CONTENTS

CHAPTER 1 - GENERAL DESCRIPTION OF THE TURRET

CHAPTER 2 - TURRET OPERATION

CHAPTER 3 - GUN ASSEMBLIES

CHAPTER 4 - SLIDES

Inspection. Each assembly should always be inspected before operating to make sure that there are no tools, rags, or other obstructions that will foul the actions. Test operation of the breech to verify normal actions of the breech, firing mechanism, and gas ejector. After firing, inspect and record the liner position at the muzzle. Check the clearance between the liner and screw box liner and record the readings.

Lubrication and preservation. Lubricate the gun assemblies according to the schedules and with the lubricants prescribed on the lubrication charts appended to this pamphlet. Observe the instructions in the Bureau of Ordnance Manual as to maintenance of oil film on all bright work. Use canvas muzzle covers to prevent water from entering the gun bores when the tompions are unshipped. See the instructions of chapter 18 for alternative lubricants and for general information concerning lubrication.

Preservation and service care

Gun. Instructions for preservation and care of all elements of the gun barrel are prescribed in the revised edition of the Bureau of Ordnance Manual, chapter 3. These include specific directions and information applicable to these particular guns. Discussed thoroughly are care of the exterior surfaces, the bore, and the chamber and data in regard to coppering, constrictions, deformations, and other items which affect the accuracy, life, or ballistic characteristics of the barrel. In addition to the instructions of the Ordnance Manual, the following should be observed:

The chromium-plated bore and the powder chamber surface must at all times be coated with a film of light mineral oil, Navy Symbol 2110. This oil film is to be applied with clean toweling wrapped around the bristle bore sponge; the film should be replenished weekly. The oil film should be removed before firing. The gun bore should be swabbed clean and rinsed immediately after firing, and it should then be gaged and lapped, if necessary, to remove copper deposits or constrictions.

Gun maintenance materials. Approved materials; unauthorized materials. Experience has shown certain materials to be adapted for certain jobs in the care and preservation of gun assemblies. Other materials, found injurious to the equipment or to personnel, must not be used. A list of approved and of unauthorized materials follows:

Coating for bore and chamber of gun. Approved oils: Preservative oil O.S. 1362, Navy Symbol 2110, and Navy Symbol 2135. Unauthorized: Heavy oil or grease; organic oils.

Wash for gun bore after firing. Approved: Soda solution (one pound laundry soda to one gallon boiling fresh water); or riflebore cleaner O.S. 1426; or Diesel oil, 7-0-2; or light mineral oil, Navy Symbol 2110; or caustic soda solution (three ounces caustic soda to one gallon boiling fresh water). Unauthorized: Solutions made with salt water; or kerosene, gasoline, or carbon tetrachloride.

Gun bore rinse after cleaning. Approved: Fresh water. Unauthorized: Salt water.

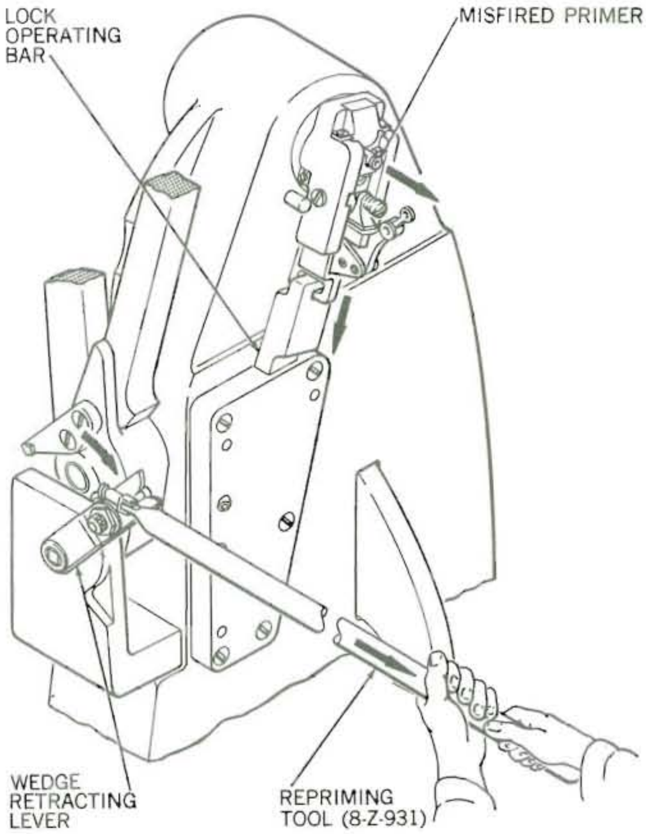

Figure 3-23S. 16-inch Gun Assemblies. Extracting Misfired Primer Without Opening Breech.

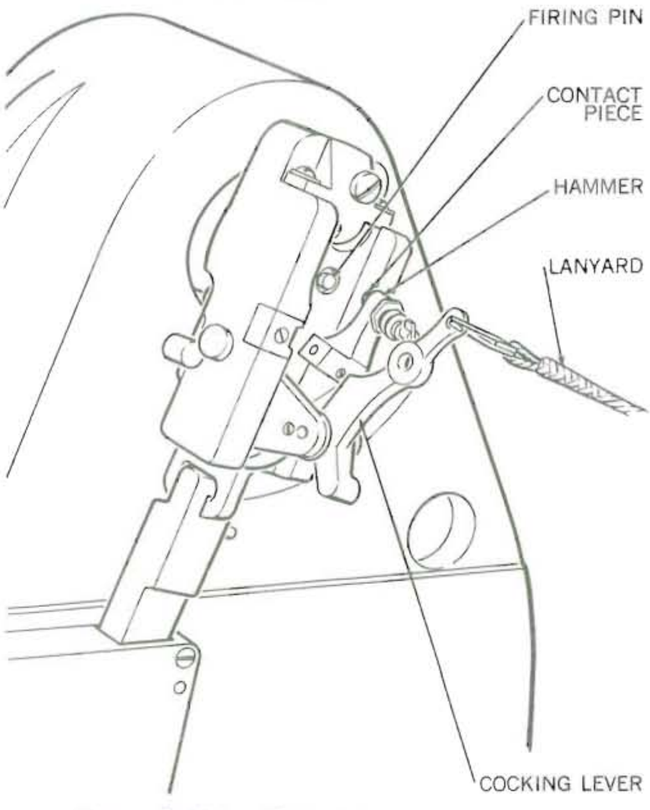

Figure 3-23T. 16-inch Gun Assemblies. Percussion Firing.

Lapping compound for removal of copper from bore. Approved: Pumice and oil paste (equal parts by volume of powdered pumice stone and light machine oil); in severe cases, standard issue wire brush; as last resort, emery, used sparingly. Unauthorized: Sandpaper or harsh abrasives.

Material for removing "smoke rings" or discoloration from gun bore. Approved: Wiping with oil soaked rag. Unauthorized: All abrasives and detergent or caustic solutions.

Coating for breech mechanism bright work. Approved: Light mineral oil, Navy Symbol 2110. Unauthorized: Heavy oil or grease, organic oils.

Solvent for cleaning firing lock. Approved: Alcohol. Unauthorized: Kerosene, gasoline, carbon tetrachloride, caustic or soda solutions.

Lubricant for firing lock after cleaning. Approved: Light mineral oil, Navy Symbol 2110. Unauthorized: Greases, heavy oils, organic oils.

Material for detection of air leaks in gas ejector system. Approved: Light oil or liquid soap. Unauthorized: Heavy oil or salt water.

Lubricant for gas check pad. Approved: Molybdenum disulfide, MIL-L-7866 (Aer). See the chapter on Lubrication for the method of application. Unauthorized: Oil lubricants 14-L-14 (Ord) and MIL-L-16785, or mixtures of white lead and tallow.

Tools and accessories. Tools used in normal care and preservation of gun assemblies include standard issue tools and supplies, as well as tools designed for specific applications. Tools for normal use include hammers, screwdrivers, standard wrench sets, and supplies such as toweling, common sponges, wire brushes, and oil stones. Bore gages, bore lapping heads, and bristle bore sponges are designed for specific uses. Each ship is supplied with a sufficient number of such tools of the proper size. Use of standard issue tools and supplies depends upon the discretion of the officer in charge. Special purpose tools must be used for no purpose other than that for which they were intended. Design identities and reference drawings of all tools and accessories are given in chapter 19.

Bore lapping head. The bore lapping head (fig. 3-24) is used for cleaning the bore and rifling of the gun. The tool consists of four segments mounted on springs in a circular block. Emery cloth is attached to the segments for cleaning the lands of the bore. In order to clean both the grooves and the lands, molten lead is poured through the openings in the bore lapping head when the head is inserted in the gun bore. The gun barrel acts as a mold for the molten lead. After the lead cools and hardens, the bore lapping head is pushed through the bore. The lead cleans the rifling as it spirals through the bore.

Bristle bore sponge. The bristle bore sponge (fig. 3-25) is used in all cleaning, swabbing, and oiling operations performed on the gun bore. The tool is a solid, cylindrically shaped, hardwood block with many rows of short, stiff bristles arranged around its circumference. At each end of the tool, eyebolts are provided for attachment of the ropes used in pulling the bore sponge through the gun.

Bore gage. The bore gage (fig. 3-26 is passed through the gun bore to test for constrictions. It is a cast steel frame with two fixed-diameter, machined steel cylinders attached at either end. The bore gage has provision for attachment of the ropes used in pulling it through the gun.

Wire brushes. Wire brushes are to be used mainly on the exterior surfaces of the gun. In severe cases of copper deposit in the bore, the wire brush may be used sparingly, but only by experienced personnel.

Breech mechanism. The breech mechanism is to be maintained clean at all times and must be free from gummed oil, paint, and foreign matter. The screw box liner and the breech plug threads are to be oiled daily with light mineral oil, Navy Symbol 2110,

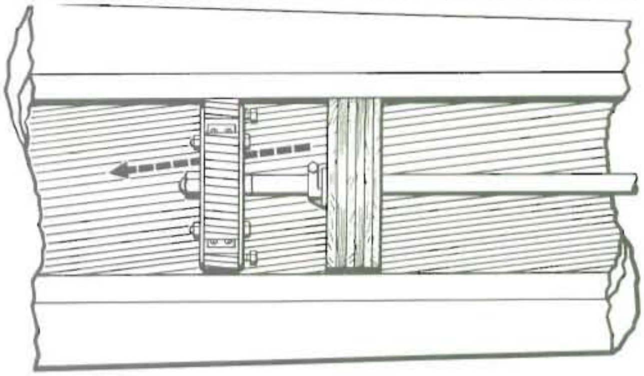

Figure 3-24. Use of Bore Lapping Head in the Care and Preservation of Gun Assemblies

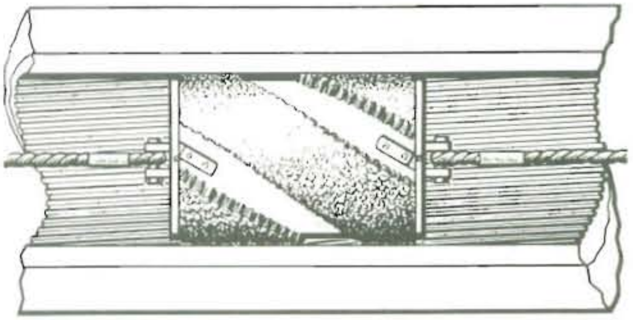

Figure 3-25. Use of Bristle Bore Sponge in the Care and Preservation of Gun Assemblies

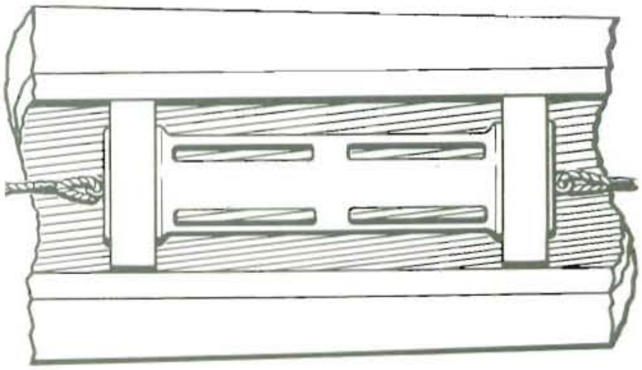

Figure 3-26. Use of Bore Gage in the Care and Preservation of Gun Assemblies

and then wiped with a clean, dry cloth. When not in service, all bright work should be coated lightly with light mineral oil as prescribed by the Ordnance Manual. Gas check pads are easily damaged or misaligned by careless handling of tools and indifferent maintenance care. Inspect the pads frequently; they must be free from cuts or scratches, particularly ones that extend from front to rear. The normal thickness of a pad is $1.759 \begin{smallmatrix} +.020 \\ -.000 \end{smallmatrix}$ inches, measured through the thickest cross section, but this dimension tends to increase as the pad is used in service. The maximum safe thickness of the pad, measured as above, is 1.81 inches. Use of a pad with a greater thickness will pull the mushroom forward, thus binding the firing lock and causing misfires. Pads should be lubricated with molybdenum disulfide, as described in the chapter on Lubrication. The split parts of the split rings must be 90 degrees apart at all times. The counterbalance springs and closing cylinder assembly should be disassembled annually and repacked with a special lubricant. The counterbalance springs should be in such adjustment that the carrier does not rebound when it contacts the opening buffer. For proper breech closure, the air closing pressure must be maintained as described in the adjustment of the Mason and Foster valves. The opening buffer and the operating lever are filled (and replenished) only with standard recoil cylinder liquid, NAVORD OS 1914. Buffers are to be filled with the gun at 0 degrees elevation. The operating lever safety ratchet mechanism assembly should be observed to ensure proper function. All components of the breech must be frequently inspected for undue wear, galling, distortion, fracture, or corrosion. The condition of these components must be verified before firing. The breech assemblies are to be exercised daily.

Firing lock. The firing lock requires the same careful lubrication and rust-preventive maintenance as prescribed for the breech mechanism. Before firing, the lock is to be washed in alcohol and lubricated.

When the firing lock is mounted on the mushroom stem, the clearance between the lower portion of the firing lock wedge and the rear face of the carrier should be between 0.130 and 0.177 inch. A clearance less than 0.130 inch may indicate that excessive expansion of the gas check pad has caused the mushroom stem to be pulled forward. This condition will bind the firing lock, thus causing misfires.

Gas ejector. Care of the gas ejector system involves maintenance of the valves, swivel joints, pipe connections, and telescoping parts. Freedom from leakage at the minimum operating pressure of 150 pounds per square inch is required. To check for leaks, apply a very light oil at frequent, regular intervals to ascertain the air tightness of connections. Swivel joints seal against leakage by pressure distension of the preformed packing. Slightly adjust the swivel joint collar to stop leakage; never screw the collar up tight. If the gas ejector valve leaks, remove it and disassemble. Lap the poppet and seat, using a fine compound, and wash in alcohol before reassembling. The stuffing box gland of the telescoping joint requires occasional resetting as wear develops. Replacement and adjustment of packing is apparent from the design details. If leakage of the seal between the gun and screw box liner develops, repack with OS 1162 as prescribed by drawing 8-Z-954.

Reduction valves. The reducing valve of the breech closing system, when operating properly, can be adjusted to completely cut off the air supply. If the reducing valve is causing loss of air supply, or otherwise operating improperly, the valve should be tested. If necessary, it should be repaired or replaced. New Mason valves and those in service are disassembled and lubricated with oil, Navy Symbol 1042, before being placed in service, and every six months thereafter. The Foster valve has a rubber diaphragm that must be protected from oil.

Operating and maintenance instructions

For the safety of personnel, and to prevent damage to the gun and slide installations, observe the following precautions and instructions.

Preparation for firing. Perform the following operations in the order given below.

1. Check the air pressure and differential oil supply of the counterrecoil mechanism. See chapter 4 for procedure.

2. Check the recoil cylinder fluid level at the expansion line filler. See chapter 4 for instructions.

3. Check the fluid level and operation of the breech opening buffer and the operating lever buffer.

4. Perform "Before operating" lubrication for breech mechanism and slide.

5. Make sure the salvo latch locking pin is not in hole B.

6. Check the gas ejector and breech closing air supply.

7. Wipe down all bright work.

8. Wash the firing lock in alcohol and lubricate in accordance with instructions of the Bureau of Ordnance Manual. Rotate the firing lock 90 degrees to mount on the mushroom stem bayonet joint. Latch the wedge to the operating bar.

9. Disengage and stow the slide securing pin and elevate the gun to loading position. Retract and stow the yoke locking device.

10. Operate the breech mechanism through two closing and opening cycles to verify normal operation of the assembly.

11. Remove the tompion.

12. Wipe the excess oil from the gun chamber and bore and from the plug threads.

13. Inspect the obturator unit for scratches and misalignment.

14. Check lubrication of the gas check pad. Lubricate with molybdenum disulfide, MIL-L-7866 (Aer), as described in the chapter on Lubrication.

15. Make sure the gas ejector orifices are clear of gummed lubricant.

Preparation for drill. Preparation for drill should include a routine check as described above. Screw the salvo latch locking screw into hole B. Observe the backing out precautions of page 3-21. After the drill be certain to return the salvo latch locking pin to the turret officer's booth.

Securing gun assembly after firing. Immediately after firing, secure the yoke locking device and perform the following procedure:

1. Clean the chamber and bore with one of the approved materials previously listed.

2. Pass the bore gage. If the bore gage will not pass, wire brushes of standard issue may be used to remove sufficient copper to permit passage of the bore gage. Use of the wire brush is permitted only where the bore gage will not pass, and then only enough to allow the bore gage to pass.

3. Remove all copper from the lands with emery cloth, if the bore gage will not pass after the use of wire brushes. The use of emery cloth is permitted only where the bore gage will not pass, and then only enough to allow passage.

4. Coat the entire surface of the bore and chamber with light mineral oil immediately after cleaning and passing the bore gage. Apply with clean toweling wrapped around a bristle bore sponge. Refer to the list of materials approved for this purpose.

5. Disconnect the wedge from the operator bar and rotate the firing lock 90 degrees to remove from the mushroom stem.

6. Disassemble and clean the firing lock. Wash all electrical contacts in alcohol to remove grease. Before assembling, give all parts a coat of light mineral oil to prevent rust. Stow the firing lock.

7. Install the tompion or muzzle cover.

8. Check the gas ejector valve and air lines for leaks, and clean the orifices.

9. Inspect the breech opening buffer and the operating lever buffer; replenish liquid if necessary.

10. Close the breech, depress the gun to 0 degrees elevation, and engage the slide securing divice.

Firing, misfires. Misfires are usually caused by a break in the electrical firing circuit. The weakest part of the electrical firing circuit is the primer. To avoid misfires, primers must be handled carefully to avoid breakage of the platinum, electrical contact bridge. If the platinum bridge is broken, electrical firing is impossible.

Firing lock. To avoid misfires, the firing lock must be perfectly clean at all times. Wash the firing lock with alcohol at frequent, regular intervals. After cleaning, lubricate with light mineral oil. The firing lock should be mounted only during action or during drill periods. At all other times, the firing lock should be carefully stowed in the turret.

Breech balancing spring. The breech mechanism must never be operated with the breech balancing spring disconnected. Operation under such conditions could wreck the assembly.

Buffer fluid. The carrier opening buffer and the operating lever buffer are designed to use standard recoil cylinder fluid. Oil, water, or other liquids must not be substituted, nor the recoil cylinder fluid diluted.

Closing pressure. The adjustment of the reduction valve must not exceed the pressure setting indicated on page 3-22. Higher pressure will result in greater closing speed and prevent latching of the operating lever.

Bore maintenance. The use of emery, wire brushes, or other abrasives to clean the bore must be limited to experienced personnel. Excessive removal of chromium plating and steel must be avoided. Refer to page 3-19 for a list of standard tools and accessories.

Backing out precautions

Damage to mushrooms frequently occurs while backing out a drill projectile. This damage occurs because a buffer of insufficient diameter is used between the projectile and the mushroom. Use of too small a buffer will permit the projectile to transmit a blow to the side of the mushroom rather than to its center. This can result in a bent mushroom stem, and the possibility of a "blow-back" is introduced. The seriousness of a bent mushroom stem is emphasized by the fact that it is not always easily seen and it may not cause malfunction of the breech mechanism. To prevent a blow-back and possible injury to personnel, proper methods of backing out drill projectiles should be observed. Whenever practicable, the guns should be trained fore and aft for a loading drill. The purpose of this is to reduce the possibility of the projectile unseating due to the roll of the ship before the cradle and spanning tray are in position. The projectile can be backed out by the methods described below:

1. With the complete dummy powder charge remaining in the chamber, the gun is elevated to unseat the drill projectile. The dummy powder charge will reduce the travel of the projectile and absorb the impact. The gun is then depressed to loading position and the dummy charge is removed. The projectile can then be withdrawn by inserting a shell eyebolt in the base of the projectile and pulling it out of the gun. The projectile can also be backed out further by inserting a buffer and elevating the gun.

2. The alternative approved method of backing out a projectile is elevation of the gun with a buffer in the powder chamber. The buffer should be cylindrical and solidly formed of woven ropes, covered with canvas. The diameter of the completed buffer should be at least as great as a powder bag so that it will spread the shock over the entire face of the mushroom.

Adjustments

General. Components of the gun, breech mechanism, gas ejector, yoke, and firing lock are of fixed arrangement, as indicated by the design details and general arrangement drawings. These components, precisely fitted at initial assembly, are not adjustable except for the following units.

Breech carrier hinge adjustment. The eccentric bearing bushing and locking screw arrangement, together with the hinge pin and bearing, are illustrated in figure 3-27. The axes of the breech plug and screw box liner are brought into accurate alignment by rotating the eccentric bushing. This adjustment is correctly made at assembly in the Naval Gun Factory and should not be altered unless there is positive indication of galling and seizing in the screw box and breech plug threads. Determine the degree of adjustment required by lightly painting the threads with a mixture of two parts tallow and one part white lead. Open and close the breech several times to find the areas of greatest thread contact. Remove the locking screw and rotate the eccentric bushings as necessary with the spanner wrench provided for this purpose, and repeat the procedure of opening and closing the breech. When this adjustment is completed, the closing air pressure must be readjusted to reduce the speed of breech closure.

Breech counterbalance springs adjustment. The counterbalance springs are adjusted to balance the breech assembly when it is opened. The adjustment is such that when the breech is normally opened, it will swing down and latch without a jarring stop or or rebound. The adjustment is made by removing the set screws from the adjusting nuts and either tightening or loosening the nuts. When the above adjustment is achieved, the set screws are replaced to lock the adjusting nuts to the spring rods.

Compensate for movement of gun hoop and hinge lug adjustment. Firing the gun sometimes causes a movement of the gun hoops. Consequently, the hinge lug would move either forward or rearward together with the hoop to which it is mounted. Movement of the hinge lug would cause a similar displacement of the breech plug. The hinge lug movement is compensated for by rotating the adjusting nut (described in the previous paragraphs, "Breech plug" and "Carrier"). Adjustment can be made, with the breech mechanism open or closed, as follows:

1. Remove the locking clamp (figs. 3-5 and 3-6) from the carrier.

2. Screw the adjusting nut in (or out) as needed, to correctly position the breech plug.

3. Replace the locking clamp on the carrier.

4. Lightly paint the screw box threads with a mixture of two parts tallow and one part white lead. Open and close the breech several times.

5. Repeat the adjustment procedure until all indications of galling or seizing, in the screw box and breech plug threads, have been removed.

Air reduction valve, breech closing adjustment. The air system assembly is equipped with either a Mason or a Foster reduction valve. These valves provide for adjustment of the air pressure delivered to the foot-operated breech closing valve. Both valve designs are adjusted by means of a square head adjusting screw at the top of the valve. The initial adjustment at the Naval Gun Factory, which is the desired service adjustment, is one that assured breech closure and convenient manual latching of the operating lever. With a clean breech assembly, having properly aligned plug and screw box, the breech should close properly with 40 pounds per square inch air pressure. In addition, the counter-

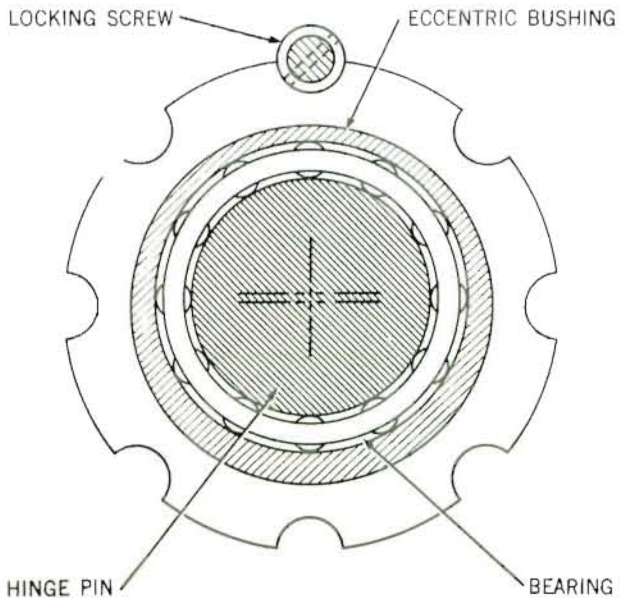

Figure 3-27. Breech Mechanism Carrier Hinge Adjustment

balance springs must be correctly adjusted and the carrier plug bearing and thread well lubricated.

Erratic breech closure, when the air pressure is correctly adjusted at 40 pounds per square inch indicates misalignment, faulty lubrication or both. The plug bearing must be properly lubricated to permit relatively free axial movement. Excessive friction and gummed lubricant will retard breech closure and prevent latching of the operating lever. The cam rollers must rotate freely when they contact the rotating cams. If the breech closure is erratic, it must not be corrected by increasing the air pressure.

Hydraulic buffer stuffing box adjustment. Adjustment of the stuffing boxes to prevent leakage should never be so tight that it prevents or slows down the spring return of the plunger. If such tight adjustment is necessary to prevent leakage, a new packing should be installed.

Air line swivel joint adjustment. Swivel joints seal against leakage by pressure distention of the preformed packing. To stop leakage, slightly adjust the collar; never screw the collar tight.

Air line telescoping joint stuffing box adjustment. The stuffing box gland requires occasional resetting as wear develops. Paint the joint with light oil and tighten the gland until all leaks disappear.

Firing lock cocking lever torsion spring. Within the cocking lever a torsion spring tends to move the cocking lever toward the lock. The tension on the cocking lever torsion spring may be adjusted by turning the torsion washer in the direction of an arrow that is stamped on it. Initial setting is with the zero mark on the washer in alignment with the index line that is scribed on the wedge.

DISASSEMBLY AND ASSEMBLY

General instructions

Disassembly and assembly of guns and gun yokes is normally performed by personnel familiar with the procedure and equipped with standard and special tools required for the job. The following paragraphs contain instructions for regunning and for removal of the yoke. Included are instructions for the disassembly and assembly of the breech mechanism and gas ejector system which might not be readily apparent after an examination of the equipment and general arrangement and detail drawings.

Reference plans. Information referring to turret structural arrangements, methods for dismantling and removing major components of the gun assemblies, and for installing gun equipment is given in BuShip Plans BB616 7204ZA, and BB616 Z7204ZF.

Regunning procedure

General. The gun assembly and turret are designed to facilitate gun replacement by sliding the gun through the gun port to remove it. The following subparagraphs list in sequence the extent of turret preparations and the routine operations involved in sliding the gun out and sliding a new gun in. The yoke design and provisions made to free it from the gun shoulder should be studied as a necessary preliminary to these operations. Gun yokes are designed with bearing strips in the front and rear, and with white lead and tallow at assembly. This coating has been found inadequate to prevent corrosion after exposure to weather. Therefore, grease

Gene Slover's US Navy Pages | Table of Contents

holes have been provided for the periodic injection of grease into the overbored area, to prevent such corrosion. These greasing holes should be used to inject penetrating oil at the time of regunning, if difficulty is encountered in removing the gun from the yoke.

Preparation for unyoking and sliding gun out of turret.

1. Prepare a plan for the deck layout of the regunning rig that will clear all parts of the ship and all deck installations.

2. Prepare a plan for suitable shoring under the location for the regunning rig. Install the shoring.

3. Lay timbers on deck as a foundation for the regunning rig. The top of the timbers must be in a plane precisely parallel to the center line of the gun.

4. Layout, drill, and tap the underside of the turret roof for the yoke supports.

5. Remove the projectile cradle and spanning tray, cradle fulcrums, and cradle operating cylinder. Remove the cradle pump expansion tank.

6. Remove the upper powder trunk door.

7. Remove the breech plug, carrier hinge lug, and complete operating assembly.

8. Elevate the gun to about 30 degrees and remove the gun cover and wiping ring.

9. Depress the gun to 0 degrees and insert the slide securing pin.

10. Bleed the counterrecoil air pressure.

11. Disconnect the recoil piston and the counterrecoil yoke rods. A special spanner wrench 8-Z-915-5 is provided for removal of the yoke rod lock nuts.

12. Clear the gun port gas seal from behind the face plate. There must be enough clearance to permit rigging an oak timber inside the gun port, above the slide, to act as a toggle. Or, remove some scarf bolts from the turret roof directly behind the gun and secure a pad eye there.

13. Secure a gun clamp or use wire rope lashing and shackle for pulling the gun out of battery.

Unyoking.

1. Pull the gun out of battery to position for rigging the yoke supports. Rods must be inserted in the yoke as the gun comes back, because there is not sufficient room to insert them when the gun reaches the unyoking position.

2. Rig the yoke supports and turn up the turnbuckles hand tight.

3. Rig the gun for pulling out.

4. Case loose the yoke locking ring.

5. Pull the gun forward until the yoke ring can be removed.

6. Remove the yoke ring. This ring is in halves. The lower half is comparatively easy to remove. Remove the securing bolts, jack the half ring out of rabbet, and drop the lower half. The upper half cannot be jacked entirely clear. It must be rotated 180 degrees until it can be dropped. Jacking bolts and small eye bolts are used in this operation.

7. Continue pulling the gun forward until the yoke key can be removed.

8. Remove the yoke key.

9. Engage one or two threads of the yoke locking ring in the yoke.

10. Continue pulling the gun clear of the yoke.

Sliding gun out.

1. Place regunning rig on supporting timbers.

2. Check to verify that the plane of the top of the rails is parallel with the axis of the gun.

3. Adjust the rails laterally until they center on the gun and are precisely parallel with the gun. This is the most important part of the procedure. If the rails are not exactly parallel with the gun, the gun will jam repeatedly in leaving or entering the slide.

4. Place a cradle with a large radius on deck behind the rails. Place a cradle with a small radius at the rear of the rails.

5. Pull the gun out until the machined surface protrudes beyond the front of the cradle and the gun breech is at the mid-point of the first or second slide liner.

6. Turn up the vertical jacking bolts on the cradle until a thin feeler will pass at the top between the breech end of the gun and the slide liner. This means that the cradle has begun to take the load. It is a very slow process to turn up the vertical jacking bolts by hauling a wrench with a pipe extension on the handle. The jacking is easier and faster when the largest size impact wrench is used.

7. Continue hauling the gun out until the breech is in the next to last, or the fifth from the rear, slide liner.

8. Install the rear cradle on the rails and jack up until the thin feeler will pass at the bottom between the breech end of the gun and the slide liner.

9. Continue pulling the gun out until it is clear of the slide and ready for lifting.

Installing new gun. Lift the old gun clear and place the new gun in the cradles, in the same position as the old gun. Secure the gun clamp to the gun. Lead stripping should be packed between gun clamp and the gun.

1. Rig the gun for pulling in.

2. Pull the new gun up close to the slide and check with a straight edge to determine whether the gun will enter. If the gun will not enter, use the jacking bolts as necessary. If adjustment of the horizontal jacking bolts is necessary, the rails must be kept parallel with their original position.

3. Pull the new gun into the slide until the second slide liner is entered. Slack down on the vertical jack

bolts of the rear cradle. When the cradle is loose, drop it to the rear of the rails.

4. Continue pulling the gun in until the key is close enough to the front of the slide to permit alignment.

5. Rig a jack under the lower side of the gun clamp; jack until the key aligns with the keyway.

6. Continue pulling the gun in until the fifth slide liner is entered.

7. Slack down on the vertical jacking bolts of the front cradle. It may be necessary to bring the rear cradle to the front and again take up the weight of the muzzle. If this is done, packing should be placed between the gun and the cradle. As an alternative, a crane can be used to take a strain under the muzzle end of the gun. Failure to do one or the other in cold weather may cause failure of part of the rig. A heavy strain is needed to start the gun moving from this very muzzle-heavy position.

8. Continue pulling the gun in until the yoke key and yoke ring can be installed. The rails are now no longer needed and can be removed.

9. Unthread the yoke locking ring and pull it forward, clear of the yoke ring rabbet.

10. Install the yoke ring and the key.

11. Continue pulling the gun in until it is in position in the yoke.

12. Secure the yoke locking ring. Remove the forward yoke supports.

13. Rig for hauling the gun back to battery.

14. Haul the gun back to battery. The gun may be hard to start in motion in cold weather. If necessary, rig a jack between the projectile cradel shelf and the yoke to start the gun's forward motion. This is done to minimize the strain on the hauling out rig.

Note: With the recoil and counterrecoil rods disconnected, there is no dashpot to cushion the gun's forward motion. Pieces of soft wood should be used between the yoke and slide to avoid metal to metal contact.

15. Remove the yoke supports.

Breech mechanism

Weight tabulation. To facilitate handling of the breech mechanism, a table of weights for principal parts is listed below:

Screw box liner, pounds	1470
Hinge lug, pounds	458
Carrier, pounds	571
Plug, pounds	1403
Counterbalance and closing cylinder assembly, pounds	248
Mushroom, pounds	223

Disassembly. The following paragraphs contain instructions pertaining to the dismantling of the breech mechanism. To do this, the gun must be at 0 degrees elevation with the slide securing pin seated and the yoke locking device connected.

1. With the breech closed, remove the bearing plate and disassemble the firing mechanism.

2. Open the breech and remove the mushroom nut and spring.

3. Lift the mushroom from the plug and remove the gas check pad and split rings.

4. Close the breech.

5. Remove and drain the breech opening buffer.

6. Remove the counterbalance and closing cylinder assemblies. When opening the breech after removing the counterbalance springs, support cribbing and rigging must be placed for lowering the carrier and plug.

7. Rotate the plug until the threads are fully disengaged from the screw box liner threads. Disconnect the operating lever connecting rod from the plug pin. Lower the carrier and plug with appropriate tackle.

8. Remove the following parts in sequence: The salvo latch group from the breech and slide. The breech handle. The gas ejector plate. The upper rotating cam. The cam and roller brackets and rollers. The breech operating lever connecting rod and pawl and bracket subassembly from the operating lever. The operating lever.

9. Remove the breech plug.

10. Remove the holding-down latch.

11. Rig shoring to support the carrier in the open position. Remove the carrier hinge pin bearings and the hinge pin. Remove the carrier.

12. Remove the hinge lug from the gun shoulder.

13. Remove the lower rotating cam.

Assembly. For assembling the breech mechanism, proceed as follows:

1. Place the lower rotating cam in position and secure.

2. Mount the hinge lug on the gun shoulder and bolt tight.

3. Rig shoring to support the carrier in open position. Assemble the carrier and hinge pin with approximate adjustment of the eccentric bearing.

4. Assemble the holding-down latch.

5. Mount the breech plug on the carrier, taking care to align the plug with the control arc.

6. Assemble the following parts in sequence: The breech operating lever. The connecting rod and pawl and bracket subassembly to the operating lever. The cam roller brackets and rollers. The upper rotating cam. The gas ejector trip plate. The breech handle. The salvo latch group to the breech and slide.

7. Raise the carrier with appropriate block and tackle. Engage the plug in the screw box liner.

8. Assemble the counterbalance and closing cylinder components.

9. Mount the breech opening buffer and fill to the proper level.

10. Open the breech.

11. Assemble the gas check pad and split rings and mount the mushroom in position.

12. Place the mushroom spring in position and tighten the mushroom nut.

13. Assemble the firing mechanism and mount the bearing plate.

The assembly operation is completed with the adjustment of the carrier hinge eccentric bearings, the counterbalance springs, and the air reduction valve.

Firing lock

Disassembly and assembly. Disassembly of the firing lock is apparent by inspection. Assembly must be performed in a definite order.

To assemble Firing Lock Mk 14 Mod 5 proceed as follows:

1. Assemble the primer retaining catch as a unit in its housing and secure the housing to the receiver.

2. Mount the extractor and the extractor cam and spring on their shaft through the receiver.

3. Insert the firing pin assembly and the firing pin spring in the wedge.

4. Place the firing spring in its hole in the wedge, and then place the hammer thrust pin in position.

5. Mount the hammer on its axle, and assemble the hammer catch with its spring in the hammer. Secure them in position with the hammer catch screw.

6. Place the torsion washer and cocking lever spring in their housing in the cocking lever; mount the lever on its axle. In assembling these parts, make the zero mark on the torsion washer coincide with the similar mark on the wedge. When the spring tension is adjusted, secure the torsion washer with the torsion screw.

7. Slide the wedge into the receiver and tighten the wedge stop screw.

Mason valve

Disassembly. Disassemble the Mason valve in accordance with the following instructions; use drawing 50266 as a reference:

1. Remove the valve from the breech.

2. Back off the adjusting screw (using Socket wrench 50266-20) until all tension is removed from the spring.

3. Place the valve in a vise, clamping to the hexagonal head of the dashpot cylinder.

4. Unscrew spring case from the body of the valve; remove the diaphragm spring, diaphragm, and diaphragm button.

5. Unscrew the pilot valve (auxiliary valve) seat, using a socket wrench. If necessary, tap lightly with a hammer to loosen

6. Disassemble the pilot valve. Use a screwdriver to turn the pilot valve; hold the nut by wedging it with a screwdriver.

7. Screw the threaded lifting bolt (50266-18) into the top of the main valve. Remove the main valve (50266-11) and the spring (50266-14).

8. Place the valve in a vise, with soft jaws against the threaded ends from which the couplings have been removed.

9. Unscrew the dashpot cylinder (50266-12) from the dashpot.

Assembly. The Mason valve is assembled as follows:

1. Insert the dashpot piston into the dashpot cylinder.

2. Place the dashpot piston into the valve body and tighten the dashpot.

3. Assemble the main valve and spring.

4. Place the pilot valve in the seat.

5. Insert spring (50266-7) and tighten nut (50266-17).

6. Screw the pilot valve assembly into the valve body.

7. Assemble spring button (50266-2), spring (50266-3), diaphragm button (50266-5), and diaphragm in the spring case and screw onto the valve body over the pilot valve.

Foster valve

Disassembly and assembly. For disassembly and assembly of the Foster valve, refer to drawing179766. When disassembling this valve, it is important to relieve the tension on the adjusting spring and to remove the diaphragm before removing the main valve assembly.

Chapter 4

SLIDES

16-inch Slide Mark 6 Mod 0

16-inch Deck Lug Mark 7 Mod 0

GENERAL DESCRIPTION

16-inch Slide Mk 6 Mod 0 is a large trunnion-pivoted assembly in which a single gun assembly is mounted (figs. 4-1 and 4-2). Each slide functions as a gun-supporting structure, a gun recoil brake, and a gun counterrecoil mechanism. Included in the gun slide assembly are devices that secure the gun in battery position and the slide in stowed position. The slide pivots on its integral trunnions in vertical rotation. The right and center slides are identical assemblies; the left slide differs in that the loader's platform bracket and slide securing device are mounted in the left rear end bracket, and the elevating screw pivot pin is mounted in the right rear end bracket.

16-inch Deck Lug Mk 7 Mod 0 is a bearing block and roller bearing assembly that provides for frictionless elevating movement of the slide and gun. Each deck lug is arranged with a bearing block and roller bearing assembly on either side of each slide. The deck lugs are virtually identical assemblies; minor structural differences are described later in this chapter.

The deck lugs are located at the front of the turret, within the gun house structure. The common axis of the radial bearings is in a line, 11 feet forward of the turret transverse centerline, parallel to

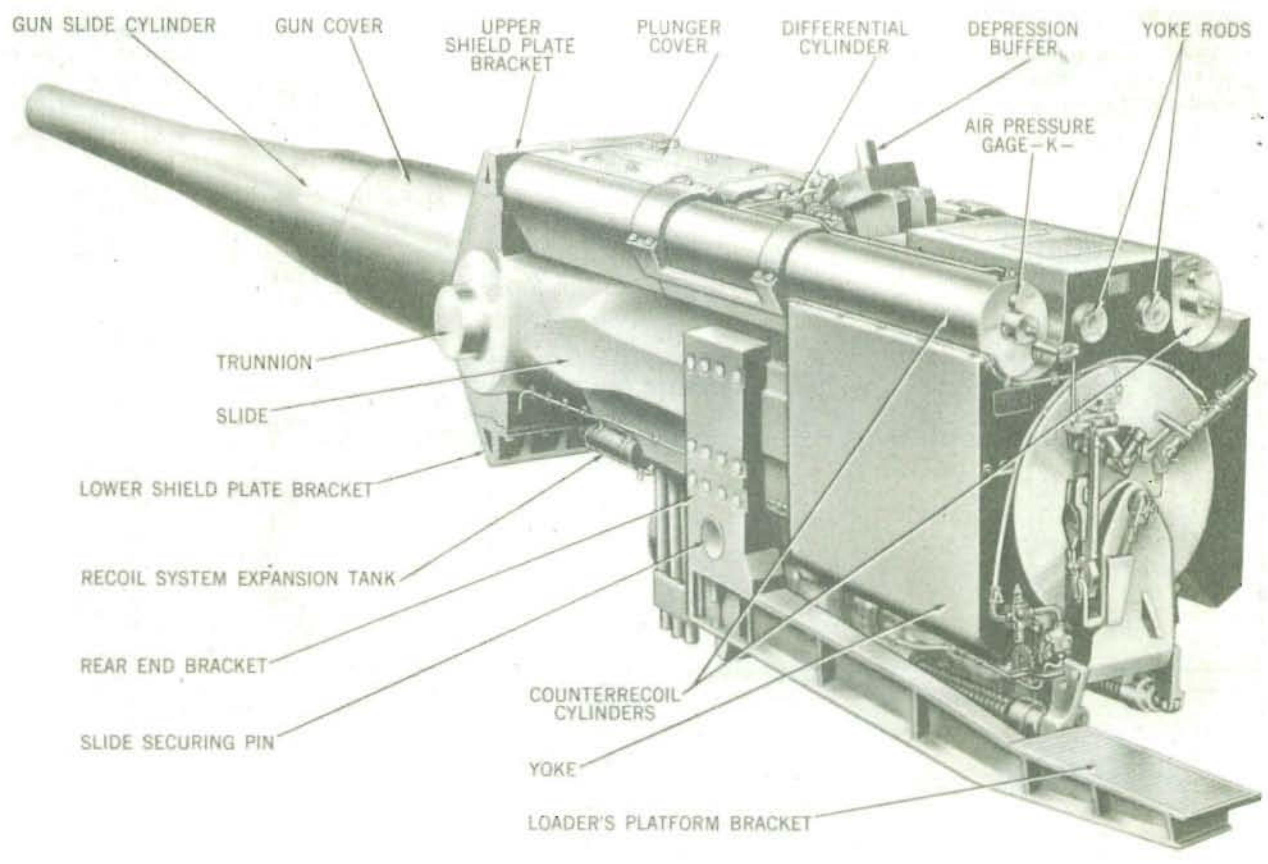

Figure 4-1. 16-inch Gun Mk 7 Mod 0, and 16-inch Slide Mk 6 Mod 0 (Operating Lever Safety Ratchet Mechanism Assembly Not Shown; See Figure 3-3)

and 16.5 feet above the axes of the rollers of the roller path. Turret structural supports for the lugs are spaced to locate the slides and their guns as follows: The axis of the center gun bore is on the turret centerline. The axes of the right and left gun bores are parallel to that of the center gun and are each spaced 122 inches from it.

Components. The main component of each slide is a large steel forging with integral trunnions that rest in the deck lug bearings. Attached to this forging is a hydraulic-type recoil brake, a hydropneumatic-type counterrecoil system, and the rear end brackets. Other parts attached to the slide structure are the loader's platform, a cylindrical gun cover, the upper and lower shield plates, a yoke locking device, and a slide securing mechanism.

Design features

The deck lugs are identical radial roller bearing assemblies, mounted in a bearing block at the top of the gun girder. Heavy caps, which bolt to the gun girder bearing blocks, prevent vertical displacement of the deck lug bearings. The bearings are secured against horizontal displacement by the rigidity of the gun girder weldment, and by bearing retainers that provide nonadjustable spacing of the bearings of each lug. The bearing retainer design ties the two trunnion bearings together through the integral structure of the slide and its trunnions.

Design differences

The three deck lug assemblies of a turret are virtually identical. The two deck lugs for the outboard slides differ in that the outer bearing blocks extend further forward than do the inner bearing blocks. This is necessary to provide for the difference in shape between the straight, flat turret face plate and the annular gun girder, which forms the outer structural bulkhead within the barbette. In addition, the flat-plate thrust bearings of the outer bearing blocks are rotated to the rear and upward in their assembly positions. Both the bearing blocks and bearing assemblies of the deck lug for the center slide are identical.

Access arrangements

Access to the deck lug bearings is provided for by parallel divisional bulkheads that are formed by the gun girder boxes, and by turret subdivision bulkheads. The two outer trunnion bearings are accessible through the sight station compartments. The remaining trunnion bearings are accessible through the space between the parallel divisional bulkheads. These spaces may be reached from the electric deck.

DETAIL DESCRIPTION

Deck lug

The three deck lugs in each turret are mounted in a transverse row within the gun house structure at the front of the turret.

Each deck lug consists of two trunnion bearings. The common axis for all six trunnion bearings forms a straight line in the forward upper part of the turret gun girder weldments. Each deck lug (fig. 4-3) is composed of two radial roller bearing assemblies and two flat thrust plate bearings arranged with a bearing block and bearing for each trunnion on either

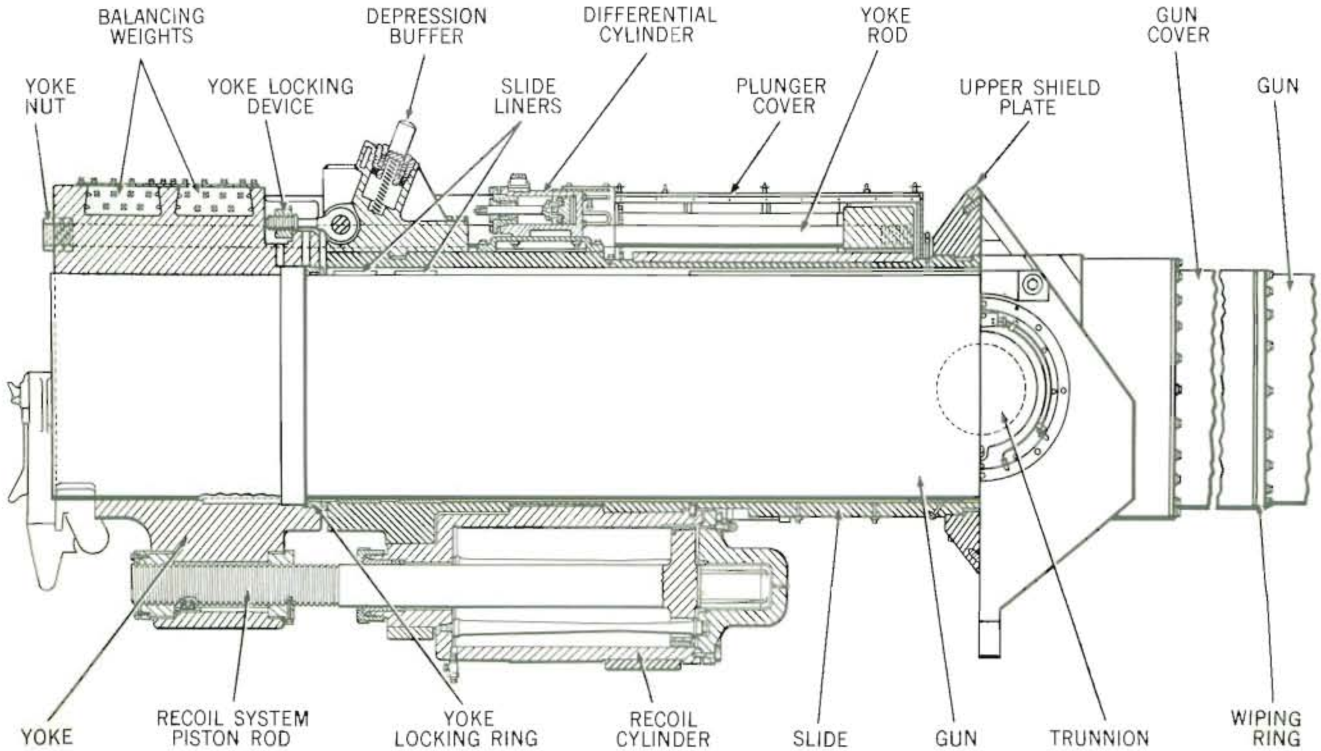

Figure 4-2. 16-inch Gun Mk 7 Mod 0 and Slide Mk 6 Mod 0, General Arrangement, Sectional View

side of the gun slide. The deck lugs are rigidly secured beneath heavy caps that are bolted to the bearing blocks of the gun girder weldment.

Design features. The turret structural design for gun girders and deck lug seats ties the trunnion bearings together without the use of transverse tie rods. The radial trunnion bearings are of frictionless design. Their rings, rollers, and cages are of noncorrosive materials or are chromium plated. All elements of the six bearing assemblies are fully enclosed and sealed with lubricant retaining devices.

Components. Each trunnion bearing of the deck lug is an assembly of the following parts:

Radial roller bearing
Thrust plate
Bearing retainer
Outer bearing seat
Cover plate

Trunnion bearing assembly (fig. 4-4).

Radial roller bearing. The radial roller bearing unit of each deck lug consists of inner and outer rings, a two-piece bronze cage, 24 cylindrical steel rollers, and 24 cage rivets. Each assembled bearing is 30.0 inches in outer diameter, 5.8 inches wide across the inner ring, and the roller axes form a circular path 25.00 inches in diameter. The rollers are solid true cylinders; each is 3.5 inches long and 2.5 inches in diameter. They are made of special roller bearing steel and are chromium plated. The rollers are equally spaced, loosely fitted in the recesses of the bronze cage, and retained by the riveted assemblage

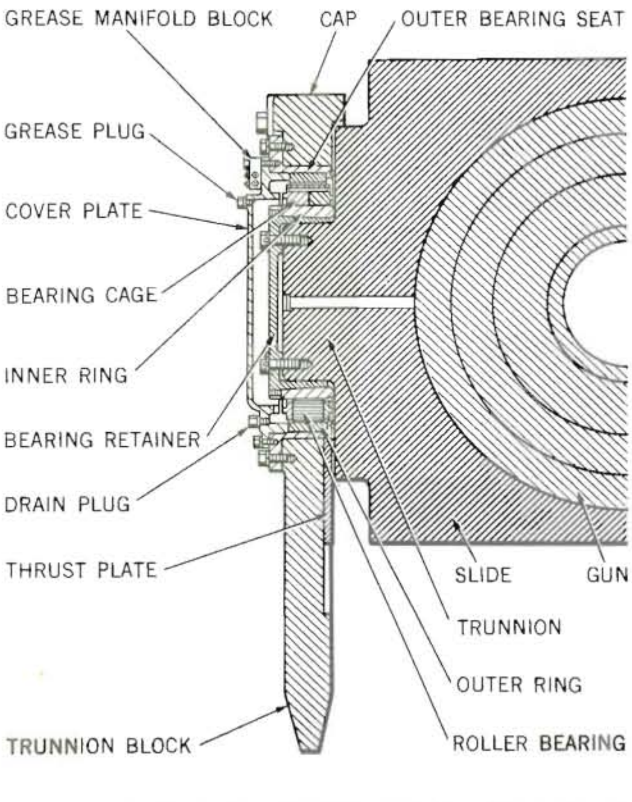

Figure 4-3. Deck Lug Mk 7 Mod 0, Gun Mk 7 Mod 0, and Slide Mk 6 Mod 0, Sectional View

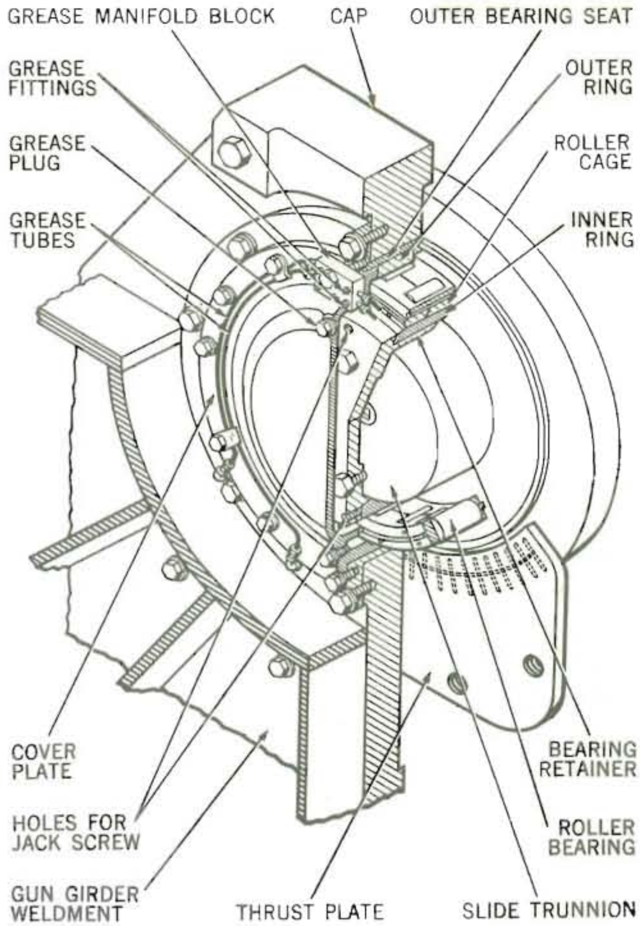

Figure 4-4. Deck Lug and Trunnion Bearing Assembly, General Arrangement

of that unit. The inner and outer rings are special steel, precision ground to provide concentric cylindrical races for the rollers. The inner ring seating area is a 3-degree tapered bore that provides a fixed wedged seat on a matching collar of the retainer. The outer ring is also fixed (cannot rotate) in its seat and is described in a following paragraph.

Thrust plate. The bronze thrust plate is secured by four bolts on the inner side of each gun trunnion block. Centered beneath the trunnion, the plate forms a 120-degree thrust bearing lubricated thrust surface for the side face of the gun slide. The plate has a system of radial grease grooves to distribute lubricant from four grease fittings. With the two bearing plate surfaces parallel to the side face of the slide, the thrust clearance between the slide and each plate is 0.002 inch. The thrust bearing and bearing block design includes provision for maintaining this thrust clearance. Excessive slide thrust clearance, caused by a gun girder spread, can be corrected by installing oversize thrust plates. The installation is made without disturbing the radial bearing assemblies. The bearing block seats for the thrust plates are milled to permit undersized plates to be dropped and new plates to be raised and bolted. This operation can be performed in the limited space beneath the slide.

Bearing retainer. The bearing retainer is a circular plate with an integral cylindrical collar that fits over the slide trunnion. The collar forms the inner ring seat and is machined with a 3-degree tapered slope to match the seat taper of the inner roller race. The inner ring seat of the bearing retainer also provides a shoulder against which the inner ring is wedged. The retainer is secured to the end face of the trunnion with 12 equally spaced bolts that lock when seated. The diameter of the slide trunnion bearing surfaces is 18.5 inches. The assembled bearings and retainers, when fully seated on the trunnions, space the two deck lug radial bearings 73.0 inches apart from center to center.

Outer bearing seat. The outer bearing seat is a flanged ring, 31.5 inches in diameter. It is secured to the bearing block and cap by eight equally spaced bolts. The outer ring of the bearing is fixed and centered by the outer bearing seat. The inner face of the seat has an annular groove for a lubricant seal. This seal is compressed against the side face of the slide. It consists of a wool felt strip, square in cross section, secured in the groove with shellac. The outer flance of the seat is arranged with 12 equally spaced holes that are tapped for the cover plate bolts. In addition, there are six holes for jack screws (so that the seat can be disassembled from the bearing block) and six smaller tapped holes in the lower half of the seat. These holes furnish selective positions for four lubrication fittings for the thrust bearing.

Cover plate. The cover plate is a large recessed disc with a machined integral bolt flange that seals against the outer bearing seat. Completely enclosing the trunnion and bearing, the cover plate provides a lubricant retaining cover with filling and drain plugs for servicing the bearing. There are two accurately machined annular rings within the cover plate and integral with it. These annular rings provide 360-degree contact with the bearing outer ring with the roller cage. When assembled, the plate secures the outer race and the roller cage and prevents thrust displacement of the bearing.

Slide (fig. 4-5)

General arrangement (fig. 4-6). The gun slide forging is the structural foundation for the other components of the slide. The entire assemblage is suspended and pivoted by the integral trunnions of the slide forging. Frictionless vertical rotation in the gun pocket is provided by the deck lugs. The upper and lower shield plates fit within the turret face plate and function to close the gun port in all slide positions.

When fired, the gun slides through the gun port in a 48-inch reciprocating movement (maximum possible stroke). This recoil-counterrecoil motion is controlled by the recoil brake and counterrecoil system of the slide. The gun is held in battery by the counterrecoil system.

The slide is elevated and depressed through the elevating screw mounted in the bottom of the slide rear end bracket. This nonrotating screw is elevated or depressed by the power driven elevating nut (chapter 5).

Elevating movement of the slide is limited by two elevation stops on the bottom of the slide. These stops are positioned in the way of two hydraulic buffers for each slide; one on the left and one on the right gun girder in the gun pocket. Depression movement is buffed by a hydraulic buffer mounted on top of the slide in position to contact a stop mounted in the turret roof.

When the slide is at 0 degrees elevation, a securing pin in one of the rear end brackets aligns with a pin socket in the adjacent gun girder. A yoke locking device (fig. 4-2) locks the gun yoke to the slide for stowage with the gun in battery position.

Components. The gun slide consists of the following components:

- Slide forging
- Gun cover
- Recoil system
- Counterrecoil system
- Yoke locking device
- Buffers
- Rear end brackets
- Loader's platform
- Slide securing device
- Recoil switch and blade contacts

Slide forging. The gun slide is a large steel forging bored to receive the slide cylinder of the gun. The slide forging, weighing 56,000 pounds, is the major component of the slide assembly. Large trunnions, integral with the slide forging, extend horizontally on either side of it. The common axis of the trunnions forms a straight horizontal line at right angles to the gun axis, 44.0 inches from the forward end of the slide forging. The total length of the forging is 196.0 inches, and it measures 79.0 inches wide from end face to end face of the 18.5-inch diameter trunnions. The gun slide bore of the forging is fitted with four bronze liners at the forward end and two at the rear. Each liner is 10.0 inches wide with a finished diameter of 49.03 inches. (The diameter of the slide cylinder of the gun is 49.0 inches.) Each liner is provided with lubrication grooves that are supplied from fittings on the under side of the slide. There is a 4-inch-wide keyway at the top of the bore to receive the gun slide cylinder key. This keyway is milled through the liners and the entire length of the slide bore. The outer surface of the slide has machined seats for attaching the counterrecoil cylinder mounting brackets and for mounting the recoil cylinder.

Gun cover. The gun cover (fig. 4-6) is a cylindrical subassembly of the slide that extends the slide bore forward and through the gun port. A cylindrical weldment of 0.50-inch steel plate, with an integral diameter of 49.5 inches, the gun cover is secured to the front face of the slide by a steel flange welded to the gun cover plates, 24 equally spaced bolts, and a gasket. A wiping ring at the forward end of the gun cover provides oil and weather seal for the slide cylinder. The gun cover is completely enclosed by a leather buckler, clamped on the outer surface of the wiping ring and mounted on the front face of the armor face plate.

Hydraulic recoil system. The recoil system (fig. 4-7) is a hydraulic throttling device that acts with the counterrecoil system to limit recoil movement. The recoil system also acts as a buffer when the gun is returned to battery position by the counterrecoil mechanism.

Components. The recoil mechanism consists of the following components:

Recoil cylinder
Cylinder head
Cylinder nut
Piston, piston rod, and piston ring
Throttling rods
Piston rod packing, gland, and nuts
Recoil liquid expansion system
Buffer

General arrangement. The recoil cylinder is secured by two straps to the bottom of the slide; the piston rod is secured to the yoke (fig. 4-7). The axis of the piston rod is parallel to the gun bore axis and 43.0 inches vertically below it. Three expansion tanks are mounted on the bottom of the slide, forward of the recoil cylinder. The tanks are connected to the recoil cylinder by a system of pipes that forms a closed system for expansion of recoil liquid. The recoil system is the same in all slide

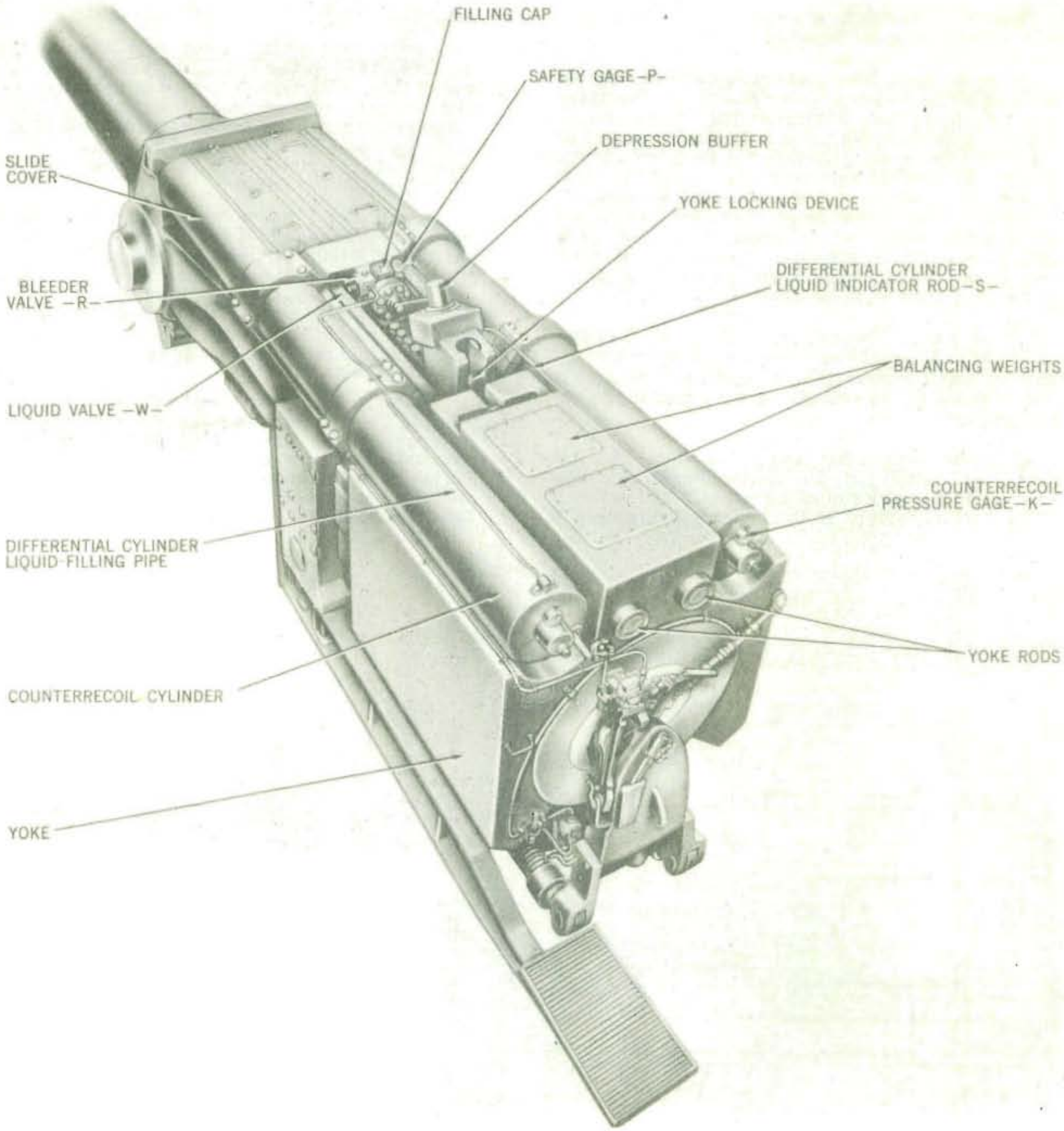

Figure 4-5. 16-inch Gun Mk 7 Mod 0 and 16-inch Slide Mk 6 Mod 0 Assembled (Operating Lever Safety Ratchet Mechanism Assembly Not Shown; See Figure 3-3)

assemblies. The cylinder head is designed with an integral dashpot that acts with the piston plunger to buff the return-to-battery of the gun.

Recoil cylinder. The recoil cylinder is secured to the bottom of the slide by two straps. Machined integral shoulders of the cylinder fit into machined seats of the slide to keep the units in alignment. The cylinder is a cylindrical, nickel steel forging, 75.25 inches long, bored for the recoil piston and piston rod. A packing gland nut seals the rear end of the cylinder around the piston rod. The forward end of the cylinder is closed by a forged nickel steel cylinder head with integral dashpot.

Cylinder head. The cylinder head closes the forward end of the recoil cylinder and forms the dashpot for counterrecoil buffing by the recoil piston plunger. A bronze bushing at the cylinder end of the head forms the bearing surface for the piston plunger. The cylinder head is secured to the recoil cylinder with a copper gasket, a dowel pin, and 20 nickel steel bolts. The forward end of the head is drilled and tapped for attaching a pressure gage; however, this hole is normally plugged. Two threaded holes in the flange, 180 degrees apart, provide for jackscrews to disassemble the head.

Cylinder nut. The cylinder nut passes over the piston rod and threads onto the recoil cylinder. When the nut is tightened, it compresses the packing gland and packing to seal the recoil liquid in the recoil cylinder.

Piston and piston rod, and piston ring. The integral piston, piston rod, and piston plunger are machined from one piece of nickel steel. The piston is threaded for assembly of the bearing-bronze piston ring. The piston has three equally placed holes bored through it for the throttling rods. The rear end of the piston rod is threaded into the yoke and secured by two locknuts.

Throttling rods. Three throttling rods, secured in the cylinder and cylinder head, pass through holes in the piston. The varying-diameter rods (fig. 4-7) are spaced at 120 degrees and are aligned parallel to the recoil cylinder axis. The rods, of variable diameter, provide a graduated flow of liquid through the piston holes during the recoil stroke to cause a gradual checking of the recoil motion.

Piston rod packing, gland, and nuts. Coil packing around the piston rod is compressed in the rear end of the recoil cylinder by a packing gland and the cylinder nut to prevent loss of recoil liquid from the cylinder. The piston rod is threaded and is attached to the gun yoke with two piston rod nuts. The nuts thread onto the piston rod and both lock and center the piston rod in the yoke.

Recoil liquid expansion system. The expansion tanks and pipe manifold system keep the recoil cylinder full of liquid and permit the liquid to expand when it heats up during firing. Three tanks, secured by straps and bolts to the bottom of the slide, are connected to each other and to the recoil cylinder head by a pipe manifold system. The system is located on the bottom of the slide, forward and above the recoil cylinder.

Buffer. The forward end of the piston rod is a dashpot plunger that operates in conjunction with the dashpot of the cylinder head to buff the last one-third of counterrecoil movement. The plunger has four variable-depth, longitudinal grooves that gradually restrict the flow of liquid from the dashpot as the gun returns to battery.

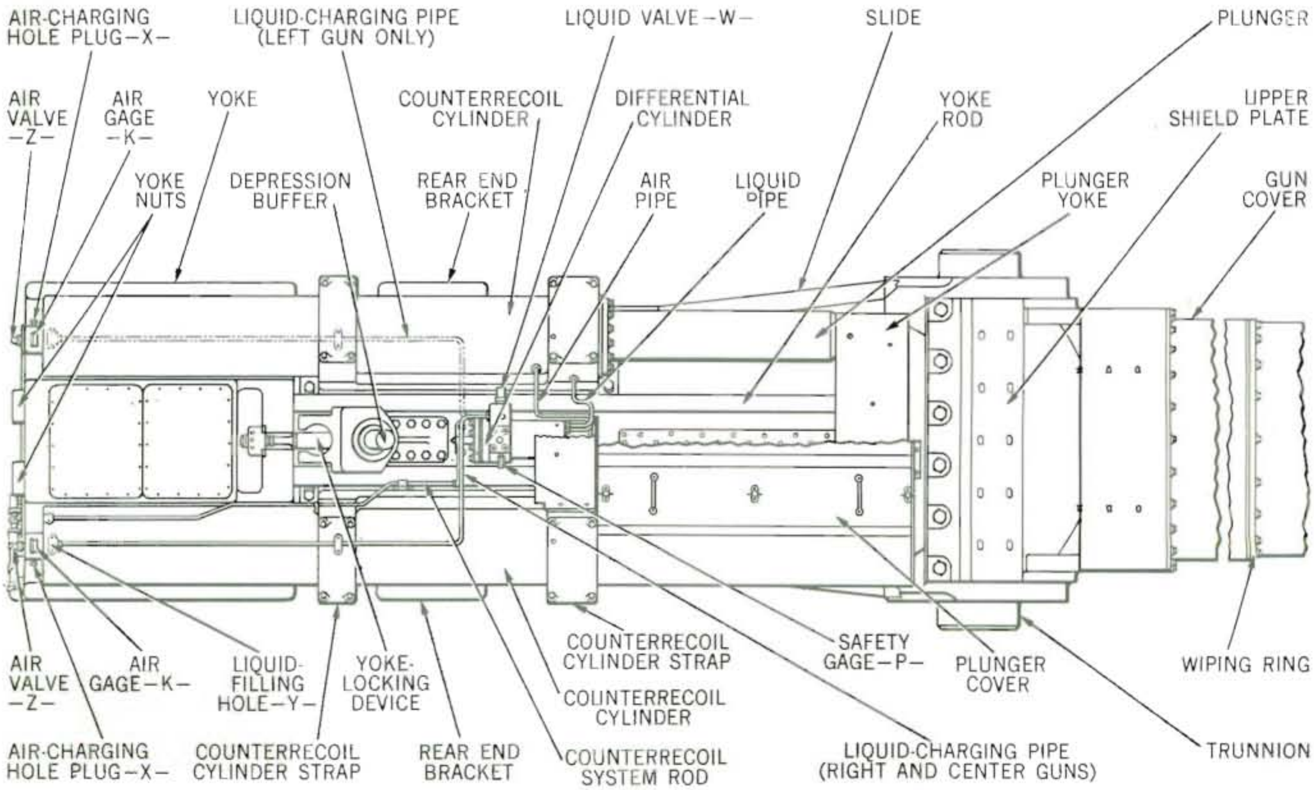

Figure 4-6. 16-inch Slide Mk 6 Mod 0, General Arrangement, Plan View

Counterrecoil system. The counterrecoil system (fig. 4-8) is a hydropneumatic gun recuperator that consists of two air bottles (or counterrecoil cylinders), two plungers and their packings, and a differential cylinder unit. A plunger yoke, yoke rods, gages, valves, and other parts, including a removable cover, complete the assembly. The system absorbs part of the energy at gun recoil to return the gun to battery. The entire assembly is located on top of the slide, as shown in figure 4-6. The axes of the two cylinders are parallel, 43.0 inches apart, and 32.5 inches above the gun centerline. The differential cylinder is centered between the counterrecoil cylinders, 38.0 inches above the gun centerline. In their installed arrangement in the slide, the chambers of the counterrecoil cylinders are each charged with air to an initial pressure of 1550 pounds per square inch. This stored energy is sufficient to hold the gun in battery at any angle of elevation. Recoil action builds up air pressure in the chambers to a peak of approximately 2150 pounds per square inch (at maximum recoil), and this stored energy thrusts the gun back into battery with sufficient force, at the end of the stroke, to require buffing by the recoil piston plunger. The differential cylinder unit varies liquid pressure on the plunger packings as the air pressure varies to seal in the high air pressures at all times.

Components. The counterrecoil mechanism consists of the following components:

- Counterrecoil cylinders
- Plungers
- Plunger packing
- Differential cylinder
- Air pressure gage
- Plunger yoke and yoke rods

Counterrecoil cylinders. A pair of counterrecoil cylinders, with a plunger in each cylinder, comprise the counterrecoil cylinder assembly (fig. 4-8). The air chambers of both cylinders are connected to the air side of the differential cylinder by piping. Pipes connect the liquid side of the differential cylinder with the plunger packing seats at the forward ends of the two cylinders. The differential cylinder is so constructed that the pressure of the liquid is always greater than the cylinder air pressure. Distended by the liquid pressure, the packings provide an air-tight seal for the cylinder and plunger assembly. The plungers slide in and out of the open, forward end of the counterrecoil cylinders when the gun recoils and counterrecoils.

Plungers. The plungers are cylindrical monel metal forgings. Each plunger is a hollow cylinder open at the rear and closed at the forward end, assembled as shown in figure 4-8. The outer surface of the plunger is highly finished so that it will slide easily through the plunger packing without disturbing the high-pressure seal of the plunger packing.

Plunger packing. The plunger packing (fig. 4-8) is an assembly of preformed-composition, chevron-type packing rings. These rings are assembled in the bore at the forward end of the counterrecoil cylinder. There are 12 chevron packing rings in this assembly, with 6 rings on either side of a steel ring called the plunger packing follower. The entire assemblage is seated and retained against a shoulder in the bore by a gland. The follower is connected by a drilled passage and pipe line to the oil chamber of the differential cylinder.

Differential cylinder. The differential unit is a cylinder with a floating piston. The cylinder chamber is divided by the piston into air and liquid chambers. One chamber is connected by pipe lines to the air chambers of the counterrecoil cylinders so that it is always charged with the same (varying) pressure that is present in the counterrecoil cylinders. The other chamber is filled with oil and is connected by pipe lines to the plunger packing seats. The area of the piston in the oil chamber is approximately 15 percent

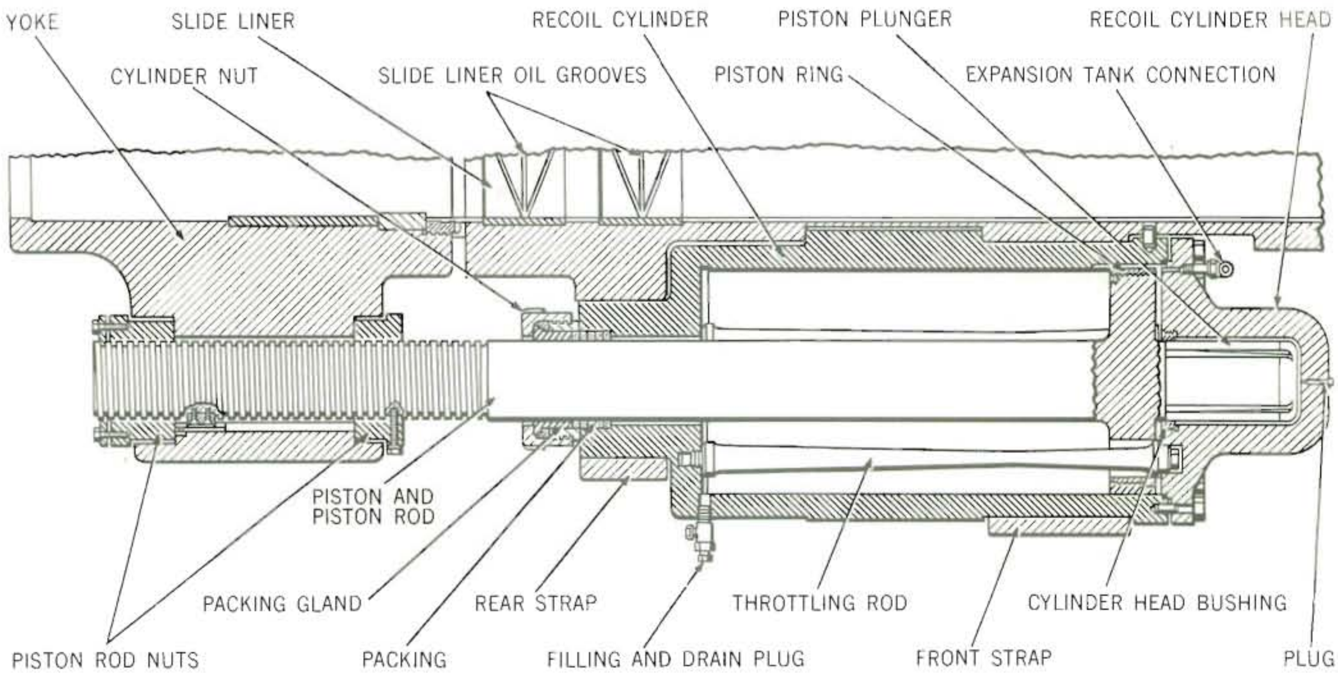

Figure 4-7. Recoil System, General Arrangement, Sectional View

less than the area in the air side because of the piston rod, which passes through a stuffing box to the atmosphere. This results in greater pressure on the liquid side to distend the chevron packing rings. If there is leakage in the system, it will be oil and not air. Leakage is indicated by the amount that the indicator rod (fig. 4-6) attached to the end of the differential piston rod protrudes at the breech. Under no condition should the indicator rod be allowed to project beyond the rear face of the yoke; when it does, the liquid in the differential cylinder must be replenished. A liquid pressure safety gage (P) (figs. 4-9 and 11) is located on top of the differential cylinder; a pipe line connects it to the liquid side of the cylinder so that the liquid pressure on the plunger packing is indicated at all times. This gage is installed with a special safety feature which prevents loss of liquid in the event of gage rupture. The mounting consists of a plate with a screw thread gage seat bolted over a cavity in the differential cylinder forging. A leather diaphragm under the plate separates the pipe line to the plunger packing from the gage lead in the block. For proper functioning, the space above the diaphragm must be filled with liquid before the system is charged.

Air pressure gage. The counterrecoil cylinders are each provided with a gage (fig. 4-1) mounted on the breech end of the cylinder. An adjacent nameplate designates the gage as "Air Gage-K." This gage is connected with the cylinder air chamber by a drilled lead provided with a valve designated "Air Valve-Z." This valve, normally closed and covered by a cap plug, is opened only to obtain a reading on the air gage or when replenishing the air pressure. Filter screens are installed in the leads connecting the gage and valve with the cylinder air chamber as a safety device to reduce the danger of explosion in the event oil leaks into the air cylinder.* Normal air pressure in the system is 1550 pounds per square inch. The pressure should not be permitted to go above 1700 pounds per square inch nor below 1400 pounds per square inch with the gun at battery. This information is included on the instruction plate, adjacent to the valve, on the rear face of the yoke.

Plunger yoke and yoke rods. The counterrecoil plungers are connected to the gun yoke through the plunger yoke and two yoke rods (fig.4-8). The plunger yoke has integral yoke shoes which slide on the plunger yoke guide rails. These rails are mounted lengthwise and parallel to each other, on the top of the slide, between the counterrecoil cylinders. The forward end of each plunger is seated in the plunger yoke and is held there by the recuperator pressure; a locking pin prevents the plunger from turning. The entire assemblage is housed beneath a plunger cover that consists of formed steel plates and flanged frames in a riveted and spot welded assembly that is bolted to the slide. Portable sections may be removed for inspection and maintenance.

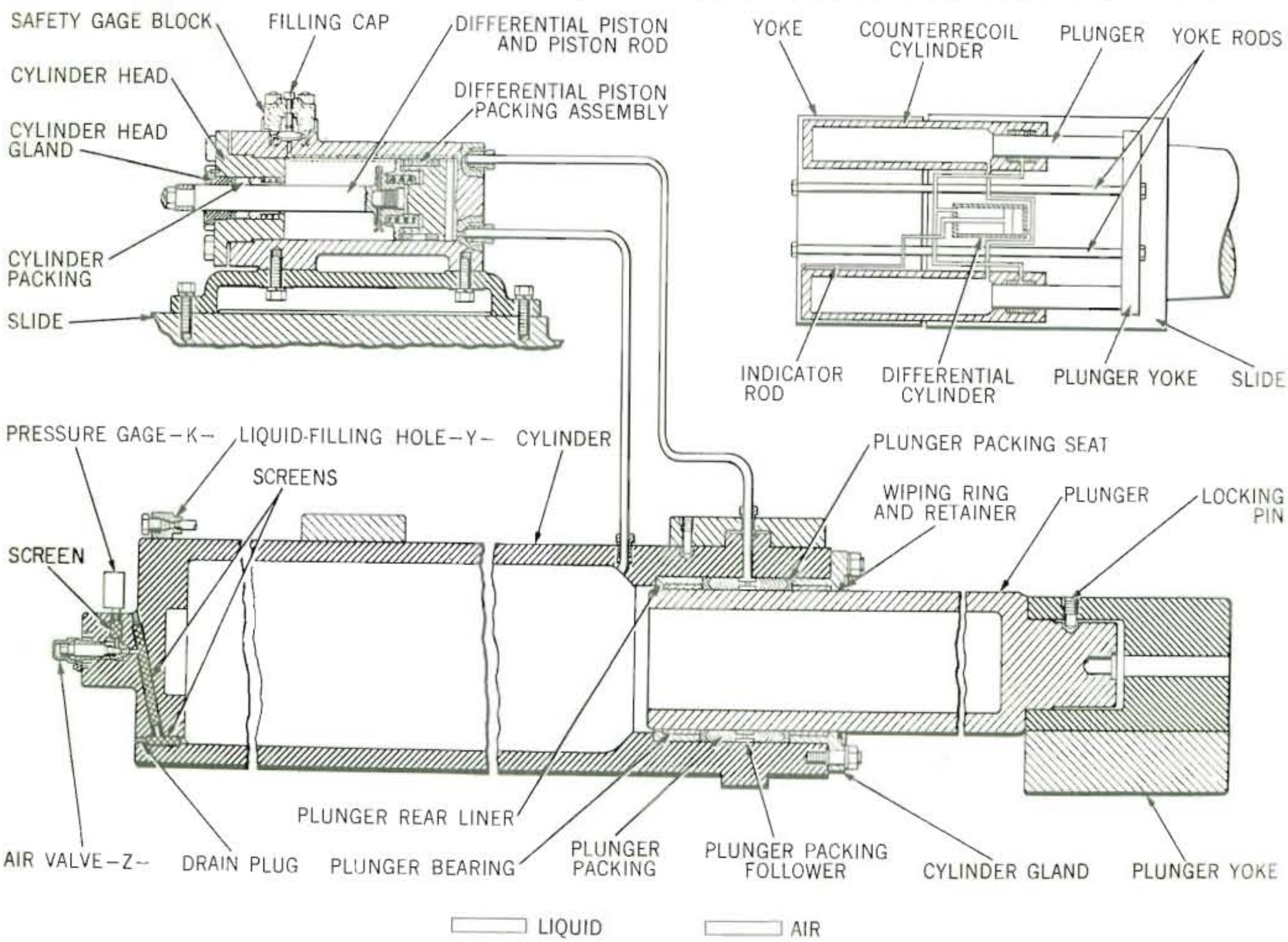

Figure 4-8. Counterrecoil System Schematic, Sectional View

*ORDALT 1324.

Yoke locking device. The yoke locking device (fig. 4-12) is located on top of the slide and is centered between the counterrecoil cylinders. The device is secured in a seat that is aligned with a notched lug on top of the yoke. The device is composed of a safety link, knurled nut, and a link pin. In its locked position, the safety link, with its nut swung down behind the notched lug of the gun yoke, secures the gun in battery. The safety link is strong enough to hold the gun in battery, with the counterrecoil cylinders empty, at any angle of elevation. The safety link will fail, without any other casualty, if the gun is fired before stowing the device.

Buffers. In addition to the mechanical automatic elevation and depression limit stops described in chapter 5, each slide is provided with hydraulic elevation and depression buffers. These buffers provide positive limits at a 45-degree angle of elevation for all turrets and a 2-degree angle of depression for turrets I and III. Limit of depression for turret II is 0 degrees elevation.

There are two elevation buffers for each slide. These are mounted on the left and right gun girders, each at the same level above the gun pocket floor. The elevation stops are mounted on the bottom of the slide rear end brackets.

The depression buffer (fig. 4-12) is bolted on top of the slide. Its housing is integral with the yoke locking device bracket. The steel depression stop is bolted to the underside of the turret roof in the way of the buffer.

Both the elevation and depression buffers are of a self-contained, hydraulic-type, spring-return design. Both have ball check valves to ensure quick return of the piston following its release.

Rear end brackets. The rear end brackets (fig. 4-13) are mounted at the rear of the gun slide, one on the left and one on the right side. They are similar right and left castings and are bolted to machined seats in the slide. The brackets are designed so that either a slide securing device and a cantilever loader's platform bracket or the elevating screw pin can be mounted to them. When assembled, the symmetrical design and arrangement of the rear end brackets adapt any slide to right, center, or left gun position of any one of the three gun turrets. The right and center guns are arranged with the platform bracket and slide securing device assembled to the right rear end bracket. The elevating screw pin is mounted in the left rear end bracket. This arrangement is reversed for the left gun. Elevation steps are located on the bottom of each bracket.

Loader's platform. The loader's platform extends rearward from the gun breech and spans the gun pocket. The platform is an integral part of the cantilever loader's platform bracket, which is attached to the rear end bracket, as shown in figure 4-1. The bracket is a steel casting. The arrangement illustrated is for the left gun; for the right and center guns the bracket is attached to the right rear end bracket.

(Slide securing device. The slide securing device (fig. 4-13) is a handwheel-operated screw and pin assemblage for stowing the gun slide at 0 degrees gun elevation. A tapered steel pin in the rear end bracket seats in a tapered socket in the adjacent gun girder. When seated, the pin relieves the elevating

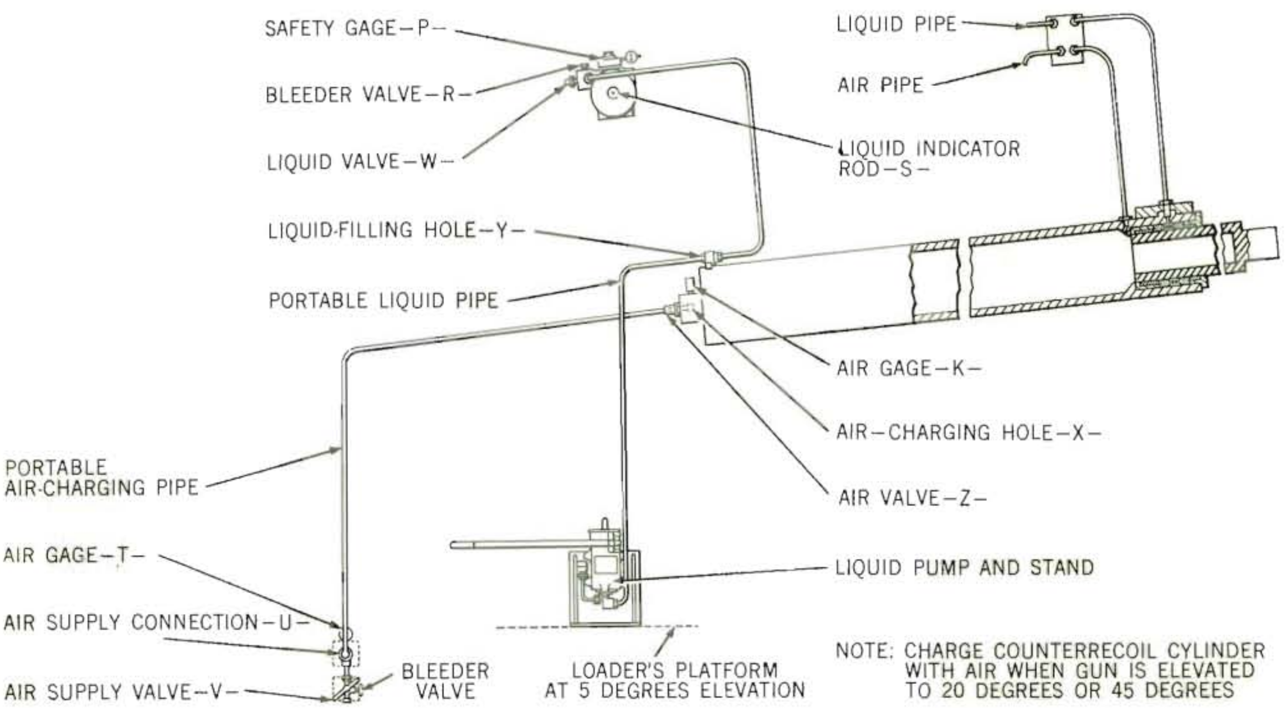

Figure 4-9. Counterrecoil System Air Charging and Liquid Devices

screw and nut assembly from dead load stresses. A securing pin latch locks the device when the pin is either fully seated or fully retracted. A second socket in the gun girder is aligned with the pin when the gun is at 20 degrees elevation. This is used to secure the slide when the portable air charging pipe is installed for replenishing the recuperator air charge (fig. 4-9). Steps and hand grips in the gun girder give access to the securing device. The device can be reached from the gun pocket floor when the gun is at either securing position.

Recoil switch and blade contacts. A lever-actuated recoil switch and a set of blade contacts are mounted on each gun slide as shown in figure 4-10. The switch is a two-circuit switch that is normally open when the gun is in battery and normally closed during recoil. In the normally open position the switch is part of a circuit containing the slide contacts and the breech closed switch; in the normally closed position the switch is connected to the coil circuit of the recoil relay, Relay Mk 5 Mod 1, and to the GUN IN RECOIL indicator lights circuit. The blade contacts are in series with the breech switch (ch. 3) and are closed when the gun is in battery. When closed, they energize a solenoid to unlock and permit the positioning of the gun captain's ready switch to READY and illuminate a BREECH CLOSED indicator light. When the gun leaves battery in recoil, the recoil switch closes, thus switching from one circuit to the other as described above. This action de-energizes the gun captain's ready switch solenoid and illuminates the recoil indicator lights. The sequence of events is so arranged that the recoil switch opens the circuit containing the breech closed switch before the slide contacts can open, thus eliminating any possible arcing of the slide contacts. The recoil switch and blade contacts are part of the interlock portion of Ready Light circuit 1R (ch. 15).

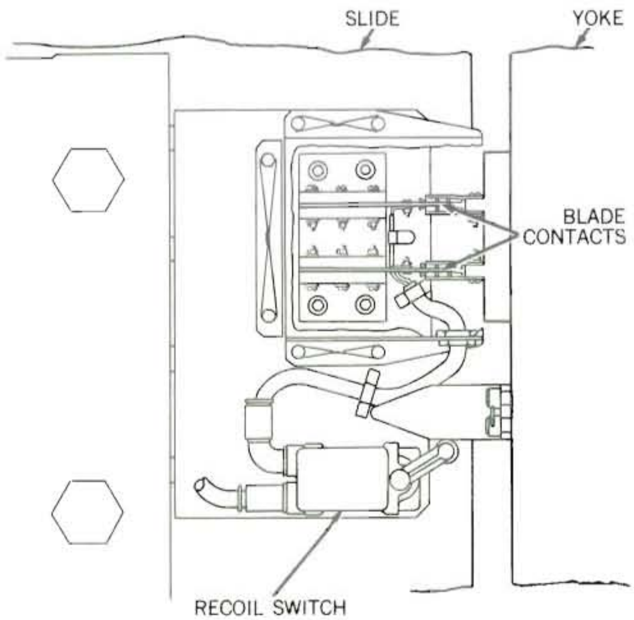

Figure 4-10. Recoil Switch and Blade Contacts

OPERATION

Slide operation when gun is fired.

Slide operation is controlled at all times by its self-contained recoil and counterrecoil systems. Before the gun is to be fired, the recoil system must be filled and the counterrecoil cylinders charged to the operating pressure.

When the gun fires and recoils, the recoil piston and the two counterrecoil plungers are drawn to the rear. The liquid in back of the recoil piston is throttled through the holes in the piston at a rate that is regulated by the varying diameter of the throttling rods. At the same time, the plungers are drawn to the rear within the counterrecoil cylinders. The initial high air pressure within these cylinders is raised by compression to a maximum pressure of 2150 pounds per square inch. The recoil is stopped within 48 inches (1/3-second) by the combined actions of the recoil and counterrecoil systems. The stored energy in the recuperator (counterrecoil cylinders) thrusts the gun back toward battery position. Return flow of liquid around the throttling rods buffs the counterrecoil to some extent; however, the major buffing action is provided by the recoil piston plunger. During the last 16 inches of return to battery movement, the recoil piston plunger displaces liquid from the dashpot in the recoil cylinder head. The liquid is forced from the dashpot through four grooves of variable depth in the plunger and through the fine clearance between the plunger and the cylinder head bushing. This action slows the return-to-battery movement and brings the oscillating gun assembly to a gentle stop as the gun reaches its battery position.

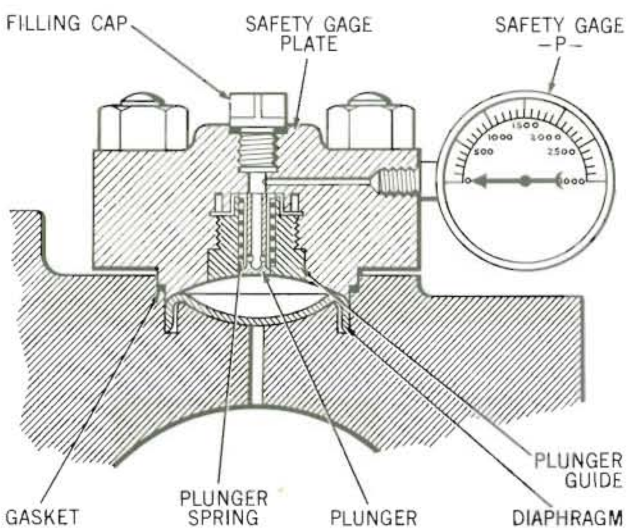

Figure 4-11. Counterrecoil System Differential Cylinder Safety Gage, Sectional View

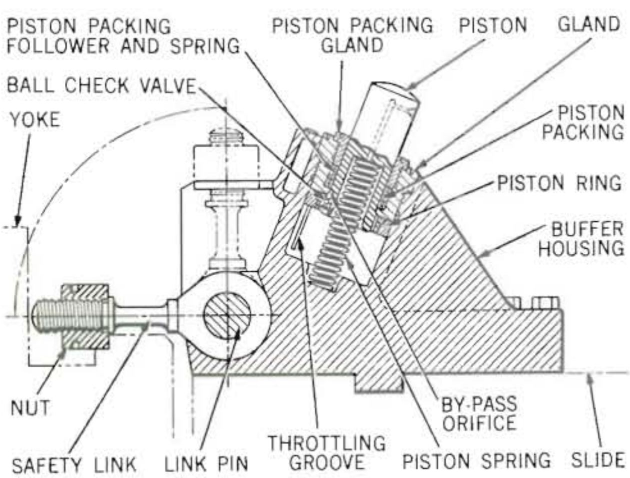

Figure 4-12. Depression Buffer and Yoke-Locking Device, Sectional View

INSTRUCTIONS

General instructions

The importance of proper care and frequent thorough inspection of the slides and deck lugs cannot be overstressed. Indifferent servicing of slide bearing surfaces and mechanisms, and of the other attached units, will result in improper functioning and serious damage. Observe the general regulations for maintenance of slides and deck lugs in the Bureau of Ordnance Manual, chapter V, the instructions on the instruction plates attached to the various assemblies, and the specific directions that follow in this chapter.

The slide assembly, particularly the hydropneumatic counterrecoil system, requires periodic exercise to keep it in good operating condition. Exercise serves the extremely important function of exercising the plunger packing chevrons, deflating and again distending them. This prevents their taking a permanent set or seizing. By keeping them pliant, their sealing capacity is retained.

To prevent unnecessary wear and consequent needless mechanical failure, keep all elements of the slide properly lubricated at all times. See the "Lubrication" paragraph following and the lubrication charts provided.

To prevent formation of rust or corrosion, all metal surfaces of the slide should have a preservative coating at all times. This coating may be paint or an oil film or other lubricant. Renew paint on painted surfaces whenever the coating is scratched, damaged, or deteriorated. Keep all bright work coated with a film of light oil except for the counterrecoil plungers, which should not be coated. Perform all lubrication as prescribed so that no bearing surface will be left unprotected.

Lubrication. Lubricate the deck lug, the slide, and all slide-mounted units according to the frequency and with the lubricants specified on the lubrication charts provided. Lubrication of the trunnion radial bearing is primarily for preservation. Keep the voids of the bearing and coverplate full of the corrosion inhibiting grease specified. Check the adequacy of lubricant at frequent intervals and observe the condition of the lubricant seals.

Gage the loss of lubricant from the bearings by regular cleaning and inspection of the bearing block surfaces. Observe whether an excessive quantity of grease has dripped from the bearings. Seepage that exceeds normal grease loss from the bearings indicates that lubricant must be replaced without delay.

Always lubricate the gun slide liner, the plunger yoke, and plunger yoke guide rails before and after firing. Do not use excessive amounts of grease; remove all spilled or exuding grease. Check the various parts for galling after firing. Refer to chapter 18 for information on the substitution of lubricants.

Routine preparation for firing. When preparing the slide assembly for firing, perform the following checks and operations:

1. Be sure that the slide is properly lubricated; perform the "before firing" lubrication.

2. Read and record the air pressure indicated on the counterrecoil air pressure gage. Recharge if at or below the minimum prescribed (1400 pounds per square inch).

3. Measure and record the projection of the counterrecoil system indicator rod S. Replenish liquid if necessary.

4. Retract and latch the pin of the slide securing device.

5. See that the recoil system liquid is at the proper level with the gun at 0 degrees elevation. Replenish, if necessary, until liquid appears at thecap plug on the expansion line.

6. Disconnect and stow the yoke locking device.

7. See that there is enough liquid in the elevating and depression stop buffers.

8. Make certain that the plunger covers are secure.

Instructions for stowing the slide after firing. Perform the following checks and operations after firing:

1. Connect the yoke locking device and draw it up tight.

2. Read and record the indicated air pressure on the counterrecoil cylinder air gage. Compare with previous reading. If an unusual loss is noted, determine and correct the cause.

3. Measure and record the projection of the counterrecoil system indicator rod S. If a loss of oil occurred during firing, determine the cause, correct it, and recharge the system with both oil and air.

4. Make an external inspection of the recoil system for evidence of loss of liquid.

5. Perform the recoil cylinder alkalinity tests prescribed by MIL-G-18694.

6. Remove the plunger covers and examine the plungers, yoke shoes, and guide rails for galling or other indications of misalignment.

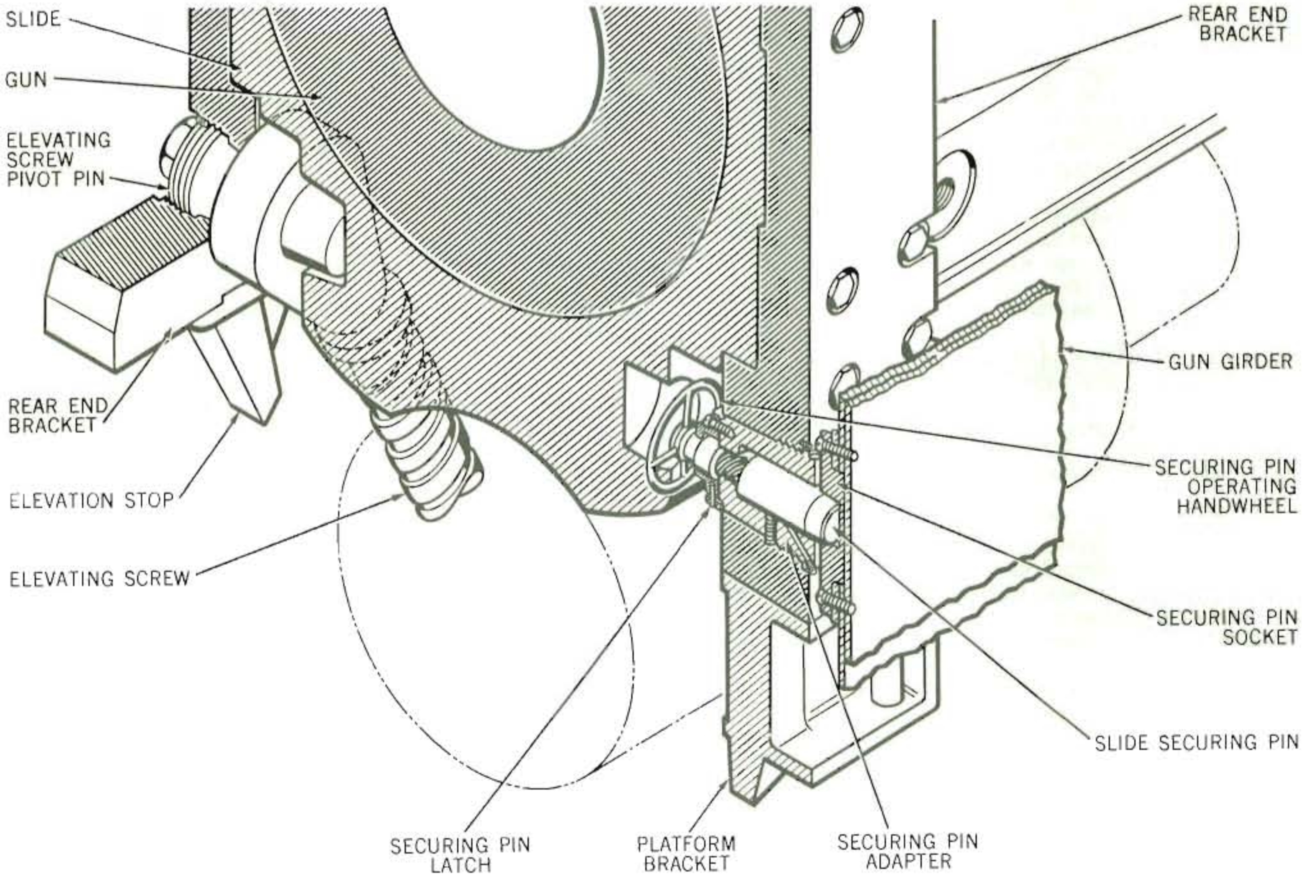

Figure 4-13. Slide Rear End Brackets, Slide Securing Device and Elevating Screw Pin, Sectional View

7. Inspect the differential cylinder leads, the gage, and the gage safety block for leakage.

8. Bring the gun to 0 degrees elevation; and latch the slide securing pin.

9. Replenish the slide liner lubricant and check the gun cover wiping ring.

General slide servicing instructions

The following instructions must be strictly observed to avoid casualties to personnel or equipment.

Recoil liquid. Never charge the recoil system with any other liquid than that prescribed by OS 1914, latest revision. When filling, strain through a fine mesh screen (at least 120 wires to the square inch, finer if possible). Whenever the system is drained, follow the instructions given in MIL-G-18694 as to care, preservation, and test.

Recuperator differential liquid. Never charge the differential cylinder with any liquid other than ice machine oil, Navy Symbol 2075. Replenish when necessary to maintain indicator rod S flush with the rear face of the indicator rear end bracket located on the counterrecoil cylinder. Always check the position of indicator rod S before firing the gun.

Air pressure. Never let the counterrecoil air pressure fall below the minimum of 1400 pounds per square inch except when making prescribed tests. Always check the air pressure before firing the gun. Recharge to 1550 pounds per square inch if below the safe minimum.

Recoil system liquid level. Maintain liquid level in the recoil system at the level of the cap plugs in the expansion line with the gun at 0 degrees elevation. Always check before firing the gun. If low, fill as directed under servicing instructions.

Recoil system valves and plugs. The drain valve, cylinder head plug, and cap plug must be securely seated at all times except when servicing the unit. Always see that they are properly secured and tight after the mechanism has been serviced.

Recuperator valves and plugs. Keep all air and liquid valves and plugs tight at all times except when performing necessary service to the mechanism. Air valve cap Z must be securely seated except when reading the air pressure. Always check the tightness of all valves and plugs before firing the gun.

Care of the recuperator plunger. Never wipe the plungers with dirty, greasy, or harsh rags. These highly finished cylindrical surfaces must be free from scars and scratches; they do not require a film of oil. Keep the plunger covers latched in place at all times except when inspecting or servicing the unit.

Thrust bearing clearance. Maintain a trunnion thrust plate clearance of 0.002 inch on each side. To correct for excessive thrust play, see the adjustment instructions on page 4-16 (deck lug adjustment).

Legibility of instruction plates. Do not deface, alter, or paint over the name and instruction plates; they must be kept clearly legible.

Tools and accessories. Special tools, spanner wrenches, open end wrenches, portable liquid and air charging pipe lines and fittings, and a liquid charging pump are provided for servicing the slide assembly. These tools and accessories, and no others, are to be used when working on the equipment.

Servicing instructions for slide recoil and counterrecoil systems

Servicing the recoil system. When filling or draining the recoil system, perform the operations listed below:

Filling routine.

1. Prepare an adequate quantity of recoil liquid in accordance with MIL-G-18694. Use no other liquid.

2. See that the yoke locking device is connected, and that the slide securing pin is seated with the gun at 0 degrees elevation.

3. Connect the standard funnel and filling hose to the filling and drain valve.

4. Support the funnel above the level of the cap plug aperture.

5. Remove one cap plug from the expansion line manifold.

6. Open the filling and drain valve.

7. Run liquid into the funnel until it flows from the cap plug opening. The last portion must be run in slowly to allow the recoil cylinder dashpot to fill.

8. Close the filling and drain valve.

9. Remove hose and replace cap.

10. Replace the cap plug.

Draining routine.

1. Connect the yoke locking device and secure the slide at 0 degrees elevation.

2. Connect the filling hose to the filling and drain valve.

3. Provide adequate containers on the gun pocket floor to catch the liquid.

4. Remove one cap plug from the expansion line manifold.

5. Open the drain valve and run the liquid into the containers.

Recoil piston rod packing replacement. Worn recoil piston rod packings that can not be set up enough to stop leakage must be replaced with new packings of the specification designated on the detail drawing. Replace as follows:

1. Drain the recoil system as outlined above.

2. Bring the gun to 0 degrees elevation and seat the slide securing pin.

3. Uncouple the yoke locking device.

4. Bleed the counterrecoil air pressure. (Do not completely exhaust the system.)

5. Jack the gun out of battery (approximately 12 inches).

6. Back off the cylinder nut with spanner wrench.

7. Slide the packing gland out.

8. Remove the split rings of worn packings.

9. Carefully clean the packing seat.

10. Position the new packing (OS 687) around the piston rod in the packing seat.

11. Install the packing gland and reseat the cylinder nut.

12. Jack the gun back into battery position; couple the yoke locking device and run the nut up tight.

13. Fill the recoil system as outlined above.

14. Retract the slide securing pin.

15. Bring the gun to 20 degrees elevation and recharge the counterrecoil air system to the required air pressure.

Servicing the counterrecoil system. The mechanisms of this system are provided with special portable pipe and pump facilities and with permanently located high-pressure air-line arrangements (in the gun pocket, turret pan floor) for the purpose of replenishing air and liquid and to permit service tests. All openings, valves, and gages are precisely designated by nameplates and the parts labeled have cross-reference instructions and diagrams compiled on drawing 232190. For convenient reference, the diagrams, servicing connections, and accessories are shown in figure 4-9, and the instructions are repeated below. These instructions are specific routines, both for initial charging of liquid and air, and for subsequent replenishment of one or both.

Part identity. The labeled parts and their symbols are:

1. On turret structure

Air supply valve	V
Air supply connection	U
Air gage	T
Bleeder valve	R

2. On each mechanism

Air valve	Z
Liquid valve	W
Liquid filling hole	Y
Air charging hole	X
Air gage	K
Safety gage	P
Indicator rod	S

Instruction plates. Instruction plates, secured to the rear face of the yoke, carry the legends reproduced below:

INSTRUCTION PLATE

AIR GAGE

AIR GAGE -K- LOCATED ON THE REAR OF EACH COUNTERRECOIL CYLINDER, PROVIDES A MEANS OF CHECKING THE AIR PRESSURE IN THE COUNTERRECOIL SYSTEM. THE AIR PRESSURE READING IS OBTAINED BY OPENING AIR VALVE -Z-. CAUTION: THE AIR VALVE -Z- SHOULD BE OPENED ONLY LONG ENOUGH TO OBTAIN AIR PRESSURE READING AND MUST BE CLOSED AT ALL OTHER TIMES. THE SERVICE PRESSURE SHOULD READ 1550 POUNDS ON AIR GAGE -K-. UNDER NO CONDITION SHOULD AIR PRESSURE BE ALLOWED TO DROP BELOW 1400 POUNDS, OR RISE ABOVE 1700 POUNDS ON AIR GAGE -K-. DO NOT ATTEMPT TO REPLENISH OR BLEED THE AIR SYSTEM WITHOUT CONSULTING ORDNANCE DRAWING NO. 232190.

INSTRUCTION PLATE

LIQUID INDICATOR

THE AMOUNT OF PROJECTION OF LIQUID INDICATOR -S- BEYOND THE REAR FACE OF ITS REAR BRACKET INDICATES THE LOSS OF LIQUID FROM THE COUNTERRECOIL SYSTEM. UNDER NO CONDITION SHOULD THE INDICATOR BE ALLOWED TO PROJECT BEYOND THE REAR FACE OF THE YOKE WITHOUT REPLENISHING THE LIQUID IN THE DIFFERENTIAL CYLINDER. DO NOT REMOVE LIQUID VALVE CAP -W-, LIQUID FILLING HOLE PLUG -Y-, NOR ATTEMPT TO REPLENISH THE LIQUID IN THE DIFFERENTIAL CYLINDER WITHOUT CONSULTING ORDNANCE DRAWING NO. 232190.

The servicing instructions and warnings quoted from drawing 232190 are:

WARNING

YOKE LOCKING DEVICE MUST BE CONNECTED AT ALL TIMES EXCEPT WHEN THE GUNS ARE TO BE FIRED OR OPERATING TESTS ARE TO BE CONDUCTED.

COUNTERRECOIL SYSTEM

THE COUNTERRECOIL SYSTEM IS LOCATED ON TOP OF THE SLIDE AND CONSISTS OF AN AIR AND LIQUID SYSTEM HOUSED IN TWO AIR CYLINDERS AND ONE DIFFERENTIAL CYLINDER. THE AIR CYLINDERS AND DIFFERENTIAL CYLINDER ARE INTERCONNECTED WITH PIPING. THE AIR SYSTEM IS FILLED WITH AIR TO A PRESSURE OF 1550 POUNDS PER SQUARE INCH.

THE LIQUID SYSTEM IS FILLED WITH ICE MACHINE OIL (NAVY SYMBOL NO. 2075). THE LIQUID SYSTEM HOLDS APPROXIMATELY 1-1/2 GALLONS. WHEN THE AIR AND LIQUID SYSTEMS ARE BOTH EMPTY, THE LIQUID SYSTEM MUST BE FILLED FIRST.

LIQUID SYSTEM

TO FILL WHEN BOTH AIR AND LIQUID SYSTEMS ARE EMPTY:

1. SET GUNS TO FIVE DEGREES ELEVATION.

2. DISASSEMBLE SAFETY GAGE PLATE.

3. DISASSEMBLE SAFETY GAGE LEATHER DIAPHRAGM.

4. REMOVE PLUG FROM LIQUID FILLING HOLE -Y-.

5. REMOVE CAP FROM LIQUID VALVE -W- AND BACK OFF VALVE STEM 3 TURNS.

6. OPEN BLEEDER VALVE -R-.

7. SECURE LIQUID PUMP TO LOADER'S PLATFORM.

8. CONNECT LIQUID PORTABLE PIPE FROM LIQUID PUMP TO LIQUID FILLING HOLE -Y-.

9. PUMP LIQUID INTO SYSTEM.

10. CLOSE BLEEDER VALVE -R- WHEN LIQUID APPEARS AT THE VALVE.

11. CONTINUE TO PUMP LIQUID UNTIL LIQUID APPEARS FLUSH WITH THE SAFETY GAGE DIAPHRAGM SEAT.

12. REPLACE LEATHER DIAPHRAGM, PRESSING IT FIRMLY AGAINST ITS SEAT.

13. ASSEMBLE SAFETY GAGE PLATE.

14. REMOVE SAFETY GAGE FILLING CAP AND GASKET.

15. WITH SMALL ROD, PUSH DOWN SAFETY GAGE PLUNGER AS FAR AS IT WILL GO: HOLDING PLUNGER DOWN, FILL SLOWLY WITH LIQUID THE SPACE ABOVE THE LEATHER DIAPHRAGM. THE SAFETY GAGE PLUNGER SHOULD BE WORKED UP AND DOWN DURING FILLING TO MAKE SURE ALL THE AIR HAS PASSED OUT OF THE SAFETY GAGE. (THE SAFETY GAGE HOLDS ABOUT 2 OZS OF THE SAME LIQUID USED IN THE LIQUID SYSTEM.)

16. WHEN THE LIQUID IN THE SAFETY GAGE IS FLUSH WITH THE FILLING CAP HOLE, REPLACE FILLING CAP AND GASKET.

17. CONTINUE TO PUMP LIQUID INTO SYSTEM UNTIL LIQUID INDICATOR ROD -S- IS FLUSH WITH REAR FACE OF THE REAR END BRACKET.

18. SCREW IN LIQUID VALVE -W- FIRMLY AGAINST ITS SEAT AND REPLACE VALVE CAP.

19. DISCONNECT LIQUID PORTABLE PIPE FROM LIQUID PUMP AND LIQUID FILLING HOLE -Y-.

20. REPLACE PLUG IN LIQUID FILLING HOLE -Y-.

TO REPLENISH UNDER AIR PRESSURE

NOTE: DUE TO LUBRICATION OF COUNTER-RECOIL PLUNGER, DIFFERENTIAL PISTON AND PISTON ROD, THE LIQUID WILL IN TIME NEED REPLENISHING. THIS REPLENISHING SHOULD BE DONE BEFORE THE LIQUID INDICATOR ROD -S- PROJECTS FLUSH WITH THE REAR FACE OF THE YOKE.

21. SET GUNS TO FIVE DEGREES ELEVATION.

22. REMOVE PLUG FROM LIQUID FILLING HOLE -Y-.

23. PERFORM OPERATIONS 6, 7, 8, 9, 10, 5, 17, 18, 19, and 20.

SAFETY GAGE P

THERE IS A SAFETY GAGE LOCATED ON THE TOP ON EACH DIFFERENTIAL CYLINDER. THE SAFETY GAGE SHOWS THE LIQUID PRESSURE ON THE SYSTEM AT ALL TIMES. IF THE GAGE IS BROKEN OFF OR DAMAGED, THE LEATHER DIAPHRAGM PREVENTS THE IMMEDIATE LOSS OF LIQUID FROM THE SYSTEM. THE SPACE ABOVE THE LEATHER DIAPHRAGM CANNOT BE FILLED IF AIR PRESSURE IS ON THE SYSTEM. THE FOLLOWING CONDITIONS MAY CAUSE THE SAFETY GAGE TO CEASE FUNCTIONING:

A. LOSS OF LIQUID FROM ABOVE THE LEATHER DIAPHRAGM.

B. THE END OF THE INDICATOR ROD -S- HAS BEEN ALLOWED TO EXTEND BEYOND THE REAR FACE OF THE YOKE, DUE TO LOSS OF LIQUID FROM THE COUNTERRECOIL SYSTEM.

C. INSUFFICIENT AIR PRESSURE ON THE SYSTEM.

D. DEFECTIVE SAFETY GAGE.

TO FILL OR REPLENISH

SAFETY GAGE P

24. BLEED AIR SYSTEM (OPERATIONS 27 AND 29)

25. PERFORM OPERATIONS 14, 15, AND 16.

AIR SYSTEM

TO CHARGE WHEN EMPTY

CAUTION: MAKE SURE YOKE LOCKING DEVICE HAS BEEN CONNECTED AND LIQUID SYSTEM HAS BEEN FILLED.

26. ELEVATE GUNS TO 20 DEGREES ELEVATION.

27. REMOVE PLUG FROM AIR CHARGING HOLE -X-.

28. CONNECT PORTABLE AIR PIPE FROM AIR SUPPLY CONNECTION -U- TO AIR CHARGING HOLE -X-.

29. REMOVE CAP FROM AIR CHARGING VALVE -Z- AND BACK OFF VALVE STEM 3 TURNS.

30. OPEN AIR SUPPLY VALVE -V- VERY SLOWLY AND CHARGE TO 500 POUNDS PER SQUARE INCH AS INDICATED ON AIR GAGE -K-.

31. CLOSE AIR VALVES -V- AND -Z-.

32. BLEED PRESSURE FROM PORTABLE AIR PIPE AT BLEEDER VALVE IN AIR SUPPLY VALVE -V- AND DISCONNECT AT AIR CHARGING HOLE -X-.

33. OPEN AIR VALVE -Z- VERY SLOWLY AND EXAMINE ESCAPING AIR AND AIR CHARGING HOLE -X- TO DETECT THE PRESENCE OF OIL.

34. IF NO OIL IS DETECTED IN OPERATION 33, PROCEED AS FOLLOWS:

A. RECONNECT PORTABLE AIR PIPE TO AIR CHARGING HOLE -X-.

B. CHARGE SYSTEM VERY SLOWLY UNTIL AIR GAGE -K- INDICATES A PRESSURE OF 1700 POUNDS PER SQUARE INCH. ALLOW THIS PRESSURE TO STAND FOR SEVERAL HOURS, THEN BLEED TO SERVICE PRESSURE OF 1550 POUNDS PER SQUARE INCH.

C. CLOSE AIR VALVES -V- AND -Z-, AND REPLACE CAP ON AIR VALVE -Z-.

D. BLEED PRESSURE FROM PORTABLE AIR PIPE AT BLEEDER VALVE IN AIR SUPPLY VALVE -V-, DISCONNECT AIR PIPE AT BOTH ENDS AND REPLACE PLUGS IN AIR CHARGING HOLE -X- AND AIR SUPPLY CONNECTION -U-.

35. IF OIL IS DETECTED IN OPERATION 33, REPEAT OPERATIONS 28 TO 33, USING A PRESSURE OF 800 POUNDS PER SQUARE INCH.

36. IF OIL IS PRESENT AFTER OPERATIONS 33 AND 35, PROCEED AS FOLLOWS:

A. DRAIN LIQUID SYSTEM, DISASSEMBLE AND EXAMINE COUNTERRECOIL AND DIFFERENTIAL CYLINDER PACKINGS.

B. DISASSEMBLE ALL PARTS OF AIR SYSTEM AS ARE NECESSARY TO INSURE REMOVAL OF ALL OIL.

C. REASSEMBLE AND PERFORM OPERATIONS 1 TO 20.

D. PERFORM OPERATIONS 26 TO 36.

TO REPLENISH

NOTE: WHEN AIR PRESSURE ON GAGE -K- DENOTES 1400 POUNDS PER SQUARE INCH OR LESS, THE AIR SYSTEM SHOULD BE REPLENISHED.

CAUTION: MAKE SURE YOKE LOCKING DEVICE IS CONNECTED.

37. CHECK AIR SUPPLY LINE BY OPENING AIR VALVE -V- AND CHECK PRESSURE ON LINE BY AIR GAGE - T-.

38. CLOSE AIR VALVE -V- AND BLEED PRESSURE OFF AIR GAGE -T- BY BLEEDER VALVE IN AIR VALVE -V-.

39. PERFORM OPERATIONS 26 TO 29 AND 34B TO D

TO OBTAIN READING OF AIR PRESSURE ON SYSTEM

NOTE: THE AIR PRESSURE IN THE SYSTEM SHOULD BE CHECKED DAILY AND THE PRESSURE SHOULD BE KEPT AT THE SERVICE PRESSURE OF 1550 POUNDS PER SQUARE INCH ON AIR GAGE -K-

40. MAKE SURE AIR CHARGING HOLE PLUG -X- IS TIGHT IN ITS SEAT.

41. OPEN AIR VALVE -Z- ONE TURN.

42. READ PRESSURE ON AIR GAGE -K-.

43. CLOSE AIR VALVE -Z-.

44. BACK OFF AIR CHARGING HOLE PLUG -X- TO BLEED PRESSURE OFF AIR GAGE -K-; THEN RETIGHTEN AIR CHARGING HOLE PLUG -X-.

General note

1. For daily, monthly, and annual inspection of the counterrecoil system, see instructions issued by the Bureau of Ordnance.

2. Caution: In closing air or liquid valves, use proper tool with no extension. Excessive force on valve may damage valve parts or seat.

3. Caution: Air valves should be opened very slowly, to prevent possible explosion or damage to air gage.

4. In no case should the counterrecoil system be charged with air if oil is in the air portion of the counterrecoil system. This would result in an explosive mixture of air and oil vapor.

5. Extreme care should be taken that the counterrecoil system is not inadvertently charged with oxygen instead of air. An oxygen and oil vapor mixture is highly explosive.

Counterrecoil plunger packing replacement. Worn counterrecoil plunger packing must be replaced to prevent formation of an explosive oil or air mixture, and to prevent loss of air or oil.

Packing specifications. The plunger packing is a chevron-type preformed composition packing ring identified by Ordnance Specification 749.

Packing replacement routine. For plunger packing replacement routine, see "Counterrecoil plunger and packing assembly and disassembly," this chapter.

Routine tests of the slide

General instructions. The slide assembly, and particularly the hydropneumatic counterrecoil mechanism, requires frequent inspection and regular exercise tests in order to assure normal performance when the gun is fired. These tests and inspections are required by instructions contained in the Bureau of Ordnance Manual. Such tests furnish exercise for the plungers and differential chevrons, deflecting and distending them, thus preventing their taking a set or seizing the plungers. By keeping the packings pliant, their sealing capacity is retained. Daily, monthly, and overhaul tests and inspections are separately listed below.

Daily inspection. Daily and immediately after firing, inspect the counterrecoil system for evidence of air or liquid leakage. Observe carefully the exposed cylindrical surface of each recuperator plunger. Proceed as follows:

1. See that the yoke locking device is connected and that the nut is drawn tight against the shoulder of the yoke.

2. Read and record the recuperator system pressures as indicated on both the safety gage and the air pressure gages. If air pressure has dropped to 1400 pounds per square inch or below, recharge the system.

3. Measure and record the protrusion of indicator rod S. If rod end projects near or beyond the rear face of the yoke, replenish the liquid.

Monthly test. Once monthly after completing the inspection prescribed above, perform the following test routine:

CAUTION: Do not elevate the gun after air has been bled from the counterrecoil system with the gun at or near horizontal position. The gun will move toward its recoil position and the plunger yoke shoe will strike the studs in the face of the counterrecoil cylinder. This will stop the gun but the inertia of the counterrecoil plunger may be sufficient to shear or damage the locking pin.

1. Check the level of the recoil system liquid with the gun at 0 degrees elevation. Replenish if necessary until liquid flows from the cap plug vent.

2. Disconnect the yoke locking device, elevate the gun to 20 degrees elevation, secure the slide and perform the following counterrecoil exercise. * Connect the portable air-charging pipe between U and X. Verify that bleeder valve V is closed. Open air valve Z three turns. Bleed air at V until the gun slides out of battery. Close bleeder in valve V and open air-supply valve until gun returns to battery. Repeat the exercise two more times and give final charge in accordance with routine outlined under "Daily inspection." Retract the slide securing pin.

3. Depress the gun to loading position. Connect the yoke locking device and perform the following differential piston exercise. Remove plug Y and valve cap W. Connect the portable liquid filling pipe to Y and place the lower end in a bracket. Open valve W and bleed off the liquid until indicator rod S is one inch from the rear face of the yoke. Mount the liquid charging pump with oil-pressure gage installed in the line, and restore the liquid. Repeat the exercise two more times and give the final charge in accordance with the routine outlined under "Daily inspection."
* The 45-degree-elevation position shown in figure 4-8 and the portable pipe indicated for that position are not intended for the sliding out exercises. The arrangement shown for 45 degrees elevation is for purpose of service operation in order to get an unbalanced gun assembly back into battery after losing air charge. Under such conditions the elevating gear must not be used to raise the gun to the 20-degree air-charging position.

4. With the liquid pump connected as above, and with the yoke locking device connected, bleed the counterrecoil air charge to zero. Pump liquid until the differential piston moves beyond its fully charged position, and until the liquid pressure gage (safety gage) reading indicates 1000 pounds per square inch. Observe that the plunger packings hold this pressure. Then recharge the air pressure to 1550 pounds per square inch. Bleed liquid until the indicator rod S is at normal full-charge position. Secure the counterrecoil system and mount.

Overhaul inspection. Supplement the above inspections and tests by overhaul inspection of the counterrecoil system at intervals designated by the Bureau of Ordnance Manual. Perform the disassembly at the home yard with the assistance of the yard force. The procedure is as follows:

1. Open the counterrecoil and differential cylinders.

2. Examine the condition of packings, glands, liners, followers, packing seats, wiping rings, working surfaces, and cylinder walls.

NOTE: Extreme care shall be exercised to prevent foreign matter entering air passages. It is not necessary to remove filter screens.

3. Clean out the cylinders and note the amount of sediment present in each. If the amount is unusually large, forward samples (properly designated) to the Bureau of Ordnance.

4. Test the air and liquid gages by comparison with a standard gage.

5. Renew all parts which are in an unsatisfactory condition and reassemble the mechanism. Use Naval Gun Factory chevrons only.

Adjustments

Adjustments are to be performed by personnel familiar with the procedure and only when found to be necessary. Non-adjustable units include the deck lug radial bearing and the gun slide with all its components including the slide forging, the gun cover, the slide liners and wiping ring, the yoke locking device, the buffers, the rear end brackets and loader's platform, and the slide securing device. Adjustments pertaining to the gun assembly, which includes the breech mechanism and gas ejector, are covered in chapter 3. Adjustable elements of the deck lugs and the procedure for making the adjustments are given in the following paragraph.

Deck lug adjustment. The deck lug is designed for fixed nonadjustable arrangement. The deck lug thrust plates are installed with a thrust clearance of 0.002 inch between the slide and each of the two plates. Check the thrust clearance, and if the clearance is excessive, correct by installing oversized thrust plates. This operation is described on page 4-3.

DISASSEMBLY AND ASSEMBLY

General instructions

Operations of dismantling, disassembly and assembly of the components are to be performed by personnel familiar with the procedure who are equipped with standard and special tools required for the job at hand. Reassembly and reinstallation of components is facilitated by precise fitting of the parts at the time of initial installation at the Naval Gun Factory. Design is such that once this initial fitting is made, a minimum of adjustment or fitting is necessary on subsequent reassembly. When disassembling or assembling components of the slide, refer to applicable general arrangement and detail design drawings for information not readily apparent from an examination of the assembly or from the instructions.

Counterrecoil plunger packing replacement. Defective chevron packing rings or other components of the plunger packings should be removed and reassembled as prescribed below. In these operations the plunger rear liner and plunger bearing must not be withdrawn. If the rear liner is to be removed (for replacement of the bearing or other reason) the counterrecoil cylinder must be disassembled intact from the slide and the plunger must be withdrawn before disassembling the packing. The operations which follow should be performed preferably with the gun at 0 degrees elevation. If the operations are performed at 20 degrees elevation (access is more convenient at this position), extreme care must be exercised to prevent the plunger from slipping into the cylinder. To disassemble and assemble the plunger packing refer to (see paragraph 4C OS5321) drawings 232376 and 236064. Proceed as follows:

1. Secure the yoke locking device.

2. Seat the slide securing pin in its socket.

3. Remove the plunger cover.

4. Secure C-clamps to the guide rails just to the rear of the plunger yoke.

5. Remove air valve cap Z and plug X.

6. Open air valve Z and completely bleed the recuperator air pressure.

NOTE: It is not necessary to drain the liquid from the differential cylinder. The position of the packing lead is such that only the liquid in the packing will be lost.

7. Remove the locking pin from the yoke, one plunger only.

8. Remove the 12 stud nuts and lock washers from the cylinder gland and slide the gland forward.

9. Place a wood block and pad beneath the plunger in front of the cylinder.

10. Loosen the plunger from the yoke and withdraw it sufficiently to remove the gland.

11. Refer to drawing 236064. Slide the plunger rearward sufficiently to assemble the connecting rod (236064-4) and the rail fixture (236064-2), with the eye nut (236064-7) on the forward end of the connecting rod, and with the stop rod (236064-6) and nut seated in the rail fixture. Attach a sheave to the yoke (use eye bolt in the plunger yoke seat). Reeve a line through the sheave and attach to the eye nut. Snub the line at the projectile hoist cradle.

12. Slide the plunger into the cylinder until the stop rod contacts the cylinder face.

13. Remove packing elements to a position on the connecting rod.

14. Draw the plunger forward until the eye nut is at the sheave.

15. Install a wood block under the forward end of the plunger.

16. Remove the eye nut and rail fixture.

17. Remove the old packing from the connecting rod and replace with new packing chevrons and gland.

18. Reassemble rail fixture and eye nut and remove the wood block.

19. Install the packing in the cylinder and secure the gland. Do not move the plunger.

20. Remove rail fixture, connecting rod, sheave, and line. Support the plunger forward end until it is seated and secured in the plunger yoke.

21. Recharge the recuperator air pressure and replenish the differential cylinder liquid in accordance with the routines outlined in "Servicing the counterrecoil system" of this chapter.

22. Remove the C-clamps and replace the plunger cover.

Chapter 5

ELEVATING GEAR

16-inch Elevating Gear Mark 5, Mods 0, 1, and 2

16-inch Elevating Receiver Regulator Mark 10 Mod 0

GENERAL DESCRIPTION

The gun elevating equipments installed in each turret are three independent elevating gear assemblies. They are designated 16-inch Elevating Gear Mk 5 Mod 0 for the right gun, 16-inch Elevating Gear Mk 5 Mod 1 for the center gun, and 16-inch Elevating Gear Mk 5 Mod 2 for the left gun. The three assemblies are identically powered and controlled and differ only as to position and arrangement of components. A typical elevating gear installation is illustrated in figure 5-1.

The elevating gear assemblies control and operate the gun laying movements of the three gun slides. These assemblies elevate and depress the guns through 47-degree arco in turrets I and III, and 45-degree arcs in turret II. The arcs are limited by stops at 45 degrees elevation in all turrets, at 2 degrees depression in turrets I and III, and zero degrees depression in turret II.

16-inch Elevating Gear Mk 5 is an electric-hydraulic machine with an elevating-screw and oscillating-bearing type of final drive. The independent selector for each gun permits selection of control of gun laying from a remote control station or hand control of gun laying from a local pointer's station. The method of gun elevation control is selected by the gun layer by positioning a control selector that is mounted on the bulkhead adjacent to his station. Automatic positioning of the gun at five degrees elevation for loading and return of the gun to automatic control is provided by a switch at the gun captain's station.

Each elevating gear comprises a power drive, an elevating screw and oscillating bearing, and control mechanisms which include 16-inch Receiver-Regulator Mk 10 Mod 0. Component locations (fig. 5-1) are similar for the three turret assemblies; all are located forward and below the respective gun pockets, in the pan floor and electric deck spaces, except for certain controls. The motor controllers are located in the upper projectile handling deck machinery space. The ON-OFF push-button control is at the gun layer's station.

The power drive is an electrically driven hydraulic transmission that drives the elevating screw through the oscillating bearing to elevate and depress the gun at maximum average rate of 12 degrees per second. The arrangement of the mechanical components of the elevating gear with respect to the power drive is shown in figure 5-2.

In automatic control, the receiver-regulator receives gun elevation order electrically from the remote control station. Actual gun elevation is automatically transmitted to the receiver-regulator through a mechanical response gear. A difference between elevation order and actual elevation results in movement of the A-end tilting box (fig. 5-2), through a hydraulic control valve and the servo piston. The amount of tilt, determined by the gun position "error," regulates the speed of the B-end as it drives the elevating screw. "Follow-up" control is provided by shafting and gearing that feed B-end response back to the receiver-regulator and to the A-end tilting box to return it to neutral. Control is entirely automatic; no action by turret personnel is required.

In hand control, the gun layer's handwheels are mechanically connected (through shafts, gears, and a clutch) to a hydraulic directional valve, which ports servo pressure to the servo piston. Movement of the handwheels moves the A-end tilting box through the directional valve and the servo piston. The B-end elevates or depresses the gun at a rate corresponding to the direction and speed of handwheel motion. Response is mechanically fed back to the A-end tilting box to return it to neutral. Because of this follow-up action, the gun will continue to move (within its limits) only as long as the handwheels are turned.

In automatic loading control, a loading valve in the receiver-regulator controls hydraulic flow to the servo cylinder to bring the gun automatically to five degrees elevation for loading.

Design differences

The right- and center-gun elevating gears are identical, with the exception of some hydraulic pipes and the positions of certain parts. In the center gun installation, the electric motor is located farther away from the A-end. The response gear shafting is rearranged to conform to the offset-from-center installation of the center-gun elevating gear.

The left-gun elevating gear differs from the right and center installations as follows: The B-end is mounted in the opposite way from the like units of the right and center installations; the hydraulic pipes are rearranged to conform to this mounting. The arrangement of the response gear is similar to that of the right gun.

Elevating gear data.

Gun movement limits	
Maximum elevation, deg	45
Maximum depression, deg	-2
Maximum depression (turret II), deg	0
Loading position, deg	5
Speed, maximum gun laying, deg per sec.	12

Power drive

Components. The components of each elevating-gear power drive are:

- Electric motor
- Controller
- Speed reducer
- Auxiliary pumps
- Motor to A-end couplings
- Hydraulic pump (A-end)
- Hydraulic motor (B-end)
- B-end coupling
- Servo and supercharge filters
- Servo and supercharge relief valves
- Expansion tank

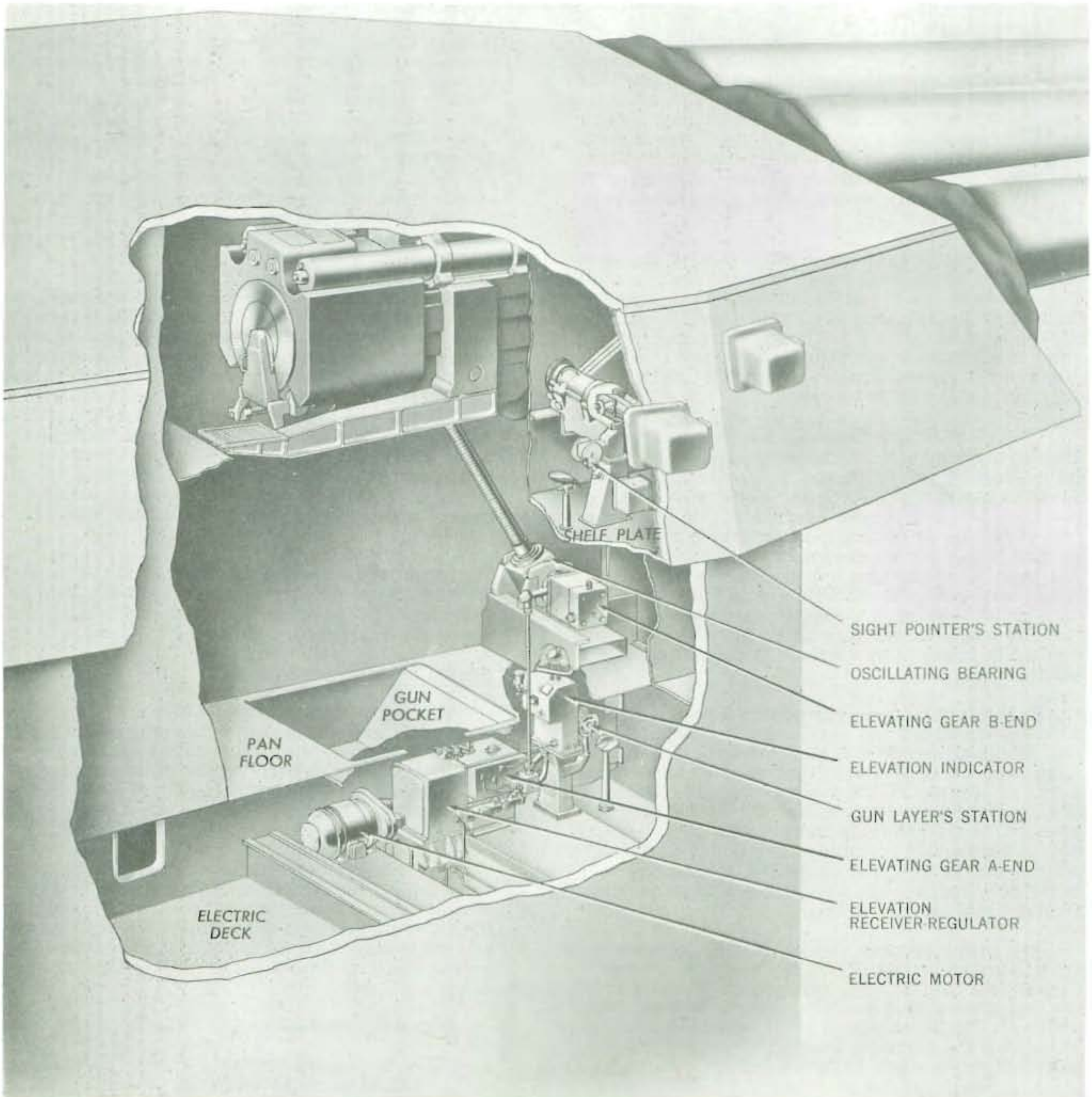

Figure 5-1. 16-inch Elevating Gear Mk 5 Mod 0, General Arrangement

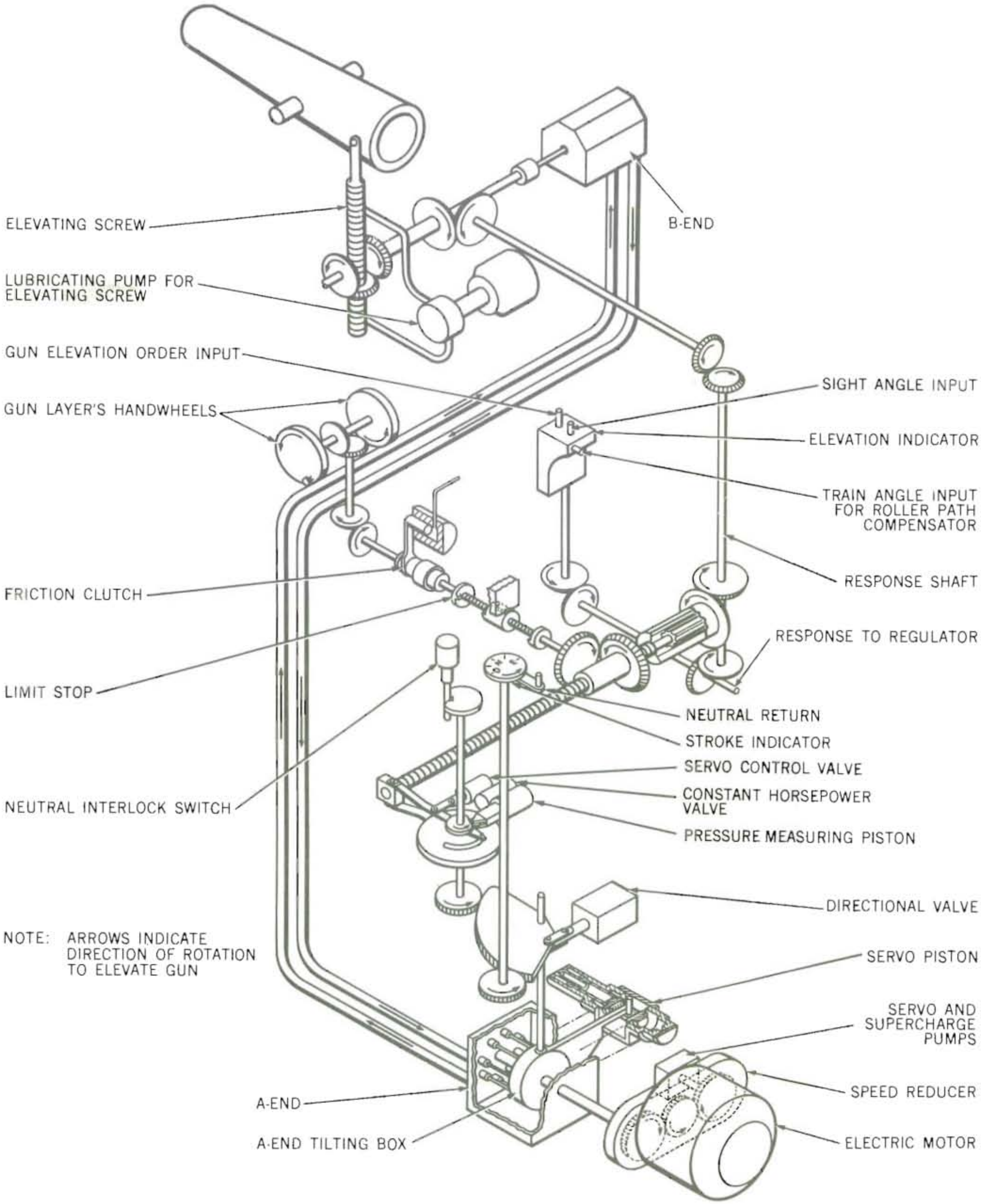

Figure 5-2. 16-inch Elevating Gear Mk 5 Mod 0, Schematic Arrangement

Electric motor. The electric motor is a squirrel-cage induction type. It is mounted on a structural foundation (fig. 5-1) that raises it slightly above the electric deck. The motor has its output shaft at the forward end, with direct drive coupling to the speed reducer (fig. 5-3).

Motor data.

Type	squirrel cage, induction
Design features	waterproof, fan cooling, horizontally mounted, reduction gear drive
Horsepower	60
Revolutions per minute, synchronous	1800
Revolutions per minute, full load	1750
Rotation (viewed at fan end)	counterclockwise
Speed class	constant
Voltage	440
Amperes, full load	81.8
Amperes, locked rotor	560.0
Phases	3
Cycles	60
Ambient temperature, C	75
Torque class	normal, low starting current
Weight (including speed reducer, lb)	1880
Manufacturer	Reliance Electric Engineering Co.
Manufacturer's designation	Type AA
Drawing	265472

Controller. Each electric motor is powered and controlled through an across-the-line magnetic-type controller. Each controller contains a main contactor, overload relays, reset relays, and a hand-operated circuit breaker. The controller is controlled from a master push button at the gun layer's station. This switch is normally open and is closed by pressing the START-EMERG push button. The switch is opened by pressing the STOP push button.

Controller data.

Type	across the line magnetic starter
Horsepower rating full load	60
Protection	
Overload	thermal type
Adjustable range, amps	80-95
Normal setting, amps	90
Short circuit, circuit breaker, amps	675
Under Voltage	
Drop-out voltage	44
Sealing voltage	374
Shock rating	50
Weight lbs	165
Manufacture	Cutler - Hammer
Drawing	365736

Speed reducer. The speed reducer (fig. 5-3) is driven by the electric motor and is bolted directly to the motor case by means of an integral flange

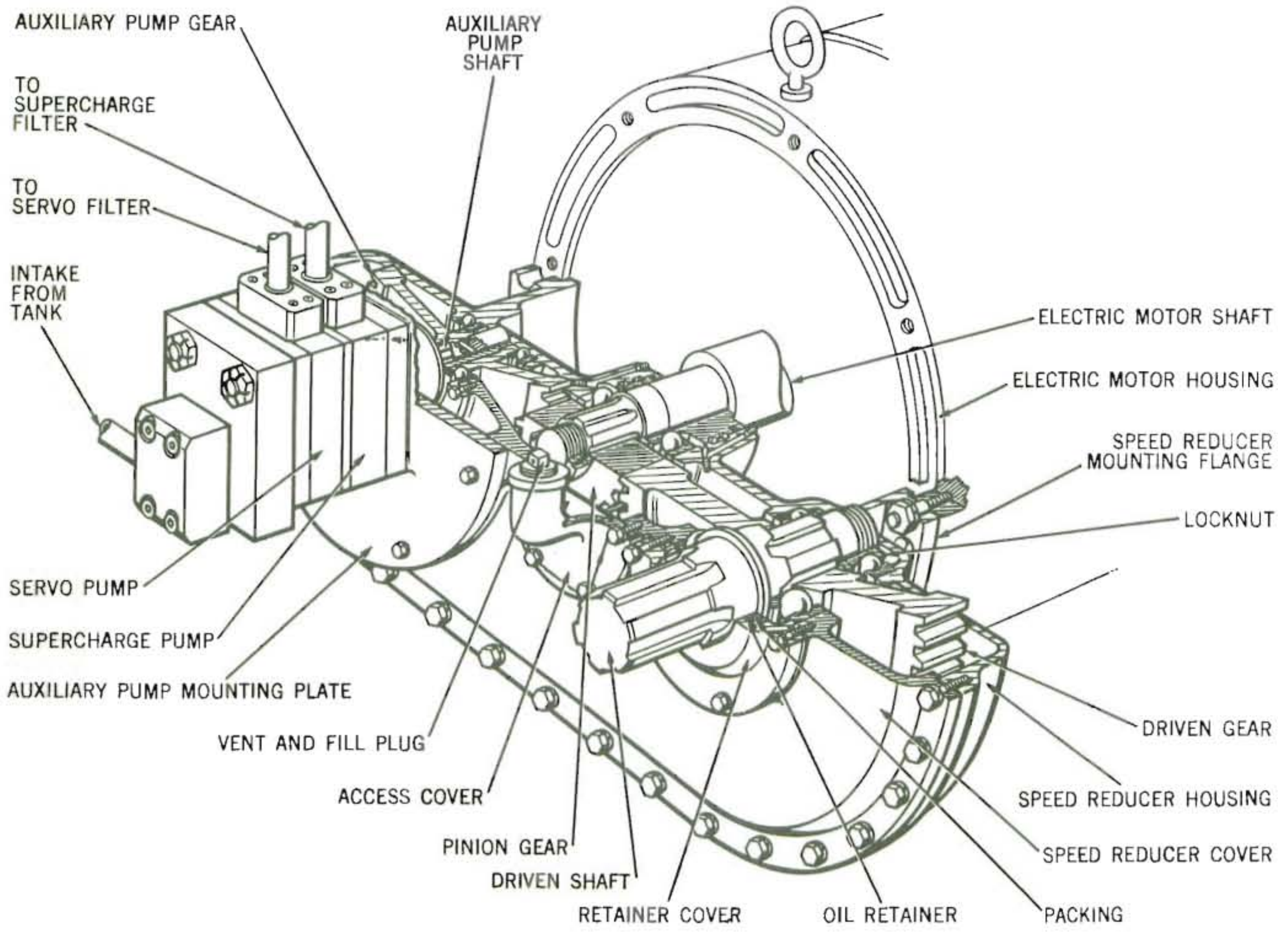

Figure 5-3. Speed Reducer Assembly, Cutaway View

of the speed reducer housing. The pinion gear, directly driven by the electric motor, drives both the driven shaft (output shaft for the A-end pump) and the auxiliary pump shaft for the servo and supercharge pumps.

Speed reducer data.

Type	enclosed spur gear train
Output shaft (ratio 3.342 to 1.00), rpm.	500
Auxiliary shaft (ratio 2.085 to 1.00), rpm.	835
Rotation (viewed from output end):	
Output shaft	counterclockwise
Auxiliary shaft	counterclockwise
Lubrication	oil bath
Manufacturer	Northern Pump Company
Drawing	268473

The speed reducer illustrated in figure 5-3 is for the right- or center-gun elevating gear. The speed reducer for the left gun is rotated 180 degrees.

Auxiliary pumps. The auxiliary pumps (fig. 5-3) are bolted on the speed reducer housing. They are arranged as a tandem-driven assemblage of functionally independent pumps. Both are rotary-gear-type pumps of identical design but of different capacities. The larger one is a servo pump that supplies the servo piston housing (fig. 5-4). The other is a supercharge pump that supplies hydraulic fluid to the main system relief valves and replenishing valves located in the valve block attached to the A-end valve plate.

Servo pump. The intake of the servo pump (fig. 5-3) is connected to the main system supply tank. The pump discharges through a duplex filter into the control selector and stroking systems. Pump capacity is 11.5 gallons per minute at approximately 400 pounds per square inch pressure.

Supercharge pump. The intake of the supercharge pump (fig. 5-3) connects to the main system supply tank through a common connection with the servo pump. The supercharge pump discharges through a duplex filter into the main system relief valves and replenishing valves. The valve block for these valves is mounted on the A-end valve plate. Pump capacity is 8.5 gallons per minute at approximately 50 pounds per square inch pressure.

Motor to A-end couplings. The connecting drive shaft, between the output shaft of the speed reducer to the main shaft of the A-end, is coupled to these units by flexible couplings. These couplings are commercial units which provide floating compensation for slight misalignment. Each is an assembly of splined hubs, which seat on respective shaft ends, and flanged sleeves which enclose the hubs.

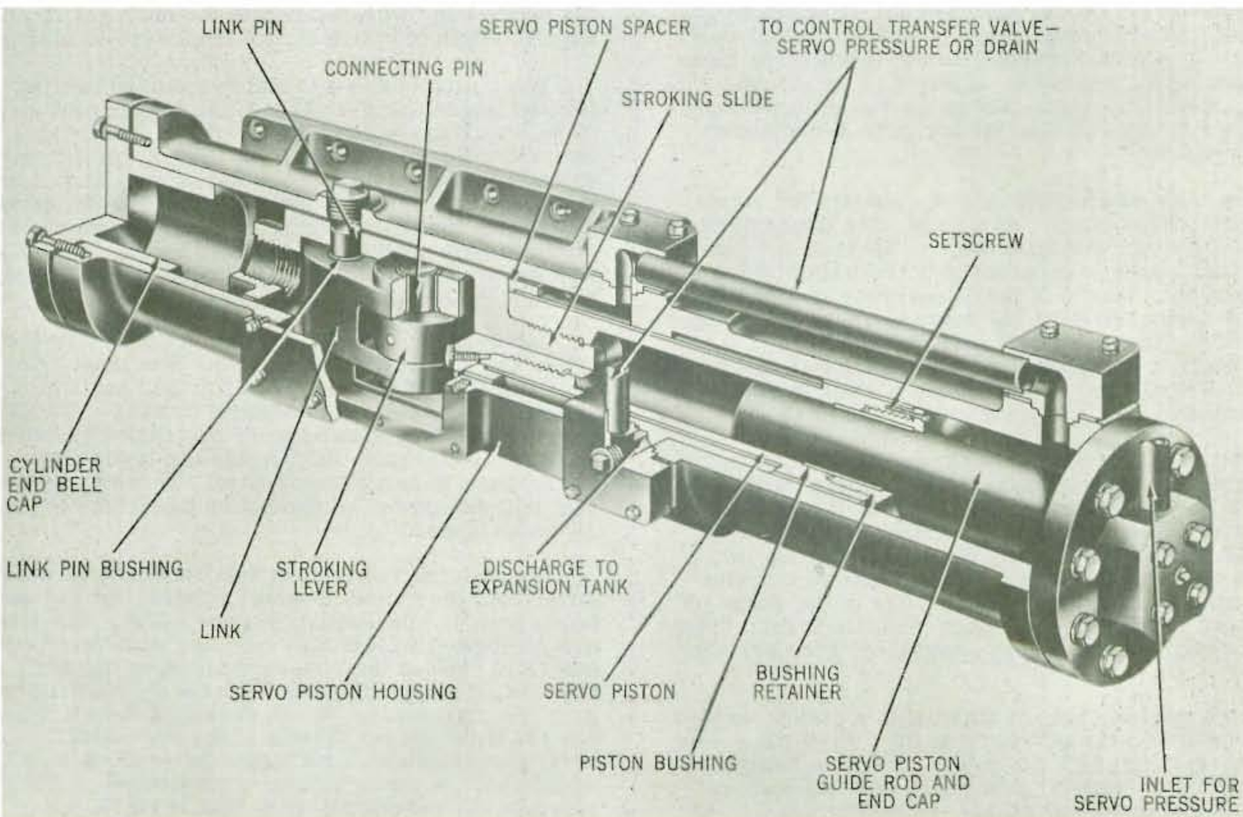

Figure 5-4. Servo Piston Assembly, Cutaway View

The sleeves have gears that mesh with gear teeth on the hubs. When installed, each coupling is partially filled with oil to provide lubrication for the gearing.

Hydraulic pump (A-end). The A-end is a type K, variable-displacement hydraulic pump of modified commercial design. It is mounted on a foundation weldment of the electric deck with its input shaft connected to the driven shaft of the speed reducer. Proper alignment of these shafts is provided by the special gear-type coupling described in the previous paragraph.

Pressure and tank connections. In addition to the pipe connections of the main system, the A-end assembly has drain, circulating, servo, and supercharge connections. The drain connections direct hydraulic fluid vented from the servo piston assembly and control box mechanism back to the expansion tank. The servo pump (delivers servo pressure to the control box mechanism) and the supercharge pump (delivers supercharge pressure to the valve block of the A-end valve plate) are supplied with fluid through a common connection with the expansion tank. The A-end and B-end and the A-end and expansion tank are interconnected by flanged fittings for fluid circulation, which aids in cooling the mechanism.

The pipes indicated above are connected by flanged fittings that are bolted in position.

Case. A square, oiltight case encloses the A-end. The case assembly consists of valve plate, case head, servo piston assembly, control box mechanism, trunnion cap, trunnion bearing assembly, and retainer. A storage tank for hydraulic fluid in which the active parts rotate, the case has attached mounting feet that are bolted to the A-end foundation weldments. The receiver-regulator is mounted on similar foundation weldments adjacent to the A-end. The general arrangement of parts within the A-end case is the same as the training gear A-end shown in figure 6-5.

The main shaft of the A-end supports the rotating parts of the pump. At a point near the center of the A-end case, the main shaft is made in the form of a closed yoke to support the universal-joint trunnion and pin. Ahead of the closed yoke is a section provided with two keys 180 degrees apart which supports the cylinder barrel. The forward end of the main shaft is supported by a ball bearing in the valve plate. The splined end of the main shaft is similarly supported by a ball bearing in the case head.

The open center of the cylinder barrel has two keyways 180 degrees apart throughout its length to mate with the two keys in the main shaft. The barrel, retained on the main shaft by a nut, is held against the valve plate by a spring which backs up against a flange on the main shaft. The cylinder barrel contains nine cylinder bores, which are of the same diameter throughout the length of piston travel. They taper sharply at the end to a small cylinder port outlet.

Each cylinder bore is fitted with a piston, ground and lapped to a smooth-working fit. When the A-end is transmitting hydraulic power, the fluid being discharged by the pistons presses against the ends of the cylinder bores and forces the barrel against the valve plate to reduce internal leakage between barrel and valve plate. This sealing effect increases as hydraulic pressure in the system increases.

A drilled hole in the center of the front face of each piston admits hydraulic fluid to lubricate the ball-shaped ends of the connecting rods.

Nine connecting rods connect the nine pistons with the socket ring. Each connecting rod has two ball-shaped ends. One end seats in a socket in the piston and is held in place by a split cap, cap nut, and nut lock. Shims are placed between the cap and piston surface to obtain proper clearance for the ball end. Each connecting rod has two ball-shaped ends. One end seats in a socket in the piston and is held in place by a split cap, cap nut, and nut lock. Shims are placed between the cap and piston surface to obtain proper clearance for the ball end. Each connecting rod is drilled throughout its entire length to provide for lubrication of the ball end sockets.

The socket ring is a circular piece that contains the nine sockets for the other ends of the nine connecting rods. Each rod is retained in its socket by a socket cap, socket cap nut, and socket cap nut lock. The socket cap is split to facilitate installation and removal. The socket ring has two ball bearing assemblies, one at the back and the other at the piston side of the socket ring. Two slots, located about the center of the socket ring and 180 degrees apart, carry the mainshaft trunnion bearing blocks of the universal joint.

Main shaft rotation is transmitted to the socket ring by a universal joint formed by a trunnion in the shaft yoke. The attached socket ring is free to rotate about the axis of the trunnion, giving a controlled variation in the length of piston stroke.

Tilting box. The tilting box varies the angle of the socket ring with relation to the main shaft, changing the length of piston stroke from zero to maximum.

The tilting box is a trunnion-mounted casting located inside the A-end case. It contains two groups of ball bearings which take the radial and axial thrusts of the socket ring. An arm of the tilting box extends through a hole of the A-end case and connects with the servo stroking piston. A shaft extends vertically from the tilting box trunnion and connects with the follow-up mechanism mounted on top of the A-end. The function of the follow-up is described on page 5-13 of this chapter.

Valve plate. The valve plate is stationary and forms one end of the A-end case. The inner, or rear, surface of the plate is a finished surface against which the cylinder barrel rotates. This surface has two semiannular grooves, called valved-plate ports, through which hydraulic liquid flows when power is being transmitted. These ports connect with the power transmission pipes between the A- and B-ends.

Between the valve ports are flat surfaces called lands. As the cylinder barrel rotates, the cylinder bores pass in succession over the lands. The lands are positioned so that they coincide with the end-of-stroke of each of the nine reciprocating pistons; there is no pumping action when the cylinder bores pass over the lands. At the center of the valve plate are the bearings for the end of the main shaft. The valve plate includes an attached valve block which houses the two main valves, a pilot valve, a cutout valve, and a directional flow shuttle valve.

Main valves. Each main valve is connected with a semiannular port of the valve plate, and each acts in two ways:

1. As a main system replenishing valve operating under supercharge pressure.

2. As a relief by-pass valve.

When power is being transmitted, a small amount of hydraulic fluid is constantly being lost from the main system. Hydraulic fluid is purposely directed from the cylinders to the socket caps for lubrication of the connecting rods. Slight leakage around the pistons and between the barrel and valve plate ensures lubrication of the bearing surfaces. The leakage must be replaced as fast as it occurs; this replacement is furnished by the main valves acting as replenishing valves. As relief valves, the main valves protect the A-end from overload by limiting the pressure in the system.

The two main valves operate through differential loading of pressure and intake (return from the B-end end). The pressure is ported through cutout and pilot valves. Positioned by servo pump pressure, the cutout valve ports main system high pressure to the top of the main valve in the high-pressure line. The top of the other main valve is now opened to low-pressure return. Centered by a spring at each end, the pilot valve moves only when main system pressure exceeds 1850 pounds per square inch in either valve plate port. When it moves, it unloads excessive high pressure in the main system from the top of the main valve and permits that valve to lift and by-pass pressure into the low-pressure side. Hydraulic fluid, delivered by the supercharge pump, enters the main system through the main valve opened to low-pressure return.

A-end data.

Driven speed, revolutions per minute	500
Oil temperatures	
Normal operating range, F	120 to 175
Maximum permitted, F	185
Displacement, cubic inches	134.82
Manufacturer	Northern Pump Company
Manufacturers designation, size	frame 7043
Drawing	268458

Servo piston assembly. The servo piston assembly (fig. 5-4) is a high-pressure piston and cylinder assembly, flange-mounted on the side of the A-end case. This assembly acts to change the position of the A-end tilting box to vary the volume delivered by the A-end to the B-end. The servo piston assembly is described in full detail on page 5-11 of this chapter.

Follow-up control. The follow-up control consists of response shafting from the oscillating bearing to the elevation indicator, the receiver regulator, and the control box mechanism. The follow-up mechanism (fig. 5-6) within the control box consists of a follow-up response gear, a control screw, and a control nut. This mechanism uses B-end response to return the A-end tilting box to its neutral stroke position. A complete description will be found on page 5-13 of this chapter.

Hydraulic motor (B-end).

The B-end is a type K, fixed-displacement hydraulic motor of modified commercial design. It is mounted on a foundation weldment of the pan floor, with its drive shaft coupled to the adjacent oscillating bearing that it drives.

Pressure and tank connections. In addition to the pipe connections of the main system, the B-end assembly has circulating and servo pressure connections. The servo pump delivers servo pressure to the valve block of the B-end valve plate. There is also a servo pressure connection between this valve block and the A-end valve assembly. The A-end and B-end units, and the A-end and expansion tank are interconnected by flanged fittings for fluid circulation, which cools the mechanism.

Case. The valve plate and angle box of the B-end are enclosed within a square case. Case, valve plate, and angle box are bolted together to form an oiltight assembly in which the torque-producing members rotate. The case has attached mounting feet that are bolted to the B-end foundation.

Main shaft. The B-end shaft differs from the A-end shaft only in dimensions. An inter-shaft disc is located in the main-shaft bearing recess formed in the valve plate. This disc compensates for any end-play that results from allowable tolerances in the manufacture of other parts.

Rotating group. The rotating group of the B-end is basically the same as the rotating group of the A-end. It consists of the main shaft and universal joint, the cylinder barrel with its pistons and connecting rods, and the socket ring.

Angle box. The angle box, in which the socket ring rotates, is permanently tilted at an angle of 20 degrees. The pistons and connecting rods therefore reciprocate through one full stroke each time the main shaft makes one revolution. The socket ring rotates in radial-thrust roller bearings.

Valve plate. The valve plate forms one end-plate cover for the B-end. The valve plate contains hydraulic liquid passages (semiannular valve plate ports) which connect with the two power transmission pipes from the A-end. The valve plate also holds the ball bearing assembly in which one end of the main shaft rotates. The cylinder barrel is held against the valve plate by a spring which backs up against a flange on the main shaft. Hydraulic liquid is drawn into, or discharged from each cylinder through the two semi-annular valve plate ports which connect with the two power transmission pipes.

Valves. The B-end valve plate includes a relief valve (by-pass arrangement), a power-off valve, and two replenishing valves.

Relief bypass valve. The B-end relief bypass valve (fig. 5-34) is a pressure safety relief valve to relieve the system in event of servo pressure failure while the gun is moving. If servo pressure fails, the spring-loaded power-off valve will close both main transmission pipes; any overhauling will build up excessive pressure in the B-end. The B-end relief valve is adjusted to relieve at a pressure slightly above the A-end pilot valve adjustment.

Power-off valve. The power-off valve is a spool-type shuttle valve, spring-loaded at one end. It functions as a blocking valve and closes both main transmission pipes when the power is off. It acts as a brake valve that provides a block in the B-end against a settling of the gun slide. The power-off valve is moved to operating position under servo pressure. This pressure is ported to the power-off valve through the adjacent power-off control valve that is positioned by a solenoid. In its operating position, the power-off valve ports servo pressure to the cutoff valve of the A-end valve plate assembly.

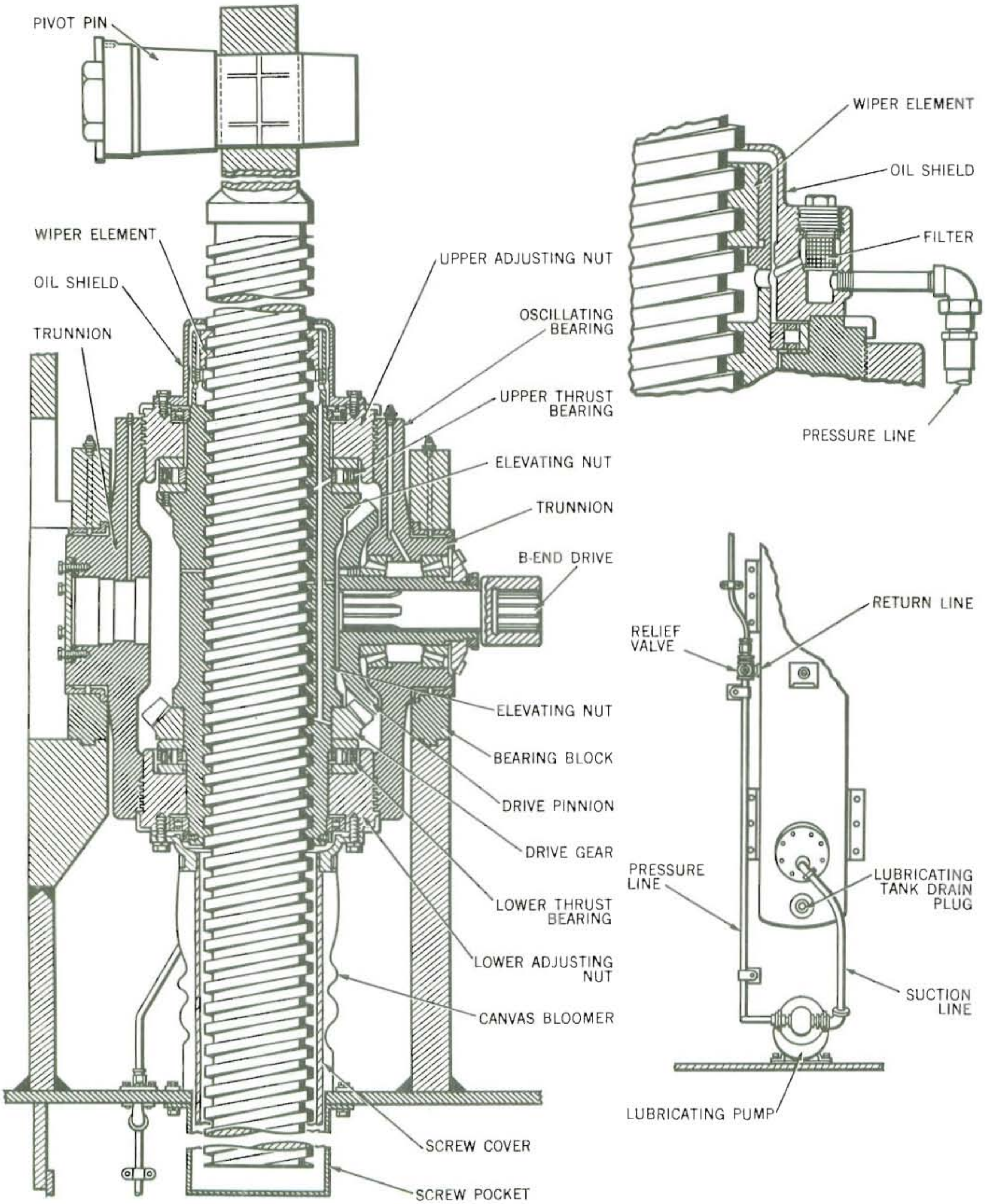

Figure 5-5. Elevating Gear Oscillating Bearing, Sectional Views

Replenishing valves. The B-end replenishing valves are plunger type with drilled leads from each valve connecting to the valve plate ports. The replenishing valves deliver hydraulic liquid to the low-pressure side of the main system. The valves are located on the rear face of the B-end valve plate.

B-end data.

Speed (maximum), rpm.	500
Torque load.	
Normal, rated, ft-lb	2000
Maximum, rated, ft-lb	2200
Oil temperatures	
Normal operating range, F	120 to 175
Maximum permitted, F	185
Displacement, cubic inches	134. 82
Manufacturer	Northern Pump Company
Manufacturer's designation, size.	frame 71 43
Drawing	26845 9

B-end coupling. The B-end output shaft is coupled to the oscillating bearing by a short drive shaft. The B-end shaft is splined and fits into a splined female hub of the drive shaft. The other end of the drive shaft is a splined male fitting and is secured in the drive pinion gear of the oscillating bearing.

Servo and supercharge filters. The duplex filters used in both the servo and supercharge systems are of modified commercial design. They keep the hydraulic fluid free of solid matter which would damage the system. Each filter assembly consists of two sumps, each sump containing a disc-type filter cartridge. A dual valve, controlled by selector handle, permits the use of either or both of the sumps.

Servo and supercharge relief valves. The servo and supercharge relief valves, connected to the discharge lines of the servo and supercharge filters,

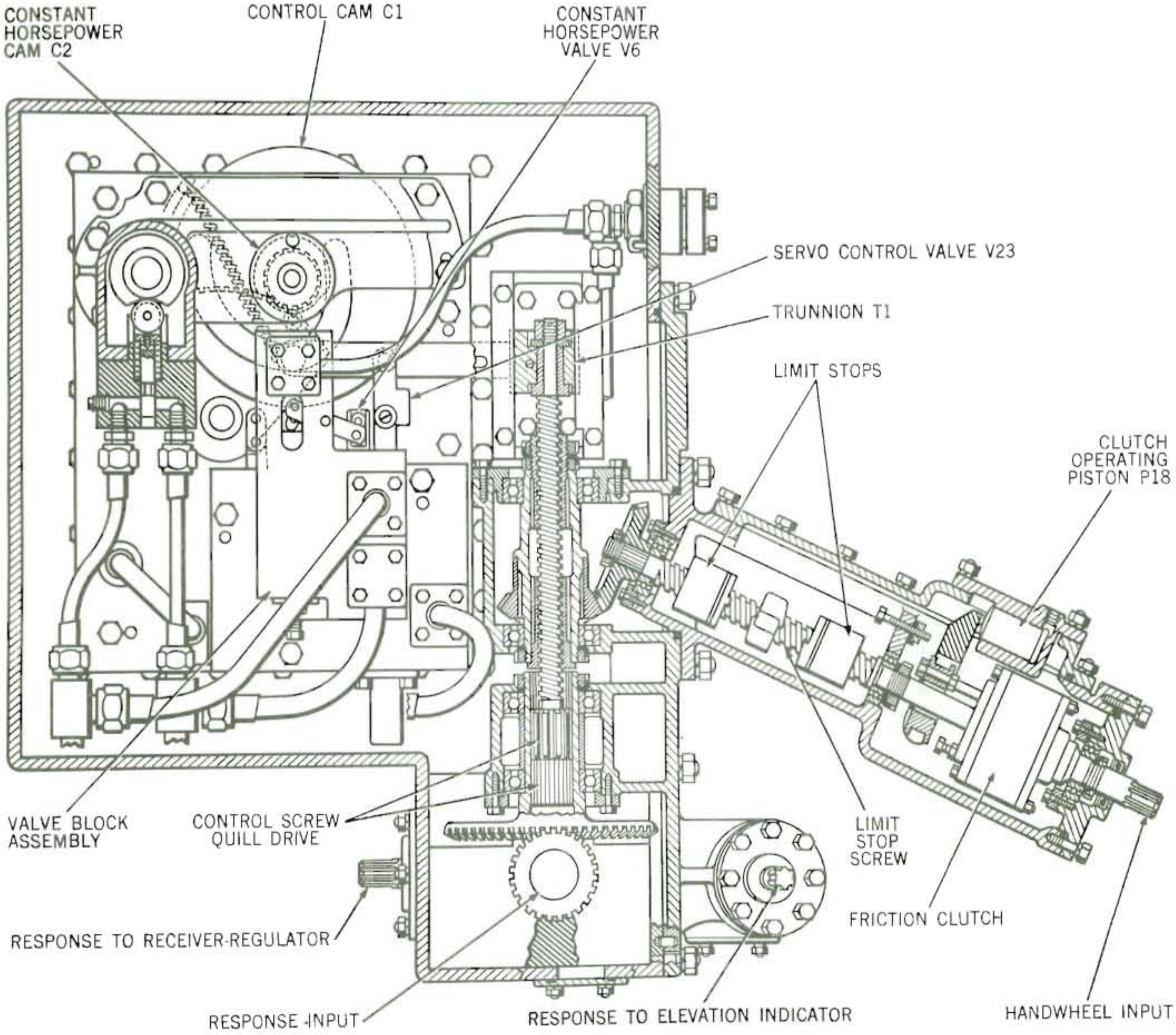

Figure 5-6. Control Box Mechanism, Sectional View

are mounted in a common valve block near the A-end. They are spring-operated, plunger-type, safety relief valves. The valves open and bypass excess pressure flow to the expansion tank when the servo and supercharge discharge lines are overloaded. The servo relief valve is farthest from the valve block mounting plate and the supercharge relief valve is nearest the mounting plate.

Expansion tank. The 28.5-gallon expansion tank for each elevating gear assembly is a vented type with gravity feed connection to the servo and supercharge pumps. Return lines lead to the tank from the A-end, the B-end, and the servo and supercharge relief valves. Located at the highest point of the hydraulic system, the tank body is box-shaped, 30.0 inches high, 20.0 inches wide, and 10.0 inches deep. It is equipped with a cover, high- and low-level trycocks, filler cap, and an oil strainer inside the tank. The tank dissipates heat from the oil returned by the recirculating system.

Oscillating bearing assembly

The oscillating bearing (fig. 5-5) is an enclosed elevating-nut pinion-drive-type assembly. The drive pinion engages the drive gear, which is keyed to the elevating nut. The elevating screw is threaded through the elevating nut and is attached to the gun slide with a pivot pin. The elevating screw is fixed and cannot rotate. The elevating nut is rotated by the drive pinion, and causes vertical movement of the elevating screw to elevate or depress the gun.

The trunnion-pivoted oscillating bearing (fig. 5-35) is aligned with the B-end with the axis of the elevating screw offset 21.0 inches from the vertical plane of the gun bore axis. The trunnion bearing blocks of the bearing form a foundation weldment above the pan floor in the forward part of the gun pockets.

Components. The oscillating bearing assembly comprises the following:

- Bearing and elevating nut
- Elevating screw
- Oil shield
- Lubrication pump
- Lubrication tank

Bearing and elevating nut. The oscillating bearing assembly is enclosed within a hollow cast steel block with integral trunnions (fig. 5-5). The oscillating bearing houses roller-type thrust bearings at each end that seat in the upper and lower adjusting nuts. The oscillating bearing trunnion adjacent to the B-end is bored to receive the drive pinion with its two tapered radial bearings. The drive pinion and drive gear are also enclosed within the bearing housing, together with the elevating nut.

The drive gear is keyed to the radially split elevating nut. The two halves of the elevating nut lock together for rotation but have adjustable axial motion to eliminate end play of the elevating screw. The lower half of the elevating nut is driven by the concentrically mounted drive gear, which is meshed with the drive pinion, as shown in figure 5-5. These parts are adjusted by means of adjusting nuts that thread into the top and bottom ends of the bearing housing.

Elevating screw. The elevating screw has a 7.75-inch outside diameter with right-hand double threads of 1.50-inch pitch. It is 153 inches long overall, with 133 inches threaded, and with a lead of 3 inches. The elevating screw is secured to a rear end bracket (fig. 5-36) of the gun slide by a bronze pivot pin at its upper end (chapter 4).

Oil shield. A cylindrical oil shield (fig. 5-5) fits around the elevating screw and is attached to the upper adjusting nut by 10 screws. The adjusting nut has 20 equally spaced and threaded holes to permit the oil shield and the lubrication pump oil lead to be attached in approximately the same position with any setting of the adjusting nut.

Three wiper elements within the oil shield are threaded to mesh with the elevating screw. The wiper elements are secured to and rotate with the elevating nut to remove oil from the emerging elevating screw threads. The oil drains downward through the bearing assembly to a cylindrical screw cover bolted to a flange of the lower adjusting nut. Oil drains from the cover into the screw pocket.

Lubrication pump. The lubrication pump (figs. 5-5 and 5-37) is an independent unit mounted on the electric deck adjacent to the gun layer's station immediately below the elevating screw pocket and lubrication tank. The pump provides circulating lubrication for the elevating screw and oscillating bearing assembly. The pump is a rotary gear-type unit, attached to and driven by a horizontally mounted 1/4-horsepower electric motor at the rate of 600 revolutions per minute. Pump delivery, at the rate of 3 gallons per minute under an operating pressure of 50 pounds per square inch, is controlled by a spring-loaded relief valve.

Lubrication tank. The lubrication tank (elevating screw pocket) is a flanged steel assembly attached to the underside of the pan floor that extends downward to the electric deck, as shown in figure 5-37. In addition to furnishing storage for the lubricant, the tank weldment also forms a pocket for the elevating screw. An oil pipe connects the tank storage space with the inlet of the pump. The pressure outlet of the pump is connected by an oil pipe to a fitting in the oil shield.

Elevating gear controls

The independent elevating gear control arrangements for each of the three guns of the turret consist of:

- Start-stop control
- Power-drive transmission control
- Control selector
- Servo stroking system
- Control gear hand gear
- Control gear response gear
- Control box mechanism
- Receiver-regulator

Start-stop control. Each elevating gear power drive is started and stopped through its electric-power motor controller (described on page 5-4). The controller is remotely operated by two push buttons adjacent to the gun layer's station. One push button is labeled START-EMERG and the other STOP.

Pressing the START-EMERG button closes a normally open, three-pole switch and energizes the coil of the main contactor to connect power to the electric motor. Holding contacts on the relays keep the power circuit closed when the START-EMERG button is released until the STOP button is pressed. In the event of a power failure, the main contactor opens and remains open until the START-EMERG button is depressed. An overlodd relay opens the circuit when current demand is too great. The main contactor may be kept closed to keep the electric motor running in an emergency by holding the START-EMERG button closed. The electric motor is stopped by pressing the STOP button.

Transmission controls. The transmission controls are the A-end control mechanisms and hydraulic-system devices that position the A-end tilting box and control the main system hydraulic pressure. They are:

Hand control elements
Automatic control elements
Loading control elements
Control screw centering mechanism

Hand control elements. The elements of the hand control system are:

1. Control selector
2. Servo stroking system
3. Control gear hand gear
4. Control gear response gear
5. Control box mechanism

The units function together so that, when the control selector is moved to HAND, the gun is elevated or depressed by manually turning the handwheels. The response gear and the control box devices provide follow-up control and limit stop control.

Automatic control elements. The elements of the automatic control system are:

1. Control selector
2. Servo stroking system
3. Receiver-regulator
4. Control gear response gear
5. Control box mechanism

The units function together so that, when the control selector is moved to AUTO, the gun is automatically elevated or depressed in response to electrical signals from a remote station. The control gear response gear provides follow-up control and limit stop control as in hand control. However, the limit stop function is supplementary to an automatic limit stop device of the receiver-regulator.

Loading control elements. The elements of the loading control system are:

1. Gun captain's switch
2. Control selector
3. Servo stroking system
4. Receiver-regulator
5. Control gear response gear
6. Control box mechanism

Loading control is automatic control action by the receiver-regulator which moves the gun from any angle of elevation to the loading position when the control selector is positioned at LOAD or when the gun captain's switch is turned to SAFE.

Control screw centering mechanism. A control screw centering mechanism prevents shifting from hand control to automatic control except when the hand control screw and the servo pilot valve are in neutral. The mechanism also keeps the control screw and the servo pilot valve in neutral while the gun is operating in automatic control.

Control selector. The control selector (fig. 5-15) is a manually positioned hydraulic valve mounted on the bulkhead adjacent to the gun layer's station. The selector permits the gun layer to select the method of control desired. The selector valve block includes a related hydraulic valve called the synchro failure valve. The synchro failure valve is normally open to allow servo pressure flow to the control selector valve. If the synchro gun order signal fails, the valve automatically acts to block servo pressure flow to the control selector valve. When this happens, the synchro failure valve shifts control away from the receiver-regulator to the gun layer's handwheels without movement of the selector valve lever.

The control selector includes a synchro power indicator light (fig. 5-15) illuminated whenever the electric gun order signal is available for automatic gun elevation control. Should the synchro power fail, the indicator light goes out.

An emergency button (fig. 5-15) is provided on the control selector to permit selector movement if the gun captain's ready switch circuit fails while the gun is in LOAD control. The emergency button is disengaged by the emergency button release (fig. 5-15).

Servo stroking system. The servo stroking system is composed of:

1. The servo pump (fig. 5-3) mounted on and driven by the electric motor speed reducer.

2. The duplex filters in the discharge line of the servo control system.

3. A servo control system relief valve.

4. The servo piston housing and piston (fig. 5-4) and the connecting arm to the A-end tilting box.

5. Stroking piston control valve.

6. Hydraulic control valves.

The system responds to hand and electrical gun elevation order signals by forcing the heavy A-end tilting box away from the neutral stroke position. System pressure is supplied by the servo pump. The pump, filters, and relief valves are described on page 5-5 of this chapter. Other elements of the system are described in the following paragraphs.

Servo piston housing. The servo piston housing assembly (fig. 5-4) is a high-pressure piston and cylinder unit flange-mounted on the side of the A-end case. The piston moves the A-end tilting box through a connecting lever in response to hand or automatic gun elevation orders.

The assembly consists of a servo piston, a piston guide rod and end cap, a piston housing, an end bell cap, a stroking lever, a link, and a tube. The arrangement of the components is shown in figure 5-4. The piston is hollow for most of its length, with the piston guide rod inserted in the piston at one end and the stroking slide threaded into the other end. Servo system pressure is ported at one end or the other to move the A-end tilting box away from its neutral stroke position. Piston movements are controlled by the receiver-regulator in AUTO and LOAD, and by the servo control valve in HAND.

Stroking piston control valve. The stroking piston control valve, located at the receiver-regulator, is a valve block arrangement of the spool-type valves. The valve block (fig. 5-31) acts as a restriction in lines 12 and 13 to the loading transfer valve V13. The larger spool-type valve PCV1 is servo pressure positioned and is controlled by two adjustable needle valves PCN. The smaller spool-type valve PCV2 is spring-loaded to port back-up pressure, controlled by an adjustable screw PCS, through line 63 to the expansion tank. The stroking piston control valve block eliminates roughness in the automatic load cycle which is caused by intermittent functioning of the constant horsepower mechanism.

Hydraulic control valves. Movement of the servo piston is automatically controlled within the power drive hydraulic system by the following interrelated valves.

Power-off valve V1N. The power-off valve V1N, located in the B-end valve plate, is a two-position, spool-type valve that opens or blocks the main hydraulic system lines between the A- and B-ends. It is spring-operated to block the main system lines when power fails or is shut off. With power on, servo pressure moves the valve to open the main system lines and to port servo pressure to the cutout valve V12N and the servo supply cutoff valve V22.

Power-off control valve V4N. The power-off control valve V4N, located in the A-end valve block, is a two-position, spool-type valve that ports or blocks the flow of servo pressure to the power-off valve V1N. The valve is spring-operated to block the flow of servo pressure to the power-off valve V1N and port this pressure to drain. When electric power is on, the valve is solenoid-positioned to port servo pressure to the power-off valve V1N.

Servo supply cutoff valve V22. The servo supply cutoff valve V22, located in the A-end control box, is a two-position, pressure- and spring-operated piston that opens or blocks the flow of servo pressure to the servo control valve V23. The cutoff valve V22 is spring-operated to block the flow of servo pressure to the servo control valve V23 when the power-off valve V1N is closed. The cutoff valve V22 is positioned against the pressure of its spring by a flow of servo pressure that is ported to it when the power-off valve V1N is open.

Servo control valve V23. The servo control valve V23 located in the A- end control box is a spring- and linkage-operated, plunger-type valve that opens or blocks the flow of servo pressure to the constant horsepower valve V6. The control valve V23 is spring-operated to block the flow of servo pressure from the servo supply cutoff valve V22 to the constant horsepower valve V6 when the controls are at neutral. The control valve V23 is positioned by linkage (actuated by movement of the handwheels) to port linkage (actuated by movement of the handwheels) to port servo pressure to the constant horsepower valve V6.

Constant horsepower valve V6. The constant horsepower valve V6 located in the A-end control box is a linkage-operated, plunger-type valve that opens or blocks the flow of servo pressure from the servo control valve V23 to the directional valve V6A. The valve is connected by linkage to the pressure measuring piston P6. When V6 is lifted slightly, it blocks servo pressure from the servo control valve V23, and ports servo pressure from the directional valve V6A to the outer chamber of the servo piston. When V6 is lifted to its limit, it blocks servo pressure from V23, and ports servo pressure from V6A to the inner chamber of the servo piston.

Constant horsepower cut-in valve V6B. The constant horsepower cut-in valve V6B is a spool-type valve mechanically connected to the constant horsepower valve V6. In AUTO control, the cut-in valve ports servo pressure to shift the transfer acceleration limiting valve TALV and the control transfer valve V3B to transfer control of the servo piston from the receiver-regulator to the constant horsepower device of the servo stroking system.

Directional valve V6A. The directional valve V6A located in the A-end control box is a linkage-operated, plunger-type valve that directs the flow of servo pressure from the constant horsepower valve V6 to either of the two chambers of the servo piston. The valve is connected by linkage attached to a sector gear that engages a gear on the tilting box shaft. When V6A is lifted, it directs the flow of servo pressure through the constant horsepower valve V6 to the inner chamber of the servo piston. When V6A is depressed, it directs the flow of servo pressure through V6 to the outer chamber of the servo piston.

Cutout valve V12N. The cutout valve V12N located in the A-end relief valve block is a spring-operated, spool-type valve that opens or blocks passages from the main system hydraulic lines to drain the A-end case. The cutout valve V12N is moved against its spring pressure by servo pressure which is ported from the power-off valve V1N when the electric motor is running and the elevating handwheel is at rest. V12N is spring-positioned to open the top chambers of the relief valves V9N and V10N to drain to the A-end case when electric power fails or is shut-off.

Pilot valve V11N. The pilot valve V11N located in the A-end relief valve block is a spring-centered, spool-type valve that moves only when main system pressure is excessively high in either end chamber. The cutout valve V12N, moved by servo pressure, ports main system pressure to either the left or right chamber of the pilot valve V11N, depending upon the direction of gun movement. Main system pressure is also ported to the top chamber of either the V9N or V10N relief valve, depending upon the direction of gun movement. When the gun is elevating, if main system pressure is excessively high, the pilot valve V11N is forced to the right to connect the top of the relief valve V9N to the low-pressure line of the main system. Main system high pressure lifts V9N and bypasses into the main system return until the high pressure drops to normal.

Relief valves V9N and V10N. The relief valves V9N and V10N, located in the A-end relief valve block, are spring-loaded, plunger-type valves that function in dual capacities as replenishing valves operating under supercharge pressure and as relief bypass valves. In both capacities the relief valves V9N and V10N operate through differential loading of pressure and suction ported through the cutout valve V12N and the pilot valve V11N. V9N is the relief bypass valve during elevation and V10N is the relief bypass valve during depression.

Check valve V13N. The check valve V13N, located in the A-end relief valve block, is a spring-loaded, ball-check-type valve that regulates the flow of supercharge pressure to the top chambers of the relief valves V9N and V10N. Normal leakage in the hydraulic system will cause main system return pressure to drop below the pressure setting of the check valve V13N. When this occurs, the system is replenished by supercharge pressure flow through V13N.

Shuttle valve V27. The shuttle valve V27, located in the A-end relief valve block, is a directional-flow, spool-type valve that is an element of the constant horsepower device. Shuttle valve V27 is free to move to either end of its sleeve porting main system high pressure to either end chamber of the pilot valve V11N, depending upon the direction of gun movement or the pressure measuring piston P6 of the constant horsepower device, which is forced down and thereby lifts the constant horsepower valve V6 through attached linkage.

Replenishing valves V5N. The replenishing valves V5N, located in the B-end valve plate, are spring-loaded, plunger-type, suction-operated valves. They are unseated by low pressure in the main system return valve plate port and connect the return line to the B-end case. When main system return pressure is normal, V5N is seated by its spring.

Neutral return valve V14N. The neutral return valve V14N located in the neutral return device is a spring-loaded, cam-positioned, plunger-type valve that ports or blocks the flow of servo pressure to the chambers of the servo piston. Movement of the neutral return lever 30 degrees either side of neutral rotates the attached cam, positioning the neutral return valve V14N so that it connects the chambers of the servo piston. Rotation of the lever beyond 30 degrees returns the tilting box to neutral. With the neutral return lever at neutral, V14N is positioned to block servo pressure and disconnect the chambers of the servo piston.

Control gear hand gear. The control gear hand gear for each gun layer is a pedestal bracket handwheel drive with bevel gear and shaft assembly arranged for hand control of the elevating gear. Located as shown in figure 5-1, the mechanism is arranged with its output shaft coupled through a friction clutch to a limit stop and geared to a differential follow-up mechanism. A mechanical linkage from the differential screw converts handwheel motion to valve movement to produce 2.5 degrees of gun elevation movement for one full turn of the handwheels. Handwheel control elements from the friction clutch to the valve linkage (fig. 5-6) are enclosed within the control box mechanism attached to the top of the A-end.

Control gear response gear. The direction and speed of B-end rotation is transmitted from the B-end upper response drive bracket to the A-end control box mechanism by a system of bevel gears and shafts (fig. 5-2). The B-end response drive is coupled to a response input shaft that drives the differential screw of a follow-up mechanism. The response drive for the right and left guns is straight shafting from the respective gun pockets to the electric deck spaces. The response drive for the center gun is composed of vertical and horizontal shafting to accommodate the offset location of the center-gun elevating-gear A-end.

Control box mechanism. Servo stroking control is actuated through a case-enclosed transmission control box mechanism (fig. 5-6), mounted on top of the A-end case. The interior arrangement of interconnected and related components of the control box is shown in figure 5-6. These components are the mechanical, electrical, and hydraulic units described in the following paragraphs.

Friction clutch. Assembled between the handwheel input shaft and the limit stop screw is a clutch unit. It is a friction-type clutch that is engaged by spring pressure and disengaged by hydraulic pressure. The clutch is engaged when the control selector lever is positioned at HAND. The clutch is disengaged when the lever is positioned at AUTO or LOAD, and whenever the constant horsepower mechanism assumes control.

Limit stop. The limit stop is a screw and traveling nut device, arranged in the control drive as shown in figure 5-6. The adjustable limit stops are positioned to decelerate and stop gun movement within turret limits of gun elevation and depression (total of 47 degrees in turrets I and III; total of 45 degrees in turret II).

Follow-up control mechanism. The follow-up device (fig. 5-6) is a differential screw and nut gear mechanism that operates the control valve units through a linkage attached to a trunnion at one end of the control screw. The screw (and valve linkage) displacement is a differential movement. It is derived from handwheel rotation of the differential nut, which turns the control screw, and from B-end response rotation of the screw, which turns the screw in the opposite direction. Response input to the screw is through a quill drive. In operation, the follow-up mechanism is an automatic mechanical device for returning the valve linkage and stroking control toward neutral. Its return-to-neutral action varies with B-end speed and rotation to produce a graded deceleration of the valve gear, servo stroking control, and gun.

Control linkage. The link attached at one end to the trunnion of the follow-up control mechanism is pivoted at its opposite end and in a cam groove of a control cam. Cam movement of the link combines with control screw movement of the link to provide differential stroking of the servo control valve V23 attached near the mid-point of the link. Cam rotation is equivalent to the angle of the A-end tilting box because the cam is driven by gearing from the tilting box shaft. The arrangements of the control link, control valve, cam, and associated parts of the valve block assembly are shown in the schematic diagrams, figures 5-24 to 5-30, inclusive.

Valve block assembly. Tilting box stroking is controlled by a servo system valve block composed of three mechanically operated, plunger type valves and two pressure-and-spring-actuated pistons. The valves are designated: servo control valve V23, directional valve V6A, and constant horsepower valve V6. The automatic pistons are designated: pressure measuring piston P6 and servo supply cutout valve V22.

The valve block assembly is shown schematically in figures 5-23 to 5-29, inclusive.

Constant horsepower mechanism. The maximum horsepower taken from the electric motor is limited by the constant horsepower mechanism. This mechanism is a mechanical and hydraulic arrangement that acts automatically under overload conditions to return the tilting box toward neutral. The constant horsepower mechanism momentarily takes control if the combination of hydraulic pressure and stroke of the A-end causes an input horsepower to the A-end in excess of the desired limit. The mechanical components of the unit include: a control cam and a constant horsepower cam (fig. 5-6) mounted on a shaft within the control box; a cam follower roller, mounted on the pressure measuring piston P6 and arranged to bear on the cam surface of the constant horsepower cam; an eccentric slot in the control cam which actuates cam end of the control valve linkage. The pressure measuring piston is connected to the constant horsepower valve V6 by a crosslink that has a center point fulcrum. This arrangement operates with tilting box movement to vary the position of the pressure-measuring-piston outer sleeve and the control valve in accordance with the predetermined cam values.

Anti-overhauling device. The constant horsepower mechanism prevents overhauling of the transmission by back pressure under conditions of unbalanced load on the elevating screw, such as gun recoil. The constant horsepower mechanism takes over as an anti-overhauling control to move the A-end tilting box toward neutral.

Neutral return device. The neutral return device provides for manual return of the A-end tilting box to neutral, should there be an electric power failure (or the power be shut off) while the tilting box is in a stroke position. The device is a hand lever unit located on top of the A-end control case. A spur gear on the lower end of its vertical shaft meshes with a sector gear that engages a gear on the tilting box shaft. A cam on the neutral return device shaft operates the neutral return valve V14N. Thirty degrees movement of the neutral return lever, either side of neutral, operates the valve to allow the servo piston to be moved freely. More than 30 degrees movement of the neutral return lever rotates the gear shaft and returns the tilting box to neutral.

Neutral starting device. The electric-motor starting-circuit interlock switch is located on the A-end control case. The switch is arranged with a plunger that extends to the top surface of the constant horsepower cam. At three degrees from the neutral position, this plunger rides into a detent on the cam and closes the starting circuit. While the cam is at any other position, the switch is open and the main electric motor cannot be started. The neutral return device must be used to restore the tilting box to neutral and thereby close the starting circuit.

Cradle and spanning tray interlock solenoid. The cradle and spanning tray interlock solenoid, located in the electric motor controller, actuates an interlock switch which is connected in series with the servo and tilting box neutral interlock switches. The solenoid is actuated by a micro switch that is mounted on a bracket attached to the hoist cradle fulcrum. The micro switch plunger extends upward to contact a piece that is mounted on the cradle. The relationship of the micro switch plunger and its contact piece is such that when the cradle and spanning tray are spanned or partially spanned, the micro switch plunger is extended and the solenoid is energized. The interlock solenoid assembly prevents gun elevating movement when the cradle and spanning tray are in a spanned or partially spanned position.

Receiver-regulator

A 16-inch Receiver-Regulator Mk 10 Mod 0 is the control instrument for automatic operation of the elevating gear. An electric-hydraulic instrument, enclosed in a square-shaped case (figs. 5-8 and 5-10), it is located on the electric deck between the electric motor and the A-end (fig. 5-7).

The receiver-regulator functions when the control selector lever is positioned at AUTO or LOAD. In these control selections, servo-system stroking pressure is ported to the stroking cylinder in response to gun orders or automatic loading orders that are received electrically in the receiver-regulator. In both of these control selections (AUTO and LOAD), the hand control servo-stroking valve gear is bypassed.

Components. Each receiver-regulator consists of the following components, all of which are enclosed within the instrument case.

- Fine and coarse control synchros
- Roller path and erosion correction input
- Elevation response gear
- Stroke response gear
- Loading cam
- Limit stop valve and adjusting cam
- Stabilizing valve
- Automatic stroking valve
- Synchronizing valves
- Loading pilot and transfer valves
- Loading control linkage
- Pressure regulator valve
- Stabilizing piston and linkage
- Amplifier piston and linkage
- Hydraulic vibrator

The arrangement of the above electrical, hydraulic, and mechanical components of the receiver-regulator is shown schematically in figure 5-30

Receiver-regulator instrument.

Fine and coarse control synchros. Gun elevation orders are transmitted to the receiver-regulator by synchro circuits. The rotors of the generators and receivers of both the fine (36-speed) and coarse (2-speed) synchros (fig. 5-13) are connected in parallel to a 115-volt, 60-cycle, single-phase, alternating-current supply. Both the fine and coarse synchros are bearing-mounted so that the stators of the synchros can be rotated by corrected mechanical response, elevation response, and stroke response. This rotation is accomplished by a system of shafts, gears, and gear differentials. The two synchros and their gear train assembly are located in the synchro compartment of the receiver-regulator (fig. 5-11).

The rotor of the coarse synchro positions the synchronizing pilot valve V15 and the synchronizing valve V3A through the synchronizing linkage designated 14. The rotor of the fine synchro positions the amplifier linkage designated L1 and its attached valves (fig. 5-9).

Roller path and erosion correction input. Corrections for roller path inclination and for gun erosion are combined in differential gearing in the elevation indicator (chapter 13). The combined correction is transmitted by a shaft from the indicator that is coupled to the correction input shaft (fig. 5-13) of the receiver-regulator. Inside the receiver-regulator, the correction is combined in a differential gear with B-end response; the output of the differential positions the stators of the coarse and fine synchros.

Elevation response gear. The elevation response gear (figs. 5-11, 5-12, and 5-13) drives one input gear of the differential that rotates the stators of the coarse and fine synchros through a gear train assembly within the receiver-regulator case.

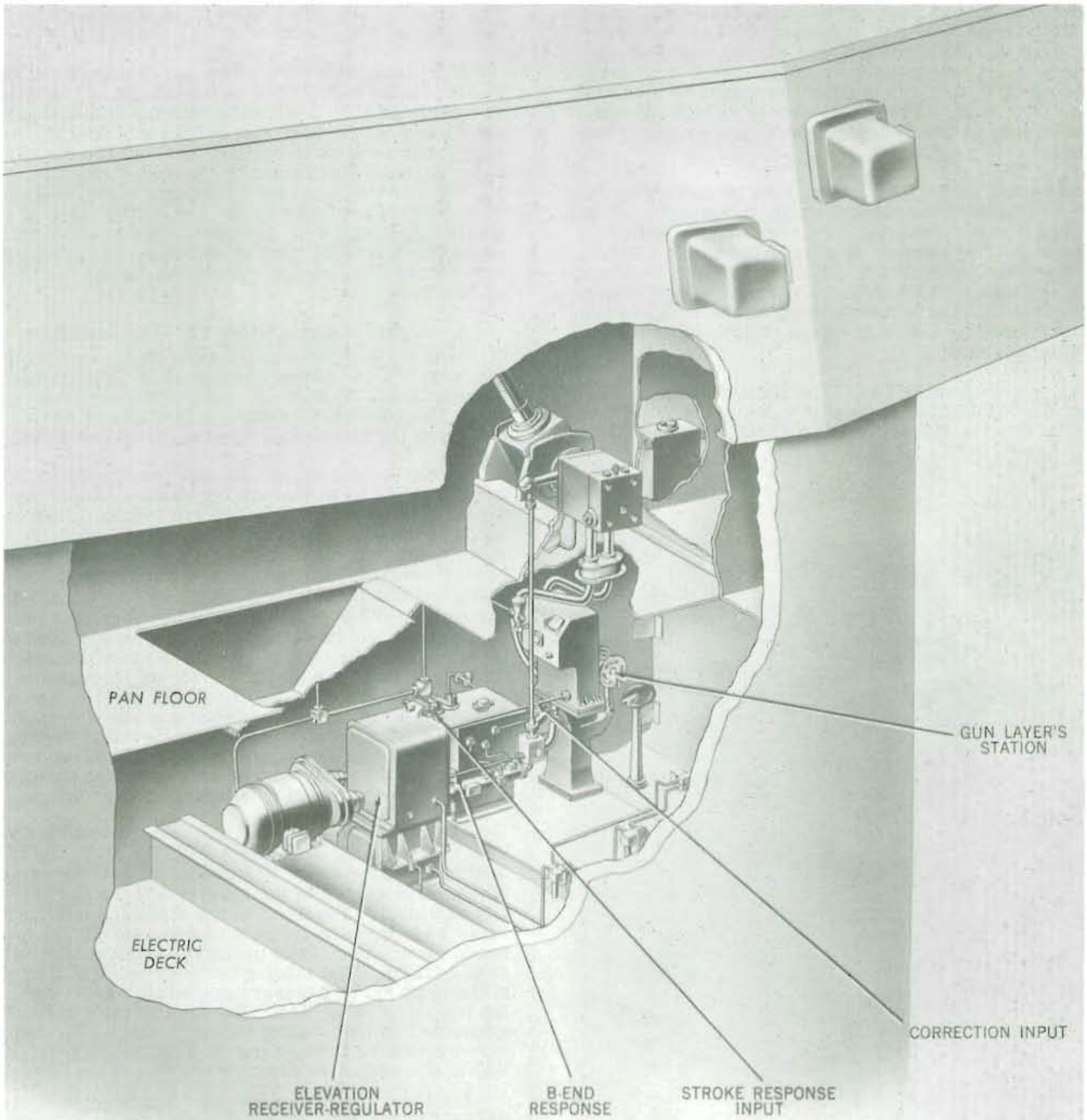

Figure 5-7. 16-inch Elevation Receiver-Regulator Mk 10 Mod 0, General Arrangement

From the B-end, elevation response is simultaneously transmitted through the upper response drive bracket to the elevation indicator and by a shaft and an adjustable coupling to the receiver-regulator. In the receiver-regulator, the B-end response rotates the loading cam and combines with roller path and erosion correction input to rotate the stators of the coarse and fine synchros. The combined B-end and stroke response inputs position the limit stop valve V34 through gear sector F and the limit stop adjustment cam.

Stroke response gear. A-end stroke response is transmitted to the receiver-regulator from the neutral return device by a system of shafts and gears, In the receiver-regulator, stroke response is combined with B-end response through differential gearing to position the limit stop valve V34 through gear sector F and the limit stop adjustment cam. Stroke response represents gun elevating speed; it is combined with B-end (gun position) response to make the limit stop valve V34 operate sooner at high speeds than it does at low speeds as the gun approaches its limit.

Loading cam. The loading cam is rotated by the B-end elevation response through a gear train; it is geared directly, without correction input, so that the gun loading position is always the same. The loading pilot valve V12 is positioned by the loading cam through a cam follower and crank arrangement. Smooth deceleration and stopping at the load position are provided by the cam, which is adjustable for gun loading position.

Limit stop valve V34. The limit stop valve V34 (fig. 5-9) is located in a valve block at the bottom of the receiver-regulator valve compartment. Positioned by a cam follower and linkage from the limit stop adjusting cam, V34 shifts servo pressure flow to and drain from the servo piston P2 to decelerate and stop the gun at its preset limit.

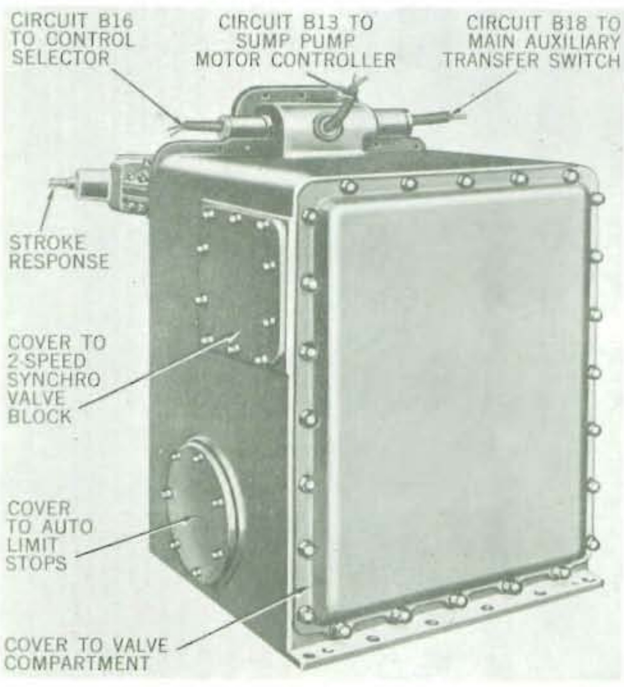

Figure 5-8. Elevation Receiver-Regulator Mk 10 Mod 0, Front View

Limit stop adjusting cam. The limit stop adjusting cam (fig. 5-31) is located in the synchro compartment of the receiver-regulator. The limit stop mechanism has two elements of data in its input. These are the position of the gun (B-end response) and the speed of the gun's movement (stroke response). Because both the position of the gun and the speed of gun movement are required for smooth, even stopping at all speeds at a definite stop position, the stroke response is added to the gun response in a gear differential within the receiver-regulator case. The output of the differential turns the limit stop adjusting cam (fig. 5-12).

Stabilizing valve V1. The stabilizing valve V1, located in the valve block at the bottom of the receiver-regulator (fig. 5-9), acts with the stabilizing piston P1 to prevent overtravel of the gun (B-end), which would result in oscillation about the elevation order signal. Positioned by the stabilizing linkage L2, the stabilizing valve V1 directs receiver-regulator control pressure to one end or the other of the stabilizing piston P1. Movement of P1 positions the amplifier piston P3 and the amplifier linkage L1 and also moves the stabilizing valve V1 back to its original position.

Automatic stroking valve V2. The automatic stroking valve V2 is located adjacent to the stabilizing valve V1, as shown in figure 5-9. Positioned by the stabilizing linkage L2, the automatic stroking valve V2 ports servo pressure flow to and drain from the servo piston through the limit stop valve V34.

Synchronizing valve V3A and synchronizing pilot valve V15. The synchronizing valve V3A and the synchronizing pilot valve V15 are located in the valve block at the upper part of the receiver-regulator valve compartment (fig. 5-9). The rotor of the coarse synchro actuates the synchronizing linkage L4 that positions these two valves. V15 ports servo pressure to V3A, which directs the servo pressure to the fine synchro valve V3 as long as gun position is within four degrees of gun elevation order. V3 then controls servo piston movement through the amplifier piston P3, stabilizing linkage L2, and automatic stroking valve V2. When gun position is more than four degrees away from gun elevation order, V3A cuts off servo pressure to V3 and ports servo pressure directly to P3 to drive the gun at full speed toward its synchronized position.

Loading pilot valve V12 and loading transfer valve V13. The loading pilot valve V12 (fig. 5-9) and the loading transfer valve V13 are located in the valve block in the center of the receiver-regulator valve compartment. Together with the loading interlock valve V44, these valves act to drive the gun at full speed toward the LOAD position, decelerate it, and stop it there. The loading transfer valve V13 is positioned by servo pressure ported to it from the loading interlock valve V44. The loading pilot valve V12, positioned by the loading control linkage L3, ports servo pressure through the loading transfer valve V13 to the amplifier piston P3.

Loading control linkage L3. The loading control linkage L3 is located in the valve compartment of the receiver-regulator (fig. 5-9). Actuated by rotation of the loading cam, the linkage positions the loading pilot valve V12.

Pressure regulator V19. The pressure regulator valve V19 is located in the valve block at the upper part of the receiver-regulator valve compartment (fig. 5-9). Servo pressure, ported to it at a pressure of approximately 350 pounds per square inch, is reduced to a control pressure of approximately 135 pounds per square inch. Control pressure is ported through the stabilizing valve V1 to the stabilizing piston P1.

Stabilizing piston P1. The stabilizing piston P1 is located in the valve block in the lower right side of the receiver-regulator valve compartment (fig. 5-9). This piston acts to change the pivot point in the stabilizing linkage L2, thereby affecting the response of the amplifier piston P3 to the movement of the fine synchro valve V3. The arrangement prevents overtravel and oscillation of the gun about the elevation order signal. The stabilizing valve V1 regulates the porting of receiver-regulator control pressure to the chambers of the stabilizing piston P1.

Stabilizing linkage L2. The stabilizing linkage L2 (fig. 5-9) mechanically connects the stabilizing valve V1 and automatic stroking valve V2 with the stabilizing piston P1 and the amplifier piston P3.

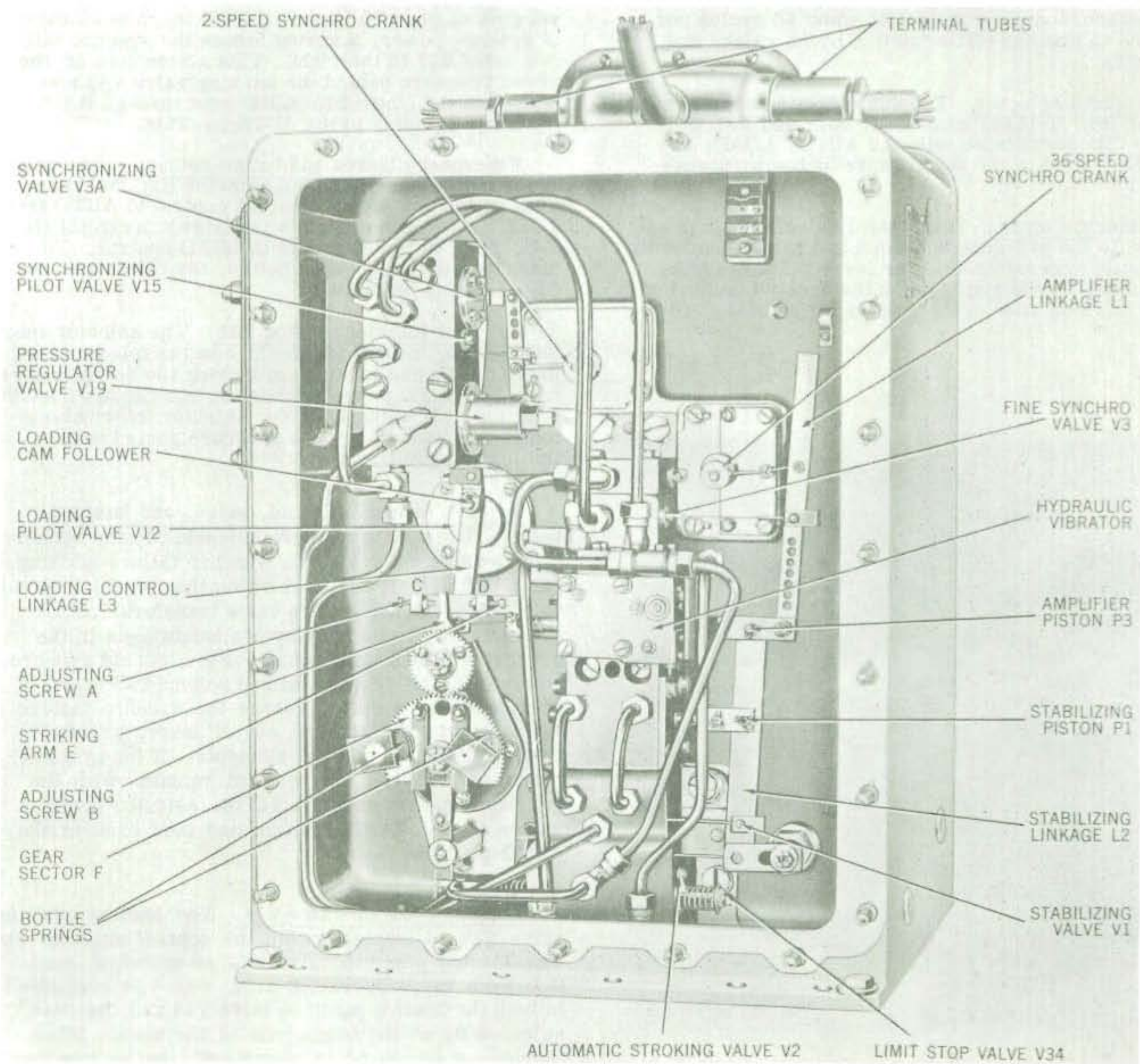

Figure 5-9. Elevation Receiver-Regulator Mk 10 Mod 0, Valve Compartment

Amplifier piston P3. The amplifier piston P3 (fig. 5-9) is moved in fine synchro control by servo pressure ported to it by the fine synchro valve V3. Amplifying V3 movement, the piston acts through the amplifier linkage L1 to return V3 to neutral. P3 acts through the stabilizing linkage L2 to position the automatic stroking valve V2. In coarse synchro control and in LOAD control, servo pressure is ported directly to P3 to drive the gun at full speed.

Amplifier linkage L1. The amplifier linkage L1 (fig. 5-9) interconnects the fine synchro rotor shaft, the fine synchro valve V3, and the amplifier piston P3. Synchro rotor movement acts through L1 to move V3. Amplifiying movement of P3 acts back through L1 to return V3 to its original position.

Hydraulic vibrator (fig. 5-14). The hydraulic vibrator, located in the center of the valve compartment, runs on servo pressure as a double-acting, two-cylinder reciprocating engine. The device oscillates the amplifier piston P3 through an amplitude of a few thousandths of an inch at about 60 cycles per second to prevent static friction in the valves and linkages.

Control selector. The gun elevating control selector (fig. 5-15) is a manually operated hydraulic valve that permits selection of AUTO, LOAD, or HAND control of the power drive hydraulic transmission.

Selector lever. The control selector unit is adjacent to the gun layer's station and is provided with a readily accessible selector lever. The lever is positioned by the gun layer to the desired method of control, indicated on the lever position dial plate by

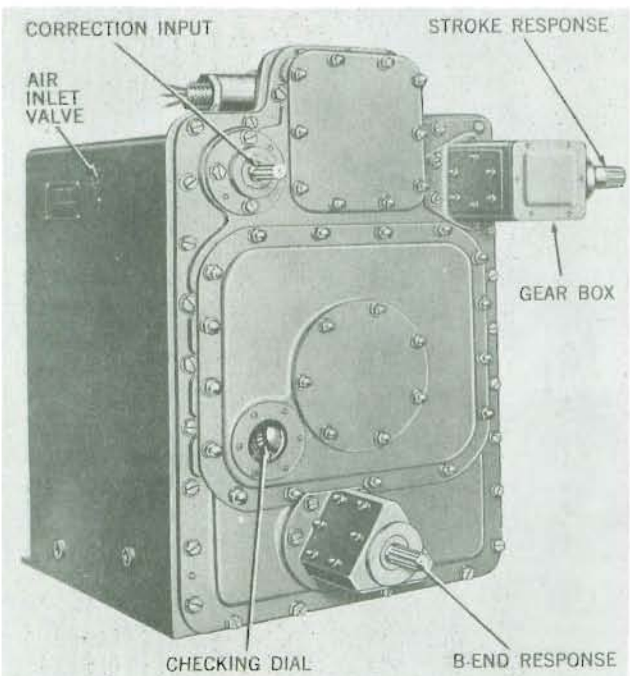

Figure 5-10. Elevation Receiver-Regulator Mk 10 Mod 0, Rear View

the selector lever. The control selector valve V4, the loading valve V43, and the loading interlock valve V44 are positioned in the control selector valve block by rotation of the selector lever. The valves are positioned by gears attached to the shaft of the selector lever that mesh with gear racks attached to the connecting rods of the valves.

Control selector valve V4. The control selector valve V4 is located in the control selector unit, as shown schematically in figure 5-30. Servo pressure is admitted to the valve block through the loading position valve V14. From this point, the servo pressure passes through the synchro failure valve V11 to the center section of the control selector valve V4 and to the left end of the latching valve V45. From the center section of the control selector valve V4, servo pressure is ported to the transfer acceleration limiting valve TALV, to the control transfer valve V3B, and to the handwheel clutch. When the selector lever is at AUTO, the control selector valve V4 ports servo pressure out of the control selector valve block via port number 10 (fig. 5-15). If there is a failure of synchro power, a spring forces the synchro failure valve V11 to the right. This action cuts off the servo pressure behind the latching valve V45 and transfers the control to HAND even through the selector lever remains in the AUTO position.

Emergency button and button release. The emergency button on the control selector (fig. 5-15) is used by the gun layer to return control to AUTO from LOAD, if the gun captain's ready switch circuit (fig. 5-30) fails while the gun is in LOAD control. To disengage the emergency button, the button release (fig. 5-15) is depressed.

Selector interlock piston P46. The selector interlock piston, located within the control selector unit, prevents the gun layer from moving the selector lever from the AUTO position while the gun captain's switch is at the SAFE position. The selector interlock piston is positioned by servo pressure ported to it by the loading position valve V14.

Synchro failure solenoid, valve, and latching valve. The synchro failure solenoid S3, the synchro failure valve V11, and the synchro failure latching valve V45 are all enclosed within the control selector unit. The synchro failure valve transfers control automatically to the gun layer's handwheels in the event of a failure of synchro power. Should synchro power fail, the synchro failure solenoid S3 is de-energized and a spring forces the synchro failure valve V11 to the right to cut off servo pressure to the automatic control elements. If the synchro power is restored, the control remains with the gun layer's handwheels until the selector lever is moved to the HAND position and then back to the AUTO position.

Loading position valve V14. The loading position valve V14 is located within the control selector unit. The loading position valve V14 is moved to position by a valve operating arm, which is connected to both the loading position valve V14 and the load solenoid S1 at the upper end of the arm. When the load solenoid S1 is energized, the loading position valve V14 moves to the right to port servo pressure directly to the loading transfer valve V13.

Loading interlock valve V44. The loading interlock valve V44 is located within the control selector unit. This valve is a sleeve that is moved back and forth in the block by the selector lever. The loading position valve V14 is moved back and forth inside V44 by the action of the load solenoid. Movement of the selector lever to LOAD positions V44 by means of a gear and rack arrangement (fig. 5-30). This mechanically connects servo pressure to the loading transfer valve V13. The arrangement provides gun layer selection of LOAD and AUTO control should the gun captain's circuit fail.

Loading valve V43. The loading valve V43 is located within the control selector unit. Movement of the selector lever positions the loading valve V43 through a gear and gear rack arrangement. The gear rack (fig. 5-30) butts up against the loading valve V43 and moves it to the left when the selector lever is moved from the AUTO to the LOAD position. This permits the gun to be brought to the load position by the selector lever when synchro power is not available.

Solenoids. The load and automatic solenoids are both located within the control selector unit.

Load solenoid. The load solenoid S1, connected to the valve operating arm, is energized when the gun captain's switch is moved to the SAFE position. When the load solenoid has been energized, it moves the operating arm so that the loading position valve V14 is moved to the left. This ports servo pressure to the loading transfer valve V13. The solenoid is de-energized by moving the gun captain's switch to READY.

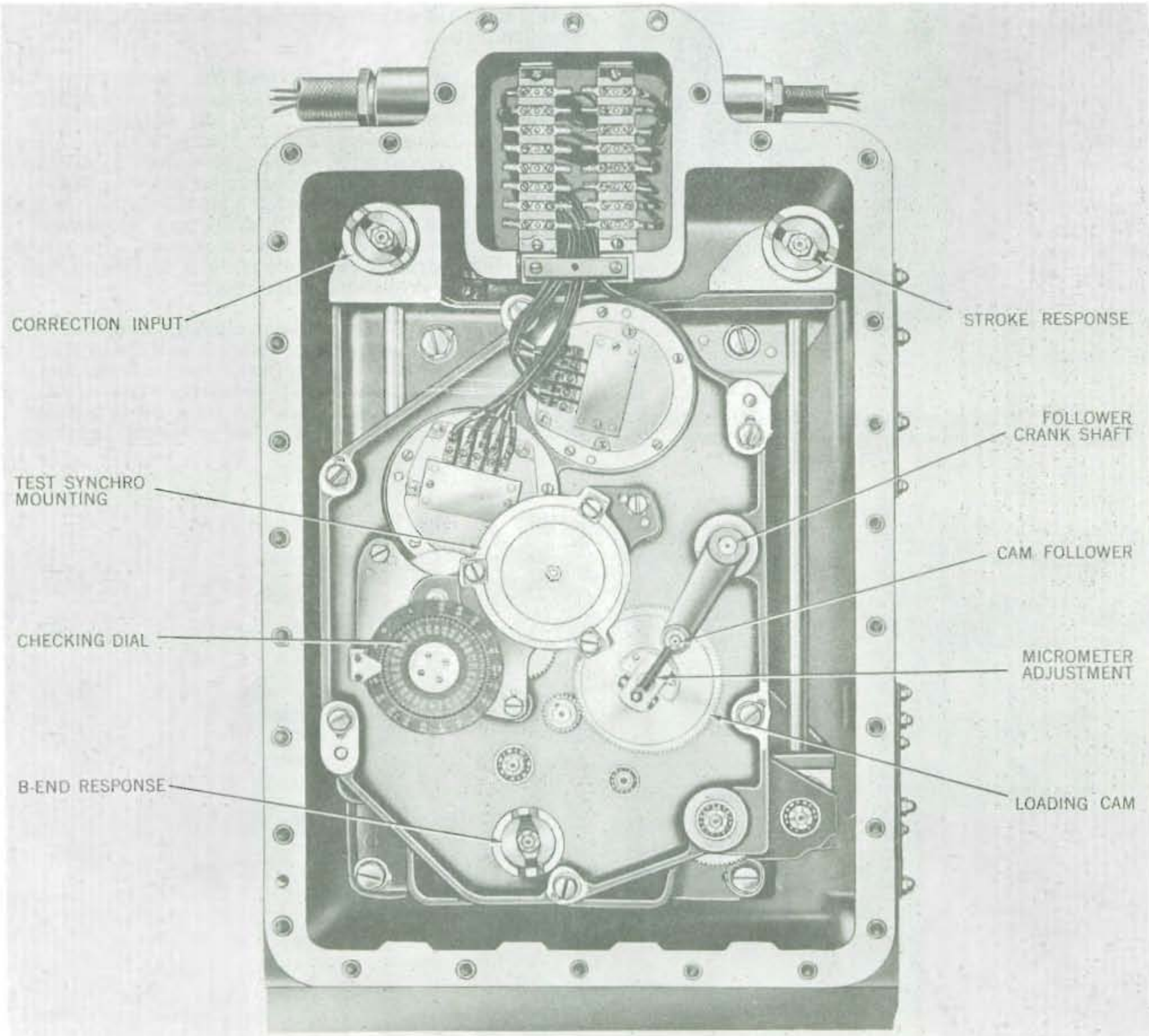

Figure 5-11. Elevation Receiver -Regulator Mk 10 Mod 0, Rear View - Back Plate Removed

Automatic solenoid. The automatic solenoid S2 is connected to the lower end of the valve operating arm. With the selector lever at AUTO, the solenoid is energized when the gun captain's switch is moved to READY. When the automatic solenoid S2 is energized, it moves the operating arm so that the loading position valve V14 is moved to the right to port servo pressure to the receiver-regulator automatic control elements.

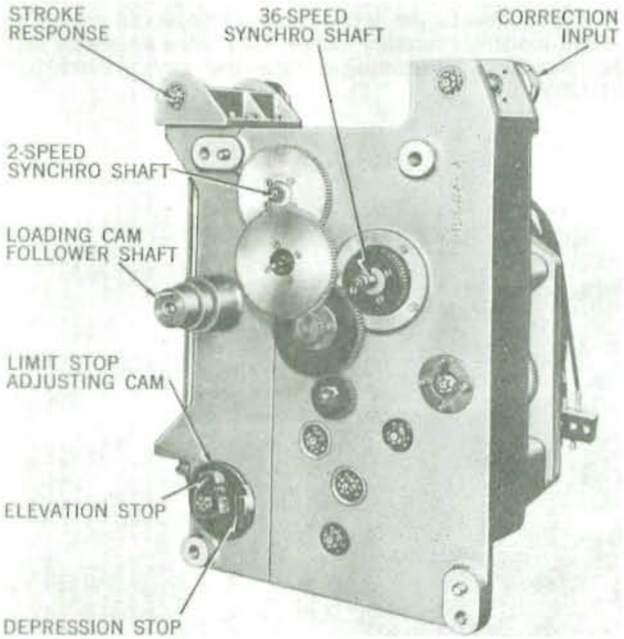

Figure 5-12. Elevation Receiver-Regulator Mk 10 Mod 0, Gear Train Assembly, Front View

Control transfer valve V3B. The control transfer valve V3B (fig. 5-16), located near the servo piston P2, transfers elevation control of the gun from the gun layer's handwheels to the receiver-regulator. When servo pressure is ported to the control transfer valve from the control selector unit, the control transfer valve is moved to the right against spring pressure. This connects the automatic stroking valve V2 in the receiver-regulator to the servo piston P2 through V3B.

Transfer acceleration limiting valve TALV. The transfer acceleration limiting valve TALV (fig. 5-18), located near the A-end, prevents excessive gun elevation speeds when shifting from AUTO to HAND. In AUTO, servo pressure is ported to the transfer acceleration limiting valve TALV from the control selector unit to hold the valve open against its spring. When the selector lever is moved from AUTO to HAND, the unbalanced valve TALV, bound against the side wall by servo pressure, closes partly and restricts flow in the line to the outside of P2. As soon as the gun synchronizes with the handwheels, V23 cuts off servo pressure to TALV, which then is moved by its spring to remove the restriction in the line to the servo piston.

Sump tank. The sump tank (fig. 5-19) forms the base on which the receiver-regulator is mounted. The tank is a rectangular, box-like weldment with internal arrangements for two floats, a valve, a mercury switch, and a hydraulic pipe manifold. There is a removable inspection cover on one side of the tank and six flanged ports for hydraulic pipes on the opposite side of the tank. A drain plug is provided in the bottom of the tank. The sump tank is a receptacle for hydraulic fluid leakage and drainage from the receiver-regulator valve block.

Sump pump. The sump pump (fig. 5-20) is a separate motor-pump set, located on the electric deck near the A-end. Hydraulic fluid leakage and drainage from the receiver-regulator valve block goes into a sump tank from which the oil is pumped back to the expansion tank. Under normal operation,

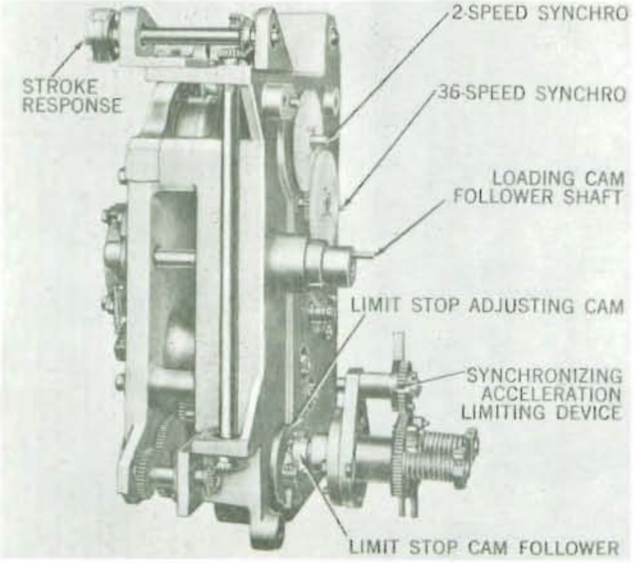

Figure 5-13. Elevation Receiver-Regulator Mk 10 Mod 0 Gear Train Assembly, Side View

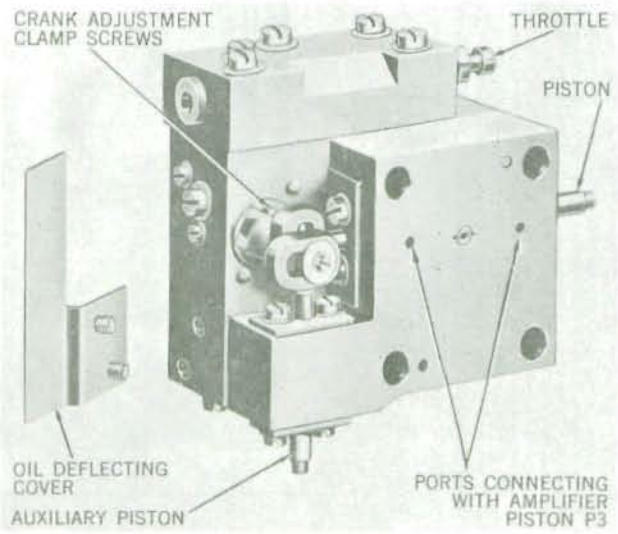

Figure 5-14. Elevation Receiver-Regulator Mk 10 Mod 0 Hydraulic Vibrator

the sump pump runs whenever the main electric motor is running. The capacity of the pump is greater than the normal drainage into the sump tank; therefore, part of the oil is recirculated back to the sump tank. Whenever the oil level drops too low, the float-operated sump pump valve V40 opens and permits the pump discharge to return to the sump tank to assure adequate supply to the pump at all times.

If the sump pump unit is not used for several days, oil may gradually fill the sump tank. Should the oil level get abnormally high, the float-operated mercury switch actuates a magnetic switch in the sump pump control unit and thereby starts the pump. The pump lowers the oil level until the float switch cuts off the pump motor circuit. Should the float switch fail, the pump may be run by closing the sump pump emergency switch.

If the sump pump should fail, the sump tank will be completely filled. Sump tank check valve V41 will close, sealing the synchro compartment, and pressure will build up in the valve compartment. When the pressure reaches eight pounds per square inch, the discharge oil will be forced through the block valve to the expansion tank.

Sump pump controller. The sump pump controller (figs. 5-21 and 5-22) is mounted on the bulkhead at the electric deck, near the training gear A-end. It consists of a standard-type controller case, inside of which is a shock-mounted switch panel, a line switch, a control transformer, and necessary interlocks. The controller contains four separate circuits which operate the sump pump motors of the elevating gears for the right gun, the center gun, the left gun, and the turret training gear. Each circuit is complete in itself.

When the electric motor of any one of the elevating gear power drives is started, the corresponding magnetic switch in the sump pump controller closes a circuit to the sump pump for that power drive. Each magnetic switch has two solenoids that are joined together mechanically and are connected to the contact mechanism. One solenoid is for 440 volts and the other is for 110 volts; either solenoid is capable of closing the switch. While the power drive is operating, the 440-volt solenoid is energized from one phase of the main controller; therefore, the sump pump operates whenever its power drive is operating.

If the power drive is not operating and fluid leakage fills the sump tank, a float-operated mercury switch (fig. 5-19) closes a 110-volt circuit and thereby closes the magnetic switch by energizing the 110-volt solenoid. The 110-volt power is supplied by a transformer in the controller unit case.

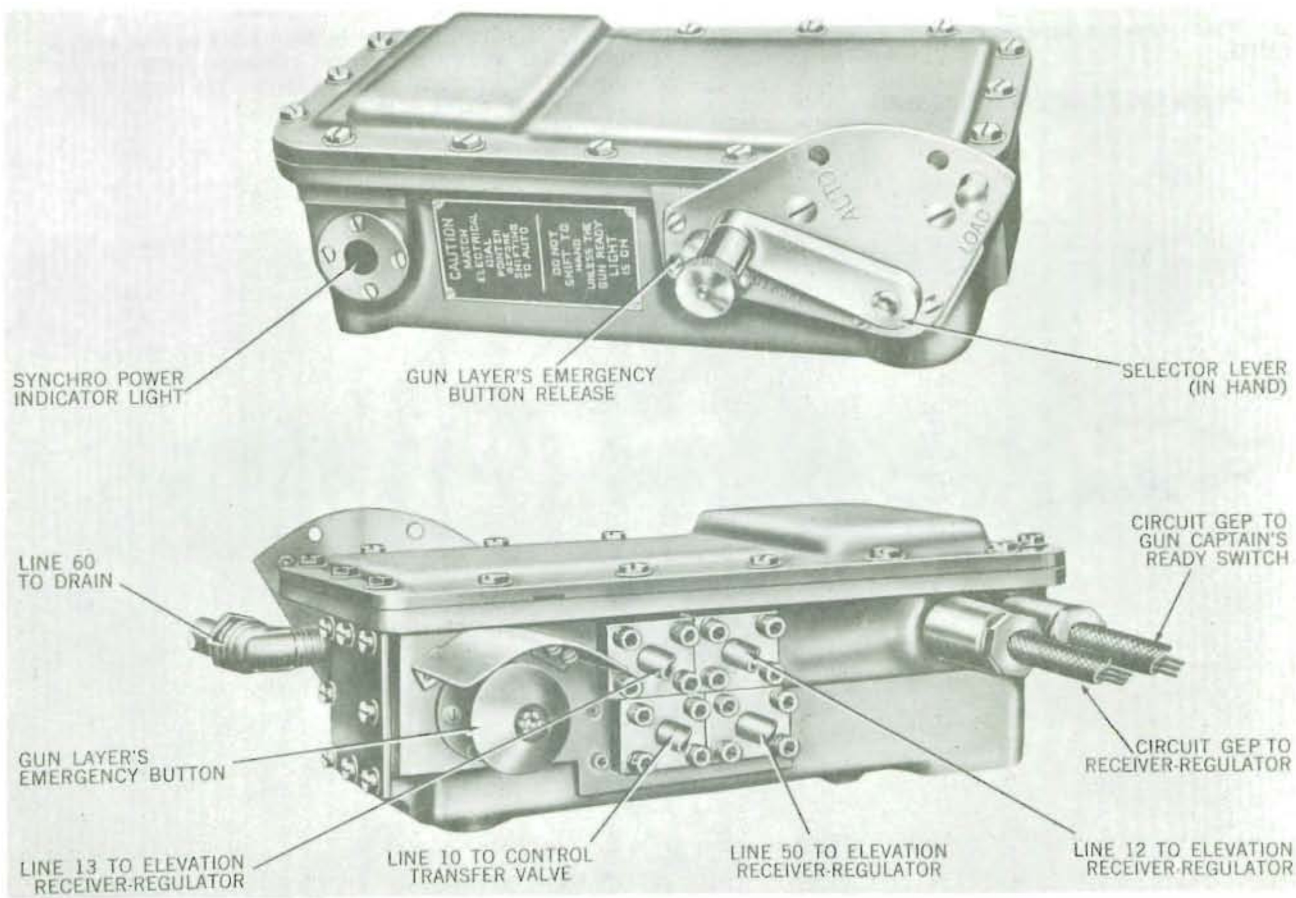

Figure 5-15. Elevation Receiver-Regulator Mk 10 Mod 0 Selector and Synchro Failure Valve

Gene Slover's US Navy Pages | Table of Contents

OPERATION

General - hand and automatic control

In normal HAND operation, the gun order signal is received in the elevation indicator. The gun layer observes the gun order signal, indicated by the pointers in the elevation indicator, and compares that signal with the position of the gun. If there is a "matching error" in the pointers, the gun layer operates his handwheels in a direction and at a speed calculated to "match pointers."

In AUTO operation, the receiver-regulator receives the same gun order signal as that received by the elevation indicator. By comparing the gun order signal with a mechanical indication of the gun position, the receiver-regulator continually measures "matching error." The receiver-regulator measures the error by electrical and mechanical devices and acts on the servo stroking piston to reduce the error. In AUTO, the receiver-regulator replaces the gun layer's function of visually checking the error and manually controlling the gun position in order to "match pointers."

Starting

Perform the following operations when starting the electric motor:

1. Place the controller circuit-breaker lever at ON.

2. Place the gun layer's control selector lever at HAND.

3. Press the START-EMERG button.

Stopping

When stopping the elevating gear, perform the following operations:

1. Place the gun layer's control selector lever at HAND.

2. Bring the gun to the desired angle of elevation and stop handwheel rotation.

3. Press the STOP button.

Hand control, servo operation

For servo operation in hand control, the gun layer's selector lever is positioned at HAND. To start the power drive, the START-EMERG push button must be depressed when the A-end tilting box is at the neutral position.

Controls neutral. With the power drive electric motor running and the elevating handwheels at rest, the following conditions exist (fig. 5-23):

1. The A-end tilting box is at neutral (zero tilt); no hydraulic fluid is being pumped, and there is no pressure in the main hydraulic lines between the A- and B-ends.

2. The power-off control valve V4N is held by its solenoid against spring action.

3. Hydraulic fluid is delivered by the servo pump (at servo pressure) through ports in the power-off control valve V4N to the left of the power-off valve V1N.

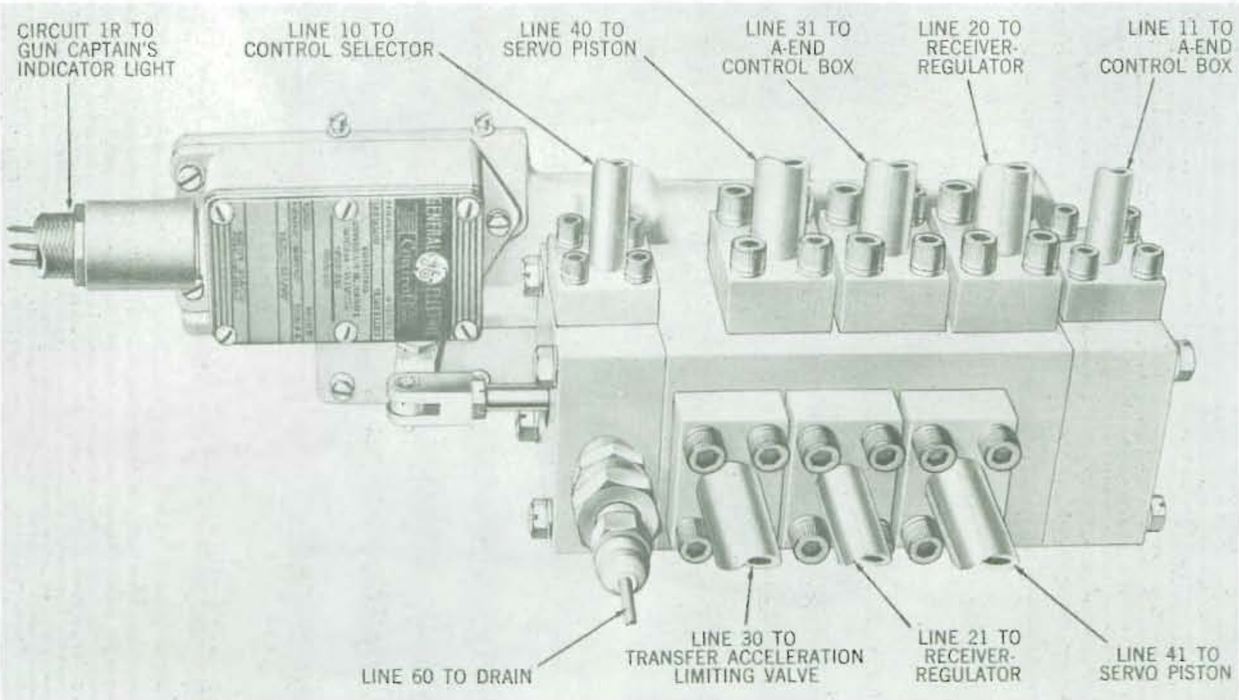

Figure 5-16. Elevation Receiver-Regulator Mk 10 Mod 0 Control Transfer Valve

4. Forced to the right by servo pressure, V1N opens the main hydraulic lines from the A-end to the B-end.

5. Movement to the right V1N also connects servo pressure to the cutout valve V12N and to the servo supply cutout valve V22. V12N is moved against its spring to open passages from the main hydraulic lines to the tops of the A-end relief valves V9N and V10N. V22 is forced down against its spring to admit servo pressure from another line to the servo control valve V23, where the pressure is blocked.

6. Servo pressure from the servo pump ported directly to the directional valve V6A is blocked by that valve in its neutral position.

7. Supercharge pressure is maintained to the A-end relief valve block (check valve V13N) by the supercharge pump to keep the main system filled with hydraulic fluid.

Normal control, elevating. With the power drive in operation (controls neutral, as shown in figure 5-23), the gun is elevated by turning the handwheels up and toward the operator. The following actions occur:

1. Handwheel motion is transmitted through the friction clutch and differential (fig. 5-25) to the trunnion to move it upward.

2. Through a linkage, pivoted in a slot in the control cam, the trunnion lifts the servo control valve V23. This ports servo pressure through grooves in the constant horsepower valve V6 through V3B to the inside of the servo piston. The hydraulic fluid on the outside of the piston drains through V3B to TALV to V6 to V23 to tank.

3. Servo pressure moves the servo piston and, through it, the A-end tilting box. Tilting box movement is transmitted mechanically through the sector gear to the control cam.

4. A-end pumping action drives the B-end to elevate the gun. The control cam moves V23 through the trunnion linkage to block further hydraulic flow to the servo piston. B-end response acts on the trunnion through the differential; trunnion displacement represents the difference between handwheel input and B-end response. At a constant handwheel speed, the servo piston, A-end tilting box, control cam, and trunnion remain in a state of equilibrium with servo control valve V23 blocking flow to the servo piston.

5. Increase in handwheel speed causes an increase in A-end tilt through further movement of the servo piston.

6. Decrease in handwheel speed combines with B-end response to move the trunnion in the opposite direction. This forces V23 down and reverses the pressure and drain connections to the servo piston to drive the A-end tilting box back toward the neutral position.

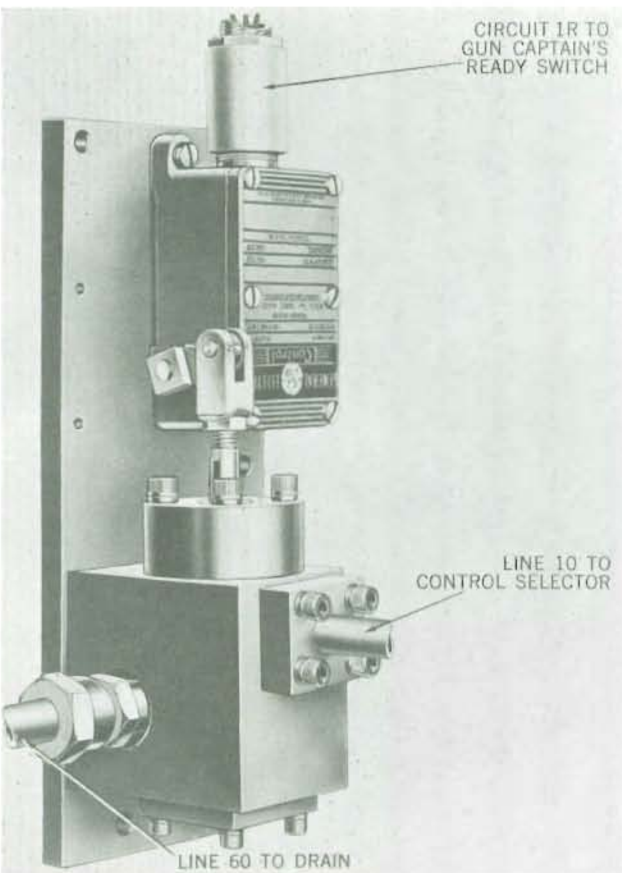

Figure 5-17. Elevation Receiver-Regulator Mk 10 Mod 0 Pressure-operated Indicator Switch

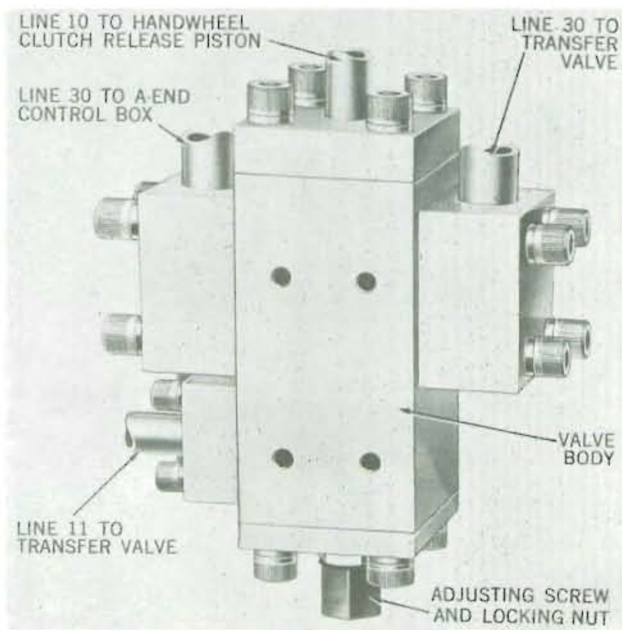

Figure 5-18. Elevation Receiver-Regulator Mk 10 Mod 0 Transfer Acceleration Limiting Valve

7. Main system high pressure is ported through pilot valve V11N and cutout valve V12N to the top of relief valve V9N to hold the valve closed. If main system pressure rises too high, V11N is forced to the right to connect the top of V9N to the low-pressure side of the main line. System high pressure then lifts V9N and bypasses into the main system return until the high pressure has dropped to normal.

8. Normal leakage will cause the main system return pressure to drop below the setting of the check valve V13N. When this occurs, the system is replenished by the supercharge pump through V13N.

Constant horsepower control, elevating. If the combination of A-end stroke and main system high pressure requires the electric motor to deliver more than the desired horsepower, the constant horsepower device takes control (fig. 5-26). When this occurs:

1. System high pressure from the shuttle valve V27 acts on the measuring piston P6 to force it down. Through a link, the piston lifts the constant horsepower valve V6.

2. In its new position, V6 blocks servo pressure from V22 and V23. Servo pressure is ported through the directional valve V6A, V6, TALV, and V3B to the outside of the servo piston to drive it back toward its neutral position. The inside of the servo piston is open to drain through V3B, V6, and V6A.

3. Movement of the A-end toward neutral turns the control cam, which changes the position of the outer sleeve of P6. When the horsepower demand has dropped to normal, the positions of P6 and its outer sleeve act to move V6 back to its normal position.

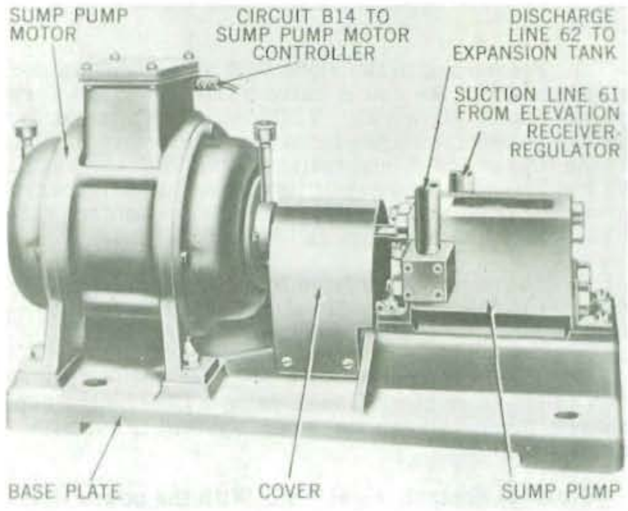

Figure 5-20. Elevation Receiver-Regulator Mk 10 Mod 0 Sump Pump

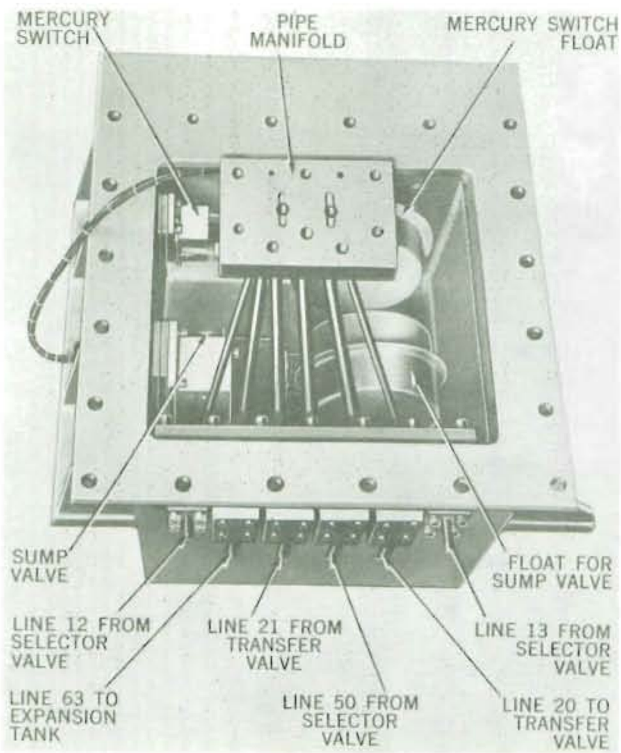

Figure 5-19. Elevation Receiver-Regulator Mk 10 Mod 0 Sump Tank, Top View

Figure 5-21. Elevation Receiver-Regulator Sump Pump Control Unit

Normal control, depressing. With the power drive in operation (controls neutral, as shown in figure 5-23), the gun is depressed by turning the handwheels down and away from the operator. The following actions occur:

1. Handwheel motion is transmitted through the friction clutch and differential (fig. 5-27) to the trunnion to move it downward.

2. Through a linkage, pivoted in a slot in the control cam, the trunnion pushes the servo control valve V23 down. This ports servo pressure around the constant horsepower valve V6 through TALV and V3B to the outside of the servo piston. The inside of the servo piston is opened to drain through V3B and other ports in V6 and V23.

3. Servo pressure moves the servo piston and through it, the A-end tilting box. Tilting box movement is transmitted mechanically through the sector gear to the control arm.

4. A-end pumping action drives the B-end to depress the gun. The control cam moves V23 through the trunnion linkage to block further hydraulic flow to the servo piston. B-end response acts on the trunnion through the differential; trunnion displacement represents the difference between handwheel input and B-end response. At a constant handwheel speed, the servo piston, A-end tilting box, control cam, and trunnion remain in a state of equilibrium, with servo control valve V23 blocking flow to the servo piston.

5. Increase in handwheel speed causes an increase in A-end tilt through further movement of the servo piston.

6. Decrease in handwheel speed combines with B-end response to move the trunnion in the opposite direction. This forces V23 up and reverses the pressure and drain connections to the servo piston to drive the A-end tilting box back toward the neutral position.

7. Main system high pressure is ported through pilot valve V11N and cutout valve V12N to the top of relief valve V10 to hold the valve closed. If main system pressure rises too high, V11N is forced to the left to connect the top of V10 to the low-pressure side of the main line. System high pressure then lifts V10N and bypasses into the main system return until the high pressure has dropped to normal.

8. Normal leakage will cause the main system return pressure to drop below the setting of the check valve V13N. When this occurs, the system is replenished by the supercharge pump through V13N.

Constant horsepower control, depressing. If the combination of A-end stroke and main system high pressure requires the electric motor to deliver more than the desired horsepower, the constant horsepower device takes control (fig. 5-28). When this occurs:

1. System high pressure from the shuttle valve V27 acts on the measuring piston P6 to force it down. Through a link, the piston lifts the constant horsepower valve V6.

2. In its new position, V6 blocks servo pressure from V22 and V23. Servo pressure is ported through the directional valve V6A, V6 and V3B to the inside of the servo piston to drive it back toward its neutral position. The outside of the servo piston is open to drain through V3B, TALV, V6 and V6A.

Limit stop control. If handwheel motion is continued in one direction until the gun is approaching its positive stop, the limit stop in the control mechanism stops the handwheels (fig. 5-29). When this occurs:

1. B-end response acts directly on the trunnion to return it to neutral.

2. Trunnion movement shifts the servo control valve V23 to port servo pressure around V6 to the servo piston to return the A-end tilting box to neutral.

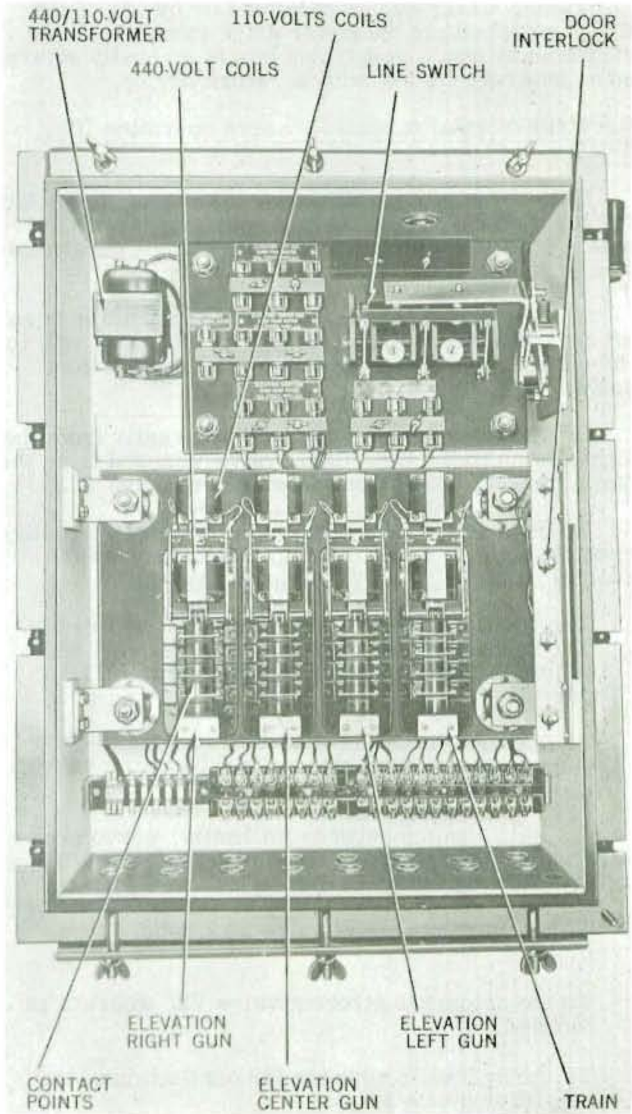

Figure 5-22. Elevation Receiver-Regulator, Sump Control Unit, Door Open

Power-off. The solenoid of the power-off control valve V4N is in the circuit of the electric motor controller. If the STOP push button is depressed or if 440-volt power fails, this solenoid is de-energized with the following results:

1. V4N (fig. 5-24) is moved by its spring to port the pressure above power-off valve V1N to drain.

2. V1N is moved by its spring to block the main hydraulic lines in the B-end. This blocks hydraulic flow between the A-end and B-end and "freezes" the gun in elevation.

3. In its power-off position, V1N ports trapped servo pressure from the cutout valve V12N to drain through the B-end case. V12N is then moved by its spring to port the spaces above relief valves V9N and V10N to drain through the throttle valve VT. This allows system high pressure to bleed to drain through the pilot valve V11N, the cutout valve V12N, and the spaces above V9N and V10N.

When the elevating gear has been stopped while in motion, either by power failure or by use of the STOP push button, the power drive cannot again be started until the A-end tilting box is manually returned to neutral with the neutral return device.

Receiver-regulator control, servo operation (fig. 5-30)

With the power transmission operating, the selector lever at AUTO, and with the gun synchronized with a stationary signal, hydraulic circuit conditions are as follows:

1. Servo pressure is delivered through the power-off control valve V4N and the power-off valve V1N to the cutout valve V12N and the servo supply cutout valve V22.

2. Servo pressure is delivered directly from the servo pump to the directional valve V6A and from the pump through V22 to the servo control valve V23.

3. Servo pressure from the servo pump is delivered through the synchro failure valve V11 and the control selector valve V4 to the following:

The friction clutch to disengage the handwheels. The transfer acceleration limiting valve TALV to position it against spring action for AUTO operation.

The control transfer valve V3B to open the passage from the limit stop valve V34 to the servo piston.

4. With the gun between its limits, servo pressure is delivered through the limit stop valve V34 to the following:

To the loading control valve V12, where it is blocked.

To the automatic stroking valve V2, where it is blocked.

To the hydraulic vibrator for oscillation of the amplifier piston P3.

To the pressure regulator valve V19, where it is reduced to control pressure and delivered to the stabilizing valve V1.

To the fine synchro valve V3 through the synchronizing pilot valve V15 and the synchronizing valve V3A. V3 is centered and blocks servo pressure between its lands.

5. Servo pressure is delivered through the loading position valve V14 and the loading interlock valve V44 to one end of the loading transfer valve V13. This positions V13 so that it connects port of V3 to corresponding ports of the amplifying piston P3.

Fundamental (fine synchro) automatic control. When the gun is within four degrees of synchronization with the gun elevation order signal, the fine (36-speed) synchro E (fig. 5-30) controls automatic operation of the receiver-regulator. With gun elevation order for increasing gun elevation, the following actions take place:

1. The synchro rotor turns an amount corresponding to the "error" between actual elevation and elevation order. Its motion is transmitted through the amplifier linkage L1 to move the fine synchro valve V3 to the right.

2. Servo pressure between the lands of V3 is ported through the loading transfer valve V13 to the right end of amplifier piston P3.

3. Servo pressure forces P3 to the left a distance corresponding to, but greater than, the movement of V3. This movement is transmitted back through L1 to return V3 to neutral. At the same time, the motion of P3 is transmitted through the stabilizing linkage L2 to the stabilizing valve V1 and the automatic stroking valve V2.

4. The stabilizing valve V1 ports control pressure from V19 to the stabilizing piston P1. This causes P1 to move to the left and change the pivot of L3 to modify the action of P3 on V2. Without this action, the entire system would overtravel and then oscillate about the input gun elevation order signal. This action makes the automatic stroking valve V2 move an amount that will limit the delivery of servo pressure to the pervo piston.

5. V2 moves to the right and ports servo pressure to the inside of the servo piston through V3B.

6. B-end response is combined with roller path and erosion correction input in a differential; the differential drives the stator of the fine synchro E. Overtravel of the servo piston would result in a reversal of the synchro rotor and regulator valve actions; this is prevented by the stabilizing action of V1 and P1, which operate in conjunction with B-end response to bring the gun smoothly into synchronization and to hold it there.

Coarse (2-speed) synchro control. Because the fine (36-speed) synchro E has identical positions 10 degrees of elevation apart, the gun position could agree with the synchro and still be 10 degrees away from the gun elevation order signal. The coarse (2-speed) synchro prevents this. Its rotor is turned electrically an amount equal to the difference between actual gun elevation and gun elevation order. When this difference is more than four degrees:

1. The rotor of synchro D has turned far enough to move (through the synchronizing linkage L4) the synchronizing pilot valve V15 to port servo pressure to the end of the synchronizing valve V3A.

VALVE AND PISTON SYMBOLS
V1N POWER OFF VALVE
V3B CONTROL TRANSFER VALVE
V4N POWER OFF CONTROL VALVE
V5N REPLENISHING VALVE
V6 CONSTANT HP VALVE
V6A DIRECTIONAL VALVE
V6B CONSTANT HORSEPOWER CUT-IN VALVE
V9N RELIEF VALVE
V10N RELIEF VALVE
V11N PILOT VALVE
V12N CUT-OUT VALVE
V13N CHECK VALVE
V14N NEUTRAL RETURN VALVE
V22 SERVO SUPPLY CUT-OUT VALVE
V23 SERVO CONTROL VALVE
VT THROTTLE VALVE
V27 SHUTTLE VALVE
CV CHECK VALVE
GV GATE VALVE
TALV TRANSFER ACCELERATION LIMITING VALVE
PD DRAIN PORTS
P2 SERVO PISTON
P6 PRESSURE MEASURING PISTON
P18 CLUTCH OPERATING PISTON
F FILTERS

ELECTRICAL SYMBOL
S7 SERVO NEUTRAL INTERLOCK SWITCH

MECHANICAL SYMBOLS
C2 CONSTANT HP CAM
C3 NEUTRAL INTERLOCK SWITCH CAM

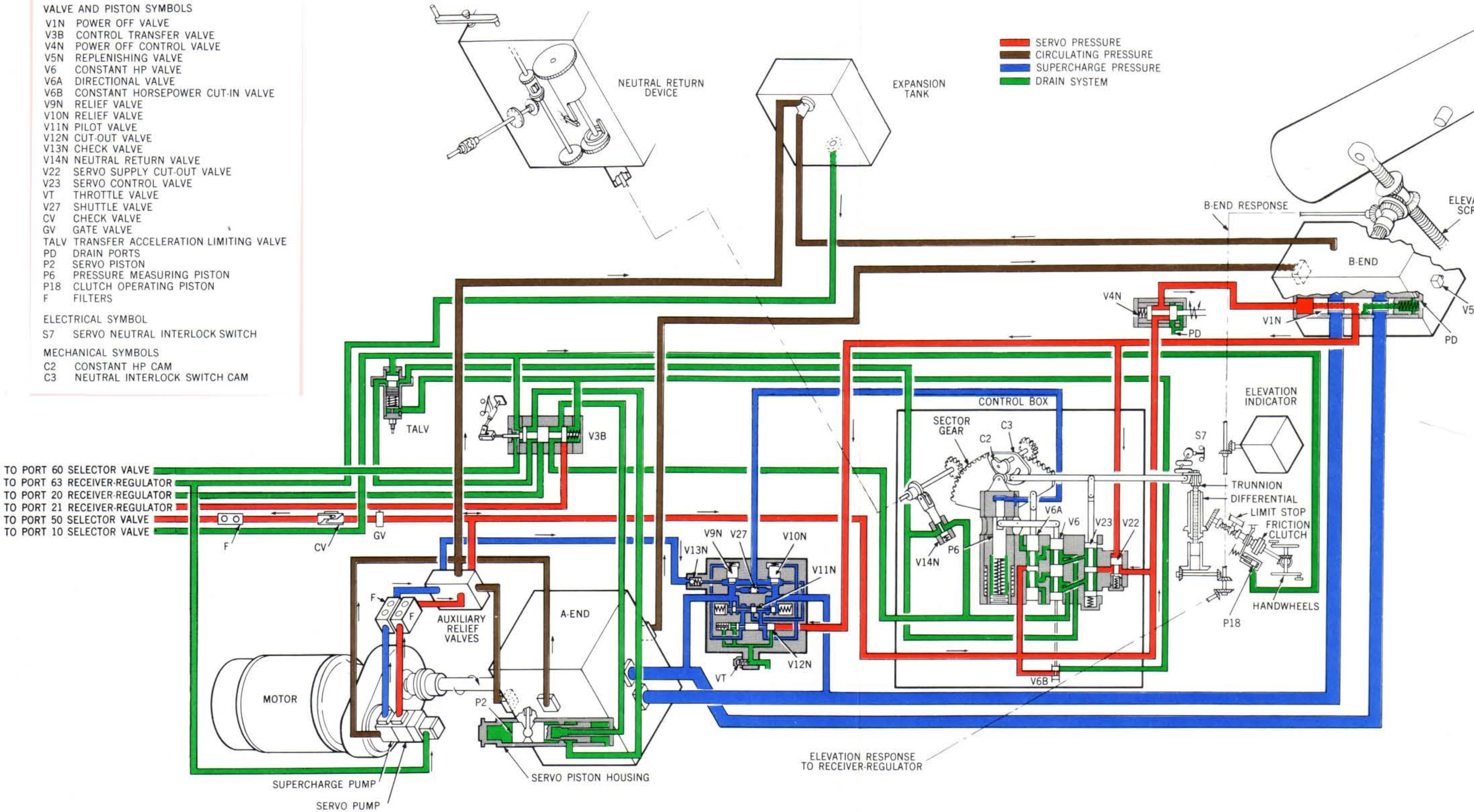

Figure 5-23. Elevating Gear Transmission Control Diagram. Controls Neutral, Selector at HAND, Power On

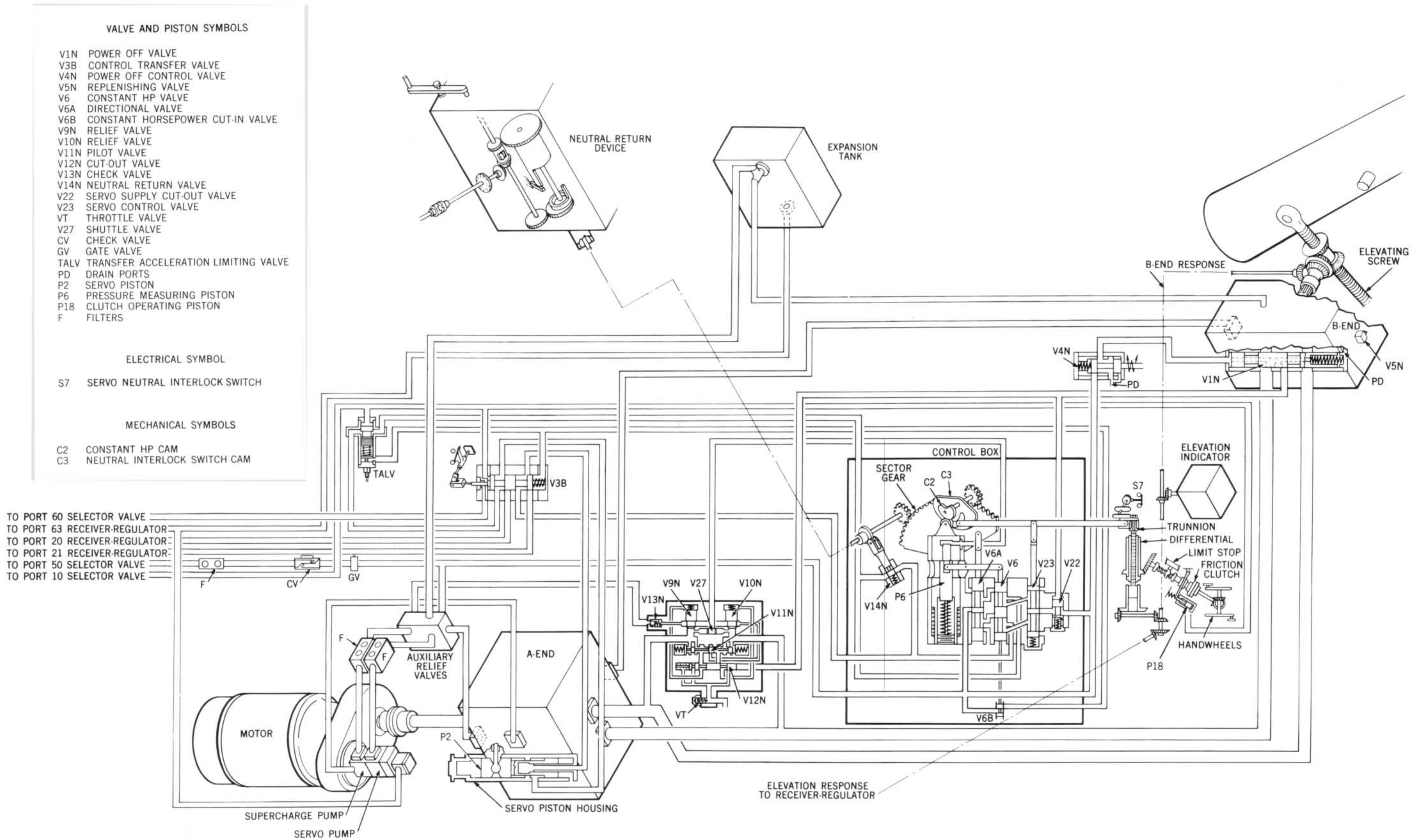

Figure 5-24. Elevating Gear Transmission Control Diagram. Power Off

Gene Slover's US Navy Pages

Table of Contents

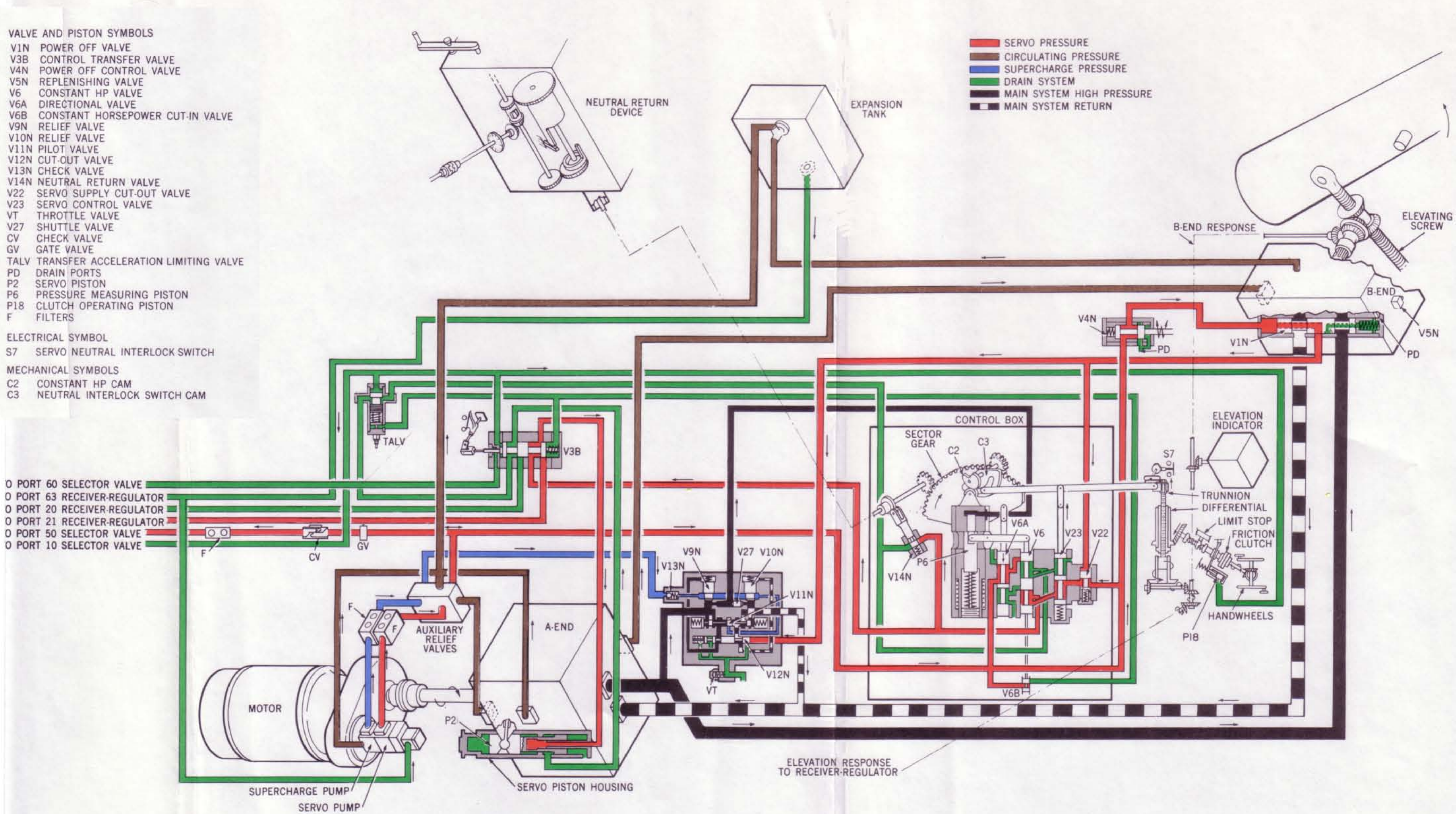

Figure 5-25. Elevating Gear Transmission Control Diagram. Gun Elevating, Selector at HAND

Gene Slover's US Navy Pages | Table of Contents

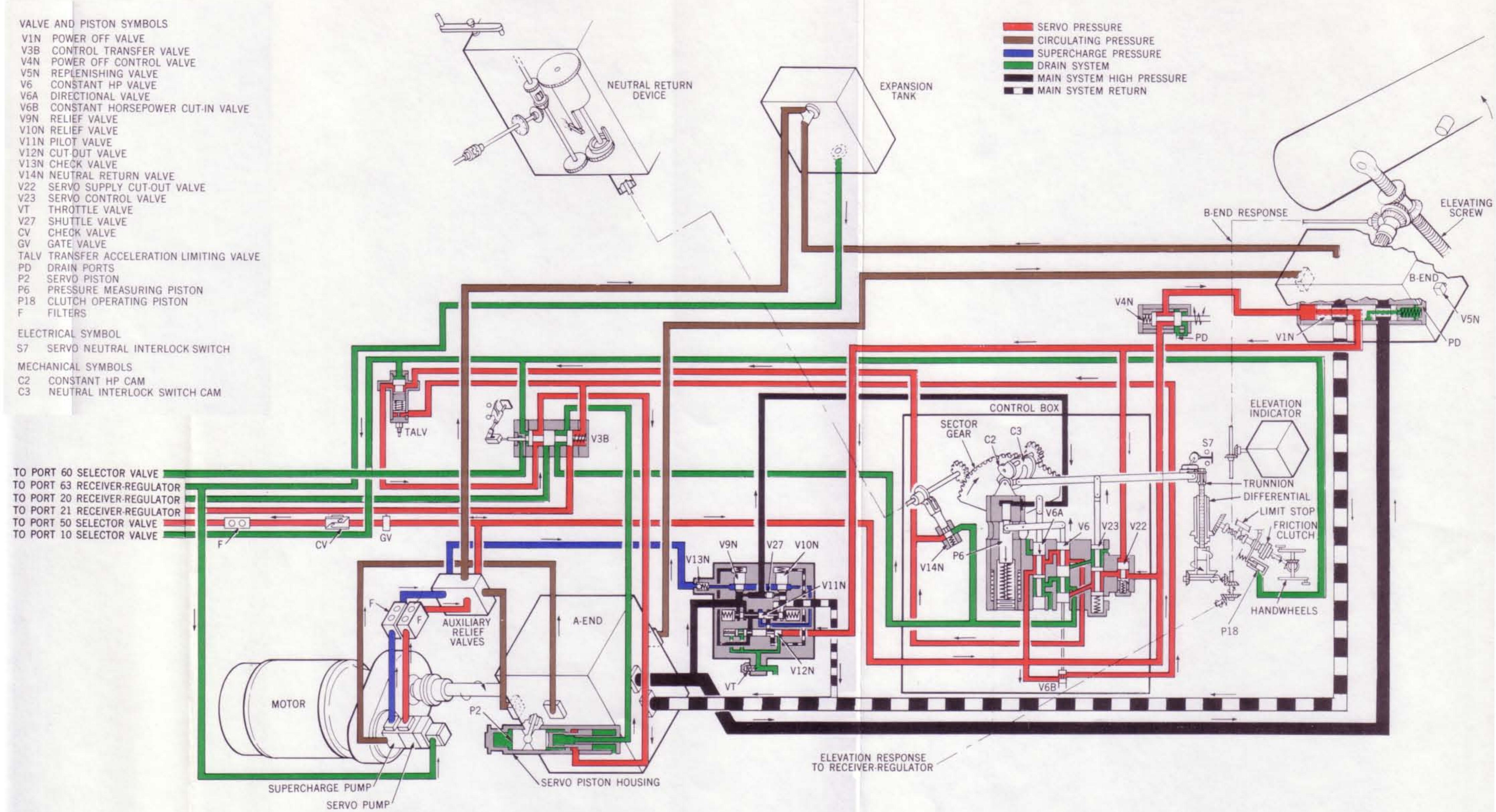

Figure 5-26. Elevating Gear Transmission Control Diagram. Gun Elevating, Selector at HAND, Constant Horsepower Control

Table of Contents

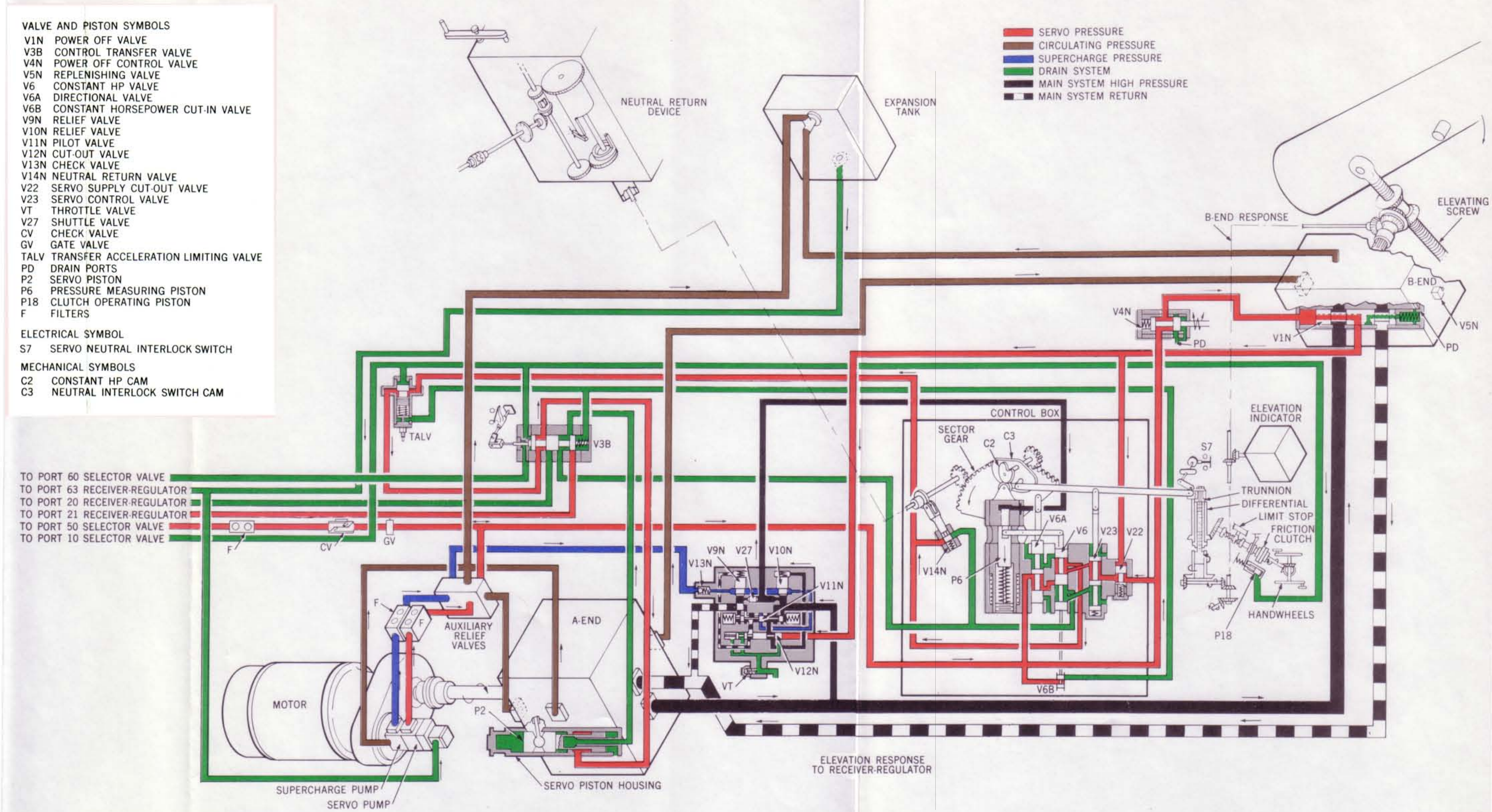

Figure 5-27. Elevating Gear Transmission Control Diagram. Gun Depressing, Selector at HAND

Gene Slover's US Navy Pages

Table of Contents

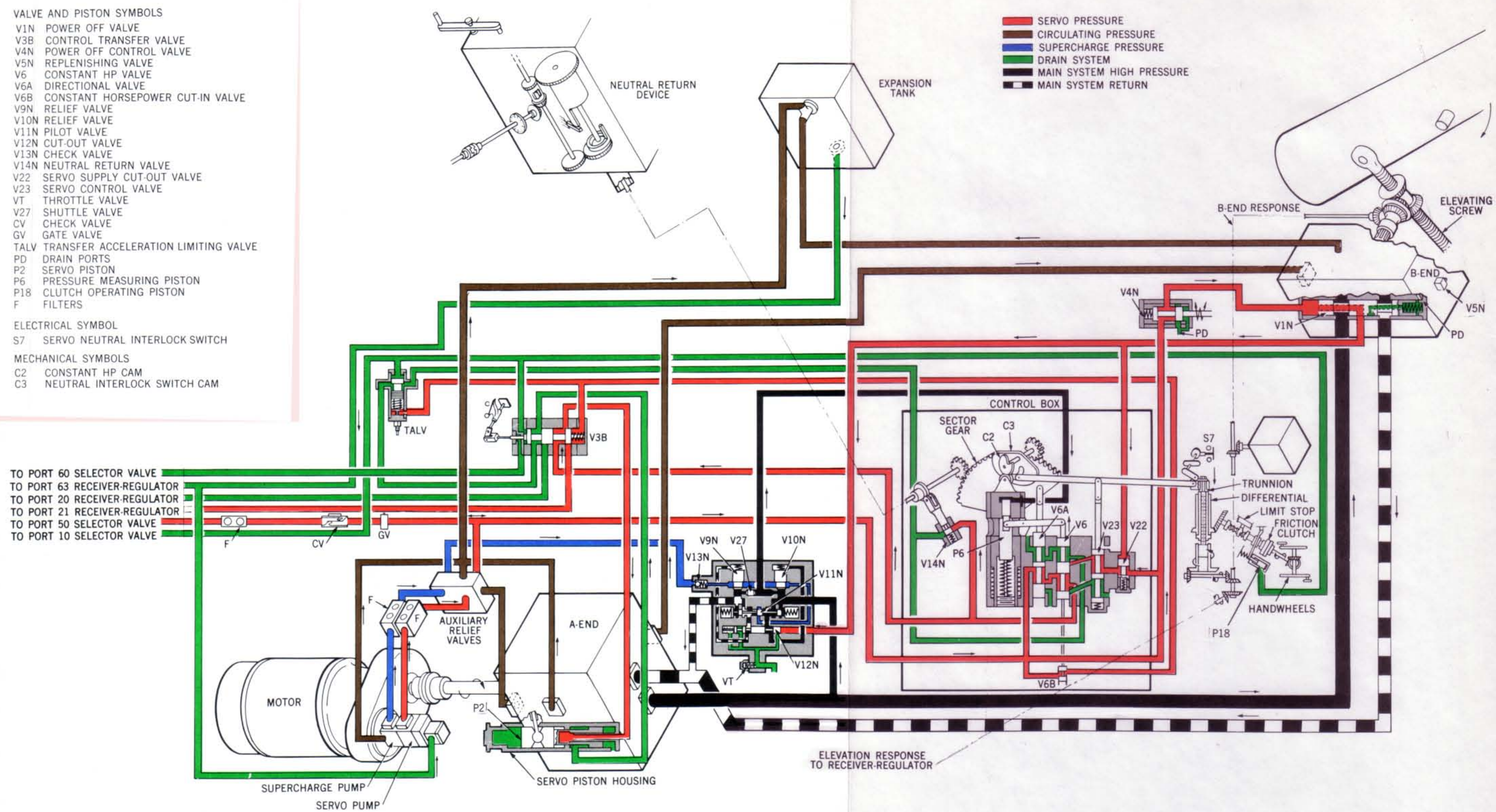

Figure 5-28. Elevating Gear Transmission Control Diagram.
Gun Depressing, Constant Horsepower Control

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Table of Contents

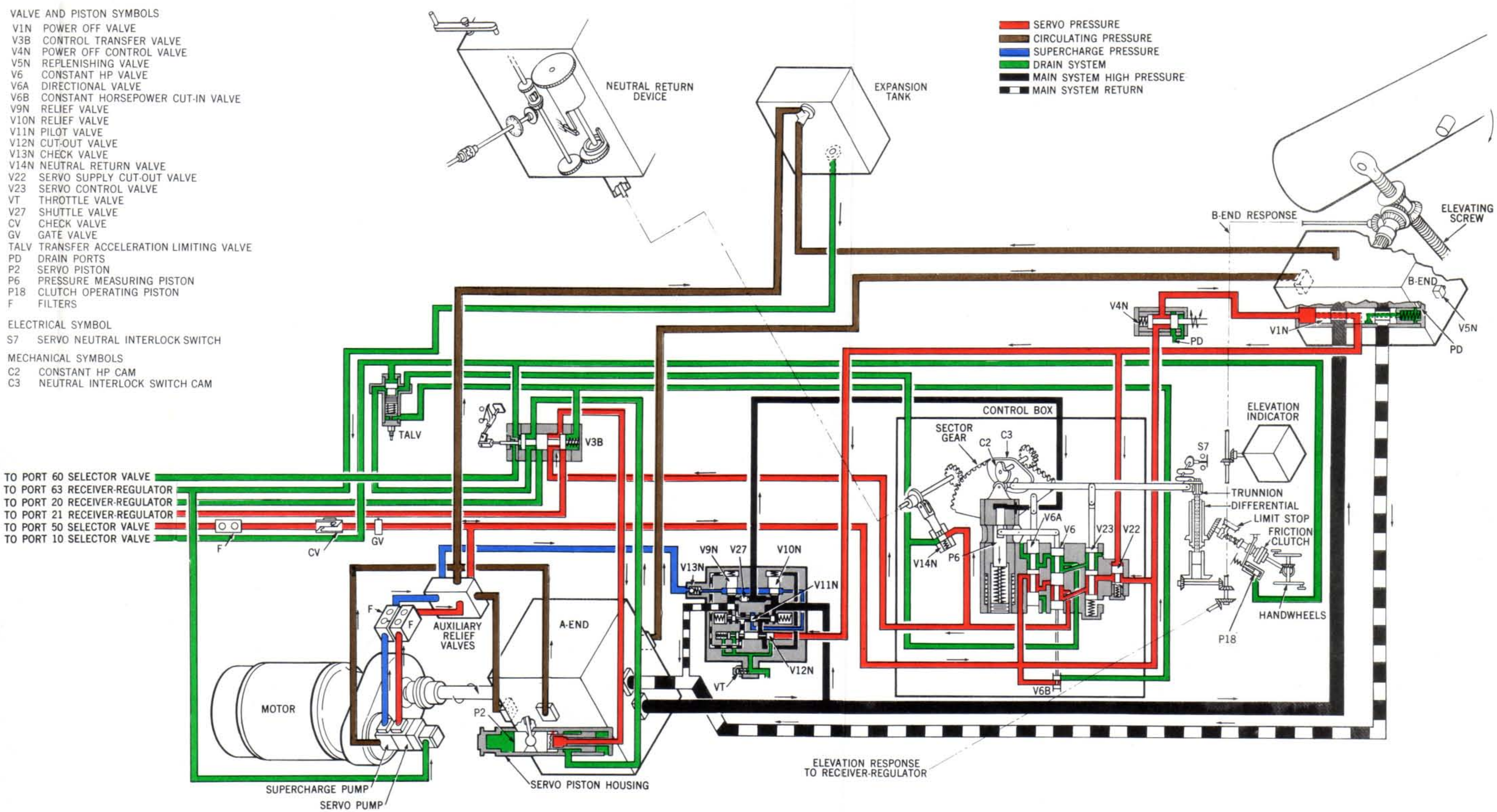


Figure 5-29. Elevating Gear Transmission Control Diagram. Gun Depressing, Limit Stop Control

Gene Slover's US Navy Pages

Table of Contents

VALVE AND PISTON SYMBOLS

V1	STABILIZING VALVE	V23	SERVO CONTROL VALVE
V1N	POWER OFF VALVE	VT	THROTTLE VALVE
V2	AUTOMATIC STROKING VALVE	PCV1	STROKING PISTON CONTROL VALVE
V3	FINE SYNCHRO VALVE	PCV2	STROKING PISTON CONTROL VALVE
V3A	SYNCHRONIZING VALVE	PCN	STROKING PISTON CONTROL NEEDLE VALVES
V3B	CONTROL TRANSFER VALVE	PCS	STROKING PISTON CONTROL VALVE
V4	CONTROL SELECTOR VALVE	V27	SHUTTLE VALVE
V4N	POWER OFF CONTROL VALVE	V34	LIMIT STOP VALVE
V5N	REPLENISHING VALVE	V43	LOADING VALVE
V6	CONSTANT HP VALVE	V44	LOADING INTERLOCK VALVE
V6A	DIRECTIONAL VALVE	V45	SYNCHRO FAILURE LATCHING VALVE
V6B	CONSTANT HORSEPOWER CUT-IN VALVE	CV	CHECK VALVE
V9N	RELIEF VALVE	GV	GATE VALVE
V10N	RELIEF VALVE	TALV	TRANSFER ACCELERATION LIMITING VALVE
V11	SYNCHRO FAILURE VALVE	PD	DRAIN PORTS
V11N	PILOT VALVE	P1	STABILIZING PISTON
V12	LOADING PILOT VALVE	P2	SERVO PISTON
V12N	CUT-OUT VALVE	P3	AMPLIFIER PISTON
V13	LOADING TRANSFER VALVE	P6	PRESSURE MEASURING PISTON
V13N	CHECK VALVE	P18	CLUTCH OPERATING PISTON
V14	LOADING POSITION VALVE	P46	SELECTOR INTERLOCK PISTON
V14N	NEUTRAL RETURN VALVE	F	FILTERS
V15	SYNCHRONIZING PILOT VALVE		
V19	PRESSURE REGULATOR VALVE		
V22	SERVO SUPPLY CUT-OUT VALVE		

ELECTRICAL SYMBOLS

D	2-SPEED SYNCHRO	S4	MERCURY SWITCH
E	36-SPEED SYNCHRO	S5	SUMP PUMP FLOAT SWITCH
H	TEST SYNCHRO	S6	GUN CAPTAIN'S READY SWITCH
S1	LOAD SOLENOID	S7	SERVO NEUTRAL INTERLOCK SWITCH
S2	AUTO SOLENOID		
S3	SYNCHRO FAILURE SOLENOID		

MECHANICAL SYMBOLS

C2	CONSTANT HP CAM	L1	AMPLIFIER LINKAGE
C3	NEUTRAL INTERLOCK SWITCH CAM	L2	STABILIZING LINKAGE
		L3	LOADING CONTROL LINKAGE
		L4	SYNCHRONIZING LINKAGE

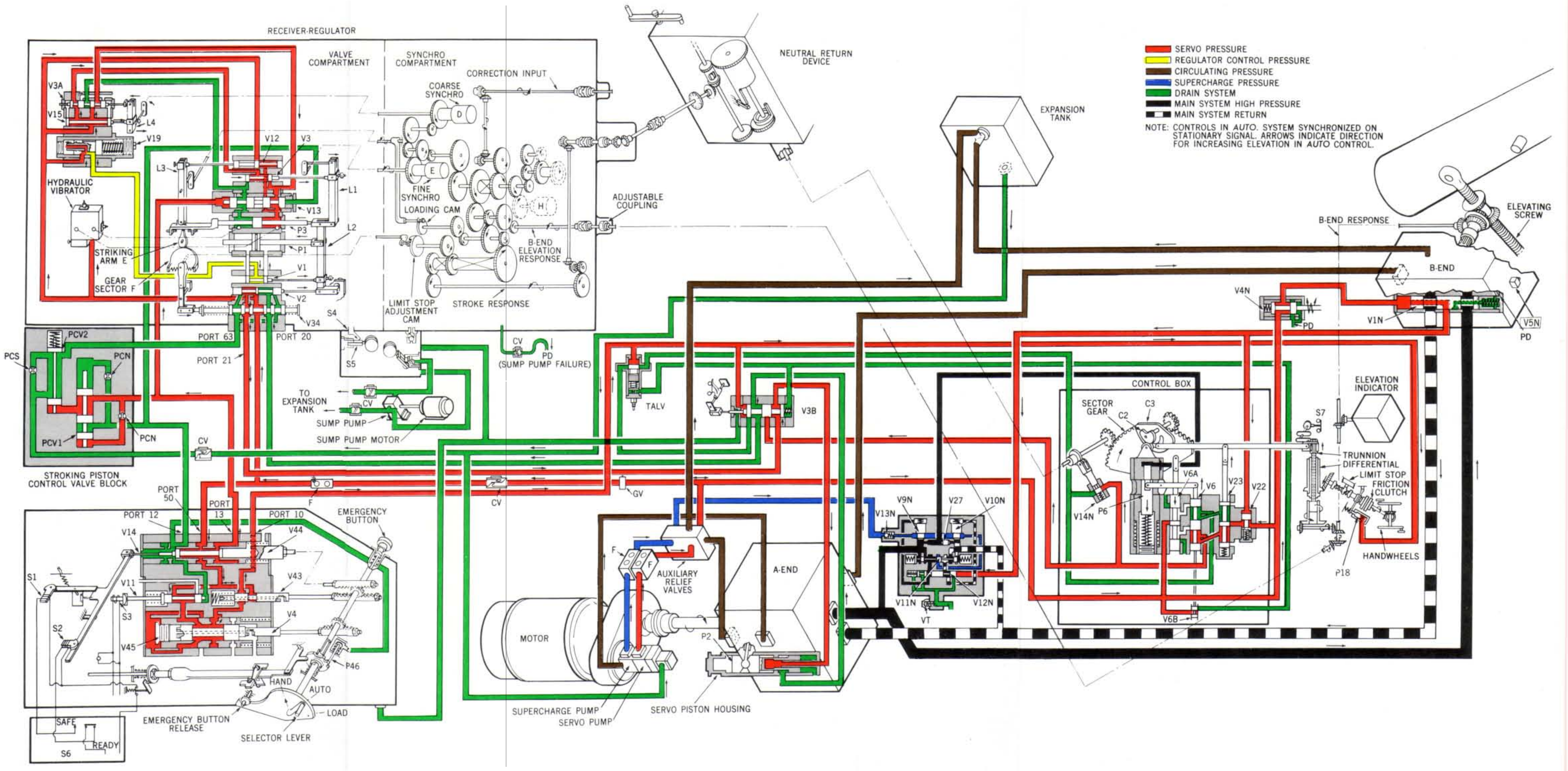


Figure 5-30. 16-inch Elevating Gear Hydraulic System, Schematic Diagram

2. Acted upon by servo pressure and L4, V3A moves to cut off servo pressure to the fine synchro valve V3. At the same time, V3A ports servo pressure to the amplifier piston P3 through the loading transfer valve V13.

3. Acted upon by servo pressure for the full length of its travel, P3 operates the automatic stroking valve V2 through the stabilizing linkage L2. Servo pressure is ported by V2 to the servo piston to force the A-end tilting box to its maximum displacement.

4. The gun is driven at full speed toward synchronization. B-end response turns the stator of synchro D.

5. As soon as the gun position is within four degrees of gun elevation order, V15 and V3A move to restore control to the fine synchro E.

Limit stop operation. The limit stop device has gun position and gun speed as the two elements of data in its input. The gun position is obtained from the elevation response input, but gun position alone is not enough for smooth, even stopping from all speeds at a definite position of rest. The speed of the gun is obtained from the stroke response input, which is used as the speed input to the limit stop device.

The stroke response is added to the elevation response through a differential gear in the receiver-regulator case. The output of the differential turns the limit stop adjusting cam. A cam follower and linkage positions the limit stop valve V34 at the proper elevation angle to cut off servo pressure to V2 and the servo piston. Because of the differential input, the limit stop begins to function farther from the stop position when the gun is moving fast than when it is moving slowly. This results in nearly uniform deceleration and a definite position of stop, regardless of the speed at which the gun approaches the stop position.

Automatic loading operation. When in AUTO, the gun can be brought to its loading position automatically either by turning the gun captain's ready switch to SAFE or by shifting the selector lever to LOAD. The positions of the loading position valve V14 and the loading interlock valve V44 in AUTO are shown in figure 5-30.

When the gun captain's ready switch is turned to SAFE, the load solenoid S1 is energized to pull the loading position valve V14 to the left (fig. 5-30). This ports servo pressure to the right end of the loading transfer valve V13 and connects the left end of V13 to drain.

Alternately, when the selector lever is moved to LOAD, the loading interlock valve V44 is mechanically moved to the right (fig. 5-30). This also ports servo pressure to the right end of V13 and connects the left end of V13 to drain.

In either method, servo pressure forces V13 to the left to block the ports from the fine synchro valve V3 to the amplifier piston P3 and to open the ports from the loading pilot valve V12 to P3.

The position of the loading pilot valve V12 is controlled by the loading cam through a cam follower and crank arrangement. The loading control linkage L3 is connected to the amplifier piston P3 in the same way as the amplifier linkage L1. Therefore, when the loading transfer valve V13 moves to the left, P3 follows the loading crank in the same manner that it follows the synchro crank when V13 is to the right. The loading cam is geared directly to the elevation response; consequently, the automatic loading position remains the same regardless of the mechanical correction input.

The shape of the loading cam is such that the gun will decelerate smoothly and come to rest when the cam follower reaches the bottom of the loading cam detent.

Synchronizing acceleration control. Acceleration of the power drive is limited by the synchronizing acceleration control device (fig. 5-13) when the gun is either going to its loading position or is matching with the gun order signal in coarse synchro control. The device prevents operation of the constant horsepower device.

The amplifier piston P3 moves to its extreme stroke in load or coarse synchro control. Its motion is used to operate the limit stop valve V34 to restrict the porting of servo pressure to the servo piston P2.

The limit stop valve has a spring arrangement so that the limit stop may function whenever necessary, regardless of the position of P3. Adjusting screws C and D are set so that V34 is not moved by the ordinary movement of P3 in following a signal. One of these screws, located in an extension of P3, contacts the striking arm E when P3 moves rapidly to either extreme position. The striking arm is geared to gear sector F (fig. 5-13), which moves V34 through a linkage (fig. 5-30).

Transfer acceleration limiting control. When the control selector is shifted from AUTO to HAND with the gun position not in correspondence with the handwheel position:

1. Servo control valve V23 ports servo pressure either through V6 and V3B to the outside of the servo piston P2 (gun depressing) or through V6, TALV, and V3B to the inside of P2 (gun elevating).

2. Servo pressure is removed from the top of TALV. Acted on by its spring, TALV tends to shift to open the line between V3B and P2. However, TALV is hydraulically unbalanced and is held against its side wall in a partially open position by pressure in the V3B-P2 line.

3. The restriction in the V3B-P2 line prevents full flow of servo pressure to P2 or full flow of return from it. This slows the movement of P2 and prevents too-rapid acceleration of gun movement.

4. When the gun position corresponds to handwheel position, V23 shuts off servo pressure and return. TALV then moves to its full open position to permit P2 to follow handwheel input without further restriction.

Synchro supply failure. If synchro power fails in AUTO, the control selector unit transfers itself to HAND control without movement of the control selector lever. When synchro power is restored, control remains in HAND until the selector lever is moved to HAND and then back to AUTO. This prevents the gun from moving without warning when synchro power is restored.

If synchro power fails:

1. Solenoid S3 is de-energized.

2. Synchro failure valve V11 is moved to the right by its spring. This cuts off servo pressure to V4 and to the space behind V45.

3. With no servo pressure from V4 to the handwheel clutch to the control transfer valve V3B, and to TALV, the system automatically shifts to HAND control.

4. Synchro failure latching valve V45 is moved to the left by its spring. This aligns the ports of V45 with the lands of V4 so that servo pressure is blocked at V4 when synchro power is restored, leaving the gun in HAND control.

After synchro power is restored, movement of the selector lever to HAND forces V45 to the right to port servo pressure behind V45 to hold it in that position. Shifting the lever to AUTO then ports servo pressure through V4 to V3B, TALV, and the handwheel clutch to restore the system in automatic operation.

Gun captain's ready circuit failure. If the gun captain's ready circuit fails with the gun in normal AUTO control, the gun is brought to its loading position automatically by shifting the selector lever to LOAD. After loading, the gun is brought back to synchronization by returning the lever to AUTO.

If the circuit fails with the gun captain's ready switch at SAFE (gun at loading position, selector lever at AUTO), the selector lever is locked at AUTO by the selector interlock piston P46.

The selector lever is unlocked by depressing the emergency button on the selector valve unit. This shifts the valve operating arm to the AUTO position and releases the selector lever by venting the pressure behind P46 to drain. Control of LOAD and AUTO then rests with the gun layer through operation of the selector lever. Control is restored to the gun captain's safety switch by depressing the emergency button release on the selector valve unit.

INSTRUCTIONS

General instructions

The gun elevating power drive assemblies are to be operated and maintained, including periodic exercise, adjustment, and lubrication, in accordance with the regulations of the Bureau of Ordnance Manual, the instructions below, and the directions contained in chapter 17.

At installation, the elevating gear is adjusted and checked for proper operation. It should give little trouble, if properly maintained. Periodic inspection of the equipment will help prolong its life and effectiveness. In many instances, a visual inspection will suffice. It is not recommended that any part of the equipment be disassembled for inspection only. The visual inspection should cover the following items:

1. Alignment of shafting

2. Electric and hydraulic connections

3. Fluid-level gages

4. Lubrication

The equipment should be exercised daily in all types of control to assure good performance. Erratic operation should be investigated to make sure it is not the beginning of serious trouble.

Operating precautions

The following operating precautions must be observed:

1. Before attempting to start the power drive electric motor, make sure that the tilting box is at neutral, the control selector lever is at HAND, the gun pits are clear, and operating personnel are in safe positions.

2. Before shifting to AUTO control, make sure that the synchro receivers are energized and that gun position is in approximate agreement with gun order.

3. The gun layer must remain at his station whenever the equipment is in operation. He must be prepared to stop the equipment immediately if any emergency arises.

4. Shift the control selector lever to HAND before shutting off the power drive electric motor.

5. Before operating the equipment, check the fluid level at the expansion tanks to make sure that there is sufficient hydraulic fluid in the system. As a further precaution, check the fluid level immediately after the electric motor has been started and at intervals thereafter. If there is an appreciable drop of fluid level between checks, the supply must be replenished.

6. Make sure that the equipment is functioning properly when shifting from one type of control to another.

Preparing for operation. To prepare the elevating gear for operation:

1. Release and completely withdraw the slide securing pin (chapter 4).

2. Perform the "Before operating" lubrication.

3. Check and replenish the hydraulic fluid in the expansion tank.

4. Verify that the filters are clear.

5. Make sure that the tilting box is at neutral.

6. Position the control selector lever at HAND.

The electric motor may now be started, by pressing the START-EMERG button.

Before operating under load:

1. Run the motor until the hydraulic fluid is at normal operating temperature.

2. Verify that the power-off control valve V4N has been energized.

3. Slowly turn the gun layer's handwheels.

4. See that the elevating screw lubricating system is pumping oil.

5. Operate to both limits of gun movement; see that the limit stop control and all buffers function correctly.

Shifting to automatic control. To place a gun in automatic control:

1. Start the electric motor (observing all normal precautions) with the control selector lever at HAND.

2. Verify that the receiver-regulator is receiving a signal. This will be indicated by the synchro power indicating light in the control selector valve block.

3. Put the gun captain's switch at READY.

4. Match pointers

5. Move the control selector lever to AUTO.

General servicing instructions

Buffer fluid. The fluid to be used in the elevation and depression stop buffers is that designated as 51F23 (Ord). The buffers should be checked for replenishment once a month, at which time they should be inspected as follows:

1. Check the full, normal spring return of the buffer plungers.

2. Check the condition of the plunger packings.

3. Verify the tightness of the buffer housing securing bolts.

4. Verify the alignment of the plungers and stops.

Hydraulic oil. The power transmission fluid to be used in the hydraulic system is that designated as 51F21 (Ord). When the hydraulic system is initially filled, and when replenishing, the fluid should be poured through a fine mesh wire strainer of at least 200 wires to the inch. Cheesecloth or rags must not be used as a strainer. New hydraulic assemblies should be drained after 15 hours (or less) of operation. The hydraulic system should then be thoroughly flushed with new 51F21 (Ord) and refilled with fresh fluid. A test inspection and analysis of an oil sample from each system should be performed monthly. If there is any evidence of sludge, water, or acidity, the system must be drained, flushed with new 51F21 (Ord), and refilled with fresh fluid.

Filling the hydraulic system. To fill the hydraulic system:

1. Disconnect the coupling between the speed reducer and the A-end shaft, so that the speed reducer and supercharge pump may be run without operating the A-end.

2. Close the control box drain valve.

3. Fill the A-end and B-end housings. First, remove the filler cap of the expansion tank and continue pouring fluid into the tank until the level remains constant at the high-level trycock.

Loosen the 1/4-inch pipe plugs in the sides of the B-end valve plate. Start the electric motor and allow it to run for a few seconds, stop the motor, and repeat the starting procedure several times. Check the fluid level continuously at the low-level trycock of the expansion tank. Add fluid to the tank as needed to maintain the fluid level, while the fluid is being pumped into the main hydraulic lines by the supercharge pump. Continue the filling and the start-stop procedure until the fluid (free of air) flows out of the 1/4-inch pipe plugs.

4. Connect the coupling between the speed reducer and the A-end; the unit is ready to operate.

5. After the limit stops have been adjusted, open the control box drain valve. When the valve is opened, hydraulic fluid will flow from the expansion tank into the control box. Add fluid to the expansion tank as needed to maintain the level at the upper trycock.

Maintenance care. When pipe fittings, flanges, or other units of the hydraulic system are disconnected and open, keep the openings covered to prevent the entrance of foreign matter. Do not remove such protection until immediately prior to reassembly. For complete instructions for care and maintenance of the hydraulic system, see chapter 17.

Transmission tests and inspections. The hydraulic system is to be serviced after initial installation as follows:

1. After the first week of operation, tighten all pipe and shaft connections and bolts.

2. After the first month of service, or 15 hours of operation, drain the system, flush with new fluid, and refill. This operation is essential to remove any foreign matter resulting from initial run-in of the new or overhauled equipment.

3. Check and clean the oil filters.

4. Drain and replace the oil in the reduction gear, gear boxes, and lubricating oil reservoirs.

Refer to chapter 17 for detailed instructions.

Lubrication. All valve gear and the rotating groups of the A-end and B-end are lubricated by hydraulic fluid. This fluid includes a rust inhibitor to preserve the enclosed parts from corrosion. It is therefore important that the fluid be checked frequently to make certain that it is clean and free of water. Other parts of the elevating gear require application of lubricants at the locations and at the periods specified by the lubrication charts. The elevating screw lubricant should be at the level of the test plug hole in the lubrication tank when the gun is at rest and at zero elevation. The oil should be replaced quarterly with fresh oil that is carefully strained through a fine mesh wire strainer. Check the lubricating oil level before operating the elevating gear. Verify the lubricating oil flow, at the screened filling plug in the oscillating bearing oil shield, immediately after starting the motor. This precaution is important because pump airlock or line stoppage (or both) can interrupt proper circulation.

Servo and supercharge pressures. The servo pressure should be between 300 and 400 pounds per square inch, and the supercharge pressure between 50 and 70 pounds per square inch. If the pressures are not within the desired ranges, make adjustments at the servo and supercharge relief valves. The servo pressure is adjusted at the relief valve farthest from the mounting plate. Remove the valve cap, loosen the locknut, and screw in the adjusting screw to increase the pressure or screw out to decrease the pressure.

The supercharge pressure is adjusted in a similar manner on the relief valve nearest the mounting plate. To check the supercharge pressure or the pressure in either of the main transmission pipes, connect gages to the 1/4-inch pipe plugs in the sides of the B-end valve plate. The servo pressure should be checked in the line between the filter and the servo flange connection on the A-end control box.

Operating trouble diagnosis

Locating and correcting elevation gear trouble requires a thorough understanding of the equipment described in this chapter. There should be no exception to the rule that:

CASUALTY CORRECTION IS NEVER TO BE ATTEMPTED BY ANYONE NOT COMPLETELY FAMILIAR WITH THE EQUIPMENT.

The causes of various troubles which may occur in the elevating gear are given in the paragraphs below. The trouble analysis is in a sequence that avoids extensive disassembly until the more common causes have been eliminated as the source of trouble.

Motor does not start. If the electric motor fails to start when the START-EMERG button is pressed, check the following possibilities:

1. Check position of tilting box. If the A end tilting box is in stroke position, the neutral interlock switch will be in an open position. The starting circuit cannot be closed until the tilting box is on neutral. The neutral return lever is manually operated to return the tilting box to neutral.

2. Check the controller, circuit breaker, and fuses. If the circuit breaker is tripped, remember that the circuit breaker is provided as a protection for the equipment. Investigate all possibilities of short circuit or overload. The 10-ampere fuse in the starting line may be burned out.

Elevation slow, excessive oscillation and noise. If the elevating gear operates sluggishly, or if there is excessive oscillation and noise, check the following possibilities:

1. Vibration and shock of gun fire may have caused the replenishing valves to unseat or the seats to back out.

2. Wrong springs may have been installed and may have jammed when the valves opened during replenishing. The valve springs should be inspected for dead coils, and the valve seats should be checked for scores at regular periods.

Drive inoperative, control pressure failure. If the power drive is inoperative, check the servo pressure in the oil line between the filter and the flange connection on the A-end control box.

1. In a malfunction of the power drive, a clogged filter is often found to be the source of trouble. Check and clean the filter when servo pressure and volume are below normal.

2. A failure of servo pressure may be caused by the servo relief valve being stuck open. Disassemble the valve and inspect.

3. A failure of servo pressure may be caused by a damaged servo pump, a sheared auxiliary shaft, or a broken or leaking pipe line. Loosen the flange fitting on the discharge line and operate the motor for just a couple of seconds. If the pump and shaft are undamaged, there should be fluid discharge. Check the pipe lines and connections for indications of leakage.

Drive inoperative, main system pressure failure. The starting point for trouble diagnosis of the main system is to verify the supercharge pressure.

1. A frequent cause for a loss of supercharge pressure is a clogged filter or a leak in the oil line. Check and clean the filter when supercharge pressure is below normal. Check the pipe lines and connections for indications of leakage.

2. Check the supercharge pump and auxiliary drive shaft for proper functioning. Loosen the flange pipe fitting on the discharge line and operate the motor for just a couple of seconds. Proper function of the pump and drive shaft will produce fluid discharge.

3. Check the main relief valves for sticking. Foreign matter or scoring may have jammed the valves. The valves should be inspected for dirt and scoring at regular periods. If the trouble is not found at this point of the check, then it is probably an internal trouble in the A-end or B-end.

4. Check the A-end and B-end for malfunction. In order to check which of the two units is the source of trouble, disconnect the interexpansion line between the units and allow the fluid from each unit to run directly to the expansion tank. If the volume of fluid from the B-end appears to be normal, the source of trouble will be found in the A-end. Disassemble and inspect the pump or motor that is found to be the source of trouble.

5. If the malfunction is such that the A-end has a below-normal pressure, and instead of increasing, the pressure suddenly drops (together with an increase in hydraulic noise), it is an indication that the main system valves are lifting prematurely. This condition may be caused by lifting of a relief valve, by a scored valve plate, or by the cylinder barrel of either the A-end or B-end lifting off the valve plate. The valves should be inspected for dirt and scoring at regular periods. Disassemble and inspect the unit that is found to be the source of trouble.

To check whether the A-end or B-end is the source of trouble, disconnect the interexpansion line between the units. The source of trouble may be determined by watching the fluid flow from the units. A scored valve plate in either unit will be indicated by an excessive amount of flow. Excessive flow will sometimes be caused by a scored piston. If the cylinder barrel in either unit is lifting off, a sudden surge of fluid will appear in the line from the faulty unit. Should these conditions exist, dissemble and inspect the unit that is found to be the source of trouble.

Oscillation about a stationary signal. If the gun oscillates about a stationary signal, check the following possible sources of troubles:

1. Check the response shafting from the B-end. Verify that the shafting is connected properly and there is a minimum of backlash in the gears and shafts. Any lost motion or backlash in the gearing or shafting will seriously affect operation. Sluggishness in response to the handwheels and failure of the B-end to stand still are symtoms of lost motion. Check the handwheels and shafting connections to the A-end input shaft for lost motion. Care should be taken not to fit the parts too tightly when removing lost motion. Too tight a fit could cause a binding action that is as detrimental to proper function as lost motion.

2. Check the expansion line connection from the A-end control box to the expansion tank, and check the control box piping, gears, and linkages.

Remove the control box cover (the A-end may be run with the control box cover removed) and examine the piping for oil leaks. Inspect all linkages and gears for lost motion. Make repairs wherever an oil leak is discovered. When correcting lost motion in the linkages and gears, take care that the parts are not fitted too tightly. This will cause a binding action that is as detrimental to proper function as lost motion.

3. Check the differential screw for lost motion. If the differential screw has any lost motion, it may be taken up by loosening the second locknut on the adjusting nut until all of the lost motion in the control screw has disappeared. Take care not to fit the parts too tightly. This will cause a binding action that is as detrimental to proper function as lost motion.

4. Check for air in the stroking piston or main lines. Loosen the lowest vent plug in the system and allow the air to escape. When fluid appears at the vent, tighten the plug. Repeat the process for successively higher vent plugs. Verify the level in the expansion tank.

5. Check for lost motion in the receiver-regulator gearing, linkage, and connecting wire couplings. Take care not to fit the parts too tightly. Smooth operation without either binding or lost motion is required.

6. Check the fine synchro valve V3 for sticky or rough operation.

7. Check the servo and supercharge filters. The filters should be cleaned and inspected at regular periods.

8. Check the servo pressure at the automatic stroking valve V2.

9. Check the hydraulic vibrator for correct crankshaft rotation speed, which should be about 3600 revolutions per minute.

Rough operation. If the operation of the gun is rough in automatic control, check the following possible source of trouble:

1. Check the hydraulic vibrator. The hydraulic vibrator is used to vibrate the amplifier piston P3 through a very small amplitude to eliminate static friction in the control linkages and valves. There are two adjustments on the vibrator, one for frequency and one for amplitude. The frequency is adjusted by means of the throttle in oil supply line. If the adjustment is correct, the vibrator crankshaft will rotate at about 3600 revolutions per minute. The vibrator should be adjusted to rotate fast enough so that rough operation is eliminated or reduced to a minimum. The amplitude (or displacement) of the vibrator is adjusted by varying the length of the crank arm (fig. 5-14). A small oil-deflecting cover must be removed from the end of the vibrator in order to make the adjustment accessible.

When the oil-deflecting cover is removed, replace the two cover screws before attempting to run the equipment. The cover screws act as plugs for oil passages in the block. Before adjusting the crank arm, measure the total travel of the pistons with a steel scale. The measurement is best made with the power off and by rotating the crank by hand; it furnishes a base dimension from which the adjustment is made.

To adjust, loosen the crank adjustment clamp screws and tighten them just enough to permit a light tap to move the crank along its slot. Measure the distance and adjust as desired. Several trials may be necessary before the proper combination of frequency and amplitude is obtained.

Refer to page 5-31 "Oscillation about a stationary signal," for additional possibilities for rough operation of the gun.

Excessive "matching" error in automatic. There should be no appreciable "matching" error when the signal is stationary and the receiver-regulator is properly lined up.

If a receiver-regulator that has been accurately lined up begins to show "matching" error, it usually means that something has slipped. The error must not be removed by arbitrarily changing the response shaft setting. To do this would change both the load and limit-stop settings, and repeated corrections would result in trouble. Investigate to find the real cause for the error.

If the "matching" error in following a signal is high, it is usually caused by:

1. Low servo pressure at the automatic stroking valve V2. Check and clean the filter when servo pressure is found to be less than normal.

2. High speed of the hydraulic vibrator crankshaft. Correct crankshaft speed is 3600 revolutions per minute. Check the hydraulic vibrator in accordance with the routine outlined under "Rough operation."

If the "matching" error in following a signal is caused by slip, some possible causes are:

1. A loose clamping screw in the response shaft coupling. A loose clamp at the adjustable shaft coupling would prevent elevation response from positioning the synchro stators.

2. A valve connecting wire that slides in its linkage clamp. Inspect all valves in the receiver-regulator valve compartment that are connected to linkage by a connecting wire. It is also possible for a connecting wire to pull out of a valve.

The automatic stroking valve is subjected to the most severe service; because of this, it is the logical place to begin a check for slip.

Gun runs away in AUTO. If the gun runs away when control is shifted to AUTO, check the following possible sources of trouble:

1. Check the synchros for torque. The synchro torque will be very low if there is an open stator lead. When checked by hand, the synchro crank will seem "soft" instead of rigid in trying to maintain correspondence. Check all connections, if a synchro is not as strong as it should be. If all connections are tight and the indications still show synchro trouble, check the flat springs on the synchro crank flexible drive assembly. The faulty part must be replaced.

2. Check the valve linkage for loose pins and connecting wires.

3. Check the valve block for sticky valves.

Gun runs away when shifted from AUTO to HAND. If the gun runs away when shifted from AUTO to HAND, check the following possible sources of trouble;

1. Check the friction clutch throwout piston; it may be stuck. This condition is indicated by proper functioning of the transfer acceleration limiting valve TALV with failure of the gun layer's handwheels to engage and move freely. The source of trouble is removed by disassembling and cleaning the clutch piston.

2. Check the handwheels for jamming. This is indicated by proper functioning of the transfer acceleration limiting valve TALV coupled with inability to turn the gun layer's handwheels in either direction. To correct this trouble, disassemble and inspect the handwheel and control screw mechanism.

3. Check the clutch and the clutch throwout spring for improper functioning or damage. This condition is indicated when the transfer acceleration limiting valve TALV is functioning properly but the handwheel clutch does not engage. It is more apt to occur when the transfer to HAND control is made while the gun is moving at high speed. To correct this trouble, disassemble and inspect the clutch and spring. Replace damaged parts.

4. Check the adjustment of the transfer acceleration limiting valve TALV. Indications are that the valve is out of adjustment when the handwheels engage, but have little or no effect on the control of the gun. To adjust the valve, remove the oil retainer at the bottom of the valve (fig. 5-18). The adjusting screw and locking nut are now accessible. Loosen the locking nut to turn the adjusting screw. The position of the adjusting screw determines the amount of pressure restriction in line 30 when the gun is in AUTO. As the screw is turned out of the block, the restriction increases and acceleration is lowered. The adjusting screw must not be turned out further than is absolutely necessary. It is possible to adjust the valve so that line 30 is completely closed. This condition must be prevented because neither the handwheels nor the hand stops would function.

Erratic operation. If the gun elevation movement is erratic, check the following possible sources of trouble.

1. Check the flat spring in the flexible drive of the synchro crank assembly.

2. Check the synchros for an open stator or rotor lead. Repair or replace the synchro.

3. Verify that the hydraulic vibrator is operating. If the hydraulic vibrator is inoperative, it should be replaced as a whole unit.

L1 linkage vibration. If the amplifier linkage L1 has a tendency to vibrate at high frequency, particularly when the oil is cold, add a small weight at the top of the linkage. The amount of weight added must be kept to a minimum.

Control selector troubles.

Regulator does not respond to gun captain's switch. If the receiver-regulator does not respond to the gun captain's switch, check the following possible sources of trouble:

1. Press the emergency button release. If there is still no response to the gun captain's switch, transfer to HAND control.

2. Check the control selector solenoids. To check the solenoids, the control selector cover must be removed. If the solenoids do not operate, short-circuit the switch in the selector valve. Next, check for loose connections or broken wires. Connect a lamp or voltmeter across each solenoid. If this check shows that there is voltage across a solenoid and it does not operate, replace the solenoid.

3. If the solenoids operate properly, remove the cover from the valve compartment of the receiver-regulator and loosen the tube fittings at the right and left ends of the loading transfer valve V13. If oil appears at the right fitting when the gun captain's switch is moved to SAFE but does not appear at the left fitting when the switch is moved to READY, the loading position valve V14 should be set farther into the selector valve block. If the oil flow conditions are reversed, adjust the loading position valve V14 farther out of the selector valve block. When the adjustment is correct, oil flow at the right fitting (when the gun captain's switch is on SAFE) should be about equal to oil flow at the left fitting (when the gun captain's switch is on READY).

Return of synchro power puts gun in AUTO. If a return of synchro power (after failure) automatically puts the gun in AUTO, check the following possible source of trouble:

The latching valve V45 fails to move all the way to the left when synchro power is lost. The most probable reason for this is dirt. The dirt may be cleared away by turning the synchro power off and repeatedly moving the control selector lever between HAND and AUTO. If this operation fails, check the adjustment of the selector valve V4. If the trouble persists after the selector valve V4 is properly adjusted, it will be necessary to disassemble the valve block to correct the trouble.

Gun does not respond to selector LOAD position. If the gun does not respond to the control selector, LOAD position, check the following possible source of trouble:

If the loading transfer valve V13 does not move to the right, the loading valve V43 is not correctly adjusted. If the transfer valve does go to automatic but the gun does not go to load position, then the loading interlock valve V44 is not properly adjusted.

Gun stays in LOAD when selector is moved to HAND or AUTO. If the gun stays in LOAD when the selector lever is moved to HAND or AUTO, the spring may not be moving the loading interlock valve V44 to the left. This binding may be due to dirt, or it may be due to mechanical interference or misalignment.

Adjustments

The equipment is adjusted and checked for satisfactory operation at the time of installation. Adjustments thereafter should be in accordance with the following instructions:

Adjustment of elevating screw. Lost motion at the juncture of the elevating screw and slide is not removable by adjustment. The elevating screw pivot pin and the pin bearing are not adjustable.

Adjustment of elevating unit. Lost motion between the elevating nut and the elevating screw threads may be removed by adjustment.

To adjust the elevating nut:

1. Disconnect the lubricating oil line from the oil shield.

2. Remove the ten securing bolts of the oil shield. Remove the oil shield.

3. Turn the upper adjusting nut in the necessary direction using spanner wrench number 8-Z-958-6.

The lower adjusting nut of the oscillating bearing assembly is adjusted in a similar manner.

Adjustment of limit stops. The limit stops must be adjusted to control the limits of gun elevation movement.

To adjust the elevating gear limit stops:

1. Remove the cover plate.

2. Loosen the lock cap set screws of both limit stops; disengage the lock caps.

3. Position the limit stops at the extreme ends of the screw to permit unrestricted movement of the traveling nut.

4. Position the control selector lever at HAND.

5. Start the power drive.

6. Depress the gun to the desired angle of maximum depression.

7. Stop the power drive.

8. Disconnect the coupling between the A-end response shaft and the B-end response shafting.

9. Disconnect the elevation response coupling to the receiver-regulator.

10. Disconnect the elevation response coupling to the elevation indicator.

11. Loosen the lock cap setscrew of the limit stop nearest the handwheels; disengage the lock cap from the limit stop.

12. Move the limit stop until it makes contact with the travelling nut; engage the lock cap.

13. Slowly turn the handwheels to back the traveling nut three threads away from the limit stop.

14. Disengage the lock cap and move the limit stop until it makes contact with the traveling nut. Engage the lock cap and secure in position.

15. Connect the response shaft couplings that were disconnected in steps 8, 9, and 10.

16. Slowly turn the handwheels to engage the traveling nut with the limit stop just set; turn the handwheels until the friction clutch slips.

17. Slowly turn the handwheels in the opposite direction 1.8 turns; this operation resets the servo control valve V23 in its approximate neutral position.

18. Start the power drive.

19. Elevate the gun to the desired angle of maximum elevation.

20. Stop the power drive. Adjust the elevation limit stop away from the handwheels). Repeat the adjustment procedure of operations 8 through 17, inclusive.

21. Replace the cover plate.

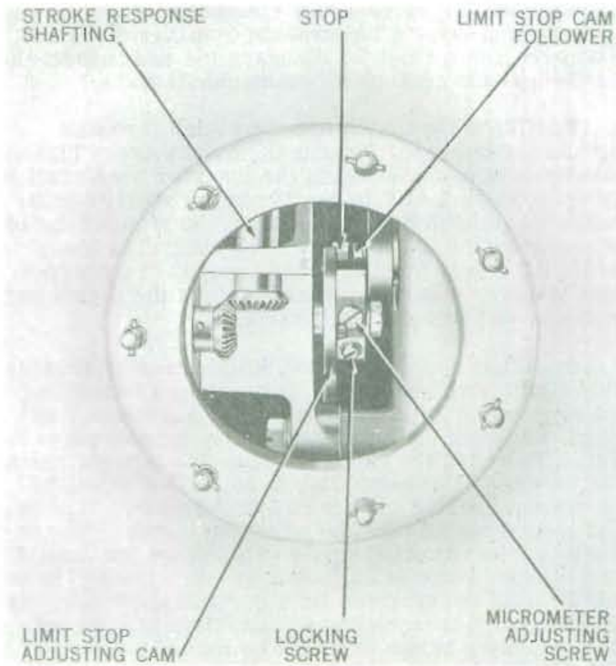


Figure 5-31. Elevation Receiver-Regulator Mk 10 Mod 0, Limit Stop Cover Removed

Adjustment of handwheel friction clutch. The spring-engaged friction clutch between the handwheels and the limit stop screw must be adjusted when it slips and does not transmit the desired torque for hand operation of the elevating gear.

To increase the friction of the clutch:

1. Remove the cover plate.

2. Tighten the three cap screws.

3. Replace the cover plate.

Adjustment of A-end pilot valve for system high-pressure relief. The pilot valve spring for each side (fig. 5-32) must be adjusted separately to control the two main valves.

To adjust the pilot valve springs:

1. Remove the valve cap.

2. Loosen the locknut.

3. Turn the valve spring adjusting screw in to raise the pressure setting; turn the valve spring adjusting screw out to lower the pressure setting. The pilot valve should unload each main valve at 1850 pounds per square inch pressure.

4. Tighten the locknut after the valve spring is adjusted.

5. Replace the valve cap.

Adjustment of constant horsepower device. The constant horsepower device must be adjusted to limit the maximum horsepower taken from the electric motor (fig. 5-33).

To adjust the constant horsepower device:

1. Remove the cover from the control box.

2. Turn the adjusting screw in to increase the horsepower taken from the electric motor; turn the adjusting screw out to decrease the horsepower taken from the electric motor.

3. Replace the cover on the control box.

The adjustment made by the manufacturer regulates the electric motor input to the A-end at approximately 108 horsepower.

Adjustment of B-end valve plate relief valve. The B-end valve plate relief valve V5N (fig. 5-34), a pressure-operated safety relief valve, must be adjusted to bypass fluid in the B-end should servo pressure failure close the power-off valve V1N.

To adjust the B-end valve plate relief valve:

1. Remove the relief valve cap.

2. Turn the valve spring adjusting nut in to raise the pressure setting; turn the valve spring adjusting nut out to lower the pressure setting.

3. Replace the valve cap.

The B-end relief valve should relieve at a slightly higher pressure than the A-end pilot valve.

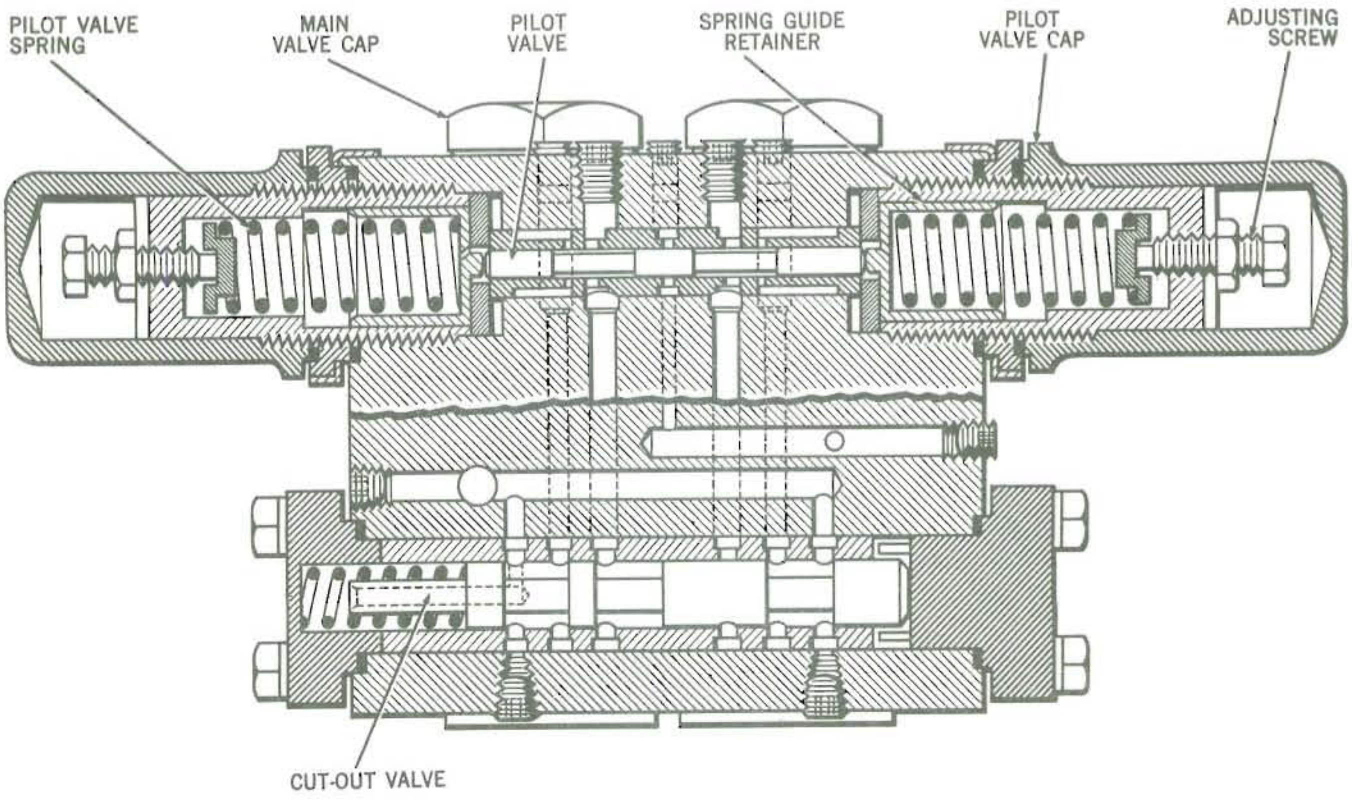


Figure 5-32. Elevating Gear Main System Relief Valve Adjustment, Sectional View

Adjustment of synchronizing acceleration control device. The synchronizing acceleration control is adjusted to remove rough gun operation caused by operation of the constant horsepower device while the gun is moving to the loading position or in coarse synchro control.

To adjust the synchronizing acceleration control device:

1. Start the power drive.

2. Position the control selector lever at AUTO.

3. Remove the cover from the receiver-regulator valve compartment (fig. 5-9).

4. Operate the gun into the elevation and depression limit stops. Measure the travel of the limit stop valve V34 while the gun is resting at each stop. Check the travel of the V34 for equal travel to each side, approximately 7/32 inch.

5. Loosen locknuts of adjusting screws A and B.

6. Back off adjusting screws A and B until they are flush with their supports C and D.

7. Place amplifier piston P3 in the center of its travel.

8. Engage striking arm E with gear sector F so that striking arm E is approximately halfway between C and D.

9. Set adjusting screws A and B so that V34 is moved approximately 5/32 inch when P3 is at its extreme travel.

This adjustment will produce a movement of V34 that is less than that required for limit stop operation. If adjusting screws A and B are set to produce travel equal to the limit stop travel, the gun will come to a halt.

10. Operate the gun to and from load position; observe the gun movement. If the movement of the gun is "jumpy" during acceleration; perform step 11.

11. Turn in the adjusting screws A and B until the "jump" is eliminated, or until the loading and synchronizing cycles are slowed down to an unobjectionable extent.

12. Tighten locknuts on A and B.

Adjustment of stroking piston control valve. The stroking piston control valve is adjusted to eliminate roughness in the automatic load cycle. Before proceeding as below check the selector valve for correct adjustment (described on page 5-40). Refer to drawing 387191.

To adjust the stroking piston control valve:

1. Start the power drive.

2. Move the gun to 4100 minutes.

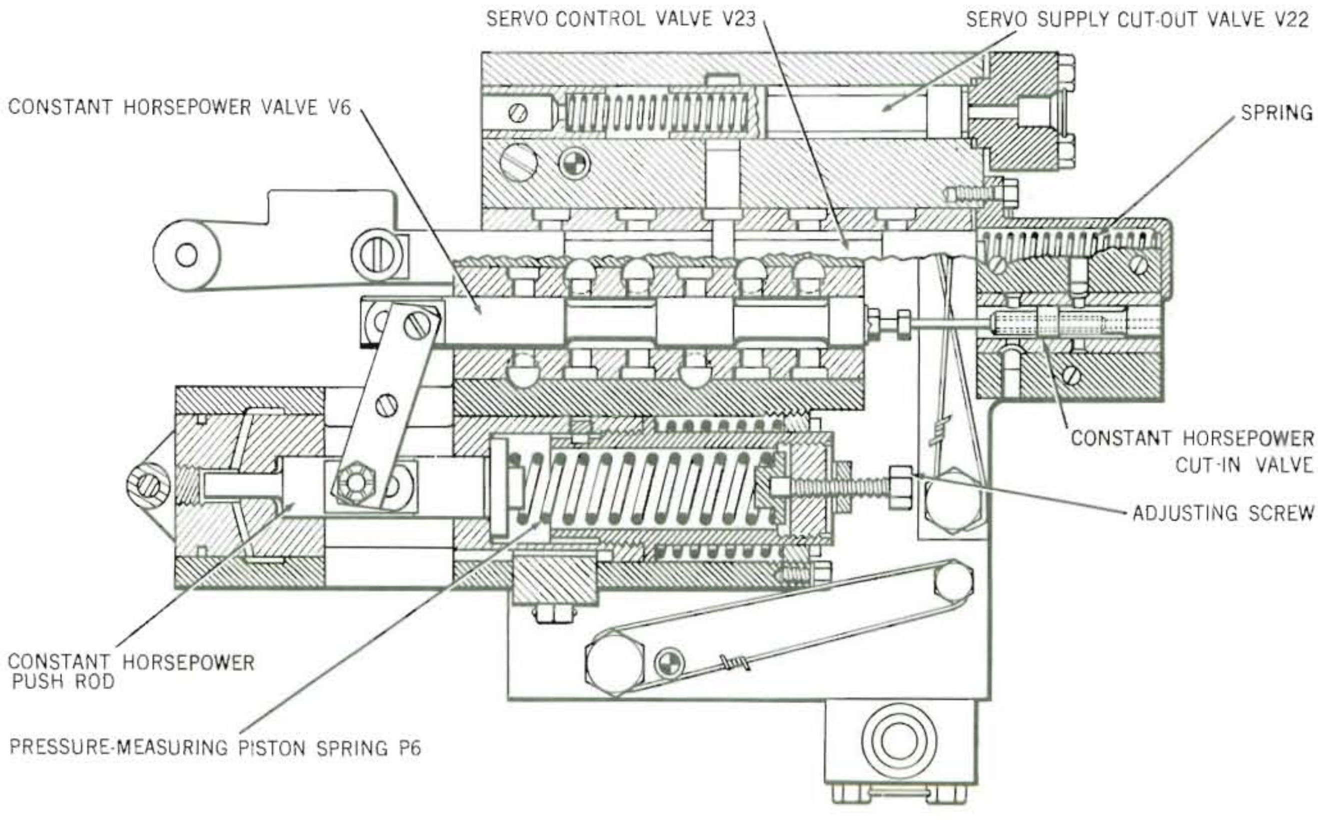


Figure 5-33. Elevating Gear Constant Horsepower Adjustment, Sectional View

3. Have a gun order signal of 4100 minutes transmitted to the receiver-regulator.

4. Move the control selector lever to AUTO.

5. Operate the gun through the automatic load cycle several times and check the number of times the constant horsepower valve or the relief valve operates.

6. Remove valve cap 387194-7 and loosen locknut 12-Z-38-59.

7. Screw in adjusting screw 387193-8 until the gun moves smoothly to its load position. If the adjusting screw is screwed in too far, the stroke response will move slowly part way and will jump before the end of stroke is reached.

8. Operate the gun through the automatic load cycle from various angles of elevation. If all operations are smooth, the adjustment is correct.

9. Tighten locknut 12-Z-38-59 and replace valve cap 387194-7.

The needle valves 387193-6 are factory adjusted to cause a time delay of 1.60 seconds in operation of valve 387193-2. This setting must be maintained.

Adjustment of gun elevation order indicating dial. The gun elevation order indicating dial must be adjusted to provide an elevation position reference.

To adjust the gun elevation order indicating dial:

1. Disconnect the elevation response shaft coupling at the receiver-regulator.

2. Disconnect the stroke response shaft coupling at the receiver-regulator.

3. Move the control selector lever to HAND.

4. Start the power drive.

5. Operate the gun to the desired angle of elevating limit stop. Stop the power drive.

6. Rotate the elevation response shaft counterclockwise until checking dial indicates desired limit stop angle of elevated gun.

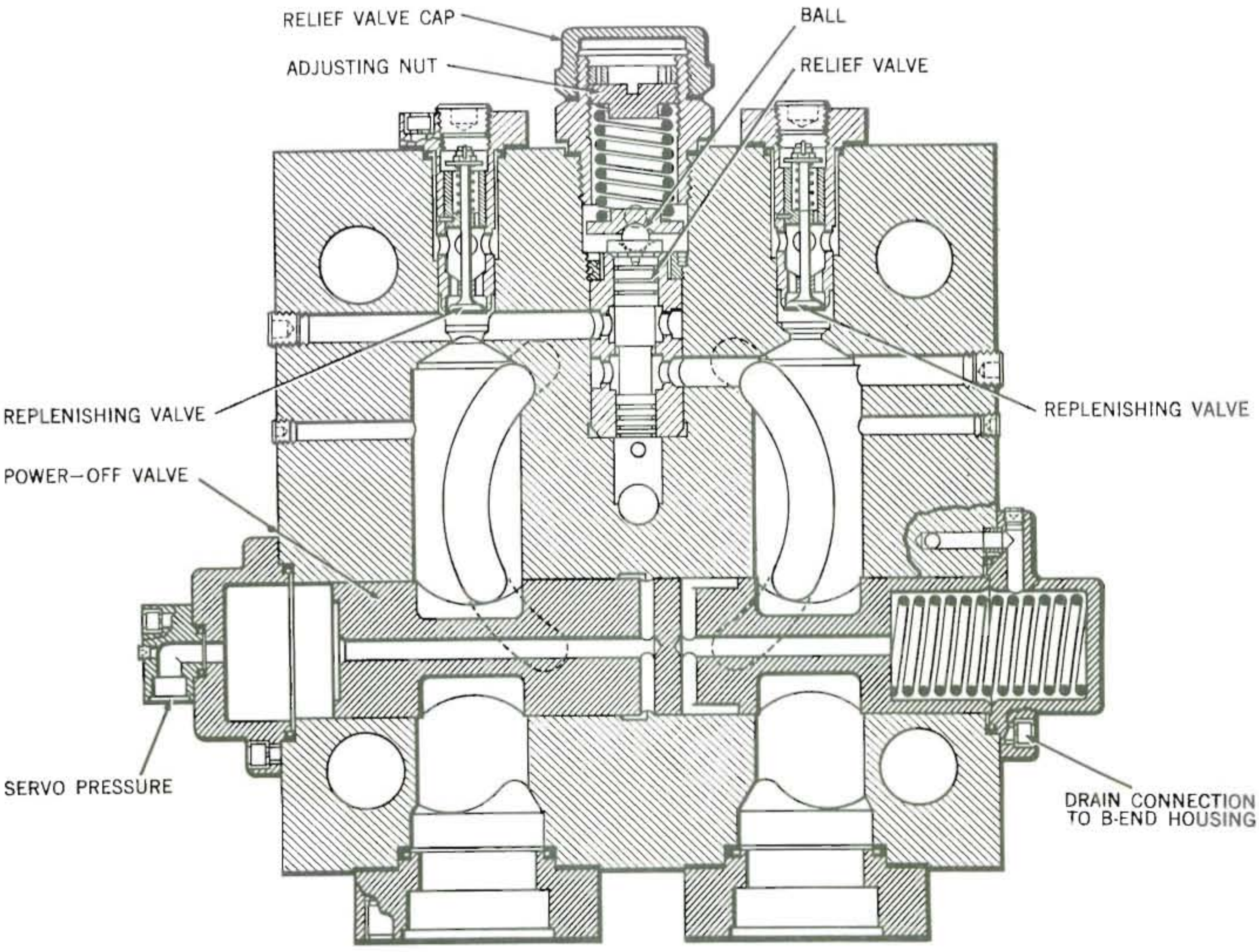


Figure 5-34. Elevating Gear B-end Relief Valve Adjustment, Sectional View

7. Rotate the stroke response shaft clockwise until the outer stop cam moves the cam follower to its limit. This operation should move the limit stop valve V34 approximately 9/32 inch to the right.

8. Connect the stroke response shaft coupling to the receiver-regulator. If it is necessary to move the receiver-regulator shaft in order to engage the coupling, the shaft must be moved clockwise so as not to change the adjustment of V34.

9. Rotate the elevation response shaft clockwise until the checking dial indicates the desired limit stop angle of depressed gun.

10. Move the inner stop cam by use of the micro adjustment (fig. 5-11) until the cam follower reaches its limit. This operation should move the limit stop valve V34 approximately 9/32 inch to the left.

11. Rotate the elevation response shaft counterclockwise until checking dial reads 2300 minutes.

12. Turn the adjusting screw on the loading cam until the cam follower is in the cam detent and is in line with the center of the cam and the center of the cam follower crankshaft. Secure the loading cam.

13. Rotate the elevation response shaft until checking dial reading is the same as that of the elevation indicator.

14. Connect the elevation response shaft coupling at the receiver-regulator.

Adjustment of linkages L1, L2, and L3. The amplifier linkage L1, positioned by the fine (36-speed) synchro is attached to the fine synchro valve V3, to the amplifier piston P3, and to the top of the stabilizing linkage L2.

The stabilizing linkage L2 interconnects the stabilizing valve V1 and automatic stroking valve V2 with the stabilizing piston P1 and the amplifier piston P3.

The loading valve linkage L3, actuated by the loading cam, is attached to the loading pilot valve V12.

These linkages must be adjusted at a mechanical zero as follows:

1. Start the power drive.

2. Position the gun at 2300 minute elevation. Stop the drive.

3. Have a gun elevation order of 2300 minutes transmitted.

4. Position the amplifier piston P3 so that it is at the center of its travel.

5. Position the amplifier linkage L1 so that it is parallel with the valve block. Secure the fine synchro E crank arm wire to the top of the amplifier linkage L1.

6. Position the synchronizing valve V3A so that it is at the center of its travel.

7. Position the coarse synchro linkage parallel to the valve block of the synchronizing valve V3A and the synchronizing pilot valve V15. Secure the coarse synchro D crank arm wire to the bottom of the valve linkage.

8. Position the stabilizing linkage L2 so that it is parallel with the center valve block.

9. Adjust the connecting wire of the automatic stroking valve V2 so that the end of the automatic stroking valve V2 is flush with the end of its sleeve.

10. Position the loading valve linkage L3 parallel with the center valve block and secure the adjustment.

Adjustment of synchronizing pilot valve V15. The synchronizing pilot valve V15, actuated by the coarse synchro, must be adjusted to control the action of the amplifier piston P3.

To zero the valve blocks hydraulically and to adjust the synchronizing pilot valve V15:

1. With the control selector lever at HAND, start the power drive.

2. Position the gun captain's switch at READY; admit hydraulic fluid to the receiver-regulator.

3. Adjust the synchronizing pilot valve V15 so that the loading valve linkage L3 is parallel to the center valve block. The fine synchro valve V3 should now have control of the amplifier piston P3.

4. Adjust the fine synchro valve V3 so that the amplifier linkage L1 is parallel to the valve block and the amplifier piston P3 is centered.

5. Adjust the stabilizing valve V1 so that the stabilizing linkage L2 is parallel to the valve block.

6. Move the gun captain's switch to SAFE. Adjust the loading pilot valve V12 so that the amplifier piston P3 is centered. The amplifier piston should not move when the gun captain's switch is moved from SAFE to READY or from READY to SAFE.

7. Position the gun and the gun order signal to 3300 minutes.

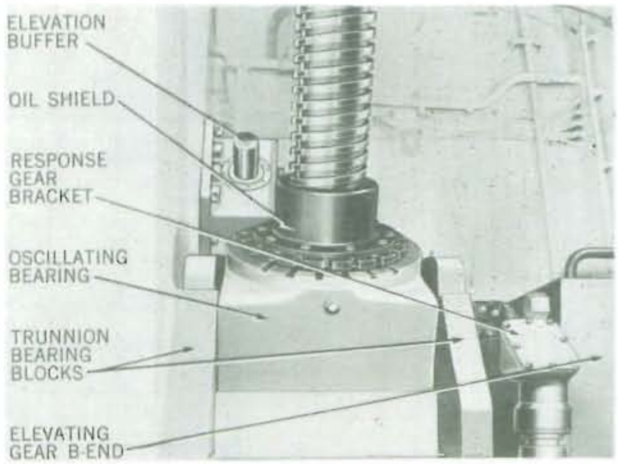


Figure 5-35. Elevation Buffer and Oscillating Bearing

8. Operate the handwheels slowly so that the gun moves from 3000 minutes to 3600 minutes.

9. Observe the position of the fine (36-speed) synchro crank arm when the coarse (2-speed) synchro relinquishes control to the fine synchro valve V3. (The amplifier piston P3 will move from its extreme position at this point.)

10. Adjust V15 toward its clevis if the larger angle of the fine (36-speed) synchro crank arm occurs during the outstroke of V15. Adjust V15 away from its clevis if the larger angle occurs during the instroke of V15.

11. Repeat operation 10 until the crank arm angles are equal.

Adjustment of automatic stroking valve V2 and stabilizing valve V1. The automatic stroking valve V2 and the stabilizing valve V1, both positioned by the stabilizing linkage L2, must be adjusted to prevent gun oscillation.

The automatic stroking valve V2 and stabilizing valve V1 are adjusted as follows:

1. Move the control selector lever to HAND.

2. Start the power drive.

3. Position the gun and the gun order signal at 3 300 minutes; move the gun captain's switch to READY. Move the selector lever to AUTO. Because the adjustment of the automatic stroking valve V2 has been only approximate, the gun will probably move off the signal as much as 15 minutes.

4. Loosen the connecting wire of the automatic stroking valve V2 so that the valve may be repositioned in its sleeve.

5. Adjust the automatic stroking valve V2 until the gun is within three minutes of the gun order signal. If V2 is not equipped with an adjusting clevis, make the necessary adjustment with the stabilizing valve V1.

Adjustment for synchro electrical zero. The synchros must be set to the input gun order signal by setting the synchro cranks at the proper positions on the rotor shaft.

To adjust for synchro electrical zero, proceed as follows:

1. Disconnect the elevation response shaft coupling at the receiver-regulator.

2. Move the control selector lever to HAND.

3. Start the power drive.

4. Position the gun at 200 minutes (zero elevation).

5. Stop the power drive.

6. Have a gun elevation order signal of 2000 minutes transmitted to the receiver-regulator.

7. Have a gun order signal for increasing gun elevation transmitted; observe direction of synchro rotation. The fine (36-speed) synchro should rotate clockwise; the coarse (2-speed) synchro should rotate counterclockwise.

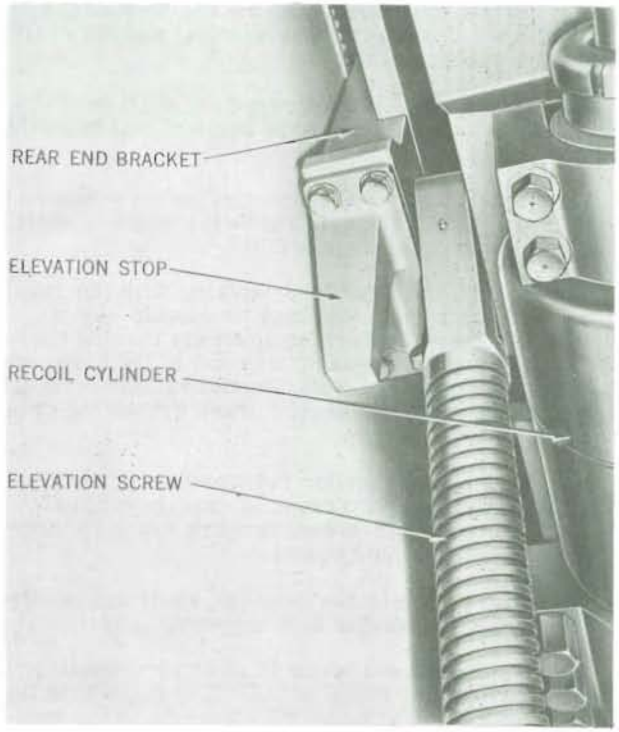


Figure 5-36. Elevating Screw

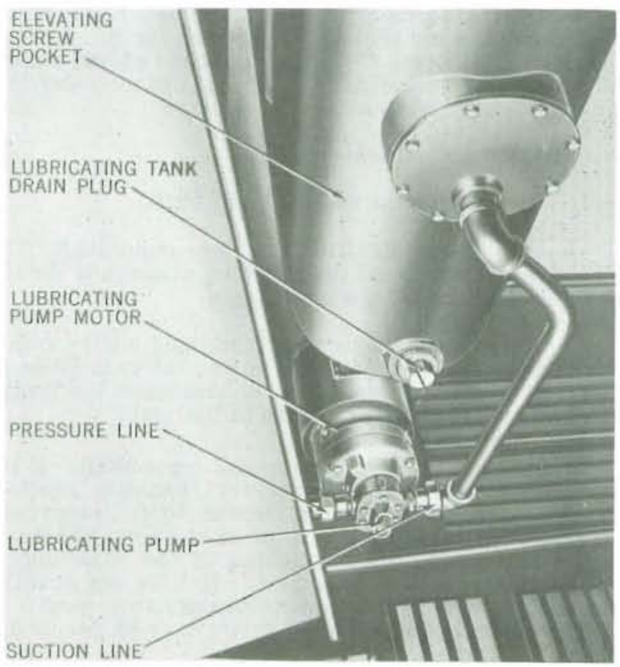


Figure 5-37. Elevating Screw Lubrication Pump and Cover

8. Have the gun order signal returned to 2000 minutes.

9. Install the crank of the coarse (2-speed) synchro with the crank arm near vertical and the crank below the synchro shaft.

10. Rotate the elevation response shaft until the crank of the coarse synchro is vertical and below the synchro shaft.

11. Install the fine (36-speed) synchro crank assembly with the crank arm above the synchro shaft and as near vertical as possible.

12. Engage the flexible-drive ring with the synchro shaft drive pins; this may be done at any of three positions, 120 degrees apart (by turning the drive pin plate 180 degrees, any one of the three positions may be used). Later-model receiver-regulators are equipped with geared crank drives for greater selectivity.

13. Rotate the elevation response shaft until the fine (36-speed) synchro crank is exactly vertical. Permit the coarse (2-speed) synchro crank to move off vertical during this operation.

14. Hold the elevation response shaft and set the checking dial to indicate 2000 minutes.

Replacement installation of receiver-regulator; initial settings and adjustments. The procedure for synchronizing and aligning the elements of the receiver-regulator, when installing the instrument, is described below. The installation should be performed only by personnel familiar with the instrument design.

Check the hydraulic piping with the schematic piping diagram on drawing 319585. Note particularly the direction of all check valves.

Check the wiring by having a gun order signal transmitted to the receiver-regulator for increasing elevation. The fine (36-speed) synchro should rotate clockwise, and the coarse (2-speed) synchro should rotate counterclockwise.

Proceed as follows:

1. Couple the correction input shaft.

2. Rotate the elevation response input shaft counterclockwise until the checking dial reads the desired stop angle for elevated gun.

3. Rotate the stroke response input shaft clockwise until the outer stop cam moves the cam follower to its extreme position. This should move the limit stop valve V34 about 9/32 inch to the right.

4. Couple the stroke response input shaft. If it is necessary to move the receiver-regulator shaft to engage the coupling, rotate the shaft clockwise so that the travel of the limit stop valve V34 is not reduced. Note that position of the adjusting screw in the stroke gear box. If it is not readily accessible, rotate the receiver-regulator shaft clockwise until the adjusting screw may be reached.

5. Rotate the elevation response input shaft clockwise until the checking dial indicates the desired limit stop angle for a depressed gun.

6. Move the inner stop cam by use of the inside micrometer adjustment (fig. 5-11) until the cam follower reaches its extreme position. The limit stop valve V34 should move to the left about 9/32 inch.

7. Rotate the elevation response shaft counterclockwise until the checking dial reading is 2300 minutes.

8. Adjust the loading cam until the cam follower is in the cam detent and is in line with the center of the follower crank shaft. Secure the adjustment.

9. Rotate the elevation response input shaft until the checking dial reading is the same as the mechanical angle reader in the elevation indicator.

10. Couple the elevation response input shaft.

11. Adjust the elevation response input shaft so that the checking dial and the elevation indicator readings correspond.

After coupleting the foregoing sequence of adjustments, make the following selector valve check:

1. Move the control selector lever to HAND.

2. Start the power drive.

3. Move the gun to 2300 minutes.

4. Have a gun order signal of 2500 minutes transmitted to the receiver-regulator.

5. Admit hydraulic fluid to the receiver-regulator.

6. Move the gun captain's switch to SAFE; the stabilizing linkage L2 should be parallel to the valve block.

7. Move the gun captain's switch to READY; the top of the stabilizing linkage L2 should move to the left. The link should respond at once when the gun captain's switch is moved.

All of the preliminary adjustments have now been completed. Place the gun in AUTO control as follows:

1. Move the gun order signal to 3300 minutes.

2. Move the gun to 3300 minutes in HAND control.

3. Position the gun captain's switch on READY.

4. Check the position of the synchro crank arms. The fine (36-speed) synchro crank arm should be vertical and up. The coarse (2-speed) synchro crank arm should be vertical and down. The amplifier linkage L1 should be vertical.

5. Move the selector lever to AUTO; the gun should not move any appreciable amount. If the gun moves off the signal and does not come to rest at once, return the selector lever to HAND immediately.

Assuming that conditions are normal, the gun is now under control of the synchro signal.

For the final limit-stop adjustments (fig. 5-31), proceed as follows:

1. Move the gun order signal slowly to the desir-elevation limit-stop angle. The gun should come to rest before the desired angle is reached.

2. "Walk" the gun slowly to the desired position by means of the micrometer adjustment on the stroke response input. Secure the locking screw. One complete turn of the adjusting screw changes the limit-stop adjustment by approximately 35 minutes. Clockwise rotation of the adjusting screw moves the limit stop position up.

3. Move the gun order signal to the desired depression limit-stop angle. The gun should come to rest before this angle is reached.

4. "Walk" the gun slowly to the desired position by means of the micrometer adjustment on the limit-stop cam. It may be necessary to turn the electric motor off in order to reach the limit stop. In such cases several trials may be required. One complete turn of the adjusting screw changes the limit-stop setting by approximately 160 minutes. Clockwise rotation of the adjusting screw moves the limit-stop position down. For example, if the limit stop has brought the gun to rest at 2060 minutes, one complete turn clockwise of the adjusting screw would move the stop position to approximately 1900 minutes.

For the final load position adjustments, proceed as follows:

1. Move the gun order signal to 2300 minutes with the gun in AUTO control.

2. Position the gun captain's switch on SAFE. The gun will probably move a few minutes. If the movement is excessive, return the selector lever to HAND and check the loading valve and linkage.

3. "Walk" the gun slowly to the desired loading position by means of the micrometer adjustment on the loading cam. One turn of the adjusting screw changes the loading position approximately 100 minutes. Clockwise rotation of the adjusting screw lowers the adjusting screw.

DISASSEMBLY AND ASSEMBLY

Disassembly and assembly of the elevating gear equipment should be performed by personnel familiar with the equipment and procedure and equipped with the standard and special tools required for the job. Instructions applying to major components presume removal from installed positions to a convenient location for disassembly. Instructions applying to hydraulic mechanisms presume draining of the system and removal of external pipe lines. Assembly procedures are omitted if they are the exact reversal of disassembly operations. The equipment drawings and illustrations should be studied carefully before starting operations.

Disassembly of the speed reducer

Before disassembling the electric-motor speed reducer, study drawing 268473.

Proceed as follows:

1. Remove the securing bolts from the servo and supercharge pump assembly. Remove the pump assembly from its mounting flange on the speed-reducer gear case cover.

2. Remove the retainer cover carefully; do not damage the oil seal.

3. Remove the gear case cover from the speed reducer housing.

4. Remove the main driven gear, the auxiliary pump gear, and the pinion gear, together with their attached shafts.

Disassembly of the A-end pump

The instructions in this paragraph give the sequence of disassembly of a complete A-end. In many cases, complete disassembly of an A-end is not necessary. It is advisable to analyze the trouble and study drawings 268458 and 268461 of the assembly carefully before starting to disassemble the unit.

Proceed as follows:

1. Disconnect all the piping to the relief valve assembly.

2. Remove the relief valve assembly after first removing the six Allen screws in the back of the relief valve assembly.

3. Remove the packing gland and the packing cover.

4. Turn the A-end over so that it rests on its front end plate with the drive shaft down. Wooden supports should be placed under the front end plate. Care must be taken to prevent the weight of the A-end from resting on the control housing or servo cylinder housing. It is not essential to turn the A-end over, as outlined above, in the disassembly of the unit; however, it does facilitate the operation.

5. Remove the cap nuts from the A-end housing studs and lift out the studs.

6. Remove the valve plate, locknut, and lock washer.

7. Remove the bearing from the drive shaft.

8. Remove the cylinder barrel from the drive shaft and pistons. When removing the cylinder barrel, care must be taken to hold the connecting rods so that the pistons will not bump into each other or into other parts of the pump unit. This must be done in order to prevent damage when the pistons are freed by the removal of the cylinder barrel.

9. Remove the cylinder barrel keys and spring. The inner assembly of all parts that are attached to the drive shaft, including the bearings, may now be lifted out of the A-end case as one assembly.

10. The tilting box cannot be removed from the housing until the control box and servo piston assembly have been removed. It is not necessary to remove the tilting box from the housing to remove the thrust bearing race. The tilting box has three 1/2-inch 13 NC thread holes, tapped in the underside. These holes are threaded for jackscrews, used for removing the thrust bearing.

Removal and disassembly of the servo piston

Before removing the servo piston, study drawings 268466 and 268545.

Proceed as follows:

1. Remove the access cover, the machine bolt, and the two pipe plugs from the servo cylinder.

2. Center the servo piston and remove the connecting pin by driving it down.

3. Remove the bolts that secure the servo cylinder to the A-end case, and remove the servo cylinder as a complete assembly.

4. Remove the cylinder end cap and the cylinder end cap and guide rod.

5. Remove the servo piston by first unscrewing it from the stroking slide.

Disassembly and assembly of the control mechanism

Before disassembling the control mechanism, study drawing 268468 carefully.

The valves, valve plungers, valve sleeves, control screws, gears, and related parts must be handled with utmost care in disassembly or assembly.

Proceed as follows:

1. Remove control case cover plate.

2. Uncouple the handwheel input.

3. Remove from the control case, as a unit, the housing containing the limit stops and friction clutch. Disassembly of this unit is apparent from the drawing.

4. Remove the differential control screw and connecting linkage.

5. Disconnect and remove the valve block assembly. Disassembly of this unit is apparent from drawing 268470.

When the control mechanism is assembled, keep all looseness in the linkages and backlash in the gears at a minimum to avoid lost motion. When oil seals are assembled on shafts, extreme care must be taken not to crack or stretch the oil seals. Use a sheet of thin brass as a thimble to start the seal over the end of the shaft.

Disassembly and assembly of supercharge and servo pumps

Disassembly of the two pumps is similar. Both pumps can be removed from the speed reducer housing as a unit, if desired. Study drawing 268463 carefully before disassembling.

To disassemble:

1. Remove the four nuts on one end of the pump and tap out the four stud bolts.

2. Remove the bearing plate, the liner plate, and the servo pump cylinder.

3. Turn the pump over and remove the mounting plate, the liner plate, and the supercharge pump cylinder.

4. Push the driven shaft down and out of the driven gear from the same end of the pump.

5. Push the drive shaft down about 1/16 inch until the key in the drive shaft touches the bearing plate. Care must be taken so that the key does not hit the bearing plate and damage it. Raise the shaft and put a shim under the gear equal to the amount that the shaft was pushed down. Repeat the procedure until the gear has been removed.

To assemble the pump:

Assembly of the servo and supercharge pumps is made in the reverse order of disassembly. When assembling, coat the mating plates with a very thin shellac. The drive shaft should be turned slowly as the nuts are tightened in order to assure clearance and alignment of the gears. The pumps must not be run unless they can be turned freely by hand.

Disassembly and assembly of the B-end

Before disassembling the B-end, study drawings 268459 and 268462 carefully.

To disassemble the B-end:

1. Remove the mounting flange and the oil seal.

2. Tip the pump on end, with the drive shaft pointing down.

3. Remove the cap nuts from the studs and remove the B-end case studs.

4. Remove the valve plate assembly from the B-end case.

5. Remove the drive shaft from the bearing.

6. Remove the cylinder barrel. Care must be taken to hold the connecting rods so that the pistons will not bump into each other or into other parts of the pump unit.

7. Remove the cylinder barrel keys and spring. The inner assembly of all parts that are attached to the drive shaft, including the bearing, may now be removed from the B-end case in one assembly.

The B-end is assembled in the reverse procedure and sequence of the disassembly. Make certain that all parts fit freely and are well lubricated.

Removal and replacement of synchros

The synchros can be removed and replaced without disassembling the gear train or removing them from the case. To remove and replace the fine (36-speed) synchro, proceed as follows:

1. Disconnect the synchro crank connecting wire from the amplifier linkage L1.

2. Remove the synchro crank assembly. It may be necessary to move the sleeve of the loading pilot valve V12 to the left in order to clear the assembly.

3. Remove the coupling piece from the synchro shaft.

4. Remove the screws that hold the drive gear to the stator. Hold the gear so that it does not drop down into the receiver-regulator.

5. Remove the back cover plate.

6. Remove the checking dial and test synchro mounting.

7. Remove the synchro brush holder.

8. Remove the synchro retainer.

9. Remove the synchro.

10. Insert the new synchro. A 6-inch piece of tubing placed over the synchro shaft will aid in guiding the synchro into place. The synchro should fit very snugly in its bearing. As a result, some difficulty may be experienced in inserting the synchro if it does not enter the bearing squarely. If the synchro resists inserting, take it out and start over. Do not force the synchro.

11. Replace the synchro retainer.

12. Replace the synchro brush holder.

13. Replace the checking dial and test synchro mounting.

14. Replace the back cover.

15. Replace the stator drive gear and tighten the holding screws.

16. Replace the coupling piece on the synchro shaft.

17. Replace the synchro crank assembly.

18. Connect the crank to the amplifier linkage.

19. Check all the adjustments of linkages and valves of the receiver-regulator.

The same procedure is followed to remove and replace the coarse (2-speed) synchro, except first break input shaft couplings and remove large gear-compartment cover.

Removal and replacement of valves in the receiver-regulator

All the valves are matched with respective sleeves; therefore, whenever replacements are made, both the valve stem and the sleeve must be replaced. The pieces are marked with serial numbers, and the stem must be assembled so that its number is on the same end of the assembly as the sleeve number. The numbers must correspond. When the sleeve is placed in the block, the number must be toward the link to which the valve stem attaches.

Removal and replacement of the hydraulic vibrator

The hydraulic vibrator may be removed as a unit by disconnecting its supply pipe and removing the four mounting screws. Except in the case of emergency, repairs to the vibrator should be made at the factory. Constant-flow valves may be interchanged where necessary. When a new hydraulic vibrator is installed, it should be adjusted in accordance with the instructions in the "Trouble analysis" section of this chapter.

Replacement limits of parts reassembled

The A-end and B-end pistons should be fitted 0.003 inch under the bore diameter in the cylinder barrel.

All replacement valve plungers in the controls should be ground 0.001 inch under the diameter of the bore in the valve sleeves. The edges should be sharp, but without burrs.

All replacement sleeves for the valves in the control should have the hole ground and lapped with the port openings sharp, but without burrs.

Chapter 6

TRAINING GEAR

16-inch Training Gear Mark 2 Mod 0

16-inch Train Receiver-Regulator Mark 18 Mod 0

GENERAL DESCRIPTION

The turret training gear, shown in figure 6-1, is the same in all turrets of the IOWA class battleships. It is designated 16-inch Training Gear Mk 2 Mod 0.

The equipment drives and controls the movements of turret train. It rotates the turret within an arc of 300 degrees, limited by positive stops 150 degrees left and right of the turret centerline position.

The 16-inch Training Gear Mk 2 Mod 0 is a stationary gear rack type with pinion gears driven by an electric-hydraulic power drive, through worms and wormwheels. The equipment is controlled by an arrangement of hand and automatic servo-type controls.

The turret training equipment includes the following design features:

Equal drive torque at each of the two worm and wormwheel assemblies drives the two training pinion gears. Twin hydraulic motors (B-ends) drive the two worms; both B-ends are powered by a single pump (A-end).

A control selector permits control selection of turret train either automatically from a remote ship's station or by hand from a local trainer's station. The method of control is selected by the train operator. These control methods are designated AUTO and HAND.

Components. The 16-inch Training Gear Mk 2 Mod 0 consists of the following major units and subassemblies:

- Power drive assembly
  - Electric motor
  - Controller
  - Reduction gear
  - Auxiliary pumps
  - A-end assembly (hydraulic pump)
  - B-end assemblies (hydraulic motors)
- Training worm, wormwheel, and pinion assemblies
  - Worm and wormwheel
  - Pinion
  - Training rack
- Training gear controls
  - Start-stop control
  - Control selector
  - Servo stroking system
  - Transmission control case
  - Receiver-regulator
- Firing stop mechanism

Component locations

The power drive electric motor, reduction gear, A-end, auxiliary pumps and receiver-regulator are all mounted on the electric deck, in the space between the pan floor and the electric deck directly below the center gun. The train operator's control station is also in the electric deck space, forward of the A-end and the train indicator, as shown in figure 6-1.

The B-end assemblies are located above the pan floor at the forward part of the turret, in the spaces between the parallel divisional bulkheads formed by the gun girder boxes, with a B-end mounted either side of the center gun girder box. The training worm, wormwheel, and pinion assemblies are located forward of their respective B-ends. Relative positions, worm couplings, and A-end manifold pipe connections are shown in figure 6-2 together with the annular training rack.

The electric power supply controller is located in the lower projectile handling deck machinery space. The remote ON-OFF push-button control is at the train operator's station.

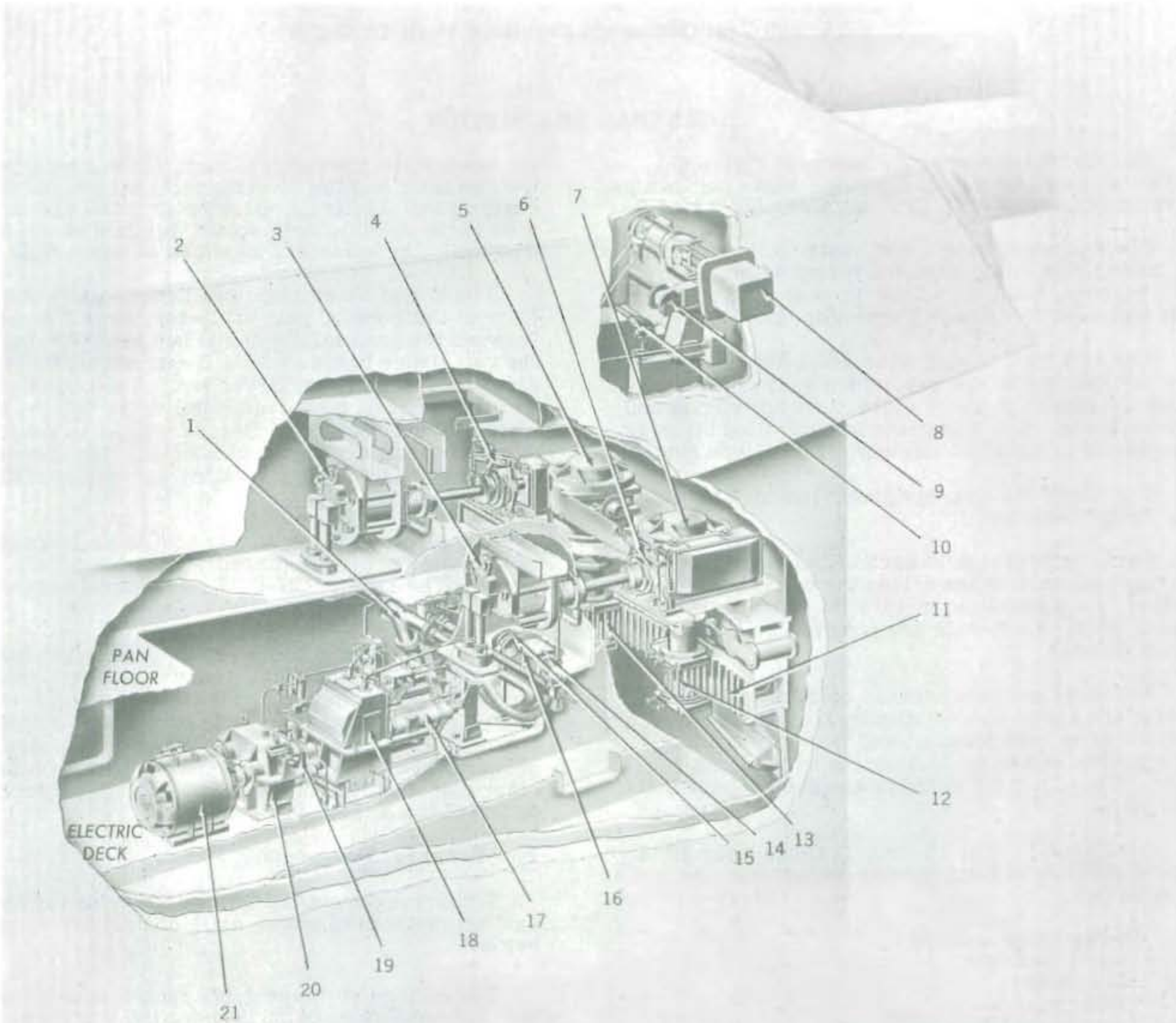
There are two stations for the local sight trainer's gear controls. A station is located at each side of the turret officer's booth. These stations are isolated from the gun compartments by turret subdivision bulkheads. A system of shafts and gear boxes connects the hand training control gear with the other control elements assembled in the control box on top of the A-end.

Functional arrangements

The arrangements of the training gear for the various methods of power drive control are described below:

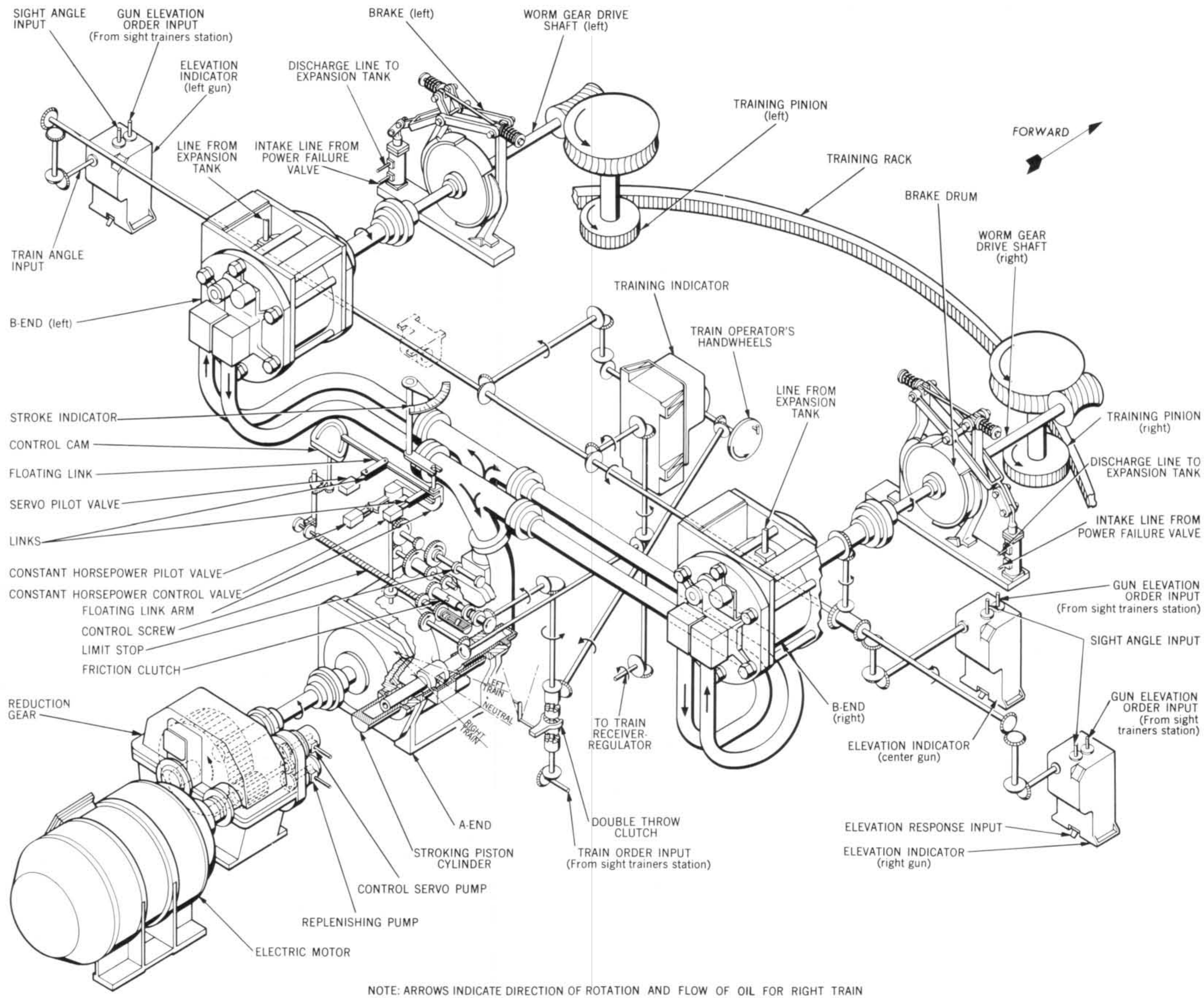
The method of power drive control is selected by the train operator, by positioning the control selector at AUTO or HAND.

In AUTO control, the receiver-regulator receives gun train order electrically from a remote control station. Actual train angle of the turret is automatically transmitted to the receiver-regulator through a mechanical response gear. A difference between train order and actual train angle results in offset movement of the A-end tilting box (fig. 6-2) through a hydraulic control valve and the servo piston. The amount the tilting box is offset from neutral, determined by the turret position "error," regulates the speed of the B-ends as they drive the worm and pinion assemblies. "Follow up" control is provided by shafting and gearing that feeds B-end response back to the receiver-regulator, and to the A-end tilting box to return it to neutral.



1. HYDRAULIC PIPE MANIFOLD
2. LEFT B-END ASSEMBLY
3. RIGHT B-END ASSEMBLY
4. LEFT BRAKE ASSEMBLY
5. LEFT TRAINING WORM AND WORMWHEEL ASSEMBLY
6. RIGHT BRAKE ASSEMBLY
7. RIGHT TRAINING WORM AND WORMWHEEL ASSEMBLY
8. SIGHT HOOD
9. SIGHT TRAINER'S HANDWHEELS
10. SIGHT TRAINER'S SEAT
11. TRAINING RACK
12. RIGHT TRAINING PINION
13. LEFT TRAINING PINION
14. NEUTRAL RETURN HAND PUMP
15. TRAIN OPERATOR'S HANDWHEELS
16. TRAIN OPERATOR'S SEAT
17. A-END ASSEMBLY
18. TRAIN RECEIVER-REGULATOR
19. AUXILIARY PUMP CLUSTER
20. REDUCTION GEAR
21. ELECTRIC MOTOR

Figure 6-1. 16-inch Training Gear Mk 2 Mod 0, General Arrangement



NOTE: ARROWS INDICATE DIRECTION OF ROTATION AND FLOW OF OIL FOR RIGHT TRAIN

Figure 6-2. 16-inch Training Gear Mk 2 Mod 0, Schematic Arrangement

Gene Slover's US Navy Pages | Table of Contents

In HAND control, the train operator's or either of the sight trainer's handwheels are mechanically connected (through shafts and gears, and the transmission control case mechanism) to a hydraulic valve block assembly which ports servo pressure to the servo piston. Offset from neutral stroke by handwheel movement, the A-end tilting box is controlled through the servo pilot valve of the control case valve block assembly. The amount and direction of tilting box offset regulates the speed and direction of rotation of the B-ends as they drive the worm and pinion assemblies to train the turret. B-end (turret) response is transmitted to the control case through shafts and gears from a take-off of the right B-end drive shaft. Handwheel input combined with B-end response in a differential screw and nut device results in follow-up control of turret train. Follow-up control automatically returns the tilting box to neutral stroke when handwheel input is stopped.

Design data

Turret train limits, speeds, and other data are as follows:

Arcs of train, all turrets, deg	300
Train limits, clockwise from above (bow zero)	
Turret I, deg	210 to 150
Turret II, deg	210 to 150
Turret III, deg	30 to 330
Train limits, dial indications	
Right train, turrets I, II, deg	150
Left train, turrets I, II, deg	210
Right train, turret III, deg	330
Left train, turret III, deg	30

Turret train speed (maximum), deg per sec. 4

DETAIL DESCRIPTION

Power drive

The hydraulic power drive of the training gear assembly is composed of a variable-displacement pump (the A-end) and two fixed-displacement motors (the B-ends). Each B-end is mechanically independent of the other, and both are independent of the A-end. The A-end is connected to both B-ends by the large hydraulic pipe manifolds shown in figure 6-2. The A-end, the B-ends, and the pipe manifold connections are the basic units that transmit hydraulic power for training the turret. They function to convert input shaft rotation of constant speed and direction to reversible, variable-speed rotation of the B-end drive shafts.

Components. The components of the power drive are:

- Electric motor
- Controller
- Reduction gear
- Auxiliary pumps
- Shaft couplings
- Hydraulic pump (A-end)
- Hydraulic motors (B-ends)

Arrangement. The arrangement of the power drive components is shown in figure 6-2. The electric motor drives the A-end pump at constant speed through the reduction gear. Two large pipe manifolds connect the valve plate ports of the A-end with the valve plate ports of the two B-ends. The B-end shafts are each coupled to separate training worm, worm-wheel, and pinion assemblies. A gear take-off drive at the right B-end shaft is connected to response inputs of the A-end and the receiver-regulator follow-up control.

Electric motor. The 300-horsepower electric motor is mounted toward the rear of the center gun pocket on a structural foundation that raises it slightly above the electric deck. The motor shaft is connected to the driving pinion of the reduction gear through a self-aligning coupling, as shown in figure 6-3.

Motor data.

Type	squirrel cage, induction
Design features	horizontal, internal and external fan cooled, watertight
Horsepower	300
Revolutions per minute, synchronous	1800
Revolutions per minute, full load	1755
Rotation (output shaft)	counterclockwise
Speed class	constant
Voltage	440
Amperes, full load	355
Amperes, locked rotor	2200
Phases	3
Cycles	60
Ambient temperature, C	40
Torque class	normal torque, low starting current
Weight, pounds	4500
Manufacturer	Electro Dynamic Works
Manufacturer's designation	Frame 304-BH/M type KNX
Drawing	231775

Controller. The electric motor is powered and controlled through an autotransformer magnetic starter-controller. The controller case and separate autotransformer case are mounted adjacent to each other at the rear center of the machinery space of the lower projectile handling deck. The contactors, overload relays, and control relays of the controller are housed in a conventional metal cabinet that includes power supply connections.

The circuits that control starting and stopping of the controller include a remote master switch, located at the train operator's station, a neutral interlock switch, located on the left side of the A-end case, and the servo interlock switch assembly, located on the rear face of the control valve block at the top of the A-end assembly. The neutral interlock and the servo interlock switches, connected in series, prevent the electric motor from being started when either switch is open due to the A-end mechanism being off neutral.

When the electric power is removed, a spring-loaded power-off solenoid functions (through a hydraulic valve) to set spring-actuated brakes on the training pinions. The solenoid is normally energized from the single-phase control circuit supply of the controller. The solenoid is located in the center gun pocket on the transverse bulkhead, immediately forward of the oscillating bearing for the center gun elevating gear.

Controller data. Motor controller data are listed on the following page.

Type	autotransformer starter, watertight, controlled by remote pushbutton
Ampere rating, full load	355
Protection	
Overload, inverse time thermal relay; automatic reset	
Adjustable range, amperes	360 to 440
Normal setting, amperes	400
Short circuit	
Main motor	none
Drop out at, volts	220
Sealing voltage	372
Shock rating	high impact
Weight, pounds	
Autotransformer	500
Starter-controller	1300
Manufacturer	Ward-Leonard Electric Co.
Drawing	318740

Reduction gear. The reduction gear, shown in figure 6-4, is a speed reducer for driving the A-end with a separate drive on the high speed input shaft for the auxiliary pumps. The unit consists of a spur gear and pinion enclosed within a vented case arranged for oil-bath lubrication. The case includes a depth-rod gage for checking the oil level. The reduction gear is mounted and coupled between the electric motor and the A-end, as shown in figure 6-2.

Reduction gear data. Reduction gear data are listed below:

Revolutions per minute	
Output shaft, A-end	350
Auxiliary shaft to pump drive	1200
Rotation (both shafts)	clockwise
Lubrication	
Type	oil bath
Capacity, gallons	14
Weight, pounds	3100
Drawing	273618

Auxiliary pumps. The auxiliary pumps are bolted on the pump drive assembly of the reduction gear through integral flanges of the pump housings. Mounted one above the other, each pump is independently driven, at 1200 revolutions per minute, through a shaft of the pump drive assembly. Of identical vane-type design, the pumps have different rated capacities. The replenishing pump, with greater capacity than the control (servo) pump, supplies the main system with hydraulic fluid. The control pump delivers pressure to the servo stroking cylinder.

Replenishing pump. With its intake line connected to the main system supply tank, the replenishing pump discharges through a duplex filter into the replenishing valves of the A-end valve plate.

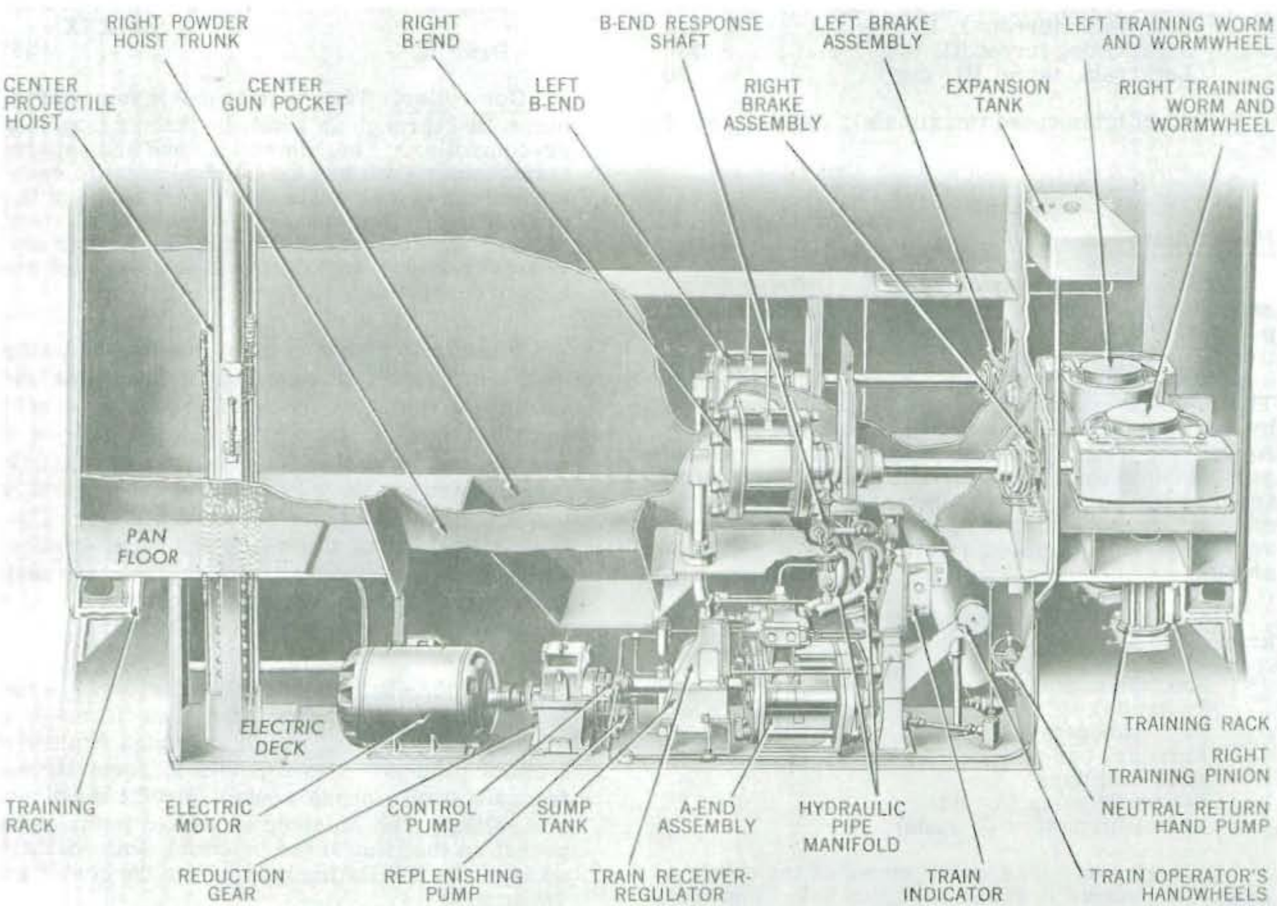


Figure 6-3. 16-inch Training Gear Mk 2 Mod 0 Power Drive, General Arrangement

The pump, with a rated capacity of 36.5 gallons per minute at a pressure of approximately 40 pounds per square inch, weighs 74 pounds.

Control pump. With its intake line also connected to the main system supply tank, the control pump discharges through a duplex filter into the control selector and servo stroking systems. The pump, with a rated capacity of 28.8 gallons per minute at a pressure of approximately 400 pounds per square inch, weight 75 pounds.

Shaft couplings. Flexible couplings are used to interconnect the power units of the training gear assembly. The couplings are all of commercial design and manufacture.

The electric motor-to-reduction gear coupling, is a direct drive connection between these two units. The coupling consists of two identical steel hubs, a specially heat-treated and tempered steel alloy grid spring, and two identical steel shells which form the cover. The coupling design provides drive connection through the grid spring which is engaged in grooves accurately milled in the outer flanges of each hub. The hubs and grid spaces are packed with lubricant that is retained within the steel shells by two grease seals.

The reduction gear-to-A-end coupling is a semi-floating unit. Each coupling is an assembly of splined hubs which seat on respective shaft ends. The hubs mounted on each end of the connecting drive shaft are rigidly secured in position. The hubs mounted on the shafts of the reduction gear and A-end provide the floating compensation for slight misalignment of the connected units and have gear teeth on the outer surface. The flanged sleeves which enclose the hubs have meshing teeth that mate with the geared hubs. When installed, each coupling is partially filled with oil to provide lubrication for the gearing.

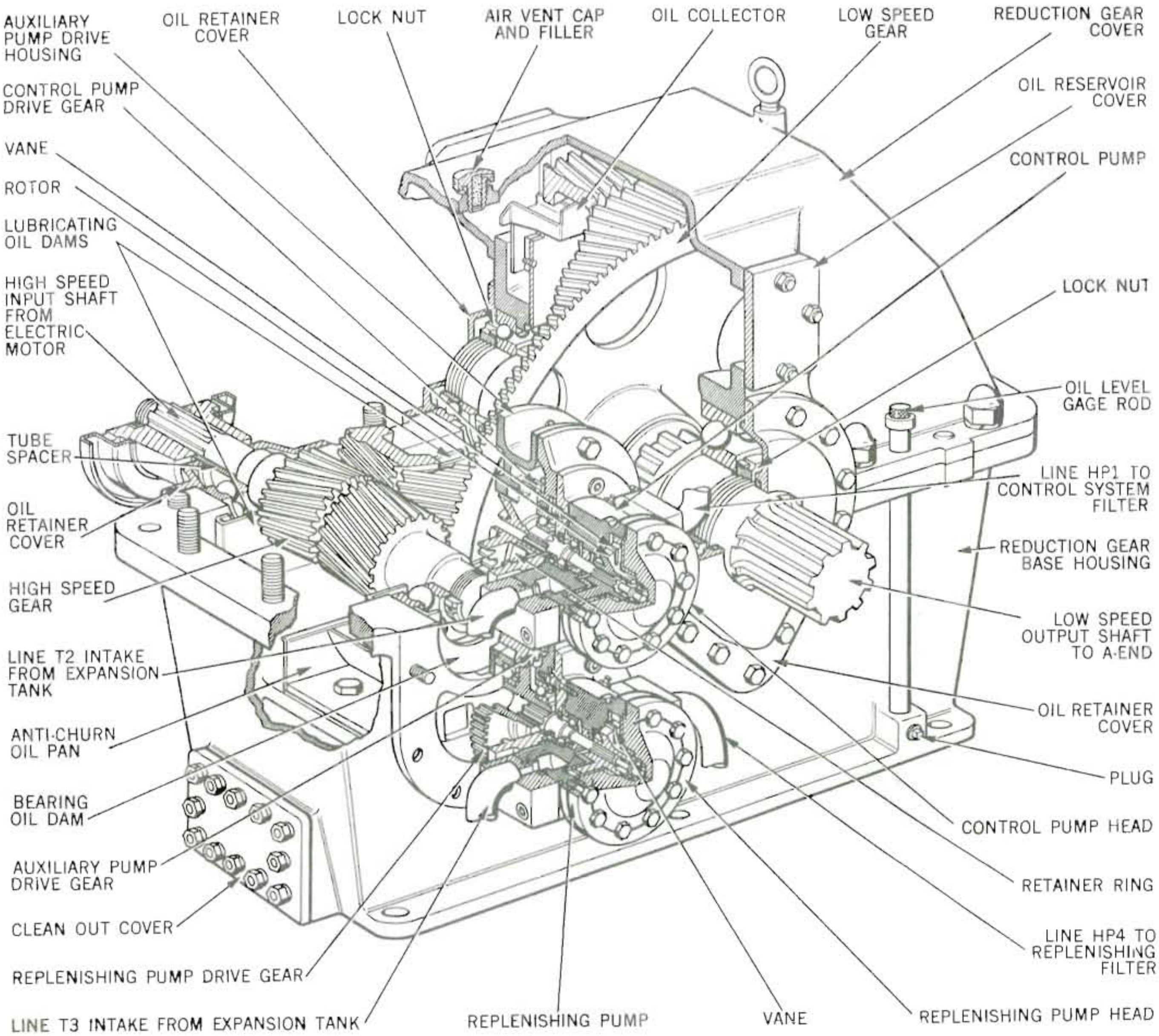


Figure 6-4. Training Gear Reduction Gear and Replenishing Pump Assembly, Cutaway View

Hydraulic pump (A-end). The (A-end) hydraulic pump (figs. 6-2 and 6-5) is a type K, size 150, variable-stroke, multi-cylinder, positive displacement pump. The assembly includes an attached stroking piston cylinder and a transmission control mechanism. The pump is a nine-piston rotating group of the same basic design as the A-end of the elevating gear (ch. 5).

Mounting. The A-end pump is mounted on a foundation weldment of the electric deck, with its input shaft aligned with the output shaft of the reduction gear. Proper shaft alignment is provided by the special gear-type couplings described on page 6-5 of this chapter.

Pressure and tank connections. In addition to the main system pipe manifolds, the A-end assembly has drain, circulating, control and replenishing connections. The drain connections direct hydraulic fluid from the stroking piston assembly and control case mechanism back to the supply tank. The control pump delivers control pressure to the stroking piston assembly and the control case mechanism. The replenishing pump delivers replenishing fluid to the A-end valve plate. The A-end and B-end units, and the A-end and expansion tank are interconnected by piping and flanged fittings, for fluid circulation, which aids in cooling the mechanism.

Associated equipment (receiver-regulator; servo stroking cylinder; transmission control case mechanism). The receiver-regulator, servo stroking cylinder, and transmission control case mechanism are each connected to the A-end either mechanically or hydraulically. These units operate the A-end tilting box to control the speed and direction of rotation of the two B-ends. The receiver-regulator provides automatic control of turret train movement from a remote ship's station. The transmission control case mechanism provides control of turret train movement from a local trainer's station.

Design differences (from elevating gear A-end). The A-end design is similar to the smaller A-end of the elevating gear assembly (chapter 5) with the following exceptions.

A-end valve plate. The A-end valve plate (fig. 6-5) is a stationary part of the A-end assembly and forms one end of the A-end case. The A-end valve plate main ports are provided with spring check replenishing valves. These valves supply the respective low-pressure sides of the main system with replenishing fluid at 40 pounds per square inch. A shuttle valve between the two ports directs high pressure to the constant horsepower valve of the A-end control case.

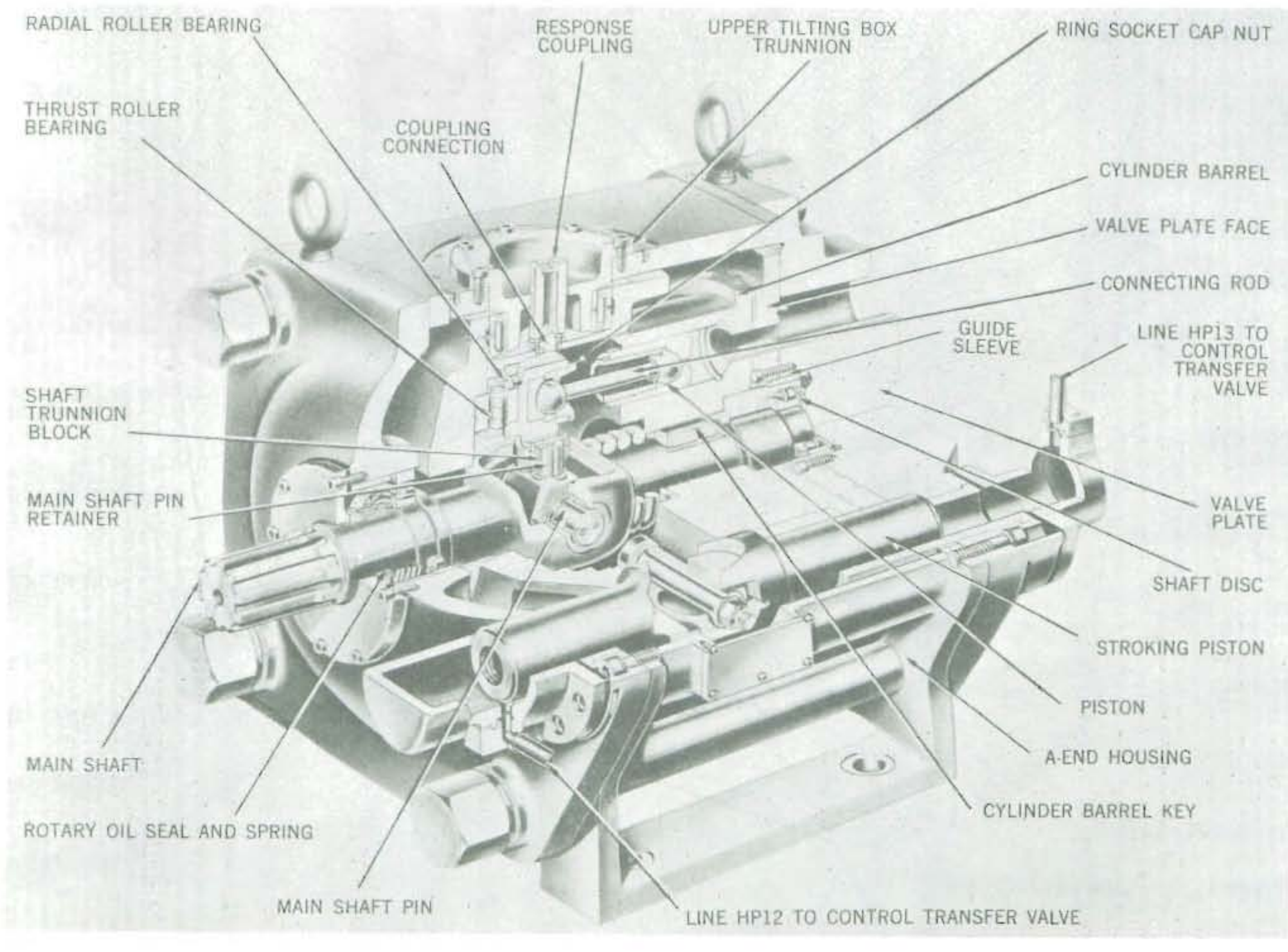


Figure 6-5. Training Gear A-end Assembly, Cutaway View

Keyway for tilting box shaft and arm. The side of the A-end control case, to which the servo stroking cylinder assembly is attached (fig. 6-5), is cut out to form a keyway that permits movement of the tilting box shaft and connecting arm linkage between the stroking piston and the tilting box.

A-end data.

Driven speed, revolutions per minute	350
Temperatures	
Normal, operating range, F	120 to 175
Maximum permitted, F	185
Displacement, cubic inches	692
Manufacturer	Waterbury Tool Co.
Manufacturer's designation	size 150
Drawing	268157

Follow-up control. The follow-up control consists of response shafting from the right B-end drive shaft to the train indicator, the receiver-regulator, and the A-end control case mechanism. The follow-up mechanism within the control case consists of a follow-up response gear, a control screw, and a control nut. This mechanism uses B-end response to return the A-end tilting box to its neutral stroke position. A complete description of this mechanism will be found on page 6-11 of this chapter.

Servo stroking cylinder. The stroking piston cylinder assembly (fig. 6-6) is a high-pressure, double-acting piston and cylinder assembly mounted on the side of the A-end case. This assembly changes the position of the A-end tilting box to vary the volume delivered by the A-end to the B-end units. The stroking piston cylinder assembly is described in detail on page 6-9 of this chapter.

Hydraulic motors (B-ends).

Type. The two hydraulic motors (B-end assemblies) are type K, size 150, fixed-displacement units of modified commercial design. Both are case-enclosed units with rotating groups similar to the A-end pump, but arranged with socket-ring bearings fixed at an angle of 20 degrees. The units differ in that the drive shaft of the right B-end has response take-off shafting (fig. 6-2).

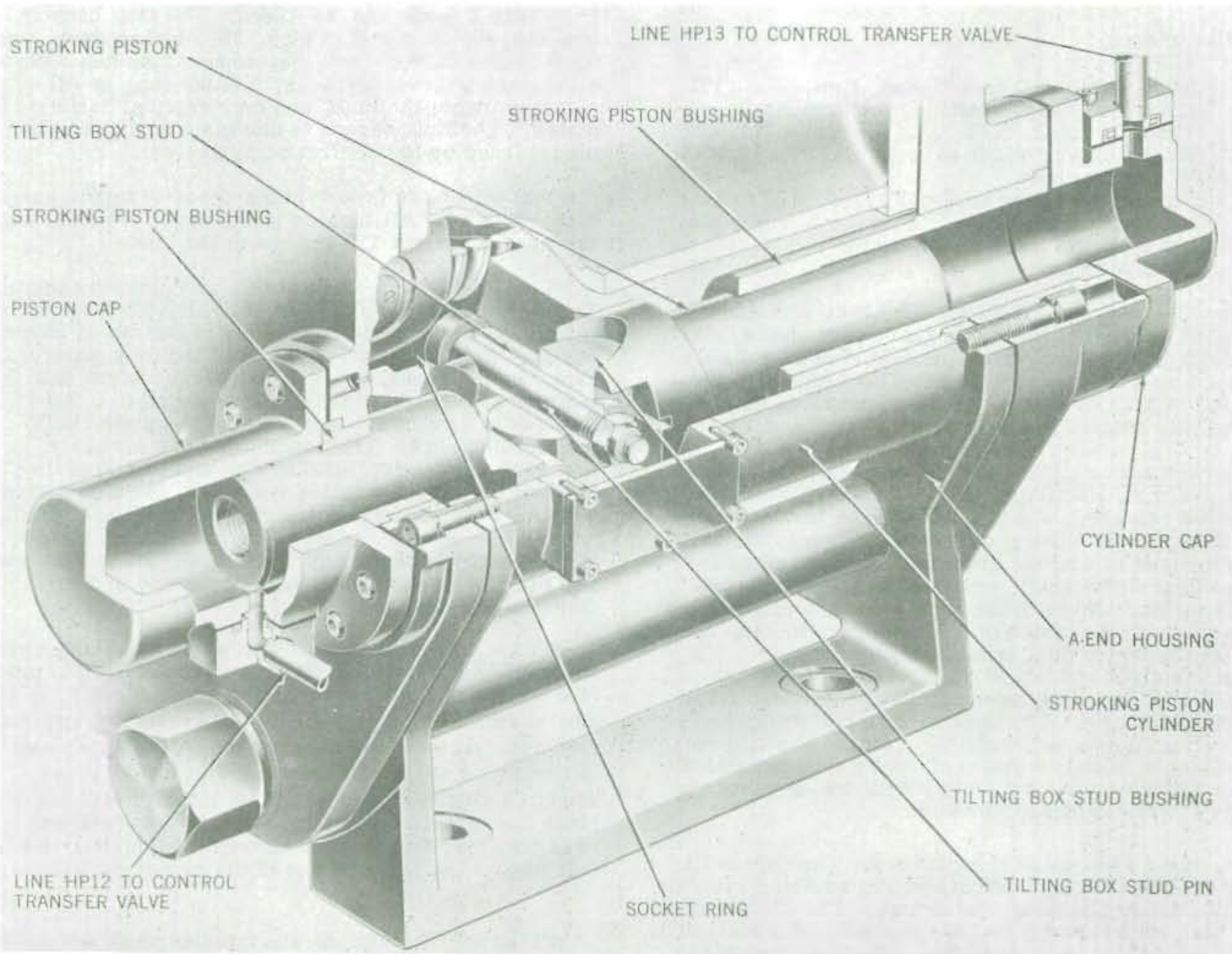


Figure 6-6. Training Gear A-end Stroking Piston, Cutaway View

Mounting. Both hydraulic motors are mounted on foundation weldments above the pan floor level at the forward part of the turret. The units are located in the spaces between the parallel divisional bulkheads formed by the gun girder boxes, with a B-end mounted on either side of the center gun girder box. Each B-end is mounted with its drive shaft coupled to the worm, wormwheel, and pinion gear assembly.

Pressure and tank connections. In addition to the pipe manifolds of the main system, the B-end assemblies are interconnected by flanged fittings for fluid circulation, and have a common drain line to the supply tank. The circulation of hydraulic fluid aids in cooling the mechanism.

Drive reduction. The total displacement of the two B-ends is equal to twice the displacement of the A-end to give a drive reduction of 2 to 1.

Design differences (from elevating gear B-end and B-end valve plates). The valve plates of the two hydraulic motors of the training gear are identical to each other. Each valve plate houses one relief valve which relieves high pressure for one direction of train. The relief valve in the left B-end valve plate relieves for right train, the relief valve in the right B-end valve plate relieves for left train. Both valves, of adjustable-spring plunger design, bypass high pressure to the main system return pipe at a pressure of 1525 pounds per square inch.

B-end data.

Speed (maximum) each B-end, rpm. . . .	175
Torque load (each shaft)	
Normal, rated, ft-lb	11,200
Maximum, rated, ft-lb	12,300
Oil temperatures	
Normal operating range, F. . . .	120 to 175
Maximum permitted, F	185
Displacement, each B-end, cubic inches per rev.	653

B-end-to-brake couplings. A brake assembly is mounted on each of the worm gear drive shafts. Each of these shafts is coupled to its B-end output shaft through a flexible gear-type coupling similar to the reduction gear-to-A-end coupling described on page 6-5 of this chapter.

Brake assemblies. Each B-end brake is a spring-actuated mechanical assembly with servo pressure actuated release. The brakes hold the turret, at any position of train when power is off. Each brake unit is composed of a brake drum spline-mounted on the worm gear drive shaft, two lined brake shoes, two main springs, three brake shoe levers, and a linkage connection to the piston of a hydraulic cylinder. Each unit is supported on a separate mounting base. The units are right and left arrangements of identical parts, and they simultaneously set or release the B-end output shafts. The hydraulic circuit valve porting arrangements automatically release the brakes when power is on. A solenoid moves a power failure valve against spring action to port servo pressure to the two brake release cylinders.

Control and replenishing filters. The duplex filters used in both the control and replenishing systems are of modified commercial design. The control filter and the replenishing filter are virtually identical, double-cartridge filter assemblies. Each assembly has a manually-operated selector lever that permits porting of the hydraulic oil through either or both cartridges.

The filter unit for each system is located in the discharge line of each pump. Each cartridge in the filter unit consists of an assembly of discs and spacers mounted on a movable spindle stacked alongside cleaner blades mounted on a fixed rod. This arrangement permits clearing the filter cartridge while the hydraulic system is in operation. One complete revolution of the cartridge handle passes the discs through the cleaner blades to remove foreign particles from the discs.

The control filter has a flow capacity of 28 gallons per minute with control pump pressure of 350 pounds per square inch. The replenishing filter has a flow capacity of 36 gallons per minute with replenishing pump pressure of 40 pounds per square inch.

Control and replenishing relief valves. The control and replenishing relief valves, connected in the discharge lines of the control and replenishing filters, are mounted in a common valve block near the A-end. They are spring-operated plunger-type safety relief valves. The valves open and bypass excess pressure flow to the expansion tank when control and replenishing lines are overloaded.

Expansion tank. The expansion tank, located at the high point for the training gear, is a vented type with gravity feed connections to the control and replenishing pumps. Return oil lines lead to the tank from both B-ends and the A-end. The tank body is box-shaped, 19.5 inches high, 35.5 inches deep, and 50.0 inches wide. The sheet-copper tank has a cover, high-and low-level trycocks, a filler cap, an oil strainer inside the tank, and four vertical baffle plates. The tank serves to dissipate heat from the oil returned by the recirculating system.

The expansion (supply) tank capacity is 150 gallons. When the oil level is at the upper trycock, there are approximately 120 gallons in the tank.

Training worm, wormwheel, and pinion assembly. The B-end units turn the turret by driving a worm, wormwheel, and pinion assembly of Bureau of Ships design. Each assembly, enclosed within a separate case, is a nonoverhauling Hindley-type worm and wormwheel. Each is fitted and adjusted to a fixed position to ensure correct mesh of the pinion with the training rack. The assemblies are securely seated in heavy structural blocks and plates at the front of the turret rotating structure. The mounting weldment aligns each worm, wormwheel, and pinion with its B-end drive shaft. The case forms an oil-tight, vented enclosure for the worm, the wormwheel, and their bearings, which are immersed in a circulating lubricant.

Worm and wormwheel. The worm and wormwheel assemblies are located within a common compartment at the front of the turret rotating structure (fig. 6-1). The wormwheel, with 28 teeth cut around its 9.8-foot circumference, is spline-mounted on the upper end of the pinion shaft. The driving unit of the wormwheel, a single-thread worm, is integral with its shaft and thrust rings. The worm and wormwheel assemblies are accessible through the hatch in the bulkhead at the forward end of the center gun pit.

Pinions. The pinions are integral shaft and spur tooth gears. Each pinion has 12 teeth of 20.53-inch pitch diameter. The faces of the pinion teeth are 20.0 inches in length.

Training rack. The training rack, an internal annular gear, is made in six equal-sized segments. The segments, butted end to end, are keyed and bolted to the structural foundation of the ship. The rack has 210 teeth with a pitch diameter of 359.29 inches.

Lubrication. The worm-gear lubricating unit is of Bureau of Ships design. The electric motor and pump are mounted on a foundation weldment between the worm and wormwheel case enclosures. The pump is supplied with lubricating oil from two sump tanks, mounted directly below the turret compartment containing the worm and wormwheel assemblies.

Training gear controls

The training gear control arrangements consist of:

Start-Stop controls
Power drive transmission controls
Control selector
Servo stroking system
Control gear hand gear
Control gear response gear
Control case mechanism
Receiver-regulator

Start-stop control. The training gear power drive is started and stopped from its controller. The controller is remotely operated by two push buttons adjacent to the train operator's station. One button is designated START-EMERG, the other STOP.

The START-EMERG button closes a normally-open, three-pole switch and energizes the coil of the main contactor to connect three-phase power to the electric motor. Holding contacts on the relays keep the power circuit closed when the START-EMERG button is released until the STOP button is pressed. The control selector lever may be moved from HAND to AUTO or AUTO to HAND without interrupting the supply of power to the electric motor. In the event of a power failure, the main contactor opens and remains open until closed by pressing the START-EMERG button. An overload relay opens the circuit when current demand is too great. The main contactor may be kept closed to keep the electric motor running in an emergency by holding the START-EMERG button closed. The electric motor is stopped by pressing the STOP button.

Transmission controls. The transmission controls are the A-end control mechanisms and hydraulic system devices that position the A-end tilting box and control the main system hydraulic pressure. They include hand control elements and automatic control elements.

Hand control elements. The elements of the hand control system are:

1. Control selector
2. Servo stroking system
3. Control gear hand gear
4. Control gear response gear
5. Control case mechanism

The units function together so that, when the control selector is at HAND, the turret is trained by manually turning the handwheels. The response gear and the control case devices provide follow-up control and limit-stop control.

Automatic control elements. The elements of the automatic control system are:

1. Control selector
2. Servo stroking system
3. Receiver-regulator
4. Control gear response gear
5. Control case mechanism

The units function together so that, when the control selector is at AUTO, the turret is automatically trained in response to electrical signals from a remote station. The control gear response gear provides follow-up control and limit-stop control as in hand control. The limit stop function is supplementary to an automatic limit stop device of the receiver-regulator.

Control selector. The control selector (fig. 6-15) is a manually-positioned hydraulic valve mounted on the bulkhead adjacent to the train operator's station. The selector permits the train operator to select HAND or AUTO control. The selector valve block includes a related hydraulic valve called the synchro failure valve which is normally open to allow servo pressure flow to the control selector valve. The synchro failure valve automatically moves to block servo pressure flow to the control selector valve when the synchro gun train order signal fails. The synchro failure valve automatically shifts control away from the receiver-regulator to the train operator's handwheels.

The control selector includes a synchro power indicator light (fig. 6-15) which is lit whenever the gun train order signal (synchro power) is available. Should the synchro power fail, the indicator light goes out.

Servo stroking system. The servo stroking system is composed of:

1. The control pump (fig. 6-4) mounted on and driven by the reduction gear.

2. The duplex filters in the discharge line of the servo control system.

3. A servo control system relief valve.

4. The stroking cylinder and piston, and the connecting arm to the A-end tilting box.

5. Hydraulic control valves

The system responds to hand and electrical gun train order signals by moving the A-end tilting box away from neutral stroke position. System pressure is supplied by the control pump. The pump is described on page 6-5 and the filters and relief valves are described on page 6-8 of this chapter. Other elements of the system are described in the following paragraphs.

Servo stroking cylinder. The servo stroking cylinder (figs. 6-2, 6-5, and 6-6) is a high-pressure double-acting piston and cylinder unit, which is mounted on the side of the A-end. The stroking piston changes the position of the A-end tilting box in response to hand or automatic turret train orders.

The cylinder assembly consists of a cylinder case, a piston, two piston bushings, a cylinder cap, a piston cap, a tilt box stud, and tilt box bushings. The arrangement of the components is shown in figure 6-6. The piston is a solid, cylindrical piece, assembled with a piston bushing on each end, mounted within the stroking cylinder case. The piston is free to slide through these bushings. Servo system pressure is ported to either end of the piston to move the A-end tilting box from neutral stroke. Piston movements are controlled by the receiver-regulator in AUTO and by the servo control valve in HAND.

Hydraulic control valves. Movement of the stroking piston is automatically controlled within the power drive hydraulic system by the following interrelated valves.

Power failure valve PFV. The power failure valve PFV, mounted on the forward bulkhead above the pan floor in the center gun pocket, is a two-position, spool-type valve that opens or blocks the brake release system hydraulic lines between the control pump and the two brake release cylinders. It is spring-operated to block the system hydraulic lines when power fails or is shut off. With power on the valve is solenoid actuated to open and port servo pressure to the two brake release cylinders.

Constant horsepower directional control pilot valve V6A. The constant horsepower directional control pilot valve V6A, located in the A-end transmission control case, is a spring-and-pressure-operated plunger type valve. Acting as a pilot valve it directs the flow of servo pressure to either the servo pilot valve V23 and the constant horsepower valve V6 or to the left end of the stroking piston transfer valve V31. Valve V6A is positioned against main system pressure by a spring. The spring, with its pressure varied by the position of the constant horsepower cam (actuated by tilting box movement) is between valve V6A and a plunger actuated by the cam. When moved toward the right by excessively high main system pressure, valve V6A directs the flow of servo pressure to the left end chamber of stroking piston transfer valve V31 to force valve V31 to the right. When moved toward the left by spring pressure, valve V6A directs the flow of servo pressure to the servo pilot valve V23 and the constant horsepower valve V6.

Servo pilot valve V23. The servo pilot valve V23, located in the A-end transmission control case, is a spring-and-linkage-operated plunger type valve. It directs the flow of servo pressure through either of the two chambers of the stroking piston transfer valve V31. Pilot valve V23 is spring operated to block the flow of servo pressure to the stroking piston transfer valve V31 when the controls are at neutral. Pilot valve V23 is positioned by linkage which is actuated by movement of the handwheels. When servo pilot valve V23 is moved toward the right, it ports servo pressure through the left chamber of the stroking piston transfer valve V31 to the right end of the servo stroking cylinder. This results in right train of the turret. Moved toward the left, control valve V23 ports servo pressure through the right chamber of transfer valve V31 to the left end of the servo stroking cylinder. This results in left train of the turret.

Constant horsepower valve V6. The constant horsepower valve V6, located in the A-end transmission control case, is a linkage-operated plunger type valve. Positioned by linkage which is actuated by the handwheels, constant horsepower valve V6 opens or blocks the flow of servo pressure from the constant horsepower directional control pilot valve V6A to the stroking piston transfer valve V31. Constant horsepower valve V6 blocks the flow of servo pressure to the stroking piston transfer valve V31 when the controls are at neutral. Constant horsepower valve V6 is positioned by linkage to port servo pressure to the stroking piston transfer valve V31.

Stroking piston transfer valve V31. The stroking piston transfer valve V31, located in the A-end transmission control case, is a spring-and pressure-operated spool type valve. Acting as a directional valve it directs the flow of servo pressure from the servo pilot valve V23 to either the right or left end of the servo stroking cylinder. Transfer valve V31, spring positioned toward the left, permits servo circuit pressure and drain flow for either left or right train as ported by the servo pilot valve V23. Stroking piston transfer valve V31, when forced to the right by servo pressure ported to its left end by the constant horsepower directional control pilot valve V6A, blocks servo pilot valve V23 and reverses the servo circuit pressure and drain flow for either right or left train. Under these conditions the constant horsepower valve V6 momentarily acts as a directional valve and tends to move the servo stroking piston toward neutral stroke.

Main system relief valves V28. The relief valves V28, one located in each B-end valve plate, are spring-loaded, plunger-type valves. Each valve serves to relieve high pressure for one direction of train. They operate to by-pass fluid directly to the low pressure transmission pipe.

Replenishing valves V32. The replenishing valves V32, located in the A-end replenishing valve block assembly, are spring-loaded plunger-type valves. They replenish the main system through the low pressure transmission pipe depending on the direction of train.

Shuttle valve V27. The shuttle valve V27, located in the A-end replenishing valve block assembly, is a directional-flow, spool-type valve that is an element of the constant horsepower device. Shuttle valve V27 is free to move to either end of its sleeve, porting main system high pressure to the left end of the constant horsepower directional control pilot valve. The action of V27 is the same in either direction of train.

Control gear hand gear. The control gear hand gear for the train operator is a pedestal bracket handwheel drive with bevel gear and shaft assembly arranged for hand control of the training gear. Located as shown in figure 6-1, the mechanism is arranged with its output shaft coupled through a friction clutch to a limit stop and geared to a differential follow-up mechanism. A mechanical linkage from the differential screw converts handwheel motion to valve movement to produce 2.0 degrees of turret rotation for one full turn of the handwheels.

Control gear response gear. The direction and speed of B-end rotation is transmitted from the right B-end response drive takeoff to the A-end control case mechanism by a system of shafts and bevel gears (fig. 6-2). The B-end response drive is coupled to a response input shaft that drives the differential screw of the follow-up mechanism. In addition, train B-end response is coupled to response input shafts of the train and elevation indicators and the train receiver-regulator.

Transmission control case mechanism. Servo stroking control is actuated through a case-enclosed transmission control mechanism, mounted on top of the A-end case. The interior arrangement of interconnected and related components of the control case is shown schematically in figures 6-22 through 6-26. The components are the mechanical, electrical, and hydraulic units described in the following paragraphs.

Friction clutch. Assembled between the handwheel input shaft and the nut of the differential follow-up mechanism is a clutch unit. A friction-type clutch, it is engaged by spring pressure and disengaged by hydraulic pressure. The clutch is engaged when the control selector lever is positioned at HAND. The clutch is disengaged when the lever is positioned at AUTO, and whenever the constant horsepower mechanism assumes control in HAND.

Automatic cutoff (limit stop). The automatic cutoff (limit stop) device in the control case mechanism limits the train movement of the turret. The device consists of a traveling nut on a screw which carries an adjustable limit stop at either end. The limit stop screw is geared to the handwheel input shaft. As the handwheels are turned, the nonrotating nut travels toward one or the other limit stop. When the nut contacts the limit stop, the turret is brought to a stop. The limit stops are set to correspond to the limits of turret train.

Follow-up control mechanism. The follow-up device is a differential screw and nut gear mechanism that operates the control valve units through a linkage attached to a trunnion at one end of the control screw. Displacement of the screw and valve linkage is a differential movement. It is derived from handwheel rotation of the differential nut and B-end response rotation of the screw, which turns the screw in the opposite direction. B-end response input positions the differential screw through a quill drive. In operation, the follow-up control mechanism is an automatic mechanical device for returning the tilting box to neutral through the valves and stroking control linkage of the control case. The return-to-neutral of the tilting box varies with the speed and rotation of the B-end, to produce a graded deceleration of the valve gear, servo stroking control, and the turret train movement.

Control linkage. The differential screw is rotated at one end by train response. At its opposite end, the differential screw vertical displacement actuates a spring-loaded, pivoted lever which functions as a differential screw follower. The follower is attached to a geared sector that actuates the control linkage through a control cam. The control linkage positions the servo pilot valve V23 and the constant horsepower directional control pilot valve V6A of the servo stroking system. Attached to the tilting box through the tilting box shaft and arm assembly of the transmission control case mechanism, the control linkage is actuated by tilting box movement. The arrangements of the control linkage and associated parts of the valve block assembly are indicated in figures 6-22 through 6-26.

Valve block assembly. Tilting box stroking is controlled by a servo system valve block composed of two mechanically operated plunger-type valves and two pressure-and-spring-actuated valves. The plunger-type valves are those designated the servo pilot valve V23 and the constant horsepower valve V6. The automatic valves are designated the constant horsepower pilot valve V6A and the transfer valve V31. The valve block assembly is shown schematically in figures 6-22 through 6-26, inclusive.

Constant horsepower device. The maximum horsepower taken from the electric motor is limited by the constant horsepower device. This mechanism is a mechanical and hydraulic arrangement that acts automatically under train overload conditions to return the tilting box toward neutral. The mechanism is actuated by a pilot valve V6A that is opened by main system pressure acting against valve spring tension. The compression of the spring is controlled by a cam which moves with the tilting box to reduce compression as the A-end moves away from neutral. The constant horsepower mechanism momentarily takes control if the combination of hydraulic pressure and stroke of the A-end causes an input horsepower to the A-end in excess of the desired limit. When this occurs, V6A takes control away from the servo pilot valve V23 by shifting the transfer valve V31 to port servo pressure to the opposite end of the servo stroking cylinder. The A-end stroke is then reduced to a point where the overload is relieved. The constant horsepower directional control pilot valve V6A is then shifted by its spring, and control is restored to the servo pilot valve V23.

Neutral return device. The neutral return device provides for manual return of the A-end tilting box to neutral should the electric power fail (or be shut off) while the tilting box is in a stroke position. A hand operated hydraulic pump, the neutral return device is located conveniently near the train operator's station. The pump, with intake connected to the expansion tank, has discharge circuit connections with the transmission control case mechanism valve block. The circuit connections (fig. 6-26) are such that hand pump pressure is directed to the left end of the stroking piston transfer valve V31 to force it to the right. Simultaneously hand pump pressure, directed by servo pilot valve V23, is ported through either chamber of transfer valve V31 to the stroking piston. The hand pump pressure and drain flow which are in reverse of the servo circuit pressure and drain flow at the time of power failure, return the stroking piston (and tilt box) to neutral.

Neutral starting device. The neutral starting device is a starting-circuit switch, which interlocks the position of the A-end tilting box with the electric motor starting circuit. The device is part of an assembly mounted on the side of the A-end. The switch is operated by a cam which is attached to and moves with the tilting box. When the tilting box is at neutral position, the switch and the motor starting circuit are closed. An additional interlock in the electric motor starting circuit is provided by a switch operated by the servo pilot valve V23. The switch closes only when train response and stroke input shafts are not in motion.

Receiver-regulator

A 16-inch Receiver-Regulator Mk 18 Mod 0 is the control instrument for automatic operation of the turret training gear.

An electric-hydraulic instrument enclosed within a case (figs. 6-8 and 6-9), it is located on the electric deck between the electric motor and the A-end (fig. 6-7). The case is divided into two compartments, one of which contains the electric synchros and related gear train. The other compartment contains the valve block and related devices.

The receiver-regulator functions when the control selector lever is positioned at AUTO. In this control selection, servo-system stroking pressure is ported to the stroking cylinder in response to train orders received electrically in the receiver-regulator. In AUTO, the hand control servo stroking valve gear is bypassed.

Components. Each receiver-regulator consists of the following components, all of which are enclosed within the instrument case:

- Fine and coarse control synchros
- Parallax computer
- Turret response gear
- Stroke response gear
- Limit stop device
- Limit stop valve V34
- Stabilizing valve V1
- Stabilizing linkage L2
- Automatic stroking valve V2
- Synchronizing valves V3A and V15
- Synchronizing valve linkage L3
- Pressure regulator valve V43
- Stabilizing piston P1
- Amplifier piston P3
- Amplifier linkage L1
- Hydraulic vibrator

The arrangement of the above electrical, hydraulic, and mechanical components of the receiver-regulator is shown schematically in figure 6-27.

Receiver-regulator instrument (figs. 6-8 and 6-9).

Fine and coarse control synchros. Gun train orders to the receiver-regulator are transmitted by synchro circuits. The rotors of the generators and receivers of both the fine (36-speed) and coarse (1-speed) synchros are connected in parallel to operate on a 115-volt, 60-cycle, single-phase, alternating-current supply. Both synchros are bearing-mounted so that the stators of the synchros can be rotated by parallax correction, turret response, and stroke response. Rotation is accomplished by a system of shafts, gears, and gear differentials. The two synchros and their gear train are located in the synchro compartment (fig. 6-11).

The rotor of the coarse synchro positions the synchronizing pilot valve V15 and the synchronizing valve V3A through the synchronizing linkage L3. The rotor of the fine synchro positions the amplifier linkage L1 and its attached valves.

Parallax computer (fig. 6-10). The parallax correction is computed for the horizontal distance between the director and the turret, and is derived from train angle and parallax range. The parallax computer mechanism enters a mechanical correction to the train order signal and the angle of turret train. The parallax value is variable for each turret, depending upon three factors:

1. The base line distance from the director to the turret.

2. The range of the target.

3. The angle of turret train.

For any angle of turret train, except dead ahead or dead astern, the parallax correction varies inversely with the range. The maximum correction when the target is abeam at short range, and the minimum correction when the target is a few degrees on the bow or quarter at long range.

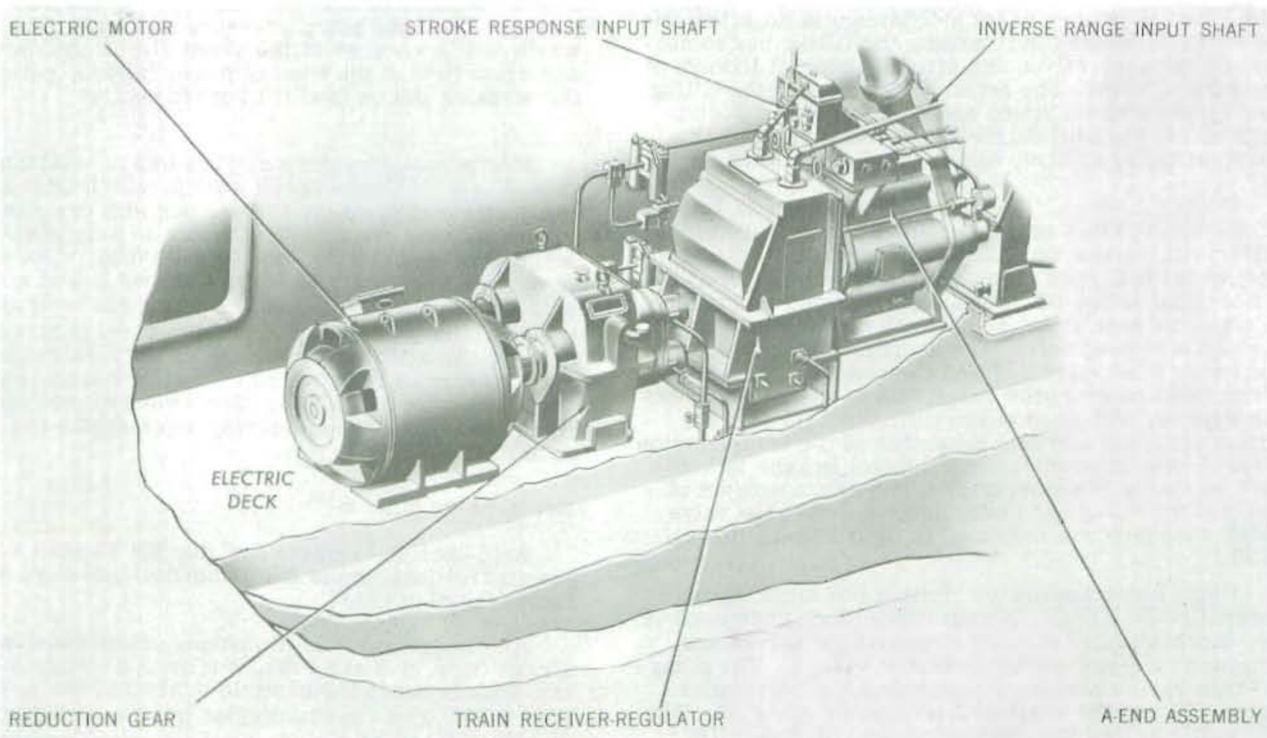


Figure 6-7. 16-inch Receiver-Regulator Mk 18 Mod 5, General Arrangement

The parallax computer solves each problem for each turret and automatically adds the correction to the train response.

The parallax computer receives a shaft input (designated as inverse range) from the train indicator. The input has a limited movement of 18.5 turns, which is equivalent to ranges from infinity to the shortest range of 3400 yards. The other shaft input to the parallax computer (designated angle of turret train) is received in the form of 1-speed input from the B-end response gear. The two designated valves are continuously converted to mechanical correction by the motions of the block (K, fig. 6-28), the crank M and the yoke rack which turns shaft 10B. The movement of the shaft 10B drives the change gears and shaft 10 that add parallax correction to the response input to the fine and coarse synchros, as shown in figure 6-28.

Train response gear. The train (B-end) response gear (figs. 6-11 and 6-12) drives one input gear of the differential that rotates the stators of the coarse and fine synchros through a gear train assembly within the receiver-regulator case. From the right B-end, train response is simultaneously transmitted to the train and elevation indicators to the transmission control case, and to the receiver-regulator. In the receiver-regulator, the B-end response combines with parallax correction to rotate the stators of the

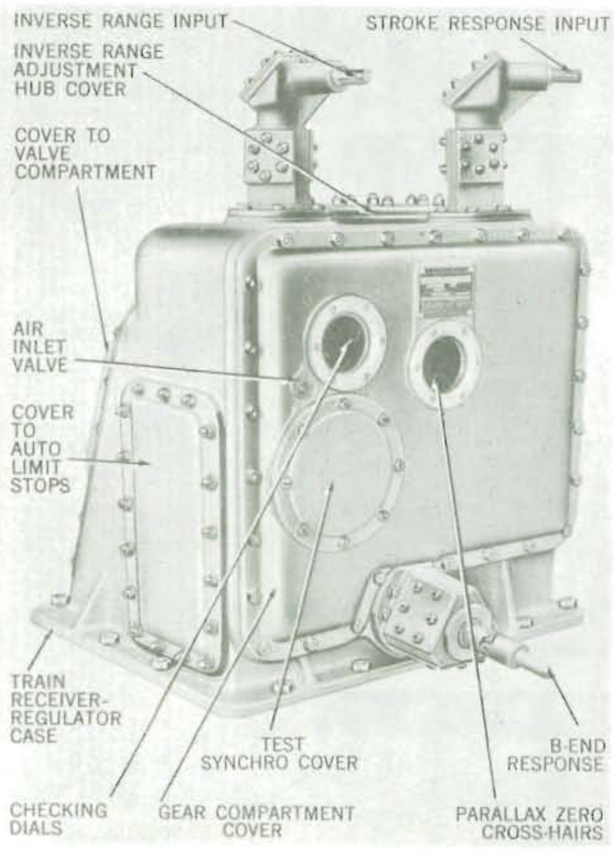


Figure 6-8. Train Receiver-Regulator Mk 18 Mod 5, Front View

coarse and fine synchros. B-end response and stroke response are combined in a differential to position the limit stop valve V34 through a connecting link from the train limit stop.

Stroke response gear. The A-end stroke response is a mechanical input derived from a gear box attached above the A-end control case. The gear box receives tilting box motion through the A-end control case and steps up the motion to a ratio of 15 to 1. This new value is transmitted as stroke response to the receiver-regulator by means of shafts connected to the adjustable coupling, designated B. In the receiver-regulator, stroke response combines with B-end response through differential gearing to position the limit-stop valve V34 through the train limit stop. Stroke response represents turret training speed; it is combined with B-end (turret position) response to make the limit stop valve V34 operate sooner at high speeds than it does at low speeds as the turret approaches its limit.

Limit stop device. The automatic train limit stop (figs. 6-13 and 6-14) receives a combination of the angle of turret train and the speed of turret train through a mechanical differential.

The device consists of series of discs and lugs which are free to rotate on shaft 8B (fig. 6-27). Each disc contains a pin which extends about 3/32 inch on either side of the disc and is pressed through the disc about 9/16 inch from its center. The discs are assembled alternately on a common shaft with the lugs. The lugs engage the pins as the drive shaft input rotates. As the disc at the input end of the assembly is rotated, the pins on successive discs engage successive lugs, until after several revolutions of the first disc the entire assembly rotates as a unit. The last lug to be engaged operates a cam which rotates the limit stop drive shaft. The shaft then moves the limit stop valve V34 which is also the sleeve for the stabilizing valve V1.

Limit stop valve (V34). The limit stop valve V34, located in a valve block at the bottom of the receiver-regulator, is positioned by the movement of a crank which is actuated by the limit stop device. V34 is normally centered in its position by a spring at either end. When displaced from center by the limit stop device, V34 shifts servo pressure flow to and drain from the stroking piston P2 to decelerate and stop the turret at its preset limit.

Stabilizing valve V1. The stabilizing valve V1, located within the limit stop valve V34 body, acts with the stabilizing piston P1 to prevent overtravel of the turret (B-ends) which would result in oscillation about the train order signal. Positioned by the stabilizing linkage L2, the stabilizing valve V1 directs regulator control pressure to one end or the other of the stabilizing piston P1. Movement of piston P1 positions the amplifier piston P3 and amplifier linkage L1 and also moves the stabilizing valve V1 back to its original position.

Stabilizing linkage L2. The stabilizing linkage L2, shown in figure 6-9, is mounted in a vertical position in the valve compartment of the receiver-regulator. At its upper end, the stabilizing linkage L2 is connected to the amplifier piston P3. The middle of L2 is connected to the stabilizing piston P1. At the lower end, L2 is connected to both the automatic stroking valve V2 and the stabilizing valve V1.

Automatic stroking valve V2. The automatic stroking valve V2 is located in a separate valve block, shown in figure 6-9, at the lower left side of the receiver-regulator valve compartment. Positioned by the stabilizing linkage L2, V2 ports servo pressure flow to and drain (through control transfer valve V3B) from the stroking piston P2.

Synchronizing valve V3A and synchronizing pilot valve V15. The synchronizing valve V3A and synchronizing pilot valve V15 are located in a valve block, shown in figure 6-9, in the upper part of the receiver-regulator valve compartment. Both valves are positioned by the synchronizing valve linkage L3, which is actuated by rotation of the rotor of the coarse (1-speed) synchro. The synchronizing pilot valve V15, when centered, ports regulator control pressure to the synchronizing valve V3A, which directs the regulator control pressure to the fine synchro valve V3 as long as the turret position is within three degrees of the gun train order. V3 then controls servo piston movement through the amplifier piston P3, stabilizing linkage L2, and the automatic stroking valve. V2. When the turret position is more than three degrees away from gun train order, V3A cuts off regulator control pressure to V3 and ports the pressure directly to P3 to drive the turret at full speed toward its synchronized position.

Synchronizing valve linkage L3. The synchronizing valve linkage shown in figure 6-9 is located in the upper part of the receiver-regulator valves compartment. L3 is actuated by rotation of the rotor of the coarse (1-speed) synchro to position V3A and V15.

Pressure regulator valve V42. The pressure regulator valve V42 is located in the valve block in the center portion of the receiver-regulator valve compartment (fig. 6-9). Servo pressure, ported to valve V42 at a pressure of approximately 350 pounds per square inch, is reduced to a control pressure of approximately 135 pounds per square inch. Control pressure is ported through the stabilizing valve V1 to the stabilizing piston P1. It is also ported to the synchronizing pilot valve V15 and through it to the synchronizing valve V3A. From V3A, control pressure is ported through the fine synchro valve V3 to the amplifier piston P3.

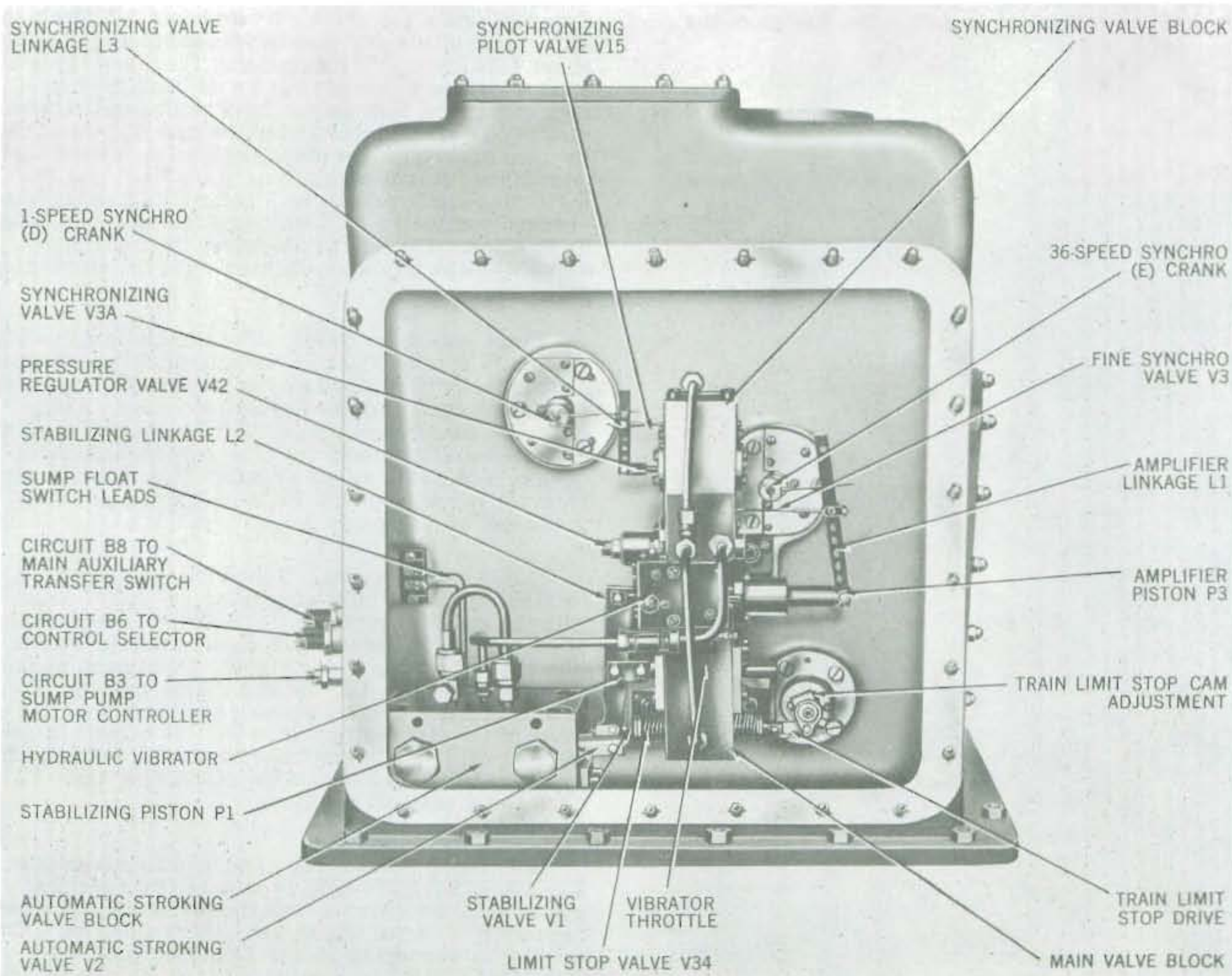


Figure 6-9. Train Receiver-Regulator Mk 18 Mod 5,Valve Compartment

Stabilizing piston P1. The stabilizing piston P1 is located in the valve block in the center of the receiver-regulator valve compartment (fig. 6-9). Piston P1 acts to change the pivot point in the stabilizing linkage L2, thereby affecting the response of the amplifier piston P3 to the movement of the fine synchro valve V3. The arrangement prevents overtravel and oscillation of the turret about the train order signal. The stabilizing valve V1 regulates the porting of regulator control pressure to the chambers of the stabilizing piston P1.

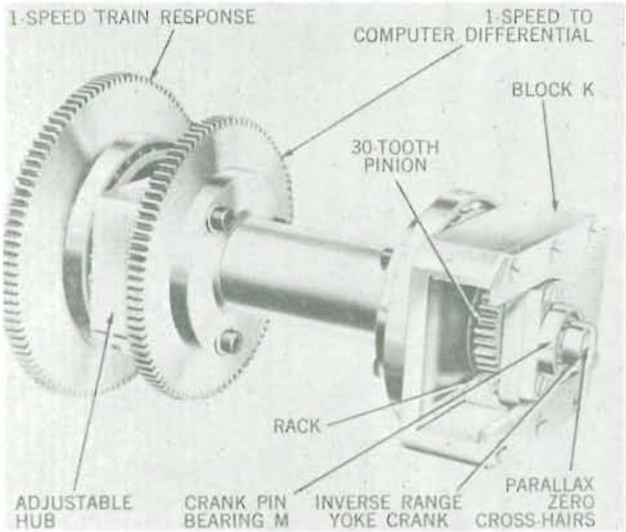


Figure 6-10. Train Receiver-Regulator Mk 18 Mod 5 Parallax Computer Drive

Amplifier piston P3. The amplifier piston P3 (fig. 6-9) is located in the valve block in the center of the receiver-regulator. P3 is moved in fine synchro control by regulator control pressure ported to it by the fine synchro valve V3. Amplifying V3 movement, P3 acts through the amplifier linkage L1 to return V3 to neutral. P3 acts through the stabilizing linkage L2 to position the automatic stroking valve V2. In coarse synchro control, regulator control pressure is ported directly to P3 to drive the turret at full speed toward its synchronized position.

Amplifier linkage L1. The amplifier linkage L1 (fig. 6-9) is located in the upper right portion of the receiver-regulator valve compartment. The upper end of L1 is connected to the rotor of the fine (36-speed) synchro, and is positioned by rotation of the rotor. The opposite end of L1 is connected to the amplifier piston P3. Synchro rotor movement acts through L1 to move the fine synchro valve V3. Amplifying movement of P3 acts back through L1 to move V3 back to its original position.

Hydraulic vibrator. The hydraulic vibrator (fig. 6-9), located in the center of the receiver-regulator valve compartment, runs on servo pressure as a double-acting, two-cylinder reciprocating engine. The device oscillates the amplifier piston P3 through a very small amplitude at about 30 cycles per second to prevent static friction in the valves and linkages.

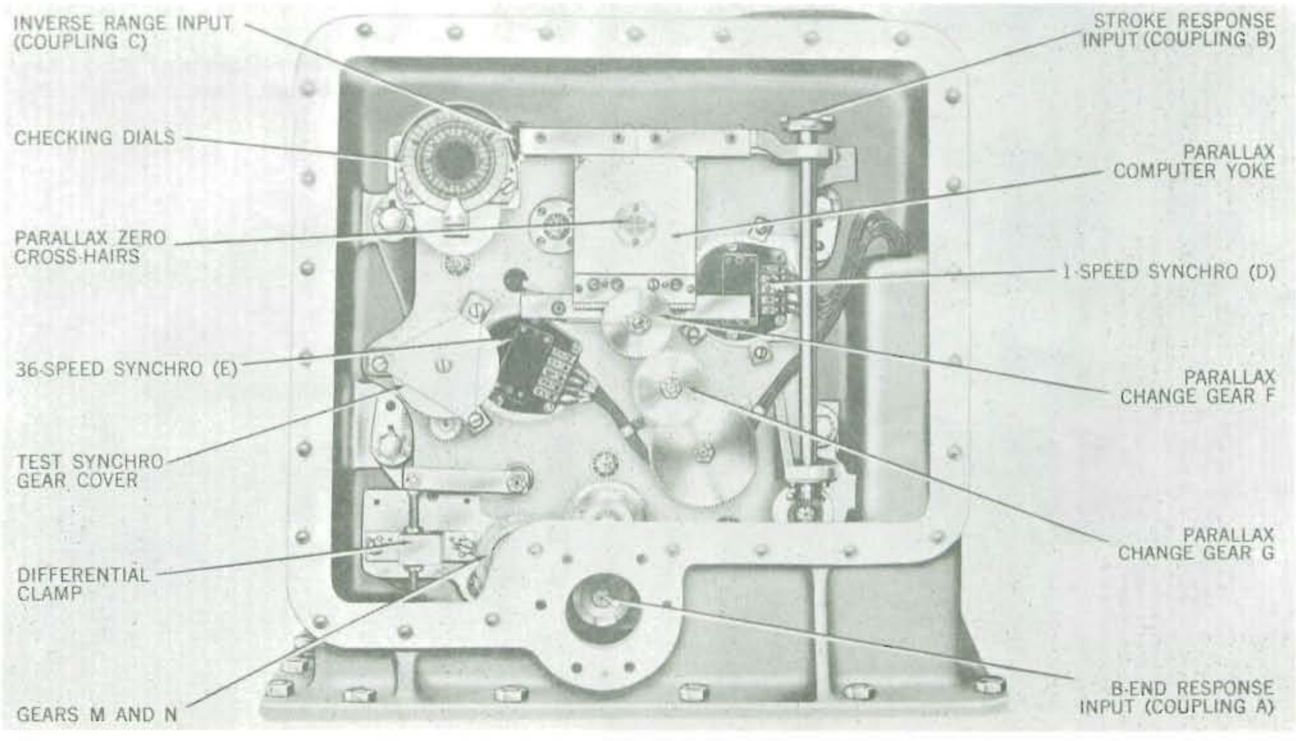


Figure 6-11. Train Receiver-Regulator Mk 18 Mod 5 Front View - Cover Removed

Control selector. The turret training control selector (fig. 6-15) is a manually operated hydraulic valve that permits selection of AUTO or HAND control of the train power drive hydraulic transmission.

Selector lever. The control selector unit is adjacent to the train operator's station and is provided with a selector lever. The lever is positioned by the train operator to the desired method of control, indicated on the lever position dial plate by the selector lever. The control selector valve V4 is positioned within the control selector valve block by rotation of the selector lever.

Control selector valve V4. The control selector valve V4 is located in the control selector unit, as shown in the schematic diagram of figure 6-28. Servo pressure, admitted to the control selector valve block through port number 50, is ported by the synchro failure valve V11 to the center section of V4 and to the chamber of the synchro failure latching valve V45. When the selector lever is at AUTO, pressure is ported from V4 to the transfer acceleration limiting valve TALV, to the control transfer valve V3B, and to the handwheel clutch.

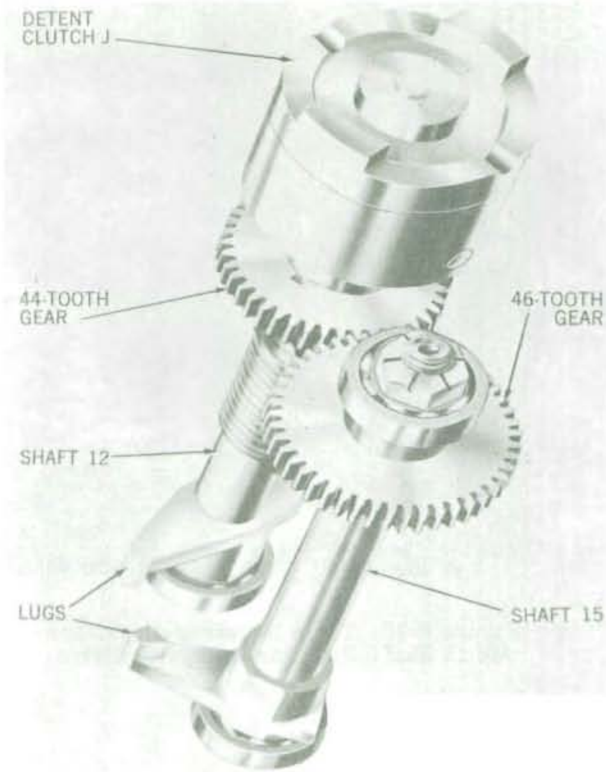


Figure 6-13. Train Receiver-Regulator Mk 18 Mod 5 Parallax-Computer Range Limit Stop Device

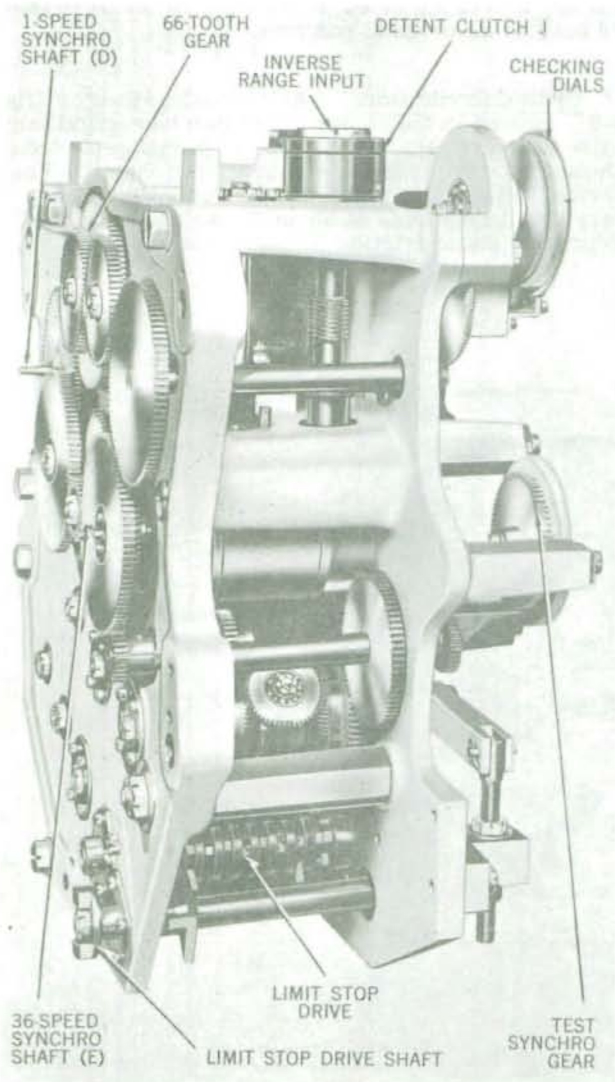


Figure 6-12. Train Receiver-Regulator Mk 18 Mod 5 Gear Box Assembly, Side View

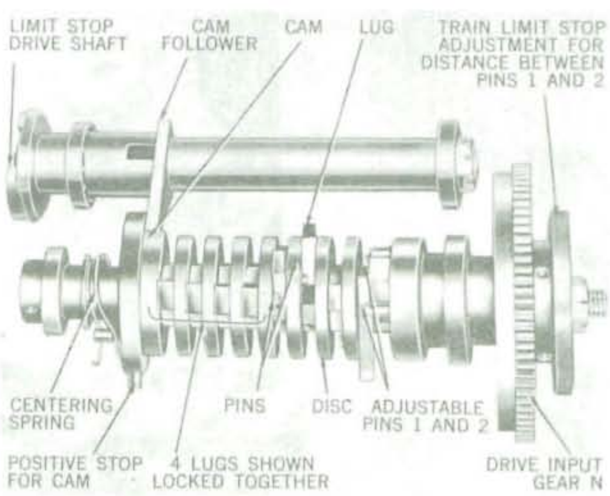


Figure 6-14. Train Receiver-Regulator Mk 18 Mod 5 Limit Stop Drive Assembly

Synchro failure valve V11. The synchro failure valve V11 is located within the control selector unit (fig. 6-27) together with the synchro failure solenoid S3. The synchro failure valve V11 transfers control automatically to the train operator's handwheels in the event of a failure of synchro power. Should synchro power fail, the synchro failure solenoid S3 is de-energized and a spring forces valve V11 to the right to cut off servo pressure to the automatic control elements. If the synchro power is restored, the control remains with the handwheels until the selector lever is moved to HAND and then back to AUTO.

Synchro failure latching valve V45. The synchro failure latching valve V45 is located within the control selector unit, adjacent to the control selector valve V4. When V11 cuts off servo pressure and causes the servo pressure behind the synchro failure latching valve V45 to fail, V45 will move to the left under spring pressure. As V45 moves to the left, it cuts off servo pressure flow through port number 10. When synchro power is restored, servo pressure cannot pass through V4 because V45 has remained all the way to the left.

Control transfer valve V3B. The control transfer valve V3B (fig. 6-16), located on the right side of the A-end, transfers turret training control from the train operator's handwheels to the receiver-regulator. When servo pressure is ported to V3B from the control selector unit, V3B is moved to the right against spring pressure. This connects the automatic stroking valve V2 in the receiver-regulator to the stroking piston, through V3B.

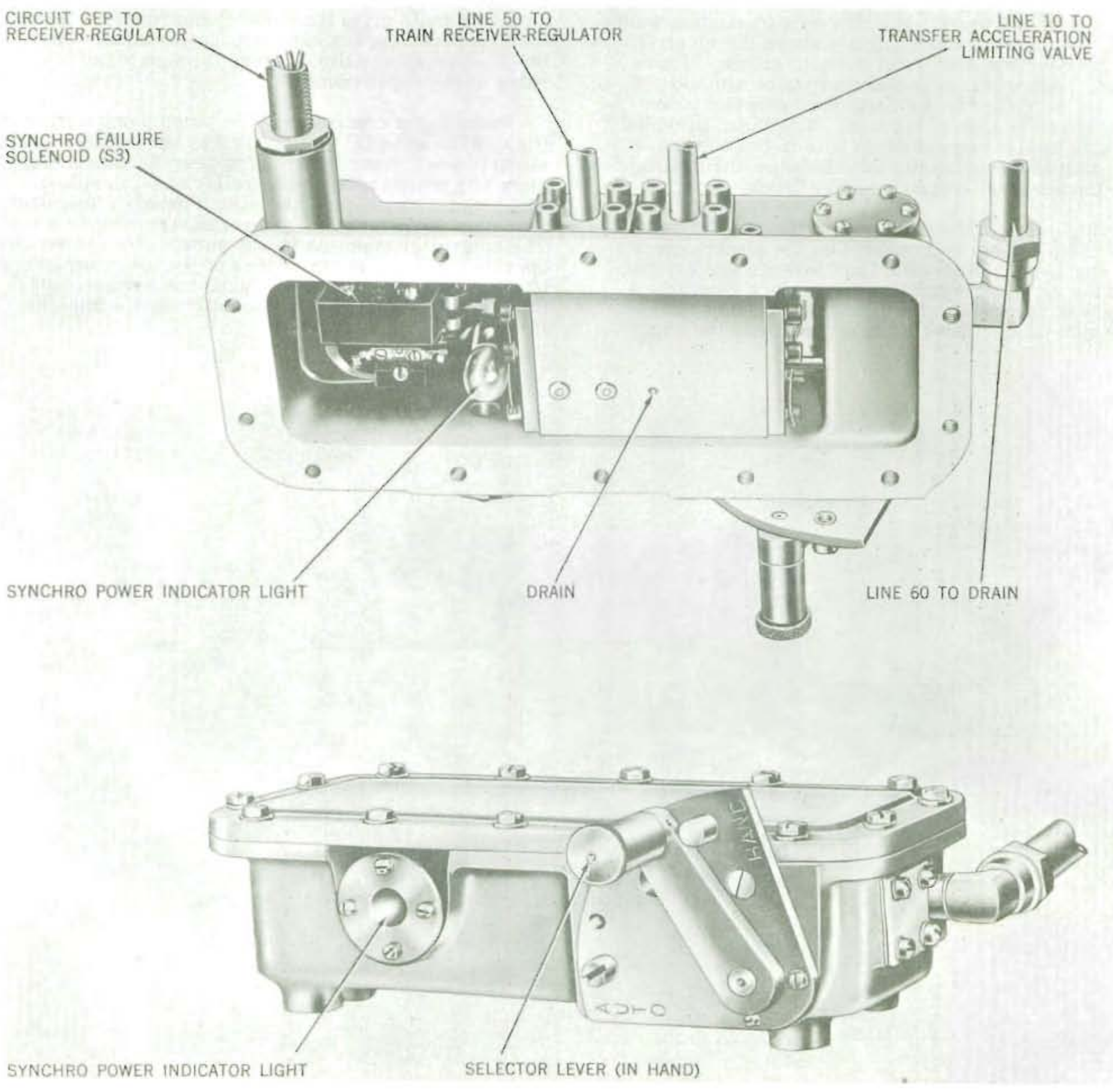


Figure 6-15. Train Receiver-Regulator Mk 18 Mod 5 Selector and Synchro Failure Valve

Transfer acceleration limiting valve TALV. The transfer acceleration limiting valve TALV (fig. 6-17), located near the A-end, prevents excessive turret train speed when shifting from AUTO to HAND. In AUTO, servo pressure is ported to TALV from the control selector to hold the valve open against its spring. When the selector lever is moved from AUTO to HAND, the unbalanced valve TALV, bound against the side wall by servo pressure, closes partly and restricts flow in the line to the left chamber of the stroking cylinder P2. As soon as the turret synchronizes with the handwheels, the servo pilot valve V23 cuts off servo pressure to TALV which then is moved by its spring to remove the restriction in the line to the stroking cylinder P2.

Sump tank. The sump tank (fig. 6-18) forms the base on which the receiver-regulator is mounted. A rectangular box-like weldment, the tank has internal arrangements for two floats, a valve, a mercury switch S4, a sump pump float switch S5, and two manifold blocks and pipes. Mounted on a foundation weldment, the tank is raised slightly above the electric deck between the A-end and electric motor. There are two removable inspection covers on one side of the tank and four flanged ports for hydraulic pipes on the opposite side of the tank. The tank, provided with a normally plugged drain hole in the bottom, is a receptacle for hydraulic fluid leakage and drainage from the receiver-regulator valve block.

Sump pump. The sump pump (fig. 6-19) is a separate motor-pump set, located on the electric deck near the A-end. Hydraulic fluid leakage and drainage from the receiver-regulator valve block goes into a sump tank from which the fluid is pumped back to the expansion tank. Under normal conditions the sump pump (a rotary gear pump driven by a one-horsepower alternating current motor) runs whenever the electric motor is running. The capacity of the pump is greater than the normal drainage into the sump tank; therefore, part of the oil is recirculated back to the sump tank. Whenever the oil level becomes too low, the float-operated sump pump valve V40 opens and permits the pump discharge to return to the sump tank to assure adequate oil supply to the pump at all times. If the sump pump unit is not used for several days, oil may gradually fill the tank. Should the oil get abnormally high, the float-operated mercury switch S4 actuates a magnetic switch S5 in the sump pump control unit and thereby starts the pump. The pump lowers the oil level until the float switch cuts off the pump motor circuit. In case of failure of the float switch, the pump may be run by closing the sump pump emergency switch.

If the sump pump should fail, the sump tank will fill completely. Sump tank check valve V41 will close, sealing the synchro compartment, and pressure will build up in the valve compartment. When the pressure reaches eight pounds per square inch, the discharge oil will be forced through the check valve to the expansion tank.

Sump pump controller. The sump pump controller (figs. 6-20 and 6-21) is mounted on the bulkhead at the electric deck, near the training gear A-end. It consists of a standard-type controller case, inside of which are a shock-mounted switch panel, a line switch, a control transformer, and necessary interlocks. The controller contains four separate circuits which operate the sump pump motors of the elevating gears for the right gun, the center gun, the left gun, and the turret training gear. Each circuit is complete in itself.

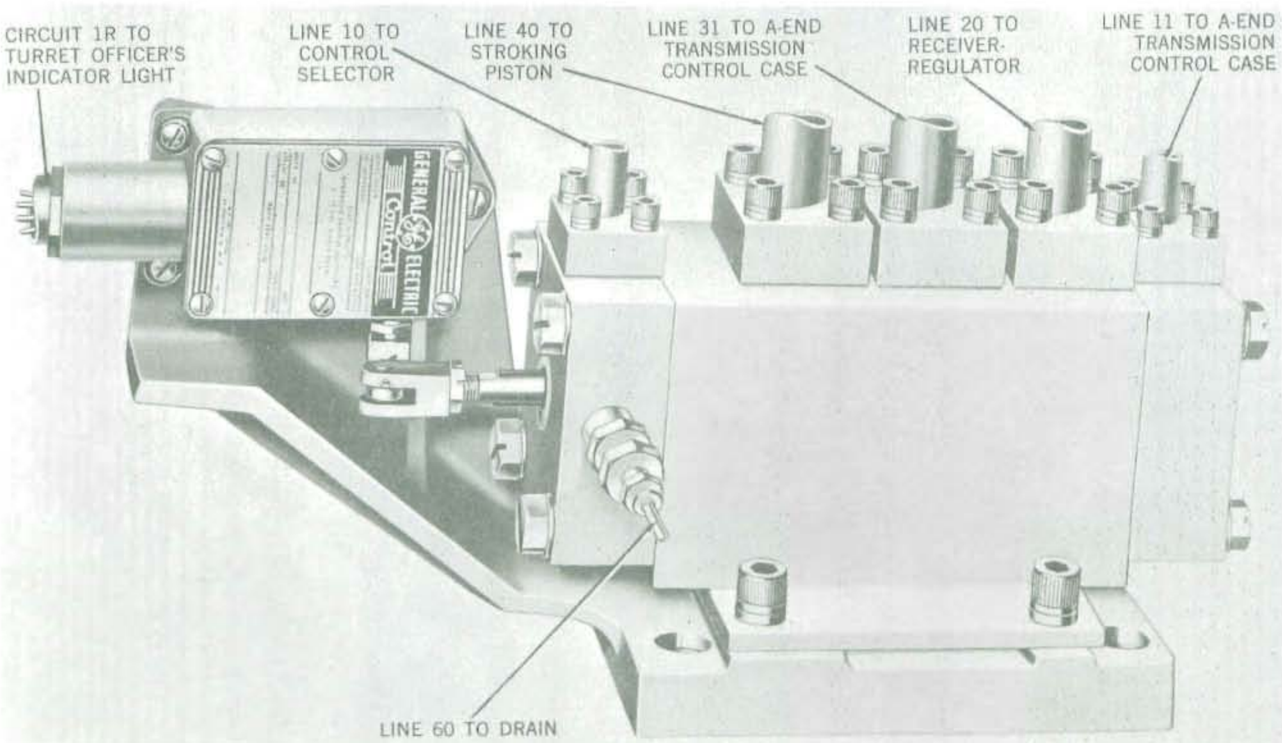


Figure 6-16. Train Receiver-Regulator Mk 18 Mod 5 Control Transfer Valve

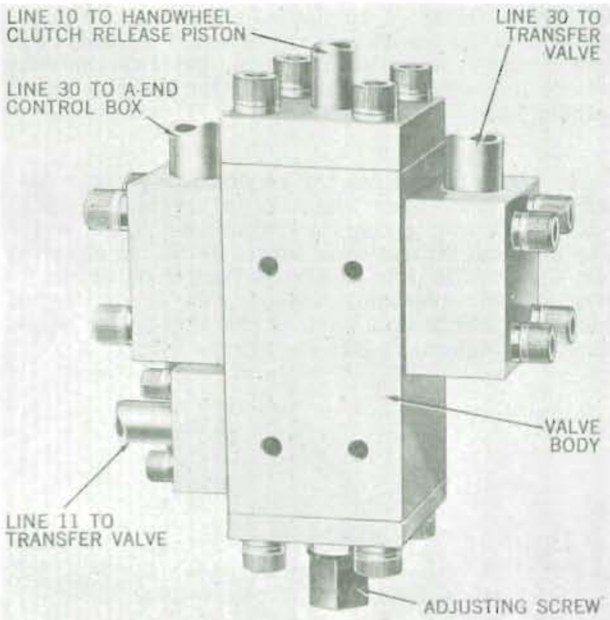


Figure 6-17. Train Receiver-Regulator Mk 18 Mod 5 Transfer Acceleration Limiting Valve

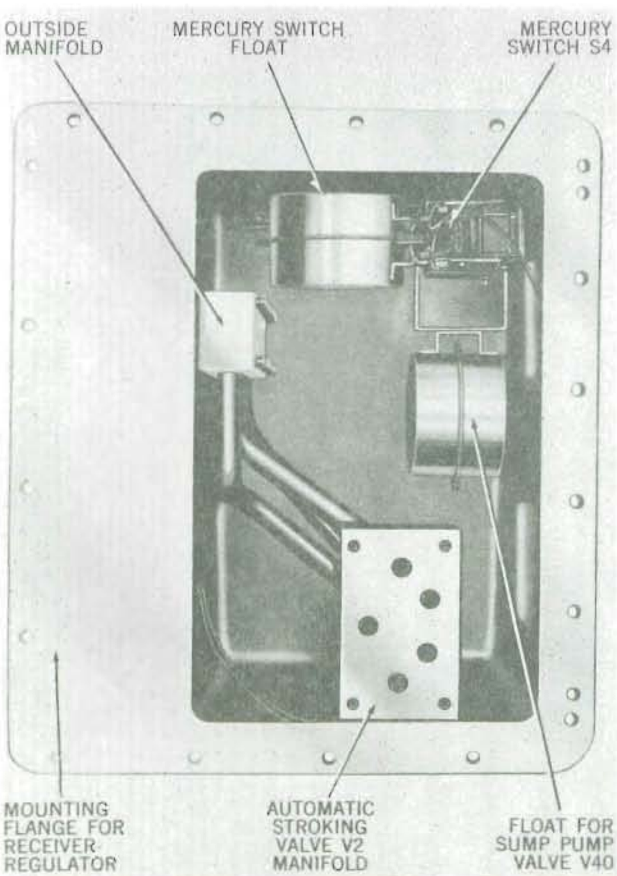


Figure 6-18. Train Receiver-Regulator Mk 18 Mod 5 Sump Tank

When the electric motor of the training gear power drive is started, the corresponding magnetic switch in the sump pump controller closes the circuit to its sump pump. Each magnetic switch has two solenoids that are linked together mechanically and connected to the contact mechanism. One solenoid is for 440 volts and the other is for 110 volts. Either solenoid can close the switch. While the power drive is operating, the 440-volt solenoid is energized from one phase of the main controller; therefore, the sump pump operates whenever its power drive is operated.

If the power drive is not operating and oil leakage fills the sump tank, a float-operated mercury switch closes a 110-volt circuit and thereby closes the magnetic switch by energizing the 110-volt solenoid. The 110-volt power is supplied by a transformer in the controller case.

Firing stop mechanism

The firing stop mechanism automatically opens the gun firing circuits and closes the signal light circuits in zones of obstructed fire. The installation is the same in each turret and consists of three pairs of cam-operated switches, each composed of an elevating movement switch and a train movement switch. The switches are connected in series, and both switches must be closed before the firing circuit for that gun is complete. Of the same design, all switches are two-circuit plunger-type interlock switches with the firing circuit normally closed and the signal circuit normally open. Each elevating movement switch is similarly located on the right deck lug of its gun. The plunger roller of the switch is positioned to be contacted by an adjustable actuating cam mounted on the lower shield plate of the slide. The three cams have identical settings to actuate and hold the switch plunger for the respective gun throughout that gun's arc of fire. The three gun train movement switches (one for each gun in a turret) are mounted on the turret holding-down clip. Their actuating cams are attached to the lower roller path. The cams actuate and hold the switch plunger for the respective gun throughout the arc of fire of the turret.

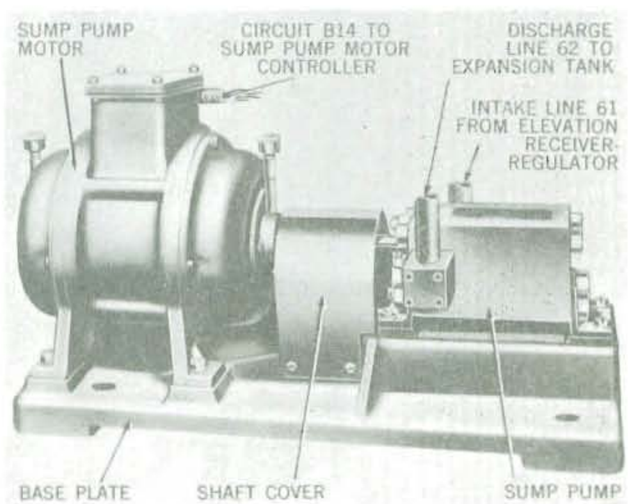


Figure 6-19. Train Receiver-Regulator Mk 18 Mod 5 Sump Tank

The signal light circuit operates a multiple arrangement of red signal lights. These include signal lights at each gun layer's station and a three-dial signal light indicator at the pointer's and trainer's stations. In addition, there are three-dial signal light indicators at the train operator's station and at the turret officer's station. The warning signal system is provided with a separate switch that functions simultaneously with, or slightly before, the firing system switch.

OPERATION

Training gear control methods are substantially different in the two control selections. Hand servo-control operation of the power drive when the control selector lever is positioned at HAND, is described on page 6-21 of this chapter. The description of HAND control is illustrated in figures 6-22 to 6-26. Automatic servo-control operation, when the control selector lever is positioned at AUTO, is described in other paragraphs of this chapter. The description of AUTO control is illustrated by figure 6-27.

General hand and automatic control

In normal HAND operation, the train order signal is received in the train indicator. The train operator observes the gun train signal, as indicated by the pointers in the train indicator, and compares that signal with the position of the turret. If there is a "matching error" in the pointers, the train operator rotates the handwheels in a direction and at a speed calculated to "match pointers."

In AUTO operation, the receiver-regulator receives the train order signal from a remote ship's station. By comparing the train order signal with a mechanical indication of turret train, the receiver-regulator continually measures "matching error." The receiver-regulator measures the error by electrical and mechanical devices and acts on the servo stroking piston to reduce the error.

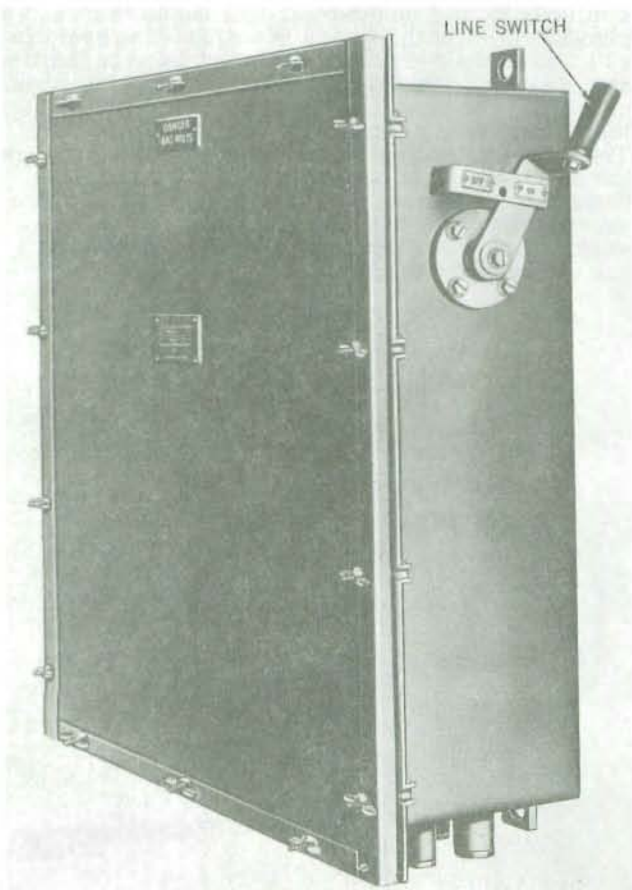


Figure 6-20. Train Receiver-Regulator Mk 18 Mod 5 Sump Pump Control Unit

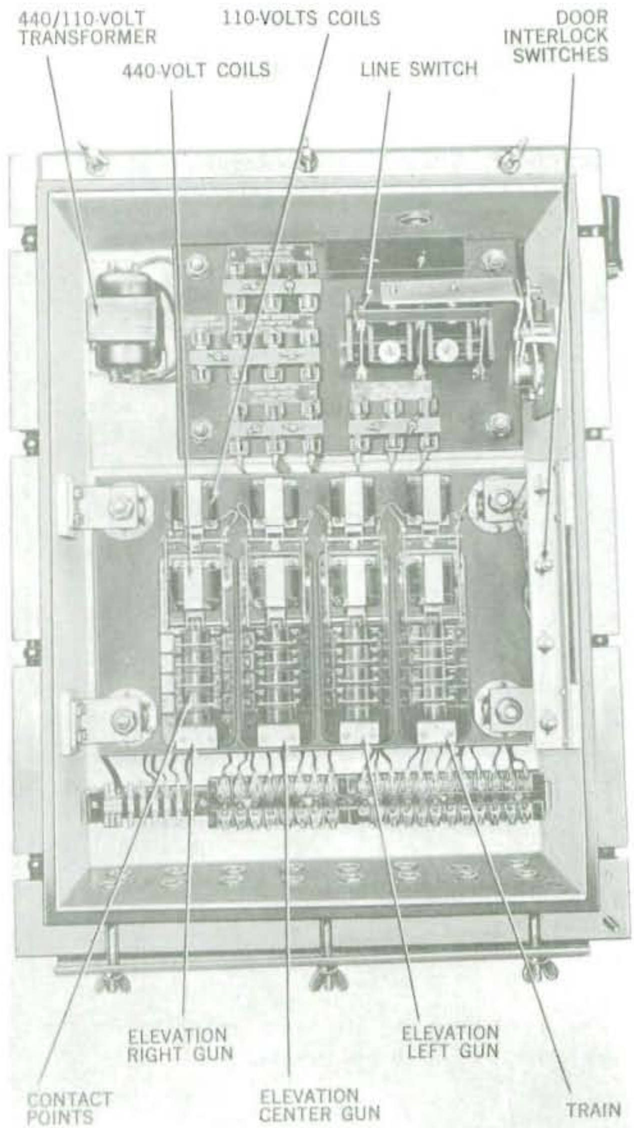
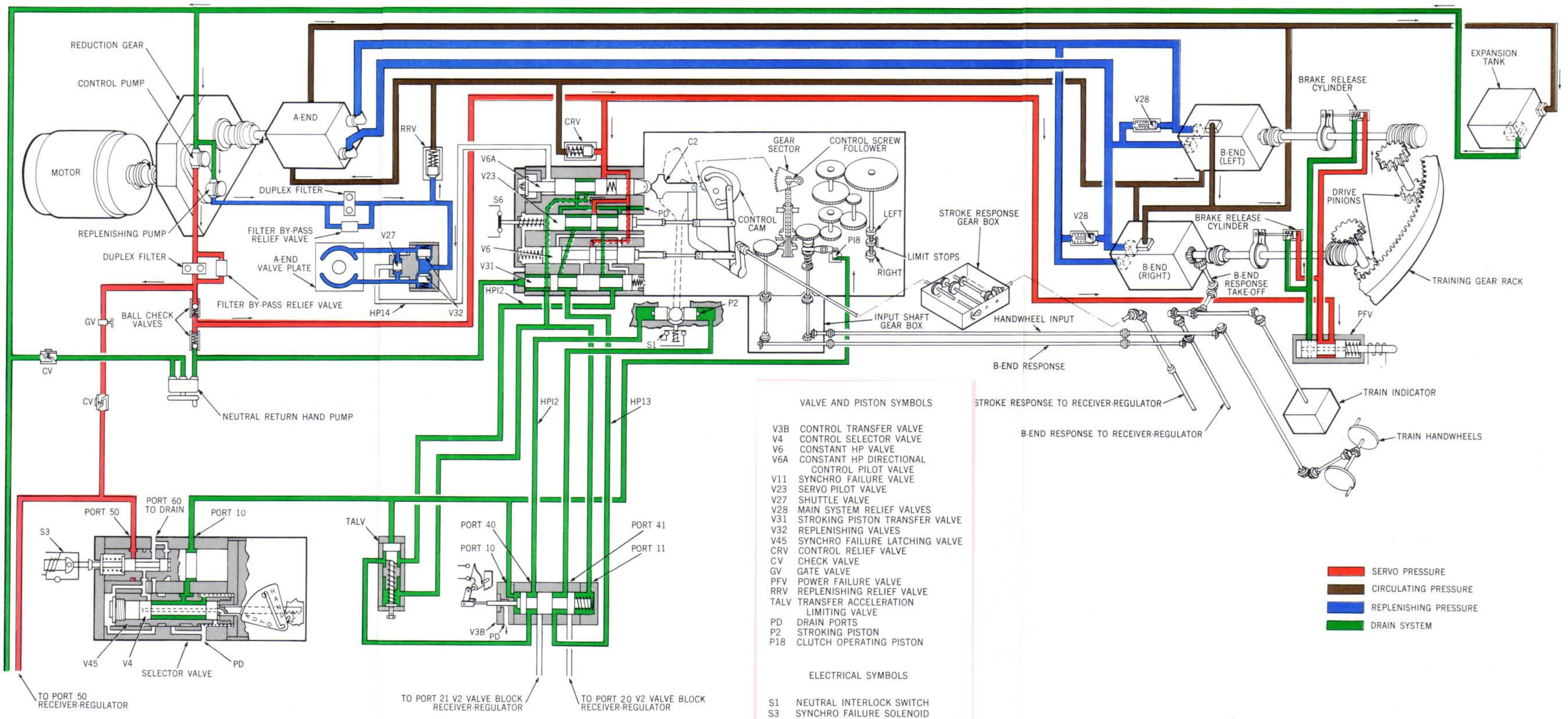


Figure 6-21. Train Receiver-Regulator Mk 18 Mod 5 Sump Pump Control Unit, Door Open



VALVE AND PISTON SYMBOLS

V3B	CONTROL TRANSFER VALVE
V4	CONTROL SELECTOR VALVE
V6	CONSTANT HP VALVE
V6A	CONSTANT HP DIRECTIONAL CONTROL PILOT VALVE
V11	SYNCHRO FAILURE VALVE
V23	SERVO PILOT VALVE
V27	SHUTTLE VALVE
V28	MAIN SYSTEM RELIEF VALVES
V31	STROKING PISTON TRANSFER VALVE
V32	REPLENISHING VALVES
V45	SYNCHRO FAILURE LATCHING VALVE
CRV	CONTROL RELIEF VALVE
CV	CHECK VALVE
GV	GATE VALVE
PFV	POWER FAILURE VALVE
RRV	REPLENISHING RELIEF VALVE
TALV	TRANSFER ACCELERATION LIMITING VALVE
PD	DRAIN PORTS
P2	STROKING PISTON
P18	CLUTCH OPERATING PISTON

ELECTRICAL SYMBOLS

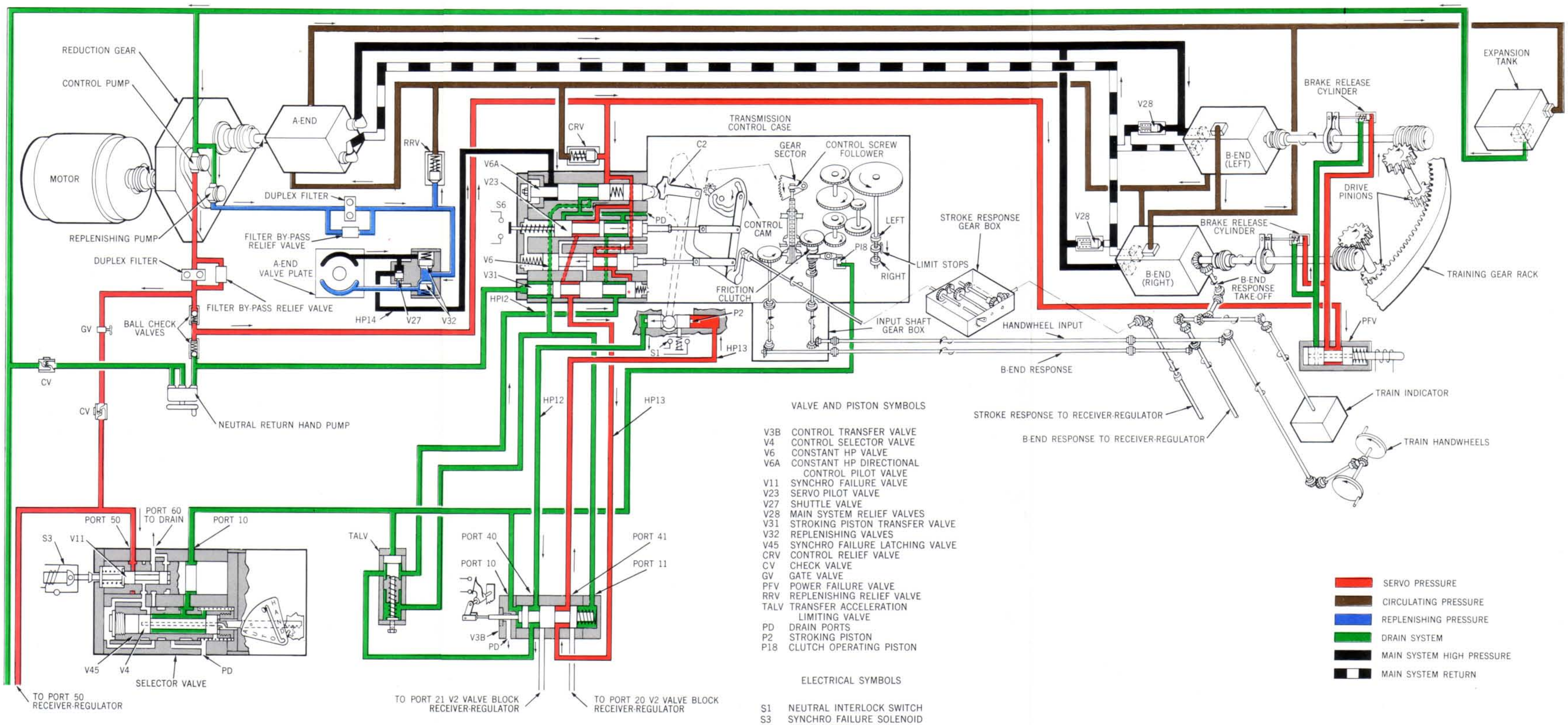
S1	NEUTRAL INTERLOCK SWITCH
S3	SYNCHRO FAILURE SOLENOID
S6	SERVO INTERLOCK SWITCH

MECHANICAL SYMBOL

C2	CONSTANT HP CAM

Figure 6-22. Training Gear Hand Control System Diagram, Transmission - Controls Neutral, Power On

Table of Contents



VALVE AND PISTON SYMBOLS

- V3B CONTROL TRANSFER VALVE
- V4 CONTROL SELECTOR VALVE
- V6 CONSTANT HP VALVE
- V6A CONSTANT HP DIRECTIONAL CONTROL PILOT VALVE
- V11 SYNCHRO FAILURE VALVE
- V23 SERVO PILOT VALVE
- V27 SHUTTLE VALVE
- V28 MAIN SYSTEM RELIEF VALVES
- V31 STROKING PISTON TRANSFER VALVE
- V32 REPLENISHING VALVES
- V45 SYNCHRO FAILURE LATCHING VALVE
- CRV CONTROL RELIEF VALVE
- CV CHECK VALVE
- GV GATE VALVE
- PFV POWER FAILURE VALVE
- RRV REPLENISHING RELIEF VALVE
- TALV TRANSFER ACCELERATION LIMITING VALVE
- PD DRAIN PORTS
- P2 STROKING PISTON
- P18 CLUTCH OPERATING PISTON

ELECTRICAL SYMBOLS

- S1 NEUTRAL INTERLOCK SWITCH
- S3 SYNCHRO FAILURE SOLENOID
- S6 SERVO INTERLOCK SWITCH

MECHANICAL SYMBOL

- C2 CONSTANT HP CAM

Figure 6-23. Training Gear Hand Control System Diagram, Right Train - Normal Control

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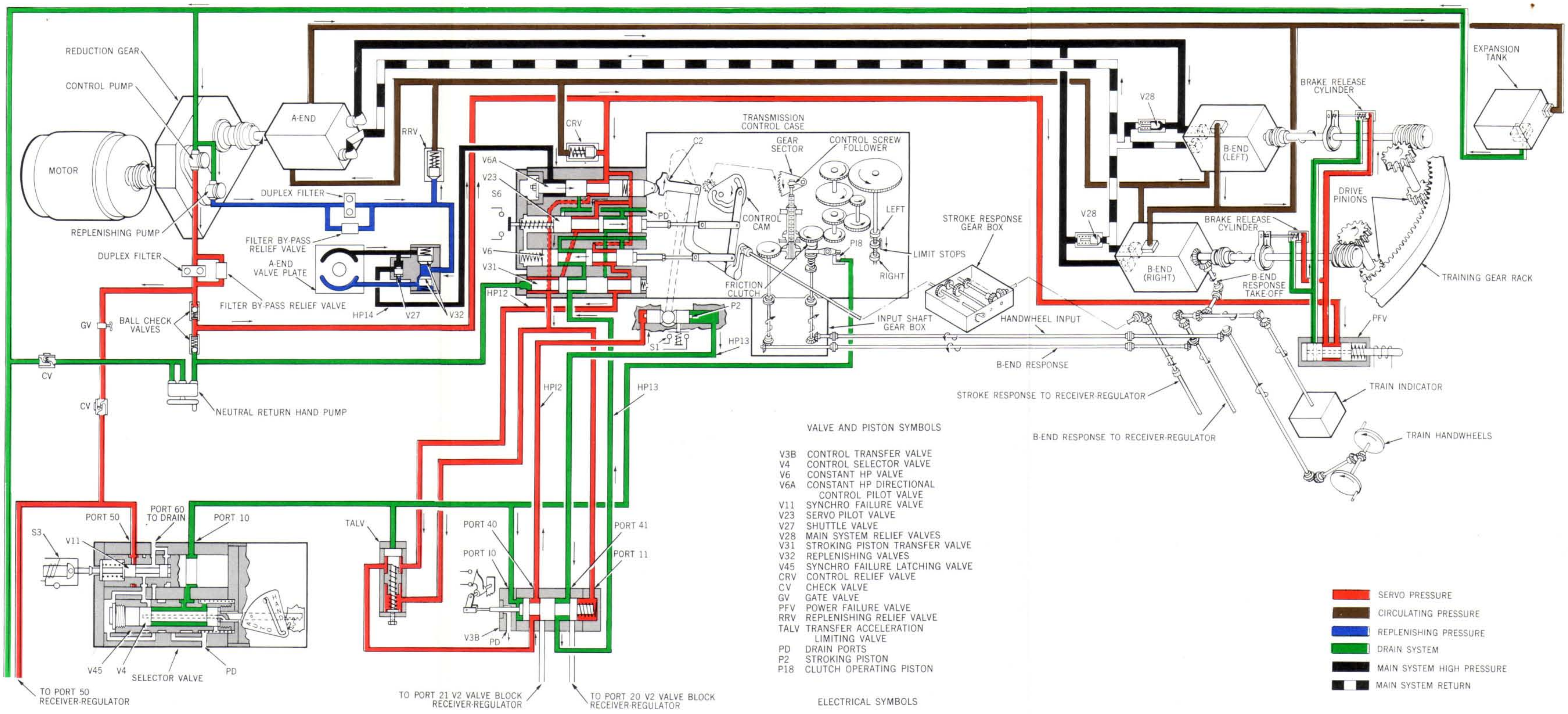
Table of Contents



VALVE AND PISTON SYMBOLS

V3B	CONTROL TRANSFER VALVE
V4	CONTROL SELECTOR VALVE
V6	CONSTANT HP VALVE
V6A	CONSTANT HP DIRECTIONAL CONTROL PILOT VALVE
V11	SYNCHRO FAILURE VALVE
V23	SERVO PILOT VALVE
V27	SHUTTLE VALVE
V28	MAIN SYSTEM RELIEF VALVES
V31	STROKING PISTON TRANSFER VALVE
V32	REPLENISHING VALVES
V45	SYNCHRO FAILURE LATCHING VALVE
CRV	CONTROL RELIEF VALVE
CV	CHECK VALVE
GV	GATE VALVE
PFV	POWER FAILURE VALVE
RRV	REPLENISHING RELIEF VALVE
TALV	TRANSFER ACCELERATION LIMITING VALVE
PD	DRAIN PORTS
P2	STROKING PISTON
P18	CLUTCH OPERATING PISTON

ELECTRICAL SYMBOLS

S1	NEUTRAL INTERLOCK SWITCH
S3	SYNCHRO FAILURE SOLENOID
S6	SERVO INTERLOCK SWITCH

MECHANICAL SYMBOL

C2	CONSTANT HP CAM

Figure 6-24. Training Gear Hand Control System Diagram, Constant Horsepower Control

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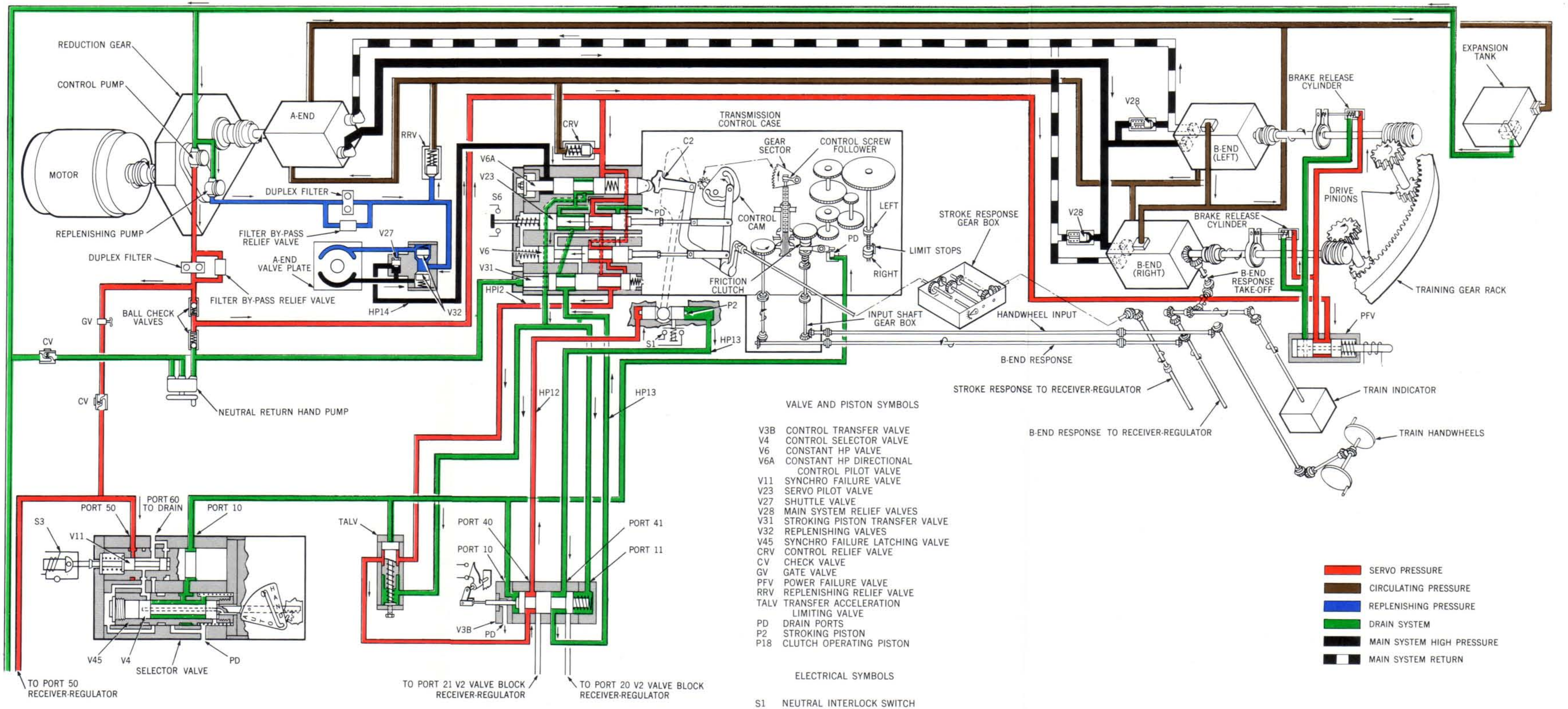
Table of Contents



VALVE AND PISTON SYMBOLS

V3B	CONTROL TRANSFER VALVE
V4	CONTROL SELECTOR VALVE
V6	CONSTANT HP VALVE
V6A	CONSTANT HP DIRECTIONAL CONTROL PILOT VALVE
V11	SYNCHRO FAILURE VALVE
V23	SERVO PILOT VALVE
V27	SHUTTLE VALVE
V28	MAIN SYSTEM RELIEF VALVES
V31	STROKING PISTON TRANSFER VALVE
V32	REPLENISHING VALVES
V45	SYNCHRO FAILURE LATCHING VALVE
CRV	CONTROL RELIEF VALVE
CV	CHECK VALVE
GV	GATE VALVE
PFV	POWER FAILURE VALVE
RRV	REPLENISHING RELIEF VALVE
TALV	TRANSFER ACCELERATION LIMITING VALVE
PD	DRAIN PORTS
P2	STROKING PISTON
P18	CLUTCH OPERATING PISTON

ELECTRICAL SYMBOLS

S1	NEUTRAL INTERLOCK SWITCH
S3	SYNCHRO FAILURE SOLENOID
S6	SERVO INTERLOCK SWITCH

MECHANICAL SYMBOL

C2	CONSTANT HP CAM

Figure 6-25. Training Gear Hand Control System Diagram, Right Train, Limit Stop Control

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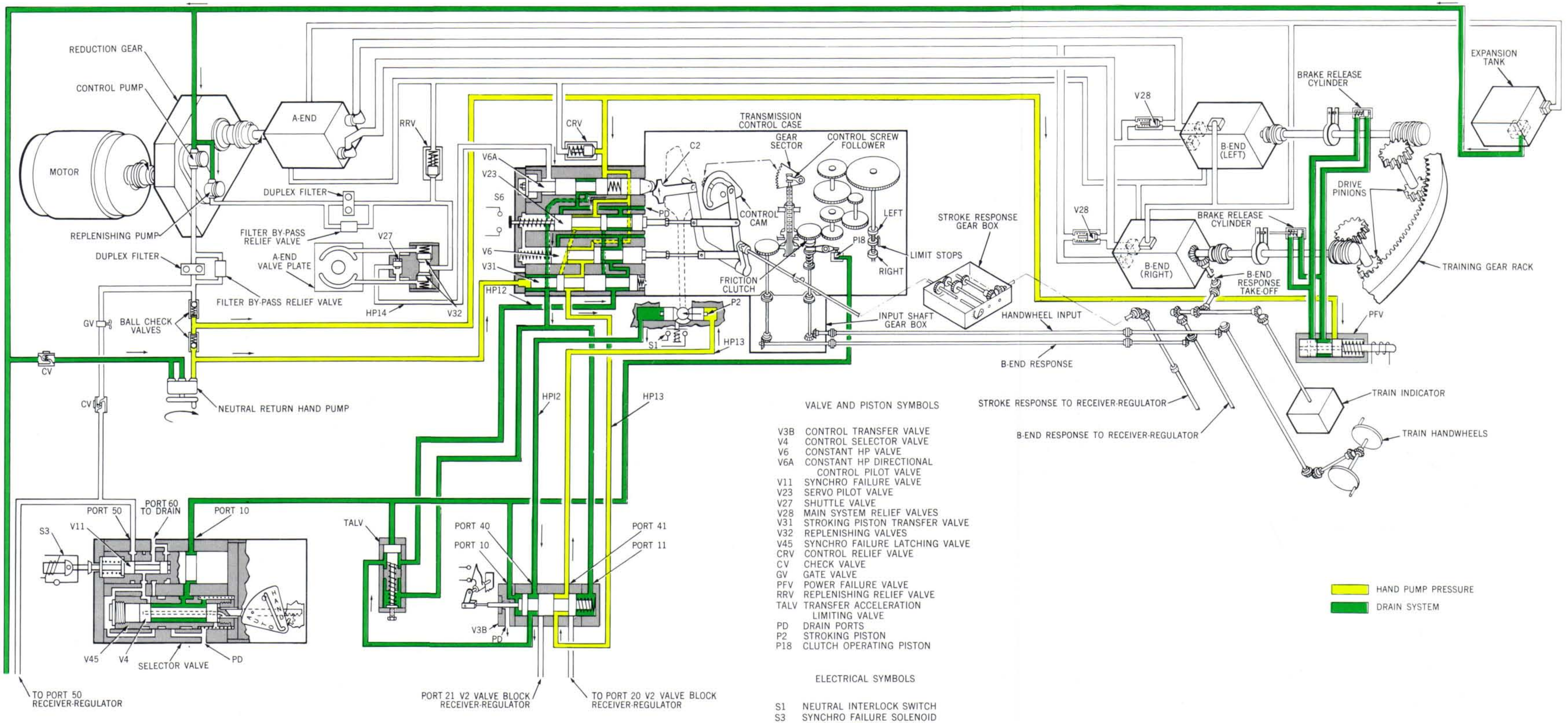
Table of Contents



VALVE AND PISTON SYMBOLS

V3B	CONTROL TRANSFER VALVE
V4	CONTROL SELECTOR VALVE
V6	CONSTANT HP VALVE
V6A	CONSTANT HP DIRECTIONAL CONTROL PILOT VALVE
V11	SYNCHRO FAILURE VALVE
V23	SERVO PILOT VALVE
V27	SHUTTLE VALVE
V28	MAIN SYSTEM RELIEF VALVES
V31	STROKING PISTON TRANSFER VALVE
V32	REPLENISHING VALVES
V45	SYNCHRO FAILURE LATCHING VALVE
CRV	CONTROL RELIEF VALVE
CV	CHECK VALVE
GV	GATE VALVE
PFV	POWER FAILURE VALVE
RRV	REPLENISHING RELIEF VALVE
TALV	TRANSFER ACCELERATION LIMITING VALVE
PD	DRAIN PORTS
P2	STROKING PISTON
P18	CLUTCH OPERATING PISTON

ELECTRICAL SYMBOLS

S1	NEUTRAL INTERLOCK SWITCH
S3	SYNCHRO FAILURE SOLENOID
S6	SERVO INTERLOCK SWITCH

MECHANICAL SYMBOL

C2	CONSTANT HP CAM

Figure 6-26. Training Gear Hand Control System Diagram, Neutral Return Action - A-end Tilting Box on Stroke for Left Train

Gene Slover's US Navy Pages
Table of Contents

VALVE AND PISTON SYMBOLS

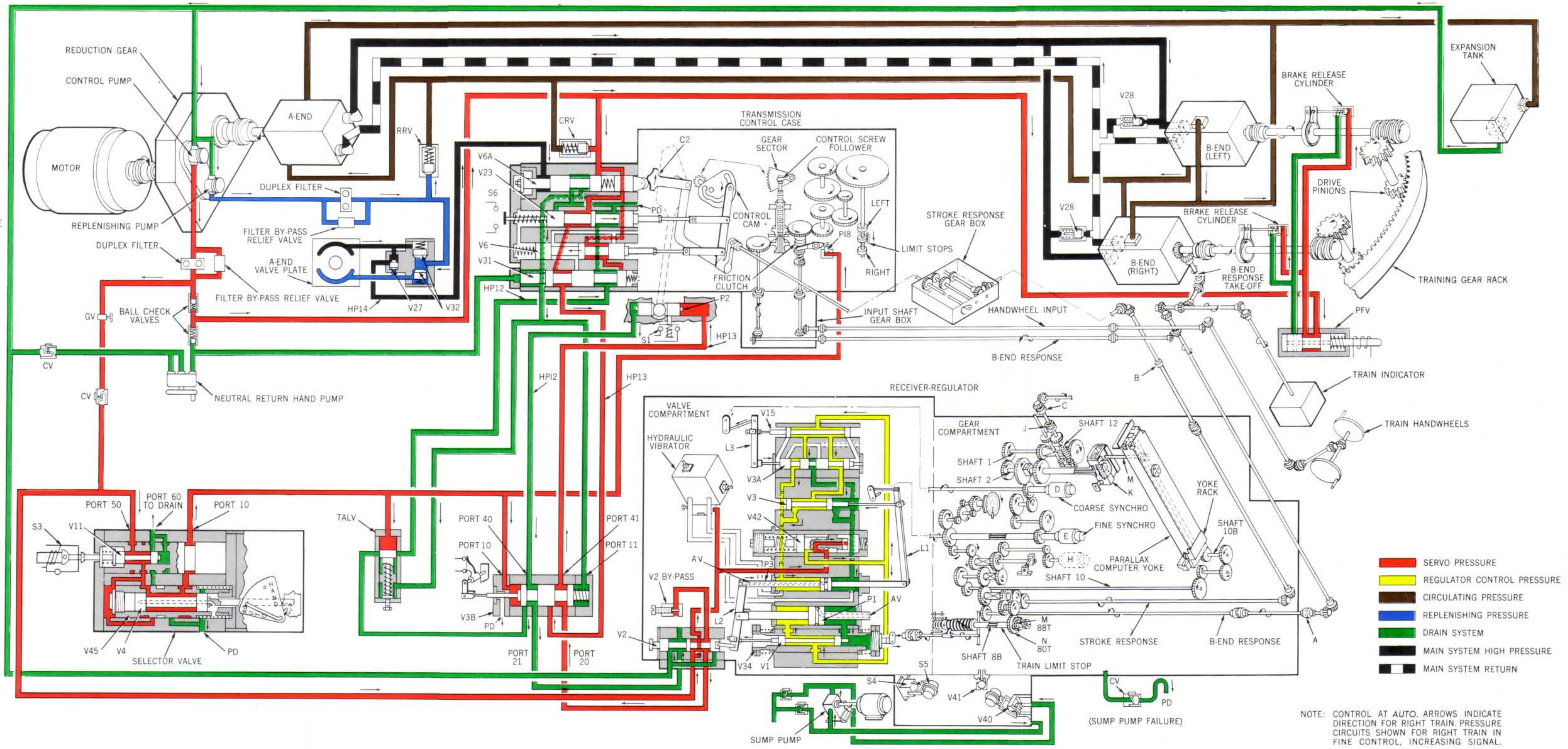
- V1 STABILIZING VALVE
- V2 AUTOMATIC STROKING VALVE
- V3 FINE SYNCHRO VALVE
- V3A SYNCHRONIZING VALVE
- V3B CONTROL TRANSFER VALVE
- V4 CONTROL SELECTOR VALVE
- V6 CONSTANT HP VALVE
- V6A CONSTANT HP DIRECTIONAL CONTROL PILOT VALVE
- V11 SYNCHRO FAILURE VALVE
- V15 SYNCHRONIZING PILOT VALVE
- V23 SERVO PILOT VALVE
- V27 SHUTTLE VALVE
- V28 MAIN SYSTEM RELIEF VALVES
- V31 STROKING PISTON TRANSFER VALVE
- V32 REPLENISHING VALVES
- V34 LIMIT STOP VALVE
- V40 SUMP PUMP VALVE
- V41 SUMP PUMP CHECK VALVE
- V42 PRESSURE REGULATOR VALVE
- V45 SYNCHRO FAILURE LATCHING VALVE
- AV AIR VENT
- CRV CONTROL RELIEF VALVE
- CV CHECK VALVES
- GV GATE VALVE
- PFV POWER FAILURE VALVE
- RRV REPLENISHING RELIEF VALVE
- TALV TRANSFER ACCELERATION LIMITING VALVE
- PD DRAIN PORTS
- P1 STABILIZING PISTON
- P2 STROKING PISTON
- P3 AMPLIFIER PISTON
- P18 CLUTCH OPERATING PISTON

ELECTRICAL SYMBOLS

- D 1-SPEED SYNCHRO
- E 36-SPEED SYNCHRO
- H TEST SYNCHRO
- S1 NEUTRAL INTERLOCK SWITCH
- S3 SYNCHRO FAILURE SOLENOID
- S4 MERCURY SWITCH
- S5 SUMP PUMP FLOAT SWITCH
- S6 SERVO INTERLOCK SWITCH

MECHANICAL SYMBOLS

- C2 CONSTANT HP CAM
- L1 AMPLIFIER LINKAGE
- L2 STABILIZING LINKAGE
- L3 SYNCHRONIZING LINKAGE



NOTE: CONTROL AT AUTO. ARROWS INDICATE DIRECTION FOR RIGHT TRAIN. PRESSURE CIRCUITS SHOWN FOR RIGHT TRAIN IN FINE CONTROL, INCREASING SIGNAL.

Figure 6-27. 16-inch Training Gear Mk 2 Mod 0 and Receiver-Regulator Mk 18 Mod 5 Hydraulic System, Schematic Diagram

Starting

Perform the following operations when starting the main electric motor:

1. Place the controller circuit-breaker lever at ON.

2. Place the train operator's control selector lever at HAND.

3. Ascertain that the servo interlock and the neutral interlock switches are closed. This condition is indicated by illumination of the neutral-start indicator light.

4. Press the START-EMERG button.

Stopping

When stopping the training gear power drive, perform the following operations:

1. Place the train operator's control selector lever at HAND.

2. Train the turret to the desired angle of train; stop handwheel rotation.

3. Ascertain that the tilting box is at neutral position. This is indicated by illumination of the neutral-start indicator light.

4. Press the STOP button.

Hand control, servo operation

For servo operation in hand control, the train operator's selector lever is positioned at HAND. With the electric motor in operation, and the power drive correctly adjusted, the theory and performance of the controls are:

Controls neutral. With the training handwheels at rest, the following conditions exist (fig. 6-22).

1. The A-end tilting box is at neutral stroke, no hydraulic fluid is being pumped, and there is no pressure in the main system lines between the A- and B-ends.

2. Hydraulic fluid is delivered by the servo pump (at servo pressure) to the power failure valve PFV, to the control selector valve, and to the control case through the relief bypass valve.

3. Opened by its solenoid, PFV admits servo pressure to the cylinders of the B-end brakes.

4. Servo pressure ported to the control case is blocked at the constant horsepower valve V6, at the constant horsepower directional control pilot valve V6A, and at the servo pilot valve V23.

5. Servo pressure is blocked in the control selector by the synchro failure valve V11.

6. Replenishing pressure is maintained to the replenishing valves V32 in the A-end valve plate to keep the main system filled with hydraulic fluid.

Normal control training right. With the power drive in operation (controls neutral, as shown in figure 6-22), the turret is trained to the right by turning the handwheels down and away from the operator. The following actions occur (fig. 6-23):

1. Handwheel motion is transmitted through the clutch and differential to the free end of the control linkage, to move the linkage to the right.

2. Servo pilot valve V23 is displaced to the right by its spring, admitting servo pressure flow through the stroking piston transfer valve V31 to line HP13.

3. Servo pressure from HP13 is ported by the control transfer valve V3B to the right chamber of the stroking piston P2, to drive piston P2 to the left. The left chamber of piston P2 drains through HP12 via V3B, TALV, V31, and V23 into the control case.

4. As the tilting box is moved to stroke position by P2, the pivot end of the control linkage moves to center valve V23 when the degree of A-end tilt corresponds to handwheel motion. As the A-end tilting box is displaced to a stroke position, the B-end units are hydraulically driven to rotate the turret.

5. When V23 is centered, servo pressure through HP13 is cut off. At constant handwheel input speed, B-end response combines with handwheel input to keep V23 centered. P2 and the A-end tilting box remain displaced an amount equivalent to handwheel speed.

6. Increase in handwheel speed causes an increase in A-end tilt through further movement of P2.

7. Decrease in handwheel speed combines with B-end response to move the control screw in the opposite direction. This moves V23 to reverse the pressure and drain connections to P2, and drive the tilting box back toward neutral stroke.

8. If main system pressure rises too high, it discharges directly into the low side of the main system through the main system relief valves V28.

9. Normal leakage will cause the main system return pressure to drop below the setting of the replenishing valve V32. When this occurs, the system is replenished by the replenishing pump through V32.

10. When the handwheels are stopped, B-end response rotates the differential screw to correct its original displacement by handwheel input. Response rotation restores the control linkage to neutral and the tilting box to neutral stroke.

Constant horsepower control. If the combination of A-end stroke and main system high pressure requires the electric motor to deliver more than the desired horsepower, the constant horsepower device takes control (fig. 6-24). When this occurs:

1. Main system high pressure, from the A-end valve through line HP-14 to the left end of the constant horsepower directional control pilot valve V6A, forces V6A to the right against its spring. The spring setting is controlled by a cam-operated plunger that is positioned by A-end tilt.

2. With V6A to the right, servo pressure is ported to the left end of the stroking piston transfer valve V31, to force V31 to the right. From the left end of V31 servo pressure is ported to the right end of the control transfer valve V3B (to move it to the left) and also to the spring end of TALV to hold it open.

3. In its new position V31 blocks normal flow of servo pressure for right train by blocking servo pressure from V23 to line HP13. Servo pressure is ported through the right end of the constant horsepower valve V6 to the left side of P2 through TALV and V3B to

drive the A-end tilting box back toward neutral. The right end of P2 is opened to drain through V3B and the center grooves of V31 and V6 to the control case.

4. Movement of the A-end tilting box toward neutral increases the pressure exerted by the constant horsepower cam on the plunger and spring to shift V6A to the left against main system pressure. When this occurs, the related mechanisms return to their normal position (fig. 6-23), and the servo pilot valve V23 takes control from V6A and V6.

Limit stop control. If handwheel operation is continued in one direction until the turret is approaching its positive stop, the limit stop in the control case mechanism stops the handwheels (fig. 6-25). When this occurs:

1. B-end response acts directly on the differential screw and control linkage to return them to neutral.

2. The servo pilot valve V23 shifts to the left to port servo pressure through V31, TALV, and V3B to the stroking piston to return the A-end to neutral.

Neutral return. When the training gear power drive has been stopped while in motion, either by power failure or by use of the STOP push button, the power drive cannot be started again until the A-end tilting box is manually returned to neutral (fig. 6-26). To do this:

1. Operate the neutral return hand pump in a clockwise direction.

2. This action builds up pressure(approximately 100 pounds per square inch) to move the stroking piston transfer valve V31 to the right. Hand pump pressure from V23 is blocked by V31 in this position. V6 is held to the right or left by the linkage from the A-end tilting box.

3. The positions of V31 and V6 port the hand pump pressure through V3B or through TALV and V3B to one end or the other of the stroking piston to drive it back to neutral from its stroke position. Figure 6-26 shows hydraulic circuit conditions when returning the A-end tilting box to neutral from a left train on-stroke position.

4. When the tilting box is returned to neutral, the pivot of the control linkage moves V6 to its center position, cutting off pressure flow to the stroking piston and increasing the resistance to hand pump operation.

5. Hand pump operation is now stopped. This permits V31 to return to its normal position. The power drive is ready for normal operation.

Receiver-regulator control, servo operation

With the power drive in operation, the selector lever at AUTO, and with the turret synchronized with a stationary signal, hydraulic conditions of the automatic control circuit are as follows:

1. Servo pressure is delivered through the power failure valve PFV to the B-end brake release cylinders. Servo pressure to the control case valve block is blocked by the center lands of V23 and V6.

2. Servo pressure is also delivered directly from the control pump to the control selector and to the automatic stroking valve V2.

3. Servo pressure from the control selector is delivered through V11 and V4 to the clutch operating piston P18 to disengage the handwheel to the transfer accelerating limiting valve TALV to hold it down against its spring, and to the control transfer valve V3B to move V3B to the right against spring pressure.

4. Servo pressure from the automatic stroking valve V2 is delivered to the hydraulic vibrator for oscillation of the amplifier piston P3, and to the pressure regulator valve V42, where it is reduced to regulator control pressure. This control pressure is ported to the stabilizing valve V1 and to the synchronizing pilot valve V15, the synchronizing valve V3A, and the fine synchro valve V3.

Automatic control. When the turret is within three degrees of synchronization with turret train order, the fine (36-speed) synchro E (fig. 6-27) controls automatic operation of the receiver-regulator. With gun train order for right train, the following occurs:

1. The fine synchro rotor turns an amount corresponding to the "error" between turret position and turret train order. Its motion is transmitted through amplifier linkage L1 to move the fine synchro valve V3 to the left.

2. Regulator control pressure between the lands of V3 is ported to the left end of amplifier piston P3.

3. Regulator control pressure moves P3 to the right a distance corresponding to, but greater than, the movement of V3. This movement is transmitted through L1 to return V3 to neutral. At the same time, the motion of P3 is transmitted through the stabilizing linkage L2 to the stabilizing valve V1 and the automatic stroking valve V2.

4. The stabilizing valve V1 ports control pressure from V42 to the stabilizing piston P1. This moves P1 to the right and changes the pivot of L2 to modify the action of P3 on V2. Without this action, the system would overtravel and oscillate about a stationary gun train signal. This action makes V2 move an amount that will limit the delivery of servo pressure to P2.

5. V2 moves to the left and ports servo pressure to the right side of P2 through the control transfer valve V3B.

6. B-end response is combined with parallax correction in a differential, which drives the stator of the fine synchro. Overtravel of the stroking piston P2 would result in a reversal of the synchro rotor and regulator valve actions; this is prevented by the stabilizing action of V1 and P1, which operate in conjunction with B-end response to bring the gun smoothly into synchronized position and to hold it there.

Coarse control. Because the fine (36-speed) synchro E has identical signals 10 degrees of train apart, turret position could agree with the synchro and still be 10 degrees away from the gun train order. The coarse (1-speed) synchro D prevents this. Its rotor is turned electrically an amount equal to the difference between actual turret position and gun train order. When the difference is more than three degrees:

1. The rotor of the coarse synchro D has turned far enough to move (through the synchronizing linkage L3) the synchronizing pilot valve V15 to port regulator control pressure to the end of the synchronizing valve V3A.

2. V3A acted upon by regulator control pressure and L3, moves to cut off regulator control pressure to the fine synchro valve V3. At the same time V3A ports regulator control pressure directly to P3.

3. Acted upon by regulator control pressure for the full length of its travel, P3 operates the automatic stroking valve V2 through stabilizing linkage L2. Servo pressure is ported to the stroking piston P2 by V2, to force the A-end tilting box to maximum displacement.

4. The turret is driven at full speed toward synchronization. B-end response turns the stator of coarse synchro D.

5. As soon as turret position is within three degrees of gun train order, V15 and V3A move to restore control to the fine synchro E.

Limit stop operation. The limit stop device has two elements of data in its input, which are turret position and training speed. Turret position is obtained from B-end response input, but is not sufficient for smooth, even stopping from all speeds to a definite position of rest. Training speed is obtained from stroke response input, which is used as the speed input to the limit stop device. The stroke response is added to the turret response through a differential gear within the receiver-regulator case. The output of the differential turns the limit stop device, which moves the limit stop valve V34 to move V2 in such a direction as to drive the stroking piston back to neutral. Through the limit stop device, the limit stop begins to function farther from the stop position if the turret is moving fast than if the turret approaches the stop slowly. The result is a nearly uniform deceleration and a definite stop, regardless of the speed of the turret.

Transfer acceleration limiting control. When the control selector is shifted from AUTO to HAND with the turret position not in correspondence with the handwheel position:

1. Servo control valve V23 ports servo pressure either through V31 and V3B to the right end of P2 (right train) or through V31, TALV, and V3B to the left end of P2 (left train).

2. Servo pressure is removed from the top of TALV. Acted on by its spring, TALV tends to shift to open the line between V3B and P2. However, TALV is hydraulically unbalanced and is held against its side wall in a partially open position by pressure in the line between V3B and P2.

3. Restriction in the V3B-P2 line prevents full flow of servo pressure to P2, or full return flow from it. This slows the movement of P2.

4. When turret position corresponds to handwheel position, V23 shuts off servo pressure and return flow. TALV moves to full open position to permit P2 to follow handwheel input without restriction.

Synchro supply failure. If synchro power fails in AUTO, the control selector unit transfers itself to HAND control without movement of the control selector lever. When synchro power is restored, the control remains in HAND control until the selector lever is moved to HAND and then back to AUTO. This prevents the turret from moving without warning when synchro power is restored. If synchro power fails:

1. Solenoid S3 is de-energized.

2. Synchro failure valve V11 is moved to the right by its spring. This cuts off servo pressure to the selector valve V4 and the space behind synchro failure latching valve V45.

3. With no servo pressure from V4 to the handwheel clutch operating piston P18, V3B, and TALV, the system automatically shifts itself to HAND control.

4. V45 is moved to the left by its spring. This aligns the ports of V45 with the lands of V4 so that servo pressure is blocked at V4 when synchro power is restored, leaving turret control in HAND.

After synchro power is restored, movement of the selector lever to HAND forces V45 to the right to port servo pressure behind it to hold it in that position. Shifting the selector lever to AUTO ports servo pressure through V4 to V3B, TALV, and P18 to restore turret control to AUTO.

INSTRUCTIONS

General instructions

The turret train power drive is to be operated and maintained, including periodic exercise, adjustment, and lubrication, in accordance with the regulations of the Bureau of Ordnance Manual, the instructions below, and the directions contained in chapter 17.

At installation, the training gear is adjusted and checked for proper operation. It should give little trouble if properly maintained. Periodic inspection of the equipment will help prolong its life and effectiveness. In many instances, a visual inspection will suffice. It is not recommended that any part of the equipment be disassembled for inspection only. The visual inspection should include:

1. Alignment of shafting

2. Electric and hydraulic connections

3. Fluid-level gages

4. Lubrication

The equipment should be exercised daily in all types of control to assure proper performance. Erratic operation should be investigated to make sure it is not the beginning of serious trouble.

Operating precautions

The following operating precautions must be observed:

1. Before attempting to start the power drive electric motor, make sure that the tilting box is at neutral, the control selector lever is at HAND, and operating personnel are in safe positions.

2. Before shifting to AUTO, make sure that the synchro receivers are energized, and that turret position is in approximate agreement with turret train order.

3. The train operator must remain at his station whenever the power drive is in operation; he must be prepared to stop the power drive if an emergency arises.

4. The control selector lever must be shifted to HAND before stopping the power drive.

5. Before operating the equipment, check the fluid level at the expansion tank to make sure there is sufficient hydraulic fluid in the system. As a further precaution, check the fluid level immediately after the electric motor has been started and at intervals thereafter. If there is an appreciable drop of fluid level between checks, the supply must be replenished.

6. Make sure that the equipment is functioning properly when shifting from one type of control to another.

Preparation for operation. To prepare the training gear for operation:

1. Release and withdraw the turret centering pin.

2. Perform the "Before operating" lubrication.

3. Check and replenish hydraulic fluid in the expansion tank.

4. Check the lubricating oil in the reduction gear. Fill with approved lubricant to the specified level.

5. Verify that the filters are clear.

6. Make sure that the tilting box is at neutral. This is indicated by an illuminated neutral stroke indicator light in the START-EMERG STOP switch.

7. Make sure that all personnel are clear of the turret power drive and training areas.

8. Position the control selector lever at HAND.

The electric motor may now be started by pressing the START-EMERG button.

Before operating under load.

1. Run the motor until the hydraulic liquid is at normal operating temperature.

2. Verify that the power-off solenoid has been energized and that the brakes are released.

3. Operate the handwheels slowly to verify normal HAND control.

4. Verify that the training pinion gear lubricating system is pumping oil.

5. Operate to both limit stops. Verify normal limit stop action.

Shifting to automatic control. To place the turret in automatic control:

1. Start the electric motor (observing all normal precautions) with the control selector lever at HAND.

2. Verify that the receiver-regulator is receiving a signal. This is indicated by the synchro power indicating light in the control selector.

3. Match pointers.

4. Move the control selector lever to AUTO.

General servicing instructions

When installing, overhauling, or servicing the power drive assembly and its connected units, the following general instructions should be complied with:

1. Couplings must not be driven or forced onto main shafts of electric motors, reduction gears, or hydraulic units. A heavy blow on the end of a shaft may damage the bearings or gears.

2. When units are being levelled or vertically aligned, use flat shims (rather than wedges) to assure full support of the unit.

3. Do not flush hydraulic pipes of hydraulic equipment with kerosene. These components must be maintained in accordance with the regulations of the Bureau of Ordnance Manual and the directions contained in chapter 17 of this ordnance pamphlet.

4. Do not start the electric motor until all equipment is properly lubricated and the hydraulic system is verified to be full.

5. When pipe flanges, fittings, or other units are disconnected and open, covers must be installed to prevent the entrance of foreign matter. These covers should not be removed until reassembly is begun.

Hydraulic oil. The power transmission fluid to be used in the hydraulic system is designated as 51F21 (Ord). When the hydraulic system is initially filled, and when replenishing, the fluid should be poured through a fine mesh strainer of at least 200 wires to the inch. Cheesecloth or rags must not be used as a strainer. New hydraulic assemblies should be drained after 15 hours (or less) of operation. The hydraulic system should then be thoroughly flushed with new 51F21 (Ord) and refilled with fresh 51F21 after the flushing is completed. A test inspection and analysis of an oil sample from each system should be performed monthly. If there is any evidence of sludge, water, or acidity, the system must be drained, flushed with new 51F21 (Ord), and refilled with fresh 51F21 after the flushing is completed.

Filling, draining, and flushing transmission system. When a new or empty hydraulic system is being filled, it is preferable to run the fluid in with the replenishing pump, as described in the following instructions:

1. Disconnect the coupling between the A-end and the reduction gear, so that the reduction gear (and replenishing pump) may be run without operating the A-end. If it is not expedient to uncouple the A-end drive shaft, oil may be run into the system from the expansion tank by gravity.

2. Fill the housings of the A-end and B-end units. Remove the filler cap of the expansion tank and continue pouring fluid into the tank until the oil level remains constant at the high-level trycock. Loosen the pipe plugs on the top face of the A-end valve block for subsequent venting of the system. Start the electric motor and allow it to run for a few seconds, stop the motor, and repeat the start-stop procedure several times. Check the fluid level continuously at the low-level trycock of the expansion tank. Fluid should be added to the expansion tank as needed to maintain the level while fluid is being pumped into the main hydraulic lines by the supercharge pump.

Continue the pumping and the start-stop procedure until the fluid (free of air) flows out of the pipe plugs, and the system is completely vented.

3. Reconnect the coupling between the A-end and the reduction gear; the unit is now ready to operate.

The transmission system can be drained by opening the drain-pipe plugs in the bottoms of both B-end housings and the A-end housing. In addition, open the pipe plugs in the valve plates of both the A-end and B-ends.

If the transmission system is to be flushed, follow the procedures outlined on page 6-24 of this chapter.

To fill the auxiliary pump unit on the reduction gear, remove the filler plug at the top of the unit and fill with 51F21 (Ord). A drain plug is provided at the bottom of the auxiliary pump unit.

Reduction gear oil, filling. The reduction gear housing should be filled to the proper level with 11.25 gallons of heavy mineral oil, Navy Symbol 3065. The proper oil level, indicated by an oil level gage mark, is read with the unit at rest. Leakage and overheating may occur if excessive oil is put into the unit. If overheating is indicated in the unit, check the oil level. If the reduction gear continues to overheat with a proper oil level, check the unit and shafts for misalignment. The reduction gear requires no special maintenance care except as follows:

1. Remove the air vent and clean the screen semiannually.

2. Drain and replace the oil with fresh oil semiannually.

3. Remove the inspection cover frequently to ascertain that the oil is being circulated.

Inspect gearing lubrication. The input shaft gearing assembly and pedestal input gearing assembly have oil sump reservoirs that are filled and replenished through oil cup fittings. Each unit requires two quarts of light mineral oil, Navy Symbol 2135.

1. Keep the units filled to oil cup level.

2. Check the oil level weekly.

3. Drain and replace with fresh oil semiannually.

4. Inspect the units frequently to ascertain that the oil is being circulated and that the pump is not airlocked.

5. Check the response input shaft bearing with the upper side plate removed.

Transmission tests, inspections, and exercise. The hydraulic system is to be serviced after initial installation as follows:

1. Tighten all pipe and shaft connections and bolts after the first week of operation.

2. Drain the system, flush with new oil, and refill after the first month of service or 15 hours of operation. This operation is essential to remove any foreign matter resulting from initial run-in of the new equipment.

3. Check and clean the oil filters.

4. Drain and replace the oil in the reduction gear, gear boxes, and the lubricating oil reservoirs.

Lubrication. All valve gear and the rotating groups of the A-end and the B-ends are lubricated by hydraulic fluid. This fluid includes a rust inhibitor to preserve the enclosed parts from corrosion. It is therefore important that the fluid be checked frequently to make certain it is clean and free of water. Other parts of the training gear require application of lubricants at the locations and at the periods specified by the lubrication charts. The charts do not include instructions for lubrication of certain parts under Bureau of Ships cognizance. The efficiency of these parts affects performance of the training gear drive. Data as to appropriate lubrication of these units are as follows:

Lubrication of roller carriage. Extreme pressure lubricant 14-G-9 (Ord) is prescribed for lubrication of the roller carriage. Fresh lubricant should be applied quarterly; the need for replenishment should be checked after every four hours of turret train operation.

Lubrication of holding-down clip. The contact surface of the lower roller track that is opposed to the holding-down clips must be coated with grease 14-G-9 (Ord). The grease should be replenished after every four hours of turret train operation.

Worm and wormwheel lubrication system. Worm gear lubricant NAVORD OS 1400 is prescribed for the lubrication system of the worm and wormwheel housing. The system should be drained, flushed clean, and filled with new oil annually.

Rack and pinion lubrication. The teeth of the training pinion and rack must be coated with extreme-pressure lubricant 14-L-8 (Ord) every four hours of turret train operation. The lubricant should be removed with solvent and fresh lubricant should be applied at least once annually.

Control and replenishing pressures. The control (servo) pressure should be between 300 and 400 pounds per square inch, and the replenishing (supercharge) pressure should be approximately 40 pounds per square inch. If the pressures are not within the desired ranges, make adjustments at the control and replenishing relief valves. Remove the valve cap, loosen the locknut, and screw in the adjusting screw to increase the pressure, or screw out to decrease the pressure.

Maintenance care - hydraulic system. When pipe fittings, flanges, or other units of the hydraulic system are disconnected and open, keep the openings covered to prevent the entrance of foreign matter. Do not remove such protection until reassembly. For complete instructions for care and maintenance of the hydraulic system, see chapter 17.

Reduction gear coupling. The coupling between the main electric motor and the reduction gear (type 14FAS) must be installed with drive clearance and alignment as prescribed below.

The drive shaft should be lined up to the driven shaft at initial assembly and at overhaul reassembly as follows:

1. Place covers on the shafts before pressing or shrinking the hubs on the shafts. Press or shrink the hubs on their respective shafts; the unit coupling half is to be tight against the spacer.

2. Adjust the units for a normal play of 0.25 inch. Line up the shafts by using a spacer block and feeler gage in the gap between the coupling faces; check at points 90 degrees apart.

3. Flat surfaces are milled on the tops of the teeth 90 degrees apart. Line up the shafts by using a straight edge over these flats. Final check-up should be made after the foundation bolts are fastened. The coupling alignment should be maintained within 0.003 inch.

4. Insert the gasket after the coupling is aligned, permitting it to hang from the hub away from the teeth. Care should be taken not to injure the gasket.

5. Fill the spaces and the gap between the coupling faces with as much grease as possible.

6. Assemble the grid spring in the grooves.

7. Pack the spaces between and around the grid spring with as much lubricant as possible. Fill the coupling to its limit with proper lubricant for proper functioning. Clean the inside of the cover pieces before assembling.

8. Draw the cover pieces together and bolt when in position. Make sure that the neoprene seals are seated on the hubs and are not pinched by the cover pieces.

Operating trouble diagnosis

Locating and correcting turret training gear trouble requires a thorough understanding of the equipment described in this chapter. There should be no exception to the rule that:

CASUALTY CORRECTION IS NEVER TO BE ATTEMPTED BY ANYONE NOT COMPLETELY FAMILIAR WITH THE EQUIPMENT.

The causes of various troubles which may occur in the turret training gear are given in the paragraphs below. The trouble diagnosis is in a sequence that avoids extensive disassembly until the more common causes have been eliminated as the source of trouble.

Motor does not start. If the electric motor fails to start when the START-EMERG button is pressed, check the following possibilities:

1. Check the position of the tilting box. If the A-end tilting box is in a stroke position, the servo interlock and the neutral interlock switches are open and the neutral-start indicator light will not be illuminated. The starting circuit cannot be closed until the tilting box is on neutral stroke. The tilting box can be returned to a neutral position by operating the hand pump of the neutral return device.

2. Check the controller, circuit breaker, and fuses. If the circuit breaker is tripped, remember that the circuit breaker is provided as a protection for the equipment. Investigate all possibilities of short circuit or overload.

Hand pump does not build up pressure. If operation of the neutral-return hand-pump lever fails to build up pressure, check the following possibility:

1. Check for air in the pipe line. A usual indication of air in the pipe line is noisy and jerky operation of the hand pump lever. Loosen the flange fitting of the discharge pipe and rotate the pump lever until the pump is clear of air.

Hand pump does not move the tilting box. If operation of the neutral-return hand pump builds up pressure but fails to move the tilting box, check the following possibility:

1. Check the stroking piston transfer valve V31 for sticking. If V31 is sticking, it may block hand pump pressure and prevent the pressure from reaching the servo cylinder to position the tilting box at neutral stroke. Free the valve so that it may operate. Check the valve spring.

Noisy operation of auxiliary pump. If the auxiliary pumps are noisy during normal operation of the power drive, check the following possibility:

1. Check for air in the suction line. Air in the hydraulic system is usually indicated by noisy operation. The system should be vented and the oil level in the expansion tank should be verified. Replenish the oil supply if necessary.

Noisy operation of hydraulic units. If the hydraulic units are noisy during normal operation, check the following possibilities:

1. Check for air in the unit. Air in the hydraulic system is usually indicated by noisy operation. The system should be vented. Replenish the oil supply if necessary.

2. Check the replenishing pressure. Vibration and shock of gun fire may have caused the replenishing valves to unseat or the seats to back out.

Wrong valve springs may have been installed and may have jammed when the valves opened to replenish. Inspect the valve springs for dead coils. Check the valve seats for scoring at regular intervals.

Tilting box movement sluggish. If the tilting box movement is sluggish during normal operation of the power drive, check the following possibilities:

1. Check the control pump pressure. In a malfunction of this type, a clogged filter is often found to be the source of trouble. Clean the duplex filter when control pressure is below normal.

2. Adjust the control pump relief valve. A failure of control pressure may be caused by the control relief valve being stuck open. Disassemble the valve being stuck open. Disassemble the valve and inspect. Remove the cause of sticking.

3. Check the pipe lines and connections for indications of leakage. Make necessary repairs.

Constant horsepower device does not function. If the constant horsepower device fails to function during normal operation of the power drive, check the following possible sources of trouble:

1. Check for a sticking valve. Disassemble the valves in the control case mechanism and inspect carefully for scoring and broken springs. Remove the cause of sticking and reassemble. Clean the duplex control system filter at regular periods.

2. Check the shuttle valve in the A-end valve plate. Disassemble the shuttle valve and inspect for sticking. Remove the cause of sticking and reassemble.

B-ends overshoot when stopping suddenly. If the B-ends overshoot when making a sudden stop of the train movement, check the following possibilities:

1. Check the control system pressure. In a malfunction of this nature of the power drive, a clogged control system filter is often found to be the source of trouble. Check and clean the control filter at regular periods.

2. If the filter was operating properly, increase the pressure adjustment of the control pressure relief valve.

Operation irregular at slow speeds. If the power drive operation at slow speeds is irregular, check the following possibility:

1. Check for air in the main system. The system should be vented and the oil level in the expansion tank should be verified. Replenish the oil supply if necessary.

2. B-ends "hunt" or oscillate slowly with handwheel stationary. If the B-ends oscillate with the handwheels stationary, check the following possibilities:

1. The temperature of the hydraulic oil may be too low. When the oil is cold, its higher viscosity will increase the effect of the servo pilot valve port and permit slight hunting of the valve and tilting box. This effect should disappear as the oil warms up after a short period of operation.

2. Check the response shafting from the B-end. Verify that the shafting is properly connected and that there is a minimum of lost motion in the gears and shaft.

Power failure devices do not function. If there is a malfunction on the part of the power failure devices, check the following sources of trouble:

1. Check the solenoid-operated power failure valve. Verify the free action of the valve and its actuating solenoid crank. If necessary, disassemble the valve and inspect. Remove the cause of sticking.

2. Check the electrical connections at the solenoid. Make the necessary repairs.

3. Check the pipe lines and connections for indications of leakage. Make necessary repairs.

Turret oscillation. If the turret oscillates about a stationary signal, check the following possible sources of trouble:

1. Check the response shafting from the right B-end. Verify that the shafting is connected properly and that there is a minimum of lost motion and backlash in the gears and shafts. Any lost motion or backlash will seriously affect operation. Sluggishness in response to the handwheels and failure of the B-ends to remain stationary are symptoms of lost motion. Check the handwheels and shafting connections to the A-end input shaft for lost motion. Care must be taken not to fit the parts too tightly when removing lost motion. Too tight a fit could cause a binding action that is as detrimental to proper function of the training gear as lost motion.

2. Check for air in the stroking piston or main system. Loosen the lowest vent plug in the system and permit the air to escape. When a steady flow of oil appears at the vent, tighten the plug. Repeat this process for successively higher vent plugs in the system. Verify the oil level in the expansion tank and replenish if necessary.

3. Check for lost motion in the receiver-regulator gearing linkage, and connecting wire couplings. If repairs are made, the parts must not be fitted too tightly. Smooth operation without either binding or lost motion is required.

4. Check the fine synchro valve V3, the synchronizing pilot valve V15, and the stabilizing valve V1 for sticky operation. Malfunction on the part of any one of these valves would be indicated in turret oscillation while the signal is stationary.

5. Check the duplex filters of the control and replenishing systems. Subnormal pressure in either of these systems could cause turret oscillation. The filters should be cleaned and inspected at regular periods.

6. Check the hydraulic vibrator for correct frequency of crankshaft rotation. Proper operation of the receiver-regulator requires about 3600 revolutions per minute of the hydraulic vibrator crankshaft.

Turret runaway in AUTO. If the turret runs away when control is shifted to AUTO, check the following possible sources of trouble.

1. Check the synchros for torque. The synchro torque will be very low if there is an open stator lead. When checked by hand, the synchro crank will seem "soft" instead of rigid in trying to maintain correspondence.

2. Check all electrical connections if a synchro is not as strong as it should be. If all connections are verified to be secure and the indications of synchro trouble persist, check the flat springs on the synchro crank flexible drive assembly. Replace the faulty part.

3. Check the valve linkage in the receiver-regulator for loose pins and connecting wires.

4. Check the receiver-regulator valve block for sticky valves.

ADJUSTMENTS

General

The equipment is adjusted and checked for satisfactory operation at the time of installation. Adjustments thereafter should be in accordance with the following instructions.

Main relief valve

Main system high pressure relief is obtained through adjustable spring plunger type valves (fig. 6-28) which operate to by-pass to the low pressure transmission pipe. The valve in the left B-end valve plate is high pressure relief for right train; the valve in the right B-end valve plate relieves for left train.

To adjust the main relief valve:

1. Remove the valve cap.

2. Insert shims (washers) in the valve cap, behind the valve spring, as needed to increase pressure setting. Remove shims to lower pressure setting.

3. Replace the valve cap.

The B-end relief valves were adjusted at the factory to relieve at a pressure of 1525 pounds per square inch.

Adjustment of control screw limit

The control screw is designed to travel slightly beyond the positions of full tilting box stroke. If the control screw reaches its stop position before the tilting box reaches full-stroke position, then the tilting box will fail to reach full stroke when it is moved to the other side.

To center the travel distance of the control screw, adjust as follows:

1. Stop the power drive.

2. Drain the A-end until the oil in the control case is at a level that exposes the control case linkage and valves.

3. Remove the top cover of the control case.

4. If the tilting box stroke was short of full stroke on clockwise rotation of the stroke indicator, turn the adjusting screw of the servo pilot valve into the valve stem.

5. If the tilting box stroke was short of full stroke indicator, turn the adjusting screw of the servo pilot valve out of the valve stem.

6. Replace the top cover of the control case.

7. Start the power drive and check the adjustment.

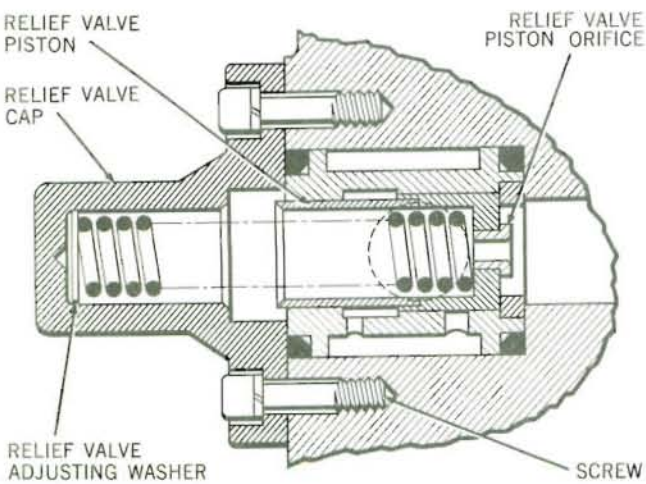


Figure 6-28. Training Gear B-end Relief Valve Adjustment

8. Repeat the procedure until the control screw travels beyond the full tilting box stroke in each direction.

Adjustment of transmission limit stops

The limit stop device is an arrangement of a screw with a traveling nut which contacts positive stops for left and right train.

To adjust the transmission limit stops:

1. Drain the limit stop housing by removing the side drain plug.

2. Remove the housing cover carefully. Do not damage the gasket.

3. Start the power drive.

4. Operate the handwheels slowly until the limit of train is reached in one direction, then reverse handwheel rotation 1/2 turn.

5. Stop the power drive.

6. Uncouple the B-end response shaft at the A-end.

7. Rotate the handwheels in the direction of limit of train until the traveling nut reaches the stop.

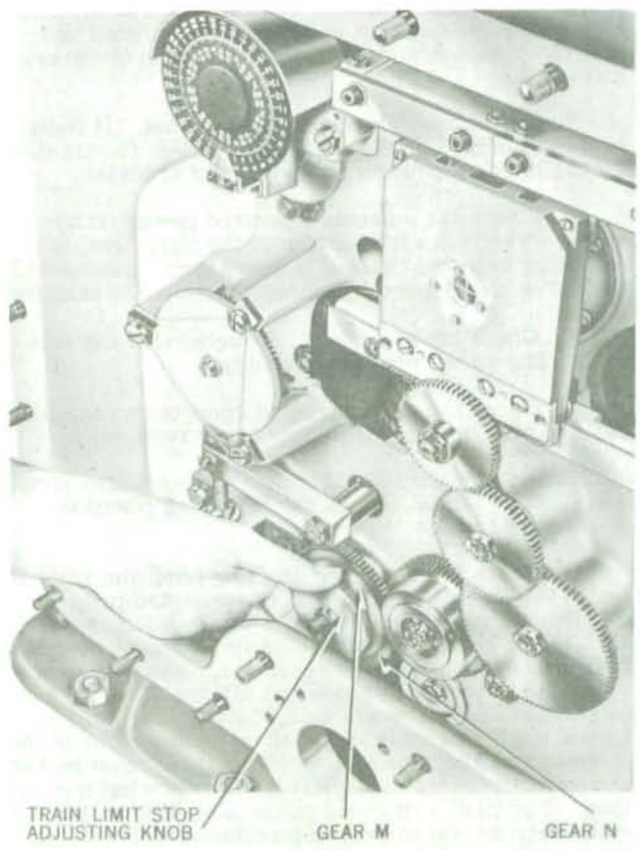


Figure 6-29. Train Receiver-Regulator Mk 18 Mod 5 Adjustment of Fine Limit Stop Spacing

8. Set the stop at the position of maximum travel.

9. Connect the B-end response shaft coupling.

10. Start the power drive and operate the handwheels slowly. Check the limit stop adjustment just made.

11. Operate the handwheels slowly until the limit of train is reached for the other direction, then reverse handwheel rotation 1/2 turn.

12. Stop the power drive.

13. Uncouple the B-end response shaft at the A-end.

14. Rotate the handwheels in the direction of limit of train until the traveling nut reaches the stop.

15. Set the stop at the position of maximum travel.

16. Connect the B-end response shaft coupling.

17. Start the power drive and operate the handwheels slowly. Check the limit stop adjustment just made.

18. Fill the limit stop housing with oil and replace the housing cover.

19. Stop the power drive.

Adjustment of constant horsepower device

The constant horsepower setting, as made by the manufacturer, is equivalent to electric motor input of approximately 540 horsepower. The adjusting device (fig. 6-30) is a pilot valve that is opened by main system pressure acting against spring tension, which varies with the position of the cam and tilting box.

To adjust the constant horsepower device:

1. Drain the A-end until the oil in the control case is at a level that exposes the linkage and valves.

2. Remove the top cover of the control case.

3. Remove the cotter pin from the adjusting screw.

4. Turn the screw in to increase horsepower, or turn out to decrease the horsepower input of the electric motor.

5. Refill the system.

The original adjustment should not be changed if the unit is functioning normally. The adjustment may be changed if the device is the cause of rough operation.

B-end synchronization

When the B-ends are coupled to the training worm gears, the B-end drive shafts are both rotated to the same position for synchronization before the couplings are secured.

To synchronize the B-ends:

1. Line up the shafts of the B-end and worm gear to be coupled, so that the numeral "5" (which indicates the position of number five cylinder) stamped on the end of each shaft matches with the other shaft.

2. Connect the coupling.

Adjustment of B-end brake

The brake shoes (fig. 6-31) should be adjusted to ride free of the brake drum when the brake is off.

To adjust the brake shoes:

1. Start the power drive.

2. Loosen the locknut on the brake shoe adjusting screw. Turn the adjusting screw in to position the brake shoe closer to the drum, to compensate for brake shoe wear.

3. Tighten the locknut.

4. Turn the adjusting nut of the brake release spring in for more positive brake release action.

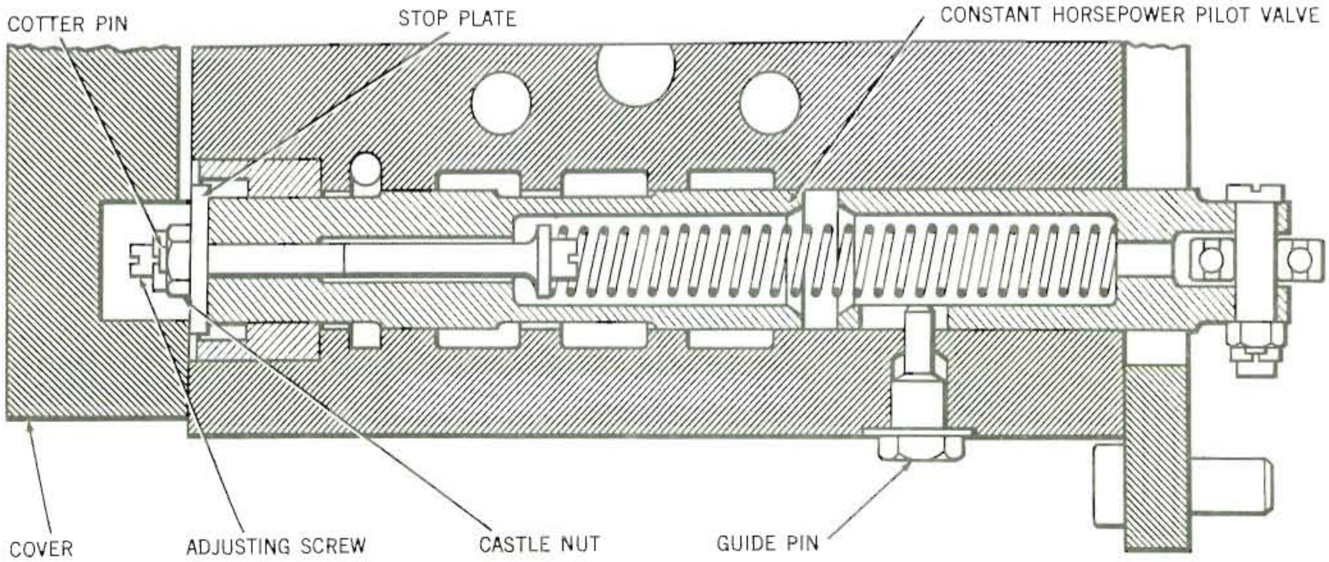


Figure 6-30. Training Gear Constant Horsepower Adjustment

Adjustment of synchro electrical zero

The synchros are set to the input train order signal by setting the synchro cranks at the proper positions on the rotor shaft.

To adjust for synchro electrical zero:

1. Disconnect the turret response shaft coupling at the receiver-regulator.

2. Start the power drive.

3. Move the control selector lever to HAND.

4. Position the turret at zero train for turrets I and II or 180 degrees for turret III.

5. Stop the power drive.

6. Have a gun train signal of zero for turrets I and II or 180 degrees for turret III transmitted to the receiver-regulator.

7. Assemble the coarse (1-speed) synchro crank as nearly in its zero position as possible. Zero position for the crank is that position at which the crank pin is located BELOW the shaft of the synchro and on the vertical centerline of the synchro when a signal is transmitted, as in step 6.

8. Assemble the fine (36-speed) synchro crank as nearly in its zero position as possible. Zero position for the crank is that position at which the crank pin is located ABOVE the shaft of the synchro, on its vertical centerline.

The cranks, when assembled to the nearest position by the flexible drive, may be slightly off center. They must be accurately set by rotating the turret response shaft. Set the coarse synchro crank first.

9. Check the checking dials for zero (or 180 degrees) after the synchros are set.

10. Check the parallax computer for zero. Rotate block K slightly through the adjustable hub until no motion of the yoke is produced by rotating the inverse range input shaft.

11. Check the settings:

(1) Check the synchro transmitted signal for zero (or 180 degrees).

(2) Check the synchro cranks for proper position (coarse synchro crank below the shaft and fine crank above the shaft).

(3) Check the checking dials for zero (or 180 degrees).

(4) Rotate the inverse range input shaft; note zero movement of computer yoke.

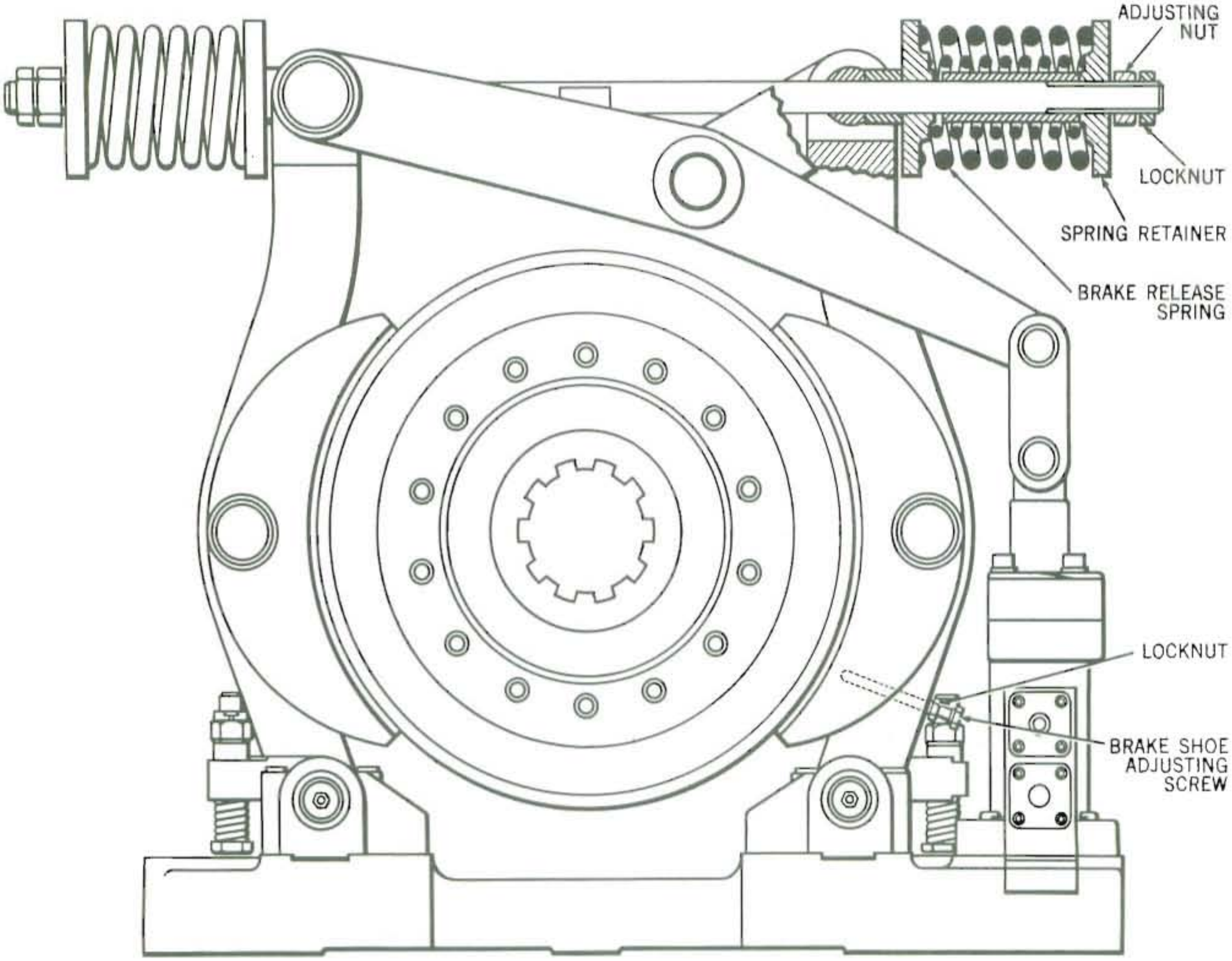


Figure 6-31. Training Gear Brake Adjustment