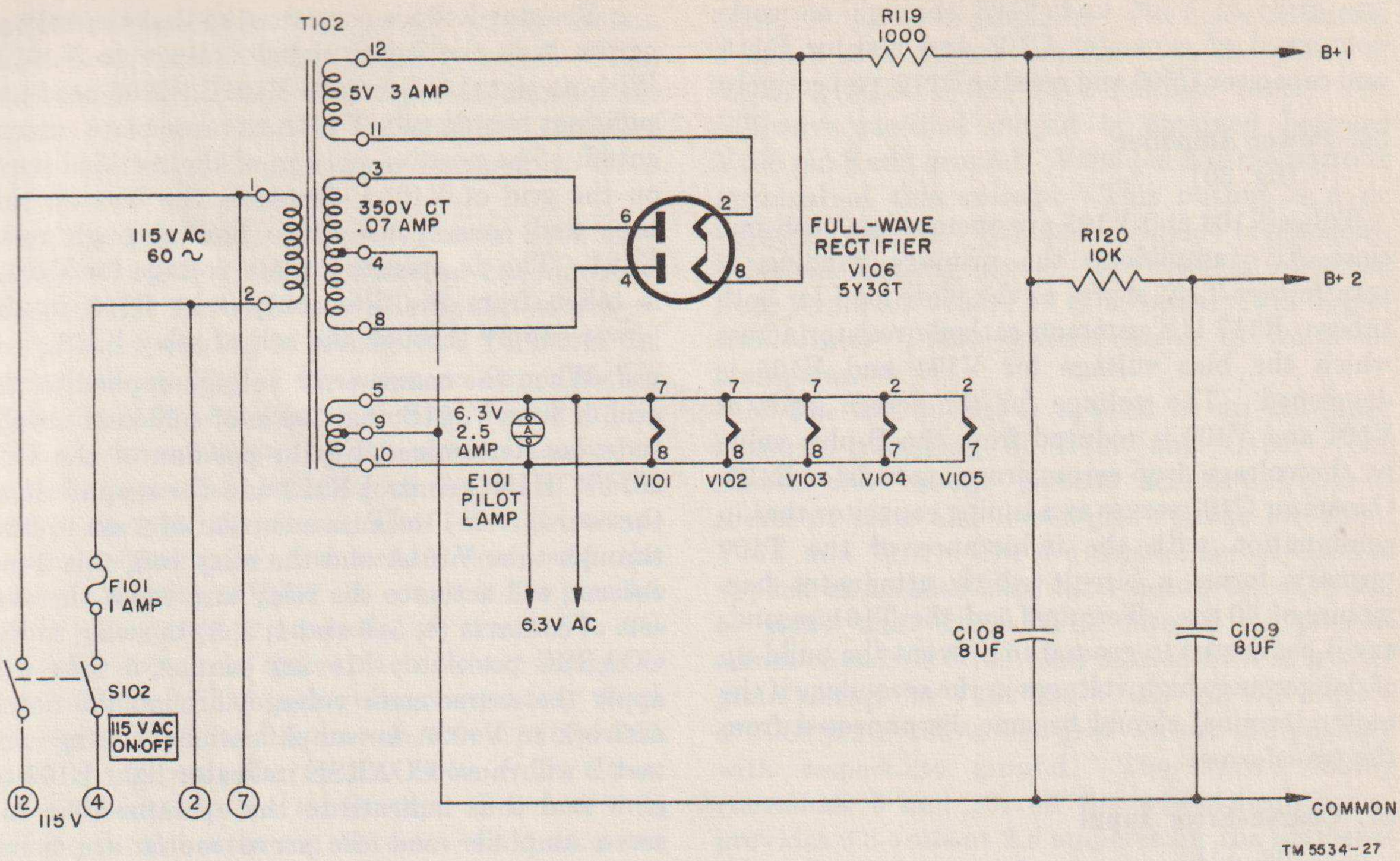


Figure 34. Power supply, functional diagram.

stabilize the dc bias developed across R106, and thereby holds the gain factor of V102A constant regardless of the high plate current flow which a high-value input signal would produce through V102A.

54. Error Voltage Amplification

The amplified output of tube V102A is developed across the V102A plate load resistor R108 (fig. 32).

a. C111 and R111 form a decoupling network for the plate circuits of both sections of V102 and act to prevent any of the signal component in the plate current of these tubes from flowing in the common B plus lead and being applied to other amplifier tubes. The V102A output signal voltage is coupled through C104 and appears across R109 (fig. 30). R110 limits the flow of grid current in V103A to a safe value on the positive half-cycles of a high-value input signal.

b. R109 is the GAIN control for the entire servo amplifier. The setting of the arm of R109 determines what portion of the signal voltage developed across R108 is applied to the grid of V103A for amplification.

c. The output voltage of tube V103A is developed across plate load resistor R113. This output voltage then is coupled through capacitor C105 to resistor R115. The voltage across R115 is the input signal voltage for tube V104.

55. Phase-Inversion Stage

The grid of the phase inverter V103B is connected to ground (fig. 30); the cathode is connected to ground through R112. Any signal voltage which appears across R112 due to the conduction of V103A thus is applied to V103B (operating as a grounded-grid amplifier) as an input signal voltage. A signal voltage which is a portion of the total output of V103A appears across resistor R112. This signal voltage is proportional to the plate output of V103A, but inverted in phase. The output of V103B is developed across the plate-load resistor R114. It is inverted in phase and equal to the output of V103A. The equality of output is achieved by the choice of the plate-load resistor values for the two vacuum tubes, by the signal voltage degeneration for V103A which occurs across the common cathode resistor R112, and by feedback from the plate of V104 through resistor R118. There are equal signal voltages of opposite phase across resistors R114 and R113. These equal but phase-inverted voltages are coupled to

the grids of V104 and V105 through networks comprised of capacitor C105 and resistor R115, and capacitor C106 and resistor R116, respectively.

56. Power Amplifier

(fig. 30)

Tubes V104 and V105 are operated as push-pull class AB1 amplifiers; the primary winding of transformer T101 serves as the plate load for both tubes. R117 is a common cathode resistor across which the bias voltage for V104 and V105 is developed. The voltage for the screen grids of V104 and V105 is reduced from the B-plus value by the voltage drop across dropping resistor R123. Capacitor C107 serves as a tuning capacitor that in combination with the inductance of the T101 primary forms a circuit which attenuates harmonics of 60 cps. Terminal 5 of the T101 secondary is connected to ground to prevent the build-up of dangerously high voltages in the secondary if the motor terminal should become disconnected from the transformer.

57. Coarse-Error Input

(fig. 33)

The complete step-by-step sequence of fine error voltage amplification thus has been traced. The amplification of coarse error voltage is similar but has one added amplifier stage involved in the process.

a. Terminal 9 of the coarse error input voltage is connected to the common ground; terminal 11 is coupled through C110 to the C F SWITCHING potentiometer R122. One terminal of R122 is connected to ground to complete the circuit for the coarse error input voltage.

b. When the SYNCHRO DATA SINGLE-DUAL switch (S101) (fig. 33) is in the DUAL position, that portion of the coarse error voltage which exists between the arm of potentiometer R122 and ground is applied as an input signal through R121 to the grid of tube V101B. Resistor R121 serves as a grid-limiting resistor for the V101B triode. The V101B triode is unbiased; therefore, it serves as a half-wave rectifier for the voltage applied to it; a half-wave voltage with a dc component exists on the plate as a result of the rectification of the coarse error voltage. Plate current from V101B flows through R105; this resistor acts as a plate-load resistor. The dc operating plate voltage for tube V101B is derived from the voltage drop across R117, the bias resistor common to tubes V104 and V105 (fig. 30).

c. Resistor R105 is connected so that the voltage across it is the input signal voltage to V101A. With no signal fed to tube V101B, R105 produces sufficient bias on tube V101A to cause plate current cutoff. The positive portion of the rectified wave on the grid of V101A decreases the bias on this tube and causes current to flow through relay K101. The dc operating plate voltage for V101A is taken from the filter output at R119 in the power supply through the coil of relay K101.

d. When the coarse error voltage applied to the grid of tube V101B (fig. 33) is of sufficient amplitude (as determined by the position of the C F SWITCHING control R122 and the amplitude of the coarse error) to cause a current of 2 ma to flow through tube V101A and the relay coil, this 2-ma current will activate the relay and cause the two sets of contacts (4, 5, 6 and 1, 2, 3) to swing to the COARSE position. Moving contact 5 then will apply the coarse error voltage through the notch network to V102A for amplification; moving contact 2 will cause COARSE indicator light E102 to glow and thus indicate to the operator that the servo amplifier and the servo motor are being actuated by a coarse error voltage.

e. Control of the servo amplifier by coarse error voltage produces rotation of the servo drive motor in such a direction as to reduce the amplitude of the coarse error voltage. Reduction of coarse error input voltage to a predetermined value reduces coil currents in the relay coil; the relay opens and causes contacts 5 and 2 to move and close the circuits to fixed contacts 4 and 1 respectively. Closing of contacts 4 and 5 connects fine error input voltage to coupling capacitor C102, and fine error input voltage then is applied to the notch network and V102A (the first amplification stage of the amplifier). The fine error voltage is amplified by the complete servo amplifier to provide motive power to the servo motor. Closing of contacts 2 and 1 connects the green or FINE indicator lamp E103 to the 6.3-volt winding of power transformer T102 to indicate that fine error voltage is now the signal source to the servo amplifier.

58. Power Supply

(fig. 34)

The power requirements of the servo amplifier filament and plate circuits, as well as the power for the main field of the servo motor, are derived from the power supply section of the servo

amplifier (fig. 62). The power supply section consists of 115V AC ON-OFF switch S102, pilot lamp E101, fuse F101, power transformer T102, full-wave rectifier tube V106, resistors R119 and R120, and filter capacitors C108 and C109.

a. The 115V AC ON-OFF switch S102 is a two-pole switch which connects or disconnects a single-phase, 115-volt, 60-cycle power source to the primary winding of transformer T102 and the main field winding of the servo motor. One leg of switch S102 is connected through fuse F101, so that all current drawn by the power transformer and the main field winding of the servo motor passes through the fuse. The 115-volt power-line-fed winding of the servo motor and the primary winding of T102 are connected in parallel across the output terminals of the 115V AC ON-OFF switch so that switch closure energizes both of them. The high-voltage secondary wind ing, terminals 3 and 8, has an ac output of 700 volts at .07 ampere, or 350 volts from either outer terminal to the center tap. Terminal 4 is the electrical center tap between the two outer terminals 3 and 8 of the transformer high-voltage winding, and is the common ground and B minus point for the servo amplifier. The outer terminals 3 and 8 of T102 are connected to the plates of V106, a 5Y3GT full-wave rectifier tube. The full-wave rectified output is obtained between V106 pin 8 and ground. V106 pin 8 is the positive terminal of this voltage. This output is a dc voltage with a 120-cycle ripple component. Filament heating power for V106 is obtained from terminals 11 and 12 (a secondary winding of transformer T102) which deliver 5 volts at 3 amperes.

b. The d-c output is applied to an RC filter network consisting of R119 and C108. The filtered d-c voltage present across C108 is a source of plate and screen-grid voltage for V104, V105, and V101. The d-c voltage across C108 is applied to an additional filter network, consisting of R120 and C109. The filtered dc present across capacitor C109 then is used as a source of plate voltage for V102 and V103. All the sources of tube plate and screen-grid voltage are positive with respect to ground. The third winding (terminals 5 and 10) on the power transformer provides 6.3 volts at 2.5 amperes for the filaments of all the servo amplifier tubes, except V106, and for the three indicator lights on the servo amplifier.

Section III. THEORY OF SYNCHRO TRANSMISSION

59. General

A synchro is an ac device used to convert mechanical rotor shaft angles to an electrical signal or vice versa. It is used in combination with similar devices for the transmission of angular position data. Complete synchro systems are made up of combinations of synchro generators (called transmitters) which transmit three voltages to one or more synchro motors (called receivers) or synchro control transformers. They are used for the transmission and reception of angular shaft-position data. Paragraphs 60 through 63 cover briefly the theory of synchro transmission. For a more complete and detailed coverage of the theory of synchro transmission, refer to TM 11–674/TO 16–1–277.

60. Generator and Control Transformer Systems

A complete synchro system may be made up of a synchro generator and a synchro control transformer. This type of system (fig. 35) is used to produce an output voltage when the angular shaft or rotor positions of the generator and control transformer are not at right angles. If the shaft positions change from the 90° difference position, the control transformer shaft is said to be in error and, therefore, the voltage output from the control transformer is called an error voltage. This error voltage will be generated as long as the control transformer shaft and the generator shaft are not 90° apart. The control transformer will not exert a torque which would tend to return the rotor to the zero error voltage output position. This must be done by some force external to the control transformer if the error voltage is to be reduced to zero. This function is performed by a servo motor.

61. Synchro Generator

A synchro generator has a rotor with two salient poles and one winding of fine wire. The winding ends are brought to two slip rings at one end of the rotor, and connection to the winding is made through brushes resting on the slip rings. These brush terminals are marked R1 and R2 on the diagrams. The synchro generator stator is cy-

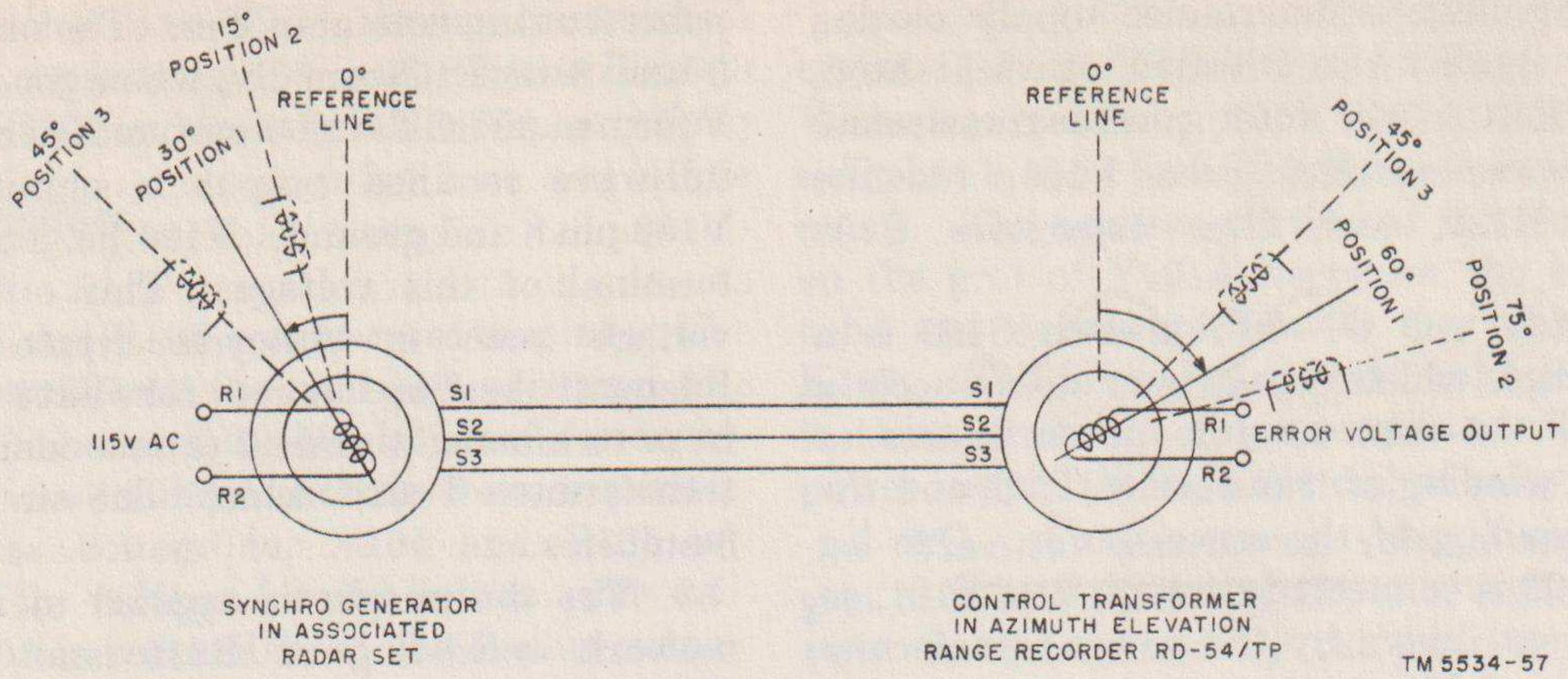


Figure 35. Control transformer used to compare two rotor shaft motions.

lindrical and slotted, and it carries three similar windings, each distributed in several slots. The three stator windings may be connected together in the same manner as the synchro control transformer, in either a wye or delta arrangement. These terminals are marked S1, S2, and S3 (fig. 36).

62. Synchro Control Transformer

The synchro control transformer has a stator similar to that of the synchro generator, except that the control transformer windings have more turns of finer wire. The control transformer rotor is cylindrical and has a single winding of a large number of turns of very fine wire. The ends of the winding are brought out to a pair of slip rings, and a pair of stationary brushes rest on the slip rings. The stator winding terminals of the control transformer are designated S1, S2, and S3; the rotor terminals are designated as R1 and R2 (fig. 36).

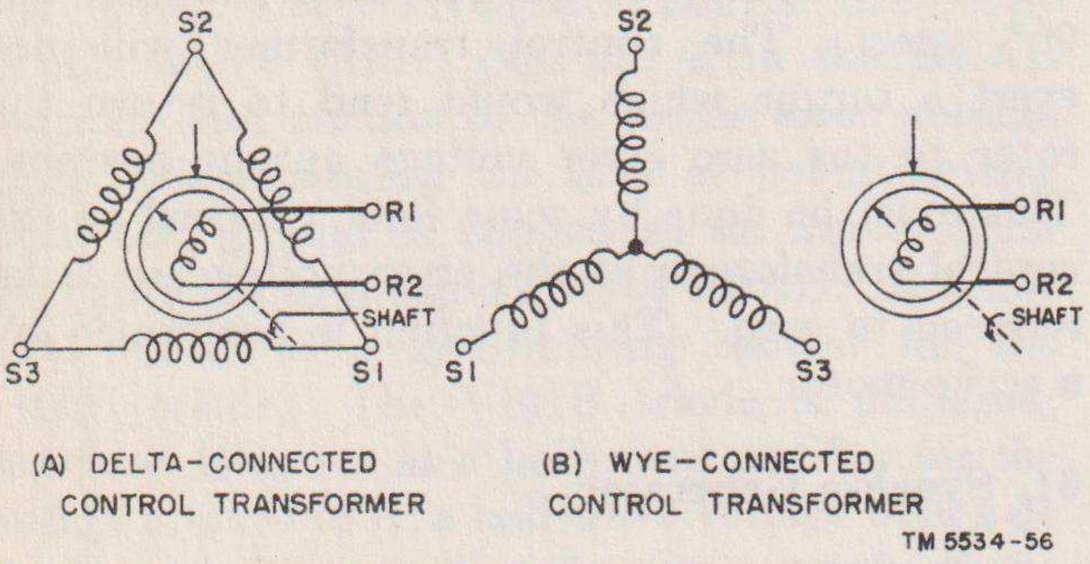


Figure 36. Synchro control transformer.

63. Theory of System

a. In a system consisting of a synchro generator and a synchro control transformer, generator terminals R1 and R2 are connected to a source of 115 volts, 60 cps. Generator terminals S1, S2, and S3 are connected to the corresponding terminals of the control transformer. Control transformer terminals R1 and R2 are the source of the output error voltage of the system.

b. The control transformer operates as a single-phase transformer with three stationary primary windings and a movable secondary winding.

c. When the position of the generator shaft changes from the 90° position, the stator voltages on the control transformer produce currents in the stator coils which establish a magnetic flux in the control transformer. For example, if the generator rotor angle, with respect to some reference line, is 30°, a corresponding magnetic flux is produced in the control transformer at the same angle (60°, position 1, fig. 35). When the generator rotor is rotated clockwise 15° to position 2, a corresponding magnetic flux angle shift of 15° is produced in the control transformer stator, and a 60-cps error voltage whose amplitude and phase correspond to a flux angle of 15° is obtained at the control transformer rotor terminals.

d. If the generator rotor is rotated counterclockwise to produce the same flux angle of 15°, but in the opposite direction (position 3), the 60-cps error voltage output from the control transformer will be equal in amplitude to the first voltage, but 180° out of phase (fig. 37). The value of the voltage induced in the rotor of the control transformer depends on the rotor position relative to the flux. No 60-cps error voltage output is secured if the magnetic axis is perpendicular to the flux (position 1, fig. 35); maximum voltage output is produced when the axes are parallel. The positive or negative initial swing of the 60-cps

output error voltage is determined by the clockwise or counterclockwise rotation of the stator flux with respect to the rotor coil magnetic axis (fig. 37).

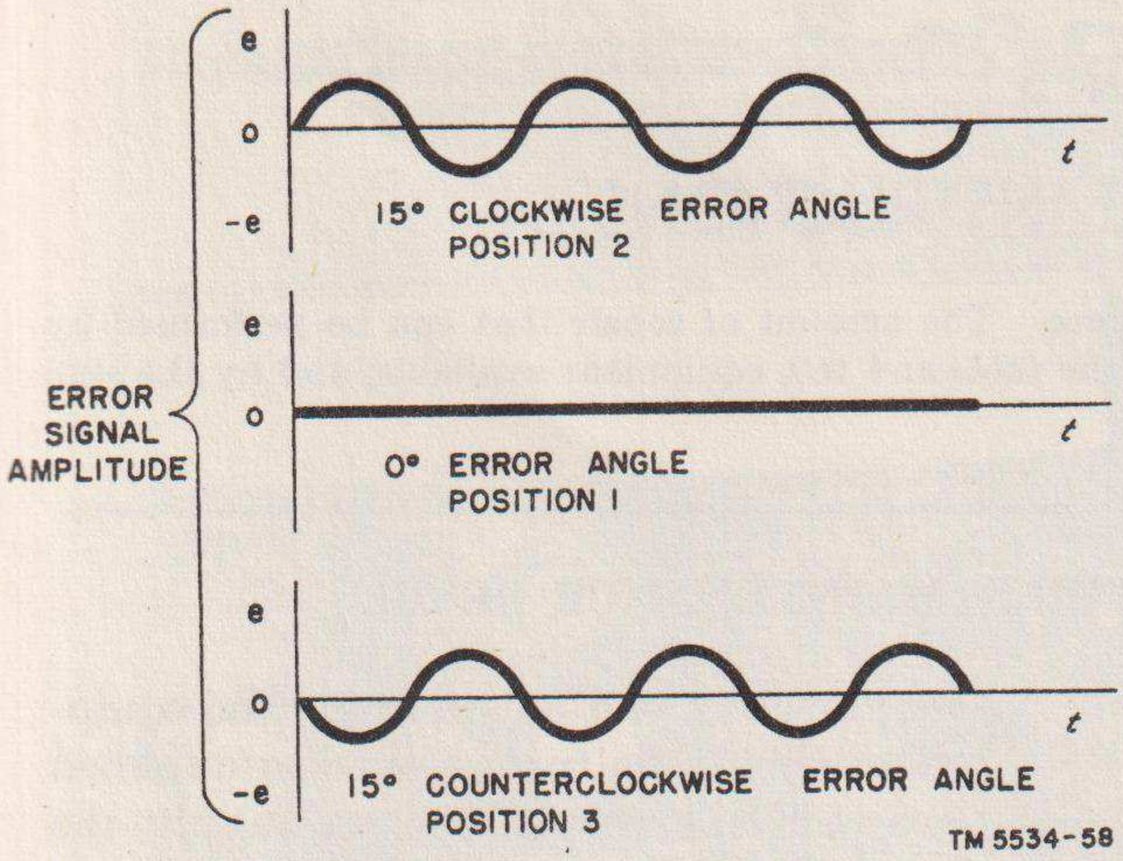


Figure 37. Relation of error signal to line voltage and error angle.

e. In a synchro system consisting of a synchro generator and a synchro control transformer, some means of external power is used to rotate the control transformer shaft so that the control transformer output voltage is zero or a small constant 60-cps voltage. Normally, when good tracking is performed, a constant 60-cps voltage output exists which has an amplitude that is proportional to the angular difference between the generator shaft and the control transformer shaft. When, however, the generator either accelerates or decelerates because of a change in the rate of travel of the object being tracked, a new condition exists in the control transformer. The stator flux and the rotor magnetic axis will now be at some other than normal flux angle, and the normal 60-cps output voltage will be modulated so that, in addition to the normal 60 cps, there will be side bands of the 60-cycle frequency. As the control transformer shaft is accelerated or decelerated to track the new motion of the generator shaft, the side band components will be reduced; only the normal 60-cps output will be present when the control transformer shaft motion is again in track with the generator. The notch network of the servo amplifier permits higher-than-normal amplification of 60-cycle side bands, so that the servo motor will have the increased power to accelerate or decelerate to move the stylus in track with the missile being tracked by the radar set.

CHAPTER 5

FIELD MAINTENANCE INSTRUCTIONS

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available, and by the skill of the repairmen.

Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

64. Scope

a. This chapter contains maintenance instructions applicable to only two of the three main components of the recorder; the Electronic Control Amplifier AM–489/TP (servo amplifier) and the console assembly (fig. 3).

b. The third component of the equipment is the recorder assembly. Because of the accuracy requirements of this component and the specialized test equipment necessary for adjustment, no repair of mechanical parts should be attempted by anyone except specifically qualified repair personnel. Chapter 6 contains complete detailed overhaul instructions for the recorder assembly. The recorder can be damaged seriously by improper disassembly or incorrect alinement.

65. Troubleshooting Procedures

The first step in servicing a defective recorder is to sectionalize the fault. Sectionalization means tracing the fault to the *major component* responsible for the abnormal operation of the equipment. The second step is to localize the fault. Localization means tracing the fault to the defective *part* responsible for the abnormal condition. Some faults that may occur in the servo amplifier, such as burned-out resistors, arcing, and shorts, often can be located by sight, smell, and hearing. The majority of faults, however, must be localized by *checking voltage and resistance.*

a. System Sectionalization.

(1) Sectionalization means determining whether the fault is of an electrical or a mechanical nature. If the failure appears to be mechanical—that is, a fault in the recorder assembly—no field maintenance can be applied. The equipment should be turned over to qualified overhaul personnel, who will apply the procedures discussed in chapter 6. If the fault is electrical, proceed with repair of the servo amplifier.

(2) If it cannot be determined immediately whether the malfunction is electrical or mechanical, refer to paragraphs 45 and 46, and follow the procedures outlined in the equipment performance checklist.

b. Localization Within Electronic Control Amplifier AM–489/TP (Servo Amplifier). The tests listed in (1) through (6) below aid in isolating the source of the trouble. To be effective, follow the procedure in the order given. Remember that the servicing procedure should cause no further damage to the servo amplifier. First, trouble should be localized to a single stage or circuit. The trouble then may be isolated within that stage or circuit by appropriate voltage, resistance, and continuity measurements.

Note. When troubleshooting any of the three servo amplifiers (Electronic Control Amplifier AM–489/TP), use the test cable (fig. 38) to connect the servo amplifier to the connector in the console assembly. This permits operation of the servo amplifier out of its rack for test purposes.

(1) *Visual inspection.* The purpose of visual inspection (par. 44) is to locate any visible trouble. Through this inspection alone, the repairman frequently may discover the trouble or determine the stage in which the trouble exists. This inspection is valuable in avoiding additional damage to the servo amplifier

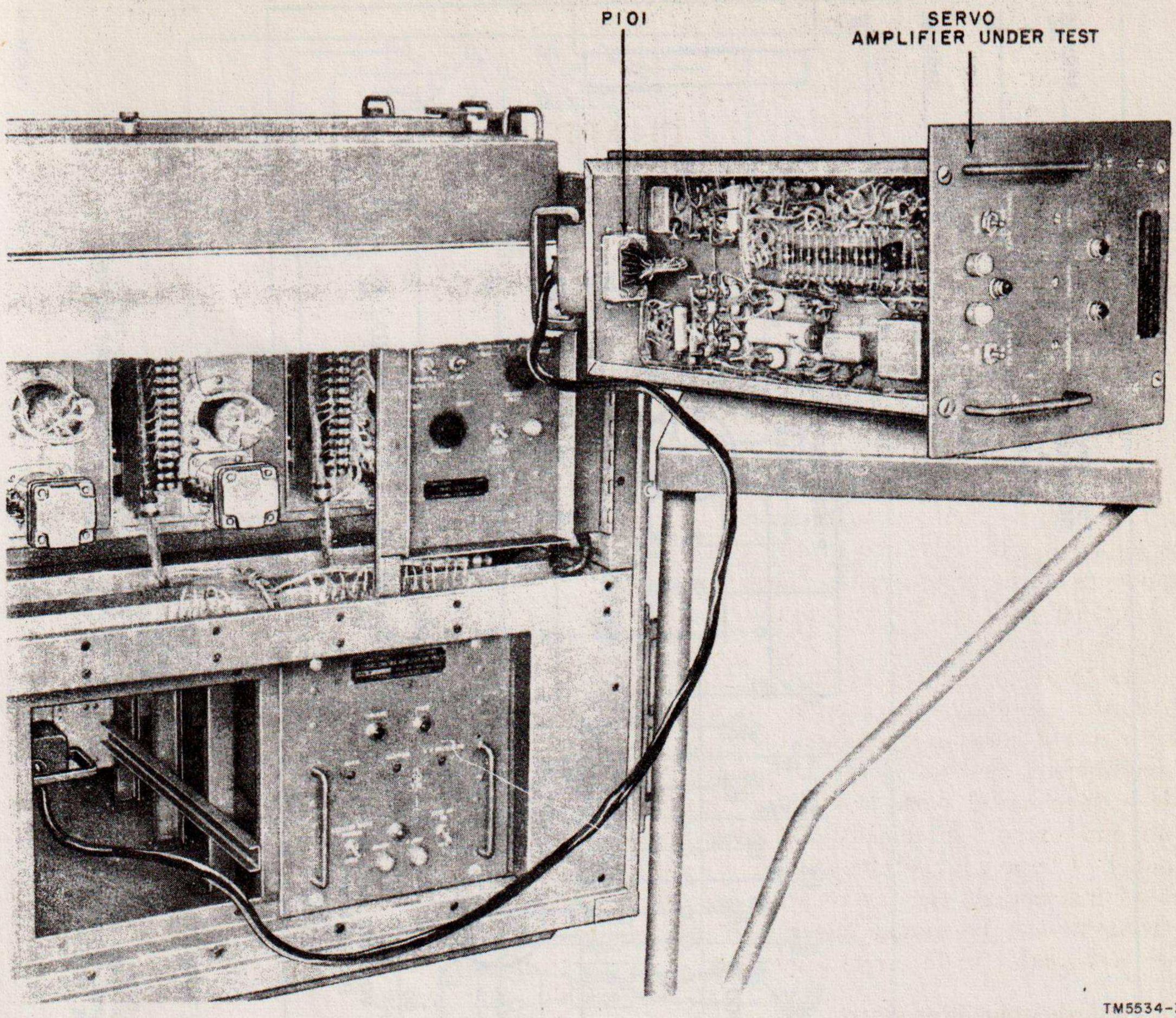


Figure 38. Electronic Control Amplifier AM–489/TP (servo amplifier), with test cable connected.

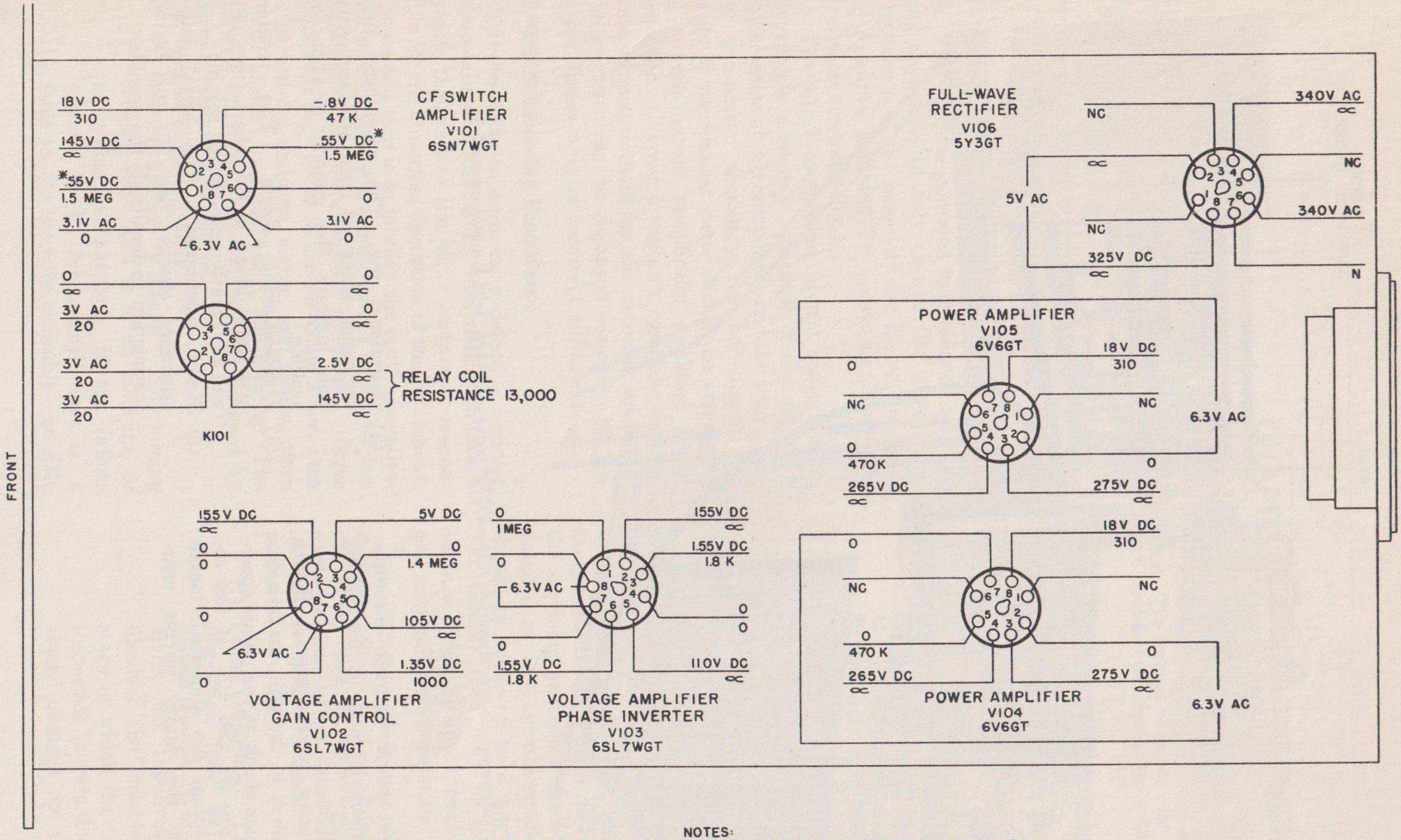
which might occur through improper servicing methods, and in forestalling future failures.

(2) *Input resistance measurements.* Before applying power to the unit, make a circuit resistance check at the points specified in figures 39 and 40. If the resistance readings are abnormal, locate and replace the faulty circuit components.

(3) *Operational test.* The equipment performance check list (par. 46) frequently will indicate the general location of trouble.

(4) *Troubleshooting charts.* The trouble symptoms listed in this chart (par. 69) will aid greatly in localizing trouble.

(5) *Signal substitution.* The signal substitutions checks (par. 70) can be of further aid in localizing the trouble.



NOTES:

1. VOLTAGE MEASUREMENTS MADE WITH:
   a. POWER (115V AC) APPLIED
   b. 115V AC SWITCH ON
   c. SYNCHRO DATA SWITCH AT DUAL
   d. C F SWITCHING CONTROL EXTREME CCW POSITION
   e. DAMPING CONTROL AT MIDRANGE POSITION
   f. GAIN CONTROL AT EXTREME CCW POSITION

2. a. NC INDICATES NO CONNECTION
   b. VOLTAGE READINGS ABOVE LINE
      RESISTANCE READINGS BELOW LINE
   c. VOLTAGE AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER VOLT METER
   d. *RELAY K101 OPERATES

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Figure 39. Electronic Control Amplifier AM-489/TP (servo amplifier), tube-socket voltage and resistance diagram.

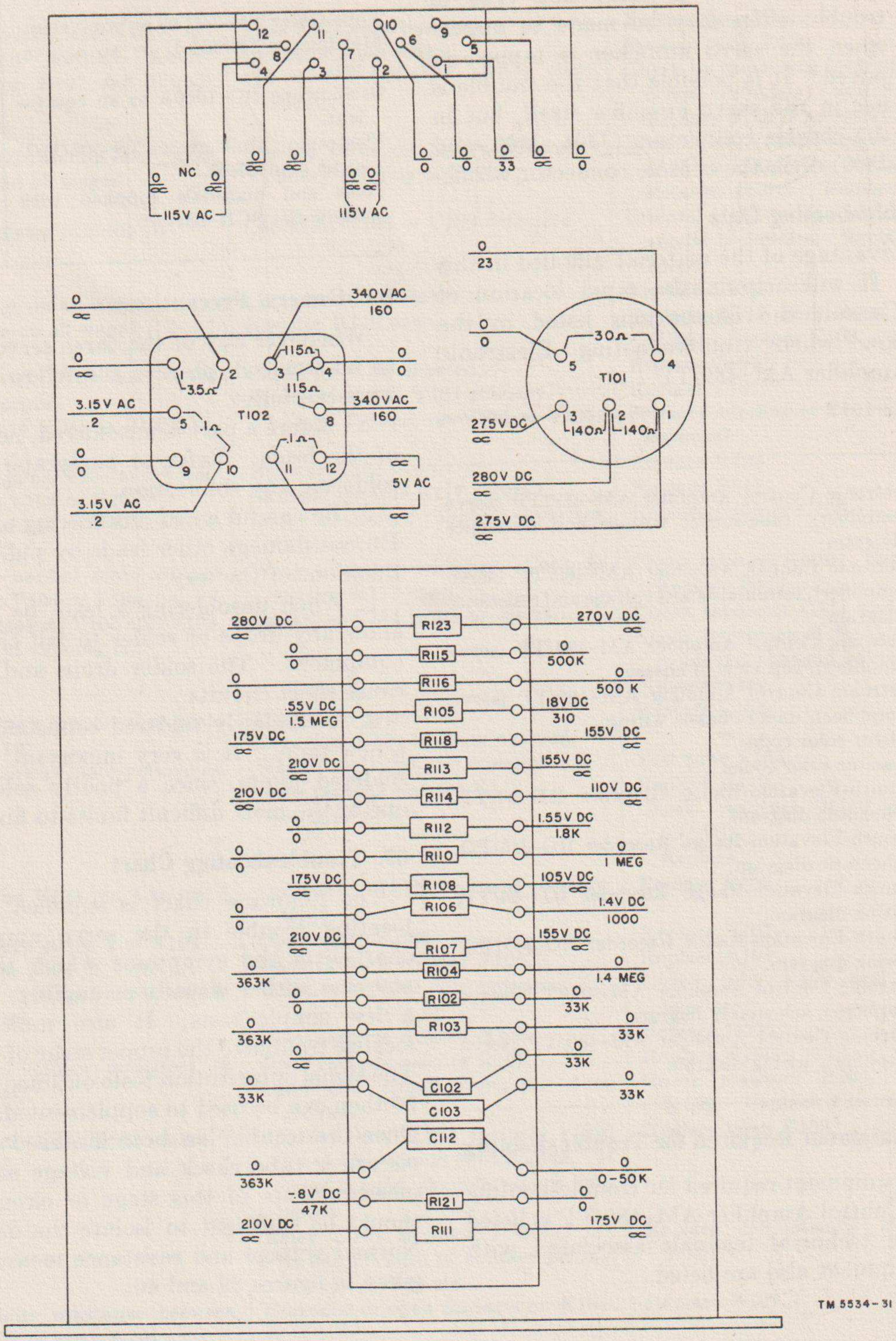


Figure 40. Electronic Control Amplifier AM-489/TP (servo amplifier), terminal board voltage and resistance diagram.

(6) *Intermittents.* In all these tests, the possibility of intermittents should not be overlooked. If present, this type of trouble often may be made to appear when the servo amplifier is tapped or jarred. It is possible that the trouble is not in the servo amplifier itself, but in the console connectors (J501, J502, and J503) or in the console connector wiring.

66. Troubleshooting Data

Take advantage of the material supplied in this manual. It will help in the rapid location of faults. Consult the illustrations listed in the table below when troubleshooting Electronic Control Amplifier AM–489/TP.

Fig. No.	Description
39	Electronic Control Amplifier AM–489/TP (servo amplifier), tube-socket voltage and resistance diagram.
40	Electronic Control Amplifier AM–489/TP (servo amplifier), terminal-board voltage and resistance diagram.
41	Electronic Control Amplifier AM–489/TP (servo amplifier), top view of chassis.
42	Electronic Control Amplifier AM–489/TP (servo amplifier), under-chassis wiring.
56	Resistor color codes.
57	Capacitor color codes.
58	Azimuth-Elevation-Range Recorder RD–54/TP, schematic diagram.
59	Azimuth-Elevation-Range Recorder RO–3/MPQ, schematic diagram.
60	Azimuth-Elevation-Range Recorder RD–54/TP, wiring diagram.
61	Azimuth-Elevation-Range Recorder RO–3/MPQ, wiring diagram.
62	Electronic Control Amplifier AM–489/TP (servo amplifier), schematic diagram.
63	Electronic Control Amplifier AM–489/TP (servo amplifier), wiring diagram.

67. Test Equipment Required for Troubleshooting

The test equipment required for troubleshooting Electronic Control Amplifier AM–489/TP is listed below. The technical manuals associated with the test equipment also are listed.

Test equipment	Technical manual
Tube tester TV–7/U or an equivalent	TM 11–5083
Multimeter TS–352/U or an equivalent.	TM 11–5527
Oscilloscope BC–1060A or an equivalent.	TM 11–2526
Electronic Multimeter TS–505(*)/U or an equivalent.	TM 11–5511
Tools and materials supplied with Radio Set SCR–584–(*).	TM 11–1524 or TM 11–1324.

68. General Precautions

Whenever any of the three servo amplifiers are to be serviced, observe the following precautions very carefully:

a. Before a part is unsoldered, note the position of the leads. Refer to paragraph 71 before unsoldering any connection.

b. Be careful when unsoldering any connection. Do not damage other leads by pulling or pushing them out of the way.

c. When unsoldering a lead, be careful not to allow any drops of solder to fall or splash in the equipment. The solder drops and splashes may cause short circuits.

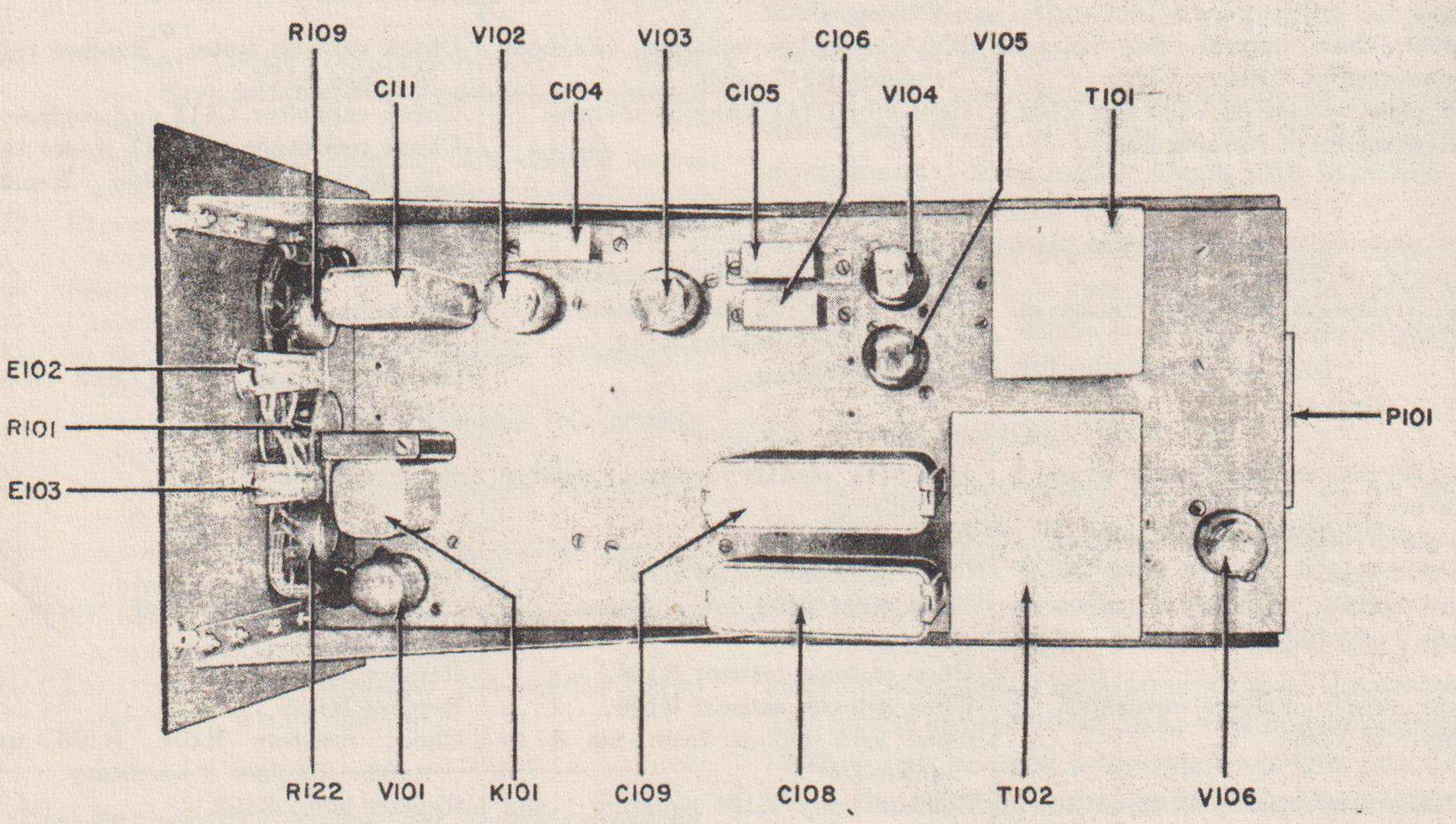
d. A carelessly soldered connection may create a new fault. It is very important to make well-soldered joints, since a poorly soldered joint is one of the most difficult faults to find.

69. Troubleshooting Chart

The following chart is supplied as an aid in locating trouble in the servo amplifiers. This chart lists the symptoms which the repairman observes, either visually or audibly, while making a few simple tests. It also indicates how to localize trouble to the proper stage of the amplifier. The signal substitution tests outlined in paragraph 70 then can be used to supplement this procedure. Once the trouble has been localized to a stage or circuit, a tube check and voltage and resistance measurements of this stage or circuit ordinarily should be sufficient to isolate the defective part. Normal voltage and resistance measurements are given in figures 39 and 40.

Symptom	Probable cause	Correction
1. Power applied to amplifier, 115 V AC switch in ON position. Amber panel indicator E101 not illuminated.	Fuse F101 defective. Indicator lamp blown. 115 V AC ON-OFF switch S102 defective.	Replace fuse F101. Replace lamp E101. Check by measuring for input voltage across terminals 1 and 2 of T102. Replace S102 if necessary.
2. Transformer T102 running hot. Low plate voltage on all stages.	Shorted turns on high-voltage secondary winding of T102.	Measure a-c voltage across secondary of T102. Refer to voltage and resistance charts. Replace T102.
3. Rectifier V106 plates running red.	Capacitor C108 or C109 defective.	Internal resistance of capacitors should be infinite. Replace capacitors.
4. Low plate voltage on all stages.	Capacitor C108 leaky.	Replace C108.
5. No plate voltage on all stages.	Resistor R119 open.	Replace R119 and check capacitor C108. Replace C108.
6. Plate voltages of V104 and V105 higher than normal.	Capacitor C107 shorted. Shorted turns in T101 primary.	Replace C107. Replace T101.
7. Screen elements of V104 or V105 running red.	No plate voltages on V104 or V105.	Primary winding of T101 open.
8. No screen voltage on V104 and V105.	Resistor R123 open.	Replace R123.
9. No grid bias on V104 or V105.	Cathode resistor R117 shorted.	Replace R117.
10. Positive grid voltage on V104 or V105.	Leaky or shorted coupling capacitor C105 or C106.	Replace C105 or C106.
11. Higher-than-normal plate voltage measured at V104 or V105.	Weak tube, low emission. Cathode resistor R117 open.	Check tube on tester. Replace tube. Replace R117.
12. Low plate voltage on V103 and V102. Resistor R111 running hot.	Capacitor C111 leaky or shorted.	Check capacitor C111 and replace. Check resistance of R111 to see that it has not changed value. Replace if necessary.
13. Low plate voltage measured at plate (pin 2) of V103.	High plate current Capacitor C104 leaky or shorted.	Replace C104.
14. Higher-than-normal plate voltage on V103.	Weak tube V103, low emission Open cathode resistor R112. Open grid circuit.	Test tube V103. Replace R112. Check resistors R110 and R109 (GAIN). Replace.
15. No grid bias on V103 pin 1 to pin 3 or 6.	Defective GAIN control resistor R109.	Replace R109.
16. No plate voltage at pin 2 of V102	Open resistor R107	Replace R107.
17. No grid bias at pin 1 of V102	Open cathode resistor R106	Replace R106.
18. Plate supply voltage measured at pin 2 of V102.	Weak tube V102, low emission Open cathode resistor R106.	Check tube V102 and replace if necessary. Replace R106.
19. Plate supply voltage measured at pin 5 of V102.	Open cathode resistor R106 Open grid circuit from pin 4 to ground.	Replace R106. Check resistors R104, R103, and R102. Replace if necessary.
20. FINE indicator lamp E103 not lit	Shorted relay K101 contacts 1 and 2. Lamp should light if good. If lamp is good, the following is indicated: Relay K101 contacts 1 and 2 not closed because of contact pitting, broken spring, etc.	Replace lamp E103. Replace hermetically sealed relay K101.
21. High or infinite resistance between pins 4 and 5 of relay K101.	Corroded or open contacts on K101	Replace K101.
22. Short pin 1 of V101 to ground momentarily; COARSE lamp E102 does not light.	Lamp E102 open Contacts 2 and 3 of relay K101 not closing. Tube V101 defective.	Replace E102. Replace K101. Test V101. Replace if necessary.

Symptom	Probable cause	Correction
23. Disconnect green lead from pin 6 of K101. Connect ohmmeter between pins 5 and 6 of K101. Momentarily short pin 1 of V101 to pin 6 of V101. No continuity between pins 5 and 6 when pin 1 of V101 is shorted.	Relay not operating	Replace relay K101.
	Tube V101 defective.	Check tube V101. Replace. Refer to items 24 and 25.
24. Relay K101 is not operating	Relay coil open	Remove K101. Check coil resistance between pins 7 and 8 of K101. If it is not 14,000 ohms replace K101.
	Capacitor C201 shorted.	Replace C201.
25. Relay not operating at proper load point of 2 ma. Check by removing K101 from socket and applying 45-v dc in series with resistor (85,000-ohm minimum value) and placing milliammeter across pins 7 and 8 of relay K101.	Weak relay springs	Replace relay K101.
	Shorted turns in relay coil.	Replace relay K101.



TM 5534-5

Figure 41. Electronic Control Amplifier AM–489/TP (servo amplifier), top view of chassis.

70. Signal Substitution Checks

The following tests should be performed to enable the repairman to check the proper operation of the servo amplifier in its overall system application. Refer frequently to the schematic and wiring diagrams (figs. 62 and 63).

a. Input and Output Check.

(1) Connect a 115-volt, 60-cycle, single-phase ac voltage to terminals 12 and 4 of servo amplifier connector P101. Connect a 115-volt, 60-cycle, single-phase ac through a voltage-varying device to two of the

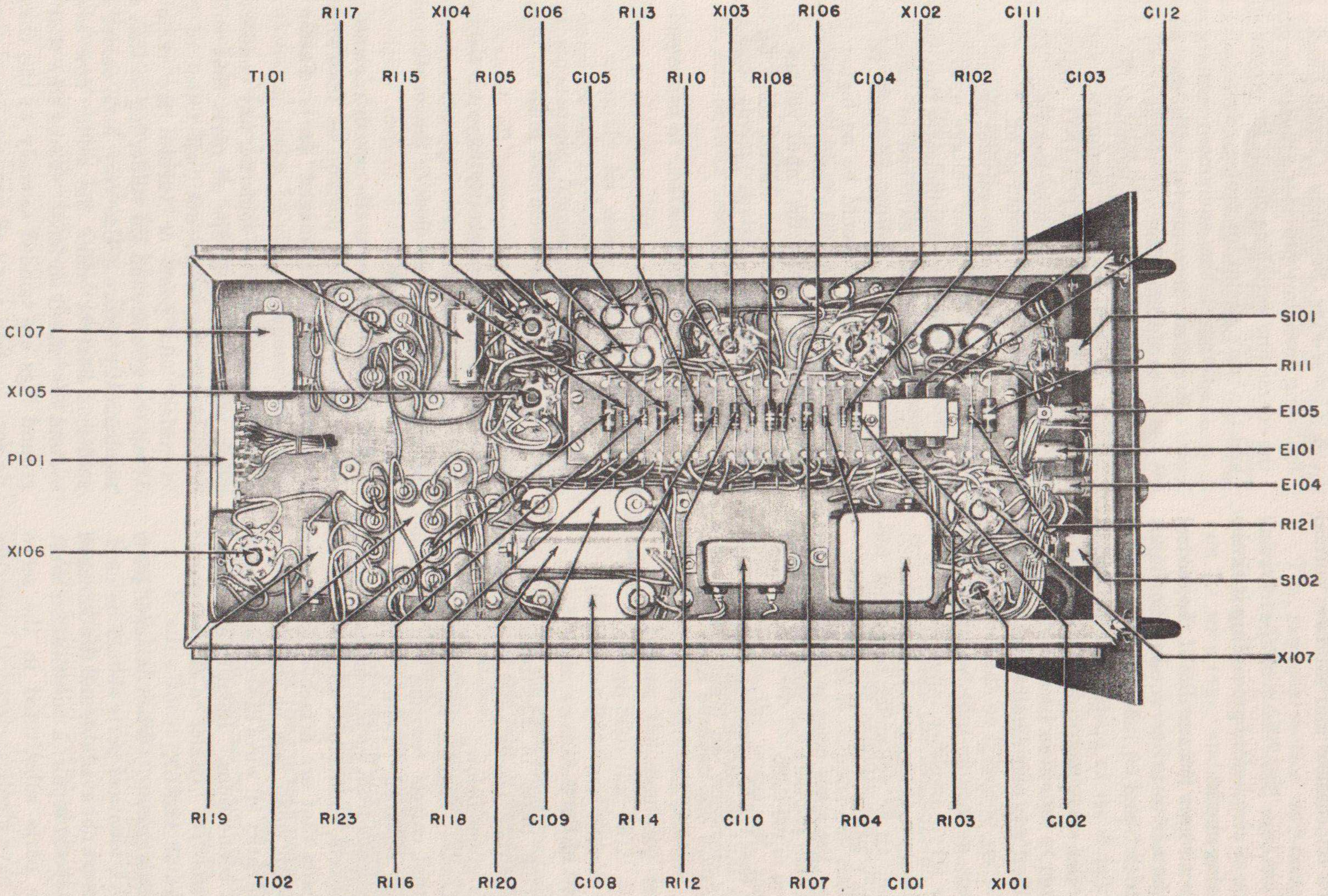


Figure 42. Electronic Control Amplifier AM–489/TP (servo amplifier), under-chassis wiring.

three stator windings of a synchro control transformer. The transformer is included in this circuit to match the circuit impedances and simulate normal operation.

Warning: Set the voltage varying device at zero before proceeding with the following checks.

(2) Connect rotors R1 and R2 of the control transformer to the servo amplifier input terminals 3 and 10. Make sure that the amplifier is set to operate on fine input.

(3) Connect a servo motor, for proper output loading, to terminals 1 and 6 of the servo amplifier (any servo motor that is equivalent to the one used on the servo units).

(4) Connect a vacuum-tube voltmeter (ac) across servo amplifier input terminals 3 and 10.

(5) Connect an ac voltmeter to output terminals 1 and 6 of the servo amplifier.

Note. Use a low range on the input meter (0 to 1 volt) and use a high range on the output meter (0 to 100 volts).

(6) With the GAIN control turned completely clockwise, an input voltage of 1 volt, and the DAMPING control (R101) adjusted for an output null, the servo amplifier gain should be from 20 to 40.

b. Coarse-Fine Switching Circuit Check. The following procedure provides a means for checking the coarse-fine switching circuit for proper voltage and the relay circuit for proper release.

(1) Connect the equipment exactly as directed in *a* above, with the following exception: Connect the synchro control transformer rotor terminals R1 and R2 to servo amplifier terminals 9 and 11.

(2) Turn C F SWITCHING control R122 completely counterclockwise. The green light, E103, should go on.

(3) Use the voltage-varying device and increase the input voltage until red light E102 lights; this indicates that the servo amplifier has switched to coarse operation. The voltage measured on the input meter should be no higher than 1-volt ac root mean square (rms).

(4) Slowly reduce the input voltage to zero. The green light should come on again, indicating that the unit has returned to fine operation.

Section II. REPAIRS

71. Replacement of Parts

When replacing parts in Electronic Control Amplifier AM–489/TP (servo amplifier), observe the precautions given below.

a. Tagging Leads. Tagging the leads is essential to assure that correct rewiring will be made when a part is replaced. Before removing or unsoldering any leads from such items as terminal boards, tube sockets, connectors, and controls, tie together the leads that are attached to each of these parts. With small tags or short pieces of adhesive tape, identify all wires in accordance with their numbered connections. Identify every lead that is to be removed. (Refer to the schematic diagrams, figures 58 and 62.)

b. Parts and Substitution. When damaged parts must be replaced, identical parts should be used. If identical parts are not available and the damaged component is beyond repair, a substitution must be made. The parts substituted in the servo amplifiers must have identical electrical properties and they must be of equal or higher voltage and current rating. Mechanical components in the recorder and console assemblies must be identical replacements.

c. Location. When substituting equivalent parts in the servo amplifier, it is extremely important to locate these parts as close to the location of the original parts as possible.

d. Mounting. Mount the new or replaced part in the same mounting position as that formerly occupied by the damaged part. Fasten all mountings securely.

e. Soldering. Before soldering any connection, clean and carefully scrape all parts that will be touched by the solder until all traces of rust, corrosion, and paint or varnish are removed. Wrap the wire around the solder lug so that it is mechanically secure. Use very little solder and sufficient heat to make the solder flow evenly around the tinned surfaces. Make sure that the ground lugs are bonded securely to the chassis. Be sure to clean away all particles or splashes of solder.

72. Inspection of Console

(fig. 3)

a. Carefully inspect both lifting eye assemblies. Inspect the lifting hooks and mounting plates for damage. Move all lifting hooks to check for broken shafts or springs.

Note. Never attempt to lift the equipment unless assured that the lifting handle assemblies are functioning properly. Whenever the console is tilted sufficiently to allow examination of the bottom (as in moving off a truck), check the vibration mounts between the skids and the console frame. If the rubber pads show signs of deterioration, or if the metal parts are damaged, replace the mounts.

b. Check both lifting handle assemblies for obvious defects. Replace worn or defective plates, handles, shafts or springs before attempting to move the equipment.

c. Inspect the three terminal boards (E504, E505, and E506) mounted inside the lower rear access panel of the console. Inspect all connections for tightness, clean contact, and for frayed insulation.

d. Inspect all panels and covers and check their fasteners; inspect all sealing gaskets before securing the covers in place.

e. Check the input data connector receptacle for dirt and obvious defects.

73. Inspection of Chassis and Panel

When a servo amplifier is removed from the console assembly for repair, inspect the chassis and panel for any obvious defect. When the unit is removed, it is possible to inspect all parts and wiring.

a. Inspect all component parts of the servo amplifier for rust, corrosion, breakage, or other mechanical damage. Inspect all wiring for loose connections and frayed or burned insulation. Thoroughly inspect all mounting hardware for mechanical defects. Examine the chassis for dirt or corrosion.

b. Examine all fixed capacitors for signs of discoloration, leaks, bulging, dirt, and loose connections. Melted or oozing wax or other dielectric is a definite sign of damage to the part. Such capacitors should be removed for electrical check and should be replaced if they are defective.

c. Examine resistors for blisters, discolorations, or other signs of overheating. Inspect connecting leads for corrosion, dirt, dust, looseness, or broken strands of wire. Discoloration of a resistor usually indicates that the component has been operating under overload conditions and should be taken as a sign of a defect in an associated circuit.

74. Adjustment of Azimuth Microswitches

The azimuth section switching circuit microswitches S601 and S602 must be adjusted whenever the position of the azimuth stylus is changed on its wire rope, and whenever the wire rope is changed. The switches may have to be adjusted if the recorder is operated in a temperature much different from that in which the switches were alined previously.

a. The azimuth switches and the mechanical azimuth stops (at each end of the plotting scale) must be adjusted so that the loss of azimuth plot (par. 49) does not exceed 45 mils.

b. Use the following procedure:

(1) Loosen the locknuts on the mechanical azimuth stops (fig. 50).
(2) Set the azimuth stops so that the stylus point is stopped one thirty-second of an inch beyond 3,200 mils and before 0 mil.
(3) Tighten the locknuts.
(4) With the power off, manually set the plotting stylus so that the stylus point rests between the 3,200-mil scale mark and its stopped position.
(5) Loosen the mounting screws on microswitch S601 (fig. 48).
(6) Adjust S601 and slide it in its mounting slots, so that it is just closed by the pin on the azimuth drive pulley. Make sure the position of the stylus point has not changed.
(7) Carefully tighten the switch mounting screws.
(8) Repeat steps outlined in (4) through (7) above, adjusting microswitch S602 with the stylus point set at the zero end of the scale.
(9) Check the microswitches to see that they are actuated before the azimuth stops limit the movement of the stylus; if not, repeat the adjustments.

c. If adjustment of S601 and S602 cannot be accomplished simultaneously, move the stylus on the stylus drive cable a short distance in the appropriate direction, and repeat the adjustments outlined in (4) through (8) above.

CHAPTER 6

MECHANICAL OVERHAUL OF THE RECORDER ASSEMBLY

Section I. GENERAL

75. General

Although the recorder depends on electrical and electronic principles for its operation, many of its parts are mechanical. Instructions for the disassembly, inspection, cleaning, and repair of the mechanical parts are given in this chapter. The subsequent text of the chapter is divided into four main sections. In section II, major parts and assemblies of the recorder are removed as units. In section III, general cleaning and inspection directions are given. In section IV, instructions are listed for further disassembly of the major components (where required), inspection and repair of all parts, and reassembly of the minor parts into their major components. Section V deals with reinstallation of the major components.

76. Instructions

Three points should be kept in mind when following the steps given in this chapter.

a. The procedures outlined are not intended to be complete to the smallest detail. Full use of the exploded views and photographs should be made to augment the text.

b. Parts should not be overhauled unless a need of repair is evident. Many of the steps given may be omitted where parts are obviously in good condition. Use discretion and avoid needless steps wherever possible.

c. The recorder assembly mechanism is an extremely accurate and highly sensitive piece of equipment and, as such, should be treated with great care at all times.

Section II. REMOVAL OF MAJOR PARTS AND ASSEMBLIES

77. Recorder Assembly

(fig. 3)

Follow the instructions given in *a* through *f* below when removing the recorder assembly from the console assembly. The recorder assembly is mounted on guide rollers and slides forward out of the console assembly when the front access panel, control panels, and several structural members of the console are removed.

a. Remove the upper front access panel (fig. 11).

b. Open the fasteners on the control panel frames located on the front of the console and swing the hinged panels forward out of the way (fig. 45).

c. Remove the four screws that hold each vertical bracket (fig. 45) to the console shelf.

d. Remove the horizontal crossmember (fig. 45) running across the top front edge of the console by removing the six screws which hold it to the console sides.

e. Disconnect all wire connections between the console and recorder.

Caution: Check each lead for proper identification before disconnecting.

f. Remove all screws and washers that hold the top of the recorder assembly to the console. The recorder assembly rolls out of the console on guide rollers (fig. 45).

78. Recorder Covers

Before removing any of the covers, unfasten the three captive screws (fig. 13). One screw locks the paper roll cover and the others lock the paper well cover.

a. Remove the screws which hold the hinge of the paper roll cover to the left side of the housing.

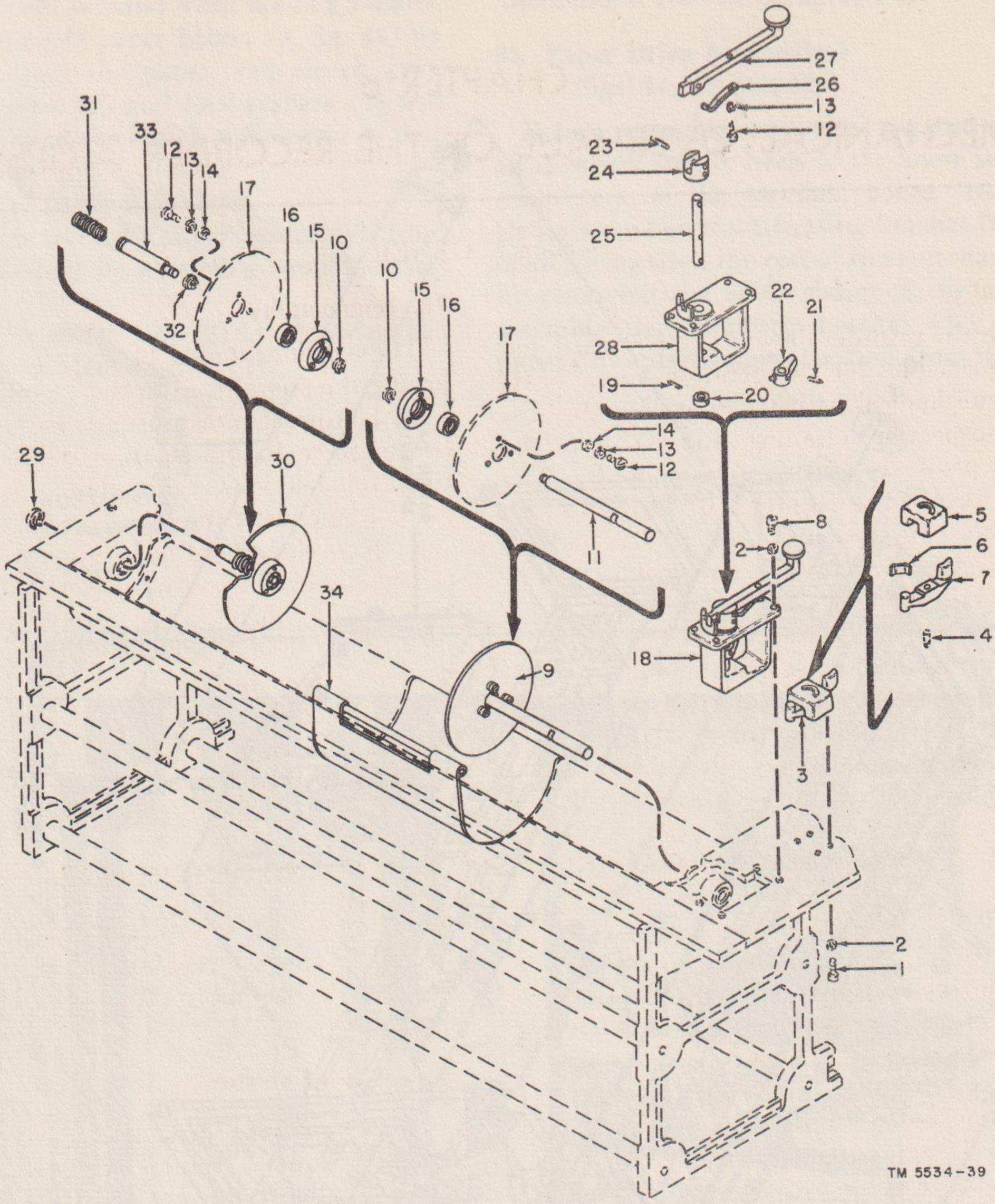
b. Disassemble the hinges from the rear cross brace and detach the paper well cover from the recorder assembly.

c. Remove the guide pulley cover by unfastening the screws that hold it to the left side housing.

79. Paper Holders, Paper Well Clutch, and Associated Parts

(fig. 43)

Before removing any parts, determine the condition of all assemblies. Operate the clutch stop and clutch. Test both paper holders for freedom



1 Fillister-head machine screw, No. 8–32 by 5/16 inch long
2 Split lockwasher, No. 8 by .047 inch wide by .031 inch thick
3 Clutch stop
4 Pivot pin
5 Clutch stop housing
6 Clutch stop spring
7 Clutch stop lever
8 Fillister-head machine screw, No. 8–32 by 3/8 inch long
9 Left-hand paper holder
10 Retaining ring
11 Shaft (O 618)
12 Fillister-head machine screw, No. 6–32 by 5/16 inch long
13 Split lockwasher, No. 6 by .040 inch by .1025 inch thick
14 Flat washer, No. 6 by 5/16 inch wide by .028 inch thick
15 Disk retainer (O 615)
16 Self-alining roller bearing (O 601)
17 Paper holder disk (left)
18 Paper well clutch
19 Roll pin
20 Locking collar (O 608)
21 Roll pin
22 Lever (O 613)
23 Roll pin
24 Yoke (O 628)
25 Shaft
26 Flat spring (O 625)
27 Handle (H 601)
28 Clutch frame (O 605)
29 Retaining ring
30 Right-hand paper holder
31 Helical compression spring (O 626)
32 Spring retainer
33 Shaft (O 619)
34 Paper roll lift

Figure 43. Paper well housing, exploded view.

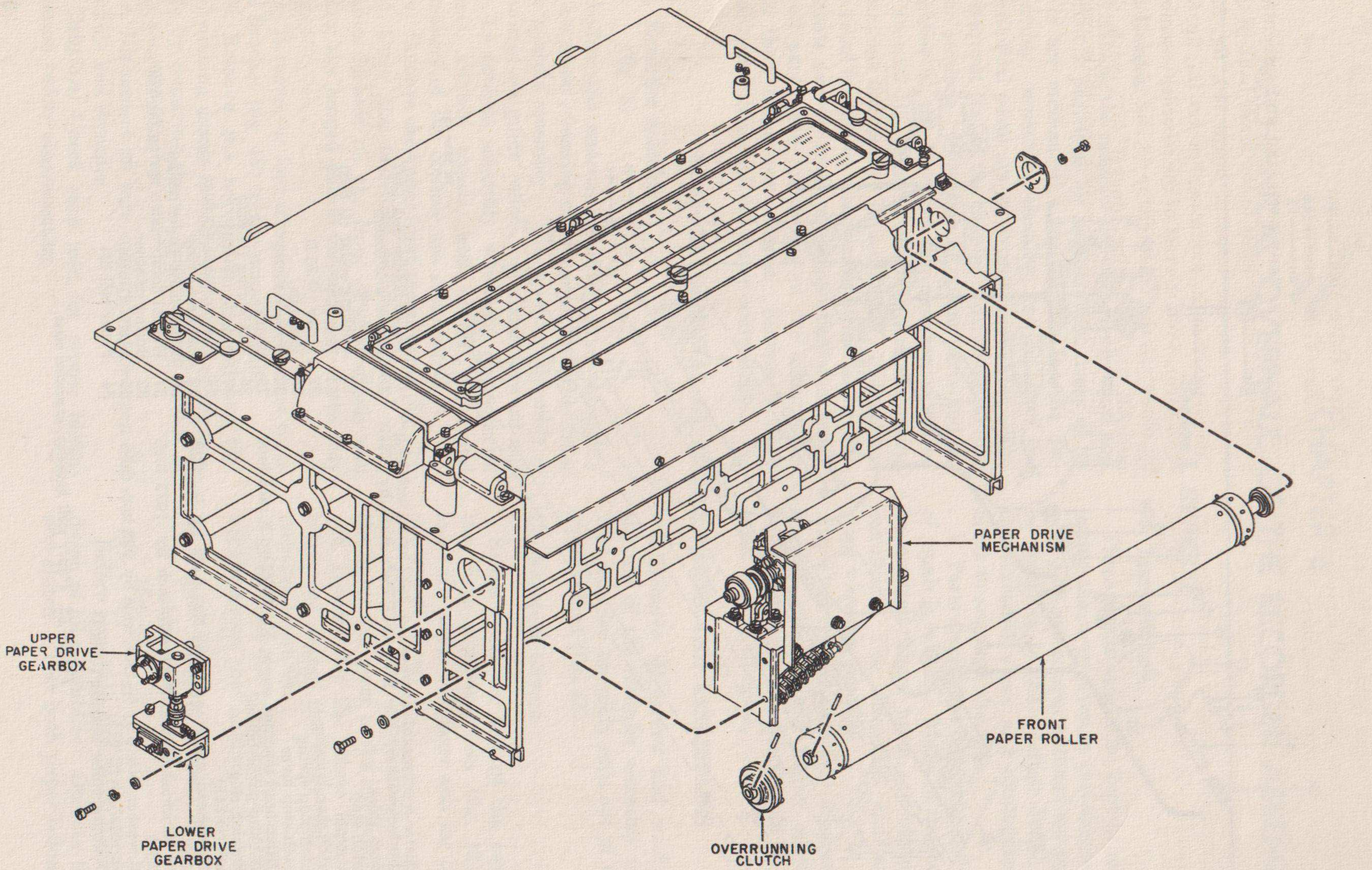


Figure 44. Paper drive mechanism.

of movement. Note any signs of defective operation and keep them in mind when making repairs.

a. Remove the left paper holder (9, fig. 43) by disengaging it from the paper well clutch (18). Removal of screws (8) and lockwashers (2) will permit the raising of the clutch sufficiently so that this may be done.

b. Remove the paper well clutch.

c. Disassemble the right paper holder (30) from the recorder housing by removing retaining ring (29).

d. Remove the clutch stop (3) by removing the four screws (1) and lockwashers (2).

e. For additional disassembly and overhaul instructions, refer to paragraph 90.

80. Paper Drive Mechanism
(figs. 44, 45, and 52)

Before removing any parts, tag and disconnect all electrical supply leads to the lower bank of the connectors on the terminal board (10, fig. 52). Completely free the mounting bracket (57, fig. 52) of all wiring from the rest of the recorder assembly by removing the cable clamp (8, fig. 52). Disassemble the mounting bracket (57), with the paper drive mechanism attached, from the recorder

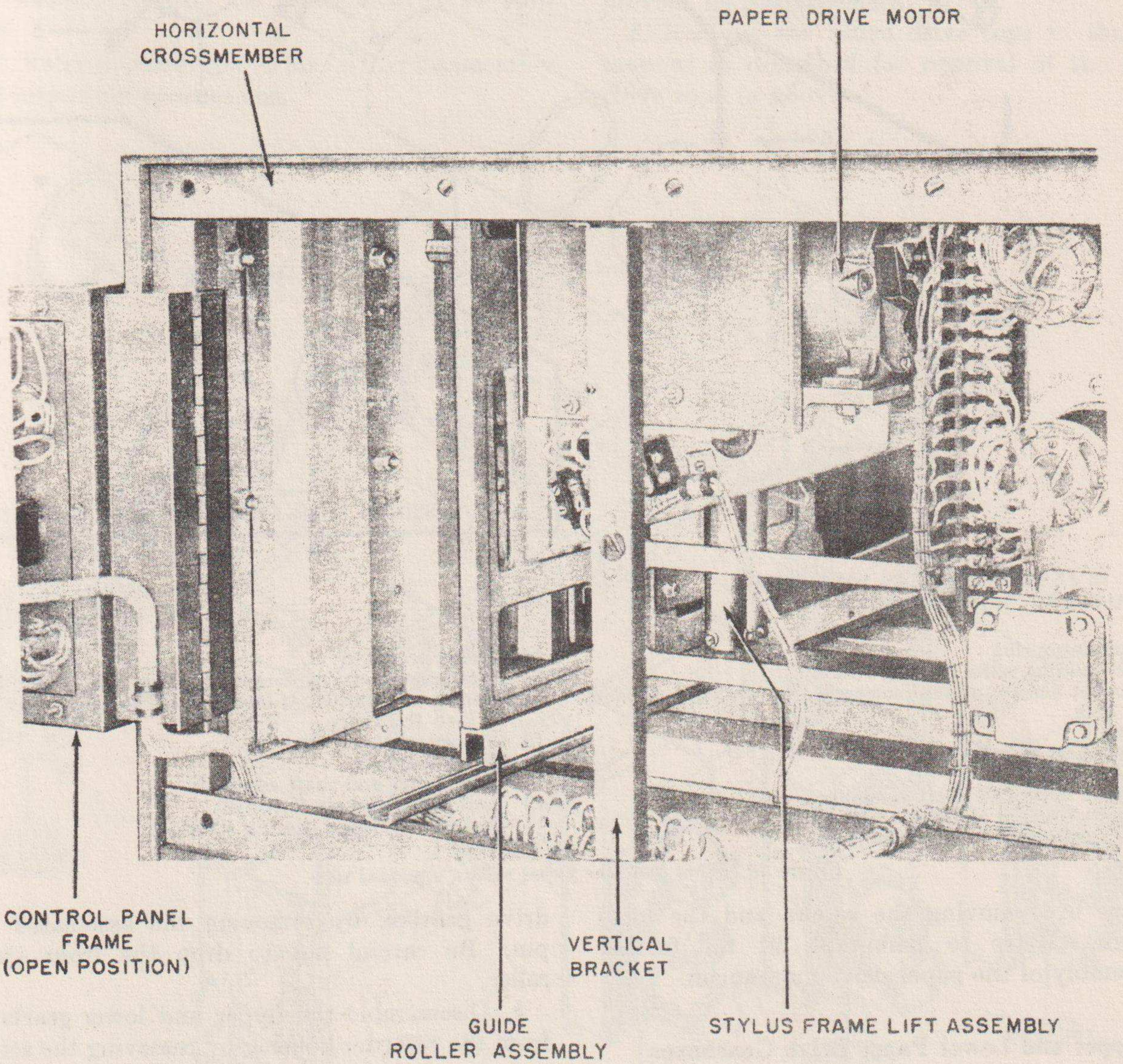
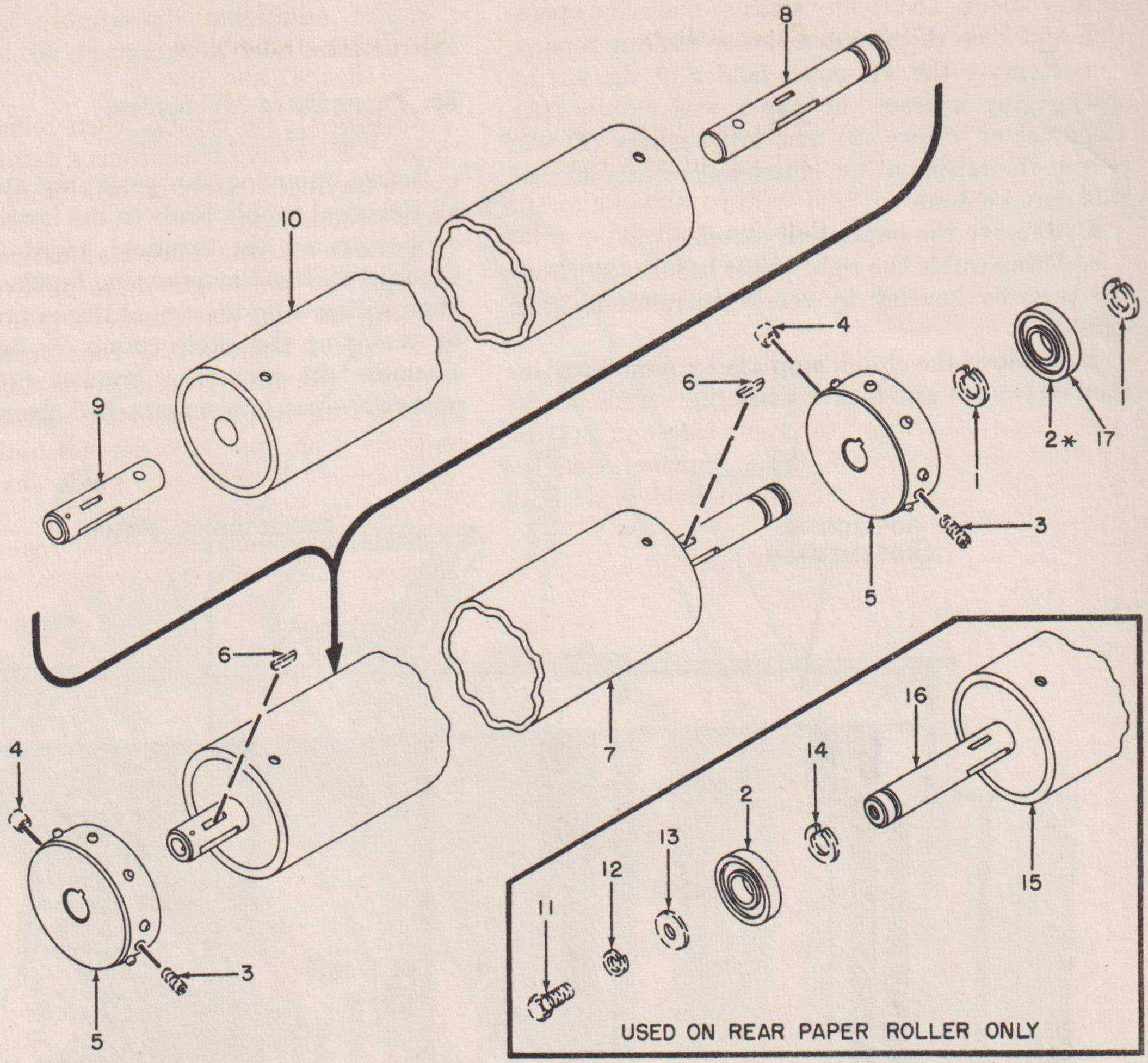


Figure 45. Azimuth-Elevation-Range Recorder RD–54/TP and/or RO–3/MPQ interior view.



*2 IS 17 IN RECORDERS WITH SERIAL NUMBERS 313 OR HIGHER.

TM 5534-40

1 Retaining ring
2 Self-alining roller bearing (O602)
3 Socket head cup point setscrew, No. 10–32 by ⅝ inch long
4 Pad
5 Pinwheel assembly
6 Key
7 Right roller and shaft assembly
8 Right front or right rear roller shaft (O620)
9 Left front roller shaft (O621)
10 Roller assembly
11 Hexagonal-head capscrew, ¼–20 by ½ inch long
12 Spring lockwasher, ¼ inch by .107 inch wide by 0.47 inch thick
13 Special washer
14 Retaining ring
15 Rear roller and shaft assembly
16 Left rear roller shaft (O622)
17 Self-alining roller bearing (O649)

Figure 46. Front and rear paper rollers, exploded view.

housing by removing the screws and the lockwashers. Refer to paragraph 91 for further disassembly of the paper drive mechanism.

81. Upper and Lower Paper Drive Gearboxes (fig. 44)

a. Disconnect the paper drive overrunning clutch from the output shaft of the upper paper drive gearbox by removing the associated roll pin. Be careful not to drop the front paper roller.

b. Disassemble the upper and lower gearboxes from the recorder housing by removing the screws and the washers. Pull the gearbox off gently so as not to damage its coupling.

c. For additional disassembly, inspection, and overhaul instructions, refer to paragraph 92.

82. Overrun Clutch and Paper Rollers

(figs. 44 and 46)

a. Disconnect the overrunning clutch from the front paper roller by removing the setscrew.

b. Remove the bearing retainer and the retaining rings (1, fig. 46). Slide the front paper roller to the right, permitting removal of the overrunning clutch. Remove the front paper roller by sliding it to the left.

c. Disassemble the rear paper roller from the recorder by removing the bearing retainers, the retaining rings (1) on the right side and (14) on the left side, the screw, the lockwasher, and the flat washers (11, 12, 13) which hold it at both ends.

d. Refer to paragraph 93 for further disassembly and inspection instructions.

83. Pulley Assemblies

(figs. 47 and 28)

Caution: Be careful when removing all wire ropes. Excessive tension may damage pulleys or cause fraying, stretching, or kinking of individual rope strands.

a. Loosen both knurled adjusting nuts (7) on each of the two height drive pulleys (17 and 18, fig. 28), allowing slack to develop in the elevation wire rope. Unhook the rope from both drive pulleys. Remove the height stylus carriage (6, fig. 28) from its guide shafting. Remove the rope entirely from the recorder assembly. Reinstall the carriage between the guide shafting rods to prevent its misplacement.

b. Remove the range drive rope in the same manner as described for removal of the height drive rope (*a* above).

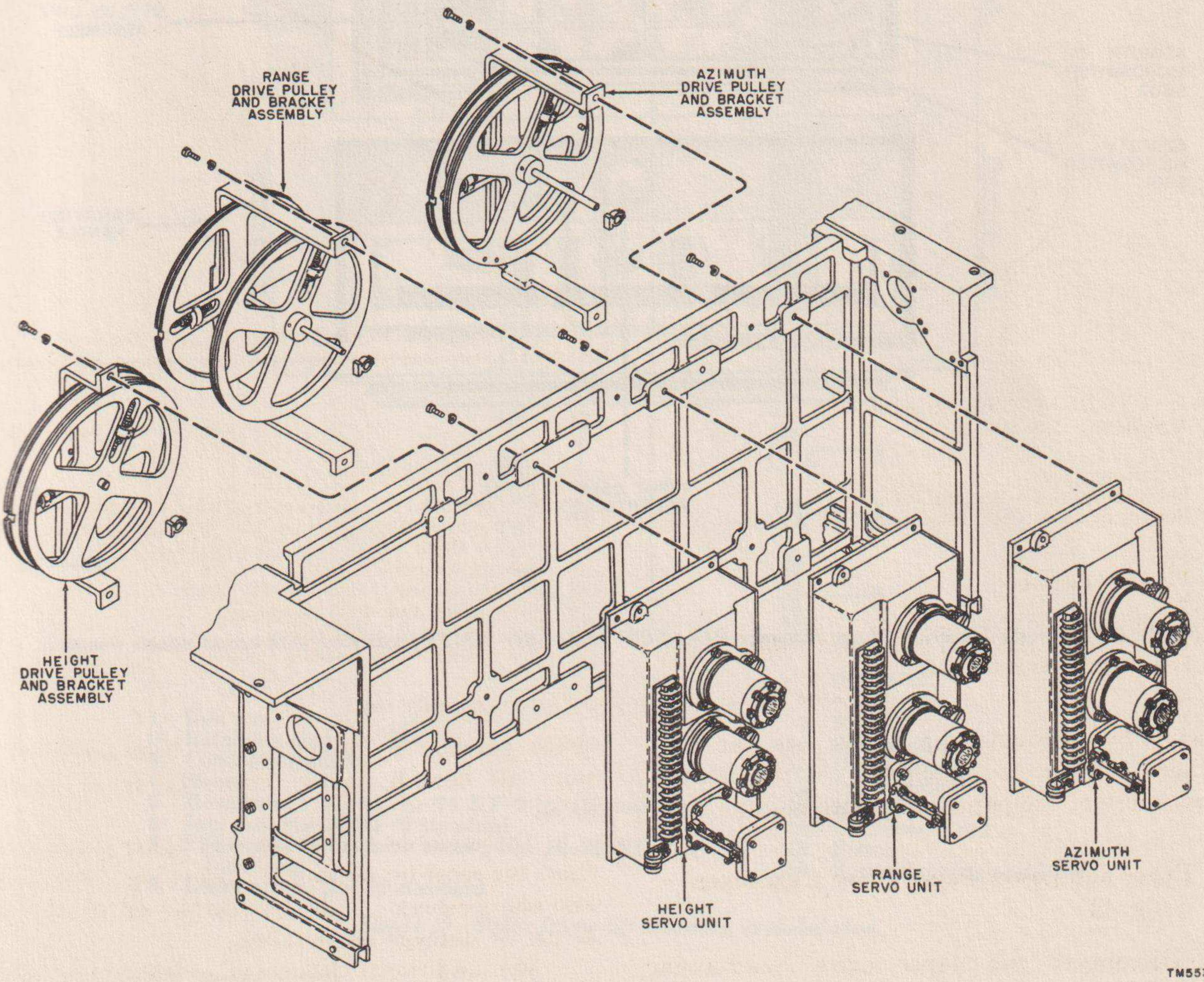


Figure 47. Azimuth-Elevation-Range Recorder RD–54/TP and/or RO–3/MPQ drive pulley assemblies.

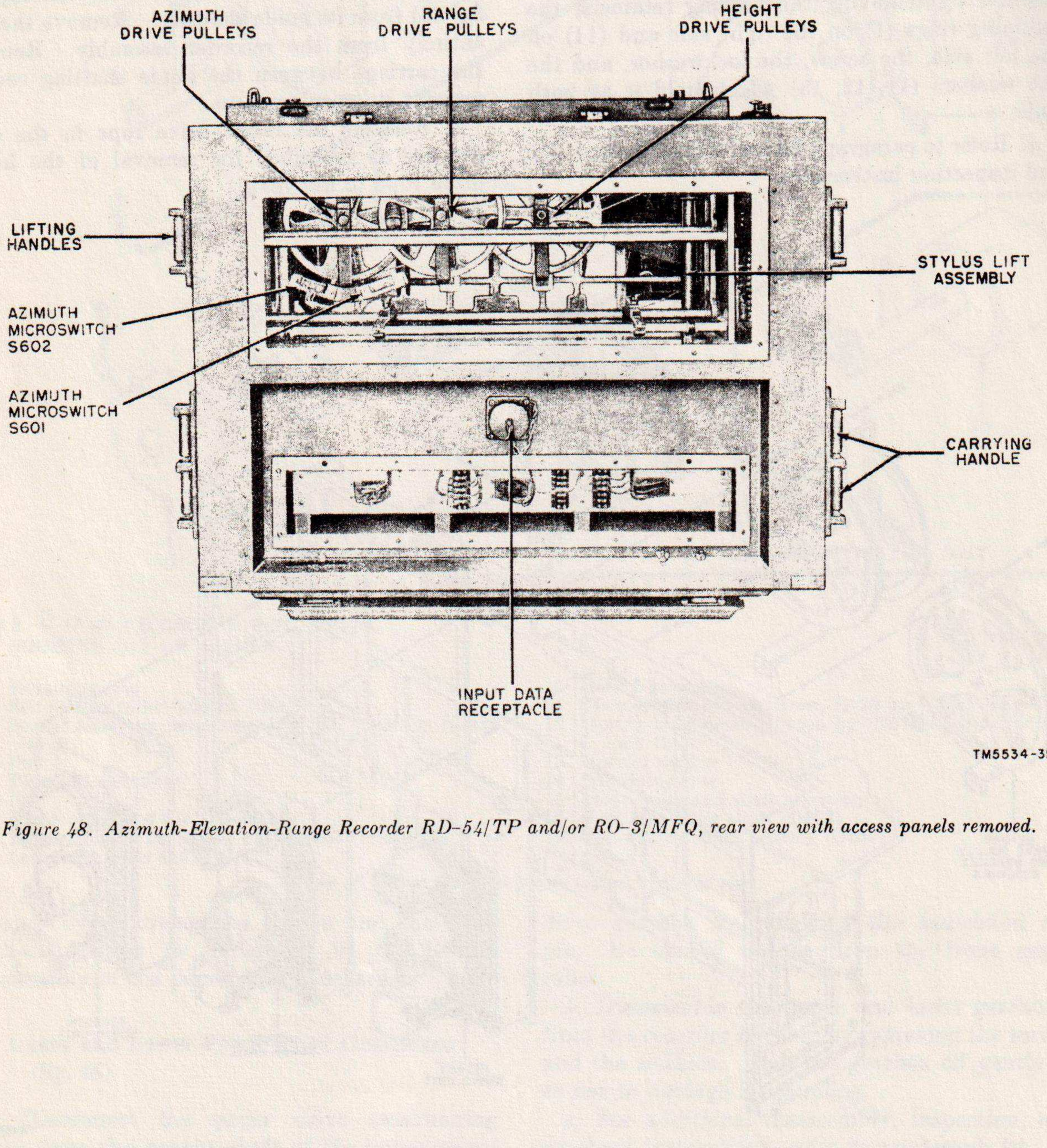
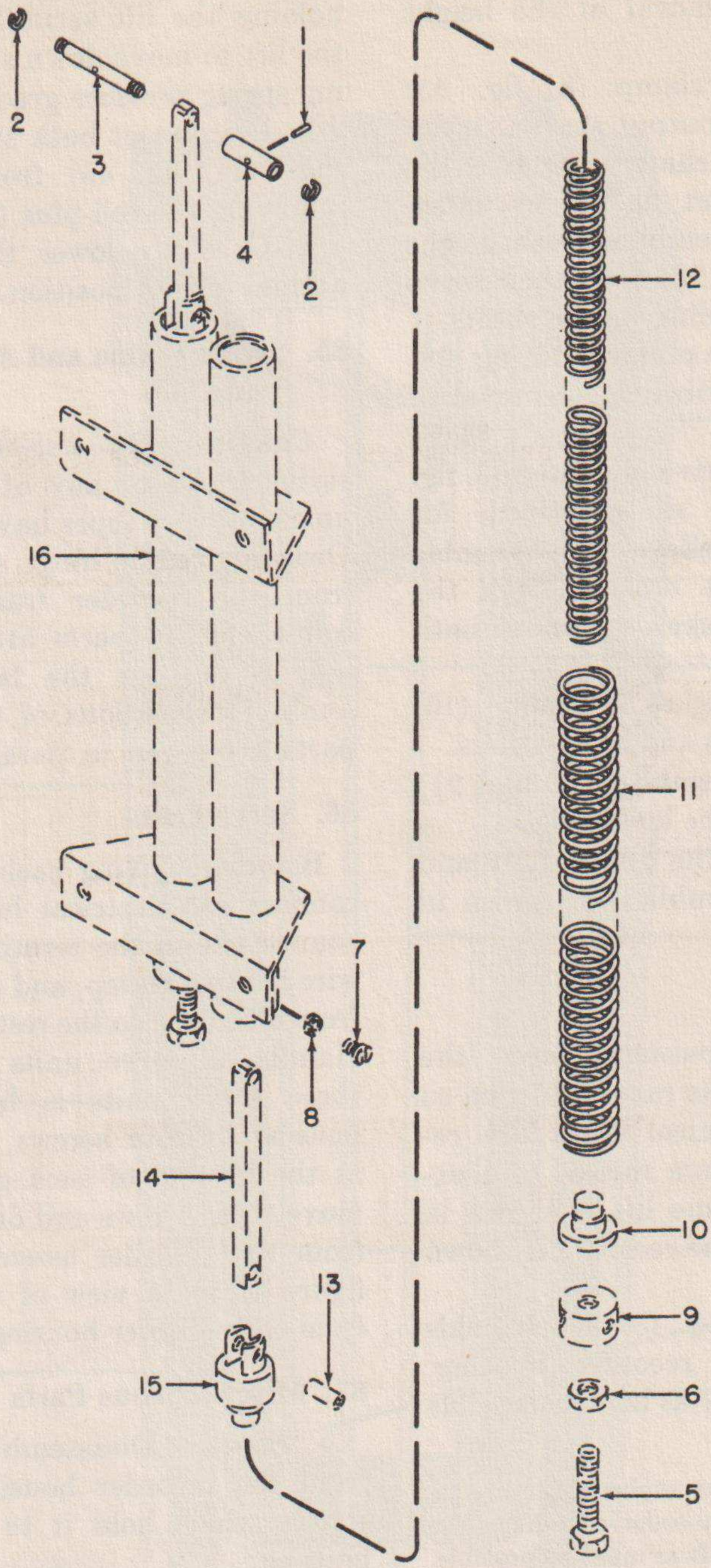


Figure 48. Azimuth-Elevation-Range Recorder RD-54/TP and/or RO-3/MFQ, rear view with access panels removed.



1 Roll pin
2 Retaining ring
3 Connecting shaft
4 Sleeve
5 Hexagonal top bolt, 5/16–24 NF–2 by 1½ inch long
6 Jam nut, 5/16–24 NF–2 standard
7 Fillister-head machine screw, No. 10–24 NC–2 by ¼ inch long
8 Lockwasher, No. 10 standard
9 Plug
10 Spring pilot
11 Outer spring
12 Inner spring
13 Roll pin
14 Connecting rod
15 Piston
16 Spring housing assembly

Figure 49. Stylus frame lift assembly, exploded view.

c. Remove the azimuth drive rope in the same manner as described for removal of the height drive rope (*a* above).

d. Loosen the coupling clamp (8, fig. 55) between the height gearbox output shaft (35, fig. 55) and the height pulley shaft. Remove the height pulley mounting bracket (fig. 47) by unfastening the screws and disassembling both height drive pulleys (17 and 18, fig. 28) from their servo unit. Do not bend the coupling or the shafts.

e. Remove the range drive pulleys (15, fig. 28) in the same manner as described for removal of the height drive pulleys.

f. Remove the azimuth drive pulleys (13, fig. 28) in the same manner as described for removal of the height drive pulleys. Disassemble the sensitive switch support bracket from the azimuth pulley mounting bracket. Remove both sensitive switches.

g. Remove the pulley bracket assembly (19, fig. 28) by removing the screws and lockwashers.

h. Remove both pulley assemblies (20 and 21) by removing the screws and the lockwashers.

i. Further instructions for the disassembly and inspection of the pulley assemblies are given in paragraph 94.

84. Stylus Frame Lift

The stylus frame lift counterbalances the weight of the stylus frame in its raised position so that no propping or mechanical stops are required to keep the stylus frame raised. An exploded view of the stylus frame lift is shown in figure 49, and its location on the recorder is shown on figure 45.

a. Trip the latch release (fig. 13) which holds the stylus assembly to the recorder housing. Raise the entire stylus assembly as high as possible and prop it securely in place.

Note. It is important that the stylus assembly be propped at its highest position in order to relieve the spring pressure of the stylus frame lift as much as possible. Do not force the assembly beyond its normal limits of travel.

b. Remove the four screws which hold the lift to the recorder housing. Be careful when removing these screws. Release the last one slowly while holding the lift securely on the housing. Allow the lift to move down slowly, relieving all remaining spring pressure gradually.

c. Disconnect both stylus frame lift connecting rods (14, fig. 49) from their pistons (15) by removing the roll pins (13).

d. Carefully lower the stylus assembly to its normal (*down*) position.

85. Stylus Frame and Associated Parts

(fig. 50)

Caution: Do not attempt to remove the stylus frame or any of the parts attached to it unless all wire ropes have been removed (par. 83). Disassemble the hinge support arms (10, fig. 51) from the recorder frame. Remove the stylus frame and all parts attached to it. Be careful not to damage the lampholder wires. Disassembly instructions of the frame and associated parts are given in paragraph 96.

86. Servo Units

Before removing each servo unit, tag and disconnect all electrical leads to the left bank of connectors on the terminal boards. Remove the wire holding clamp, and disconnect the servo units from all wiring to the rest of the recorder assembly. Handle all servo units carefully. Each of the three servo units is fastened to the recorder housing by four screws, two at the top and two at the bottom of each gearbox back plate. Remove these screws and disassemble the servo units from the recorder assembly carefully. Refer to figure 47 for a view of the servo units exploded from the recorder housing.

87. Miscellaneous Parts

a. *Platen*. Disassemble the platen (fig. 14) from the recorder housing by removing the 12 screws which hold it to the assembled recorder housing.

b. *Housing*. Disassemble the center support housing, the side housings, and the tie rods of the recorder assembly from each other when all other parts have been removed.

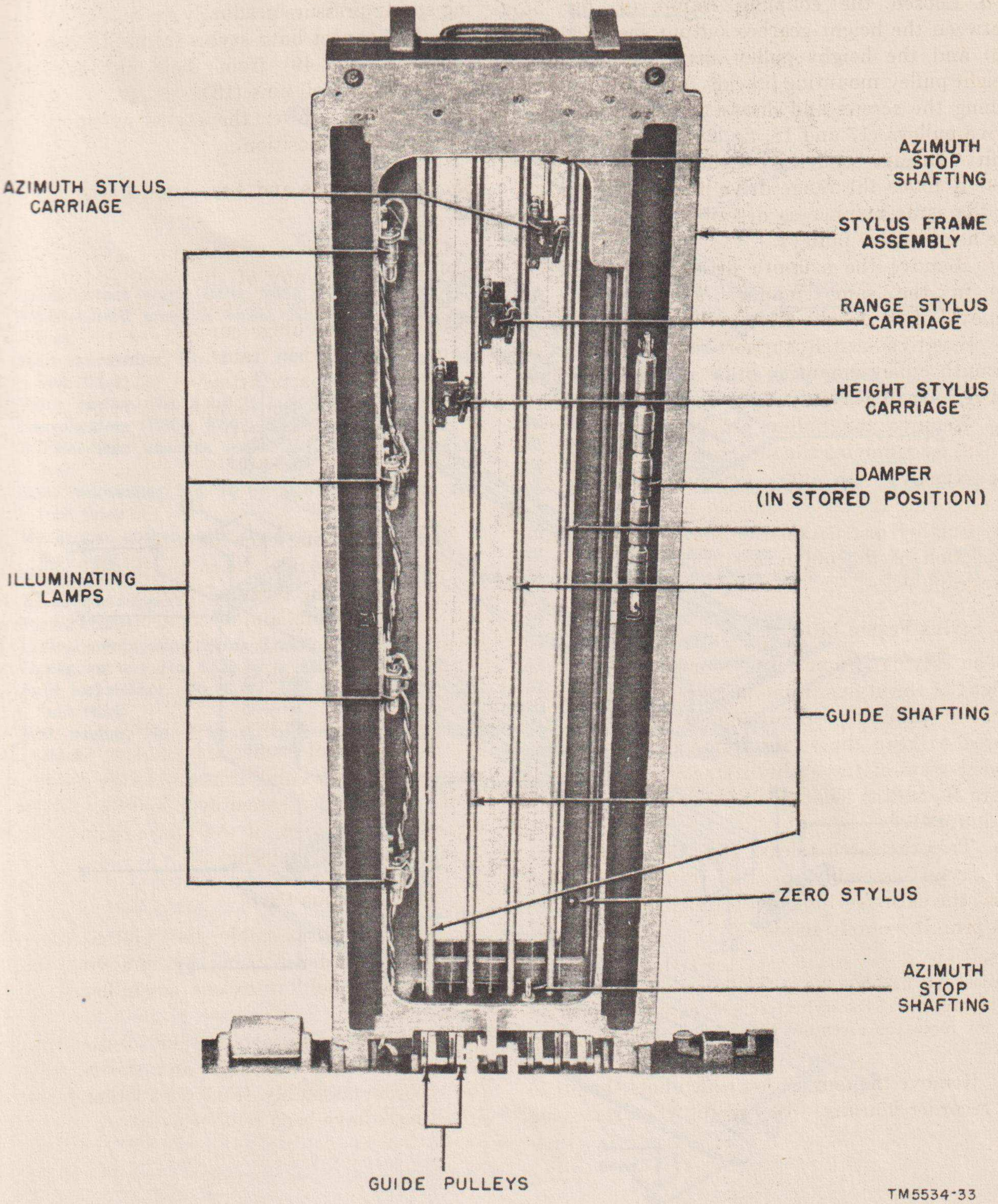
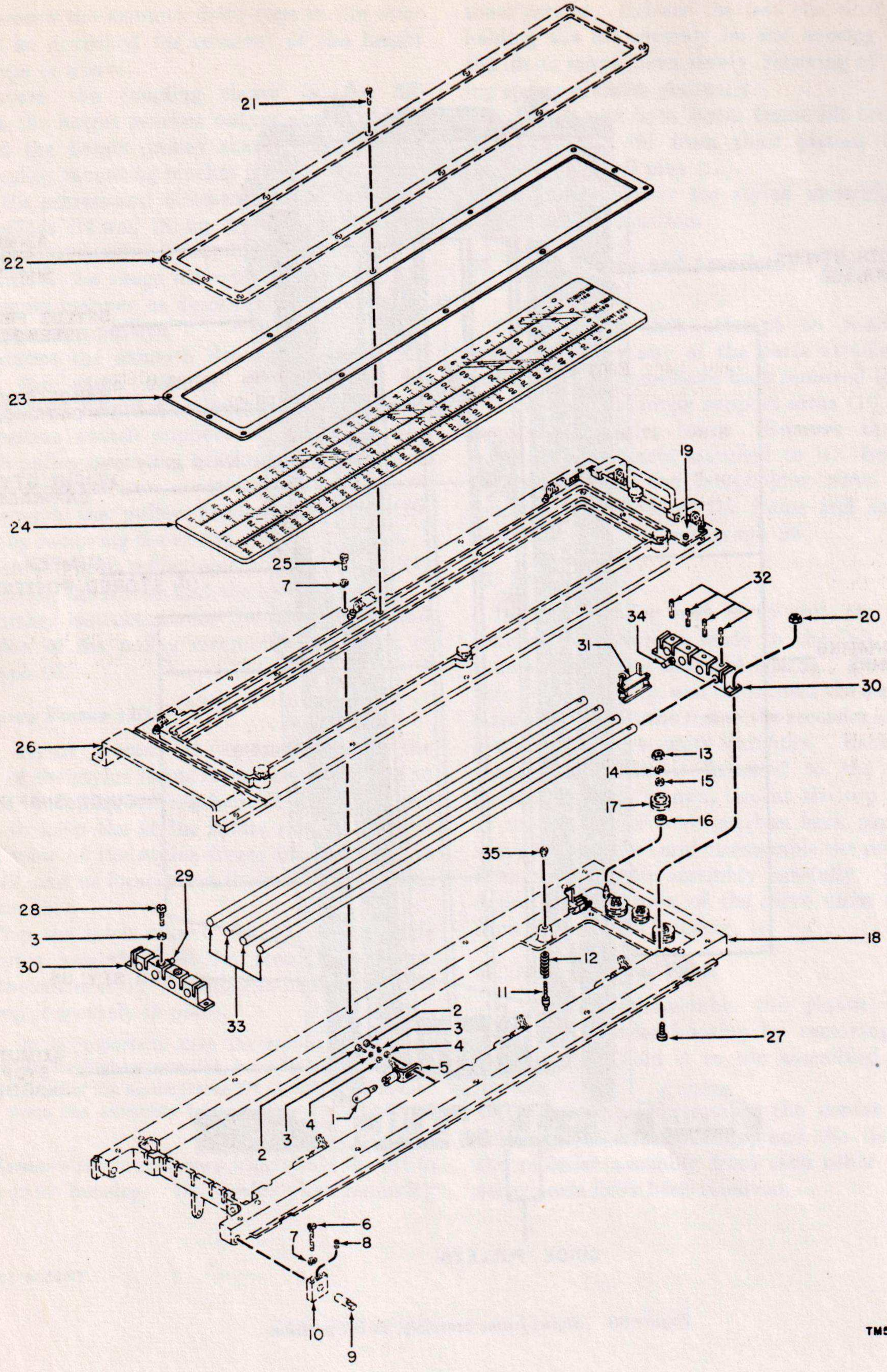


Figure 50. Stylus frame assembly, in lift position.



TM5534-44

Figure 51. Stylus frame assembly, exploded view.

1 Incandescent lamps (E601, E602, E603, and E604)
2 Fillister-head machine screw, No. 8–32 by 5/16 inch long
3 Split lockwasher, No. 8 by .047 inch wide by .031 inch thick
4 Plain washer, No. 8 by 3/8 inch by .032 inch thick
5 Lampholders (E608, E609, E610, and E611)
6 Fillister-head machine screw, No 10–24 by 1½ inch long
7 Split lockwasher, No. 10 by .055 inch wide by .040 inch thick
8 Hexagonal socket-head setscrew, No. 4–48 by ¼ inch long
9 Hinge arm
10 Hinge arm support
11 Stylus (H604)
12 Helical compression spring (O632)
13 Hexagonal nut, No. 6–32 by ¼ inch
14 Split lockwasher, No. 6 by .047 inch wide by .031 inch thick
15 Flat washer, No. 6 by 5/16 inch wide by .029 inch thick
16 Self-alining roller bearing (O603)
17 Rope return pulley
18 Housing
19 Cover plate
20 Self-locking nut, No. 8–32 by ¼ inch
21 Flathead machine screw, No. 6–32 by 5/16 inch long
22 Cover frame
23 Gasket (O629)
24 Plotting scale (N601)
25 Fillister-head machine screw, No. 10–24 by 3/8 inch long
26 Frame and cover assembly
27 Flathead machine screw, No. 8–32 by 5/8 inch long
28 Fillister-head machine screw, No. 8–32 by 7/8 inch long
29 Stylus carriage stop (O630)
30 Mounting (A607)
31 Stylus carriage assembly
32 Roll pin
33 Shafting (O624)
34 Stylus carriage stop (O631)
35 Plain knurled nut (H603)

Figure 51—Continued.

Section III. CLEANING DISASSEMBLED PARTS

Caution: Do not submerge the parts in solvent. Many of the assemblies removed contain roller bearings. Try to keep the solvent from reaching the lubricant in these bearings.

88. General Cleaning Instructions

Wipe the external surfaces of all metal parts with a lint-free cloth that has been moistened with solvent (SD). Use a short, stiff-bristled brush (such as a toothbrush) to reach difficult corners and dislodge dirt, grease, and other accumulations. Dry all parts carefully with a jet of clean air or with a clean, dry, lint-free cloth. Remove rust, scratches, and burrs with No. 000 sandpaper. Repair rusted surfaces as necessary.

89. Inspection of Covers

Check the condition of all covers and the captive screws which lock them to the recorder assembly. If a cover is damaged or sprung so that it does not seat correctly, replace it. Replace all missing or damaged captive screws.

Section IV. OVERHAUL OF MAJOR COMPONENTS

Note. Paragraphs 90 through 98 contain specific overhaul directions for all maintenance parts of the recorder assembly. Repairs of parts not mentioned specifically should be made as necessary, according to the judgment of the repairman. Individual parts should be cleaned as necessary when removed from their main assemblies.

90. Paper Well Clutch, Paper Holders, and Associated Parts

(fig. 43)

a. Disassembly of Paper Well Clutch. Disassemble the clutch shaft (25) from its frame (28) by removing pins (19 and 21) and pulling the shaft out of its frame releasing lever (22). Remove spring (26) and yoke (24) by removing pins (23), screw (12), and lockwasher (13).

b. Disassembly of Left Paper Holder. Disassemble shaft (11), disk retainer (15), and bearing (16) from the left paper holder disk (17) by removing retaining ring (10), screws (12), and washers (13 and 14).

c. Disassembly of Right Paper Holder. Disassemble spring (31), shaft (33), disk retainer (15), and bearing (16) from the right paper holder disk (17) by removing retaining ring (10), screws (12) and washers (13 and 14).

d. Inspection and Replacement.

(1) Check spring (26) for evidence of wear or fatigue. Inspect frame (28), handle (27), yoke (24), lever (22) and collar (20). Replace worn or damaged parts.

(2) Check the paper well clutch stop for correct action. If it does not function correctly, replace it.

(3) Inspect the roller bearings (16). They should rotate freely, without evidence of binding or excessive wobble. Examine the paper holder shafts for wear. Inspect the spring (31) for signs of breaking or fatigue. Replace all worn or damaged parts.

e. Reassembly. No special assembly instructions are required, all parts being reassembled in the reverse order of disassembly.

91. Paper Drive Mechanism

(fig. 52)

a. Disassembly.

(1) Remove cover (4). Disassemble terminal board (10) and terminal strip marker (11) from the motor mounting bracket (57).

(2) Remove the dust cover (59) and the wire support bracket (60).

(3) Disassemble the terminal board (62) from the motor mounting bracket.

(4) Free the electrical solenoid (13) from the clutch yoke (50) by removing roll pin (12). Remove the solenoid.

(5) Remove the motor wiring, and disassemble the AC motor (36) with the governor (22) from the mounting bracket by removing the hexagonal nuts (18), the split lock washers (19 and 20), and the hexagonal head cap screws (21).

(6) With an offset screw driver, loosen screws (24) which hold the bearing seal plate (32) to the governor spring and housing assembly (33). Remove the governor vanes (25) and the motor flange coupling

(29) by removing the screws (24). Disassemble the coupling (28) from the motor flange coupling by removing the nut (26) and special screw (27). Remove governor spring and housing assembly (33) by removing retaining ring (30). Remove the governor flywheel (35) by removing the roll pin (34).

(7) Disassemble the clutch frame (51) from the motor mounting bracket (57). Remove the clutch actuating springs (38) and the clutch yoke (50) by removing screws (37), lockwashers (6), and roll pin (49). Remove the coupling (42) and pull the clutch drive shaft (43) out of its bearings. Pry off the retaining ring (44) and remove the clutch tube (48) from the clutch frame. Remove both the bearings (47) from the tube. Disassemble the female clutch (40) from the clutch drive shaft (43) by removing roll pin (39).

b. Inspection, Testing and Replacement.

(1) Inspect the terminal boards (10 and 62) for loose, stripped, or broken connections. Examine the electrical solenoid (13) for any external signs of damage. Replace it if it is damaged.

(2) Check the no-load rpm of the motor. With 115 volts AC applied, the speed should be 3,450 rpm $\pm$10 percent. If the speed is outside these limits, or if the motor gives any other evidence of faulty operation, replace it.

(3) Replace ball bearings (47) with new ones if necessary.

(4) Inspect the helical compression spring (46) to determine its condition. Replace this spring if it is cracked, broken, fatigued, or damaged in any way.

(5) Check both the female and male clutch (40 and 54) and the clutch facing (53) for signs of excessive wear. If any are worn, replace both halves of the clutch.

(6) Inspect the couplings (28 and 42) for wear or damage. Replace these parts if they are damaged.

c. Reassembly.

(1) Fasten the clutch yoke (50) to the clutch frame (51) with roll pin (49). Assemble the clutch frame (51) to the motor mounting bracket (57). Assemble the female clutch (40) to the clutch drive shaft (43). Insert the ball bearings (47) in the clutch tube (48). Place the spring (46) and the washers (45) between the upright arms of the clutch frame (51), in the order shown in figure 52. Insert the clutch tube (48) so that it passes through the spring and the two washers. Separate the washers and install the retaining ring (44).

(2) Install the clutch drive shaft (43) through both bearings (47). Assemble the coupling (42) to the shaft and pin it in place with roll pin (41).

(3) Install the actuating spring (38), fastening it with the screws (37) and lockwashers (6).

(4) Assemble the governor flywheel (35) to the motor output shaft and pin it in place with roll pin (34).

(5) Install the bearing (31) in the spring and housing assembly (33) and assemble the bearing seal plate (32) to the housing, leaving the screws (24) loose. Place the spring, housing, and the assembled parts on the flywheel (35) and install the retaining ring (30).

(6) Fasten the coupling (28) to the motor flange coupling (29) with special screw (27) and nut (26).

(7) Assemble the governor vanes (25) and the motor flange coupling (29) to the spring and housing assembly (33) with screws (24), using an offset screw driver to tighten the rear screws.

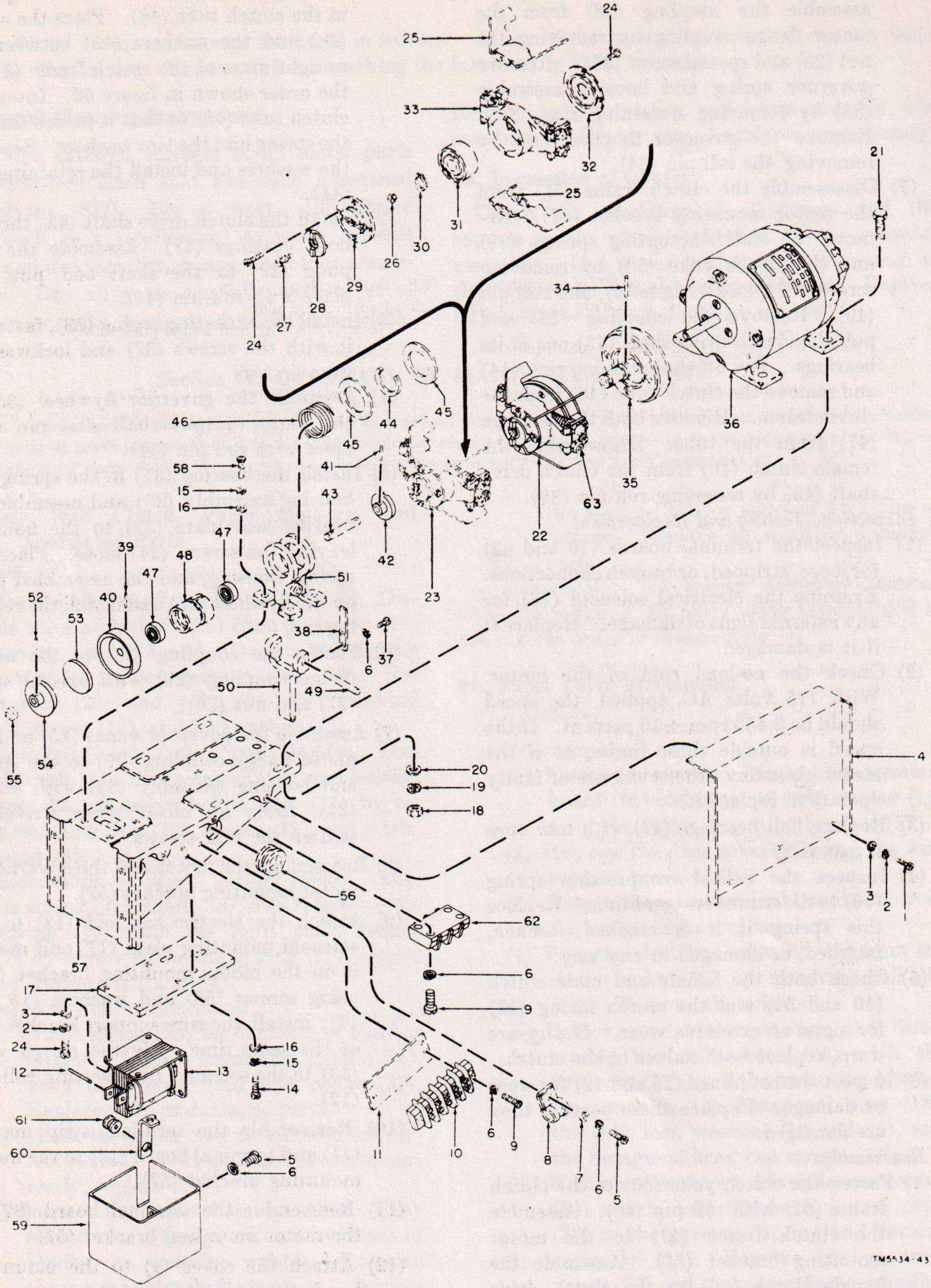
(8) Reassemble the motor and the governor to motor mounting bracket (57).

(9) Attach the electric solenoid (13) to the solenoid mounting plate (17) and mound it on the motor mounting bracket (57), using screws (58) and washers (15 and 16); install the wire support bracket (60) at the same time. Fix the clutch yoke (50) to the solenoid by inserting roll pin (12).

(10) Reassemble the terminal strip marker (11) and terminal board (10) to the motor mounting bracket (57).

(11) Reassemble the terminal board (62) to the motor mounting bracket (57).

(12) Attach the cover (4) to the mounting bracket.



TM5534-43

Figure 52. Paper drive motor, exploded view.

1 Fillister-head machine screw, No. 8–32 by 5/16 inch long
2 Split lockwasher, No. 8 by .047 inch wide by .031 inch thick
3 Flat washer, No. 8 by 3/8 inch wide by .032 inch thick
4 Cover
5 Fillister-head machine screw, No. 6–32 by 5/16 inch long
6 Split lockwasher, No. 6 by .040 inch wide by .025 inch thick
7 Flat washer, No. 6 by 5/16 inch wide by .028 inch thick
8 Cable clamp
9 Fillister-head machine screw, No. 6–32 by ½ inch long
10 Terminal board (E612)
11 Terminal strip marker
12 Roll pin
13 Electrical solenoid (L601)
14 Fillister-head machine screw, No. 10–24 by 5/8 inch long
15 Split lockwasher, No. 10 by .055 inch wide by .040 inch thick
16 Flat washer, No. 10 by 7/16 inch wide by .036 inch thick
17 Solenoid mounting plate
18 Hexagonal nut, ¼–20 by 7/16 inch
19 Split lockwasher, ¼ by .107 inch wide by .047 inch thick
20 Flat washer, ¼ by 9/16 inch wide by 3/32 inch thick
21 Hexagonal head cap screw, ¼–20 by 1 inch long
22 Governor (O612)
23 Governor vane, spring and housing assembly
24 Fillister-head machine screw, No. 8–32 by 3/8 inch long
25 Governor vane
26 No. 4–40 elastic stop hexagonal nut
27 Special screw
28 Coupling (O609)
29 Motor flange coupling
30 Retaining ring
31 Ball bearing
32 Bearing seal plate
33 Governor spring and housing assembly
34 Roll pin
35 Governor flywheel
36 Alternating current motor (B601)
37 Fillister-head machine screw, No. 6–32 by ¼ inch long
38 Clutch actuating spring
39 Roll pin
40 Female clutch (O606)
41 Roll pin
42 Coupling (O610)
43 Clutch drive shaft
44 Retaining ring
45 Special washer
46 Helical compression spring (O627)
47 Ball bearing
48 Clutch tube
49 Roll pin
50 Clutch yoke
51 Clutch frame
52 Roll pin
53 Clutch facing
54 Male clutch (O607)
55 Spacer
56 Grommet
57 Motor mounting bracket
58 Fillister-head machine screw, No. 10–24 by 9/16 inch
59 Dust cover
60 Wire support bracket
61 Grommet
62 Terminal board (E613)
63 Speed adjusting nuts

Figure 52—Continued.

92. Upper and Lower Paper Drive Gearbox

(fig. 53)

a. Disassembly.

(1) Disassemble the upper and the lower gearboxes from each other by removing the male and female flexible couplings (1 and 42).

(2) Remove the lower gearbox top and side plates (7 and 6) and the retaining ring (15).

(3) Remove the lower gearbox top and bottom covers (11 and 5). Loosen setscrew (12) and remove the locking collar (13). Withdraw the lower gearbox coupling shaft (18) and disengage the lower gear box output worm gear (17) from the input worm gear (23).

(4) Disassemble the roller bearings (14) from the top cover (11) and housing (27). Remove the retaining rings (15) from the coupling shaft (18).

(5) Remove all the retaining rings (20) and drive out the roll pin (22). (Support the input shaft (24), to prevent bending.)

(6) Withdraw the lower gearbox input shaft (24) and disassemble the roller bearings (21) (21 and 43 for equipments bearing serial number 313 or higher) from the lower gearbox housing (27).

(7) Remove the accessible retaining ring (31) from the upper gearbox output shaft (35).

(8) Remove the upper gearbox front and rear covers (28 and 29).

(9) Remove screws (8 and 40) and washers (9, 30, and 41) which fasten the rear bearing (32) to the gearbox output shaft (35).

(10) Remove the remaining retaining rings (31) and withdraw the shaft from the bearing, disengaging the output worm gear (34) from the input worm gear (37).

(11) Remove the roller bearings (32) from the upper gearbox housing (39) and the front cover (29).

(12) Remove the upper gearbox bottom cover (36). Loosen the setscrew (12) and remove the locking collar (13).

(13) Remove all the retaining rings (15) and drive out roll pin (22). (Support the coupling shaft (38) to prevent bending.)

(14) Withdraw the upper gearbox coupling shaft (38) and disassemble the roller bearings (14) from the upper gearbox housing (39).

(15) Remove the spacer (4) from the coupling shaft (38).

b. Inspection and Replacement. Before proceeding, inspect all gears and shafts. If a gear or shaft is worn or bent, replace the gearbox of which it is a part.

(1) Replace the roller bearings (14, 21, and 32) (14, 21, and 32), for equipments bearing serial number 313 or higher with new parts.

(2) Check the condition of the retaining rings (15, 20, and 31); replace any that are bent, out of shape, or broken.

(3) Examine the coupling sections (1 and 42) to determine their condition. If they show any sign of deterioration, replace them.

c. Reassembly.

(1) Install the upper gearbox input worm gear (37), spacer (4), and both the inner retaining rings (15) on the upper gearbox coupling shaft (38). Insert the shaft through the holes in the upper gear box housing (39). Install the upper roller bearing (14), anchoring it with the outer retaining ring (15). Install the lower roller bearing (14) and lock it with the locking collar (13). Reassemble the bottom cover (36) to the upper gearbox housing.

(2) Install the rear roller bearing (32); seat it securely against the shoulder in the housing. Install the upper gearbox output worm gear (34) and both inner retainer rings (31) on the output shaft (35). Insert the upper gearbox output shaft (35) in the upper gearbox housing. Mesh the output worm gear (34) with the input worm gear (37). Fasten the rear bearing to the shaft with washers (9, 30, and 41) and screws (8 and 40). Reassemble the rear cover (28) to the housing. Reassemble the front cover (29) to the housing. Install the front roller bearing (32) and the outer retaining ring (31).

(3) Install the lower gearbox input worm gear (23) and both the inner retaining rings (20) on the lower gearbox input shaft (24). Insert the shaft in the gear-

box housing (27). Place the outer roller bearing (21) securely in the housing, and fasten it with the outer retaining ring (20). Press the spacer (19) in the same hole as the bearing until its outer edge is flush with the outside of the housing. Reassemble the side plate (6) to the housing.

(4) Install the lower roller bearing (14). Install the lower gearbox input worm gear (17) and both inner retaining rings (15) on the lower gearbox coupling shaft (18). Insert the shaft in its housing; mesh the input worm gear (17) with the output worm gear (23). Install the locking collar (13). Reassemble the bottom and top covers (5 and 11) to the housing (27). Install the upper roller bearing (14) and outer retaining ring (15). Reassemble the top plate (7).

(5) Reassemble the lower gearbox to the upper gearbox, joining the output shaft of the former to the input shaft of the latter with couplings (1 and 42).

93. Front and Rear Paper Rollers

(fig. 46)

a. Disassembly.

(1) Disassemble the roller bearing (2) (17, for equipments bearing serial number 313 or higher) from the right side of the front paper roller if necessary. Loosen the setscrews (3) and remove both pinwheel assemblies (5). Remove the pads (4) from the pinwheels. Remove both roller shafts (8 and 9) by driving out the pins which hold them to the roller assembly (10).

(2) Disassemble the roller bearing (2) from the left side of the rear paper roller by removing screw (11), washers (12 and 13), and retaining ring (14). Disassemble the roller bearing (2 or 17) from the right side by removing the retaining rings (1).

(3) Disassemble the pinwheels (5) from the right and left shafts. Remove the pad (4) from the pinwheel. Remove both roller shafts (8 and 16) by driving out the pins which hold them to the roller assembly (15).

b. Inspection and Replacement.

(1) Replace all roller bearings (2 or 17) with new parts if necessary.

(2) Check the condition of all pinwheels (5). Replace a wheel having damaged, bent, or worn pins.

(3) Check the condition of all roller shafts (8, 9, and 16) and the roller assemblies. Replace any parts that are scratched, worn, or scored.

c. Reassembly.

(1) Reassemble the roller shafts (8 and 16) to the roller assembly (15) with the keyways up.

(2) Insert the pads (4) in the inside holes of the pinwheels (5), in the same sides that the setscrews will be located. Place the pinwheels (with the pads trapped in place) on both roller shafts (8 and 16). Install the keys (6) and move the pinwheels into position. Tighten the setscrews (3) so that they bear against the pads, locking the pinwheels to the shafts.

Note. Check pins on both pinwheels for radial alinement; corresponding pins on both pinwheels should be alined within 1°. If alinement is inaccurate, check all the parts and replace the defective items.

(3) Install the inner retaining rings (1 and 14) on their respective roller shafts. Reassemble the bearings (2 and/or 17) to their shafts, fastening the right-hand bearing with retaining ring (1) and the left-hand bearing with washers (12 and 13) and screw (11).

(4) Reassemble both roller shafts (8 and 9) to the roller assembly (10).

(5) Install both pinwheels (5) on the front roller and shaft assembly (7), following the procedure outlined in (1) and (2) above. Check the pin alinement. Assemble the roller bearing (2 or 17) on the right-hand shaft (8) and fasten it with retaining rings (1).

94. Pulley Assemblies

Pulley assemblies (19, 20 or 21, fig. 28) should be replaced as units if more than one bearing of each assembly is worn.

a. Additional Disassembly.

(1) If necessary for replacement of individual bearings remove the roll pin (1, fig. 54) which holds the main shaft of the pulley assembly in place and withdraw the main pulley shaft (8). The countershaft pulleys (11 and 6) (upper pulley

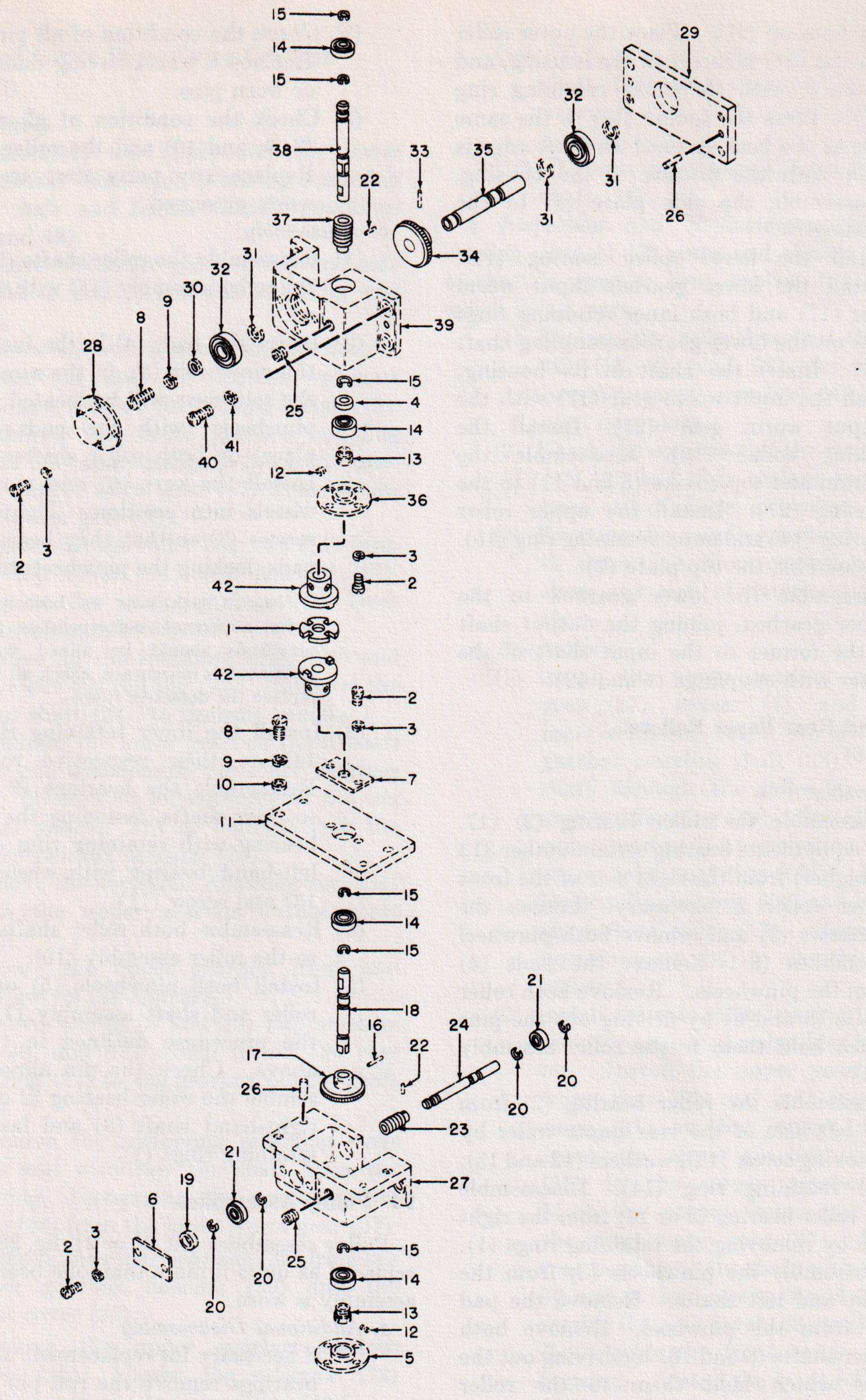


Figure 53. Upper and lower paper drive gearbox, exploded.

1 Female flexible coupling
2 Fillister-head machine screw, No. 6–32 by 5/16 inch long
3 Spring lockwasher No. 6 by .040 inch wide by .025 inch thick
4 Spacer
5 Lower gearbox bottom cover
6 Lower gearbox side plate
7 Lower gearbox top plate
8 Fillister-head machine screw, No. 10–24 by ½ inch long
9 Spring lockwasher, No. 10 by .055 inch wide by .040 inch thick
10 Plain washer, No. 10 by 7/16 inch wide by 1/32 inch thick
11 Lower gearbox top cover
12 Hexagonal socket-head setscrew, No. 6–40 by ⅛ inch long
13 Locking collar
14 Self-alining roller bearing (O639, O643)
15 Retaining ring (O641, O647)
16 Roll pin
17 Lower gearbox output worm gear
18 Lower gearbox coupling shaft
19 Spacer
20 Retaining ring (O642)
21 Self-alining roller bearing (O640)
22 Roll pin
23 Lower gearbox input worm gear
24 Lower gearbox input shaft
25 Plug
26 Dowel pin
27 Lower gearbox housing
28 Upper gearbox rear cover
29 Upper gearbox front cover
30 Special washer
31 Retaining ring (O646)
32 Self-alining roller bearing (O645)
33 Roll pin
34 Upper gearbox output worm gear
35 Upper gearbox output shaft
36 Upper gearbox bottom cover
37 Upper gearbox input worm gear
38 Upper gearbox coupling shaft
39 Upper gearbox housing
40 Fillister-head machine screw, ¼–20 by ½ inch long
41 Split lockwasher ¼ by .107 inch wide by .047 inch thick
42 Male flexible coupling

Figure 53—Continued.

assemblies only) may be disassembled from their shafts by removing the respective retaining rings (9). Withdraw the main shaft of the pulley assembly slowly, to prevent loss of any parts. To facilitate correct reassembly, place the parts side by side in the order of their removal.

(2) Remove the bearings (11, fig. 28) from the pulley bearing supports (12, 14, and 16).

b. Inspection and Replacement.

(1) Replace the bearings as necessary. Be extremely careful when installing new bearings in the supports. Never strike a bearing directly with a hammer. Place a recessed block of wood against the outer race of the bearing and tap the wood gently.

(2) Carefully check the condition of the two pins on the rear azimuth drive pulley (13, fig. 28). Replace these pins if they are bent or otherwise damaged.

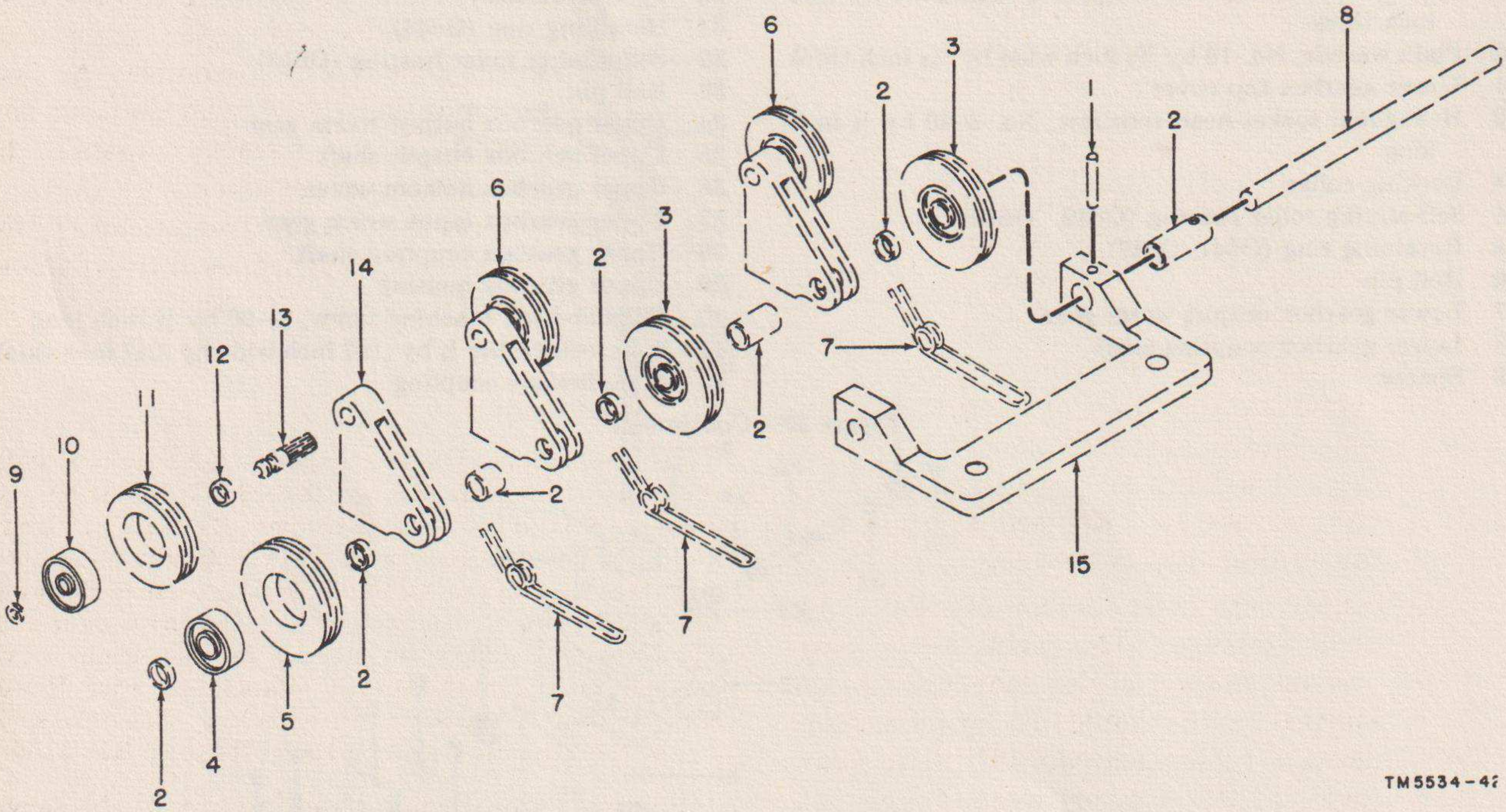
(3) Inspect all six drive pulleys (13, 15, 17, and 18) for scratches, wear, or other damages. Replace a pulley that is imperfect.

Caution: Never try to repair these pulleys if they are damaged. Any repairs will destroy the alinement of the pulley and render it useless.

(4) Examine all three pulley bearing supports (12, 14, and 16) and replace any that are damaged.

(5) Carefully check all three drive wire ropes (1, 3, and 5) for fraying, kinks, or broken strands. If a rope is damaged, replace it. New rope must be cut to the necessary length as it is installed (par. 104).

c. Reassembly. Reassemble the pulley assemblies. The spacers (2, fig. 54) between the pulleys on the main shafts must be installed in their correct relative positions. If in doubt as to correct alinement, check the detailed instructions given for restringing of wire ropes (par. 104).



1 Roll pin
2 Main shaft spacer
3 Pulley and bearing assembly
4 Self-alining roller bearing (O634)
5 Main shaft pulley
6 Bracket and pulley assembly
7 Pulley support spring
8 Main pulley shaft
9 Retaining ring
10 Self-alining roller bearing (O635)
11 Countershaft pulley
12 Countershaft spacer
13 Countershaft
14 Bracket
15 Pulley mounting bracket

Figure 54. Stylus assembly guide pulleys, exploded view.

95. Stylus Frame Lift

No special overhaul instructions are required for the stylus lift. Figure 49 shows the relationship of all parts to each other. Figure 49 should be used as a guide if replacement of any part is necessary. Refer to paragraph 84 for disassembly instructions.

96. Stylus Frame and Associated Parts
(fig. 51)

a. Additional Disassembly.

(1) Remove the cover frame (22), gasket (23), and plotting scale (24) from the stylus frame and cover assembly (26).

(2) Disassemble the frame and cover assembly (26) from the housing (18).

(3) Remove the three stylus carriage assemblies (31). Disassemble both mountings (30) from the housing (18). Disassemble the shafting (33) from the mountings by removing the roll pins (32). Remove the azimuth stylus carriage stops (29) and (34) from both mountings.

(4) Remove the knurled nuts (35), disassembling the stationary stylus (11) and its helical compression spring (12) from the housing (18).

(5) If necessary, for replacement of pulley roller bearings (16), the rope return pulleys (17) may be disassembled from the housing (18) by removing the nut (13) and washers (14 and 15).

b. Inspection and Replacement.

(1) Check the condition of all the incandescent lamps (1) and their lampholders (5). If a lamp is known to be burned out, replace it. Replace a lampholder that is damaged in any way.

(2) Inspect all three stylus carriages (fig. 5) for damage. The stylus helical compression spring, stylus loop spring, and knurled nuts should be examined for damage. Replace any of these parts that are broken or worn. The stationary stylus (11, fig. 51) its spring (12), and nuts (35) should be inspected similarly.

(3) Check the condition of the four roller bearings (16). If replacement of a bearing is necessary, disassemble the pulley from the housing (18), as directed in *a* above.

(4) Inspect the rigid shafting (33) stylus carriage stops (29) and (34) and mountings (30). The various shafts should be free of wear, bending, scratches, or other damage. Check the mountings for defects. Replace the damaged parts individually.

(5) Examine the gasket (23) and replace it if worn or broken.

(6) Check the plotting scale (24) to determine its condition. All the numbers should be visible and the markings clear. Replace a scale that is broken, cracked, or difficult to read.

c. Reassembly.

(1) Reassemble all the rope return pulleys (17) to the housing (18) if previously disassembled.

(2) Assemble the stationary stylus (11) with its spring (12) and nuts (35) to the housing.

(3) Assemble the stylus carriage stops (29 and 34) to their mountings (30). Attach the right hand mounting to the housing. Insert all shafts and fasten them with the roll pins (32). Assemble the left hand mounting (30) to the shafting and fasten it to the housing. Install the three stylus carriage assemblies (31).

(4) Attach the frame and cover assembly (26) to the housing (18). Install the plotting scale (24), gasket (23), and cover frame (22).

97. Servo Units

Note. The following information is applicable to both the Azimuth-Elevation-Range Recorder RO–3/MPQ and Azimuth-Elevation-Range Recorder RD–54/TP. However, the detailed gear train for the height and range gearboxes used on the Azimuth-Elevation-Range Recorder RO–3/MPQ is not identical to that shown in figure 55. The COARSE control transformer for the height servo unit on the Azimuth-Elevation-Range Recorder RO–3/MPQ is nearest the servo drive motor. The reverse is true on the Azimuth-Elevation-Range Recorder RD–54/TP.

Be very careful when handling any of the servo units and when performing overhaul operations. Improper treatment will destroy the accuracy of these units and render them useless. Under no circumstances should repairs be attempted except at a depot. Since the three servo units are basically the same, the disassembly, inspection, replacement, and reassembly instructions which follow are applicable to all. Perform no further disas-

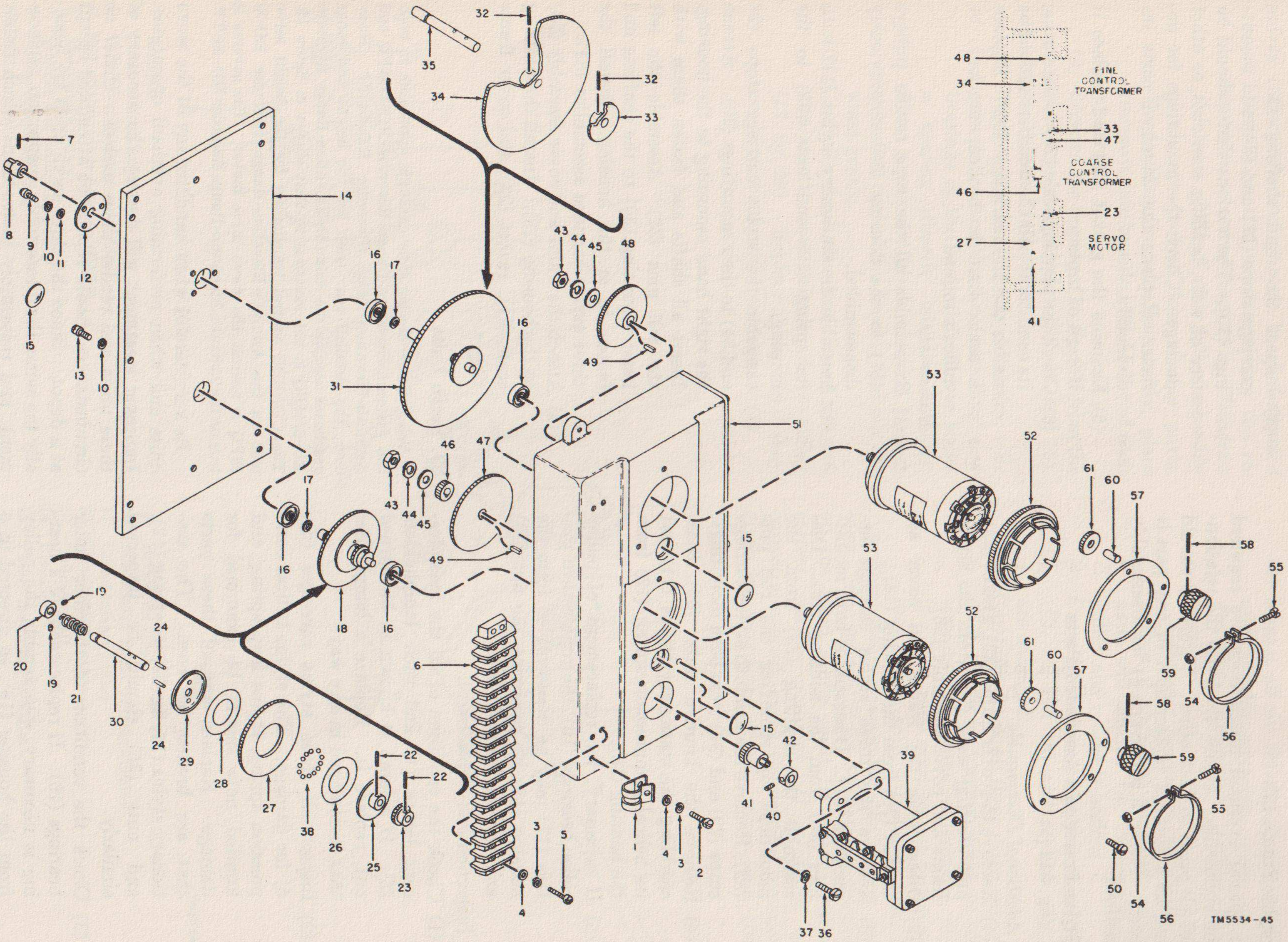


Figure 55. Servo gearbox assembly, exploded view.

1 Cable clamp
2 Fillister-head machine screw, No. 6–32 by ⅜ inch long
3 Split lockwasher, No. 6 by .040 inch wide by .025 inch thick
4 Flat washer, No. 6 by 5/16 inch OD by .028 inch thick
5 Fillister-head machine screw, No. 6–32 by ⅝ inch long
6 Terminal board (E605, E606, and E607)
7 Roll pin
8 Coupling
9 Fillister-head machine screw, No. 8–32 by 5/16 inch long
10 Split lockwasher, No. 8 by .047 inch wide by .031 inch thick
11 Flat washer, No. 8 by ⅜ inch OD by .032 inch thick
12 Bearing plate
13 Fillister-head machine screw, No. 8–32 by ⅜ inch long
14 Bottom plate
15 Expansion plug
16 Self-alining roller bearing
17 Ring
18 Clutch and gear assembly
19 Hexagonal socket-head cup point setscrew, No. 6–40 by ⅛ inch long
20 Collar
21 Spring
22 Roll pin
23 Pinion
24 Pin
25 Clutch
26 Clutch facing
27 Gear
28 Clutch facing
29 Clutch disk
30 Shaft
31 Gear and shaft assembly
32 Roll pin
33 Gear
34 Gear
35 Shaft
36 Fillister-head machine screw, No. 8–32 by ⅝ inch long
37 Split lockwasher, No. 8 by .047 inch wide by .031 inch thick
38 Steel balls
39 Motor (B608, B609, and B610)
40 Hexagonal socket-head cup point setscrew, No. 6–40 by ⅛ inch long
41 Pinion
42 Collar
43 Hexagonal nut, ¼–28 by 7/16 inch
44 Split lockwasher, ¼ by .107 wide by .047 inch thick
45 Flat washer, ¼ by 9/16 inch OD by 3/64 inch thick
46 Pinion
47 Gear
48 Gear
49 Key
50 Binding head machine screw, No. 6–32 by ⅝ inch long
51 Housing
52 Clamp gear
53 Synchro control transformer (B602, B603, B604, B605, B606, and B607)
54 Hexagonal nut, No. 6–32 by ¼ inch
55 Fillister-head machine screw, No. 6–32 by ⅜ inch long
56 Clamp
57 Clamp ring
58 Roll pin
59 Knob
60 Shaft
61 Pinion

Figure 55—Continued.

sembly than that described, since only control transformers, the motor, and terminal boards are replaceable.

a. Terminal Board. Tag and disconnect all electrical leads from the motor (39, fig. 55), the control transformer (53), and from the right bank of the connectors on the terminal board (6). Remove the terminal board.

b. Motor. To remove the motor, remove the screws, and lockwashers (36), and (37) from the motor mounting base corners. Draw the motor straight away from the gearbox so that the shaft pinion (41) clears the motor mounting hole on the gearbox.

c. Synchro Control Transformers. It will be necessary to disassemble the servo gearbox partially before a control transformer can be removed. The flat washer, lockwasher, and shaft nut (45, 44, and 43) will not clear the teeth of the gear and shaft assembly (31), and the gears (27 and 48) will not clear the hole in the servo gearbox.

(1) Remove the gearbox side cover by removing the seven sets of screws, lockwashers, and flat washers which hold the cover to the box. Lay the cover plate aside.

(2) Reach inside the gearbox with a 7/16-inch open-end wrench and loosen the shaft nut (43) on the fine synchro control transformer shaft. Remove the nut and its lockwashers (44) and flat washers (45).

(3) Remove the gearbox bottom plate screws and lockwashers (13 and 10). Draw the bottom plate straight away from the housing. Clutch and gear assembly (18) and gear and shaft assembly (31) will be removed with the plate.

(4) If the fine synchro transformer (53) is to be replaced, proceed as follows:

(*a*) Remove the key (49) and slide the pinion (46) and the gear (47) off the fine transformer shaft.

(*b*) Remove the three binding head screws (50). The transformer is now free.

(*c*) Loosen the clamp (56) by means of the clamp screw (55).

(*d*) Push the transformer through the ring assembly (57 through 61, 51, and 52).

(*e*) Replace the transformer and assemble it in reverse order.

(5) If the coarse synchro transformer is to be replaced, proceed as follows:

(*a*) Repeat the procedure outlined in (1), (2), (3) above.

(*b*) Remove the coarse synchro shaft nut, lockwashers, and flat washers (43, 44, and 45).

(*c*) Remove the coarse synchro transformer and repeat the procedures given in (4)(*b*) through (4)(*e*) above.

d. Test After Reassembly. Before reinstalling any of the three servo units to the Azimuth-Elevation-Range Recorder RD-54/TP, various tests should be made to insure that these components will be operating properly.

(1) Each servo unit must be subjected to three major tests before reinstallation. The tests are as follows:

(*a*) Backlash requirements.

(*b*) Slip clutch tension.

(*c*) Running voltage.

(2) The backlash requirements test procedure is as follows:

Note. On the Azimuth-Elevation-Range Recorder RO–3/MPQ, do not make measurements on the coarse synchro shaft of the height servo unit.

(*a*) Clamp the fine or coarse synchro shaft (depending on the backlash measurement to be made) in a fixed position relative to the servo unit housing.

(*b*) Mount a radius bar on the output shaft and mount a dial indicator at a point 5 inches from the shaft center.

Caution: Extreme care should be taken to make sure that there is no backlash in the radius bar arrangement with respect to the output shaft.

(*c*) Use a spring scale and deflect the radius bar to its extreme with a torque of approximately 10 ounce-inches in each direction. The total deflection of the shaft as read on the dial indicator should be no greater than the following:

Fixed shaft	*Total deflection (in.)*
Height, fine	.0088
Height, coarse	.0260
Range, fine	.0050
Azimuth, fine	.0050

(3) The slip clutch tension test procedure is as follows:

(*a*) The slip clutches are adjusted by loosening or tightening the setscrews on the slip clutch collars. These collars, when moved, vary the tension on the pressure spring.

(*b*) Clamp the motor shaft to the gearbox case with any convenient clamp.

(*c*) Connect a torque wrench to the output shaft. The torque wrench should have a calibrated dial or indicator to show the amount of torque applied.

(*d*) The slip clutch is adjusted correctly when the output shaft turns at 10 inch-pounds, ±2½ inch-pounds.

(4) The final test on the servo unit, prior to reinstallation on the Azimuth-Elevation-Range Recorder RD–54/TP and/or RO–3/MPQ, consists of a running voltage test. The running voltage test is used to determine whether the servo unit is clean and free from noise. Proceed as follows:

(*a*) Connect 120 volts, 60 cycles, single-phase, ac, to terminals 1 and 3 of the servo motor.

(*b*) Use a voltage regulating device and connect a variable voltage through a series 2-μf capacitor to the motor control field, terminals 2 and 4, of the servo motor. Correct operation is indicated when the gearbox will run on less than 10 volts of signal applied to terminals 2 and 4.

(*c*) A further test can be made by connecting 110 volts, 60 cycles, single-phase, ac, to terminals 1 and 3 of the servo motor. Start the servo unit turning in either direction. The motor should continue to run without further aid.

98. Miscellaneous Parts

a. Platen. Inspect the platen (fig. 14) for scratches, dents, or other damage. Remove small burrs or ridges with fine sandpaper. Replace a platen that is broken, dented, or severely bent.

b. Housings. Carefully examine the recorder housings for bends, cracks, or breaks. Replace parts of the housing, as necessary, if damaged.

Section V. REASSEMBLY OF MAJOR PARTS

99. Miscellaneous Parts

a. Housings. If previously disassembled, reassemble the center support housing, side housings, and tie rods.

b. Platen. Reassemble the platen to the housing.

100. Servo Units

Caution: Exercise extreme care when handling all servo units.

a. Mount each of the servo units on the center housing.

b. Reconnect all electrical leads to their proper terminals. Connect each cable clamp to its gearbox.

101. Stylus Frame and Associated Parts

Reassemble the stylus housing (18, fig. 51) to the recorder housing by attaching the hinge arm supports (10).

102. Stylus Frame Lift

a. Trip the latch which holds the stylus frame to the right housing. Raise the entire stylus frame as high as possible and prop it securely in place.

b. Connect both stylus frame lift connecting rods (14, fig. 49) to their pistons (15) by inserting the roll pins (13).

c. Fasten the stylus frame lift assembly to the recorder housing.

d. Remove the prop which was used to hold up the stylus frame. Adjust the stylus frame lift to hold the weight of the stylus frame. Turning bolts (5, fig. 49) inward will increase spring compression and provide additional support.

e. Adjust the bolts (5) evenly so that both sets of springs support approximately equal loads.

103. Pulley Assemblies

Note. Throughout this paragraph *front* is used as referring to the front of the recorder assembly. *Clockwise* and *counterclockwise* directions are as viewed from the rear of the recorder assembly.

a. Reassemble both the pulley assemblies (20 and 21, fig. 28) to the recorder housing.

b. Install the pulley bracket assembly (19).

c. Reassemble the azimuth sensitive switches to their mounting bracket. Attach the sensitive switch support bracket to the azimuth pulley bearing support (12).

d. Place the coupling clamp on the azimuth drive pulley assembly shaft. Slip the azimuth drive pulley assembly shaft into the servo unit output coupling and, at the same time, seat the other end of the shaft in the bearing in the azimuth bearing support (12). Fasten the bearing support securely to the center housing. Tighten

the clamp between the pulley shaft and the servo unit output shaft.

e. Install the range drive pulleys (15) and their bearing supports (14) in the same manner (*d* above).

f. Install the height drive pulleys (17 and 18) and their bearing support (16) (*d* above).

g. Turn the wire rope adjusting nuts (7) of all pulleys until the screws are extended fully.

104. Wire Rope, Pulleys, and Stylus Carriage Assembly

a. Installation of Azimuth Wire Rope. Remove cover plate (19, fig. 51) by removing the appropriate screws and lockwashers.

(1) Using a wire rope of the correct length and with preformed end loops, mount the stylus carriage assembly at the approximate center of the wire. Leave the stylus carriage assembly loose on the wire so that it can be moved during final adjusting.

(2) Mount the stylus carriage between the appropriate guide shafts (fig. 50).

(3) Feed the wire rope through the appropriate slot in the left hand mounting (30, fig. 51), around the azimuth return pulley (17), and back through the slot in the mounting.

(4) Feed the two ends of the wire rope through the second and third pulley groups, as viewed from the rear recorder assembly, in pulley assemblies (20 and 21, fig. 28) and the pulley bracket assembly (19).

(5) Attach the front wire rope to the front azimuth drive pulley (13); feed the rope above the azimuth pulley shaft. Attach the rear wire rope to the rear azimuth drive pulley; feed the wire under the azimuth drive shaft. Adjust the nuts (7) to provide enough tension to prevent the wire rope from falling off the guide pulleys.

b. Installation of Range Wire Rope. Mount the stylus carriage assembly on a wire rope of the correct length and having preformed ends. Leave the stylus carriage assembly loose on the wire rope for further adjustment in final test.

(1) Position the stylus carriage between the appropriate guide shafts (fig. 50).

(2) Feed the wire rope through the appropriate slot in the left hand mounting (30, fig. 51), around the range return pulleys (17), and through the front slot in the left hand mounting.

(3) Feed the wire rope down through the first and fourth pulley groups, as viewed from the rear of the recorder assembly, in pulley assemblies (20 and 21, fig. 28) and pulley bracket assembly (19).

(4) Connect the front wire rope to the front range drive pulley (15); feed the wire under the shaft. Connect the rear wire rope to the rear range drive pulley; feed the wire over the range drive shaft.

(5) Tighten the adjusting nut (7) sufficiently to prevent the wire from falling off the pulley.

c. Installation of Height Wire Rope. Mount the stylus carriage assembly on the wire rope of the appropriate length and with preformed ends. Leave the stylus carriage assembly loose on the wire rope for adjustment and final testing.

(1) Position the stylus carriage assembly between the appropriate guide shafts (fig. 50).

(2) Feed the wire rope through the appropriate slot in the left hand mounting, around the height return pulley (17, fig. 51), and through the rear slot in the left hand mounting.

(3) Feed the wire rope through the fifth and sixth pulley groups, as viewed from the rear of the recorder assembly in pulley assemblies (20 and 21, fig. 28) and pulley bracket assembly (19).

(4) Connect the front wire rope to the front height drive pulley (18); feed the wire under the shaft. Connect the rear wire rope to the rear height drive pulley (17); feed the wire over the shaft.

(5) Tighten the adjusting nut (7) sufficiently to prevent the wire from leaving the drive shaft.

(6) Replace the cover plate (19, fig. 51).

d. Adjustment of Wire Rope, Pulleys, and Stylus Carriage Assembly. With the stylus frame in its lowered position, adjust the tension nuts (7, fig. 28) until the wire ropes are reasonably tight (par. 20).

(1) Zero in the equipment as outlined in paragraph 22 except that the stylus should be positioned at exactly zero since it is positioned loosely on the wire rope.

(2) Loosen the coupling between the drive pulley shaft and the servo unit output

shaft on all three channels. With the units operating and zeroed, rotate the drive pulleys until the wire rope is played out to the appropriate end.

(3) Tighten the coupling.

Caution: Make sure that there is approximately 1¼ inches of wire laid flat in the pulley groove before the wire rope leaves the pulley groove toward the pulley bracket assembly.

(4) Move the stylus carriage assembly on the wire rope until it is approximately at zero.

(5) Turn off the servo amplifier of the applicable channel and, holding the stylus carriage assembly fixed with the wire rope, move the stylus carriage to the center of the board, moving the drive pulleys along with it.

(6) Slide the stylus carriage assembly out of the guide shaft and tighten the four screws on the clamp plate which are used to fasten the stylus carriage assembly to the wire rope.

(7) Return the stylus carriage to the zero position, and turn on the channel servo amplifier.

(8) The stylus now should be positioned at zero. If it is off by less than one-eighth of an inch, reset the stylus as instructed in the initial adjustment (par. 22).

(9) If the adjustment is off by more than one-eighth of an inch, repeat the steps outlined in (5) through (8) above.

(10) Repeat the above steps for the other two channels.

105. Overrunning Clutch and Paper Rollers

a. Assemble the rear paper roller (fig. 15) to the recorder side housings.

b. Place the front paper roller (fig. 44) in position between the recorder side housings. Assemble the overrunning clutch to the front paper roller with the setscrew. Install the bearing retainer.

106. Paper Drive Gearboxes

Assemble the output shaft of the upper paper drive gearbox (35, fig. 53) to the overrunning clutch. Fasten both gearboxes to the left housing. Key the gearbox output shaft to the overrunning clutch by inserting the appropriate pin.

Caution. To avoid damaging the paper drive pins of the front paper roller, place a block of wood under the roller when installing the pin.

107. Paper Drive Mechanism

a. Install the spacer (55, fig. 52), the male clutch (54) and the clutch facing (53) on the lower gearbox input shaft, anchoring these parts with roll pin (52).

b. Assemble the paper drive mechanism to the left hand housing by attaching the mounting bracket with the screws and washers (fig. 44).

c. Reconnect all electrical leads.

d. When all other parts of the recorder have been installed, adjust the speed of the paper travel (par. 21).

108. Paper Holders, Paper Well Clutch, and Associated Parts

a. Install the paper well clutch stop (3, fig. 43).

b. Assemble the right hand paper holder (30) to the recorder side housing; fasten with retaining ring (29).

c. Place the paper well clutch (18) in position in the hole in the left side housing, but do not fasten. Install the left hand paper holder (9), raising the paper well clutch slightly to allow its shaft to pass through the hole in the clutch frame and then engage with the clutch lever (22).

d. Fasten the paper well clutch to the left side housing. Test the paper well clutch, paper well clutch stop, and both paper holders to determine whether or not they are operating correctly.

109. Recorder Covers

(fig. 13)

Install the guide pulley cover, the paper well cover, and the front paper roll cover. No special instructions are required, except that the captive screws which lock these covers down should be installed after attaching the covers to the housing.

110. Recorder Assembly in Console

a. Carefully roll the recorder assembly into place in the console. Insert the screws and washers which hold the top of the recorder assembly to the console.

b. Reconnect all electrical leads.

c. Install the top front crossmember of the console assembly.

d. Install the four screws that hold the two vertical brackets to the console shelf. Close the two control panels.

e. Install the upper front access panel.

302513 O—54——7

CHAPTER 7

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

111. Repacking for Shipment or Limited Storage

The exact procedure in repacking for shipment or limited storage depends on the material available and the conditions under which the equipment is to be shipped or stored. Reverse the instructions given in paragraph 12.

112. Protective Packaging

Whenever practicable, place a dehydrating agent such as silica gel inside the waterproof barrier. Protect the equipment with a waterproof paper barrier. Seal the seams of the paper barrier with waterproof sealing compound or tape. Pack the protected box in a padded wooden case, providing at least 3 inches of excelsior padding or some similar material between the paper barrier and the packing case.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

113. General

The demolition procedures outlined below will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

114. Methods of Destruction

a. Smash. Smash capacitors, transformers, resistors, the stylus frame lift assembly, the recorder frame, the servo gearboxes, paper drive gearbox, the recorder castings, vacuum tubes, sockets, plugs, and other components in the servo amplifiers. Use sledges, axes, handaxes, pickaxes, hammers, crowbars, or other heavy tools.

b. Cut. Cut wiring; use axes, handaxes, or machetes.

c. Burn. Burn all paper rolls, technical manuals, records and forms, resistors, capacitors, and transformers; use gasoline, kerosene, oil, flamethrowers, or incendiary grenades.

d. Bend. Bend all chassis, panels, and covers.

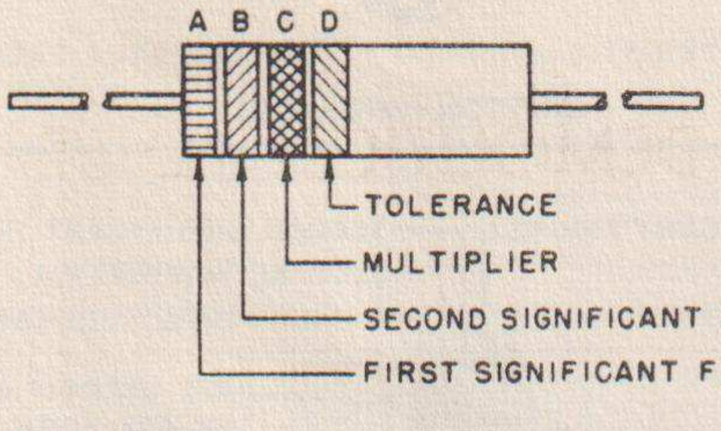
e. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

f. Disposal. Bury or scatter the destroyed parts in slit trenches, foxholes, or other holes, or throw them into a stream.

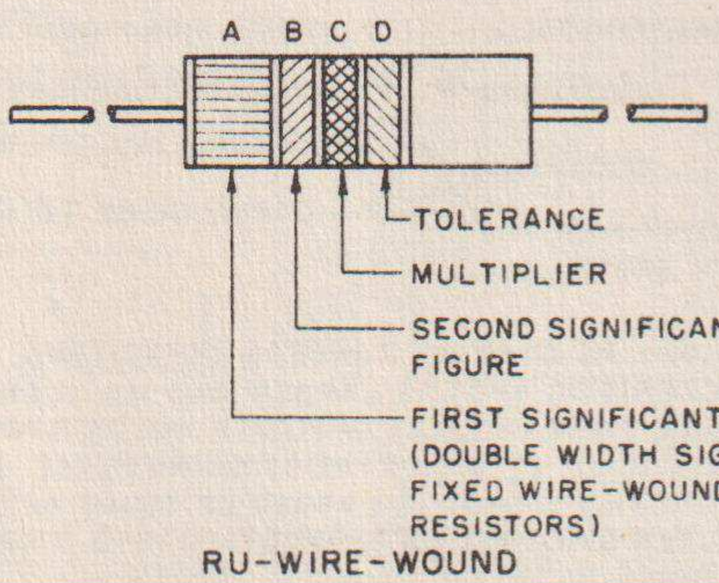
g. Destroy. Destroy everything.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)

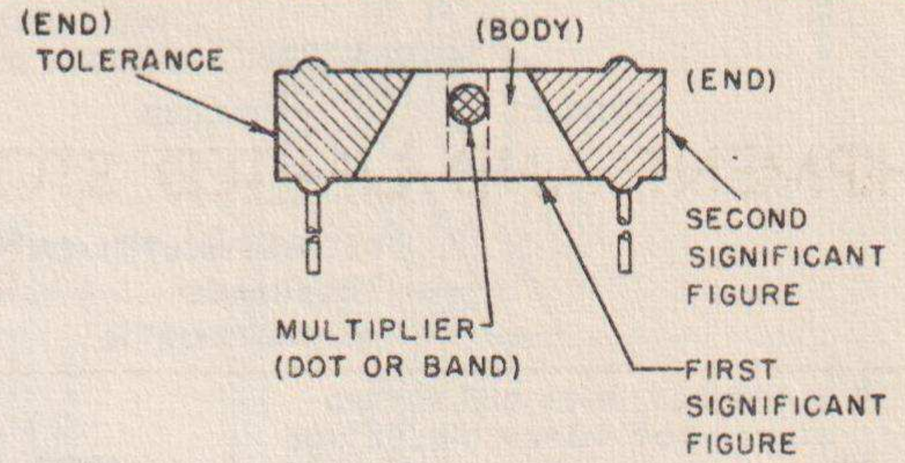


RC-COMPOSITION

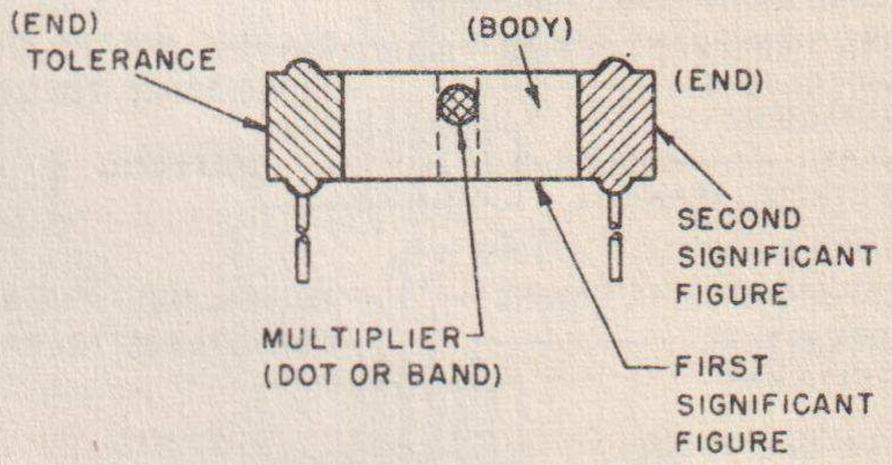


RU-WIRE-WOUND

RADIAL-LEAD RESISTORS (UNINSULATED)



RZ-COMPOSITION



RZ-COMPOSITION

RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

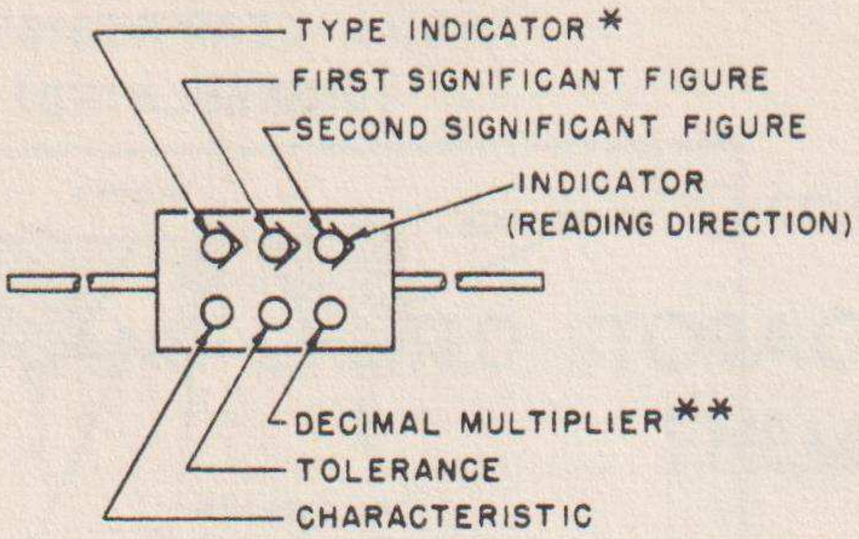
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-RI

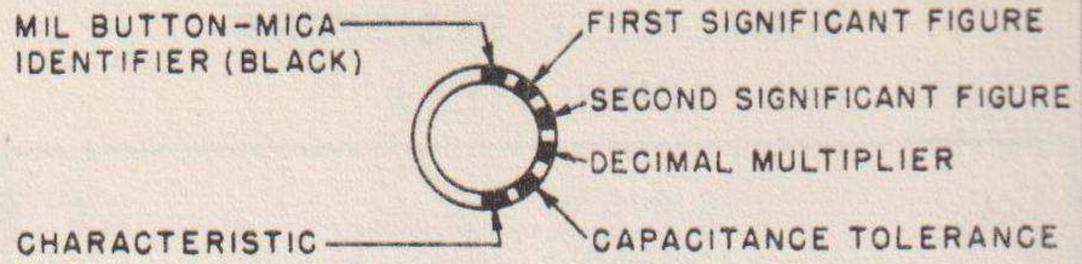
Figure 56. Resistor color codes.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)

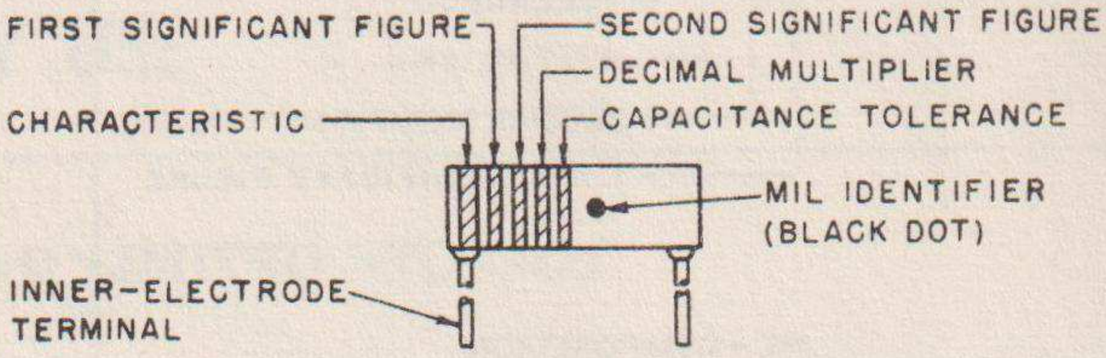


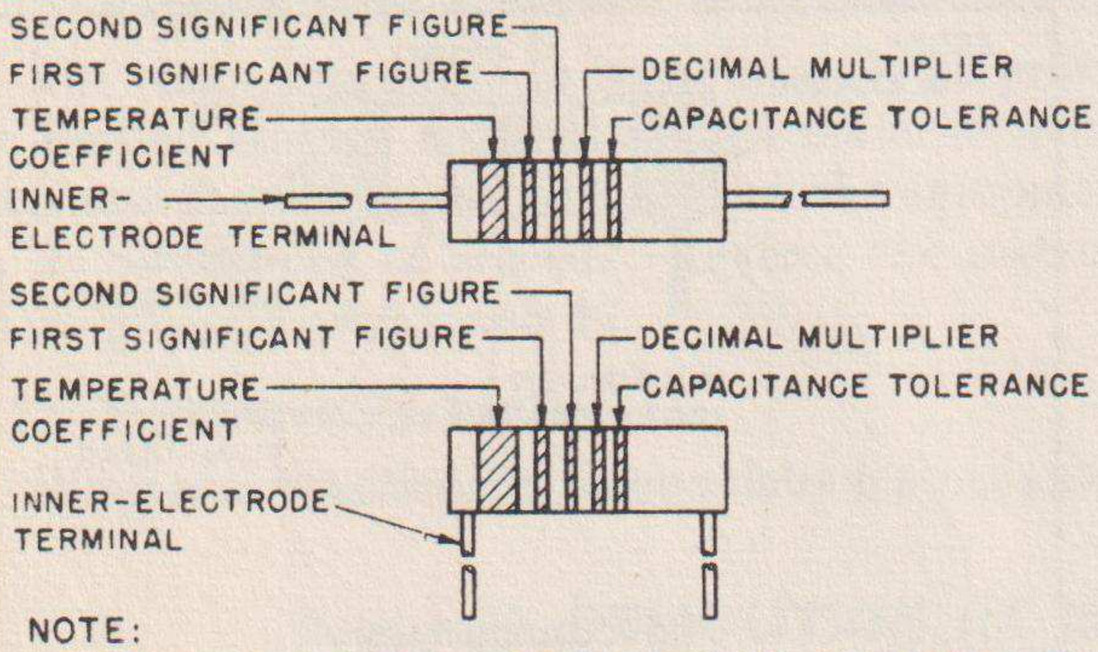
* BLACK DOT: MICA DIELECTRIC
SILVER DOT: PAPER DIELECTRIC
** INDICATES NUMBER OF ZEROS ON PAPER TYPE.

MICA (CM) AND PAPER (CN)



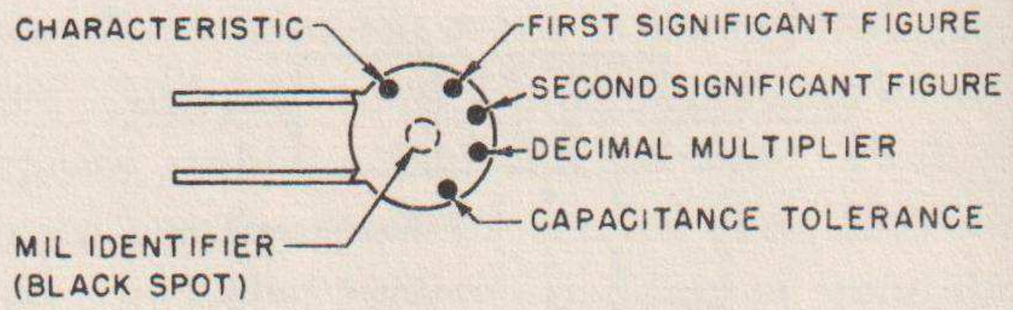
BUTTON-MICA (CB)





NOTE:
SPOTS MAY BE USED INSTEAD OF BANDS; TEMPERATURE COEFFICIENT MARKING IS LARGER.

CERAMIC-TEMPERATURE COMPENSATING (CC)



NOTES:
1. SPOTS MAY BE USED ON TUBULAR CAPACITORS; CHARACTERISTIC SPOT IS LARGER AND MIL IDENTIFIER IS ON SIDE DIAMETRICALLY OPPOSITE COLOR SPOTS.
2. MIL IDENTIFIER OF DISK TYPE IS ON REVERSE SIDE; CHARACTERISTIC SPOT IS LARGER OR SPACE BETWEEN CHARACTERISTIC AND TOLERANCE SPOTS IS THREE TIMES SPACE BETWEEN ADJACENT SPOTS.
3. TOLERANCE: YELLOW, +100%, -20%.

CERAMIC-GENERAL PURPOSE (CK)

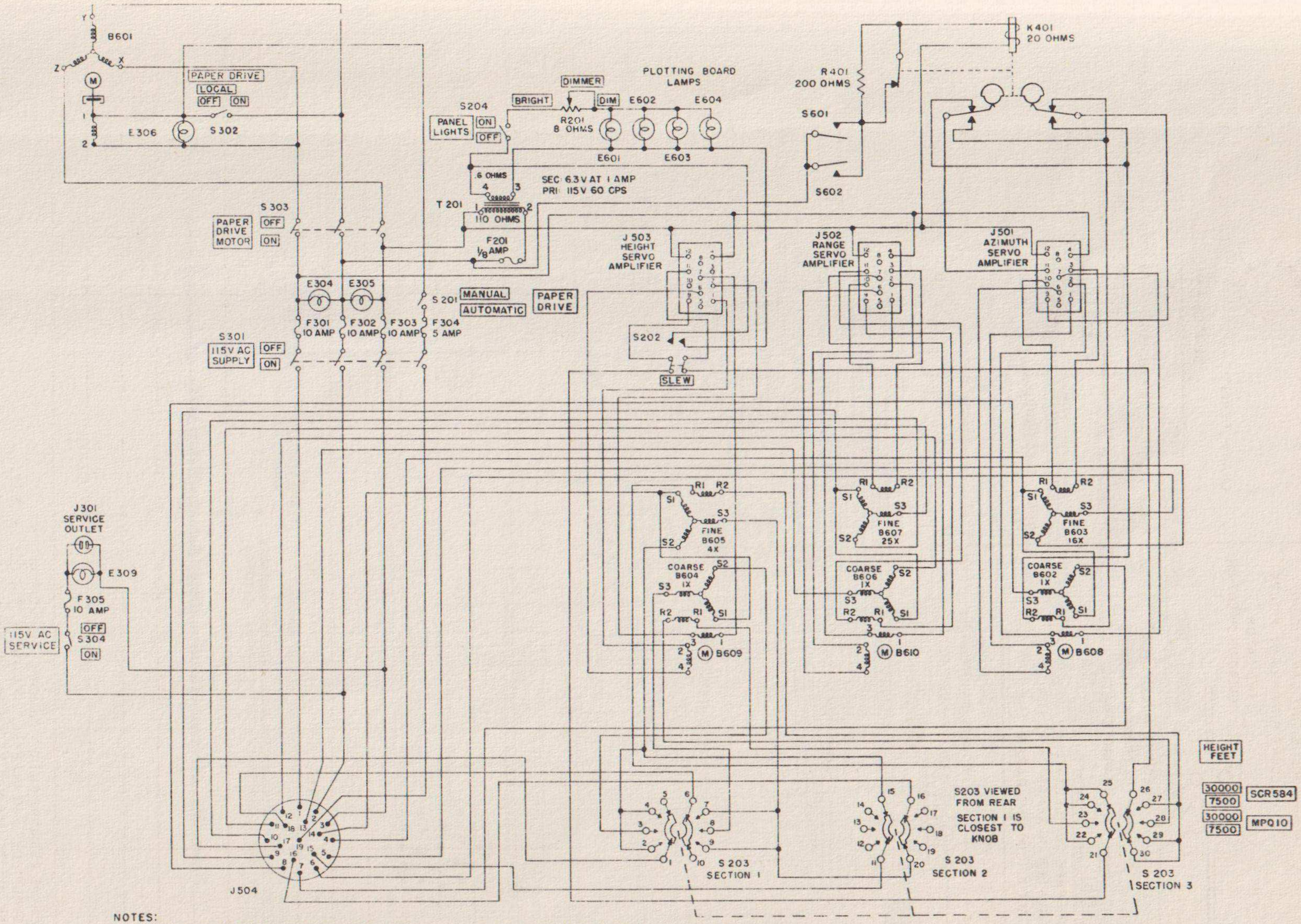
CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE 2					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC OVER 10UUF	CC 10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500) [3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-CI

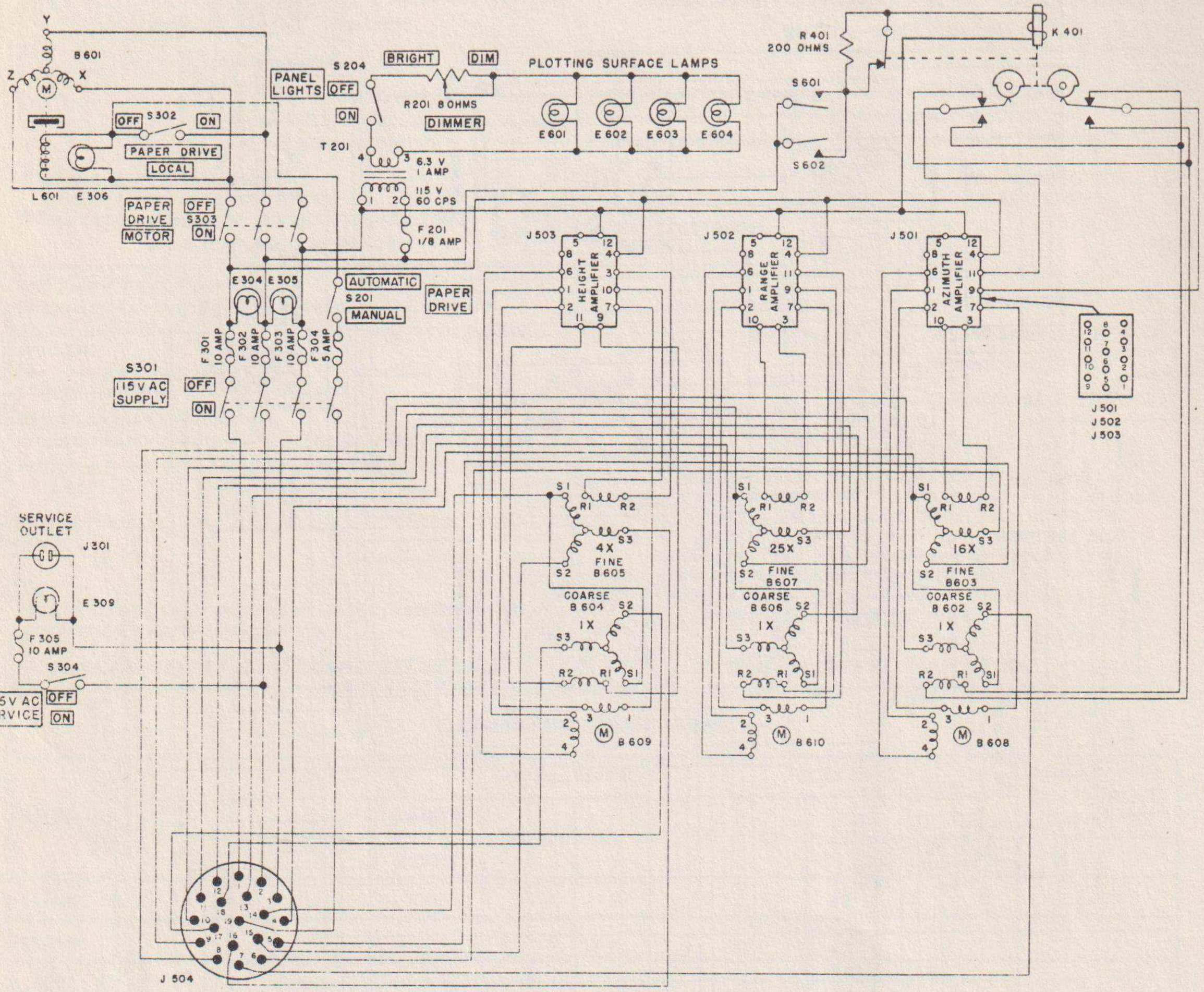
Figure 57. Capacitor color codes.



NOTES:

1. SHAFT OF HEIGHT MOTOR B609 DRIVES ROTORS OF HEIGHT CONTROL TRANSFORMERS B604 AND B605. RANGE MOTOR B610 AND AZIMUTH MOTOR B608 PERFORM SIMILAR FUNCTIONS FOR B606, B607, B602 AND B603.
2. LIMIT SWITCH S601 OR S602 IS CONTROLLED BY THE STYLUS AT EITHER END OF ITS TRAVEL.
3. PAPER DRIVE AUTOMATIC-MANUAL SWITCH S201 IS SHOWN IN THE MANUAL POSITION.
4. HEIGHT FEET SWITCH S203 IS SHOWN IN THE MPQ10-7500 POSITION.

Figure 58. Azimuth-Elevation-Range Recorder RD-54/TP, schematic diagram.

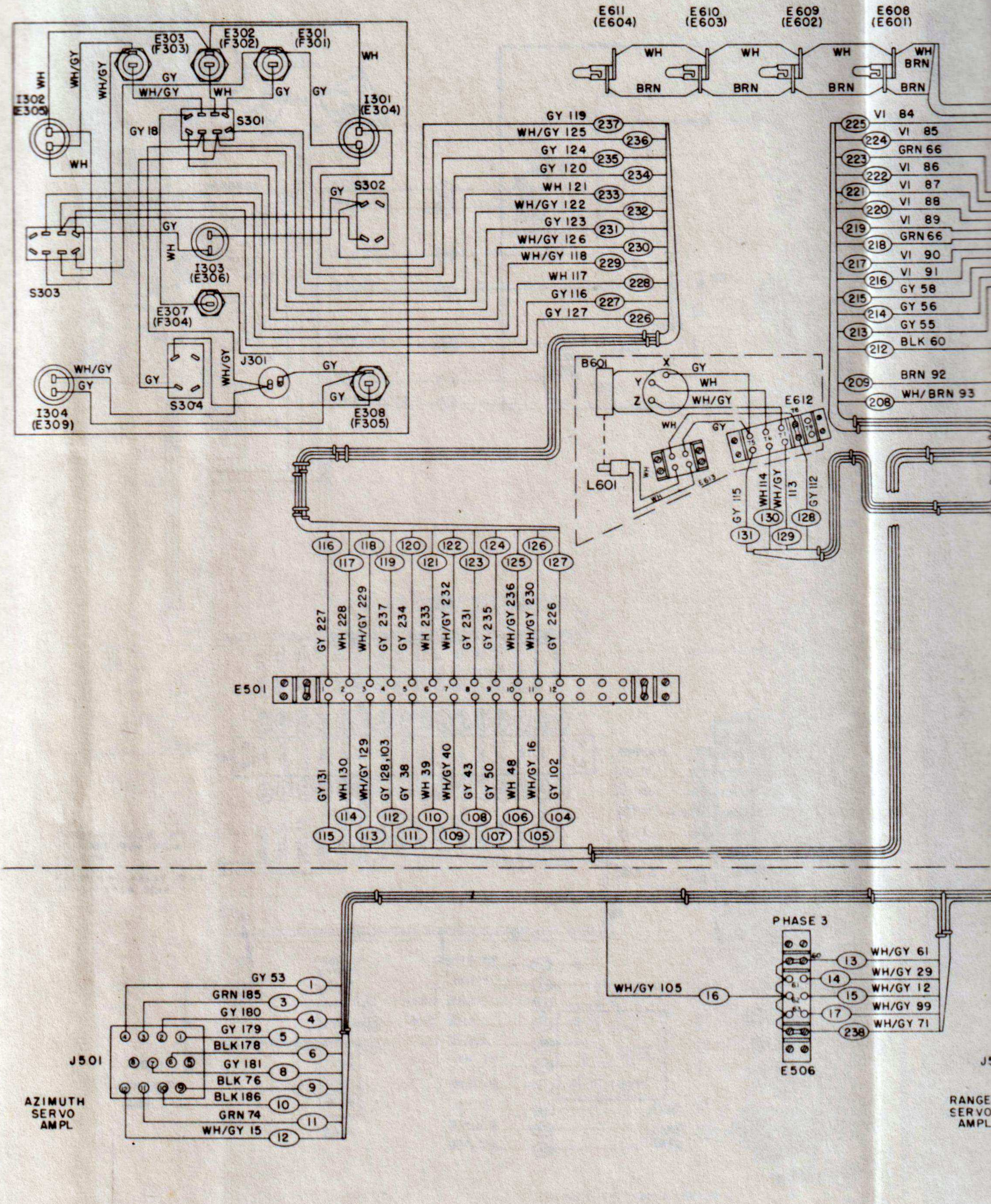


NOTES:

1. SHAFT OF HEIGHT MOTOR B609 DRIVES ROTORS OF HEIGHT CONTROL TRANSFORMERS B604 AND B605. RANGE MOTOR B610 AND AZIMUTH MOTOR B608 PERFORM SIMILAR FUNCTIONS FOR B606, B607, B602 AND B603.
2. LIMIT SWITCH S601 OR S602 IS CONTROLLED BY THE STYLUS AT EITHER END OF ITS TRAVEL.
3. PAPER DRIVE AUTOMATIC-MANUAL SWITCH S201 IS SHOWN IN THE MANUAL POSITION

TM5534-74

Figure 59. Azimuth-Elevation-Range Recorder RO-3/MPQ, schematic diagram.


E611 (E604)
E610 (E603)
E609 (E602)
E608 (E601)
WH
BRN
E303 (F303)
E302 (F302)
E301 (F301)
WH/GY
GY
I302 (E305)
I301 (E304)
S301
GY 18
S302
S303
I303 (E306)
E307 (F304)
I301
J301
I304 (E309)
S304
E308 (F305)
GY 119
WH/GY 125
GY 124
GY 120
WH 121
WH/GY 122
GY 123
WH/GY 126
WH/GY 118
WH 117
GY 116
GY 127
237
236
235
234
233
232
231
230
229
228
227
226
VI 84
VI 85
GRN 66
VI 86
VI 87
VI 88
VI 89
GRN 66
VI 90
VI 91
GY 58
GY 56
GY 55
BLK 60
BRN 92
WH/BRN 93
225
224
223
222
221
220
219
218
217
216
215
214
213
212
209
208
B601
X
Y
Z
L601
E612
E613
GY 115
WH 114
WH/GY 113
GY 112
131
130
129
128
116
117
118
119
120
121
122
123
124
125
126
127
GY 227
WH 228
WH/GY 229
GY 237
GY 234
WH 233
WH/GY 232
GY 231
GY 235
WH/GY 236
WH/GY 230
GY 226
E501
GY 131
WH 130
WH/GY 129
GY 128,103
GY 38
WH 39
WH/GY 40
GY 43
GY 50
WH 48
WH/GY 16
GY 102
115
114
113
112
111
110
109
108
107
106
105
104
PHASE 3
WH/GY 61
WH/GY 29
WH/GY 12
WH/GY 99
WH/GY 71
WH/GY 105
13
14
15
16
17
238
E506
GY 53
GRN 185
GY 180
GY 179
BLK 178
GY 181
BLK 76
BLK 186
GRN 74
WH/GY 15
1
3
4
5
6
8
9
10
11
12
J501
AZIMUTH SERVO AMPL
RANGE SERVO AMPL

E608
(E601)

WH
WH
BRN
BRN
BRN

HEIGHT SERVO GEARBOX

E605

B604

B605

B609

RANGE SERVO GEARBOX

E607

B606

B607

B610

VI 84
VI 85
GRN 66
VI 86
VI 87
VI 88
VI 89
GRN 66
VI 90
VI 91
GY 58
GY 56
GY 55
BLK 60
BRN 92
WH/BRN 93
WH/BRN
BRN

BLK 26
GRN 28
GRN 32
GRN 37
GRN 41
BLK 27
GRN 20
GRN 32
GRN 34
GRN 36
GY 25
GY 21
GY 22
BLK 23

VI 75
VI 73
GRN 42
GRN 47
GRN 30
BLK 10
GRN 3
GRN 42
GRN 45
GRN 46
GY 8
GY 4
GY 5
BLK 6
GY 72
GY 83

E502

GY 158
GY 157
GRN 159
BLK 160
WH/GY 153

GY 112
GY 104
GRN 62
BLK 63
WH/GY 17

WH 106

PHASE 2

E505

WH 98

WH/GY 61
WH/GY 29
WH/GY 12
WH/GY 99
WH/GY 71

J502

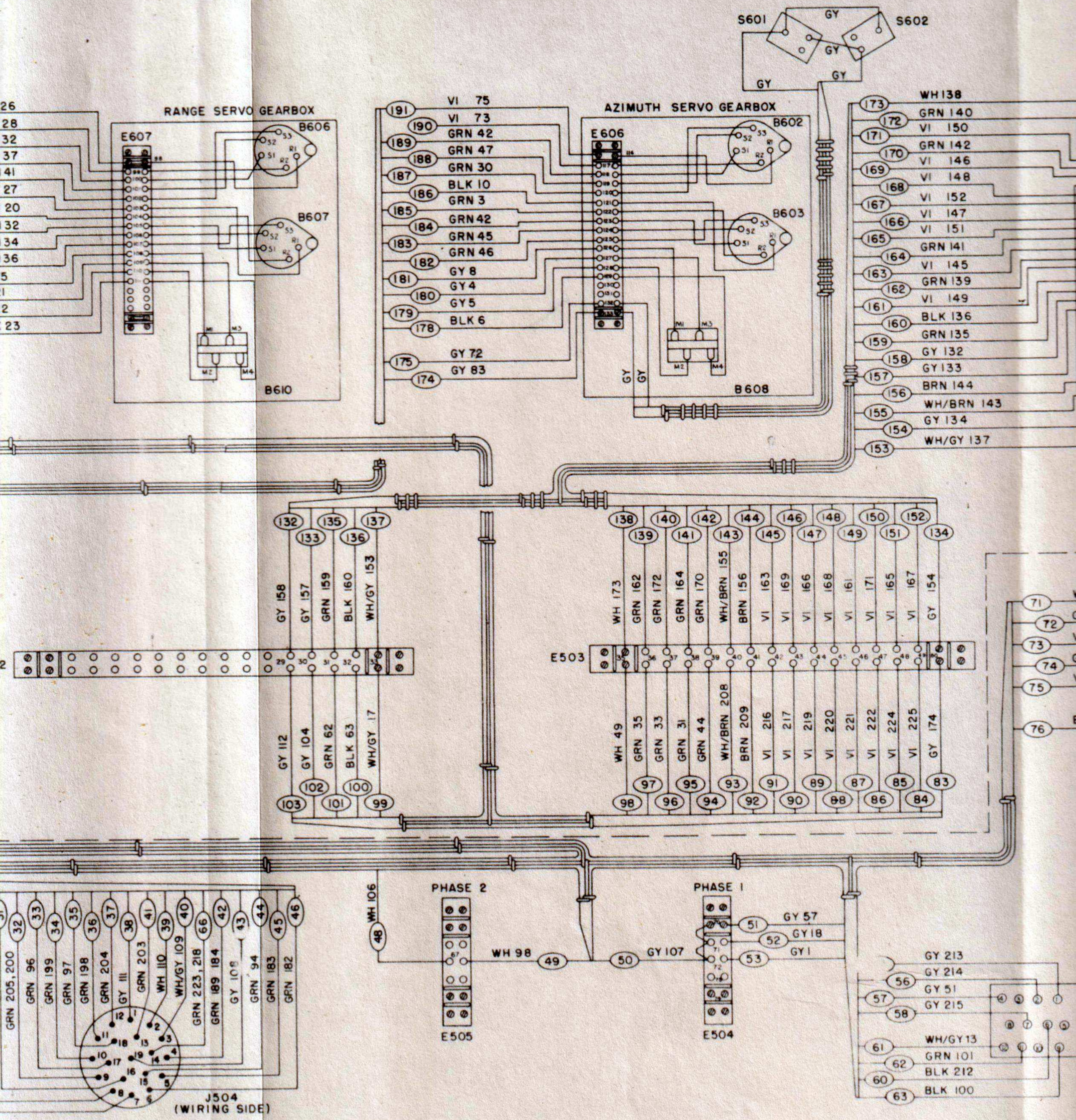
RANGE
SERVO
AMPL

GY 52
GRN 201
GY 196
GY 195
BLK 194
GY 197
BLK 207
BLK 202
GRN 206
WH/GY 14

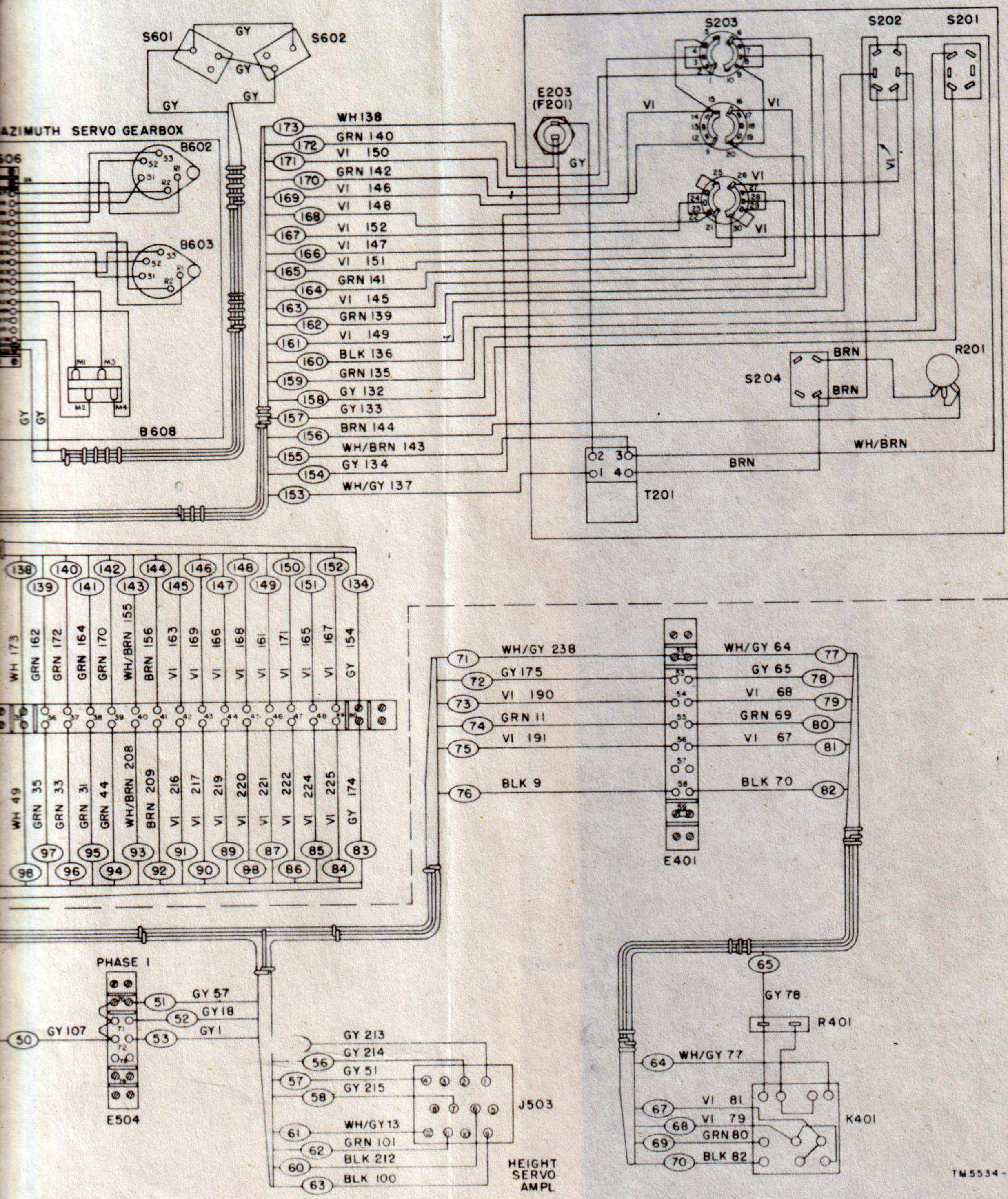
GRN 188
GRN 187
GRN 95
GRN 205, 200
GRN 96
GRN 199
GRN 97
GRN 198
GRN 204
GY 111
GRN 203
WH 110
WH/GY 109
GRN 223, 218
GRN 189 184
GY 108
GRN 94
GRN 183
GRN 182

J504
(WIRING SIDE)

Figure 60. Azimuth-Elevation-Range Recorder RD-54/TP, wiring diagram.



Elevation-Range Recorder RD-54/TP, wiring diagram.


S601
S602
GY
GY
GY
GY
AZIMUTH SERVO GEARBOX
B602
B603
B608
S203
S202
S201
E203
(F201)
VI
VI
VI
VI
WH138
173 GRN 140
172 VI 150
171 GRN 142
170 VI 146
169 VI 148
168 VI 152
167 VI 147
166 VI 151
165 GRN 141
164 VI 145
163 GRN 139
162 VI 149
161 BLK 136
160 GRN 135
159 GY 132
158 GY 133
157 BRN 144
156 WH/BRN 143
155 GY 134
154 WH/GY 137
153
S204
BRN
BRN
R201
WH/BRN
BRN
T201
138 WH 173
139 GRN 162
140 GRN 172
141 GRN 164
142 GRN 170
143 WH/BRN 155
144 BRN 156
145 VI 163
146 VI 169
147 VI 166
148 VI 168
149 VI 161
150 VI 171
151 VI 165
152 VI 167
134 GY 154
98 WH 49
97 GRN 35
96 GRN 33
95 GRN 31
94 GRN 44
93 WH/BRN 208
92 BRN 209
91 VI 216
90 VI 217
89 VI 219
88 VI 220
87 VI 221
86 VI 222
85 VI 224
84 VI 225
83 GY 174
71 WH/GY 238
72 GY 175
73 VI 190
74 GRN 11
75 VI 191
76 BLK 9
E401
77 WH/GY 64
78 GY 65
79 VI 68
80 GRN 69
81 VI 67
82 BLK 70
65 GY 78
R401
64 WH/GY 77
67 VI 81
68 VI 79
69 GRN 80
70 BLK 82
K401
PHASE I
50 GY 107
51 GY 57
52 GY 18
53 GY 1
E504
56 GY 213
GY 214
57 GY 51
58 GY 215
61 WH/GY 13
62 GRN 101
60 BLK 212
63 BLK 100
J503
HEIGHT
SERVO
AMPL
TM5534-29

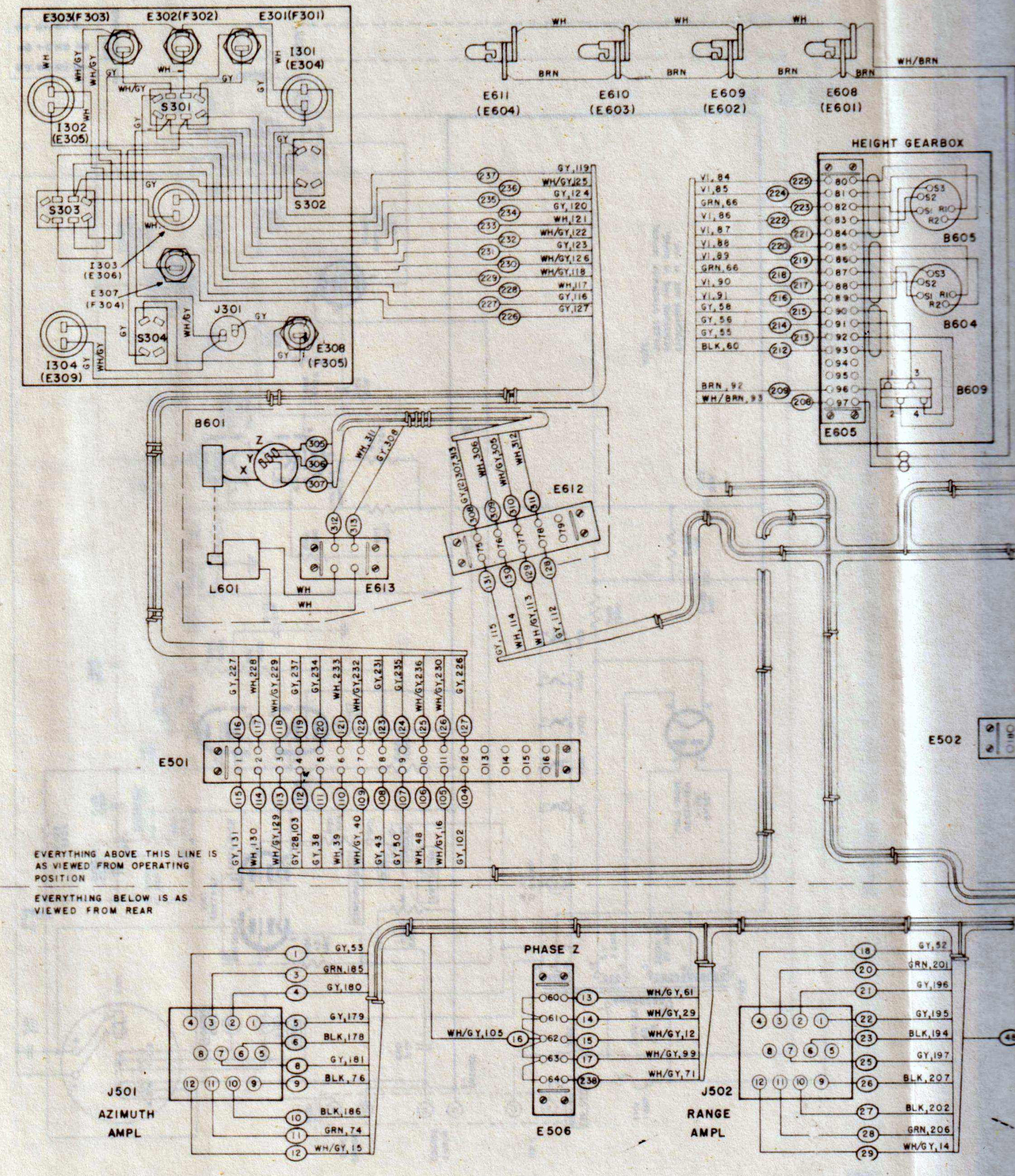
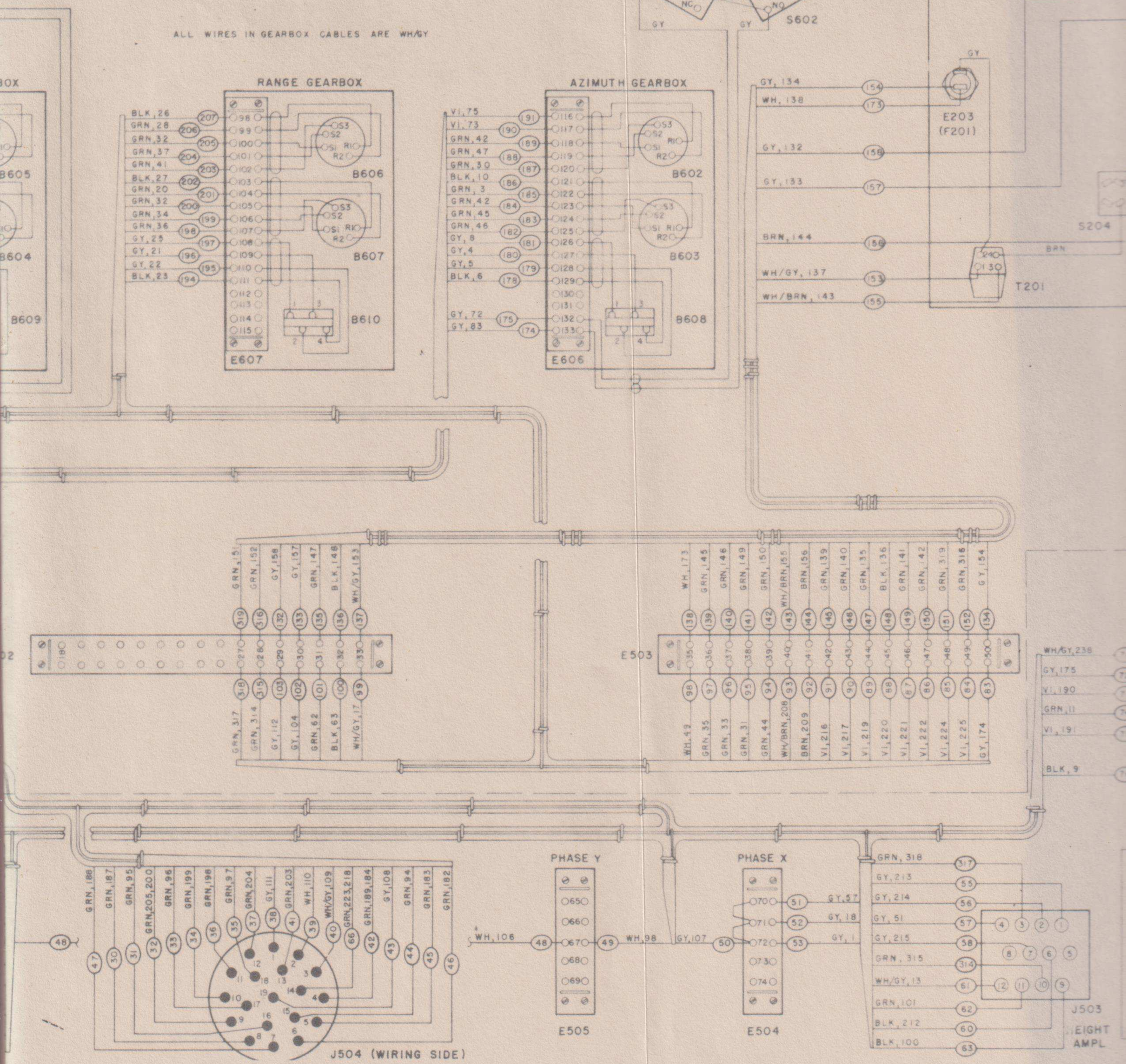


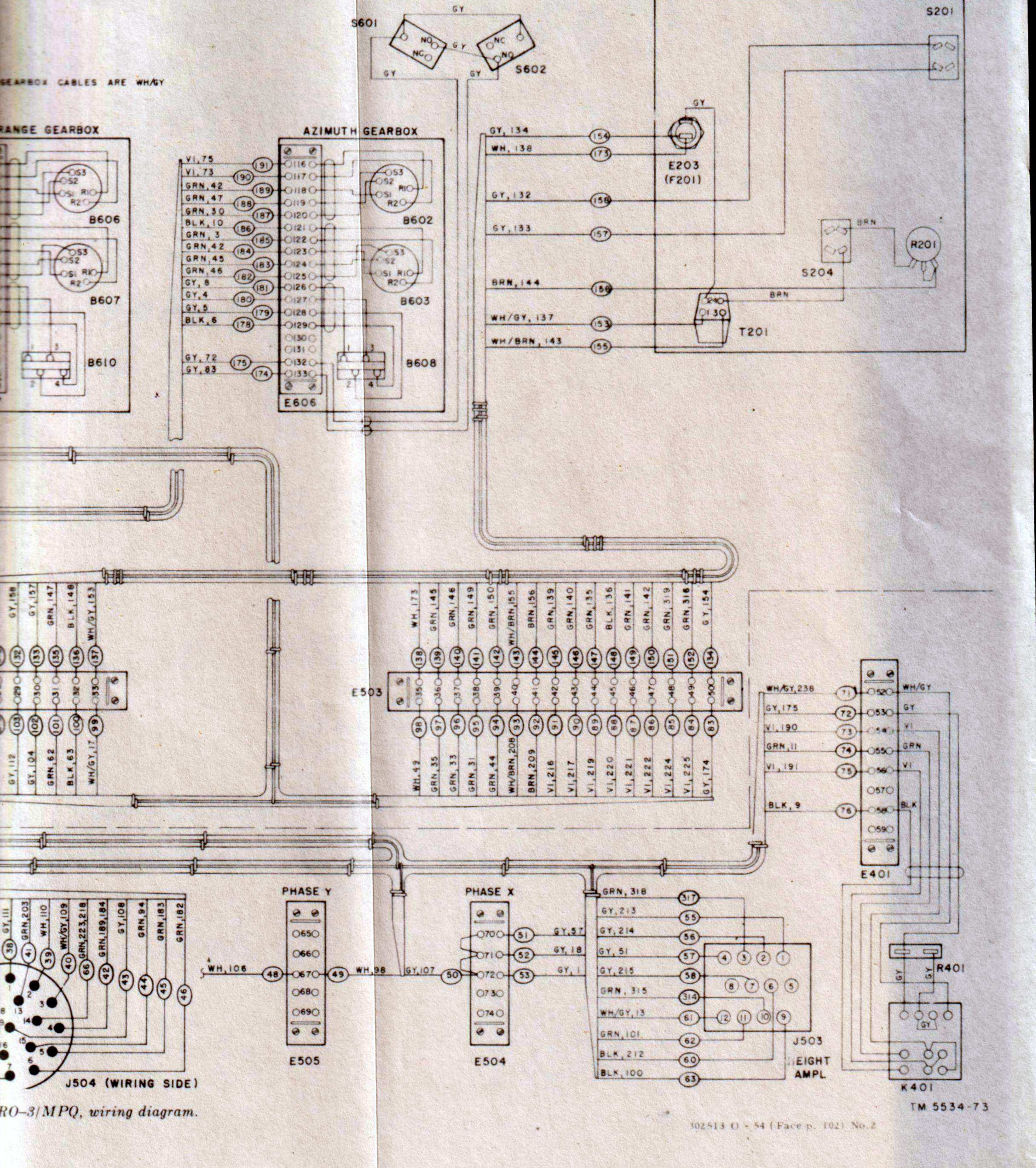
Figure 61. Azimut

ALL WIRES IN GEARBOX CABLES ARE WH/GY



Azimuth-Elevation Range Recorder RO-3/MPQ, wiring diagram.

GEARBOX CABLES ARE WH/GY



RO–3/MPQ, wiring diagram.

TM 5534-73

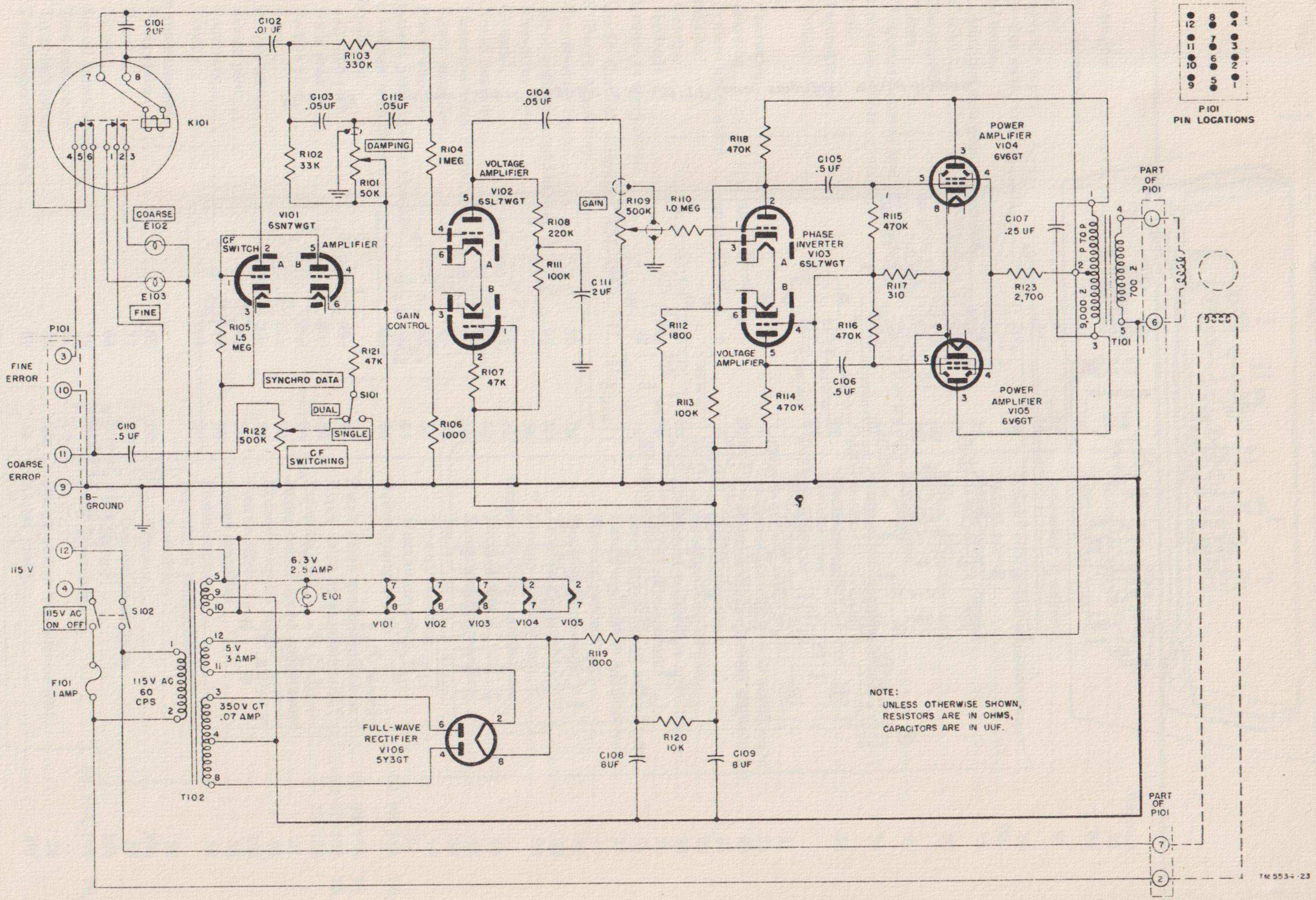


Figure 62. Electronic Control Amplifier AM-489/TP (servo amplifier), schematic diagram.

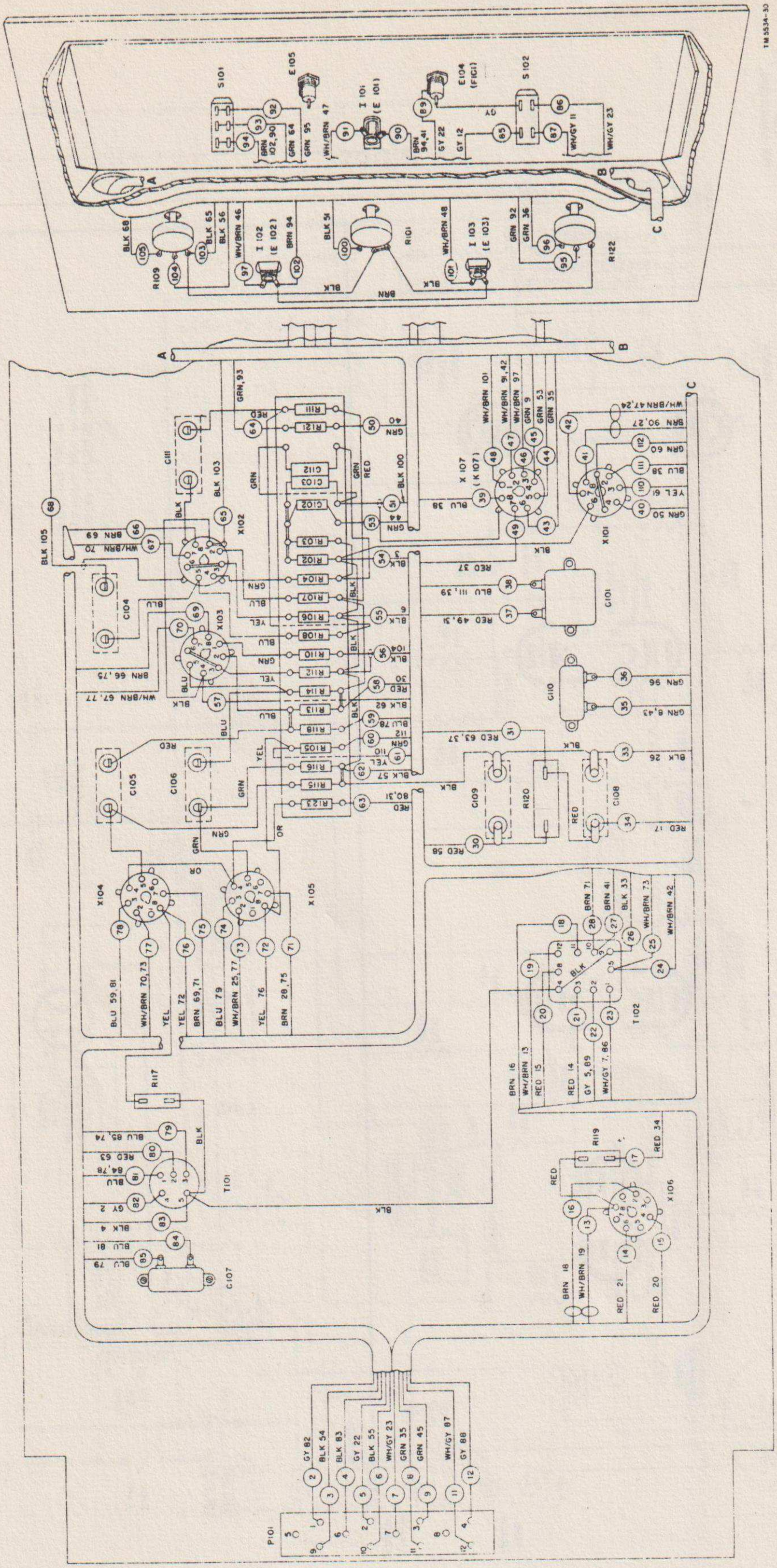


Figure 63. Electronic Control Amplifier AM–489/TP (servo amplifier), wiring diagram.

INDEX

	Paragraph	Page
Azimuth plot	29*e*	35
Cabling connections	15	22
Cleaning	88	82
Coarse-error input	57	56
Coarse-fine switching	23	32
Components:		
Additional equipment required	11	13
Cables	9	11
Description	8	9
Table	7	7
Trajectory curves and plotting aid	10	11
Control transformer, synchro	62	58
Controls:		
Instruments	18	28
Use	17	22
Data:		
Packaging	6	7
Reading	29*g*	35
System application	4	5
Demolition:		
General	113	98
Methods	114	98
Differences in equipment	8*e*	11
Electronic Control Amplifier AM–489/TP (Servo Amplifier):		
Coarse-error input	57	56
Error voltage amplification	54	55
Fine-error input	52	52
General	51	52
Notch network	53	52
Phase-inversion stage	55	55
Power amplifier	56	56
Power supply	58	56
Equipment performance checklist	46	44
Error voltage amplification	54	55
Extrapolation:		
Azimuth plot	29*e*	35
Data reading	29*g*	35
Height plot	29*d*	34
Need	29*a*	33
Pickup effect	29*c*	34
Range plot	29*f*	35
Summary	29*h*	36
Theory	29*b*	34
Field maintenance:		
Precautions	68	64
Repairs	71	68
Scope	64	60
Signal substitution	70	66
Test equipment	67	64
Troubleshooting	65	60
Troubleshooting chart	69	64
Fine-error input	52	52
Fuse chart	8*d*	11
Generator, synchro	61	57
Height coarse-fine adjustment	26	33
Height plot	29*d*	34
Height servo channel	48	48
Initial adjustments	20	29
Lubrication	40	42
Microswitches, adjustment	74	69
Notch network	53	52
Operation:		
Arctic climate	31	36
Azimuth coarse-fine adjustment	25	33
Coarse-fine switching adjustment	23	32
Desert climate	33	37
Extrapolation of plots	29	33
Height coarse-fine adjustment	26	33
Initial adjustments	20	29
Paper travel speed adjustment	21	31
Range coarse-fine adjustment	24	32
Starting procedure	19	29
Stopping procedure	28	33
Tropical climate	32	37
Zeroing procedure	22	31
Organizational maintenance:		
Lubrication	40	42
Rustproofing, painting	42	42
Tools	34	38
Troubleshooting	45	43
Weatherproofing	41	42
Overrunning clutch	82, 93, 105	75, 87, 97
Paper drive gearboxes	81, 92, 106	74, 86, 97
Paper drive mechanism	80, 91, 107	73, 82, 97
Paper holders	79, 108	70, 97
Paper travel speed adjustment	21	31
Phase-inversion stage	55	55
Pickup effect	29*c*	34
Power amplifier	56	56
Power supply	58	56
Preventive maintenance:		
Definition	36	38
Exterior	39*a*	38
General techniques	37	38
Interior	39*b*	41
Pully assemblies	83, 103, 104	75, 95, 96
Range coarse-fine adjustment	24	32
Range plot	29*f*	35

	Paragraph	Page
Recorder assembly, mechanical overhaul:		
Cleaning	88	82
Overrunning clutch and paper rollers	82, 93, 105	75, 87, 97
Paper drive gearboxes	81, 92, 106	74, 86, 97
Paper drive mechanism	80, 91, 107	73, 82, 97
Paper holders	79, 108	70, 97
Pulley assemblies	83, 103, 104	75, 95, 96
Recorder cover	78, 89, 109	70, 82, 97
Removal of parts	77	70
Servo units	86, 97, 100	78, 91, 95
Stylus frame	85, 96, 101	78, 91, 95
Stylus frame lift	84, 95, 102	78, 91, 95
Repairs:		
Azimuth microswitches, adjustment	74	69
Chassis and panel, inspection	73	69
Console, inspection	72	69
Replacement of parts	71	68
Servicing instructions:		
Cabling connections	15	22
Paper roll, installation	14	19
Reconditioned equipment	16	22
Recorder, installation	13	17
Uncrating equipment	12	15
Servo motor	50	51
Shipment	111	98
Signal substitution	70	66
Starting procedure	19	29
Stopping procedure	28	33
Synchro transmission:		
Control transformer, synchro	62	58
General	59	57
Generator, synchro	61	57
System theory	63	58
Table of components	7	7
Test equipment	67	64
Theory:		
Azimuth servo switching circuit	49	50
Electronic Control Amplifier AM–489/TP (servo amplifier)	51	52
Height servo channel	48	48
Servo motor	50	51
Synchro transmission	59	57
Trajectory curves	10	11
Trouble shooting:		
At field maintenance level	64	60
Equipment performance checklist	46	44
Scope	43	43
Visual inspection	44	43
Zeroing procedure	22	31

[AG 413.682 (15 Apr 54)]

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