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.

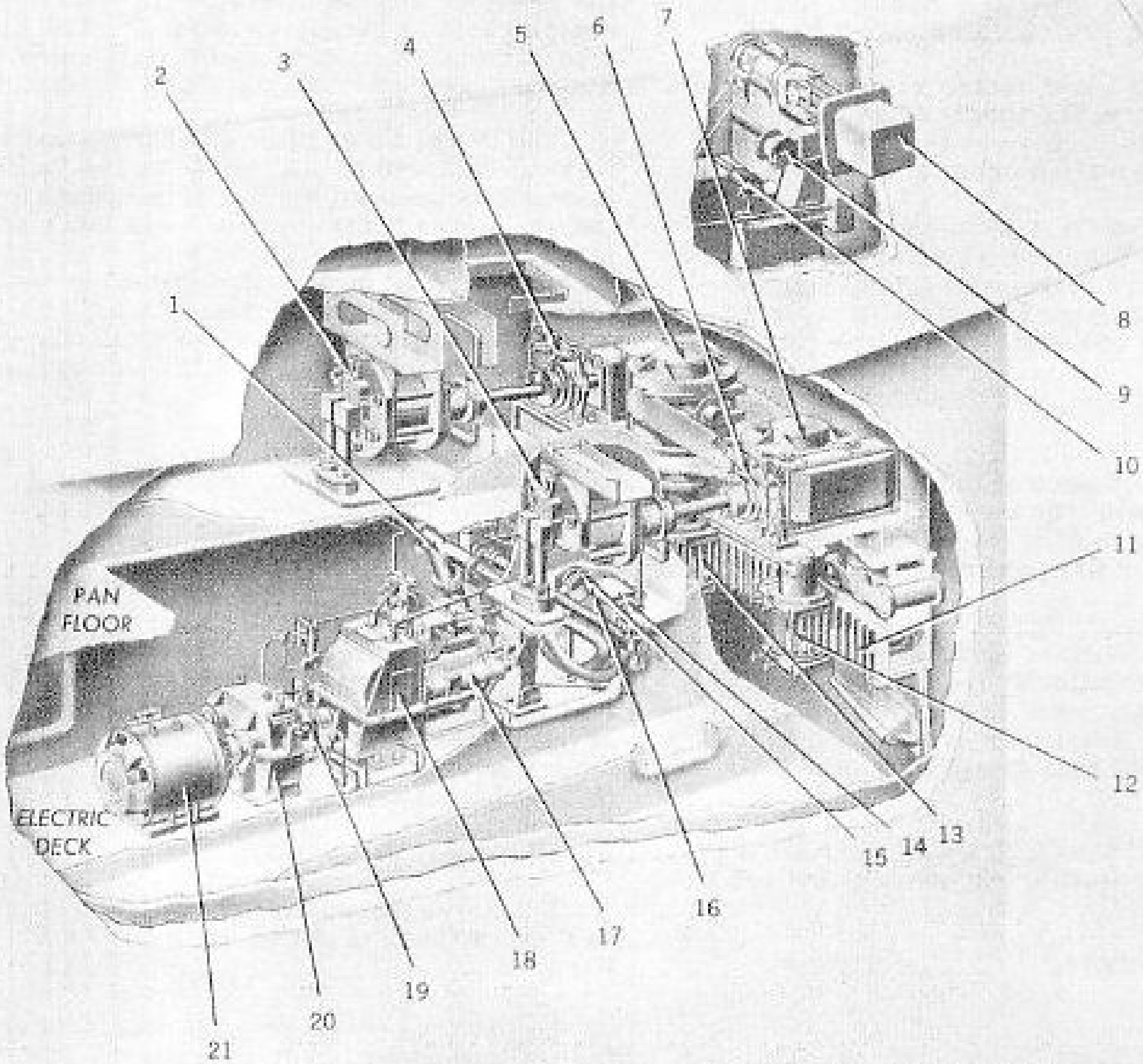
There are two stations for the local sight trainer's gear controls. A station is located at each side of the turret officer's booth. These stations are isolated from the gun compartments by turret subdivision bulkheads. A system of shafts and gear boxes connects the hand training control gear with the 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:

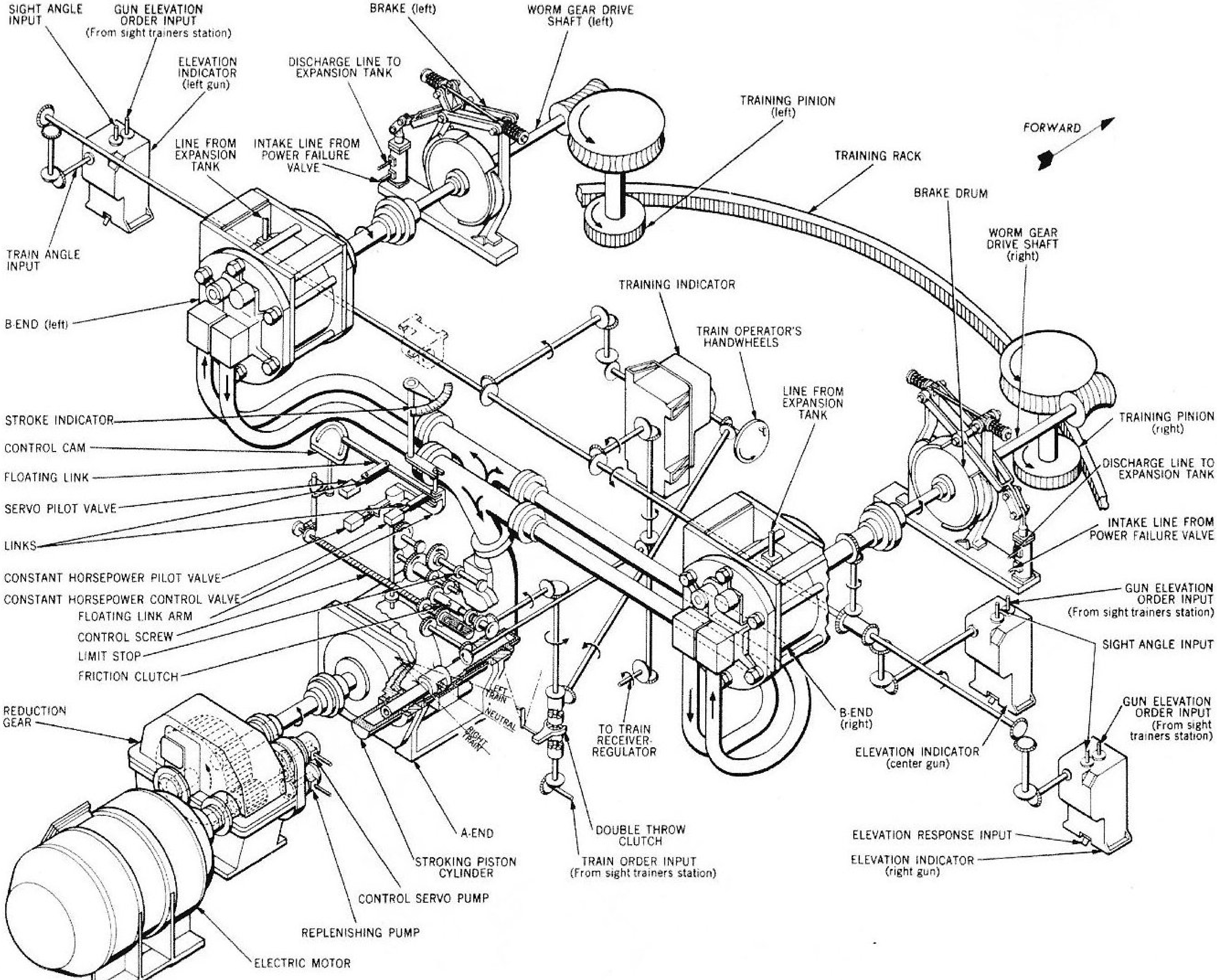
The method of power drive control is selected by the train operator, by positioning the control selector at AUTO or HAND.

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

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.

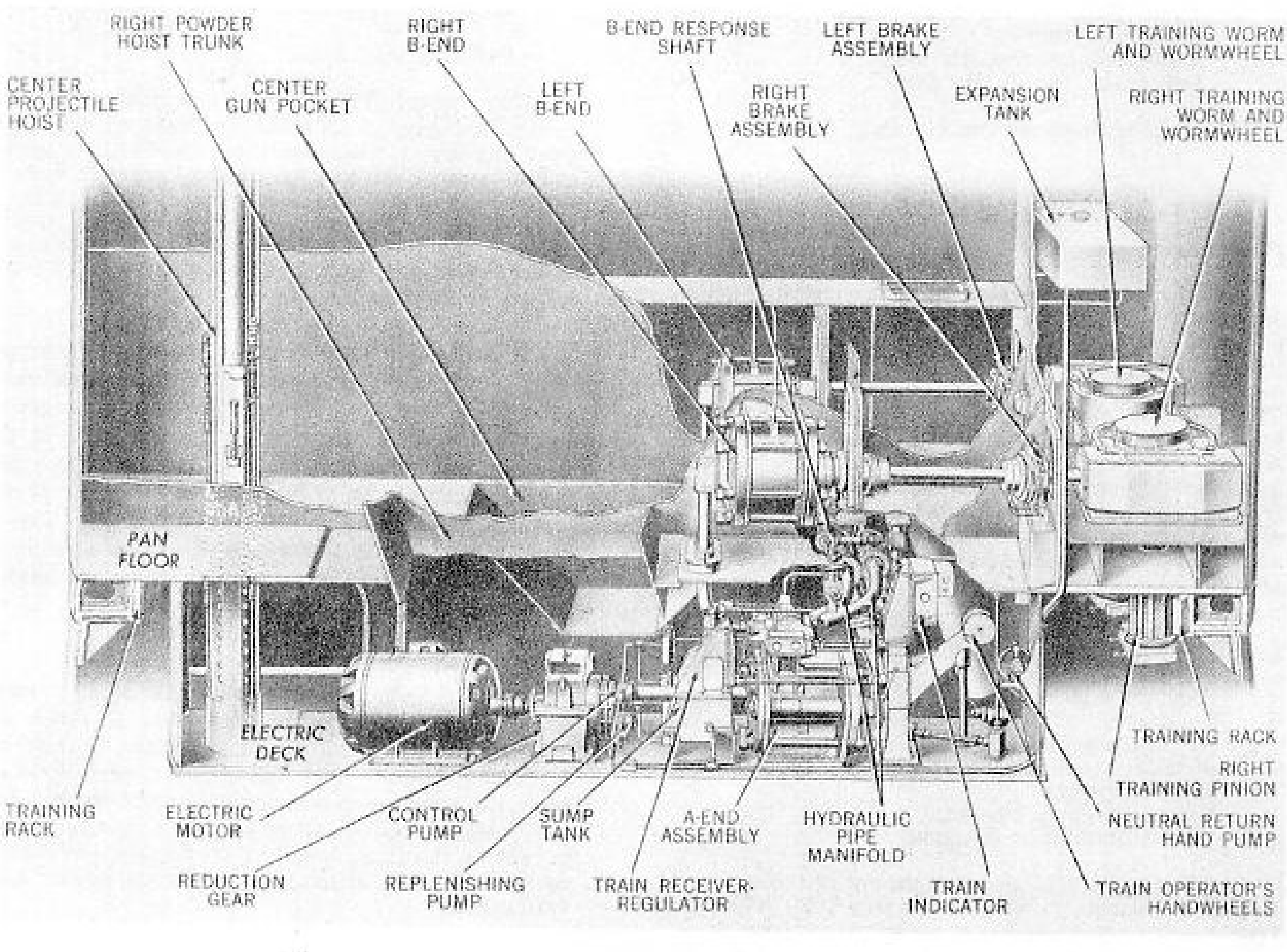


Figure 6-3. 16-inch Training Gear Mk 2 Mod 0 Power Drive, General Arrangement

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.

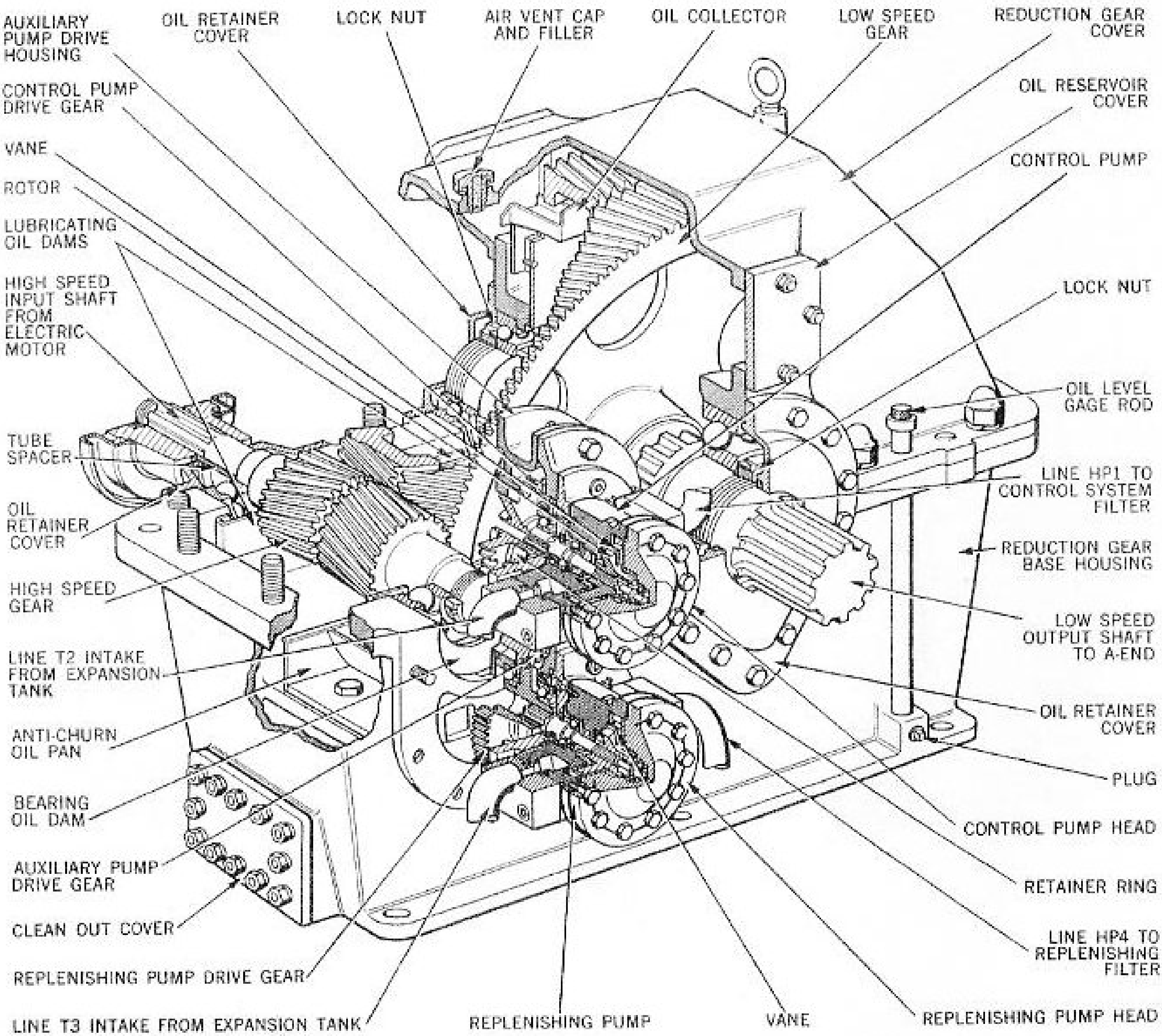


Figure 6-4. Training Gear Reduction Gear and Replenishing Pump Assembly, Cutaway View

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.

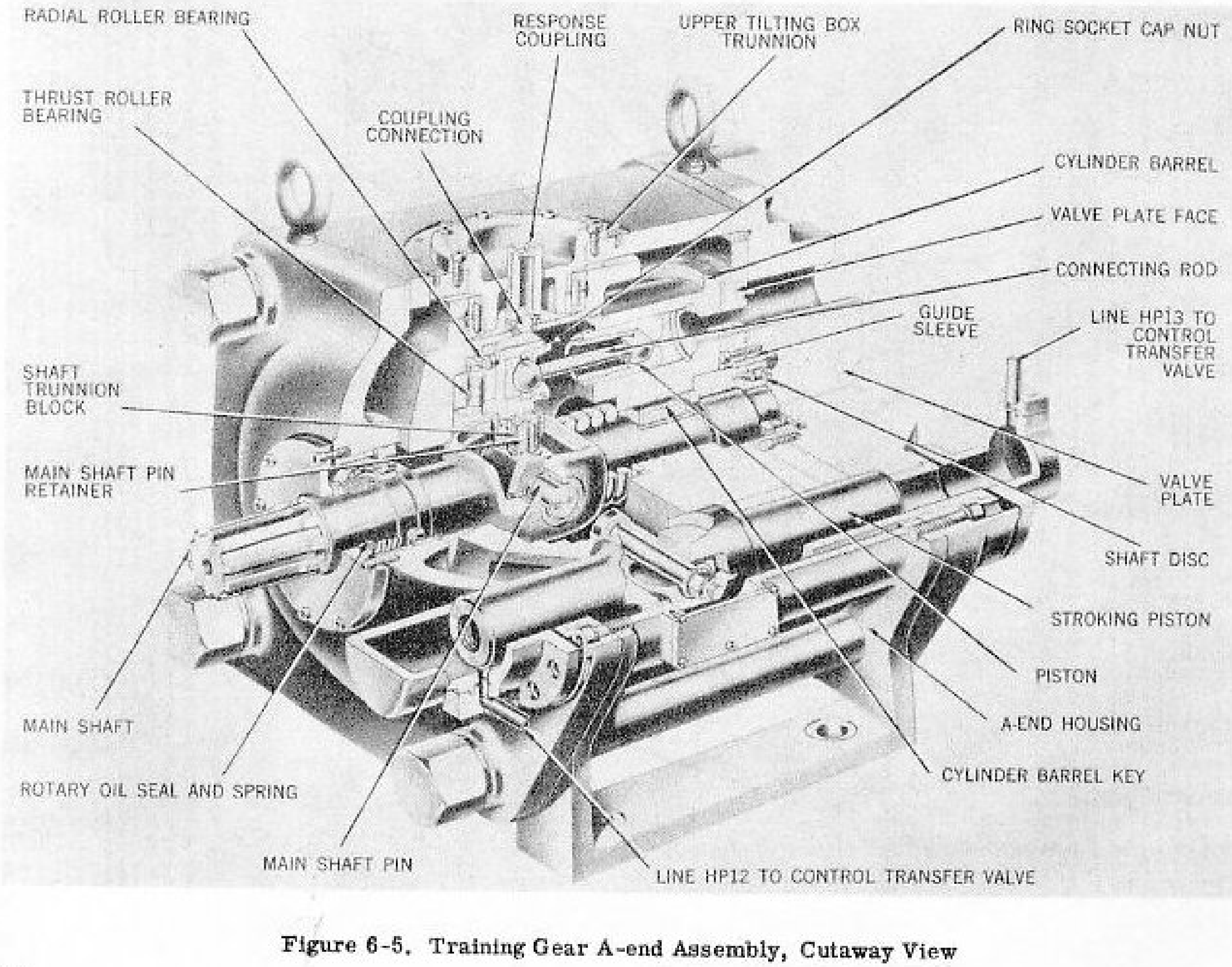


Figure 6-5. Training Gear A-end Assembly, Cutaway View

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 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).

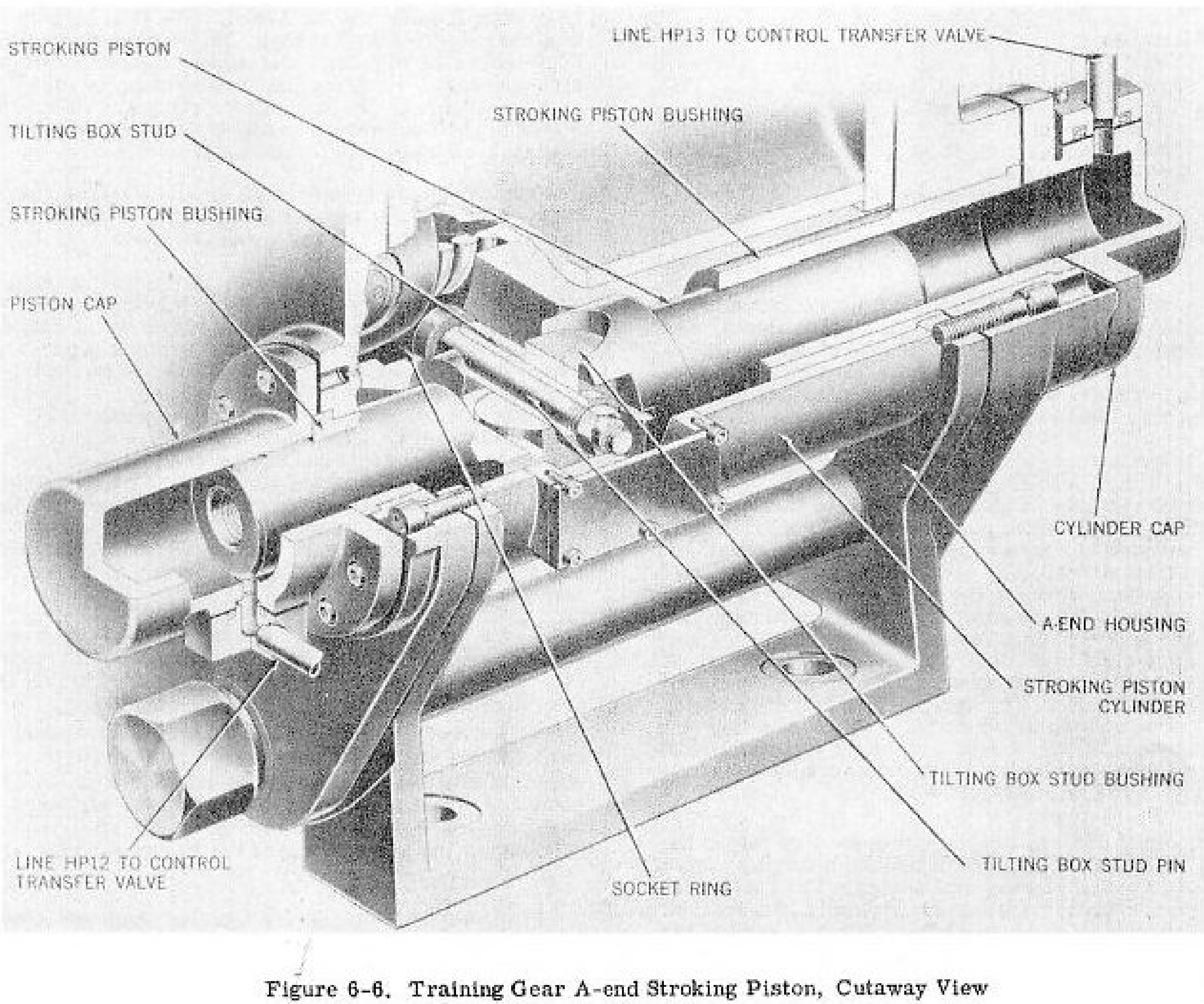


Figure 6-6. Training Gear A-end Stroking Piston, Cutaway View

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 arrangment 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.

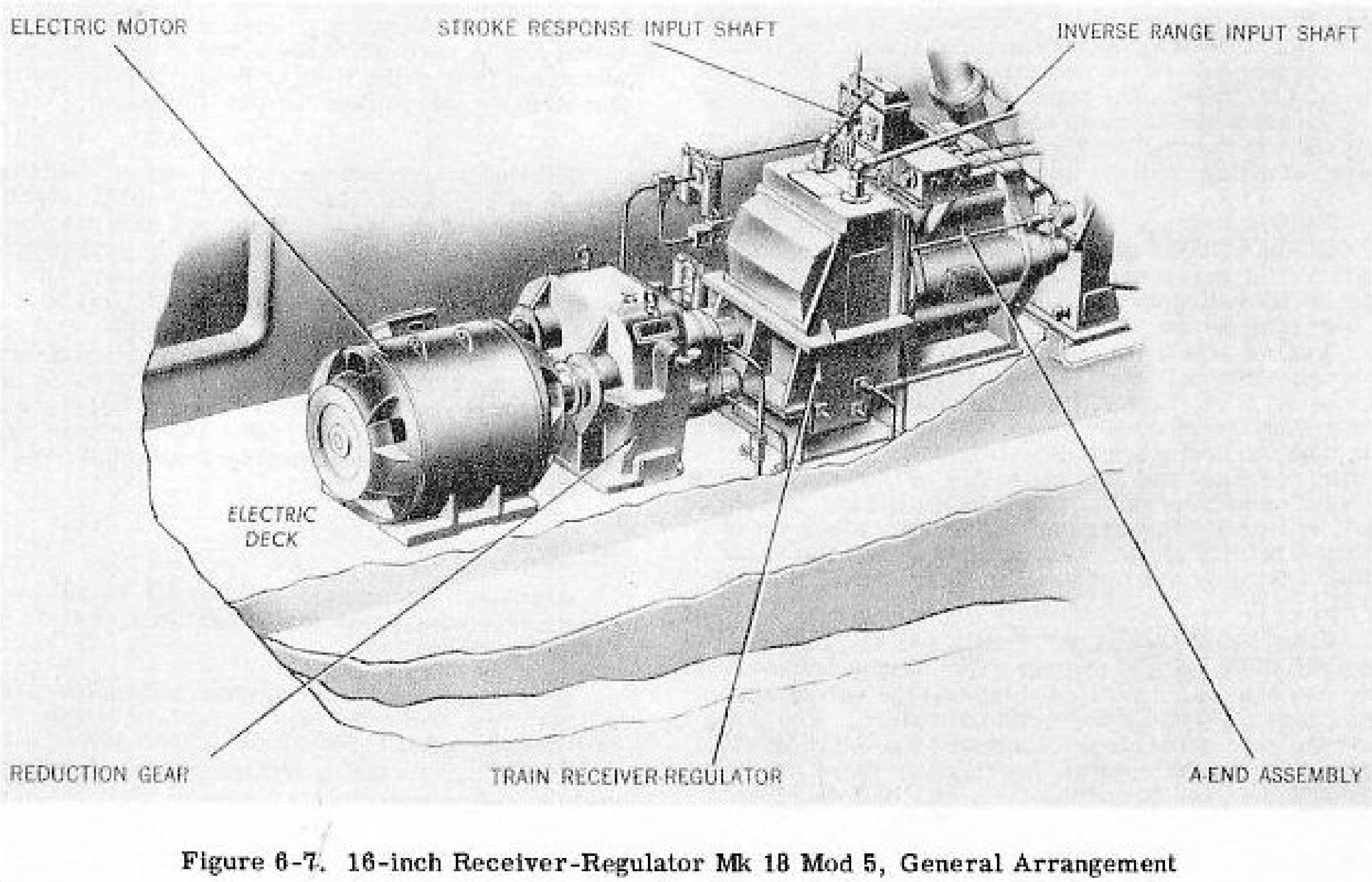


Figure 6-7. 16-inch Receiver-Regulator Mk 18 Mod 5, General Arrangement

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 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.

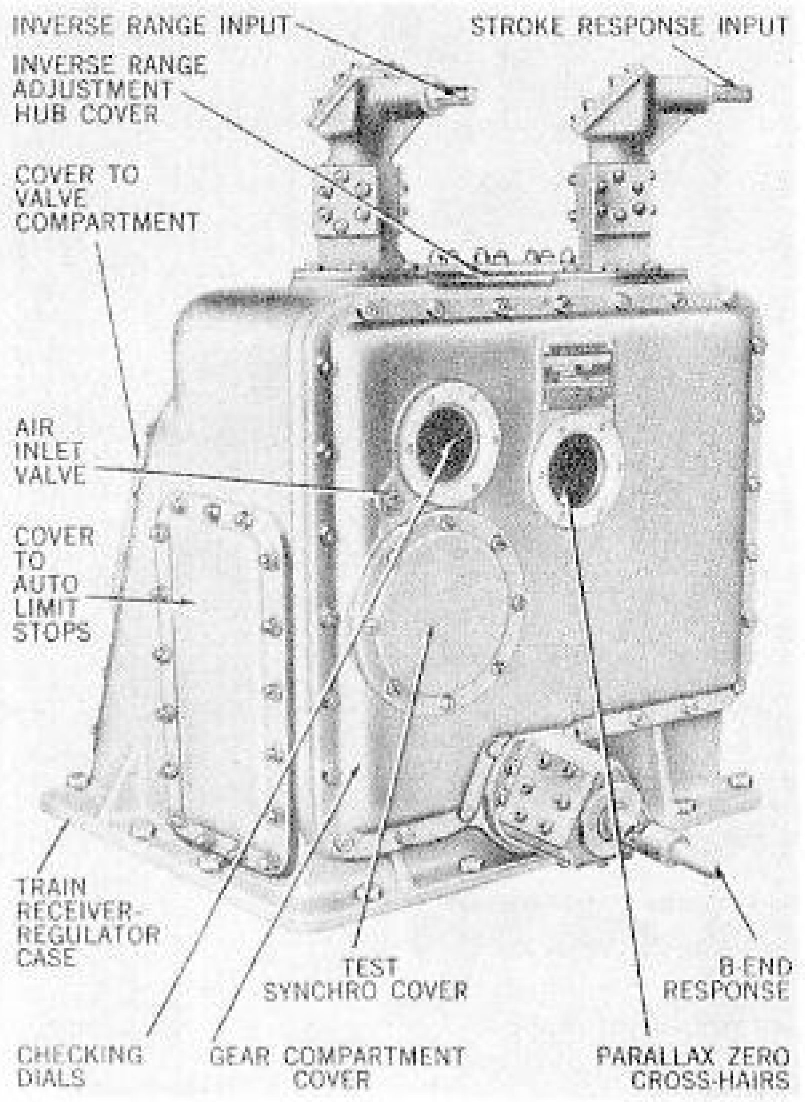


Figure 6-8. Train Receiver-Regulator Mk 18 Mod 5, Front View

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.

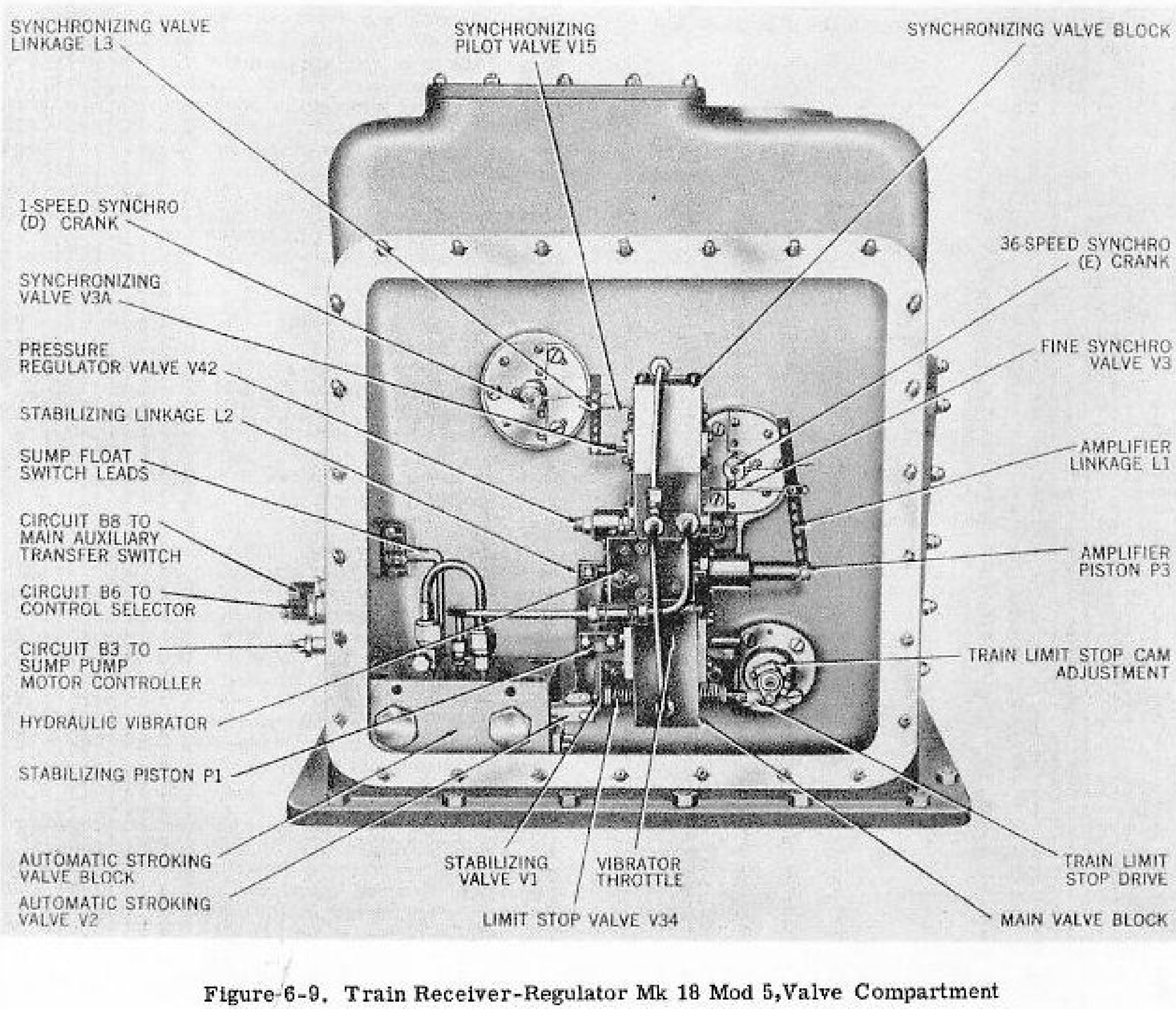


Figure 6-9. Train Receiver-Regulator Mk 18 Mod 5,Valve Compartment

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.

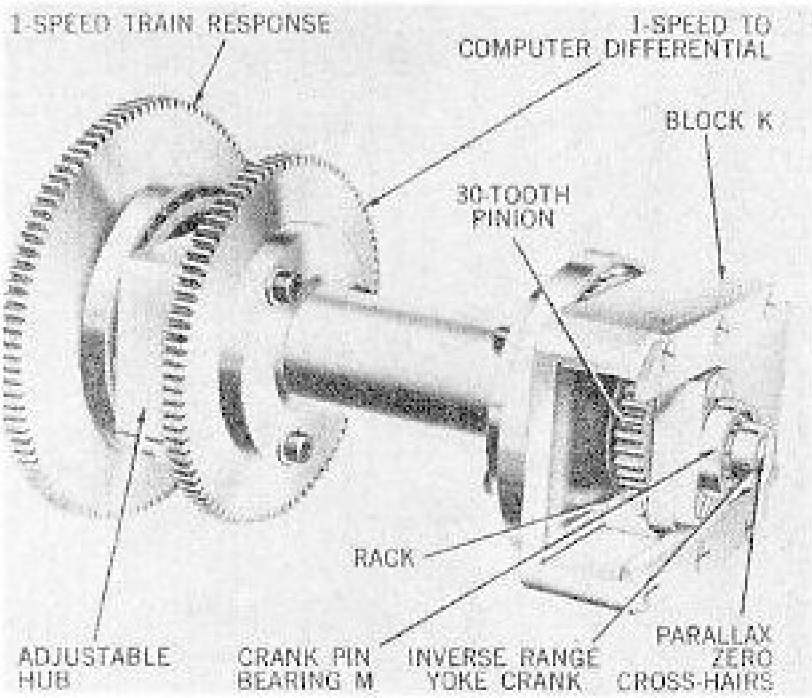


Figure 6-10. Train Receiver-Regulator Mk 18 Mod 5 Parallax Computer Drive

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.

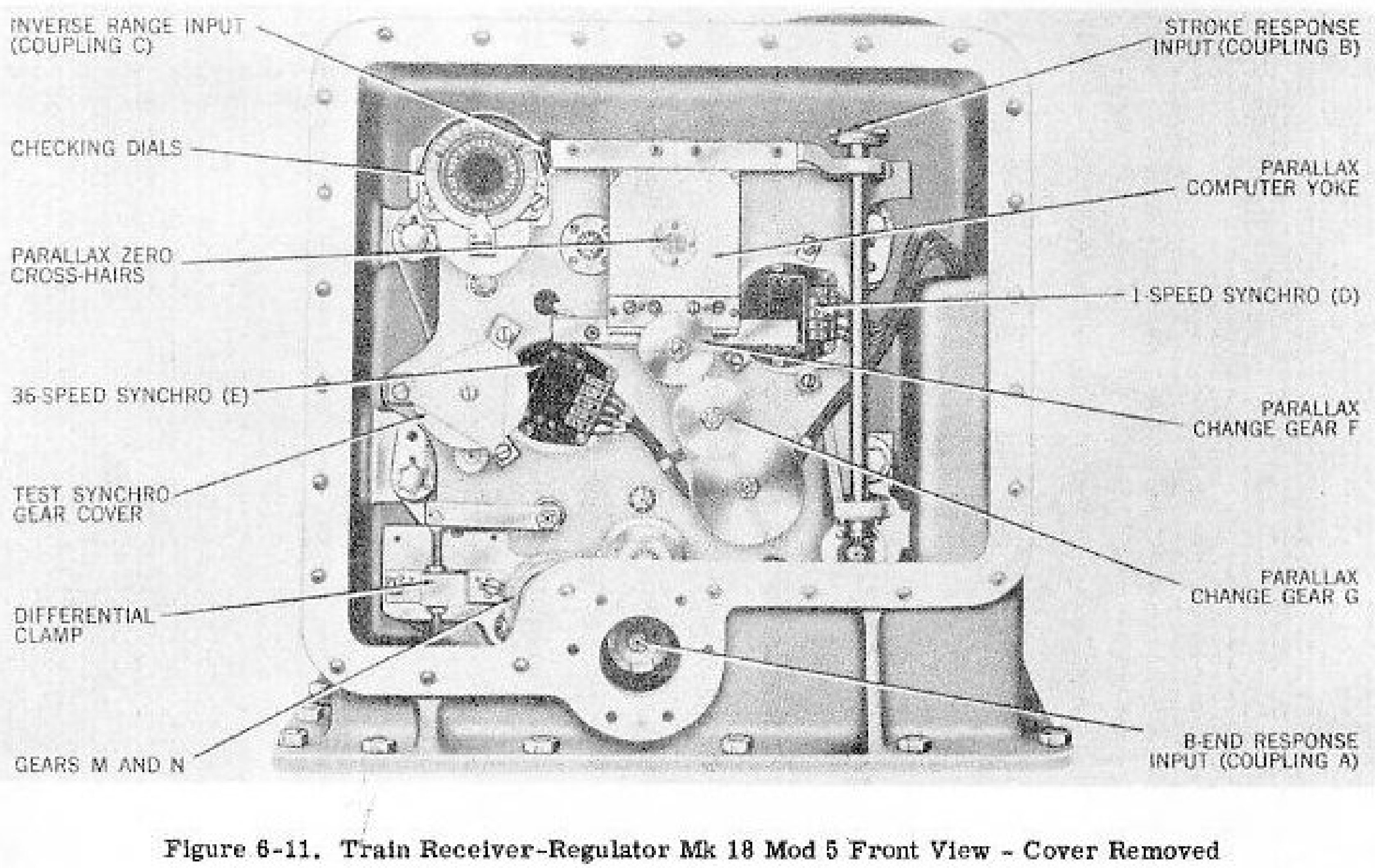


Figure 6-11. Train Receiver-Regulator Mk 18 Mod 5 Front View - Cover Removed

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.

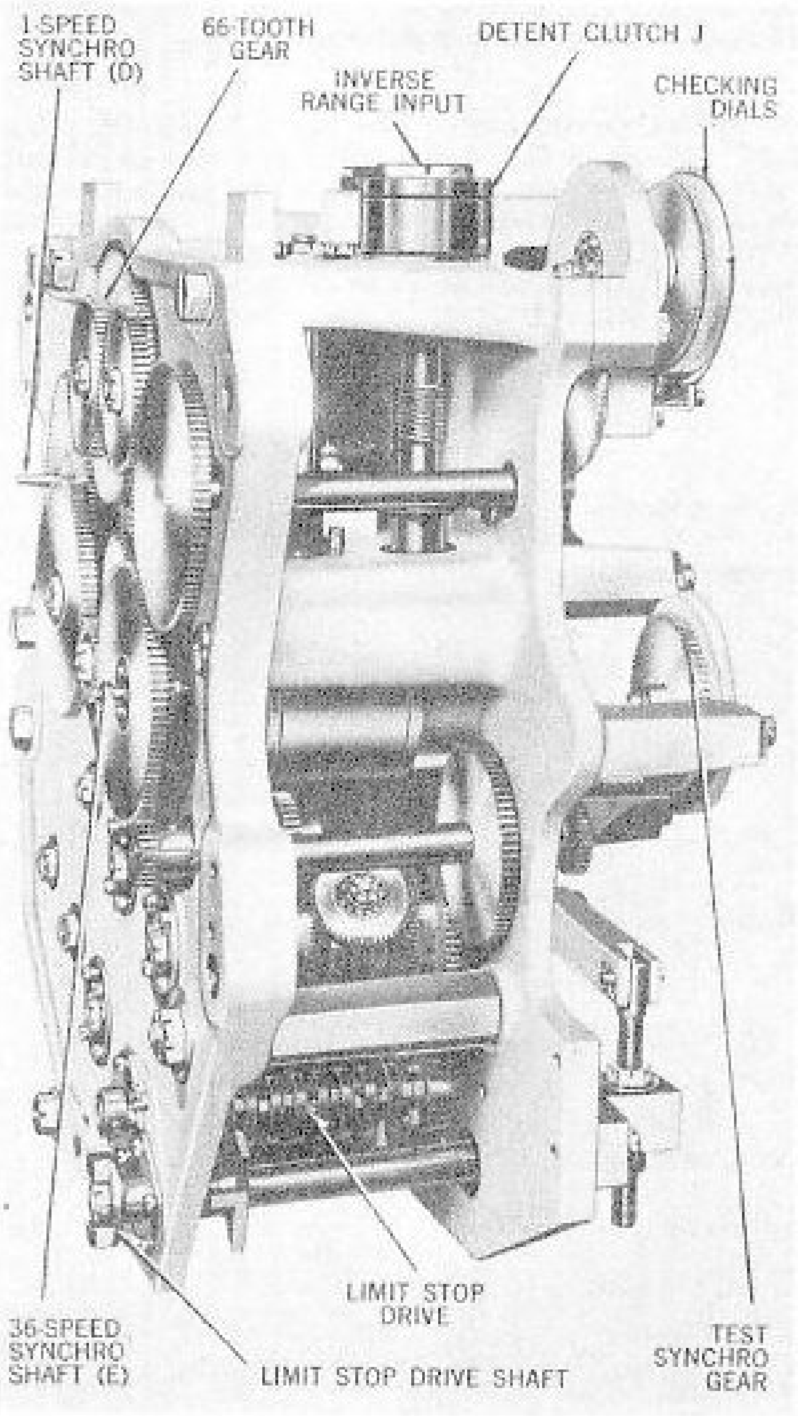


Figure 6-12. Train Receiver-Regulator Mk 18 Mod 5 Gear Box Assembly, Side View

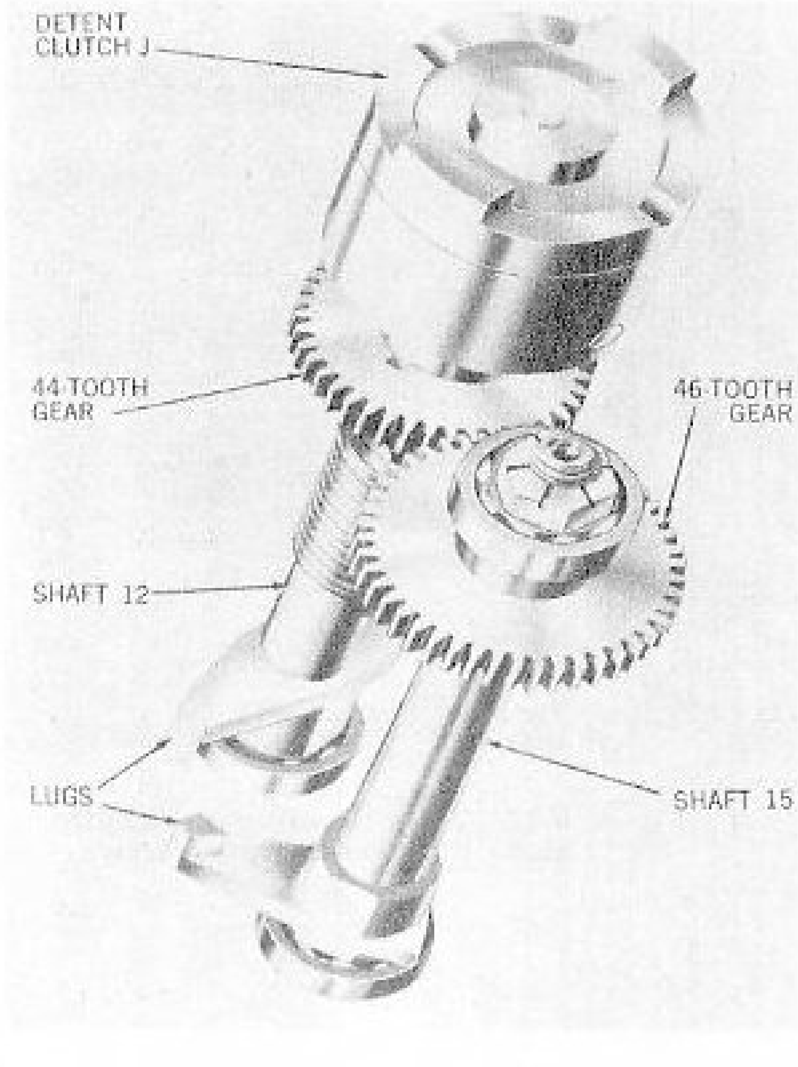


Figure 6-13. Train Receiver-Regulator Mk 18 Mod 5 Parallax-Computer Range Limit Stop Device

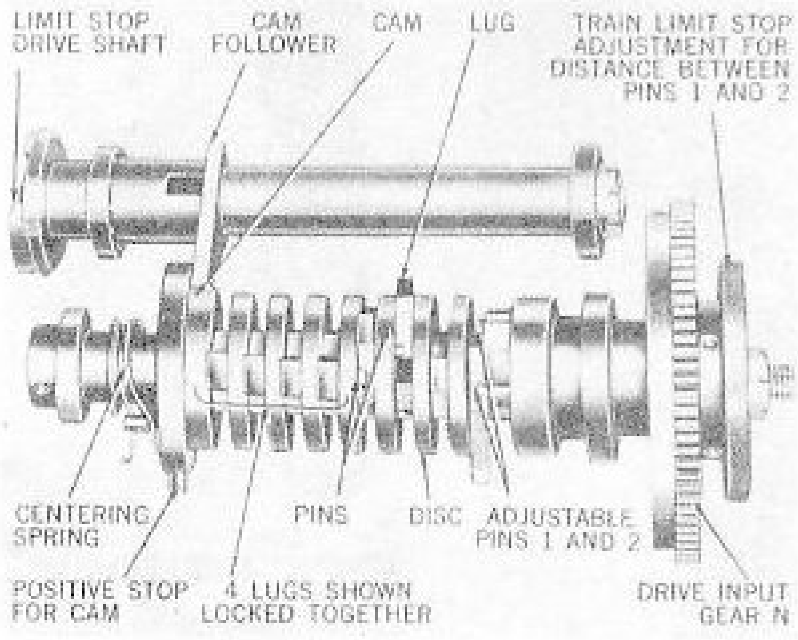
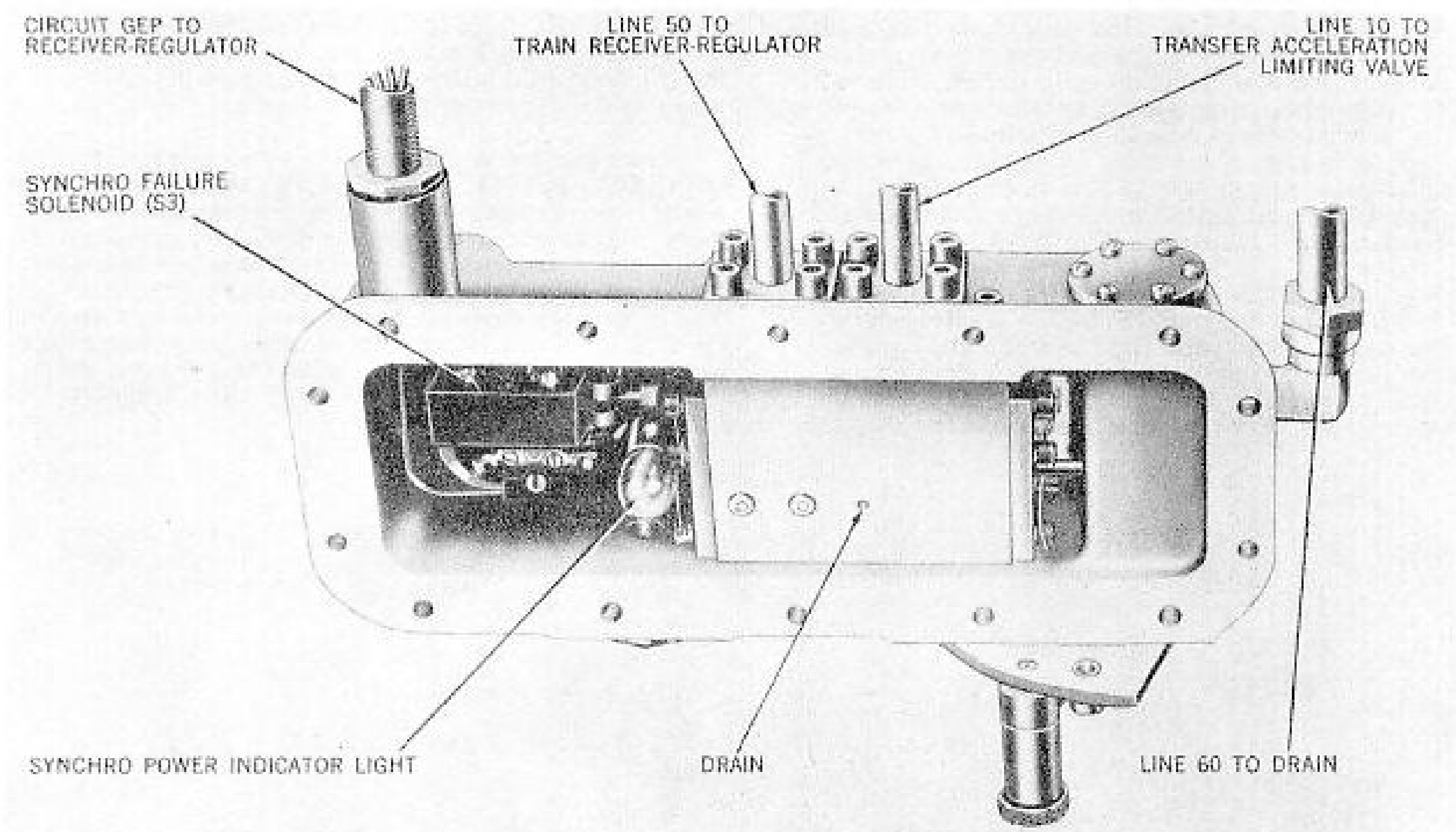


Figure 6-14. Train Receiver-Regulator Mk 18 Mod 5 Limit Stop Drive Assembly

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.



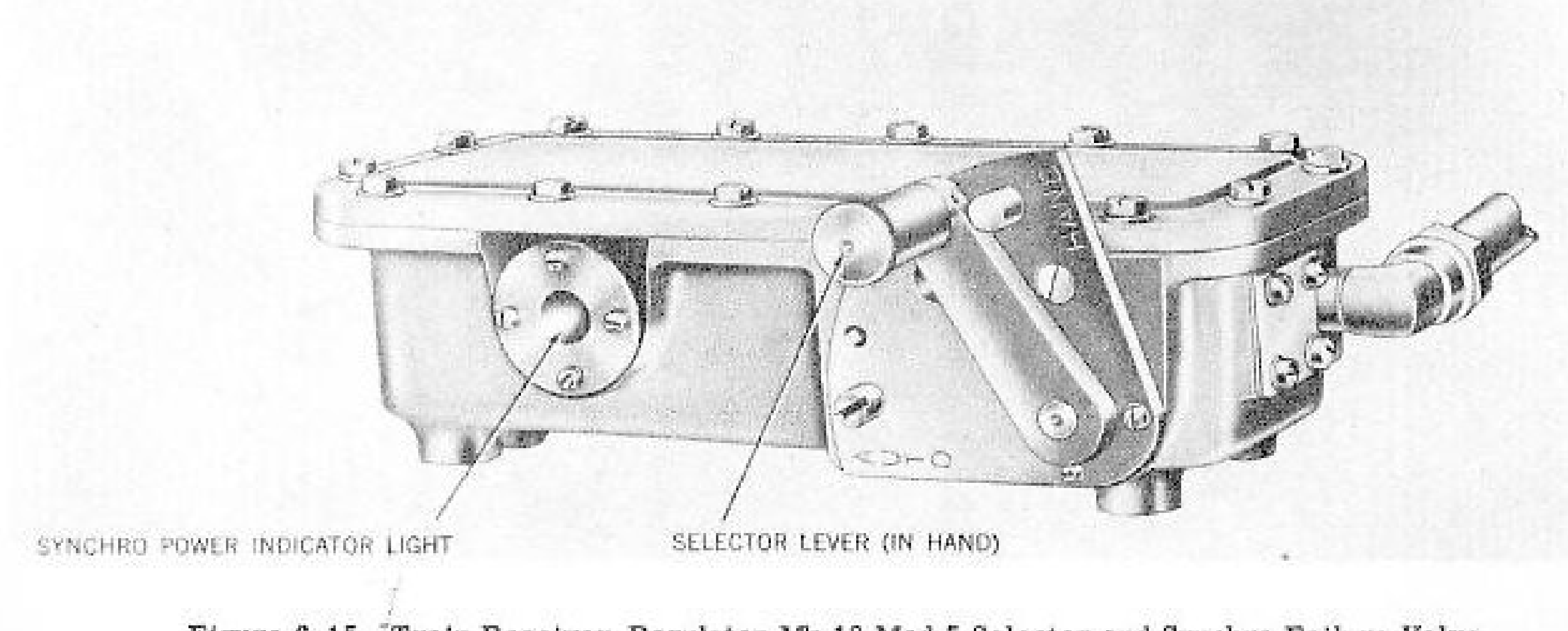


Figure 6-15. Train Receiver-Regulator Mk 18 Mod 5 Selector and Synchro Failure Valve

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.

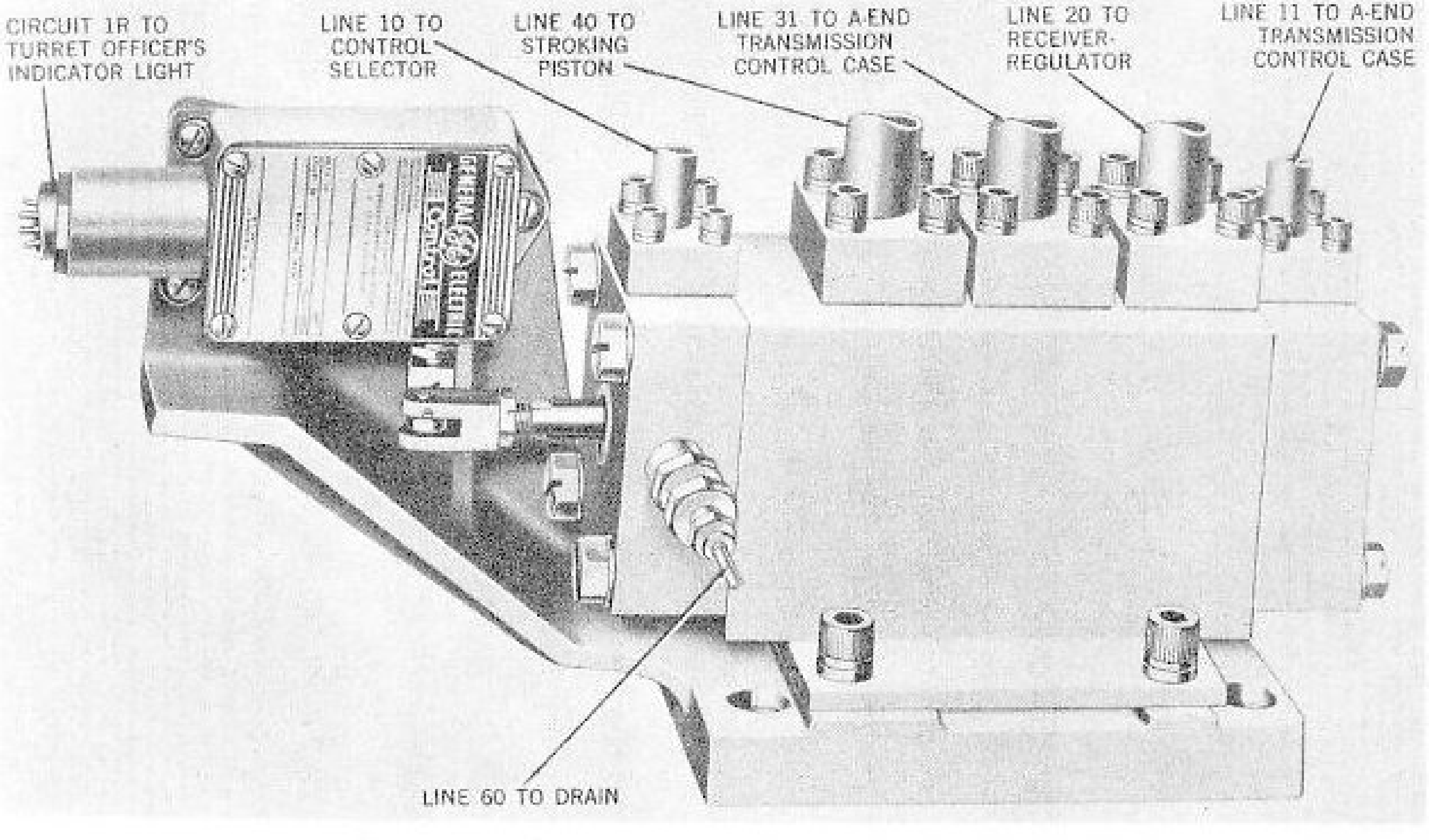


Figure 6-16. Train Receiver-Regulator Mk 18 Mod 5 Control Transfer Valve

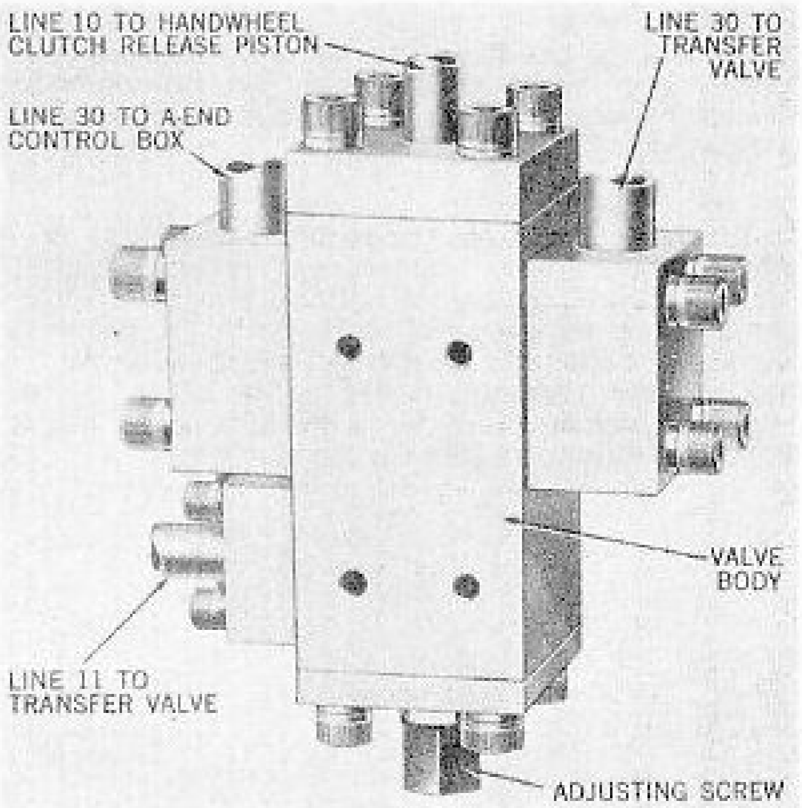


Figure 6-17. Train Receiver-Regulator Mk 18 Mod 5 Transfer Acceleration Limiting Valve

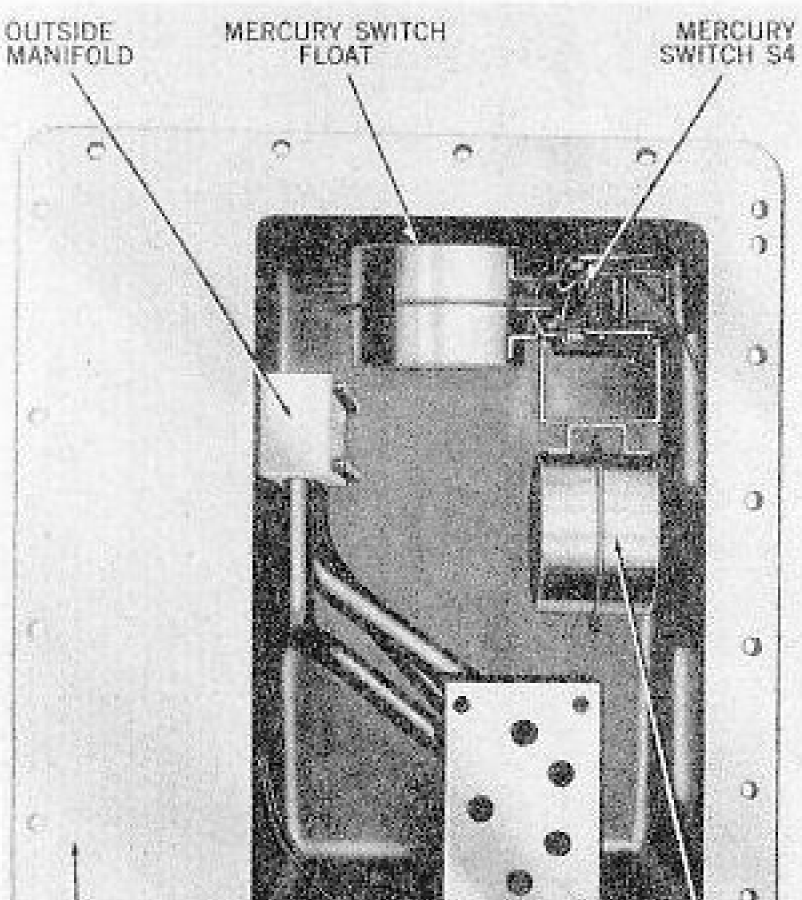


Figure 6-18. Train Receiver-Regulator Mk 18 Mod 5 Sump Tank

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.

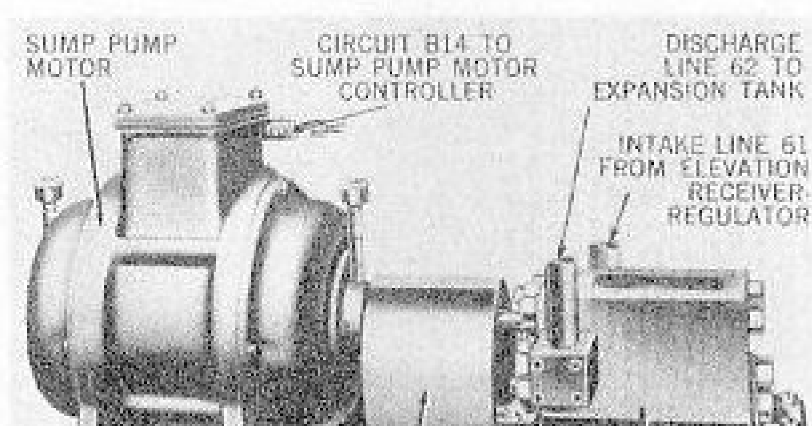


Figure 6-19. Train Receiver-Regulator Mk 18 Mod 5 Sump Tank

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.

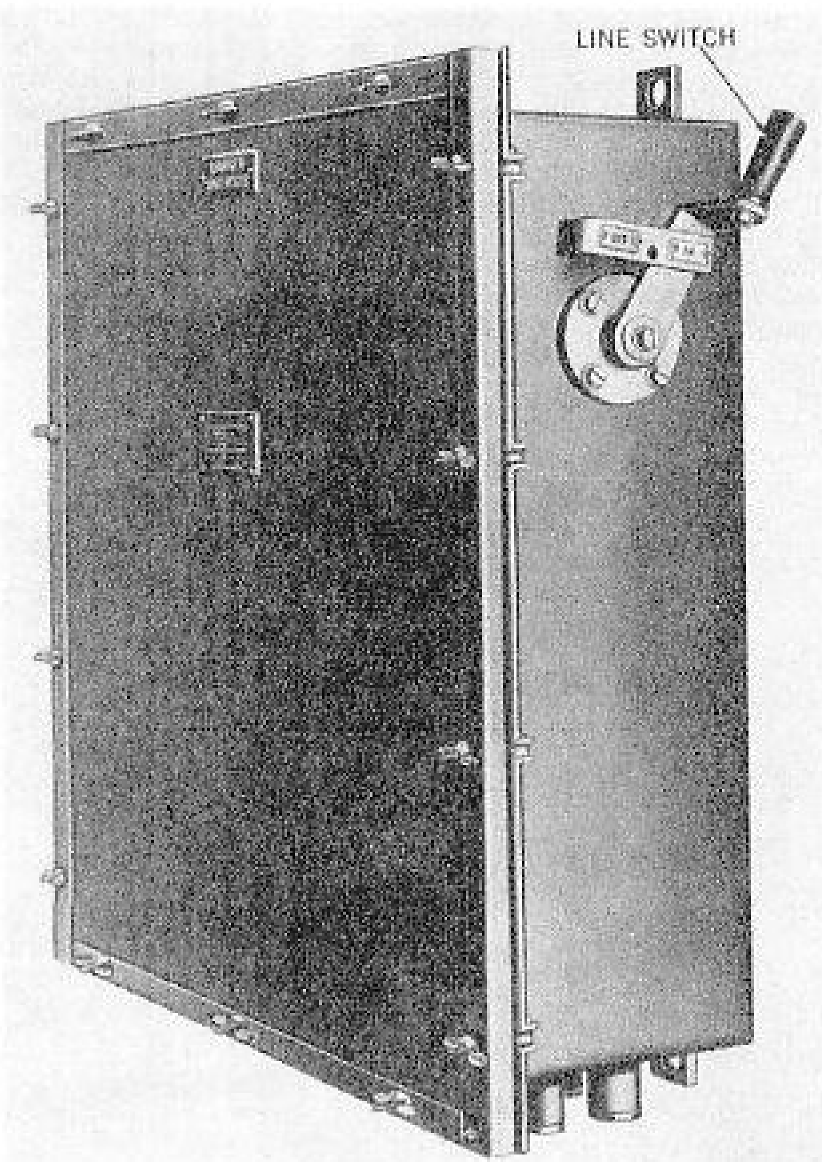


Figure 6-20. Train Receiver-Regulator Mk 18 Mod 5 Sump Pump Control Unit

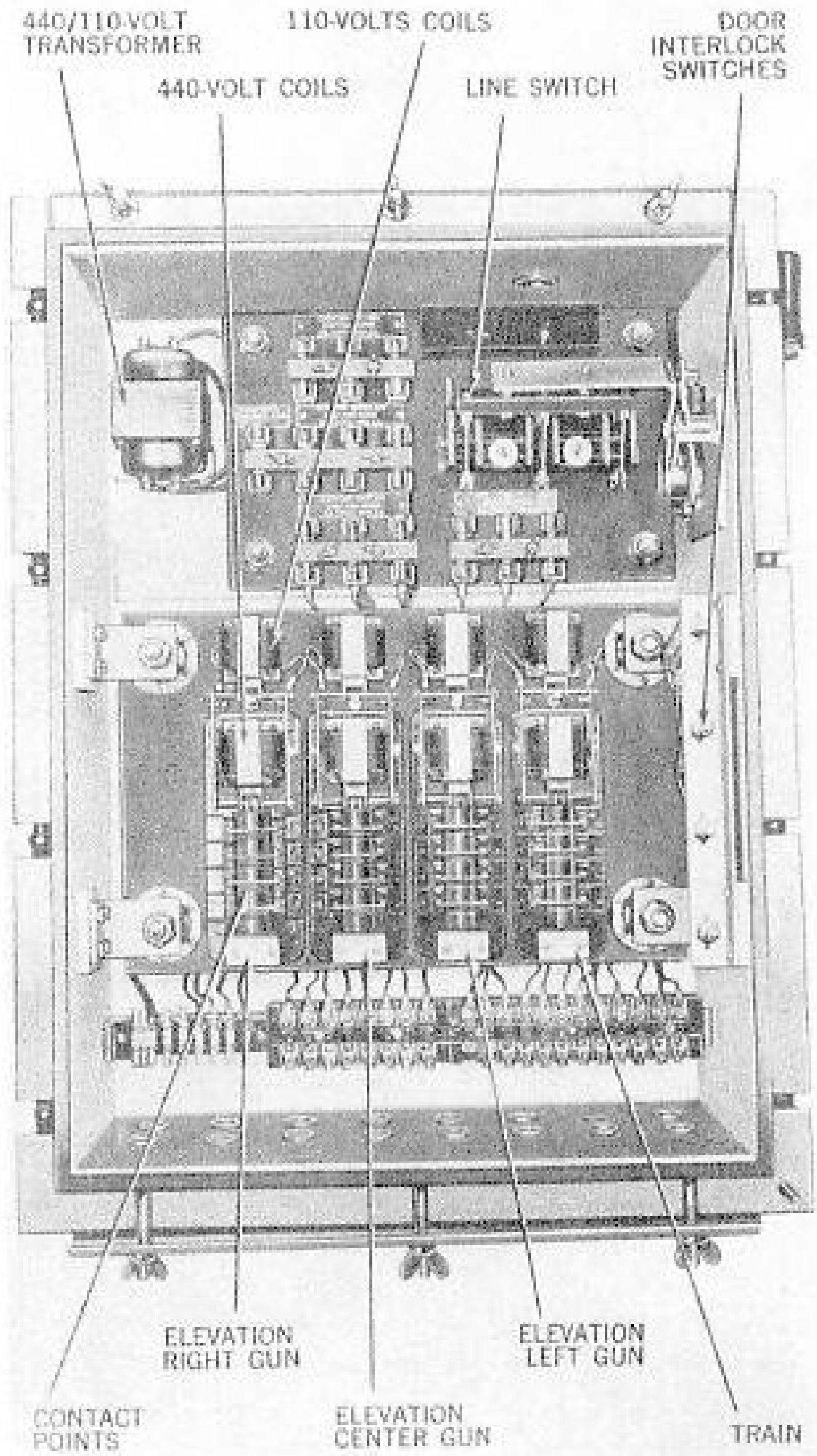


Figure 6-21. Train Receiver-Regulator Mk 18 Mod 5 Sump Pump Control Unit, Door Open

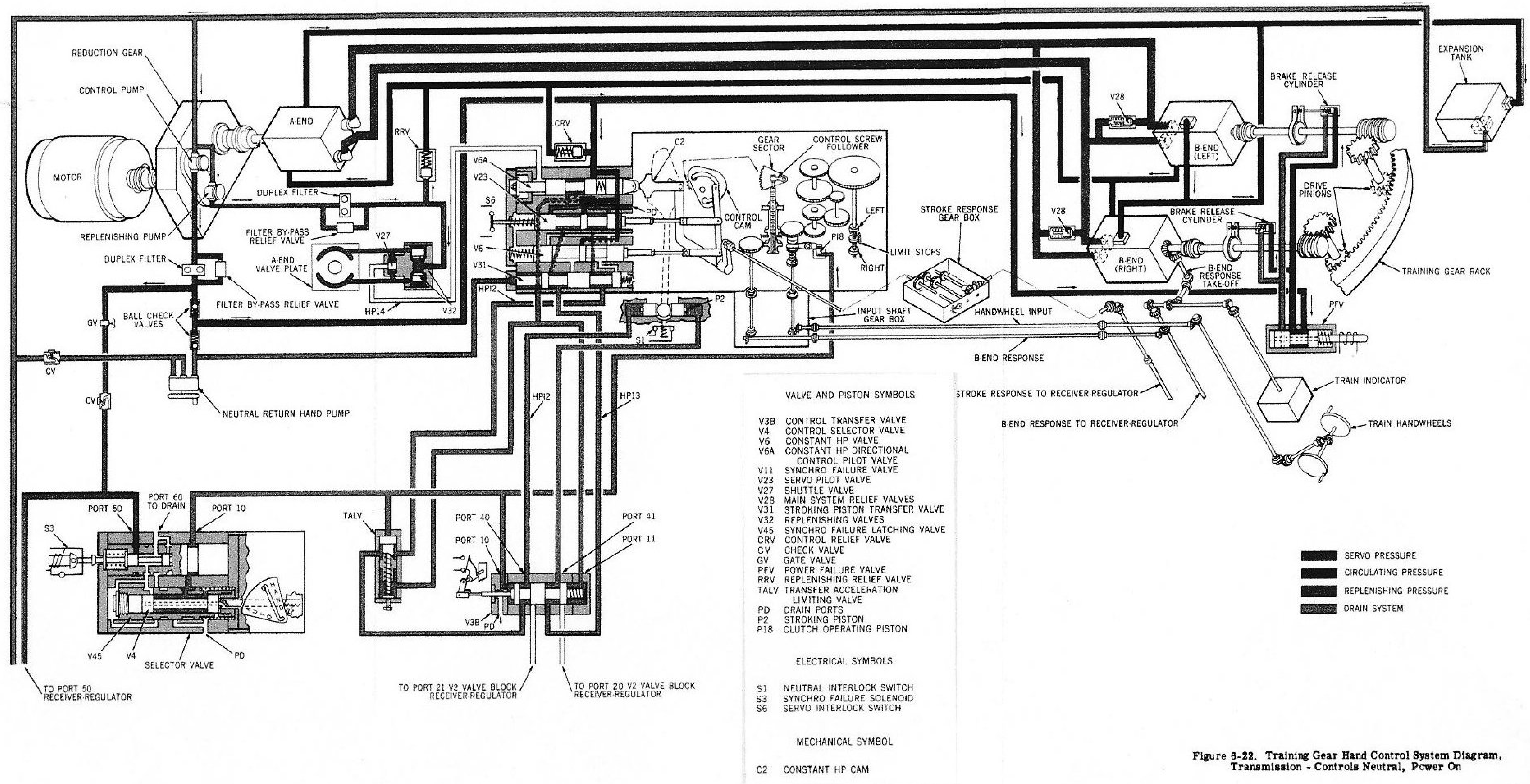


Figure 6-22. Training Gear Hand Control System Diagram, Transmission - Controls Neutral, Power On

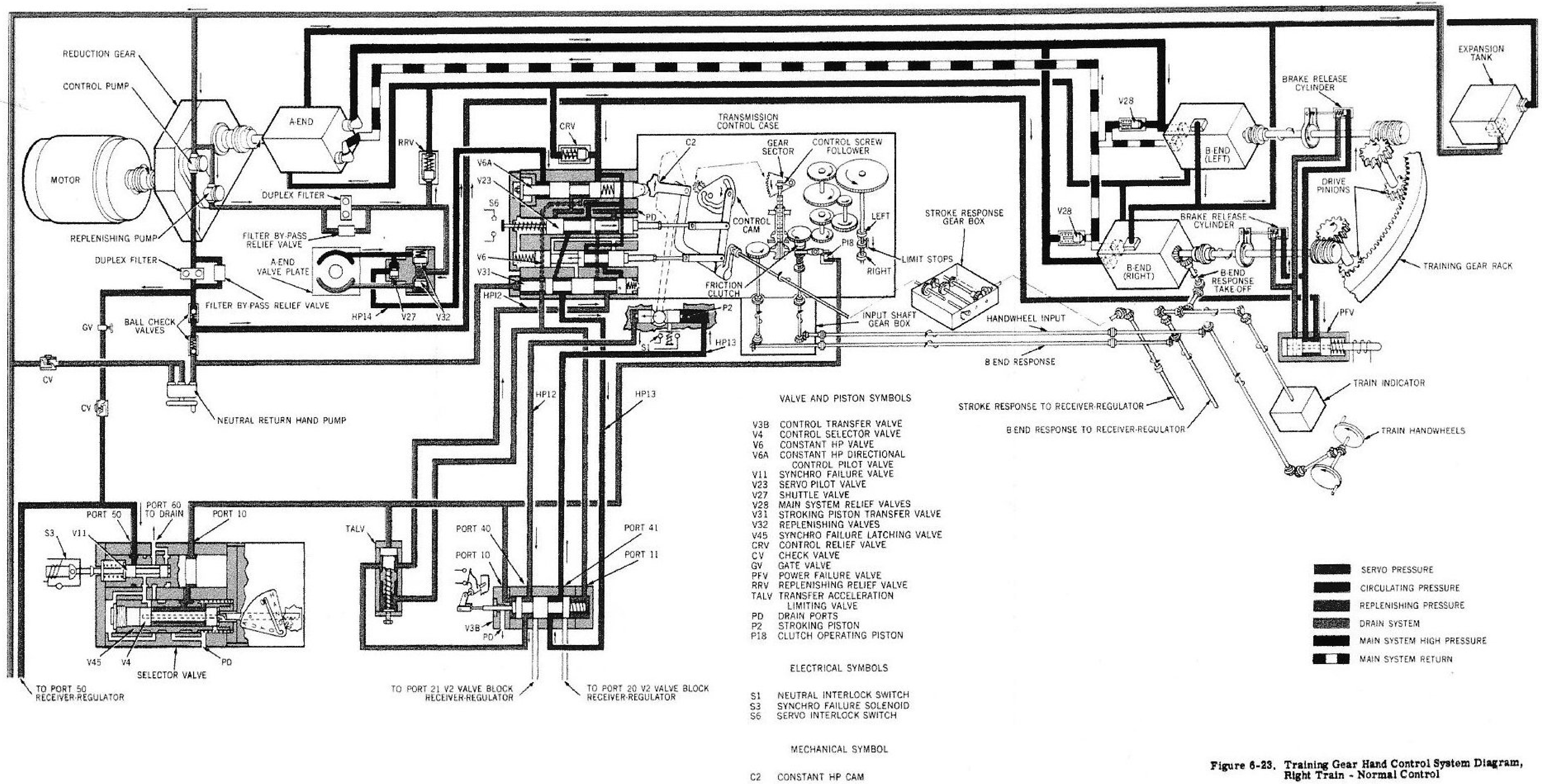
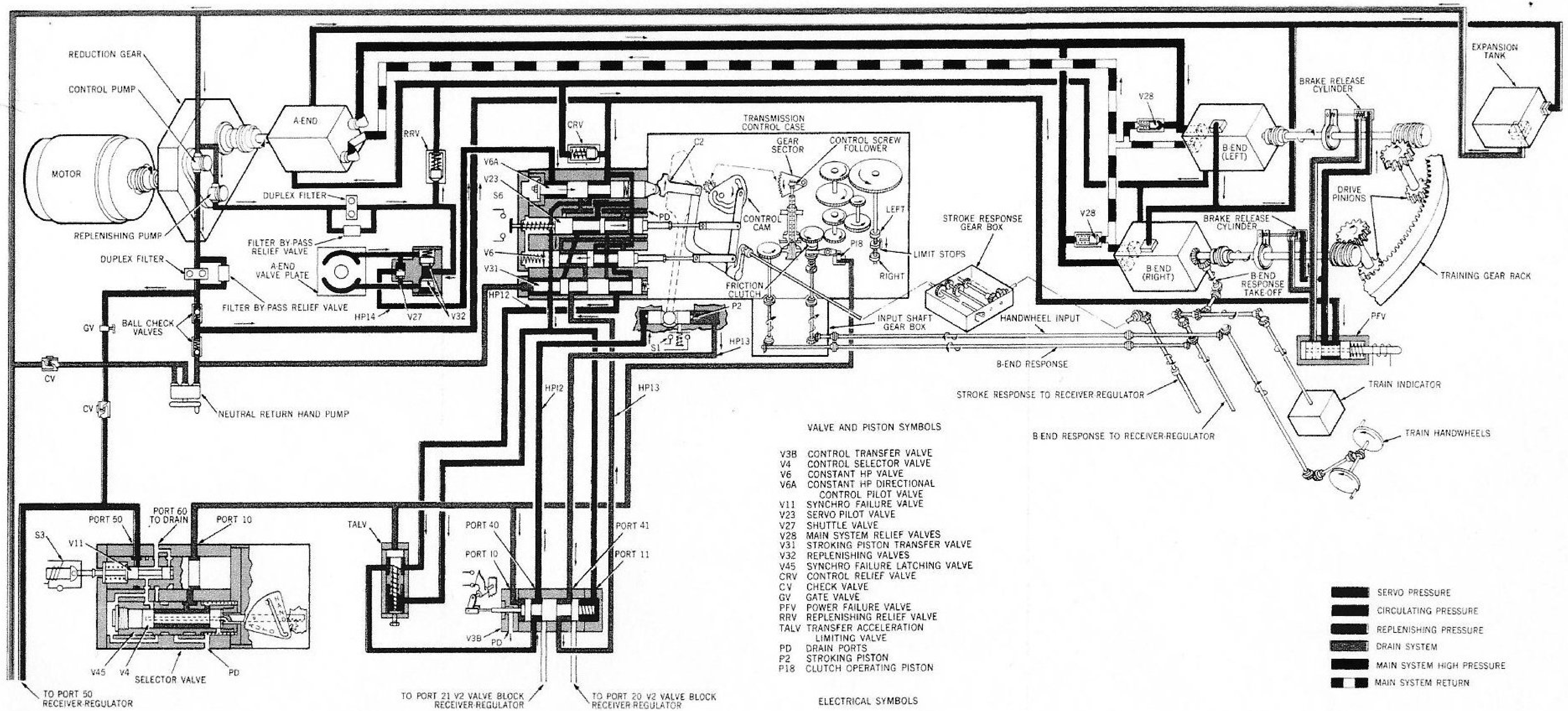


Figure 6-23. Training Gear Hand Control System Diagram, Right Train - Normal Control



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

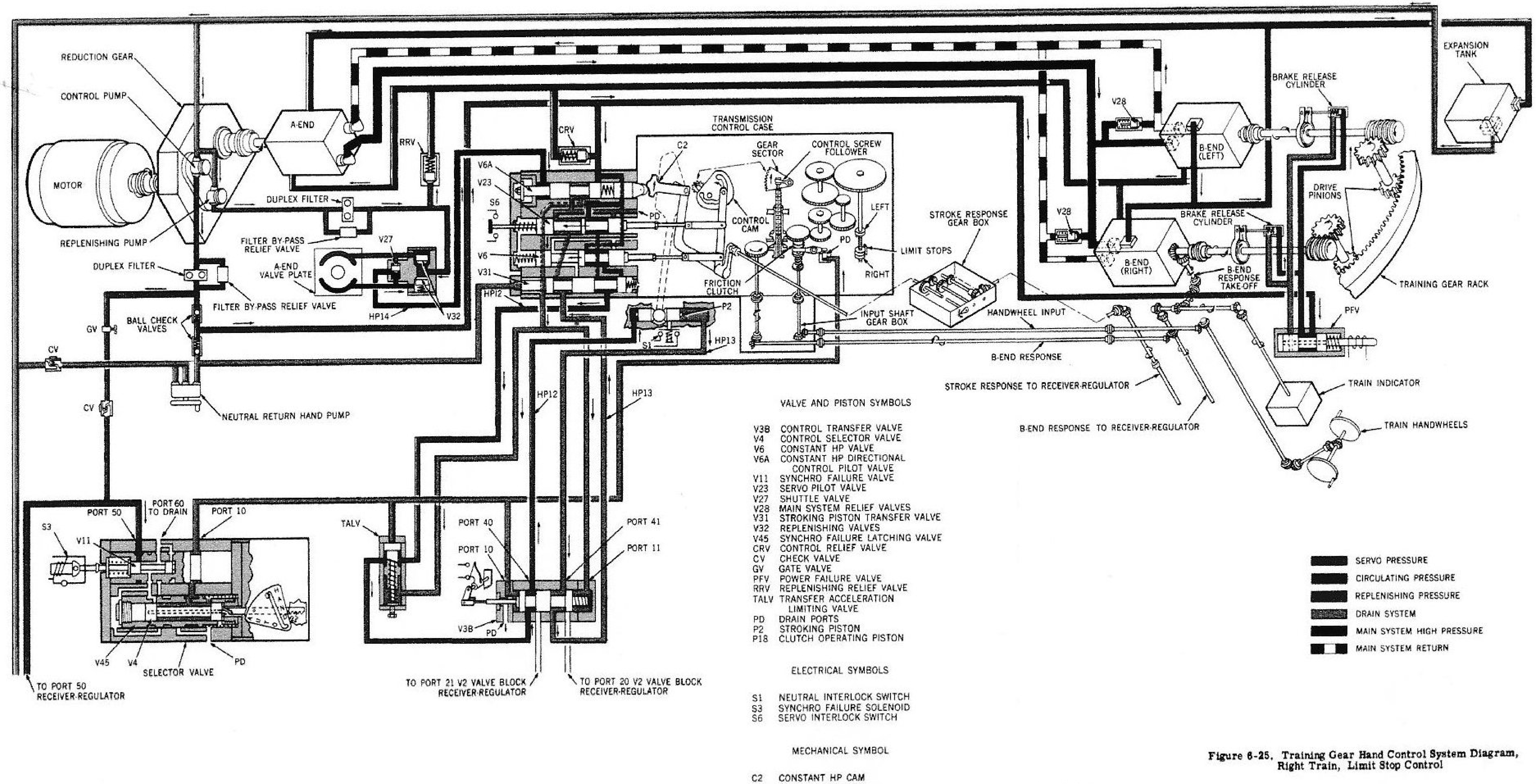
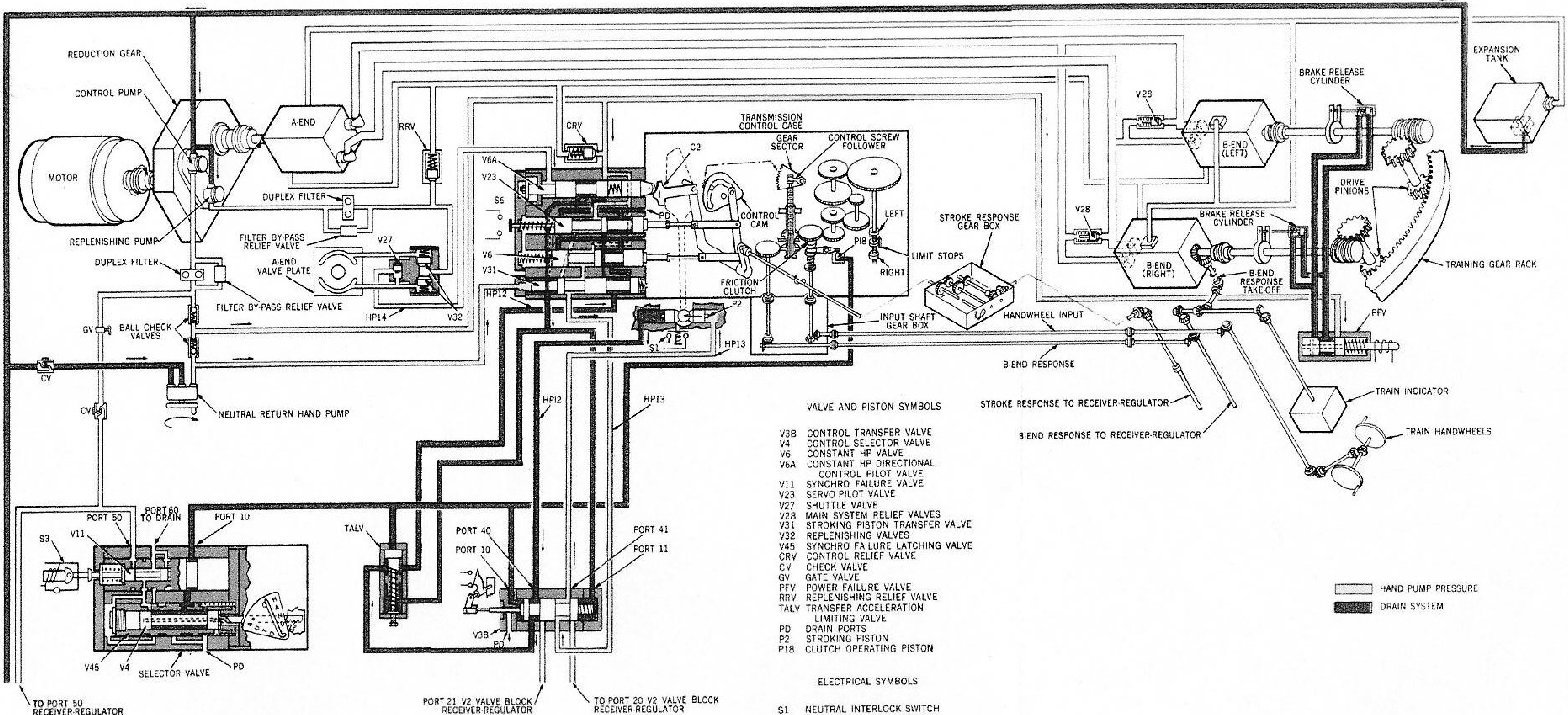


Figure 6-25. Training Gear Hand Control System Diagram, Right Train, Limit Stop Control



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

VALVE AND PISTON SYMBOLS

V1	STABILIZING VALVE	V40	SUMP PUMP VALVE
V2	AUTOMATIC STROKING VALVE	V41	SUMP PUMP CHECK VALVE
V3	FINE SYNCHRO VALVE	V42	PRESSURE REGULATOR VALVE
V3A	SYNCHRONIZING VALVE	V45	SYNCHRO FAILURE LATCHING VALVE
V3B	CONTROL TRANSFER VALVE	AV	AIR VENT
V4	CONTROL SELECTOR VALVE	CRV	CONTROL RELIEF VALVE
V6	CONSTANT HP VALVE	CV	CHECK VALVES
V6A	CONSTANT HP DIRECTIONAL CONTROL PILOT VALVE	GV	GATE VALVE
		PFV	POWER FAILURE VALVE
V11	SYNCHRO FAILURE VALVE	RRV	REPLENISHING RELIEF VALVE
V15	SYNCHRONIZING PILOT VALVE	TALV	TRANSFER ACCELERATION LIMITING VALVE
V23	SERVO PILOT VALVE		
V27	SHUTTLE VALVE	PD	DRAIN PORTS
V28	MAIN SYSTEM RELIEF VALVES	P1	STABILIZING PISTON
V31	STROKING PISTON TRANSFER VALVE	P2	STROKING PISTON
V32	REPLENISHING VALVES	P3	AMPLIFIER PISTON
V34	LIMIT STOP VALVE	P18	CLUTCH OPERATING PISTON

ELECTRICAL SYMBOLS

D	1-SPEED SYNCHRO	S3	SYNCHRO FAILURE SOLENOID
E	36-SPEED SYNCHRO	S4	MERCURY SWITCH
H	TEST SYNCHRO	S5	SUMP PUMP FLOAT SWITCH
S1	NEUTRAL INTERLOCK SWITCH	S6	SERVO INTERLOCK SWITCH

MECHANICAL SYMBOLS

C2	CONSTANT HP CAM	L2	STABILIZING LINKAGE
L1	AMPLIFIER LINKAGE	L3	SYNCHRONIZING LINKAGE

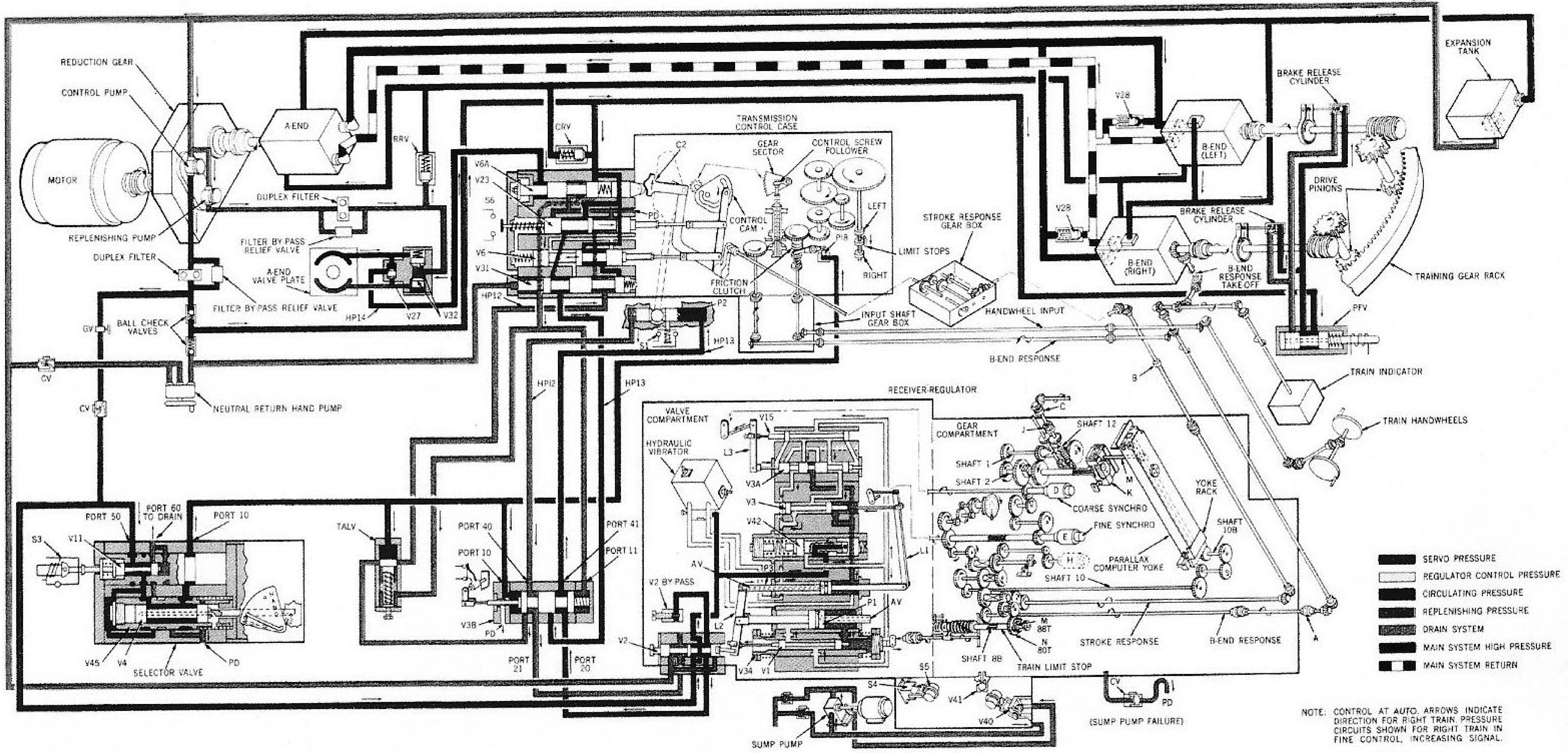


Figure 6-27. 16-inch Training Gear Mk 2 Mod 0 and Receiver-Regulator Mk 18 Mod 5 Hydraulic System, Schematic Diagram

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.

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.

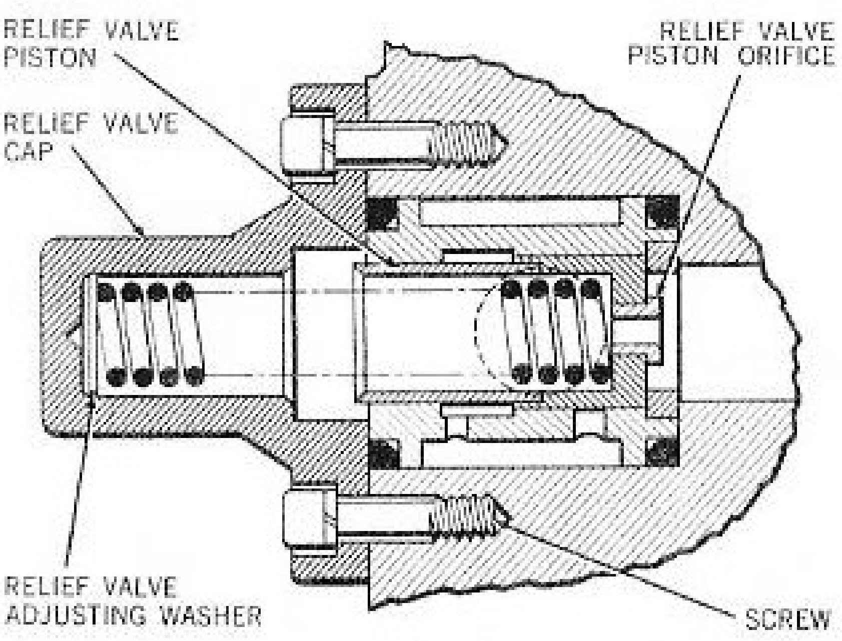


Figure 6-28. Training Gear B-end Relief Valve Adjustment

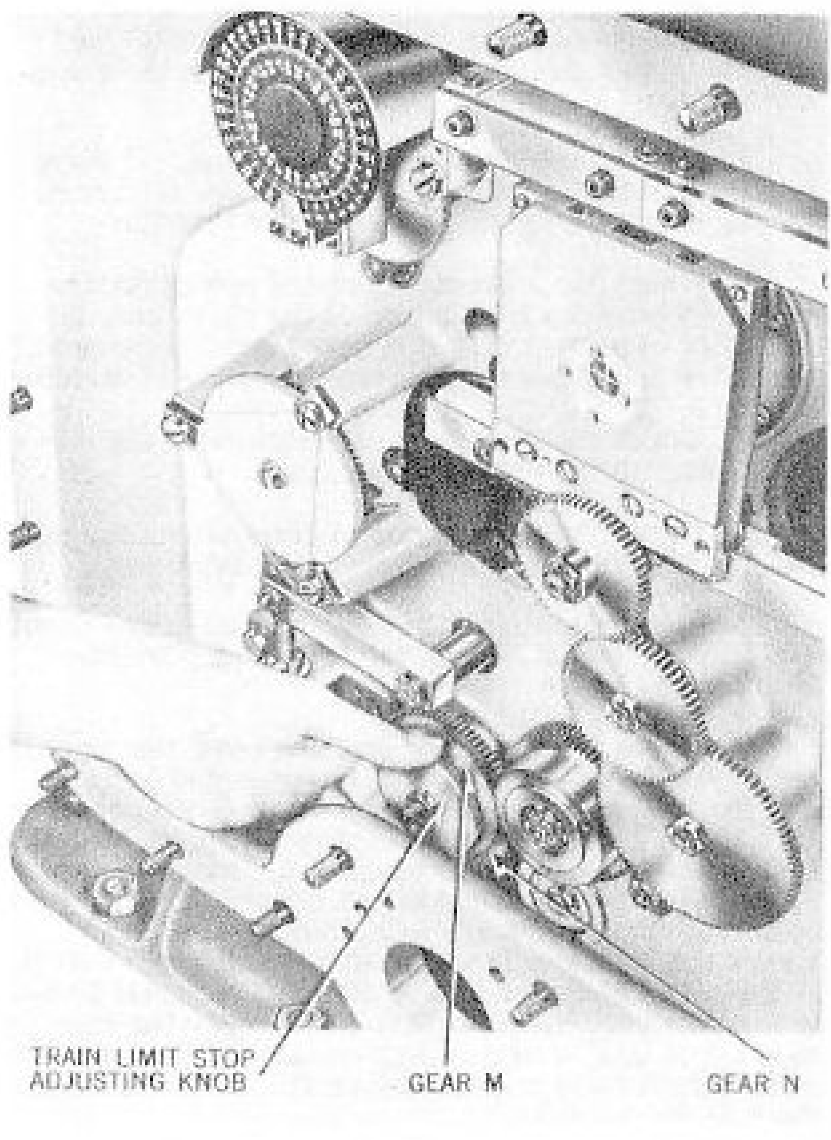


Figure 6-29. Train Receiver-Regulator Mk 18 Mod 5 Adjustment of Fine Limit Stop Spacing

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.

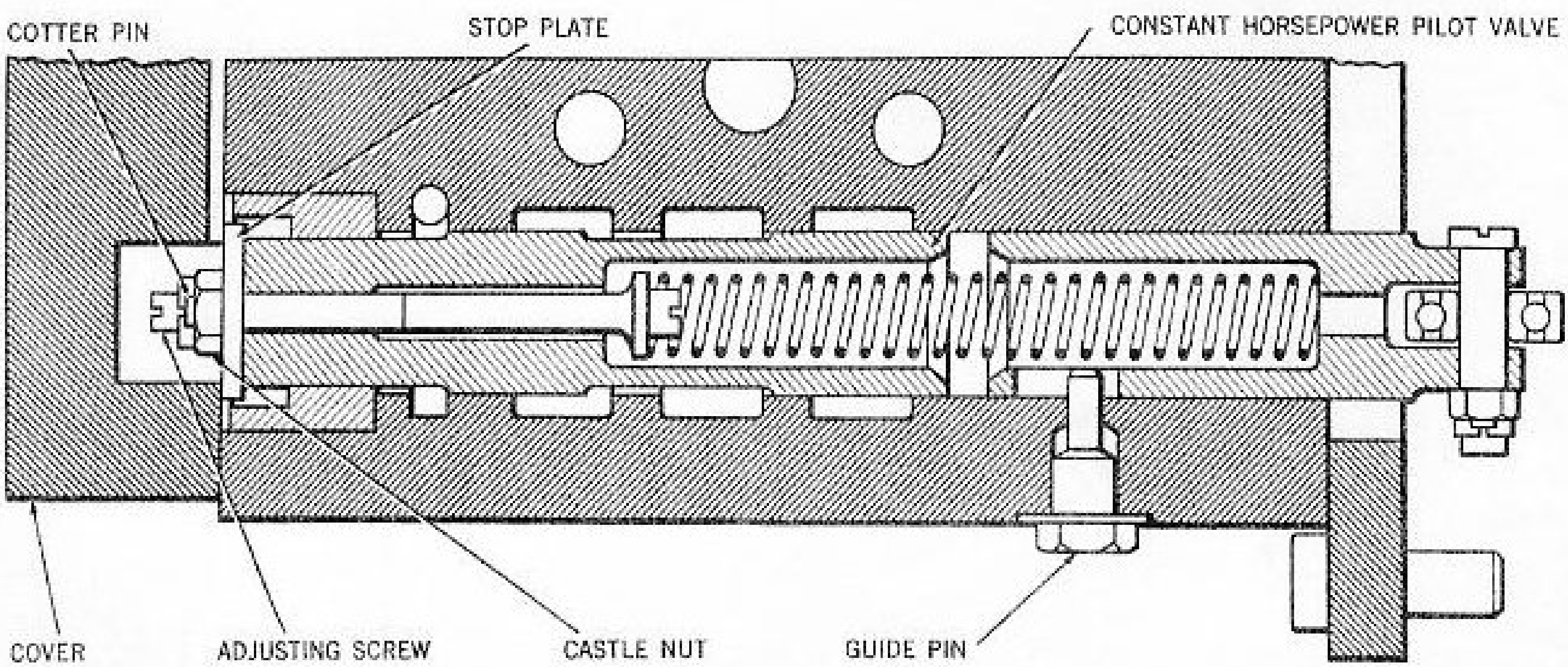


Figure 6-30. Training Gear Constant Horsepower Adjustment

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.

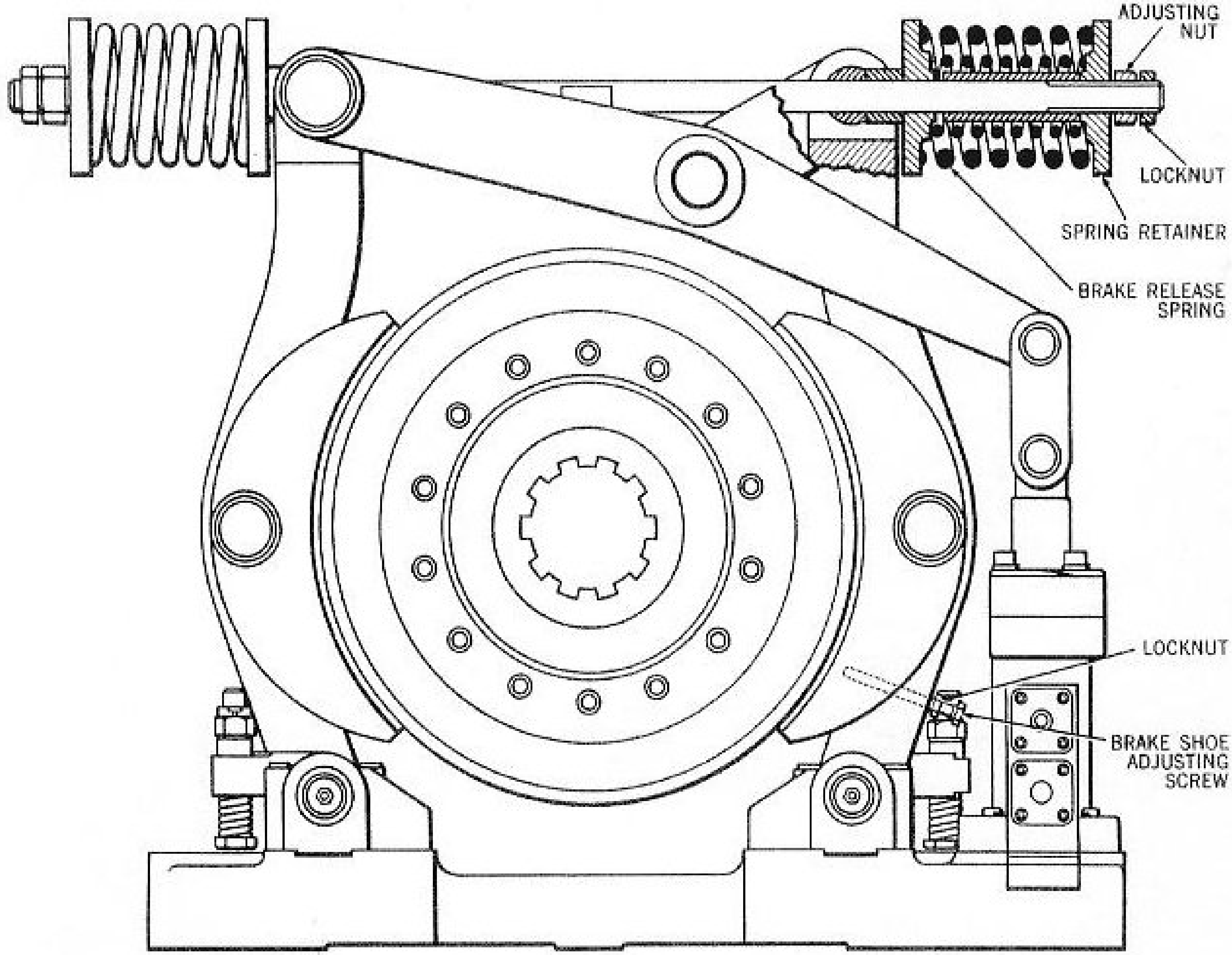


Figure 6-31. Training Gear Brake Adjustment

Zeroing the parallax computer (figs. 6-10 and 6-13)

When the parallax computer is assembled, its limit stops must be assembled in the proper relationship to the length of the crank arm to crank pin M (fig. 6-27).

To make this adjustment proceed as follows:

1. Verify that the detent clutch J is engaged.

2. Disengage the mesh of the 66-tooth gear on the end of shaft number 2.

3. Rotate shaft number 2 until crank pin M lines up with crosswires, as seen through the window in the computer yoke. This action places pin M in line with the centerline of shaft number 2. Regardless of the rotation of block K, no motion should be produced on the computer yoke. This input corresponds to infinite range, and no correction is produced regardless of train angle. For a fine adjustment of the zero motion, rotate the turret response input shaft, thereby rotating block K, and adjust shaft number 2 until no motion is produced on the computer yoke.

4. Rotate the inverse range input shaft counterclockwise (as indicated by the arrow on shaft 12, fig. 6-27) until the stops are reached with the 66-tooth gears remaining disengaged. Rotate shaft 12 0.5-to 0.7-turn back from the stop, and engage the 66-tooth gears. If the gear teeth do not line up within the fractional allowance, it will be necessary to run the 30-tooth gear, on shaft 2, off the track (which carries crank pin M) and re-engage the gear one tooth removed from its previous position. This can be done without disassembling the computer yoke if block K is rotated to a horizontal position. Exercise great care because the yoke carrier bearings may bind in the carrier rails as the yoke moves beyond its normal operating range.

5. Rotate the inverse range shaft clockwise to its stop after the 66-tooth gears have been meshed and secured. Rotate block K at least one complete turn (by rotating the response shaft) and check for interference. The computer yoke should travel through its entire range as block K is rotated.

6. Rotate block K, by turning the response shaft until the parallax arrow points upward. In this position, the adjustable hub should have the adjusting screws on top. With the hub in this position, adjust it until rotation of the inverse range input produces no motion on the computer yoke. This indicates zero (or 180 degree) train angle for block K. No parallax correction is needed at this angle of train regardless of the range. Crank pin M merely slides up and down in the yoke slot. A slight change of adjustment may be necessary after the synchros are zeroed.

Setting the checking dials

Set the checking dials at zero for turrets I and II, and 180 degrees for turret III with the hub and block K (as in step 6 of the previous set of directions).

To set the checking dials, position the dials on their respective mountings.

The dials should be accurately reset after the synchros have been zeroed.

Setting the synchros

Setting the synchros to the transmitted gun train signal must be done after assembling the gear train to the receiver-regulator case. The synchros are set by positioning the synchro cranks properly on their rotor shafts.

To set the synchros:

1. Set the receiver-regulator at zero degrees train for turrets I and II (180 degrees for turret III), using the checking dials as a reference.

2. Refer to adjustment of synchro electrical zero on page 6-30. Perform step 6.

3. Assemble the coarse synchro crank, as in step 7. The crank, when assembled to its nearest position below the rotor shaft by the flexible drive, may be slightly off center. Set accurately by rotating the turret response shaft.

4. Assemble the fine synchro crank, as in step 8. Set the crank accurately, as above.

5. Check the checking dials for zero (or 180 degrees) after the synchros are set.

6. Check the parallax computer for zero. Rotate block K by turning the response shaft until the parallax arrow points upward. In this position, the adjustable hub should have the adjusting screws on top. With the hub in this position, adjust it until rotation of the inverse range input produces no motion on the computer yoke.

7. Check the settings, as in operation 11,page 6-30.

Zeroing the valve block

When the valves are in neutral (fig. 6-9), the amplifier linkage L1 and the stabilizing linkage L2 should be vertical and parallel to the valve block.

To adjust these components:

1. Start the power drive.

2. Position the control selector lever at HAND, and position the turret at zero degrees train (180 degrees train for turret III); admit hydraulic fluid to the receiver-regulator.

3. Have a gun train signal of zero (180 degrees for the after turret) transmitted to the turret. The fine synchro E crank should be up, and the coarse synchro D crank should be down, and both cranks on the vertical centerlines of their respective synchros.

4. Stop the power drive.

5. Move amplifier piston P3 to its center position by first moving it to its limit on each side and then taking the average center position. Measurements taken with a steel scale are sufficiently accurate.

6. Connect the fine synchro E crank arm and adjust the connecting rod so that the amplifier linkage L1 is parallel to the valve block.

7. Connect the coarse synchro D crank arm and adjust the connecting rod so that the synchronizing valve linkage L3 is parallel to the valve block, and the synchronizing valve V3A is centered in the valve block.

8. Press the START-EMERG button with the control selector lever at HAND. The turret may train slightly when the electric motor is started. Verify the zero (or 180 degree) angle of train. This is the reference point.

9. Restore the synchronizing valve V3A to its center position. To do this, adjust the synchronizing pilot valve V15 until the synchronizing linkage L3 is again parallel to the valve block. These components must be carefully aligned.

10. Adjust the fine synchro valve V3 so that the amplifier piston P3 is centered once again. The amplifier linkage L1 should be parallel to the valve block.

11. Adjust the stabilizing valve V1 so that the stabilizing linkage L2 is parallel with the V2 valve block.

CAUTION: While adjusting the stabilizing valve V1, do not get fingers caught between stabilizing valve V1 adjusting screw and the block of the automatic stroking valve V2.

The adjustments made up to this point may not be exactly correct, because so far the automatic stroking valve V2 has not been centered. In the next step, the automatic stroking valve V2 is adjusted. Slight readjustment of the stabilizing valve V1 may be necessary.

12. Position the control selector lever at AUTO. The turret will probably train a few degrees and thus disturb the parallel condition of the linkages. The turret will come to rest with the automatic stroking valve V2 centered.

13. Adjust the stabilizing valve V1 so that the linkages are parallel with the valve block. The turret should then be back at zero degrees (or 180 degrees). If the turret is not at zero (180 degrees), it may be necessary to readjust the turret response input at coupling A, and reset the checking dials. Only slight readjustment should be necessary.

Replacement installation of receiver-regulator, initial settings and adjustments

The procedure for synchronizing and aligning the elements of the receiver-regulator are described in following paragraphs. In the following description it is assumed that the receiver-regulator is mounted in position on the sump tank, and that the personnel doing the work are familiar with the design of the instrument. Refer to drawings 319805 and 319766.

Response drive setting and coupling.

To connect the response input shaft:

1. Start the power drive.

2. Position the turret at zero degrees train (or 180 degrees for turret III). If the train indicator has been accurately set, it may be used for the train angle reading. Otherwise the turret must be trammed.

3. Set the inverse range input on zero to insure proper setting of the response shaft. This is done by rotating the inverse range input shaft until the marker on the end of the parallax computer lines up with the cross hairs of the parallax computer yoke. In this position, the crank arm is in line with centerline number 2, and regardless of the train angle (as represented by the position of block K), no motion is produced on the computer yoke. Check that no movement of the computer yoke results by rotating block K through rotation of the turret response shaft.

4. After the inverse range shaft has been set, inspect detent clutch J and make sure that it is properly engaged. Set the turret indicator for INFINITE RANGE, and connect the inverse range shaft. Final adjustment may be made at adjustable coupling C. Check by setting the turret indicator to 3400 yards and inspect detent clutch J once again. Set the turret indicator to its stop (2800 yards) and inspect detent clutch J. The clutch should not disengage. If it does, the stops in the indicator may be improperly set, the inverse range shaft may have been improperly coupled, or the receiver-regulator inverse range limit stops may be improperly assembled. Reset the indicator to INFINITE RANGE and recheck for zero movement of rack C as the turret response shaft rotates. The indicator should remain set at INFINITE RANGE while the turret response shaft is being connected.

5. Rotate the turret response shaft until the checking dials indicate the known angle of turret train.

6. Connect the turret response shaft and make final adjustment at coupling A.

7. Set the checking dials as directed on page 6-31 of this chapter.

Set the automatic limit stops before the turret train is tested in AUTO. This is extremely important, because serious damage will occur if, while in AUTO, the speed gear should over-run the HAND limit stop.

Automatic limit stop operating range adjustment. The operating range is determined by the number of active discs in the assembly together with the spacing of the adjustable pins 1 and 2 in the first disc. Each active disc represents 20 degrees of train angle, and the spacing of pins 1 and 2 represents 16.4 minutes of train angle per tooth in the mesh of the gears M and N, shown in figure 6-29. The number of active discs may be varied by locking any desired number of discs to their adjacent lugs.

To adjust the operating range:

1. Remove the side and rear covers from the receiver-regulator gear compartment.

2. Remove the knurled adjusting knob, the 80-tooth drive gear N, and the bearing retainer.

3. Force the discs apart so that about 1/8-inch clearance is obtained between any disc and its adjacent lug.

4. Lock the discs by placing the ends of the pins into holes of the lugs.

5. Lock the desired number of lugs together.

6. Reassemble gear N and the bearing retainer.

7. Make the fine adjustment by disengaging the knurled adjusting knob and reengaging it in a different position (fig. 6-29).

The 88-tooth gear set M and N acts as a many tooth spline, connecting pins 1 and 2 to each other so that they function as a single unit. The distance between the pins determines the amount of train angle represented by the first disc.

Limit stop position adjustment. The adjustment described previously deals only with the train operating angle. It is necessary to place this angle between the limits of travel for the turret.

To adjust the limit stop position:

1. Start the power drive.

2. Operate the handwheels slowly until the limit of train is reached in one direction, then reverse the handwheels 1/2 turn.

3. Uncouple the stroke response shaft.

4. Rotate the stroke response input to set the stop at the position of maximum travel. Make final adjustment at coupling B.

5. Train the turret to the opposite stop in order to check the operating range.

Adjustment of limit stop valve V34. The limit stop valve V34 is spring centered, movable only by the limit stop drive shaft. V34 should be carefully centered by the adjusting nuts at the springs while the drive linkage is disconnected. The adjusting screw on the crankarm of the limit valve drive shaft should be set so that no force is exerted by the cam follower on the detent of the cam.

To adjust the limit stop valve:

1. Disconnect the stroke response shaft.

2. Determine the approximate operating range and lock the required number of discs and lugs (as described on page 6-32 of this chapter), then re-engage gears M and N.

CAUTION: Read step 9 below before training. While training, rotate the stroke response input shaft by hand so that the cam follower remains in the cam detent.

3. Train the turret slowly in HAND toward one of the train limit positions. This position (usually when training toward the port side) should be the stop on the side at which the fixed pin (the long adjustable pin of set 1 and 2) becomes active. This leaves the movable pin available for adjustment at the opposite stop.

4. Rotate the stroke response input shaft so that the limit stop valve V34 moves about 3/16 inch in the direction necessary for stopping the turret at the end of the travel previously set. If the turret is training to the right into the stops (increasing train angle), the valve V34 should move toward the crank linkage. If training to the left, the valve V34 should be pushed into the valve block, away from the crank linkage.

5. Connect the stroke response shaft.

6. Train away from the stop about 15 degrees. Match pointers and switch to AUTO. Train slowly in AUTO toward the stop and adjust coupling B until the automatic stop brings the turret to a halt at the desired position.

7. Train in AUTO to the opposite limit stop position. That position may be set by adjusting the fine range adjustment on the knurled adjusting hub (as described on page 6-32).

8. With the turret control in AUTO, train slowly into each stop and check the stop position. If necessary, adjust the stop position at stroke response shaft coupling B.

9. The automatic limit stops should function slightly ahead of the hand limit stops - never between the hand limit stops and the positive stop buffers. If the automatic limit stops are set to function after the hand limit stops, there is danger of damaging the speed gear controls and hand limit stops.

Position of synchro cranks. The synchro generator-receiver system must be energized to check and adjust the position of the synchro cranks.

Position the synchro cranks as follows:

1. Place the gun train order in correspondence with the turret position. The coarse synchro D crank should extend downward and the fine synchro E crank should extend upward.

2. Have the gun train order increased for right train. The coarse synchro D crank should rotate clockwise and the fine synchro E crank should rotate counterclockwise.

Change gears for the parallax computer. The change gears determine the amount of correction for a given condition of inverse range and train angle. They must be the correct gears for the turret in question.

Change gears for the Iowa class turrets are:

Mod. number	Turret number	Base feet	Drawing 298318 Gear F	Drawing 298318 Gear G
5	I	119	piece 3	piece 4
6	II	47	piece 11	piece 12
7	III	299	piece 13	piece 14

Hydraulic vibrator. The hydraulic vibrator acts to vibrate the amplifier piston P3 through a very small amplitude and thereby eliminate static friction in the control linkages and valves. There are two adjustments on the hydraulic vibrator, one for frequency of vibration and the other for amplitude of vibration. To adjust the hydraulic vibrator:

1. Adjust the frequency through the throttle device in the servo pressure supply line for the vibrator. The factory throttle adjustment, made with a stroboscope, is for a crank shaft rotation of 1600 revolutions per minute. If the throttle requires readjustment aboard ship, and a stroboscope is not available, the shaft rotation speed is difficult to determine. The vibrator frequency should be fast enough so that hunting of the turret is at an absolute minimum. If the frequency of vibration is too rapid (about 1800 revolutions per minute), matching error increases. The frequency should be set sufficiently fast for minimum hunting, and at the same time, not so fast that matching error is objectionable.

Adjust the displacement of the vibrator by varying the length of the crank arm.

2. Remove the oil deflecting cover from the end of the vibrator in order to make this adjustment.

3. Replace the two cover screws before running the power drive. The cover screws function as plugs for oil passages in the vibrator block.

4. Measure the total travel of the pistons with a steel ruler. This data furnishes a base dimension from which to start the adjustment. This data is best obtained with the power off and by rotating the crank by hand.

5. Loosen the crank adjustment clamp screws just enough to permit tapping the crank along its slot by means of a light blow. Measure the travel and adjust for the desired amount.

6. Tighten the clamp.

The deflecting cover need not be replaced for trial training runs.

The adjustment should be set for minimum error. If error recording equipment is not available, the crank should be set for the maximum travel that will not cause the turret to hum with the vibration frequency. Several trials may be necessary before the proper combination of frequency and amplitude is obtained.

DISASSEMBLY AND ASSEMBLY

General

Disassembly and assembly of the training gear equipment should be performed by personnel who are familiar with the equipment and procedure, and who are equipped with the standard and special tools required for the job. All instructions applying to major components presume removal from installed position to a convenient location for disassembly. Instructions for removal from installed positions are given in the reference of the next paragraph. All instructions applying to hydraulic mechanisms presume draining of the system and removal of external pipe lines. Assembly procedures are omitted in instances of exact reversal of the disassembly operations. The equipment, drawings, and illustrations should be studied carefully before starting disassembly. The following general instructions should be carefully followed to prevent unnecessary damage to the equipment:

1. All work should be done in a clean area, and special precautions should be taken to prevent contamination of parts during handling.

2. If parts are to be left disassembled for any length of time, they should be washed with an approved solvent and coated with some adequate rust preventative.

3. For handling the larger units, adequate hoisting facilities are required.

4. Garlock and rotary oil seals must be handled carefully when being removed, in order to prevent damaging them on shaft splines. A small scratch or tear in the seal is enough to cause a leak.

5. Shafts which contact oil seals are made with carefully polished surfaces. It is advisable to protect such surfaces immediately after disassembly by wrapping with gummed paper or some other protective covering to prevent scratching or nicking.

6. Except as particularly noted in the following text, gear meshes are not indexed or referenced in any particular manner. In disassembling gearing, it is important to keep gasket, shims, and spacers in their original sets, so as not to upset the gear meshes.

7. It is advisable to keep all associated parts in sets when disassembling, and to use labels or tags to identify similar parts.

8. Do not permit the parts to contact each other and become damaged.

<u>Disassembly of the auxiliary pump cluster.</u> Study drawings 363188 and 363191.

1. Remove the pump mounting screws and lock washers.

2. Remove the pump from the cluster.

3. Slide the pump shaft out of the cluster. The shaft may be removed with bearing and packing gland in order to replace the packing.

4. Remove the pump head screws, the pump head, the head end bushing, the rotor with vanes, pump ring with pin, and the bushing. The pump is now completely disassembled.

5. Wash all parts carefully in a non-acid cleaning fluid to ensure cleanliness and freedom from foreign matter.

The pump assembly procedure is a reversal of the disassembly operations. Special care must be taken to:

1. Check the pump rotation. Rotation is indicated by the arrow stamped on the pump body. There are arrows on both bushings and the rotor; all arrows must point in the direction of desired rotation.

2. Assemble the vanes with the chamfer on the trailing edge.

3. Tighten the pump head screws that are diametrically opposite. It is a good practice to turn the pump shaft while the screws are being tightened to ensure that the rotor is not binding.

4. Assemble the packing gland with its large diameter against the outer race of the shaft bearing.

<u>Disassembly of the reduction gear pump cluster mounting.</u> Study drawings 363188 and 363191.

1. Remove the eight pump cluster mounting screws.

2. Remove the pump assemblies.

3. Remove the four housing screws that are accessible after the pump assemblies are removed.

4. Remove the housing adapter.

5. Remove the bearings, gears, and pinion from the housing.

6. Remove the oil retainer with oil seal.

Further disassembly is evident by reference to the drawings.

Check rotation of the reassembled unit by removing the plug in the cover. Direction of rotation of the pinion thus exposed is as indicated by the arrow on the cover.

Disassembly of the hand gear pump. Study drawing 363193.

1. Remove the securing screws; remove the pump unit from its bracket.

2. Remove the two dowel pins and 12 screws that secure the head to the pump body.

3. Remove the pump shaft, bearing, spacer, oil seal, and packing.

Further disassembly is evident from the drawings.

Care must be taken, when reassembling the pump, to assemble the spacer with the raised portion toward the bearing. Do not damage the oil seal.

Disassembly of the A-end unit. Study drawings 268157, 268158, and 268159.

To disassemble:

1. Remove the control case assembly. The A-end and control case are dowelled together; do not cant the control case when lifting.

2. Remove the main shaft end cap 290237-2.

3. Remove the rotary oil seal 268203-28. Do not damage the seal when passing it over the shaft splines.

4. Remove the stroking cylinder end cap.

5. Remove the main case bolts 268203-3 from the A-end assembly, using adjustable wrench 8-Z-936; leave the auxiliary bolts in place.

6. Turn the A-end over so that the drive shaft is down and the valve plate is up. Block up the lower end of the servo piston so that the tilting box is approximately at neutral.

7. Remove the auxiliary case bolts 268202-22 and lift off the valve plate. Extreme care must be taken not to mar the pressure surface of the valve plate.

8. Remove the rotating group by means of an eye bolt threaded into the end of the main shaft.

9. Remove the side inspection cover. Loosen and remove the tilting box stud pin, and tap out the stud, tapping from inside the tilting box.

10. Remove the stroking piston.

11. Remove the tilting box. To do this, support the weight either by a hoist (using lifting rings threaded into the tapped holes provided) or by blocking up the tilting box from underneath to take the weight off the trunnions.

12. Remove the trunnions and lift the tilting box from the A-end case.

To disassemble the rotating group:

1. Place the rotating group with the cylinder barrel face down on two supports that are so arranged that they straddle the projecting shaft end and leave it readily accessible.

2. Compress the heavy barrel spring 290268-3, by means of a jacking bolt inserted in the threaded hole in the shaft end; use spanner wrench 8-2-958 to remove lock nut 268203-19.

3. Remove the jacking equipment. Remove all ring socket cap nuts and ring socket caps. Keep all parts in numbered sets corresponding to the sockets from which they were removed.

4. Remove the main shaft and socket ring from the cylinder barrel by means of a lifting ring threaded into the splined end of the main shaft. Leave the piston and rod groups behind.

5. Remove each piston group separately and disassemble. Keep in sets with the rods and the ring socket caps and nuts.

6. Remove the screws that hold the trunnion bearing blocks and remove the shaft from the socket ring.

7. Disassemble the universal joint by first removing the bearing retainers and slipping off the trunnion bearing blocks and bearings.

8. Remove the snap rings; knock out the tapered main shaft pin and its bearings. Knock the pin out by tapping on the small end which is indicated with a file mark.

9. Disassemble the universal joint bearings and remove the snap rings of the inner race and remove the inner race.

10. Slip a round plug, of the same diameter as the inner race, into the void in order to prevent the rollers from falling from the outer race. Further disassembly is evident from the drawings.

Disassembly of the B-end units. Study drawings 369676 and 369677.

To disassemble:

With the two exceptions indicated below, the procedure for disassembly of the B-ends is an exact step-by-step parallel of A-end disassembly.

1. Remove the response housing cap, oil seal, and entire gear housing and gears before the valve plate and rotating group of the right B-end are removed.

2. Remove the bearing retainer and with it the outer race and roll group of the bearing. This permits the main shaft some lateral movement. Remove the rotating group.

This procedure is necessary because the socket ring can not be put in a neutral stroke position. It is at an angle of 20 degrees to the B-end main shaft.

Disassembly of the control gearing assembly. Study drawing 36715.

To disassemble:

1. Remove the complete valve block assembly.

2. Remove the top cover and all the cover plates with the exception of the end cover.

3. Remove the stud and the floating link.

4. Remove the tilt box arm from its shaft.

5. Take off the bearing retainer and draw the tilting box shaft down, out of the housing.

6. Remove the end cover.

7. Remove the bearing cap and locknut, and draw out the response shaft, leaving the gear, spacer, and ball bearing in the housing.

8. Remove the locknut and pinion, and take off the idler shaft from the housing, removing all gears, bearings, and spacers as the shaft passes through the opening.

9. Remove the bearing cap from the signal shaft and the locknut from the inner end of the shaft. Remove the shaft, slipping off the gear and its bearings, and also the clutch and its spring.

10. Take off the bearing cap and turn the control screw until it projects as far as possible from the control nut. Remove the control screw response gear until its outer bearing can be taken off. Disengage the control screw from the sliding spline (quill drive) of the control screw. Remove the control screw through the side or top of the control housing.

11. Remove the screws from the bearing retainer and slide out the entire control screw and nut assembly, complete with control screw signal gear and all bearings.

12. Remove the limit stop end covers and locknut. Turn the limit stop nut to the right as far as possible, and slide the entire assembly to the left until all gears and spacers can be released from the right end of the shaft and taken out. Remove the left bearing, limit stop, and clamp, and slide the shaft back to the right as far as possible. Turn the limit stop nut to the left until it can be removed from the screw, and then be removed from the machined slip-ways. The shaft may now be withdrawn to the left from the housing.

Replacement of synchros

The fine and coarse synchros are so mounted as to facilitate removal without disassembling the mechanism in the gear compartment. Adapter rings carry the synchro stator bearings so that each synchro can be removed through the front of the gear box. A study of the assembly and general arrangement drawings should precede the operations outlined below. Remove the covers of the valve and the gear compartments and proceed as follows:

1. Disconnect the synchro crank from the linkage in the valve compartment.

2. Remove the synchro crank assembly, the crank plate, and the gasket.

3. Remove the gear mounting screws from the synchro (in the valve compartment).

4. Unclamp the synchro retainer, in the gear compartment, and remove the synchro by tapping it lightly from the valve compartment side. If the coarse synchro D is being removed, it is necessary to disassemble the parallax rail and yoke units before removing the synchro retainer.

5. Remove the synchro brush plate.

6. Remove the synchro from the gear compartment.

Removal of synchro cranks

To remove the synchro crank for either synchro, remove the valve link connecting rod and the screws that hold the assembly to the receiver-regulator case partition.

Disassembly of the receiver-regulator main block assembly.

For disassembly of the main block assembly, study drawing 298301.

The main valve block assembly, including the synchronizing valve block and the hydraulic vibrator, may be removed as follows:

1. Disconnect the synchro cranks and the limit stop drive crank.

2. Remove the pipe from the automatic stroking valve V2 block.

3. Remove the pressure reducer valve V42 by removing the four mounting screws in its flange and removing it from the valve block.

4. Disconnect the link connecting the automatic stroking valve V2 to the stabilizing linkage L2.

5. Remove the four Allen-head screws which hold the valve block to the case partition.

6. Remove the valve block assembly. It is not necessary to drain oil from the system because check valves in the supply lines prevent the flow of oil to the receiver-regulator case.

Receiver-regulator gear train

The gear train assembly drawing 319571 may be removed from the receiver-regulator case as described below:

1. Remove the response shafting.

2. Remove the three response shaft gear cases containing adjustable couplings A, B, and C.

3. Disconnect the wiring from the synchro terminal bases.

4. Remove the synchro cranks and limit stop drive crank from the valve compartment side of the partition.

5. Remove the four large mounting bolts on the gear train frame. The gear train assembly can then be lifted from the case. In some installations, it may be necessary to loosen the case from the pump tank

before the gear train assembly can clear the A-end. To do this, remove the four manifold mounting screws which are in the top of the block of the automatic stroking valve V2. Disconnect the leads of the sump pump float switch from the junction block in the valve compartment. Remove the row of bolts from the case mounting flange, and raise the receiver-regulator case. Be careful not to damage the check valve V41, which is secured in the bottom of the receiver-regulator case.

Receiver-regulator pressure reducer

The pressure reducer valve V42 may be removed from the valve block as a unit. This is done by removing the mounting screws in its flange and sliding the complete unit out of the block.

Receiver-regulator valves

All valves are matched with their respective sleeves; therefore, whenever a replacement is necessary, both the valve and the sleeve must be replaced. Valves and sleeves are marked with serial numbers. The valve must be assembled so that its number is on the same end of the assembly as the sleeve number. The numbers must match as to location and numerical order. When the new sleeve and valve assembly is placed in the valve block, the serial numbers must be toward the linkage to which the valve stem is attached.

Chapter 7

PROJECTILE RINGS

16-inch Projectile Ring Mark 2

GENERAL DESCRIPTION

Turret stowage

Projectile stowage in each turret is located in the upper and lower projectile flats. In addition to the two projectile flats, turret II is provided with a third projectile stowage level. The stowage arrangements of the projectile flats, illustrated in figure 7-1 (the third level of turret II is not shown), are described in the following paragraphs of this chapter.

Compartments. The compartment subdivisions of the upper and lower projectile flats, and their space arrangements for stowing and handling projectiles, are identical. Each projectile flat is separated into two compartments, inner and outer, by a circular bulkhead. The inner compartment is the machinery space. Within this enclosed space are the projectile ring power drive machinery, and the electric motor controllers. The floor of the outer compartment

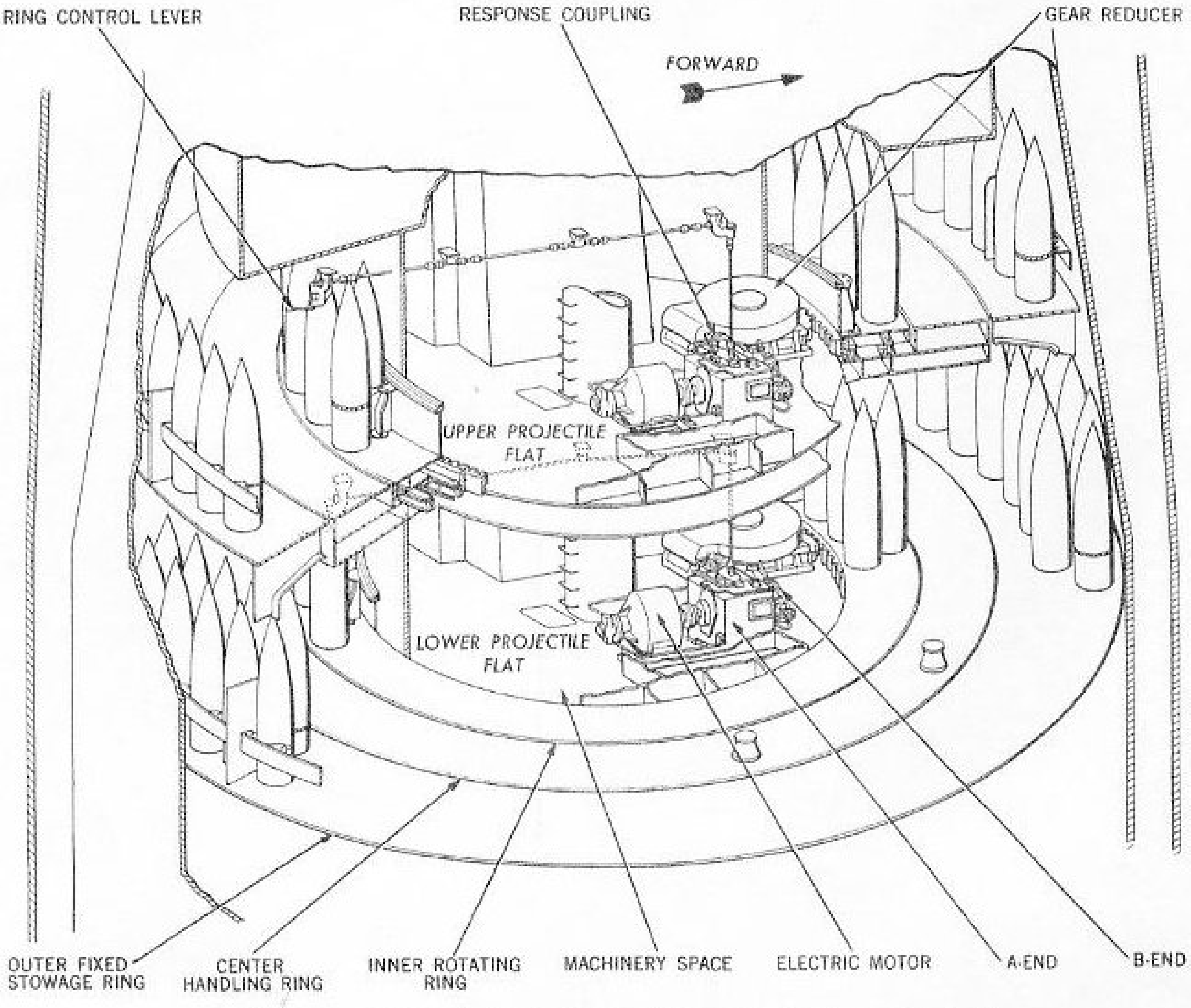


Figure 7-1. 16-inch Projectile Ring Mk 2 Mod 0, General Arrangement

is subdivided into three concentric, ring-shaped platforms. The outer ring, a nonrotating platform, is attached to the cylindrical turret foundation and provides an area for the fixed stowage of projectiles. The inner ring, a rotating platform, is mounted on rollers that are supported by the rotating structure of the turret. The inner ring provides a projectile stowage area that is power-driven either to the left or to the right, with respect to the center ring. The center ring, a part of the rotating structure of the turret, is the projectile handling platform. Located in the rear part of the center ring are the three projectile hoist tubes. This part of the handling platform is an area for personnel operating when parbuckling projectiles from the stowage platforms to the projectile hoist loading apertures. The arrangements of the projectile flats and parbuckling gear also provide for parbuckling projectiles from the fixed stowage platform to the rotating stowage area. The projectile hoist tubes are arranged with loading apertures at each projectile flat. The three projectile hoist tubes can be served simultaneously from one projectile flat.

Stowage compartments. The inner stowage rings of each flat, identical weldments, are roller-mounted carriages. Each carriage is composed of a low cylindrical coaming mounted around the inner edge of a platform plate. The platform plate provides sufficient space for stowing two concentric rows of projectiles, with each projectile standing on its base and lashed to a coaming flange and securing plates. The carriage roller assembly is located below the platform plates of the flat. The top of the inner ring platform plate is flush with the platform plates of the center and outer rings.

The stowage arrangement of the outer rings provides sufficient space for stowing two concentric rows of projectiles (one row in turret II, upper projectile flat only). The projectiles, stowed standing on base end, are lashed to a coaming flange and securing plates which are attached to the turret foundation encircling the outer edge of the stowage ring.

Turret II is provided with a third level of fixed projectile stowage. This projectile platform is located in the powder handling room, immediately below the outer ring of the lower projectile flat. The stowage arrangement provides sufficient space for stowing two concentric rows of projectiles with each projectile standing on its base and all projectiles lashed in the same manner as those on the outer rings of both flats.

The inner ring of each flat is equipped with an independent power drive assembly. Each drive assembly is arranged with manual control selection and starting control for clockwise or counterclockwise drive of the inner ring, and its load of projectiles. When started, the drive assembly moves the ring through an arc of 30 degrees, and then stops automatically. This action moves an unloaded section of the inner ring out of the way and places a supply of projectiles where they may be parbuckled into the aperture of the hoist tubes.

Projectile parbuckling mechanisms are described in chapter 8. The gypsy heads of the parbuckling gear are mounted in the projectile handling space of the center ring. Transfer of projectiles is always performed by use of the parbuckling gear.

Stowing projectiles

Two separate routes and certain special equipment are utilized for moving projectiles from the main deck outside the turret to the stowed positions on the projectile flats. A separate stowage route is located on each side of the turret. The routes (or ammunition loading trunks) are formed by hatch openings in each deck, each opening being located directly below the main deck hatch. The accessory equipment installations and the special provisions for stowage handling are similar for both routes and are described below. The equipment includes ship's structural arrangements and equipment, and Ordnance accessories.

Stowage handling

Ship and turret arrangements for projectile stowage handling are similar for both routes (port and starboard). Each route comprises an ammunition trunk outside of the turret, extending from the main deck to the magazine level. At the bottom of each trunk are overhead trolley conveyor arrangements that lead to, and travel around, the annular handling space between the powder handling room and the powder magazines. There are hatches inside the turret, leading upward from the annular handling space to the projectile flats.

The ammunition loading trunks are accessible only after the turrets have been trained to predetermined angles. The angle of train for turret I is 266 degrees, for turret II the angle of train is 230 degrees, and for turret III the angle of train is 193 degrees. After the turrets are trained to these positions, portable beams are bolted to the tops of the gun house structures. The portable beams each suspend a sheave and hoisting hook directly over a trunk.

Structural arrangements for the stowage handling routes are the trunks, the annular handling space, and hatch arrangements within the turret. The arrangements within the turret consist of two round hatches in each projectile flat. Each hatch is fitted with a hinged cover that fits flush with the floor plates when closed. These hatches are located at the rear of each outer ring. The hatches are arranged in pairs, with a hatch in the upper flat aligned directly above a hatch in the lower flat. Both hatches in a pair are aligned directly above the annular handling space of the magazine level. Projectiles may be stowed on the normally closed hatch covers.

Hoists. Equipment arrangements for the stowage handling routes are two sets of hoists and the overhead trolley conveyor at the magazine-level. The main deck hoists are 1 1/2-ton electric-motor-driven with remote start-stop controls. The hoist motors each rotate a drum and are mounted on a foundation weldment that is secured to the underside of the main deck. A wire rope with swiveling hook is led upward from the hoist drum through a sheave that is mounted on the outer end of the portable beam. The control for lowering and hoisting projectiles is a pushbutton station located at the main deck hatch.

The hoists, for lifting projectiles from the annular handling space to the projectile flats, are electric-motor-driven chain hoists of 1 1/2 tons capacity, with remote start-stop controls and an automatic stop. The hoists are permanently mounted on the overhead of each projectile flat, adjacent to and above the round hatch opening in the floor below the hoist. The hoisting chain is led downward from the hoist through a sheave that is secured to the floor alongside of the round opening. From the sheave in the floor, the hoisting chain is led upward to a second sheave that is secured to the overhead directly over the center of the round hatch opening in the floor of the ring.

The control for lowering and hoisting projectiles is a push-button station located on the turret foundation bulkhead adjacent to the hatch.

Conveyor. The trolley equipment for moving projectiles from the bottom of the main-deck strikedown hatches (ammunition trunks) through the annular handling space, is an overhead monorail trolley with a manually operated traveling 1 1/2-ton chain hoist. At the end of the monorail, the projectiles are transferred from the trolley to the hook of the electric-motor-driven chain hoist described in the preceding paragraph.

Projectile carrier. Accessory Ordnance equipment, provided for handling projectiles by the previously described routes, consists of an adequate allowance of 16-inch Projectile Carrier Mk 3 Mod 1. The carrier is a projectile holding yoke and base stirrup with a wire rope sling and becket. The arrangement and use of the carrier are shown in figure 7-2. The carrier is a two-position carrying design. It is used to carry projectiles in the horizontal position as well as vertical.

The carrier is removed from each projectile after the projectile is delivered in a vertical position to the magazine level at the bottom of the trunk. A similar carrier is then fitted into position on the projectile, and the first carrier is hoisted empty to the main deck. The projectiles are transported in a horizontal position through the annular handling space, by means of the second carrier and the overhead trolley-conveyor, to a position beneath the turret strike-down hatches. The projectiles are then hoisted in a vertical position through the hatches to the projectile flats. Stowing of projectiles on the inner and outer rings is performed by parbuckling.

Projectiles, when positioned on the stowage rings, are secured as illustrated in figure 7-3.

Serving the rings and securing projectiles

The stowage of the projectiles on the inner and outer stowage rings is accomplished by the following procedure:

After the projectile has been hoisted to either projectile flat, it must be secured in position on either the fixed outer ring or the rotating inner ring. To do this, the projectile must be removed from the personnel working area in the vicinity of the turret strike-down hatches. This is done by parbuckling the projectile onto the inner ring and then rotating the ring so that the projectile is delivered to the desired part of the projectile flat. The handling personnel may either remove the projectile to the outer ring by parbuckling or secure it to the inner ring.

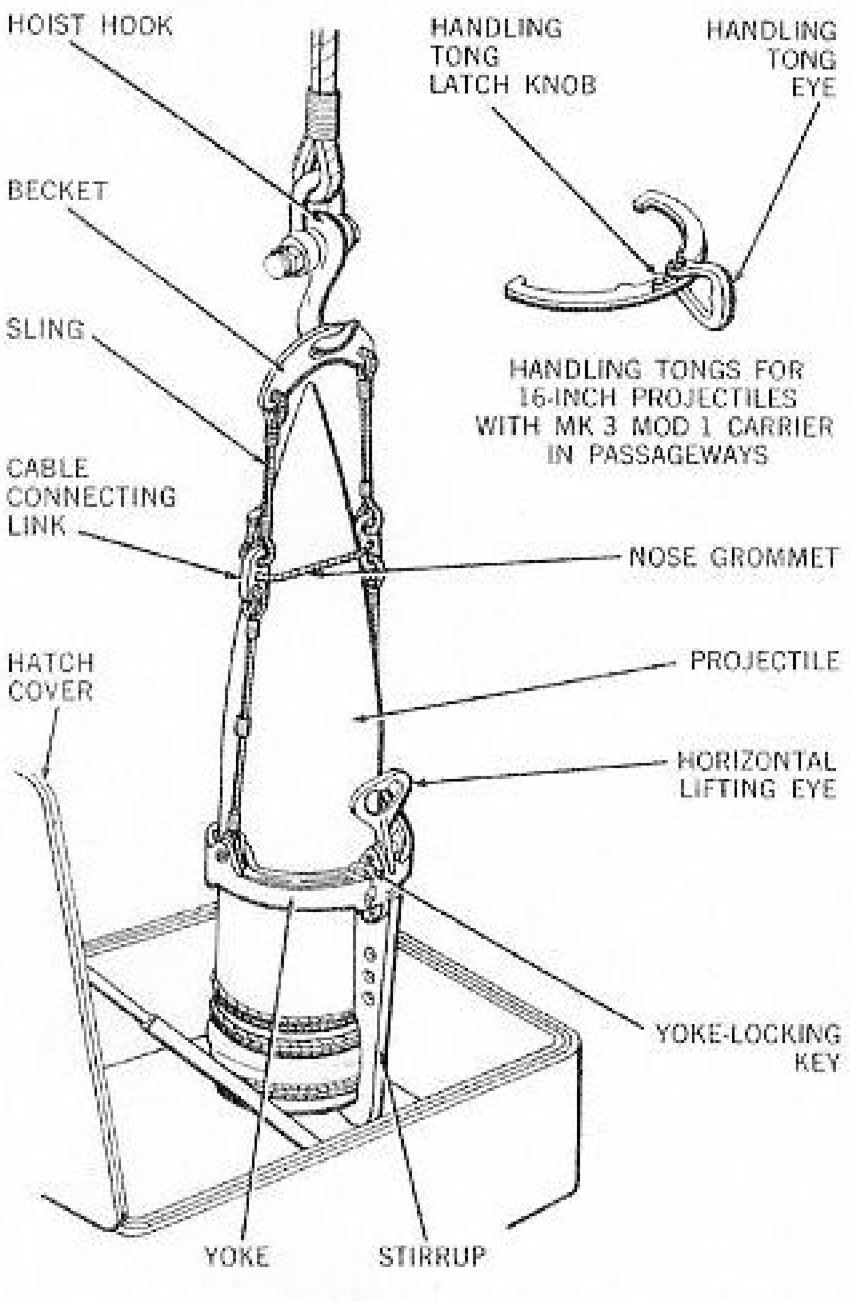


Figure 7-2. 16-inch Projectile Carrier Mk 3 Mod 1 Handling Ammunition

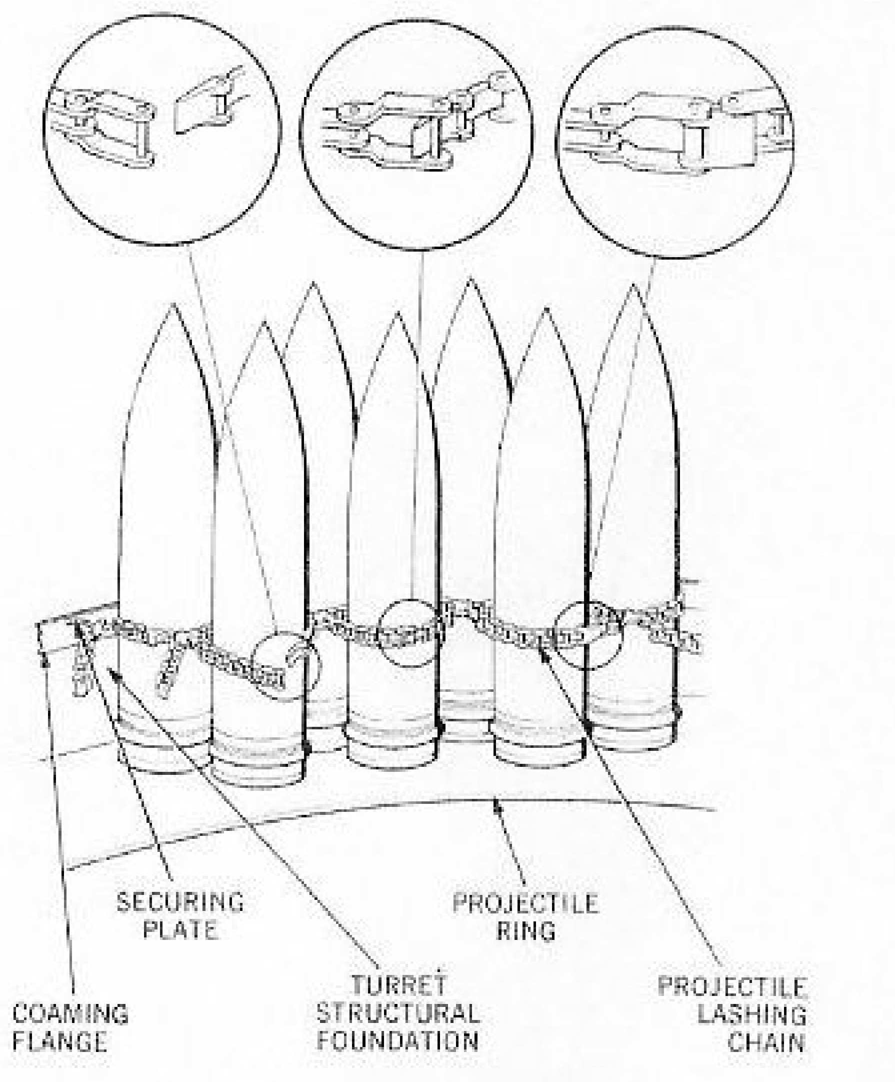


Figure 7-3. Method of Lashing Projectiles in Stowed Position

The stowing procedure described requires rotation of the inner projectile rings in order to load their empty stowage spaces. Ring rotation is through the projectile ring power drive. The action is manually initiated by moving a hand lever control device. Rotation of the ring can be stopped with the hand lever as each empty stowage space comes close to the personnel working area adjacent to the chain hoists. As an alternative to manual start-stop operation of projectile ring rotation, the ring drive may be permitted to continue its operation to an automatic stop. This semiautomatic operation moves the inner ring through a 30 degree arc.

Securing projectiles. When projectiles have been served to the stowage ring, they are positioned as shown in figure 7-3, and are secured by special chain lashings. The outer row of projectiles of the outer ring fit into notches in a flange, and are chained to the flange. The inner row of projectiles are secured by chains that are connected by toggles to the flange chains. The method of securing projectiles to the rotating inner ring is identical to that of the outer ring. All securing chains are equipped with pelican-type fasteners, which permit rapid and separate unlashing of the projectiles.

Projectile stowage quantities

The storage arrangements and capacities of the turrets differ. The stowage allocations for the inner and outer rings and the total stowage of each turret are tabulated below:

PROJECTILE STOWAGE DATA

Service projectiles:	Number
Turret I	
Upper projectile flat, outer ring	120
Lower projectile flat, outer ring	126
Each inner ring	72
Total stowage	390
Turret II	
Upper projectile flat, outer ring	70
Lower projectile flat, outer ring	125
Each inner ring	72
Fixed stowage, third level	121
Total stowage	460
Turret III	
Upper projectile flat, outer ring	100
Lower projectile flat, outer ring	126
Each inner ring	72
Total stowage	370

Power drive

The electric-hydraulic power drive assemblies that rotate the inner rings of each turret are separate Ordnance installations that are designated 16-inch Projectile Ring Mk 2 Mod 0. Both the upper and lower assemblies of this design are identical installations of the components identified in the next paragraph. Installed positions of the inner ring drives of both flats and their control arrangements are shown in figures 7-1 and 7-4.

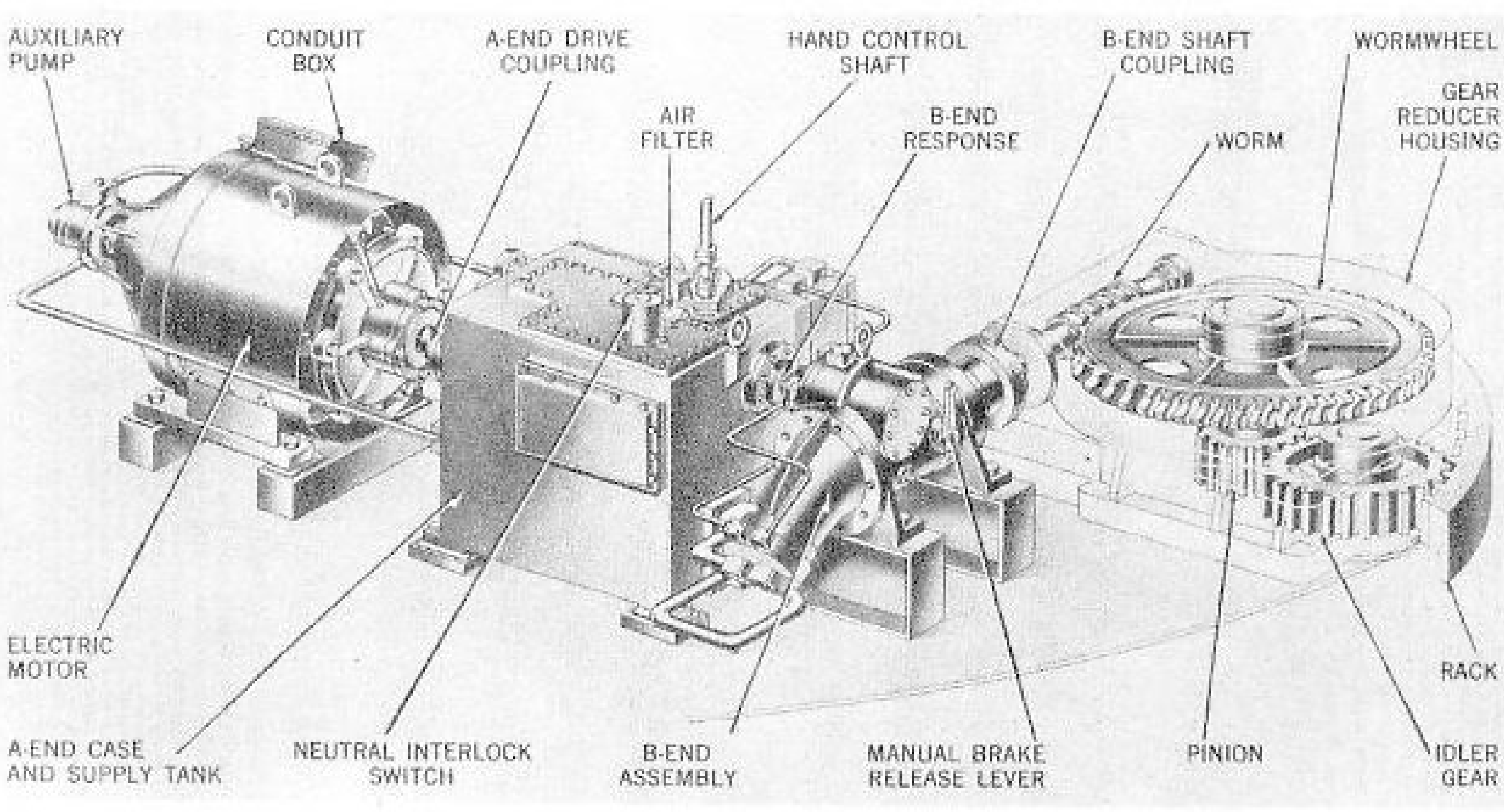


Figure 7-4. 16-inch Projectile Ring Drive Mk 2 Mod 0, General Arrangement

Components. Each of the two projectile ring drives is composed of the following principal units:

Electric motor
- Electric motor controller
- Motor to auxiliary pump coupling
- Auxiliary pump
- Motor to A-end coupling
- A-end assembly
- B-end assembly
- Hydraulic pipe installation

Component locations and arrangements. In each projectile flat the electric motors, A-end assemblies, and B-end assemblies of the inner ring drives are similarly mounted on the floor of the inner compartment. Each electric motor is arranged with rotor shaft coupling provisions for the auxiliary pump and A-end. Flange-mounted on the motor case, the motor case, the auxiliary pump is coupled directly to the rotor shaft. The A-end is coupled to the motor through a self-aligning flexible coupling. Mounted on a foundation weldment adjacent to the A-end, the B-end has its output shaft coupled to a wormshaft of a pinion drive mechanism. Hydraulic pipes connect the valve plate ports of the B-end motor with the A-end pump.

The electric motor controller for the upper projectile flat is mounted on the circular subdivision bulkhead, within the machinery space, immediately forward of the power drive assembly. The controller for the lower projectile flat is mounted on the center powder hoist trunk, within the machinery space. Each controller includes master and emergency stop push-button switches, which are located and arranged as indicated in the detail description of the controllers, and as shown in figure 7-6.

The response gear, worm-driven by the B-end drive shaft, is coupled to an input shaft of the A-end by means of a flexible coupling.

The levers of the manual control mechanism, similarly located for both the upper and lower projectile flats, are adjacent to the projectile handling area of each flat and are suspended from the overhead by a bracket.

Data. General data concerning the power drive speeds, movements, operating pressures, and loads are as follows:

Ring speed, maximum revolution per minute	
Ring movement, arc per cycle, deg	30
Hydraulic operating pressure	
Main drive, relief setting, psi . . .	2200
Auxiliary pump system, psi	100

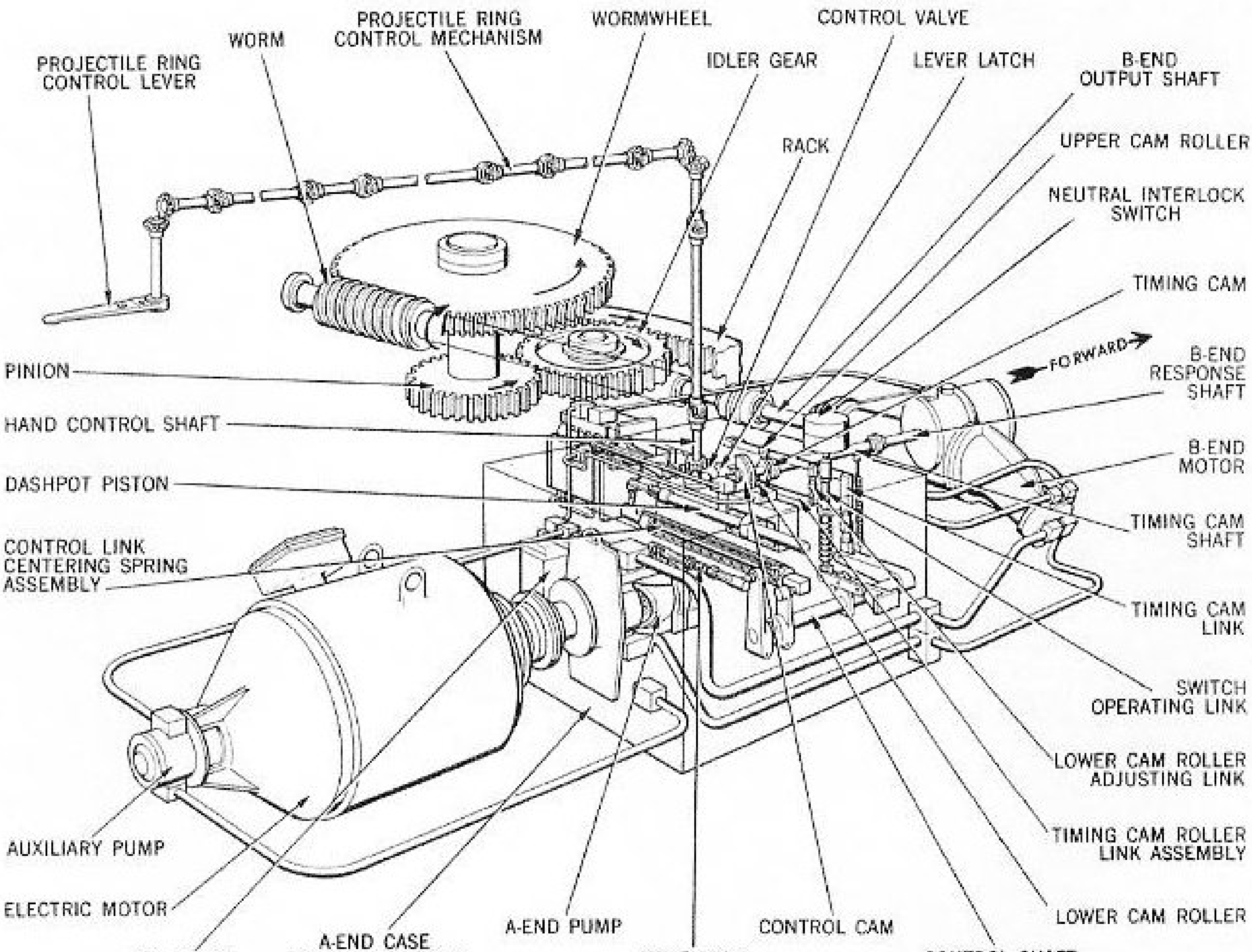


Figure 7-5. Projectile Ring Drive Components, Schematic Arrangement

DETAIL DESCRIPTION

Power drive

Design and functional details of the electric motor, controller, A-end and B-end assemblies, and their control and connecting arrangements, are shown in figures 7-4 and 7-6, and are described in the following paragraphs. These details are characteristic of all power drive installations except as noted.

Components. The projectile ring-power drive is composed of the following:

Electric motor
Electric motor controller
Motor to auxiliary pump coupling
Auxiliary pump
Motor to A-end coupling
A-end assembly
B-end assembly
Hydraulic pipe installation

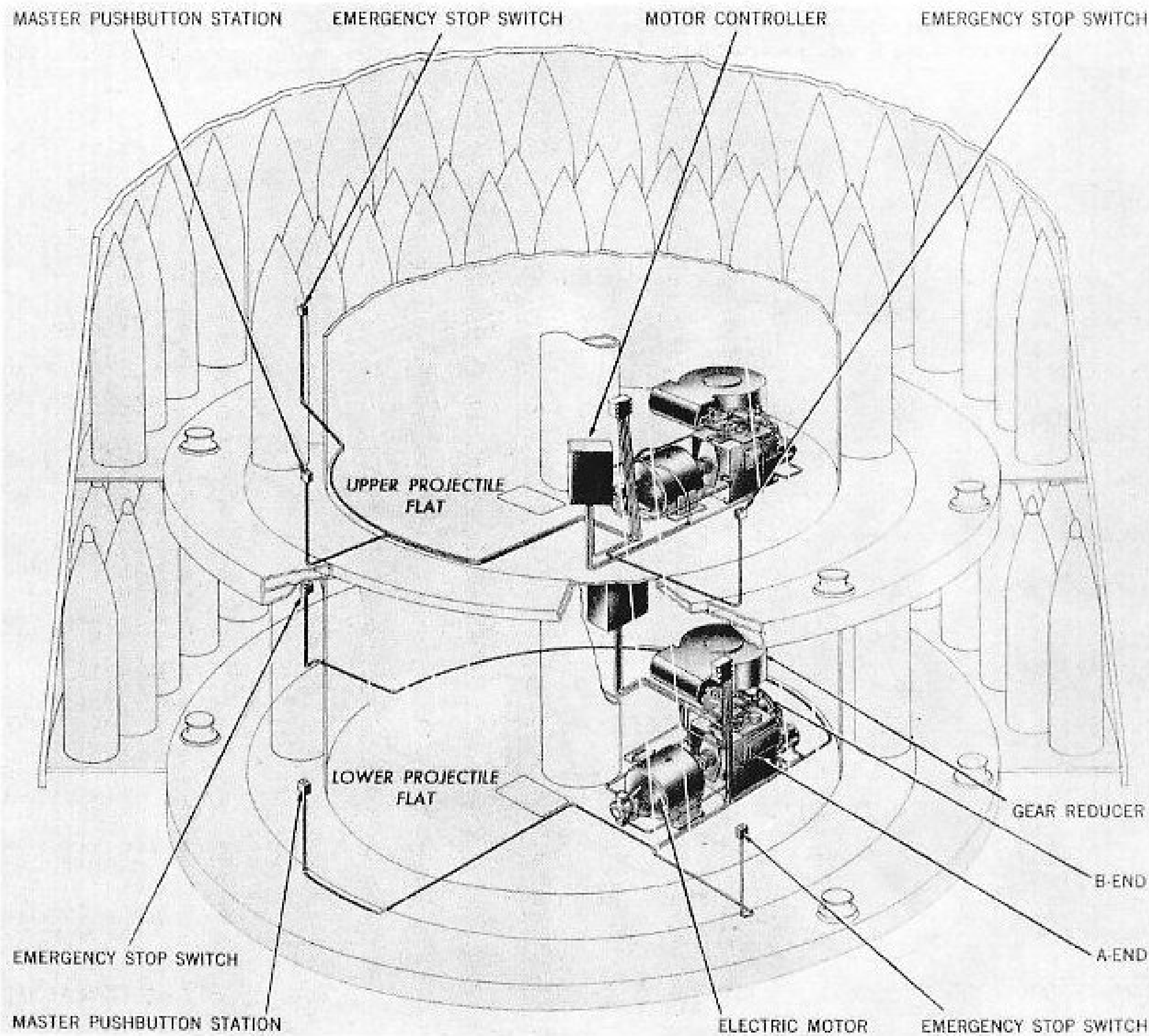


Figure 7-6. 16-inch Projectile Ring Mk 2 Mod 0, Electrical Installation

Electric motor. The electric motor is a 40-horsepower, squirrel cage, induction type, of commercial design and manufacture. The motor is mounted horizontally at the right side of the machinery space, adjacent to the A-end it drives.

Motor data

Type	Squirrel cage, induction
Design features	waterproof, fan cooling, direct coupling drive, horizontally mounted
Horsepower	40
Revolutions per minute, synchronous	1200
Revolutions per minute, full load	1160
Rotation (at drive end)	counterclockwise
Speed class	constant
Voltage	440
Amperes, normal full load	48
Amperes, locked rotor	400
Phases	3
Cycles	60
Ambient temperature, deg C	40
Torque class	normal torque, low starting current
Weight, pounds	1200
Manufacturer	Louis Allis Co.
Manufacturer's designation	Type RX-445-S
Drawing	231543

Controller. The controllers are assemblies of commercial design and manufacture. They provide control and protection for the electric motors previously described. Each controller is an enclosed cabinet, across-the-line, magnetic starter arranged with remote push-button control switches. The circuit arrangements of the remote control switches include a master push-button switch and two emergency stop push-button switches for each controller. The power supply is arranged with a manual disconnect switch, externally accessible and interlocked with the cabinet cover. The starting circuit includes a neutral interlock switch, mounted on the A-end assembly. Controller data (first design) applies to the IOWA and the NEW JERSEY. Controller data (second design) applies to the MISSOURI and the WISCONSIN.

Controller data (first design).

Type	semiautomatic, across-the-line magnetic starter, controlled by remote push button
Ampere rating, full load	48
Protection:	
Overload	thermal type, automatic reset
Adjustable range, amperes	59.1 to 71.0
Normal setting, amperes	60.0
Short circuit, ampere fuses	400
Undervoltage	
Drop-out voltage	110
Sealing voltage	374
Shock rating	50
Weight, pounds	130
Manufacturer	Ward Leonard Electric Co.
Drawing	231756

Controller data (second design).

Type	semiautomatic, across-the-line magnetic starter, controlled by remote push button
Ampere rating, full load	48
Protection:	
Overload	thermal type, automatic reset
Adjustable range, amperes	47.5 to 58.1
Normal setting, amperes	52.8
Short circuit, ampere fuses	250
Undervoltage	
Drop-out voltage	110
Sealing voltage	374
Shock rating	high impact
Weight, pounds	150
Manufacturer	Ward Leonard Electric Co.
Drawing	293881

Motor to auxiliary pump coupling. The electric motor to auxiliary pump coupling is shown in figure 7-7. The coupling serves as a direct drive connection between these two units. It is enclosed within the end housing of the electric motor. The coupling consists of two identical steel hubs, a specially heat-treated and tempered steel allow grid-spring, and two identical steel shells, which form the cover. The coupling design provides direct-drive connection through the grid spring, engaged in grooves milled in the outer flanges of the hubs. The hubs and grid spaces are packed with lubricant confined within the steel shells by grease seals.

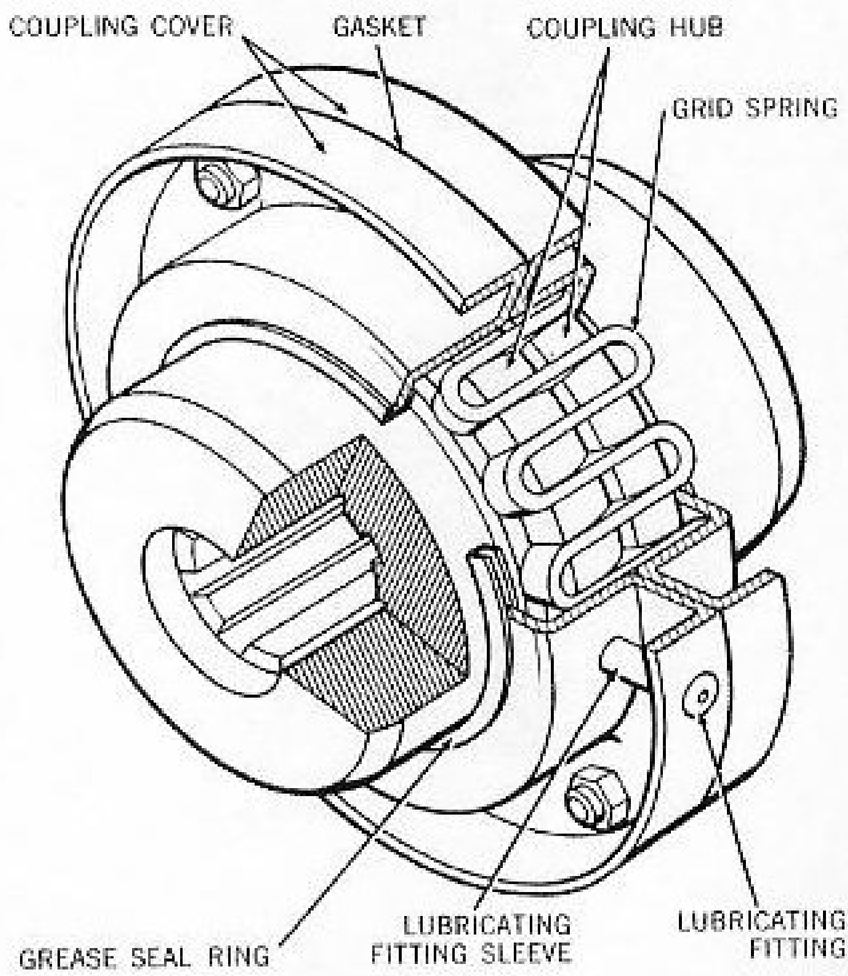


Figure 7-7. Projectile Ring Drive, Motor to Auxiliary Pump Coupling, Cutaway View

Auxiliary pump. The auxiliary pump (fig. 7-8) is a constant-displacement balanced-vane type. It is flange-mounted on the electric motor and is driven directly from the rotor shaft (and opposite the A-end coupling) at a speed that is approximately constant. Principal components of the pump are a rotor, 12 vanes, a pump ring, and two bronze bushings mounted inside a housing that consists of a body, pump head, and mounting flange. The rotor is supported by ball-bearings in the head and mounting flange. The vanes are free to slide in the rotor slots as they are rotated within the elliptical pump ring. Semiannular ports in the head and in the bushings are aligned radially with suction and pressure ports between the rotor and pump ring. Two grooves cut in each bushing between the pressure ports, and a circular groove aligned radially with the base of the vanes, force the vanes into constant engagement with the pump ring. As the rotor is rotated, the vanes form pockets with the pump ring. These alternately increase in size across one pair of opposite ports, causing suction. The pockets decrease across the other pair of ports, creating pressure and pumping action. The pump operates at a constant pressure limited by the auxiliary relief valve which is set to relieve at a pressure of approximately 100 pounds per square inch. The pump supplies fluid for operating the control circuit and for replenishing the main system.

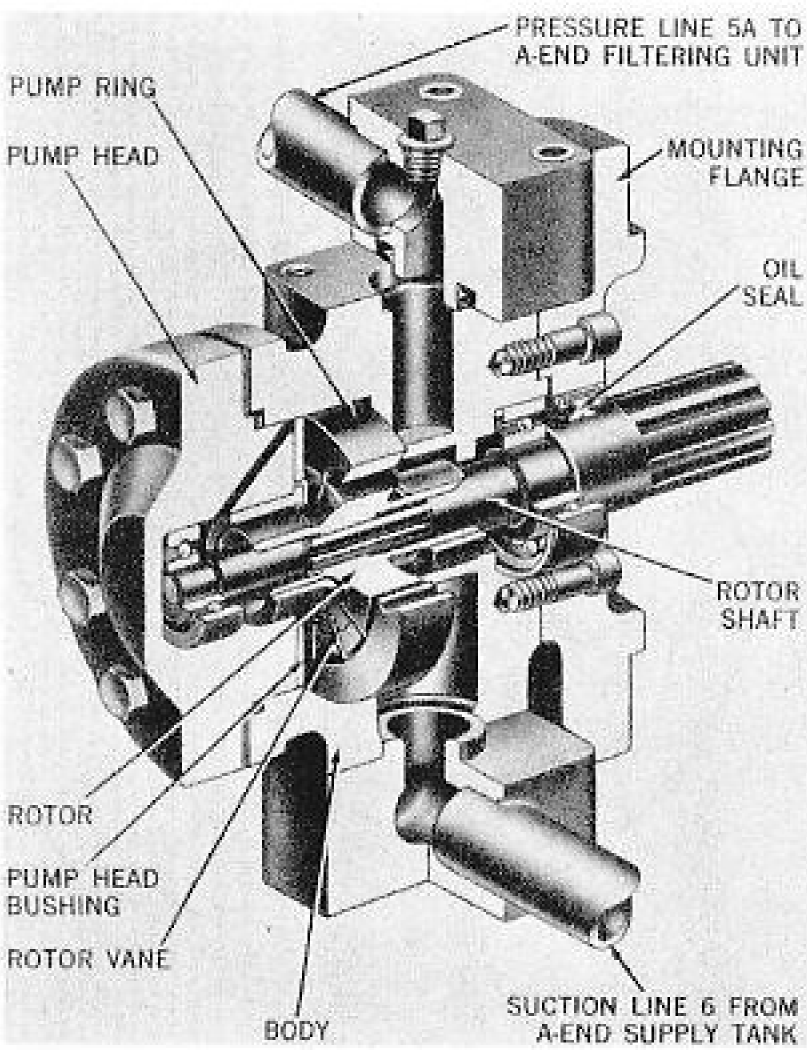


Figure 7-8. Auxiliary Pump Assembly, Cutaway View

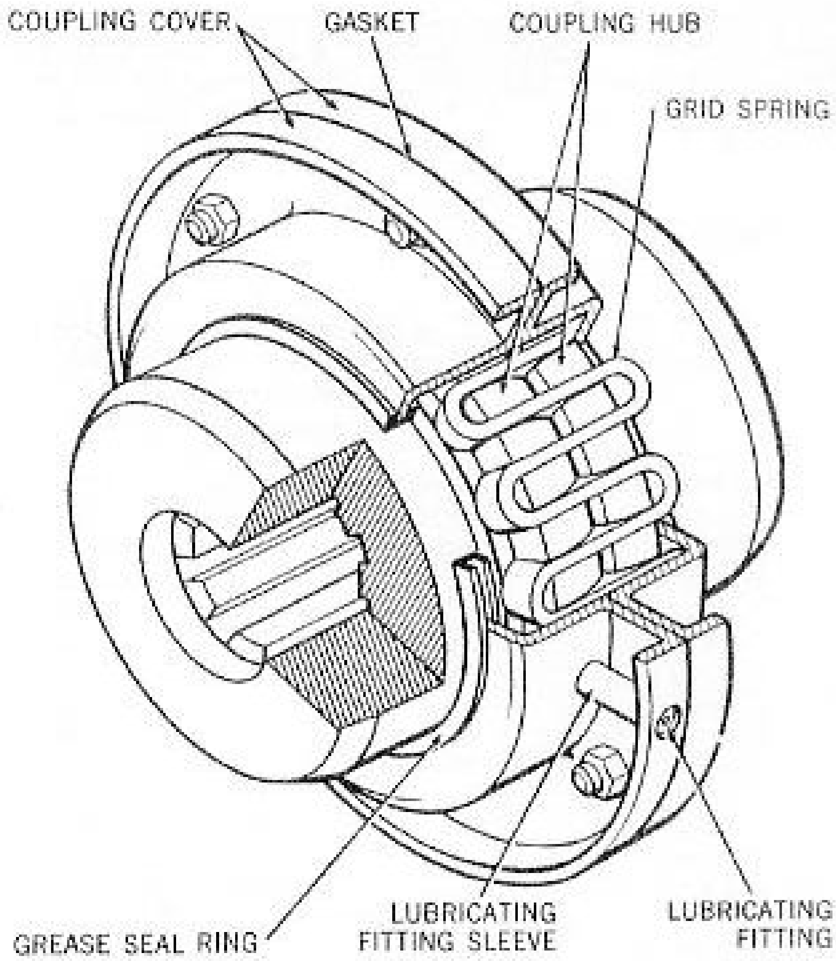


Figure 7-9. Projectile Ring Drive Motor to A-end Coupling, Cutaway View

Auxiliary pump data.

Speed, revolutions per minute	1200
Delivery, gallons per minute	510
Pressure, pounds per square inch . .	100
Rotation	counterclockwise
Weight, pounds	36

Motor to A-end coupling. The electric motor to A-end coupling is shown in figure 7-9. The coupling serves as a self-aligning, direct-drive connection from the electric motor rotor shaft to the A-end drive shaft. The coupling is a larger unit of the same design as the auxiliary pump coupling described in a previous paragraph.

A-end assembly. The A-end assembly consists of the components listed below. The type, arrangement, and functional purpose of these components are described in the following paragraphs.

Hydraulic pump
Safety relief valves
Case
Pump yoke
Timing and control mechanism
Manual control mechanism
  Control shaft coupling
Control valve block
Oil filters
Oil filter relief valves
Neutral interlock switches

Hydraulic pump. The A-end hydraulic pump is a multi-piston, reciprocating, variable-stroke, rotating type. It is mounted horizontally at the end of the case adjacent to the electric motor, which drives it continuously at approximately constant speed. The pump drive shaft and the rotor of the electric motor are directly connected by the coupling described in a previous paragraph and shown in figure 7-9. Mounted in a housing and yoke, the pump is provided with a special relief valve block. The rotating group is composed of a cylinder block, nine pistons and connecting rods, a universal link and pin assembly, and a drive shaft. The non-rotating assembly is a yoke, valve block with two relief valves, and a valve plate. The drive shaft has ball-bearing mountings in the pump housing. The cylinder block and piston assembly is ball-bearing-mounted and spring-held against the valve plate. The link and pin assembly is a ball-joint, mounted inside the cylinder block and drive shaft. This arrangement provides a flexible drive connection between the drive shaft and the cylinder block.

The pump regulates hydraulic motor speed as it is tilted or offset from neutral by its yoke. Pintle-mounted from the housing, the yoke is connected to the control devices and the manual control mechanism. The special relief valve block, mounted at the outer end of the yoke, encloses two valves which are arranged in the main pump ports, as described in the next paragraph. Piston cylinder ports in the cylinder block are aligned radially with semiannular ports in the valve plate and valve block. These are connected to the B-end through the valve block and yoke coring, pintles, and hydraulic pipe connections, by a closed hydraulic circuit. Fluid flows in a continuous cycle between the A-end and B-end. The only external connections are through replenishing check valves to compensate for normal internal leakage. Through the control mechanism, the cylinder has offset movement with relation to the axis of the main shaft. Rotation of the main shaft, together with offset of the cylinder block, causes reciprocation of the pistons and consequent pumping action through the valve plate ports. Zero reciprocation (neutral stroke) exists when the axes of the cylinder block and main shaft are in line. Maximum stroke occurs when the axis of the cylinder block is offset approximately 20 degrees in either direction.

Safety relief valves. The two safety relief valves are arranged in an opposed position in the valve block at the end of the pump yoke. A valve functions, to relieve the hydraulic transmission system, in each direction of projectile ring drive. Each valve is connected to either the intake or the pressure side of the transmission system, depending on the direction of yoke offset. The valves prevent excessive pressure rise in the transmission system which may be caused by a binding condition in the drive gear assembly or by the pump yoke being shifted too rapidly. The valves by-pass fluid from the pressure to the intake side of the pump, and are set to relieve at 2200 pounds per square inch pressure.

Case. The A-end case serves two purposes. The case provides support and housing for the A-end units, and it serves as a reservoir tank for hydraulic fluid for all circuits. The A-end units are mounted on cover plates bolted to the case to form its sides and top. The design of the case assembly aids in A-end disassembly, and provides a means of quick access for maintenance and adjustment of the timing and control mechanism and other components. A fill cap, drain plug, and two trycocks provide means for replenishing and maintaining a proper level of hydraulic fluid. Proper fluid level exists when fluid flows from the lower trycock. The capacity of the projectile ring hydraulic system at this level is approximately 25 gallons.

Pump yoke. The pump yoke is the component of the nonrotating A-end assembly through which pump reciprocation is varied from neutral stroke to full stroke. When the yoke is at neutral stroke position, the cylinder block is also at neutral stroke, and the pump is not displacing hydraulic fluid. Movement of the yoke from neutral stroke causes displacement of hydraulic fluid to the B-end, and thereby causes projectile ring rotation. Movement of the yoke to the opposite side of neutral stroke reverses the flow of the hydraulic fluid, and also reverses the direction of projectile ring rotation.

Timing and control mechanism. The timing and control mechanisms are semiautomatic, projectile ring cycle-control devices. The mechanisms control projectile ring starting speed and operate automatically to stop ring rotation at the end of a cycle. The components of the timing and control mechanism are described in the following order.

- Hand control shaft and holding brake
- Control dashpot
- Control link centering spring
- Control shaft
- Yoke link
- Timing cam roller link
- Timing cam shaft

Hand control shaft and holding brake. The hand control shaft and holding brake assembly (fig. 7-10) is a shaft, pinion, and cam arrangement. The assembly transmits control action initiated by the projectile ring operator, through the manual control mechanism to the starting control valve and to the other timing and control devices. The holding brake assembly is

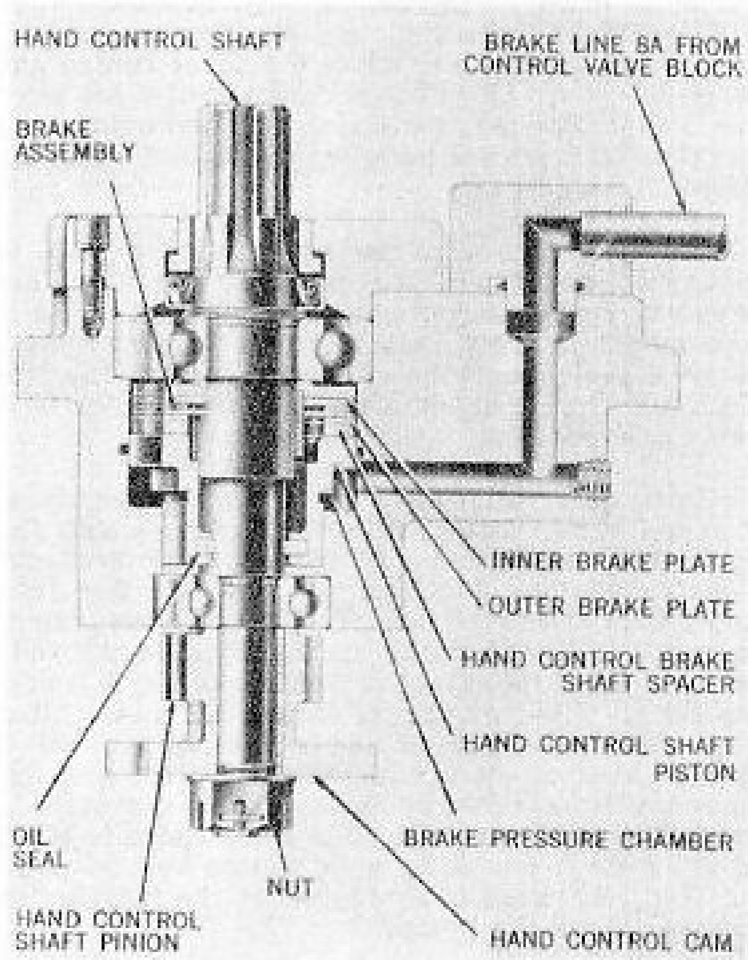


Figure 7-10. Hand Control Shaft Assembly, Sectional View

a hydraulically operated arrangement of brake discs. It acts to overcome the force of the control link centering spring to keep the hand control shaft in its initially offset position until the end of an operating cycle is reached. The holding brake is set when control pressure, ported from the control valve block, is applied to the underside of the brake piston at the beginning of the operating cycle. The control pressure is vented to the reservoir, the brake is released, and the handlever is automatically returned to neutral position when either the starting valve or control valve is in the stop position. The frictional force of the holding brake does not prevent manual operation of the handlever at any time.

Control dashpot. The control dashpot assembly (fig. 7-5) is composed of a piston, piston housing, and two ball check valves. The assembly prevents overload of the electric motor by limiting the speed with which the control handlever can offset the A-end pump yoke. The piston and the handlever connected to it can move only as fast as fluid can flow through a restriction in the dashpot piston. Fluid in the dashpot is continuously replenished by pressure from the auxiliary pump. The ball check valves permit fluid to be pumped to the suction side of the piston chamber.

Control link centering spring. The control link centering spring assembly (fig. 7-5) is a spring-type linkage which has two functions. The assembly permits full movement of the manual control handlever while the A-end pump is in neutral position. In addition, the control link centering spring assembly exerts a force which causes the timing cam link roller to follow the contour of its timing cam throughout the ring operating cycle, thus controlling the offset of the pump yoke and keeping the speed of the B-end under complete control.

Control shaft. The control shaft assembly (fig. 7-5) is composed of a shaft and lever arrangement which correlates the actions of the other timing and control devices. Mounted on the control shaft assembly is a neutral interlock switch link and cam which opens the interlock switch when the A-end pump yoke is offset from neutral.

Yoke link. The yoke link assembly (fig. 7-5) is composed of an adjustable turnbuckle and clevis arrangement which connects the control shaft to the A-end pump yoke. This assembly is adjusted to position the A-end pump yoke at neutral stroke when the control and timing mechanism is in the stop or between-cycle position.

Timing cam roller link. Two timing cam roller link assemblies, upper and lower, are mounted above and below the inner and outer timing cams respectively. Each assembly functions for only one direction of projectile ring rotation. The assemblies transmit cam action to the control shaft and thus permit the cams to control the offset movement of the A-end pump yoke. The timing cam roller link assemblies are attached to each other and to the control shaft by an adjustable turn-buckle and clevis arrangement. This permits a necessary clearance to be obtained between the cam link roller and its respective timing cam when the A-end pump yoke is in a neutral position. The clearance is equivalent to the starting offset movement of the pump.

Timing cam shaft. The timing cam shaft assembly is a cam and shaft arrangement with three cams which control the offset of the A-end pump yoke and return it to neutral stroke. Rotation of the cam shaft is controlled from the B-end through the response mechanism. The cams include a control cam and two timing cams which are keyed to the cam shaft and turn one revolution for each cycle of ring rotation. Positioned to engage the cam link rollers, the timing cams control movement of the mechanical timing and control mechanism. The control cam is positioned to engage a control valve and through that valve to regulate operation of the hydraulic system. Contact between the control valve and control cam is made with a lever which engages a latch in the cam, thus ensuring positive engagement at the stop position.

Manual control mechanism. Manual control mechanism (fig. 7-5) of the upper and lower projectile ring drives is an arrangement of shafts, gears, and a hand control lever for manually actuating projectile ring control movement. Mechanism extends from the A-end assembly to the outer side of the projectile flat circular subdivision bulkhead. It is an assembly of shafts, bevel gears, universal joints, and couplings suspended from the projectile flat overhead by J-shaped brackets at each end, and two T-shaped brackets at the middle part of the assembly. Inner end of the shaft assembly is attached to the hand control shaft of the A-end assembly. A J-bracket mounted hand lever, which can be rotated 170 degrees in either direction to actuate projectile ring rotation, comprises the outer end of the shaft assembly. Direction of hand lever movement, limited by positive stops, is the same as ring rotation. Each outer J-bracket is provided with a spring-loaded locking plunger which engages a recess in the hand lever at neutral stroke to prevent the handlever from being accidentally moved.

Control shaft coupling. Shaft-to-shaft connections in the manual control assembly are made with self-oiling universal joints. These units permit the shafts to rotate at angles up to 22 degrees from alignment, and to facilitate installation and disassembly. Shaft connection arrangements of opposite ends of each universal joint are the same. The joint ends are splined to the shafts and pinned in position.

Control valve block. The control valve block is mounted at the upper left side of the A-end case, when viewed from the shaft end. It is a machined block which contains the valves and hydraulic passages that are necessary for circuit control. The auxiliary pump delivers fluid under circuit control pressure to the valve block. The following valves are contained in the control valve block.

VALVE NAME	VALVE SYMBOL
Starting valve	V1
Interlock valve	V2
Control valve	V3
Auxiliary pump relief valve	V4
Hydraulic motor by-pass valve	V5
Main system replenishing check valve	V6 and V7

These valves are arranged as shown in figure 7-11. The valves open or close the hydraulic passages in the valve block to provide drive control, system replenishment, circulation, and pressure relief. Their purposes and system arrangements are described in the following paragraphs.

Starting valve V1. The starting valve V1 is a spring-and-cam-actuated valve that operates, when ring rotation is begun, to port control pressure to the control shaft holding brake and the B-end shaft brake.

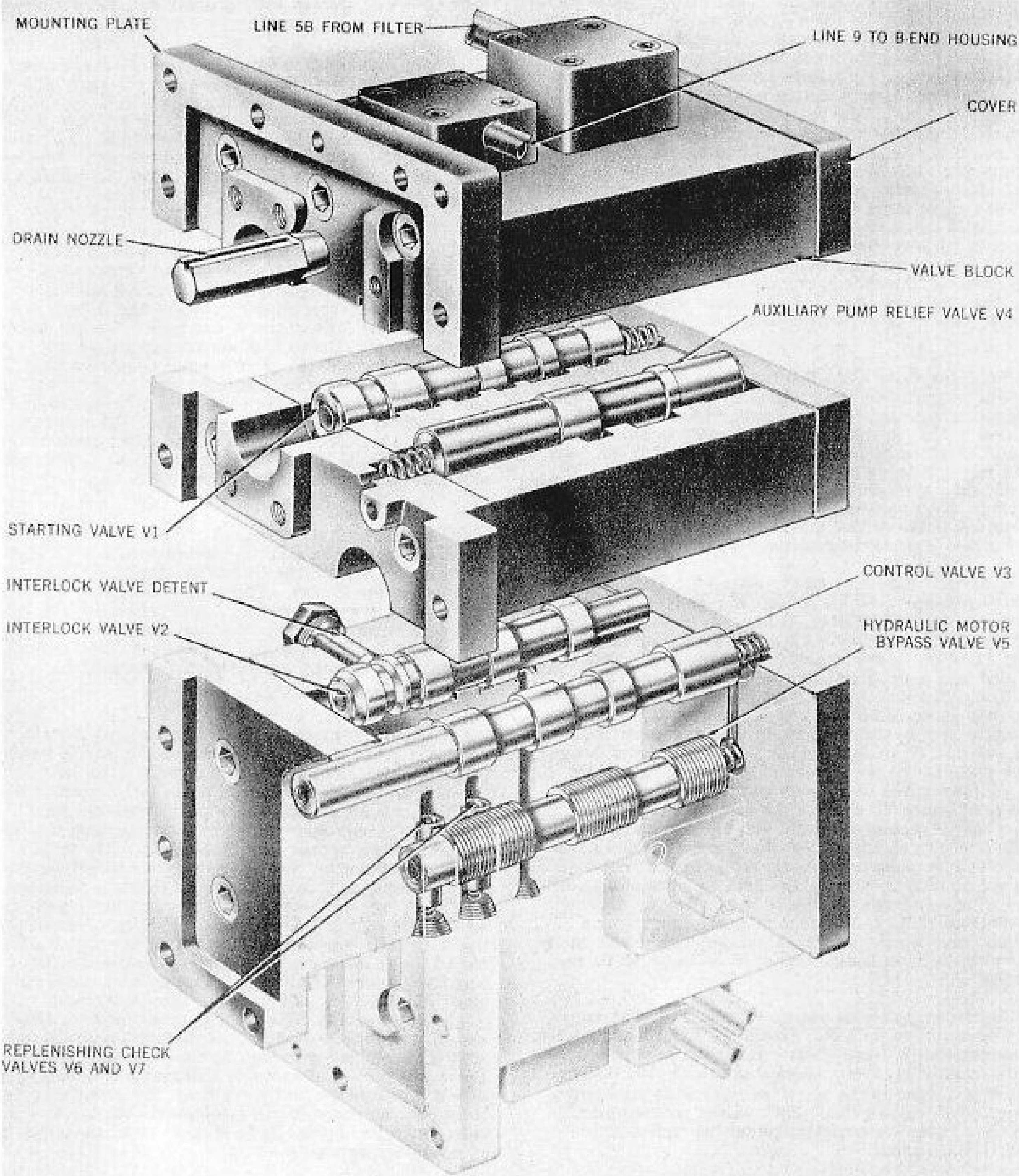


Figure 7-11. A-end Control Valve Block, Cutaway View

V1 also ports control pressure around the interlock valve V2 to the end chamber of the control valve V3. These actions of V1 are initiated by manual control mechanism movement of the starting cam C5. At the end of the drive cycle the valve spring returns V1 to a position to cut off its venting and pressure porting action.

Control valve V3. The control valve V3 is hydraulically operated from its stop to its starting position and is then cam-actuated to its running and stop positions. Hydraulic pressure from V1 moves V3 to its starting position by acting on the starting valve piston. V3 cuts off the port connections that vent the auxiliary pump pressure when the valve is in its stop position. In addition, V3 ports auxiliary pump pressure to shift the hydraulic motor by-pass valve V5 to its operating position. The control valve cam C3 and spring move V3 to its running position, where it remains for the rest of the cycle. In this position, V3 ports control pressure to return the interlock valve V2 to its starting position. V3 is moved to its stop or cutoff position by spring action. In this position, the pressure line to the by-pass valve V5 is vented, and V5 is permitted to move to the stop position.

Interlock valve V2. The interlock valve V2 is a pressure-operated valve, which is moved to its running position by hydraulic pressure from V3, as described in the previous paragraph. V2 is moved to its stop position by hydraulic pressure from V3, when V3 is in its running position. In both postions, V2 is held by a spring detent plunger. In its run position, V2 vents the piston end of V3; in its stop position V2 resets the port connections to the control valve piston for the next starting action.

Hydraulic motor by-pass valve V5. The hydraulic motor by-pass valve V5 is a spring-and-hydraulic-pressure-operated valve. It has two positions: operating and by-passing. V5 is pressure-actuated from V3 to move it to its operating position, as described in a preceding paragraph. In its operating position, V5 releases the B-end brake. When control pressure is vented at the end of the operating cycle, the valve spring shifts V5 to its by-pass position. In this position V5 cross-connects lines from the B-end valve plate to the two replenishing check valves V6 and V7 (described in the next paragraph). This by-pass position of V5 enables the high-pressure pipe of the main transmission lines to relieve and equalize to the lower pressure of the other main transmission line. The by-pass position thereby causes B-end rotation to stop by venting the brake piston and allows the spring to engage the B-end brake discs. During the interval that the B-end is at rest, the by-pass position enables the auxiliary pump supply to be delivered to both main transmission lines in order to replenish.

Replenishing check valves V6 and V7. The two main system replenishing valves V6 and V7 are spring check valves. V6 and V7 are arranged in opposed positions with separate oil passages and pipe connections that extend to the main transmission pipe ports of the B-end valve plate. Both valves are supplied with fluid from the auxiliary pump through an interconnecting passage.

Auxiliary pump relief valve V4. The auxiliary pump relief valve relieves auxiliary pump pressure to the fluid reservoir when the setting of the V4 spring is exceeded.

Starting cam C5. The starting cam C5 is keyed to the hand control shafting. When the hand control operating lever is offset from neutral stroke in either direction, the lever acts through shafting and gears to rotate C5. As C5 rotates, it forces the roller on the end of the starting valve V1 out of the starting cam recess. This action positions the starting valve V1, against spring pressure, in its starting position.

Control valve cam C3. The control valve cam C3 is keyed to the B-end response input shaft to the control mechanism. When the B-end is in operation, B-end response acts through the input shaft to rotate the control valve cam C3. As C3 rotates, it forces the lever latch out of the control valve cam recess. This action positions the control valve V3, against spring pressure, in its starting position.

Oil filters. Two pressure-type screen filters in the auxiliary pump hydraulic circuit remove foreign material from the hydraulic fluid before it enters the control and operating circuits. The filters are located on the side of the A-end case. Design details and the duplex filter chamber arrangements are shown in figure 7-12. For normal operation both filters should be used simultaneously. However, a control valve is provided in the filter design to permit the individual use of either filter. This feature makes it possible to clean a fouled filter element without stopping the power drive. There is a relief valve in the discharge line of each filter.

Oil filter relief valves. The relief valves are in the discharge lines and function as safety devices to by-pass oil around the filters in case both filter elements become fouled. The valves are set to relieve at a higher pressure setting, approximately 120 pounds per square inch, than the auxiliary pump relief valves. This is to prevent the oil filter relief valves from opening during normal operation.

Neutral interlock switch. The neutral interlock switch (fig. 7-13) is an electric switch that is used in the electric motor starting circuit. Located on the top of the A-end case, the switch opens the starting circuit whenever the pump yoke is offset from neutral stroke. This prevents starting overload on the electric motor when the power drive is at a mid-cycle position with the pump yoke offset from neutral stroke. Design features include a plunger-operated, two-pole normally closed switch, with a watertight seat at the plunger stuffing box. The stuffing box gland houses a spring which, through a packing washer, maintains constant pressure against packing around the plunger. The packing does not bind the plunger, but permits free movement without leakage either by pumping action or capillary action. When lifted against the pressure of a plunger spring, the plunger moves an inner plunger assembly. The inner plunger assembly includes a shoulder which lifts a movable contact away from two stationary contacts that are mounted in a terminal board. The movable contact is normally held down in a closed position by a contact spring.

B-end assembly. The B-end assembly is mounted in the machinery space of the projectile flat, as shown in figure 7-1. The B-end is coupled directly, through its output shaft, to the projectile ring drive worm.

The B-end assembly is composed of the following:

- Hydraulic motor
- Brake
- Brake release lever
- Response mechanism
- B-end response coupling
- B-end drive coupling

Hydraulic motor. B-end hydraulic motor is a multi-piston, fixed-stroke type, similar to the A-end pump except that its cylinder and valve plate have fixed offset position. Its driven main shaft is coupled directly to the worm of the gear reducer. Motor consists of a valve block, valve plate, a motor housing, and a rotating assembly of cylinder, pistons, piston rods, and a shaft connecting rod. Its housing is bolted to the B-end shaft housing. Rotating assembly is driven through a closed hydraulic circuit from the A-end pump, connected to the B-end valve block. Hydraulic motor speed and direction of rotation are determined by the direction and degree of the A-end yoke offset.

Brake. The B-end brake (fig. 7-15) is a friction disc-type, mechanical assembly which is spring applied and hydraulic pressure released. The brake is composed of multiple discs alternately attached to the B-end output shaft and to the brake disc retainer. The discs and the retainer are concentric with the B-end output shaft and are enclosed within the B-end shaft housing. A piston enclosed spring exerts sufficient pressure on the discs to cause their engagement and thus prevent the shaft from turning when the projectile ring drive is not operating. The brake is held in its applied position by this brake spring except when the ring is rotating, or when it is released by the manual brake release lever. During operation, control pressure from the auxiliary pump is ported through the control valve block to a brake release cylinder. This compresses the brake spring and disengages the brake discs to permit the output shaft to rotate. The brake holds the projectile ring in a fixed position in the intervals between cycling actions.

Brake release lever. The brake release lever operates a manual brake release assembly that disengages the brake when the projectile ring is to be turned by means other than by power. The assembly is a cam-operated release plate, engaged to the brake piston. The device is operated through a shaft arrangement by the manual brake release lever.

Response mechanism. The B-end response mechanism (fig. 7-14) is a worm, wormwheel, and response shaft. This mechanism is coupled to the A-end timing cam shaft as indicated on page 7-10. The worm of the mechanism is keyed to and rotates with the B-end output shaft and has a fixed value of 60 revolutions for each cycle of projectile ring rotation. The worm and wormwheel are lubricated by hydraulic fluid in the B-end housing.

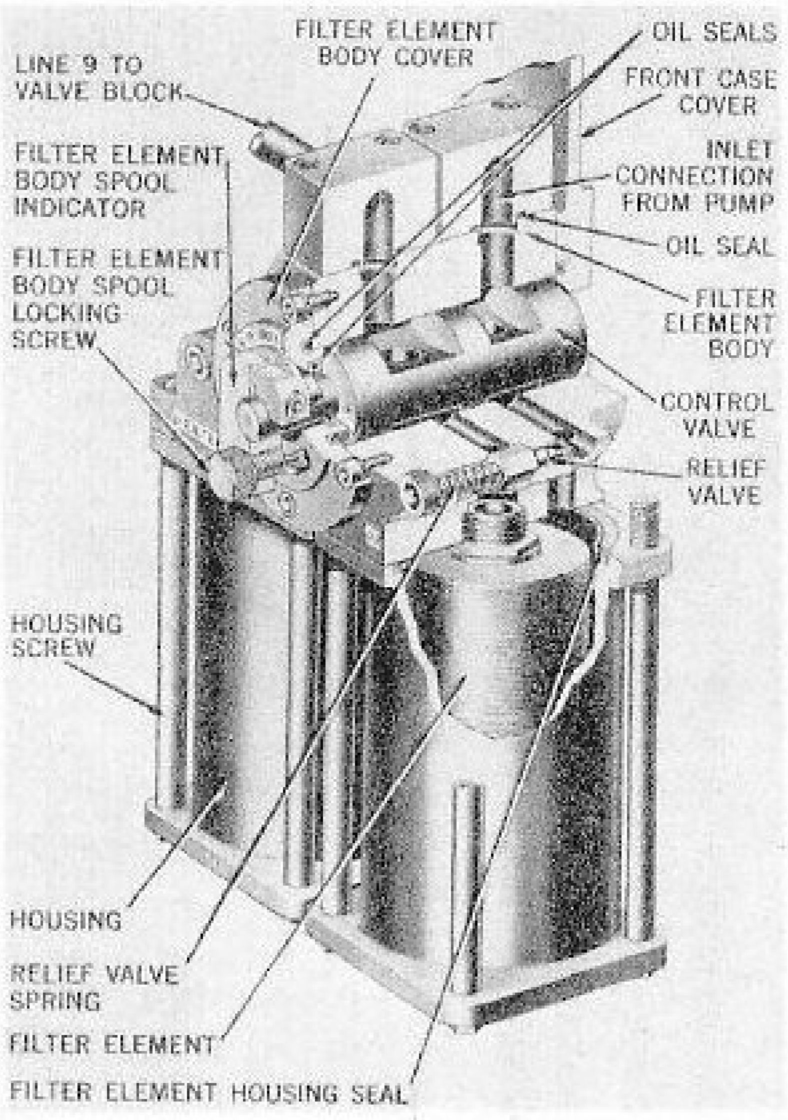


Figure 7-12. Filter Assembly, Cutaway View

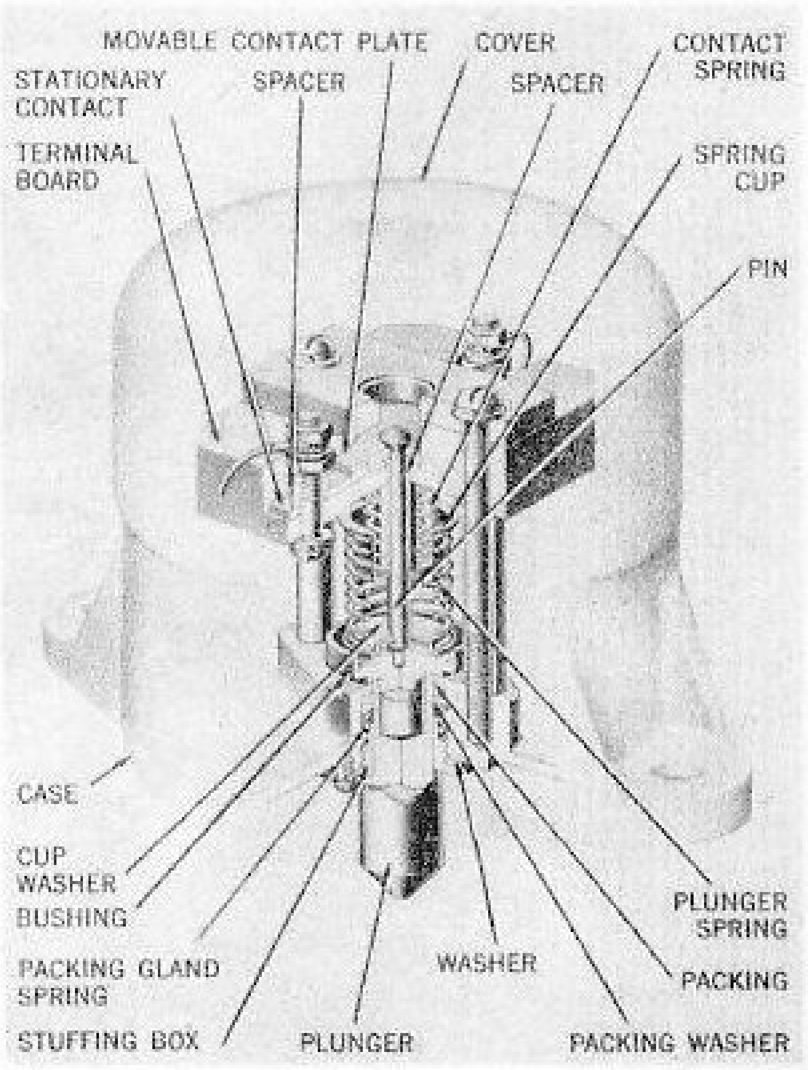


Figure 7-13. Neutral Interlock Switch, Cutaway View

B-end response coupling. The B-end response coupling (fig. 7-6) connects the response shaft to the control cam shaft. A floating center member, mounted between jaw flanges, is constrained to slide across the face of one flange on a line passing through the center, and across the face of the second flange in a direction at right angles to the first. The floating center member has special removable graphite-impregnated bearing strips, mounted between the center member and the flanges, together with a grease reservoir for lubrication.

B-end drive coupling. The B-end drive shaft coupling (fig. 7-17) is a direct-drive, self-aligning connection between the B-end output shaft and the gear reducer worm shaft. Composed of two identical hubs, male sleeve, female sleeve, sleeve gasket, and two oil seals, the coupling provides a flexible connection through meshing of the internal gears of hubs and sleeves. Openings for adding lubricant, which is retained by the oil seals and gaskets, are normally closed by oil plugs.

Hydraulic pipe installation. Details of the hydraulic pipe installations for the upper and lower projectile ring drives, connecting the previously described A-end pump, B-end motor, and valve block components, are identical. The hydraulic pipe installation for one projectile ring drive is shown in figure 7-25.

Projectile rings

Components. Each upper and lower inner projectile ring is composed of the following major units and subassemblies:

Carriage ring assembly

- Carriage ring weldments
- Rack
- Carriage securing devices
- Stowage fittings

Roller cage installations

- Roller cage
- Doubler plates

Pinion drive mechanism

- Gear reducer
- Drive coupling

Carriage ring assembly. The carriage ring assembly, arranged as shown in figure 7-18, rests on rollers of the roller cage installations (described on page 7-16). Secured against lifting by holding down flanges that are mounted on the circular bulkhead enclosing the machinery space, the carriage ring assembly is rotated on the rollers by pinion drive of the rack.

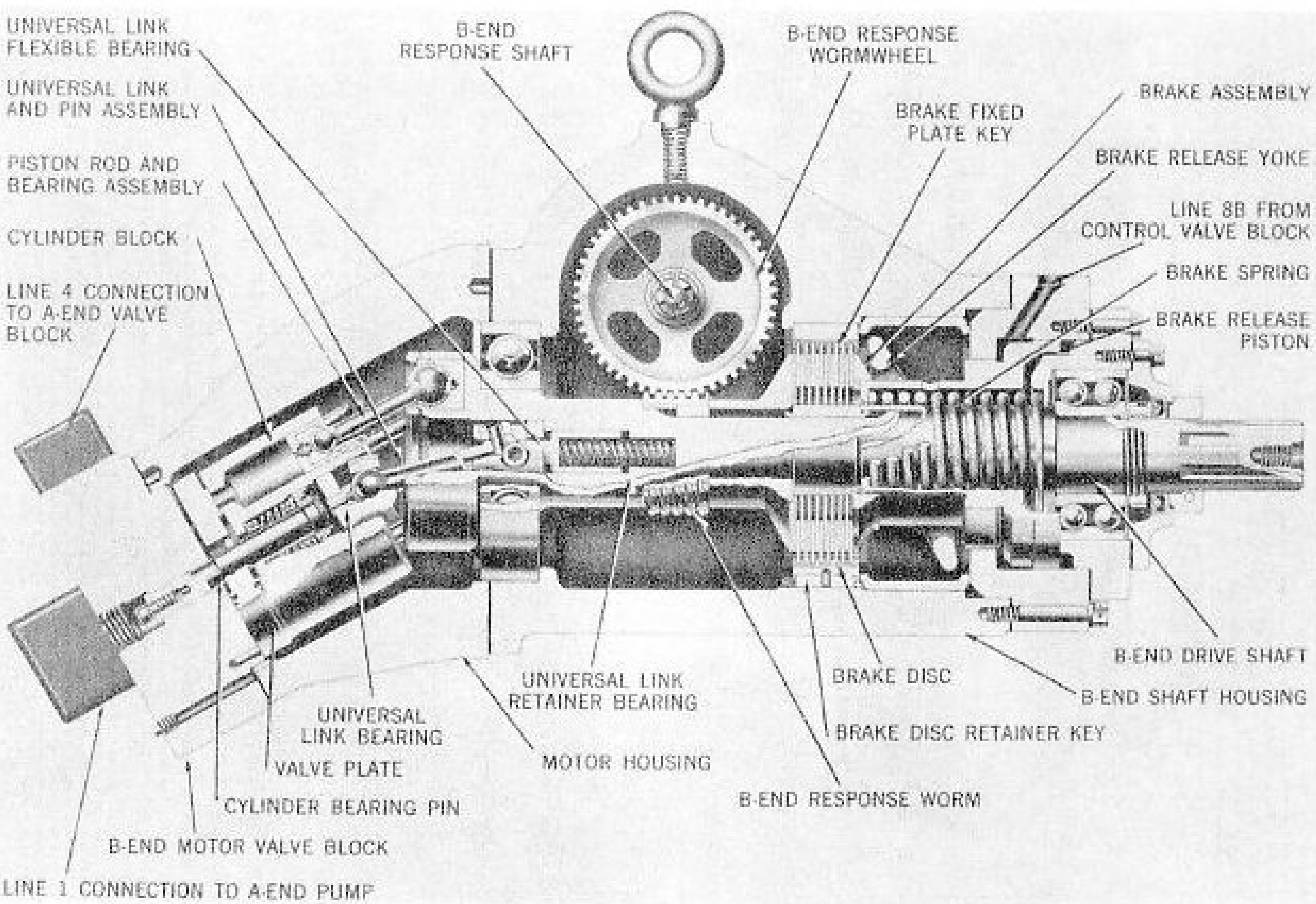


Figure 7-14. B-end Assembly, Sectional View

Carriage ring weldments. The projectile stowage rings (rotating) of both projectile flats are identical, with a platform diameter of 23 feet each. The platforms, each 36 inches wide, are welded assemblies of circular platform segments, two rings (designated rack retainer and outer track support), two other rings (designated inner and outer tracks), and a cylindrical coaming with a coaming flange.

Rack. Racks, large annular spur gear segments, are bolted on and keyed to the rack retainer to form a complete circular gear with internal teeth. Four similar 65-tooth segments give a total of 260 teeth in the whole rack. Pitch diameter of the rack is 208 inches. Identical drive pinions for both the upper and lower racks have 21 teeth with a pitch diameter of 16.8 inches.

Carriage securing devices. In addition to the holding-down flanges, each ring is equipped with devices to prevent accidental rotation of the ring when it is not in use. Two centering pins in each ring carriage (fig. 7-18) stow the rotating ring and relieve the rack, pinion, and pinion drive from stress, when the rings are not in use. The centering pins are located 180 degrees apart at 15 degrees and 195 degrees from the turret longitudinal centerline. Mating sockets for the pins are bolted in position in the assembly of fixed roller cages. Each pin is a screw type which is retracted by a special wrench. The wrenches are stowed close to each socket.

Stowage fittings. The projectile stowage details of the rotating and fixed stowage rings of both projectile flats are similar. Each rotating ring is provided with a coaming flange which is equipped with uniformly spaced projectile lashings. The fixed stowage spaces are equipped with similar lashings which are secured to uniformly spaced securing plates. These plates are welded to the cylindrical foundation bulkhead. The lashings consist of roller chain devices that are similarly toggle-connected to the coaming flange and the securing plates, as shown in figure 7-18. All lashing chains are equipped with pelican type fasteners.

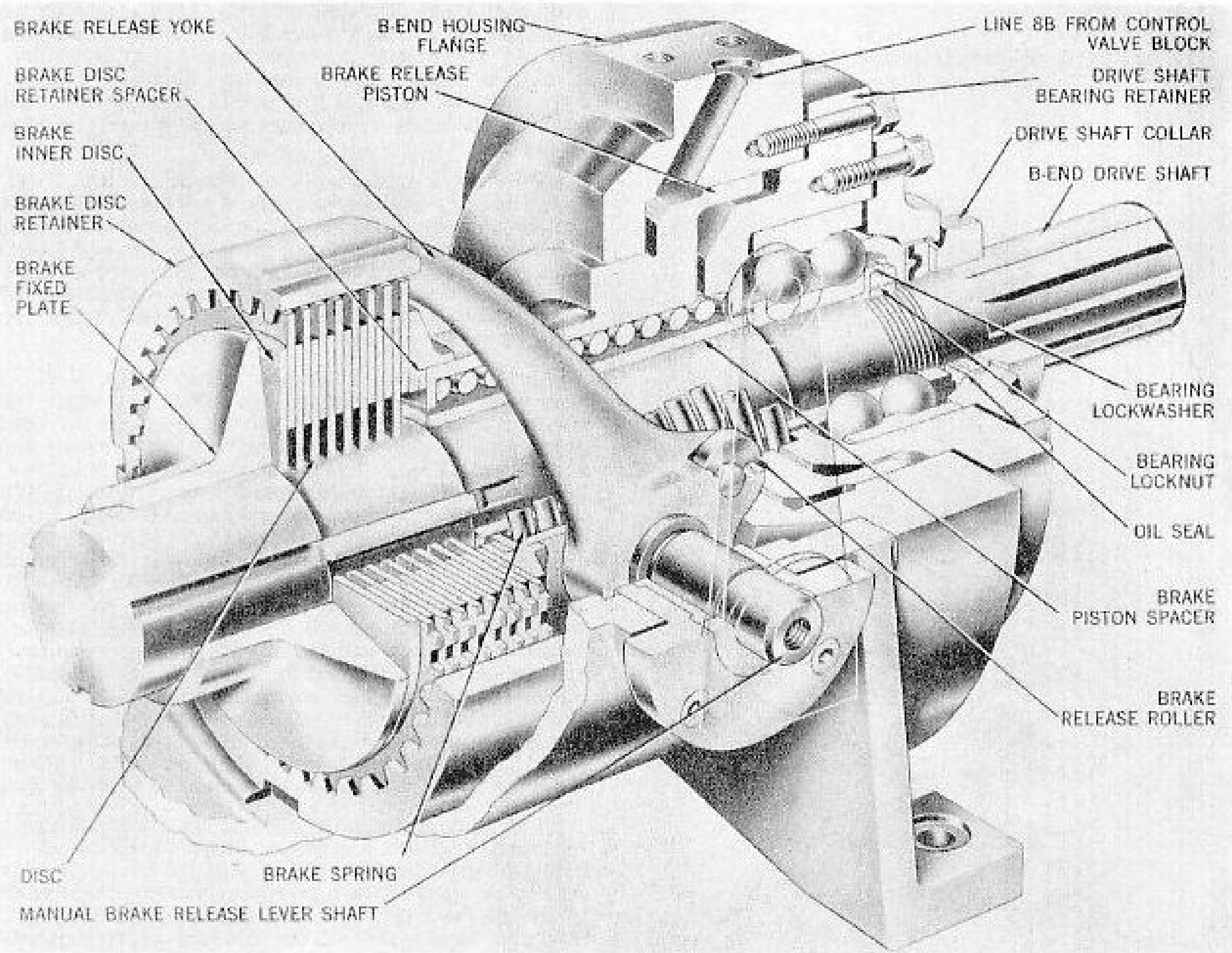


Figure 7-15. B-end Brake, Cutaway View

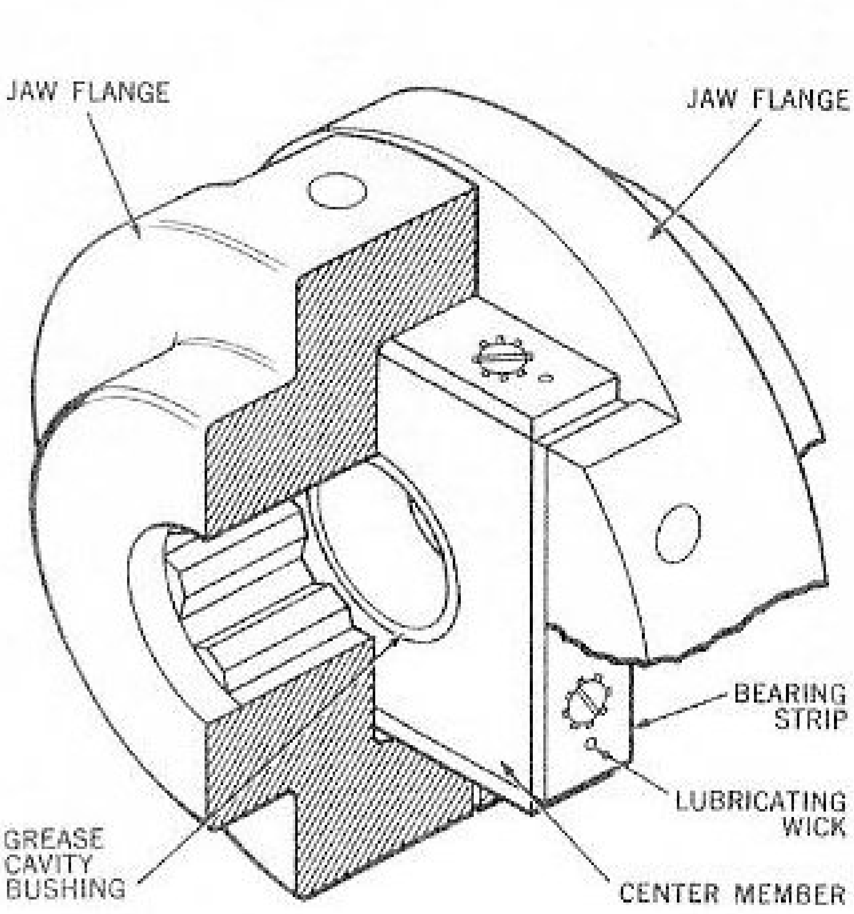


Figure 7-16. B-end Response Coupling, Cutaway View

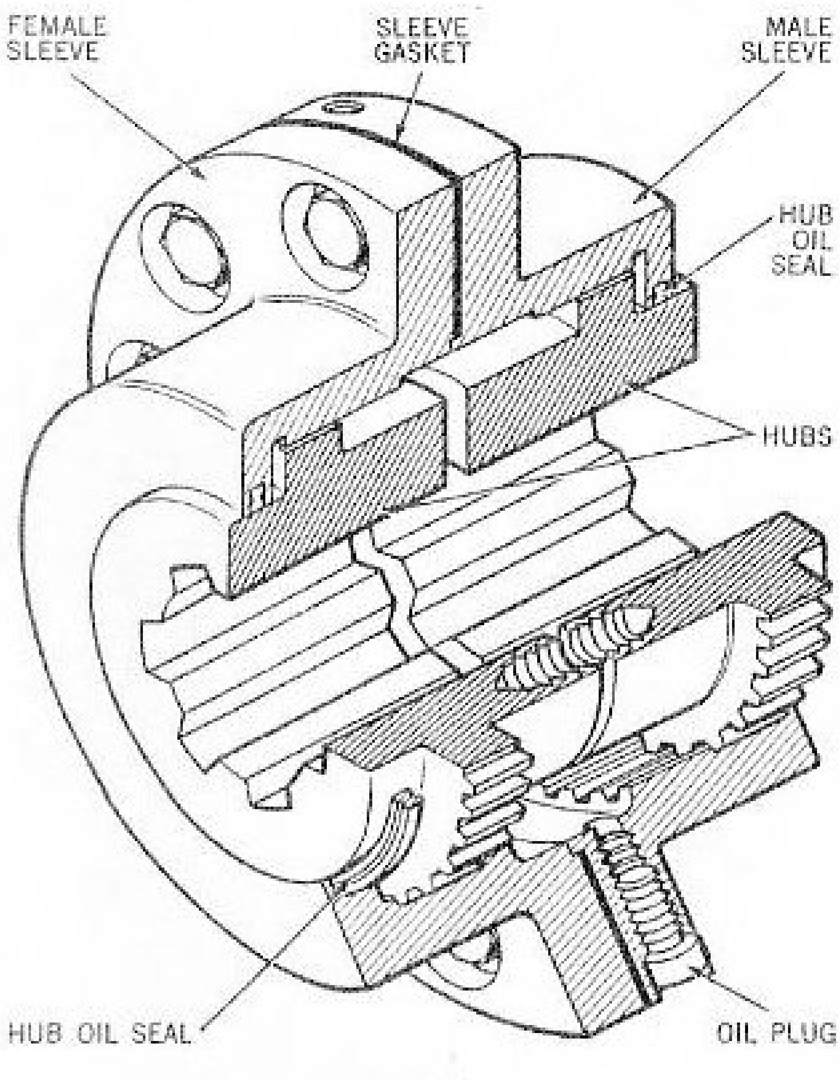


Figure 7-17. B-end Drive Coupling, Cutaway View

Roller cage installations. The inner projectile stowage rings rotate on fixed roller cage installations. The cages are bolted in the projectile flat recesses and do not rotate with the carriage. Each carriage ring rotates on an inner and an outer roller cage assembly which supports inner and outer tracks of the carriage ring weldments. In addition to rollers for the tracks, the inner roller cage assemblies have equally spaced radial-thrust rollers. The inner and outer roller cage installations are each made up of 18 equal segments which are fitted together, end to end, to form two complete, concentric circles.

Roller cage. Each roller cage segment is a cast steel frame. The segments for the outer roller cage assembly are provided with pin bearings for four carriage supporting rollers. Each segment for the inner roller cage assembly is provided with pin bearings for four radial-thrust rollers in addition to the four carriage supporting rollers. The radial-thrust rollers confine the thrust movement of the rotating ring and accurately maintain uniform engagement between the pinion and rack. Each radial-thrust roller is mounted on an eccentric bolt so that all radial-thrust rollers of the inner roller cage assembly can be adjusted to center the carriage ring. In addition, this feature ensures the desired pitch-line contact between the pinion and rack.

Doubler plates. The doubler plates are flat inner and outer rings that are secured in the recesses beneath the roller cage assemblies. The doubler plates provide true planes for supporting and aligning the circles of roller cage segments. Each outer roller cage segment bears at five points on the doubler plates, while each inner roller cage segment bears at nine points.

Pinion drive mechanism. The pinion (fig. 7-4) is mounted on the output shaft of a housed mechanism called the gear reducer. This unit is mounted within the machinery space of the projectile flat and is positioned for correct engagement of the pinion with the rack. The unit is coupled to the drive shaft of the B-end assembly. Both the upper and lower pinion drive units of the turret are alike.

Gear reducer. Each gear reducer (fig. 7-4) is a heavy-duty worm, wormwheel, and pinion shaft drive assembly. It is arranged with the pinion at the bottom, below an oil reservoir housing that encloses the worm and driven wheel. The worm and wormwheel are a lap-fitted set, match-marked for correct mesh. These two components are not interchangeable with like parts of other ring drive gear reducers. The gear reducer design is a non-overhauling, double-thread, Hindley-type worm. The wormwheel is made with 72 teeth and has a pitch diameter of 31.5 inches. The worm has a pitch diameter of 5.0 inches. Both shafts are mounted in thrust-radial roller bearing groups that are non-adjustably fitted for correct alignment at initial assembly. The wormwheel is keyed onto and drives a shaft together with a spur gear that is also keyed onto the same shaft. This spur gear is made with 13 teeth and has a pitch diameter of 10.4 inches. It drives the pinion gear which meshes with the rack.

The housing includes special details for filling, draining, venting, and gaging lubricant level. A filling plug is located at the top of the housing, adjacent to an open elbow pipe fitting that provides ventilation for the house mechanism and lubricant. Two trycocks in the side of the housing provide minimum and maximum oil level inspection points. Twelve gallons of a special high pressure lubricant designated Navy Symbol 5190, are required to fill to the upper trycock.

Drive coupling. The worm shaft of the gear reducer is coupled to the B-end shaft of the hydraulic power drive by a self-aligning flexible coupling of commercial design. This coupling is one of four special coupling devices included in the power drive. The coupling is shown in figure 7-17, and is described on page 7-14 of this chapter.

Projectile ring controls and interlocks

The projectile ring operating controls and interlocks include starting and stopping controls, a central interlock switch, manual control mechanism, timing and control mechanism, a manual brake release lever, and a projectile ring ready indicator. These control devices and their functions are described in following paragraphs.

Start-stop control. The master start-stop switch for the projectile ring controller of each of the upper and lower projectile flats is a conventional pushbutton type. The switch is of enclosed, watertight design with two buttons that are designated START-EMERG and STOP. The switch is similarly located on the center projectile hoist tube of each projectile flat. Each switch is normally open and is closed by pressing the START-EMERG button. The switch is opened by pressing the STOP button. The master start-stop switches described above are arranged in the controller starting circuit with another switch contact that must be closed to complete the circuit when the START-EMERG button is pressed. This switch contact is the neutral interlock switch which is closed when the A-end is at neutral stroke.

Pressing the START-EMERG button closes a normally open three-pole switch and energizes the coil of the main contactor. By the action just described, the three-phase power is connected to the main electric motor. Holding contacts on the relays maintain the power circuit connections when the START-EMERG button is released, and until the STOP button is pressed.

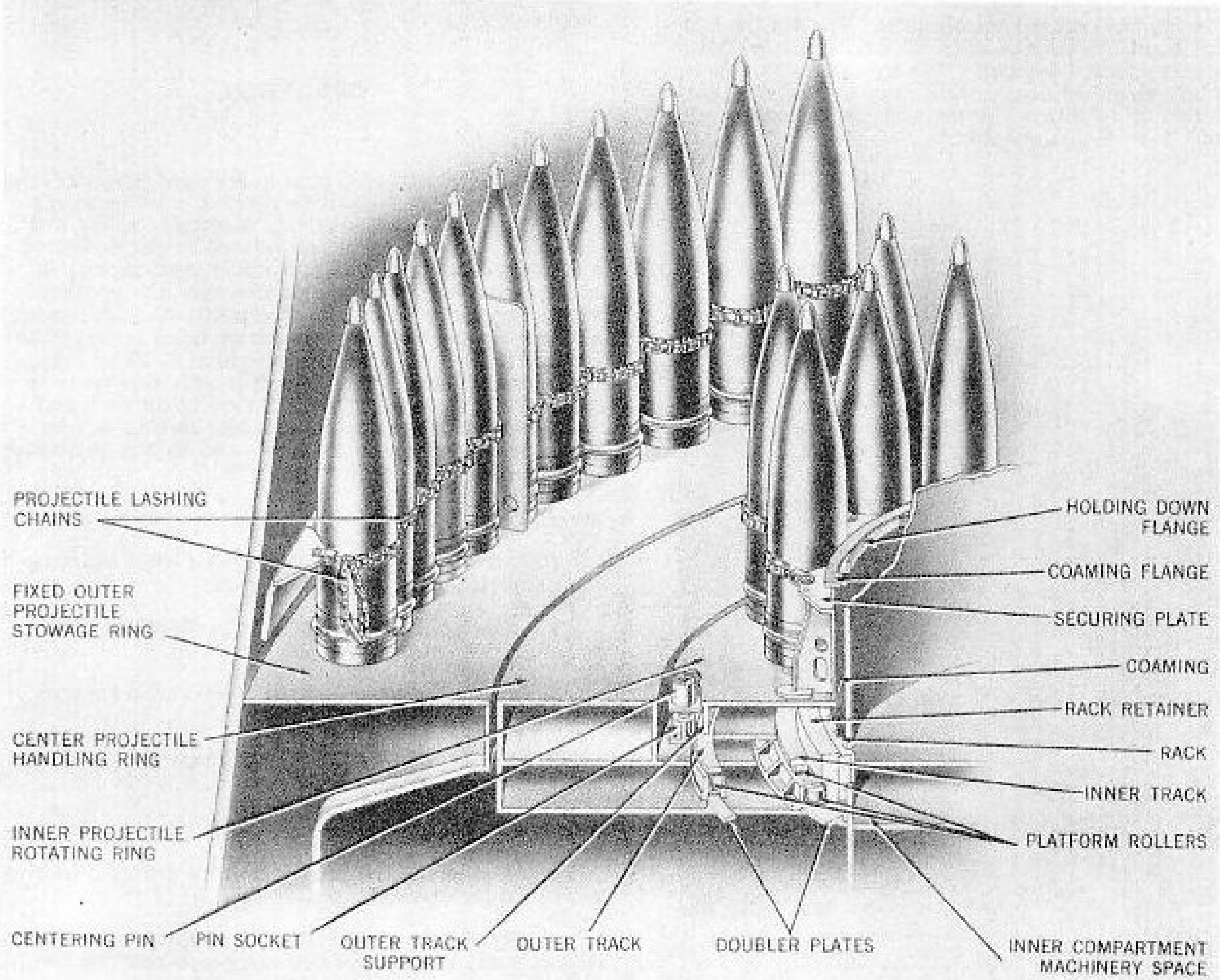


Figure 7-18. Projectile Stowage Ring, Sectional View

Stop pushbutton switches. Two emergency stop switches are provided for each projectile ring controller. These switches are of enclosed, watertight design with one pushbutton. The switches are similarly located on each projectile flat, one switch on each side of the projectile handling platforms, two switches on each projectile flat. The switches are the normally closed type and are opened by pressing the button designated STOP.

Neutral interlock switch. The neutral interlock switch is an electric switch that is used in the motor starting circuit. It functions to prevent starting overload on the electric motor when the drive is at mid-cycle position, with the pump yoke offset from neutral.

Manual control mechanism. The manual control mechanism of the projectile ring drives of the upper and lower projectile flats is an arrangement of shafts, miter gears, and a hand control lever. The hand control lever is for manually actuating projectile ring control movement. The manual control mechanism extends from the A-end assembly in the inner compartment to the outside of the projectile flat circular subdivision bulkhead. The mechanism is described on page 7-10 of this chapter, and is shown in figure 7-19.

Timing and control mechanism. The timing and control mechanisms are semi-automatic projectile ring cycle control devices. The mechanisms control starting speed and operate to stop ring rotation at the end of a cycle. The mechanism is described on page 7-9 of this chapter.

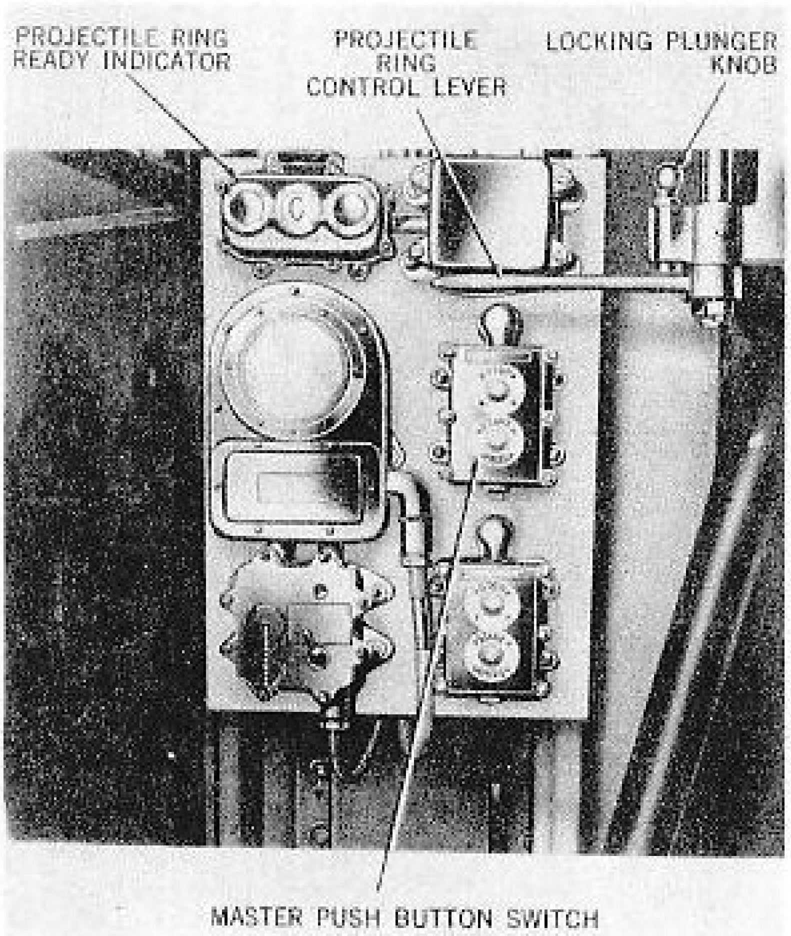


Figure 7-19. Projectile Ring Manual Control Mechanism

Brake release lever. The B-end mechanical brake is a friction disc type that is spring-applied and is normally released by hydraulic pressure. A piston-enclosed spring exerts sufficient pressure on the discs to engage them, and thus prevent the B-end output shaft from turning when the projectile ring drive is not operating. The brake is held in its applied position by the brake spring except when the ring is rotating, or when it is released by the manual brake release lever. The manual brake release lever is located on the side of the B-end, forward of the adjacent A-end assembly. The brake release lever is rotated through an arc of 36 degrees from an applied to a release position.

Projectile ring ready indicator. The upper and lower projectile handling flats are each equipped with an independent ready light circuit. The ready light circuit functions to notify the projectile ring operator as to when the rotating ring may be moved. Each ready light circuit is composed of three contact makers (one is located at each projectile hoist operator's station) and a three-dial indicator light (located at the projectile ring operator's station). The dial designations of the indicator light at L, C, and R, for the left, center, and right projectile hoists, respectively. Each circuit contact maker closes only the circuit to its respective dial on the indicator.

OPERATION

General

With both centering pins in a raised position, the projectile ring is free to be rotated in either direction. The control of starting, stopping, speed and direction of rotation is determined by the direction and degree of handlever movement, except when a ring station is reached, at which time the projectile ring stops automatically. The position of the control and timing mechanisms, resulting from initial offset of the handlever, is shown in figures 7-20 to 7-24, inclusive. These schematic diagrams illustrate in sequence the phases of circuit flow conditions and resultant movement of components during a complete operating cycle as described in the following paragraphs.

Starting

Perform the following operations when starting the projectile ring electric motor:

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

2. Place the hand control lever at the neutral stroke position.

3. Press the START-EMERG button.

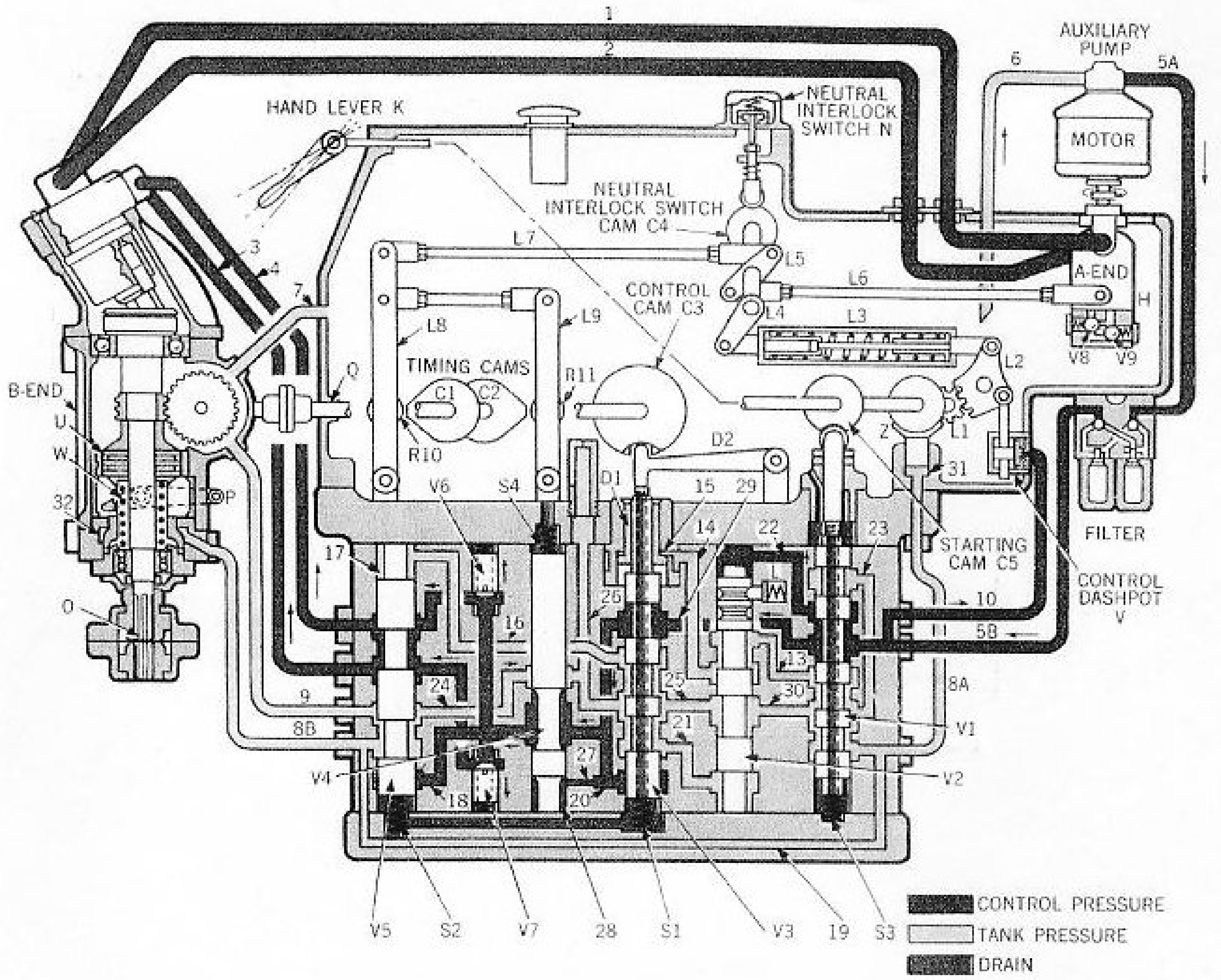
Stopping

When stopping the projectile ring drive, perform the following operations.

1. Rotate the projectile ring to the desired position of rest, so that the centering pins may be run in.

2. Place the hand control lever at the neutral stroke position.

3. Press the STOP button.



VALVE AND HYDRAULIC SYMBOLS

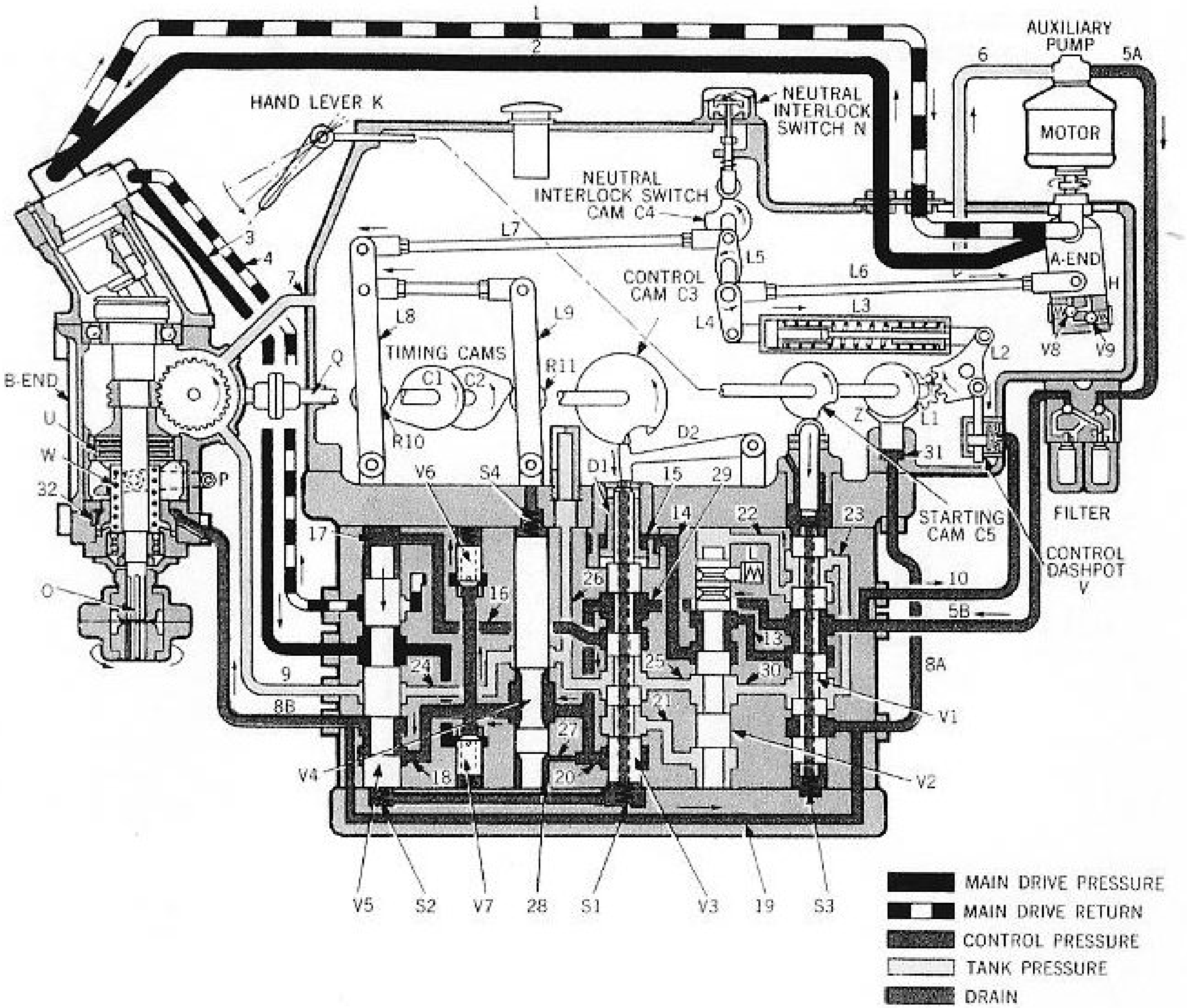
D1	CONTROL VALVE PISTON	V1	STARTING VALVE	V6	REPLENISHING CHECK VALVE
S1	CONTROL VALVE SPRING	V2	INTERLOCK VALVE	V7	REPLENISHING CHECK VALVE
S2	BYPASS VALVE SPRING	V3	CONTROL VALVE	V8	SAFETY RELIEF VALVE
S3	STARTING VALVE SPRING	V4	AUXILIARY PUMP RELIEF VALVE	V9	SAFETY RELIEF VALVE
S4	AUXILIARY PUMP RELIEF VALVE SPRING	V5	HYDRAULIC MOTOR BYPASS VALVE		

1, 2, 3, 4, 5A, 5B, etc. HYDRAULIC LINES, PASSAGES, AND CHAMBERS

MECHANICAL SYMBOLS

L	INTERLOCK VALVE DETENT PLUNGER	U	B-END BRAKE DISCS	L2	GEAR SEGMENT	L7	TIMING CAM LINK
O	B-END DRIVE SHAFT	W	BRAKE SPRING	L3	CONTROL LINK	L8	TIMING CAM ROLLER LINK
P	MANUAL BRAKE RELEASE LEVER	Z	HOLDING BRAKE	L4	YOKE LINK LEVER	L9	TIMING CAM ROLLER LINK
Q	B-END RESPONSE INPUT SHAFT	D2	LEVER LATCH	L5	YOKE LINK LEVER	R10	CAM ROLLER
		L1	CONTROL GEAR	L6	A-END YOKE LINK	R11	CAM ROLLER

Figure 7-20. Projectile Ring Circuit Diagram, Neutral Position



VALVE AND HYDRAULIC SYMBOLS

D1 CONTROL VALVE PISTON
S1 CONTROL VALVE SPRING
S2 BYPASS VALVE SPRING
S3 STARTING VALVE SPRING
S4 AUXILIARY PUMP RELIEF VALVE SPRING

V1 STARTING VALVE
V2 INTERLOCK VALVE
V3 CONTROL VALVE
V4 AUXILIARY PUMP RELIEF VALVE
V5 HYDRAULIC MOTOR BYPASS VALVE

V6 REPLENISHING CHECK VALVE
V7 REPLENISHING CHECK VALVE
V8 SAFETY RELIEF VALVE
V9 SAFETY RELIEF VALVE

1, 2, 3, 4, 5A, 5B, etc. HYDRAULIC LINES, PASSAGES, AND CHAMBERS

MECHANICAL SYMBOLS

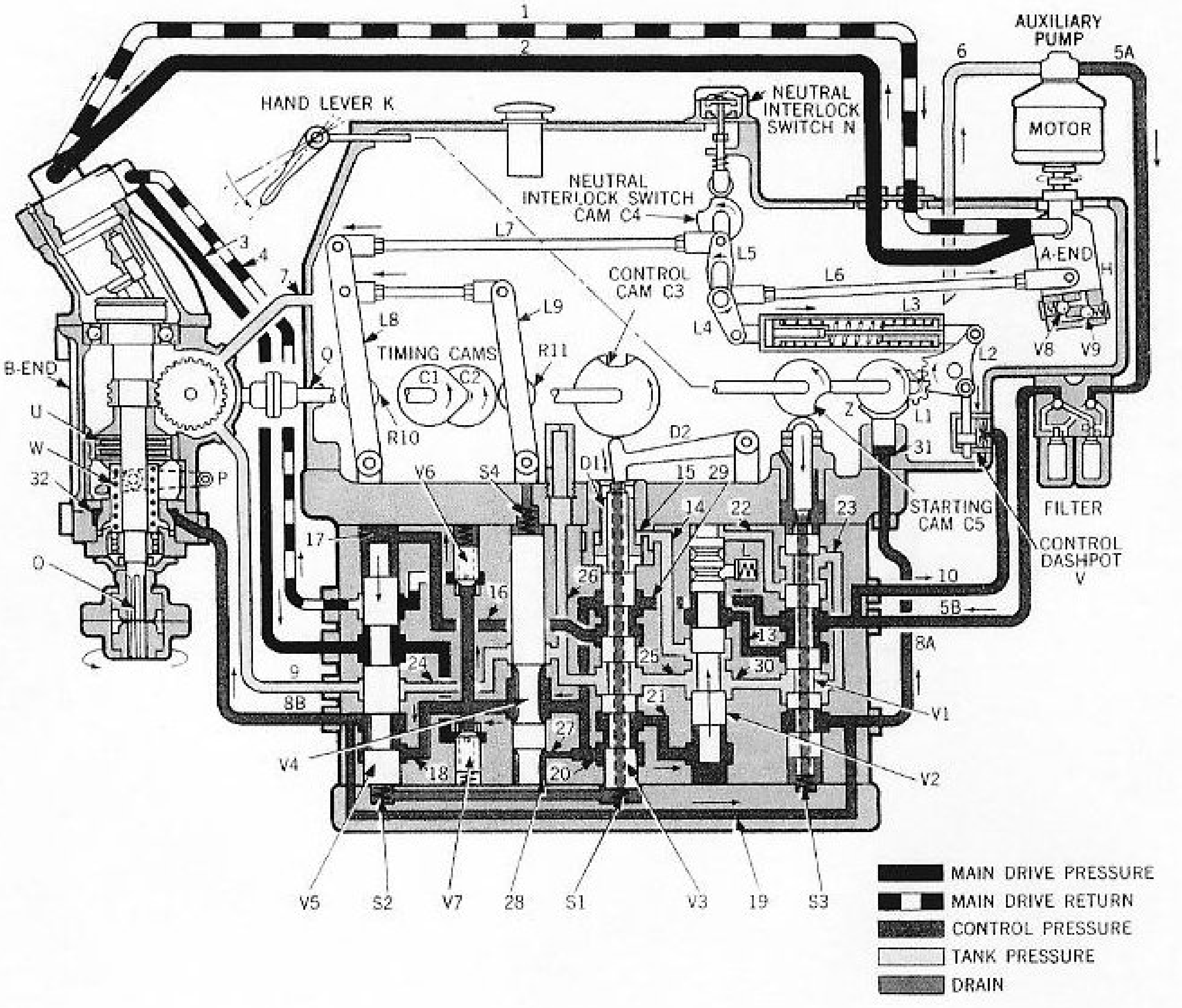
L INTERLOCK VALVE DETENT PLUNGER
O B-END DRIVE SHAFT
P MANUAL BRAKE RELEASE LEVER
Q B-END RESPONSE INPUT SHAFT

U B-END BRAKE DISCS
W BRAKE SPRING
Z HOLDING BRAKE
D2 LEVER LATCH
L1 CONTROL GEAR

L2 GEAR SEGMENT
L3 CONTROL LINK
L4 YOKE LINK LEVER
L5 YOKE LINK LEVER
L6 A-END YOKE LINK

L7 TIMING CAM LINK
L8 TIMING CAM ROLLER LINK
L9 TIMING CAM ROLLER LINK
R10 CAM ROLLER
R11 CAM ROLLER

Figure 7-21. Projectile Ring Circuit Diagram, Starting Position



VALVE AND HYDRAULIC SYMBOLS

D1 CONTROL VALVE PISTON
S1 CONTROL VALVE SPRING
S2 BYPASS VALVE SPRING
S3 STARTING VALVE SPRING
S4 AUXILIARY PUMP RELIEF VALVE SPRING

V1 STARTING VALVE
V2 INTERLOCK VALVE
V3 CONTROL VALVE
V4 AUXILIARY PUMP RELIEF VALVE
V5 HYDRAULIC MOTOR BYPASS VALVE

V6 REPLENISHING CHECK VALVE
V7 REPLENISHING CHECK VALVE
V8 SAFETY RELIEF VALVE
V9 SAFETY RELIEF VALVE

1, 2, 3, 4, 5A, 5B, etc. HYDRAULIC LINES, PASSAGES, AND CHAMBERS

MECHANICAL SYMBOLS

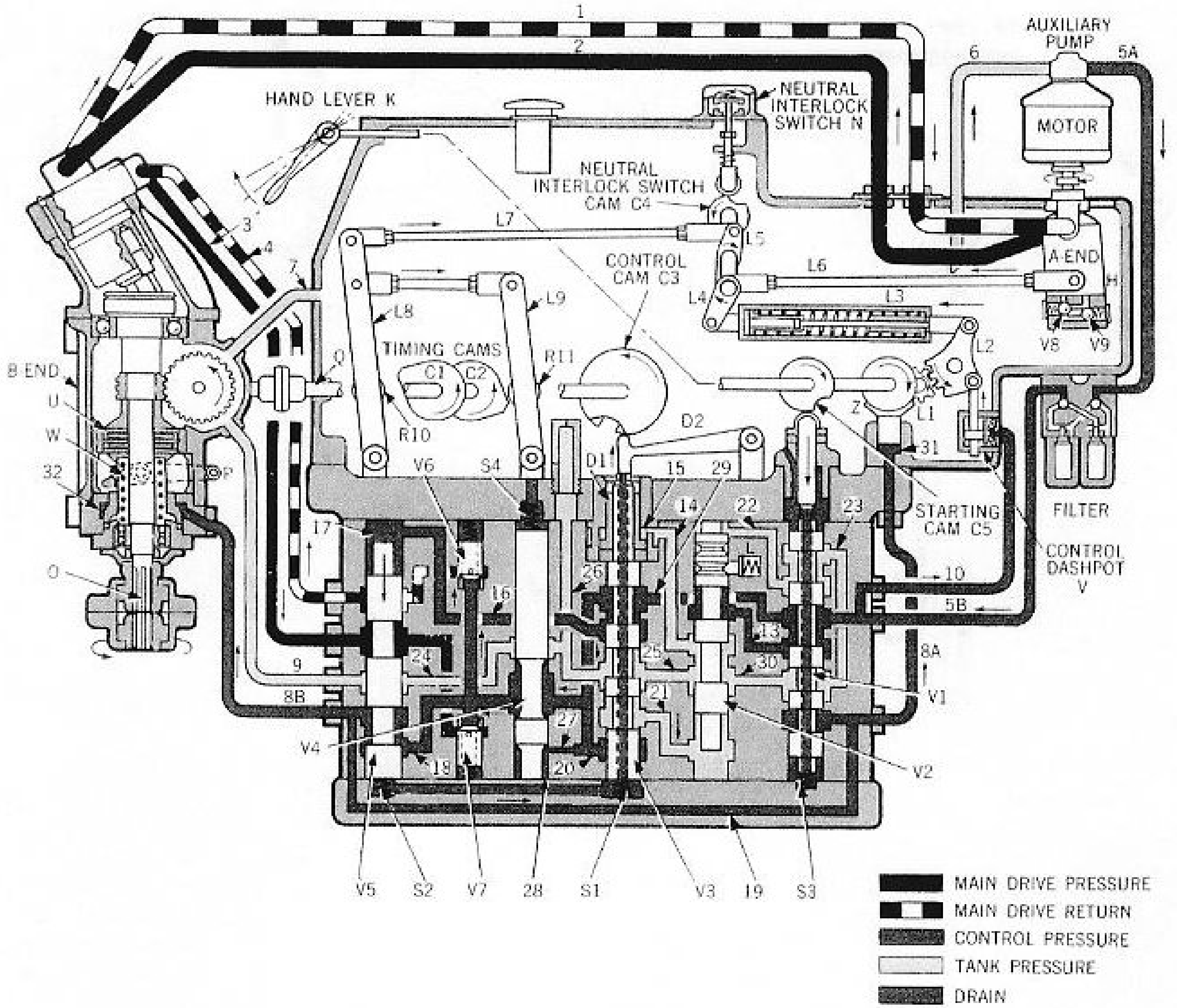
L INTERLOCK VALVE DETENT PLUNGER
O B-END DRIVE SHAFT
P MANUAL BRAKE RELEASE LEVER
Q B-END RESPONSE INPUT SHAFT

U B-END BRAKE DISCS
W BRAKE SPRING
Z HOLDING BRAKE
D2 LEVER LATCH
L1 CONTROL GEAR

L2 GEAR SEGMENT
L3 CONTROL LINK
L4 YOKE LINK LEVER
L5 YOKE LINK LEVER
L6 A-END YOKE LINK

L7 TIMING CAM LINK
L8 TIMING CAM ROLLER LINK
L9 TIMING CAM ROLLER LINK
R10 CAM ROLLER
R11 CAM ROLLER

Figure 7-22. Projectile Ring Circuit Diagram, Running Position



VALVE AND HYDRAULIC SYMBOLS

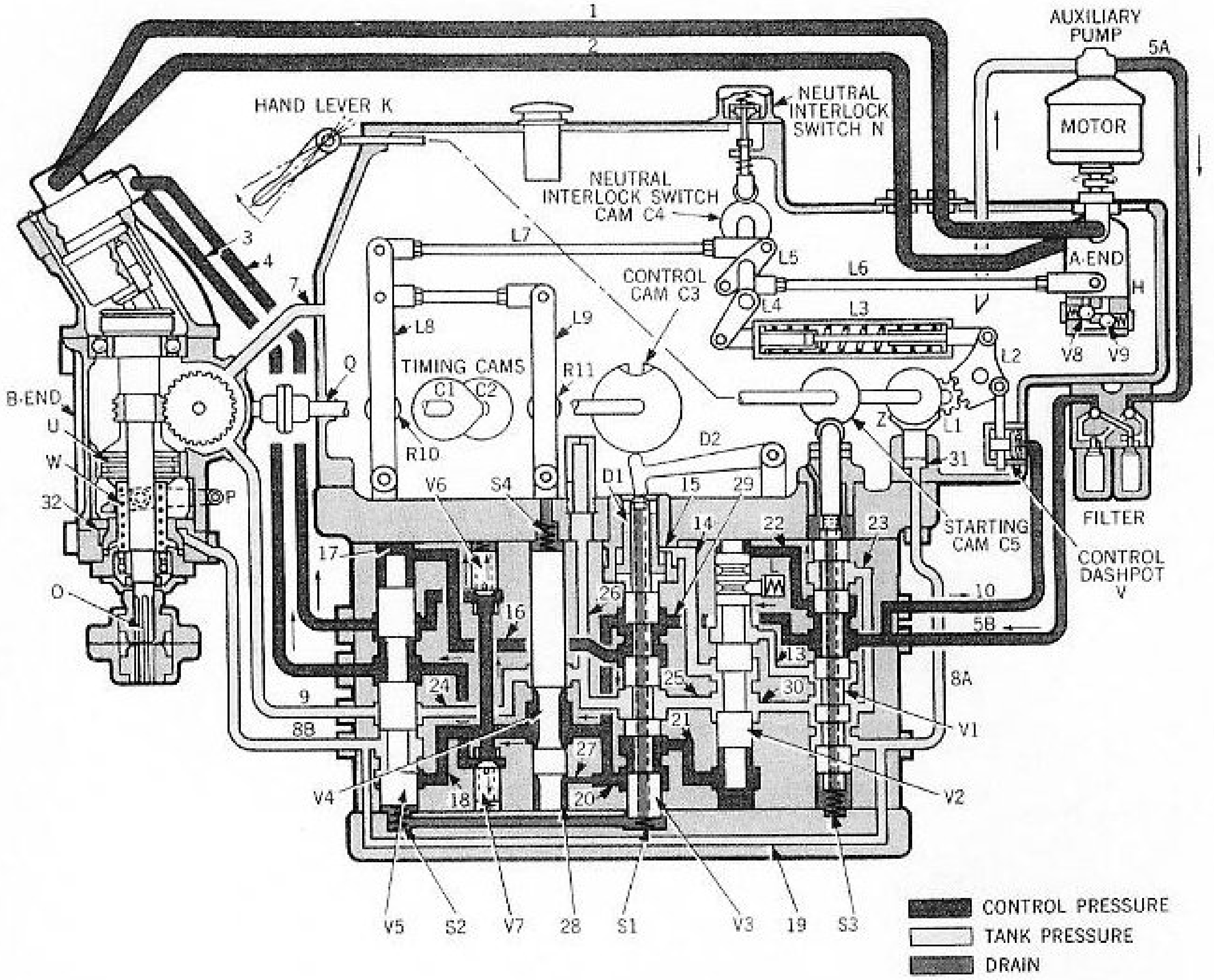
D1	CONTROL VALVE PISTON	V1	STARTING VALVE	V6	REPLENISHING CHECK VALVE
S1	CONTROL VALVE SPRING	V2	INTERLOCK VALVE	V7	REPLENISHING CHECK VALVE
S2	BYPASS VALVE SPRING	V3	CONTROL VALVE	V8	SAFETY RELIEF VALVE
S3	STARTING VALVE SPRING	V4	AUXILIARY PUMP RELIEF VALVE	V9	SAFETY RELIEF VALVE
S4	AUXILIARY PUMP RELIEF VALVE SPRING	V5	HYDRAULIC MOTOR BYPASS VALVE		

1, 2, 3, 4, 5A, 5B, etc. HYDRAULIC LINES, PASSAGES, AND CHAMBERS

MECHANICAL SYMBOLS

L	INTERLOCK VALVE DETENT PLUNGER	U	B-END BRAKE DISCS	L2	GEAR SEGMENT	L7	TIMING CAM LINK
O	B-END DRIVE SHAFT	W	BRAKE SPRING	L3	CONTROL LINK	L8	TIMING CAM ROLLER LINK
P	MANUAL BRAKE RELEASE LEVER	Z	HOLDING BRAKE	L4	YOKE LINK LEVER	L9	TIMING CAM ROLLER LINK
Q	B-END RESPONSE INPUT SHAFT	D2	LEVER LATCH	L5	YOKE LINK LEVER	R10	CAM ROLLER
		L1	CONTROL GEAR	L6	A-END YOKE LINK	R11	CAM ROLLER

Figure 7-23. Projectile Ring Circuit Diagram, Approaching Automatic Stop



VALVE AND HYDRAULIC SYMBOLS

- D1 CONTROL VALVE PISTON
- S1 CONTROL VALVE SPRING
- S2 BYPASS VALVE SPRING
- S3 STARTING VALVE SPRING
- S4 AUXILIARY PUMP RELIEF VALVE SPRING
- V1 STARTING VALVE
- V2 INTERLOCK VALVE
- V3 CONTROL VALVE
- V4 AUXILIARY PUMP RELIEF VALVE
- V5 HYDRAULIC MOTOR BYPASS VALVE
- V6 REPLENISHING CHECK VALVE
- V7 REPLENISHING CHECK VALVE
- V8 SAFETY RELIEF VALVE
- V9 SAFETY RELIEF VALVE

1, 2, 3, 4, 5A, 5B, etc. HYDRAULIC LINES, PASSAGES, AND CHAMBERS

MECHANICAL SYMBOLS

- L INTERLOCK VALVE DETENT PLUNGER
- O B-END DRIVE SHAFT
- P MANUAL BRAKE RELEASE LEVER
- Q B-END RESPONSE INPUT SHAFT
- U B-END BRAKE DISCS
- W BRAKE SPRING
- Z HOLDING BRAKE
- D2 LEVER LATCH
- L1 CONTROL GEAR
- L2 GEAR SEGMENT
- L3 CONTROL LINK
- L4 YOKE LINK LEVER
- L5 YOKE LINK LEVER
- L6 A-END YOKE LINK
- L7 TIMING CAM LINK
- L8 TIMING CAM ROLLER LINK
- L9 TIMING CAM ROLLER LINK
- R10 CAM ROLLER
- R11 CAM ROLLER

Figure 7-24. Projectile Ring Circuit Diagram, Stopped Between Stations by Operator

Circuit operations

Stop position (fig. 7-20). With the projectile ring stopped at one of the ring stations, and the control hand lever at neutral stroke position, the following conditions exist:

Starting valve V1. The starting valve roller is resting in the recess of the starting cam C5. In this position, the starting valve:

1. Ports control pressure from the auxiliary pump through line 22 to hold the interlock valve V2 in the reset position.

2. Vents tank pressure from chamber 15 of the control valve piston D1 through line 14, the interlock valve V2, and lines 13, 30, 25 and 26 to the tank.

3. Vents chamber 31 of the holding brake Z to the tank through lines 8A, 30, 25, and 26. It also vents chamber 32 of the B-end brake through lines 8B, 30, 25, and 26. (The brake chamber is also vented through lines 8B, 24, and 26.)

Interlock valve V2. The interlock valve is held in reset position and vents chamber 15 of the control valve piston D1 as described above.

Control valve V3. The control valve is spring actuated to hold the lever latch D2 in the recess of the control cam C3. In this position, the control valve:

1. Vents chamber 17 of the bypass valve V5 to the tank through lines 16 and 26.

2. Vents the interlock valve V2 to the tank through lines 21 and 26.

Bypass valve V5. The bypass valve is positioned by spring S-2 to its bypass position when chamber 17 is vented to the tank, as previously described. In this position, the bypass valve:

1. Bypasses the pump-to-motor power transmission lines 1 and 2 so that the hydraulic motor will not rotate even if the pump yoke (H) is slightly offset from neutral stroke.

2. Vents chamber 32 of the B-end brake through lines 8B, 24, and 26.

3. Vents chamber 31 of the holding brake through lines 8A, 19, 8B, 24, and 26.

Relief valve V4. Control pressure from the auxiliary pump flows through lines 5B, 29, 20, and 27 to chamber 28 of the relief valve. When pressure in the control circuit and in chamber 28 exceeds the setting of the relief valve spring S4, the valve moves up against the spring and connects lines 20 and 26, which vents the circuit to tank.

Replenishing check valves V6 and V7. The replenishing check valves may be closed or slightly opened, depending on the extent of leakage in the pump-to-motor transmission lines 1 and 2 and lines 3 and 4. In their open position, the replenishing check valves port control pressure to the drive circuit through lines 3 and 4, and the bypass valve V5.

Timing cams C1 and C2. With the pump yoke in neutral stroke position, there is a slight clearance (0.060-inch) between the timing cams and their link rollers R10 and R11.

Interlock switch N. The roller of the neutral interlock switch is in its recess in cam C4. In this position the power starting circuit through the switch to the electric motor is closed. The electric motor can be started when the control mechanism is in neutral position only.

Start position (fig. 7-21). When the hand lever K is offset through any part of its 170° arc, in either direction, it acts through the shafts and miter gears of the hand control mechanism to rotate the starting cam C5, gear L1, and gear segment L2. The speed of movement of the gear segment is restricted by the control dashpot V, which thus limits the speed of movement of the hand lever K. The rotation of the gear segment L2 causes movement of links L4, L5, L7, L8, and L9 to take up the clearance between the timing cam C2 and the link roller R11. Also, rotation of the gear segment L2 causes movement of link L6 to offset the A-end pump yoke H. Movement of link L4 is limited, so the balance of the hand lever full movement is taken up by compression of the control link pump yoke, and linkage in the positions described above, valves and associated components function as described in the following paragraphs:

Starting valve V1. When the starting cam C5 rotates, it forces the starting valve roller out of the cam recess and positions the starting valve V1 in its start position. In this position, the starting valve:

1. Vents the top of the interlock valve V2 to the tank through lines 22, 23, 30, 25, and 26. V2, held by a detent, does not move from the reset position.

2. Closes the vent lines of chamber 31 of the holding brake and chamber 32 of the B-end brake by disconnecting line 8A from line 30.

3. Ports control pressure from line 5B, through lines 13 and 14, to chamber 15 of the control valve V3 piston.

Control valve V3. As control pressure is ported through the starting valve V1 and enters chamber 15 of the control valve piston, it moves the control valve piston which forces V3 to its start position. A shoulder on the valve block limits movement of the piston. After the control valve is positioned at its start position, control pressure is ported from line 29 through line 16 to chamber 17 of the bypass valve V5. V5 is forced down against spring S2 into its "bypass blocked" position.

Bypass valve V5. In its "bypass blocked" position, the by-pass valve:

1. Closes vents of chamber 31 of the holding brake and chamber 32 of the B-end brake by disconnecting line 8B from line 24.

2. Ports control pressure to chamber 32 of the B-end brake from line 5B through lines 29, 20, 18, and 8B. V5 also ports control pressure to chamber 31 of the holding brake from line 8B through lines 19 and 8.

3. Disconnects line 3 from line 4. This permits main drive pressure to build up in transmission line 1 or 2 (depending on direction of pump yoke offset) as the pump yoke is offset from neutral stroke and the A-end pump begins delivery.

Holding brake Z. When control pressure is ported to chamber 31, the holding brake Z engages the shaft of the hand control mechanism and holds it in position until chamber 31 is vented. Chamber 31 of the holding brake is not normally vented until a cycle is completed, unless the hand lever is manually returned to a stop position before completion of a cycle.

B-end brake. When control pressure is ported to chamber 32 of the B-end brake, the brake spring W is compressed. This removes pressure from the brake discs U and permits the B-end drive shaft O to turn. The offset of the pump yoke permitted by the clearance between timing cam C2 and roller R11 is enough to start B-end rotation.

Response mechanism. As the B-end rotates, the response worm gear rotates the B-end response input shaft Q, timing cams C1 and C2, and control cam C3. As timing cam C2 rotates, the link roller R11 follows the cam contour and causes linkage movement to increase the pump yoke H offset. This action accelerates the projectile ring to full speed. As the control cam C3 turns, lever latch D2 is moved out of its cam recess and thereby positions the control valve to its full "running position" (fig. 7-22).

Running position (fig. 7-22). The running position differs from the starting position only in that the degree of pump yoke H offset is greater, and that the control valve V3 and interlock valve V2 are positioned as described below:

Control valve V3. When the control valve V3 is moved to its running position, by the control cam C3, it ports control pressure from line 20 to line 21. This action positions the interlock valve V2 in its running position, where it is held by the detent.

Interlock valve V2. When the interlock valve is positioned in its running position, it vents chamber 15 of the control valve piston D1 to the tank through lines 14, 25, and 26. The control valve V3 through lever latch D2 is now forced to follow the contour of the control cam C3 by the pressure of the control valve spring S1, until D2 engages the cam recess at the end of the angle.

Approaching automatic stop position (fig. 7-23). As the cycle nears completion, the rotating speed of ring and hydraulic drive units is being decelerated by the movement of the pump yoke H toward neutral. This movement, caused by the contact of the timing cam C2 with the roller R11, is taken up by the spring in the control link as the holding brake Z maintains the original position of the control shaft. As the end of the cycle is reached, the valves and related components function as described in the following paragraphs:

Control valve V3. When D2 engages the recess in C3, V3 is returned to its stop position, and:

1. Vents the lower chamber of the interlock valve V2 to the tank, through lines 21 and 26.

2. Vents chamber 17 of the bypass valve V5 to the tank through lines 16 and 26.

Bypass valve V5. After chamber 17 is vented, the bypass valve spring S2 positions the valve to its bypass position, where it:

1. Connects lines 3 and 4, and bypasses the transmission lines 1 and 2.

2. Vents chamber 32 of the B-end brake to the tank through lines 8B, 24, and 26. This action permits the brake spring W to apply pressure to the brake discs and thereby stop rotation of the B-end drive shaft O.

3. Vents chamber 31 of the holding brake to the tank through lines 8A, 19, 24, and 26. This action releases the holding brake Z.

Starting valve V1. When the holding brake Z is released, the control link spring L3 returns the hand-lever K to neutral position at a speed regulated by the dashpot V. When the hand lever is at neutral, the recess of the starting cam C5 is aligned with the roller of V1. The starting valve spring S3 moves the roller into the recess and thus positions V1 in its stop position. In this position, V1 ports control pressure to the upper end chamber of V2 through lines 5B and 22.

Interlock valve V2. As the lower end chamber of V2 is vented by the repositioning of V3, and control pressure is ported to the upper end chamber of V2 by movement of V1 to its starting position, V2 shifts to its reset position. The control system has now resumed the neutral position shown in figure 7-20.

Between stations, stop position (fig. 7-24). The projectile ring may be stopped by the ring operator between cycles by returning the hand lever to neutral stroke. If such action is performed, the following conditions exist.

Starting valve V1. When the manual control hand lever K is returned to neutral, against the braking friction of the holding brake Z, the starting valve spring S3 forces the starting valve up and engages the roller in the detent of the starting cam C. V1 then:

1. Ports control pressure to the chamber at the upper end of V2 through lines 5B and 22.

2. Ports control pressure to chamber 17 of V5 through lines 5B, 29, and 16.

3. Vents line 8A to the holding brake, and lines 8B and 19 to the B-end brake through lines 30, 25, and 26.

Interlock valve V2. Control pressure is ported to the upper end of this valve, as described above, but V2 remains in its running position because it has equal pressure at the lower end, which is ported through lines 5B, 29, 20, and 21.

Bypass valve V5. When ring rotation is stopped between cycles, V5 oscillates between a partial and a full "bypass blocked" position. This condition is ported to chamber 17 of V5 through the repositioning of V1, as described above, which positions V5 in its "bypass blocked" position. In this position, chamber 17 is vented to the tank through lines 16, 20, 18, 19, 30, and 26. However, when the pressure in chamber 17 is vented, the bypass valve spring S2 tends to return the valve to bypass position.

This would close off the venting action of line 18 (and of chamber 17) so that control pressure ported to chamber 17 again returns the bypass valve V5 to its "bypass blocked" position. While the bypass valve is oscillating, a connection is maintained between lines 3 and 4, which bypasses the main drive pressure in lines 1 and 2. The holding brake Z has been released and the B-end brake has been applied, as described above under the starting valve V1. Due to these conditions, the projectile ring rotation is stopped, and rotation cannot resume until the hand lever K is moved from neutral position. When the hand lever is moved, V1 is moved to its running position and all mechanisms resume normal running operation, as shown in figure 7-22.

INSTRUCTIONS

General instructions

The projectile ring 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 hydraulic system maintenance instructions in chapter 17.

General servicing instructions

Hydraulic oil. The fluid to be used in the hydraulic system is that designated by the Bureau of Ordnance as 51F21 (Ord). The fluid must be poured into the system through a fine mesh wire strainer of at least 200 wires to the inch. Do not use cheesecloth or rags. After 15 hours of operation (or less), new assemblies should be drained, thoroughly flushed with clean 51F21 (Ord), and refilled with new hydraulic fluid. Perform the test inspection and analysis of oil samples from each system monthly. If there is evidence of excessive sludge, water, or acidity, drain, flush, and refill with fresh oil. The amount of fluid required to fill each projectile ring drive unit is approximately 25 gallons. Proper procedure for filling an empty system is as follows:

1. Remove the filler cap from the A-end case and fill the case to the level of the upper trycock.

2. Start the electric motor and allow it to run for several minutes in order to fill all spaces in the control and operating circuits.

3. Remove the filler cap and add sufficient fluid to fill to the upper trycock.

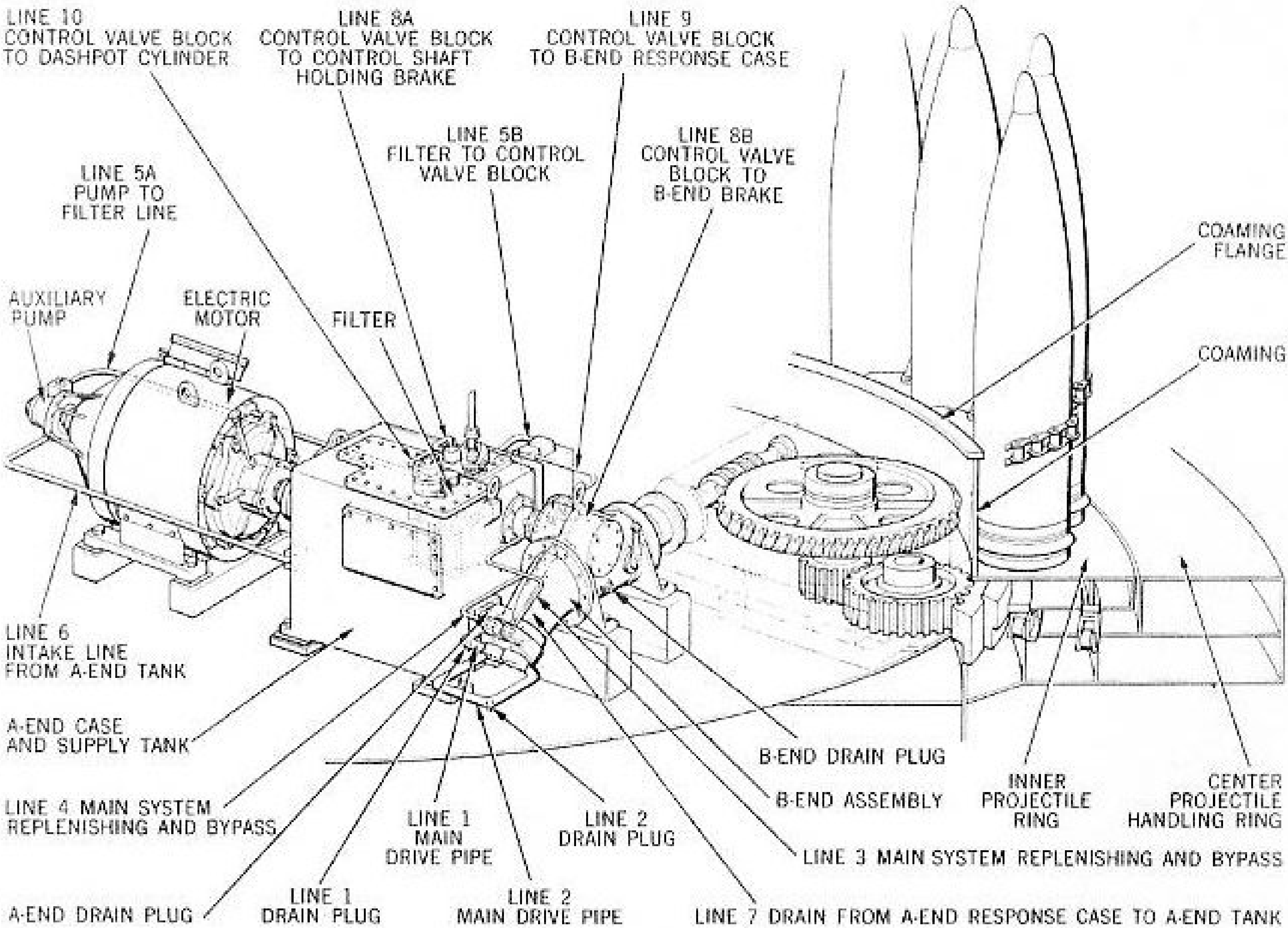


Figure 7-25. Projectile Ring Drive Arrangement

Lubrication. All hydraulic power units are self-lubricating. Other elements of the projectile ring assembly, such as the electric motor, response gear, couplings, and hand control mechanisms, are to be lubricated in accordance with instructions on the lubrication charts.

Operating precautions

The following precautions must be observed before rotating the projectile ring or operating the power drive unit.

Electric motor, direction of rotation. If the power drive unit is new or reassembled, or if the power leads to the motor or controller have been disconnected and subsequently reconnected, the direction of electric motor rotation must be verified. To verify the direction of motor rotation, run the motor for just a few seconds and check direction of rotation with directional arrow on housing. Running the electric motor in the wrong direction will damage the auxiliary pump.

Brake lever position. The B-end manual brake lever must be in its "power on" position at all times.

Adjustments

General instructions. All elements of the projectile ring drive units have fixed installations, except the following: the control link assembly, the cam timing and cam roller link assemblies, the control shaft yoke link assembly, the interlock switch linkage assembly, and the safety relief valve. Instructions for adjusting these elements and directions for correctly synchronizing the B-end output shaft with the timing mechanism, and the neutral position of the handlever with the control mechanism (the A-end pumps included), are given in the following paragraph. If the equipment has been disassembled, all components except the control link assembly may be assembled and installed before making adjustments. The A-end side cover (with filters attached) and the top cover should be left off to provide access for adjustments. Adjustments may be reduced to a minimum, at reassembly, if all mating parts are marked before disassembling.

Control link adjustment (fig. 7-26). The control link centering spring must be adjusted before it is installed in the A-end case. The purpose of the adjustment is to eliminate lost motion between the long and short retainers.

To adjust control link:

1. Screw in the short retainer until all lost motion between it and the long retainer is taken up.

2. Tighten the locknut to lock the short retainer in position.

Cam timing link adjustment (fig. 7-27). Before the cam timing link can be adjusted, the control link assembly must be properly installed, and the timing cams must be in a latched position.

To adjust cam timing link:

1. Loosen the right-hand thread lock nut and the left-hand thread lock nut of the cam timing link only.

2. Rotate the turnbuckle until the specified clearance of 0.060-inch is obtained between the timing cam and the cam upper roller.

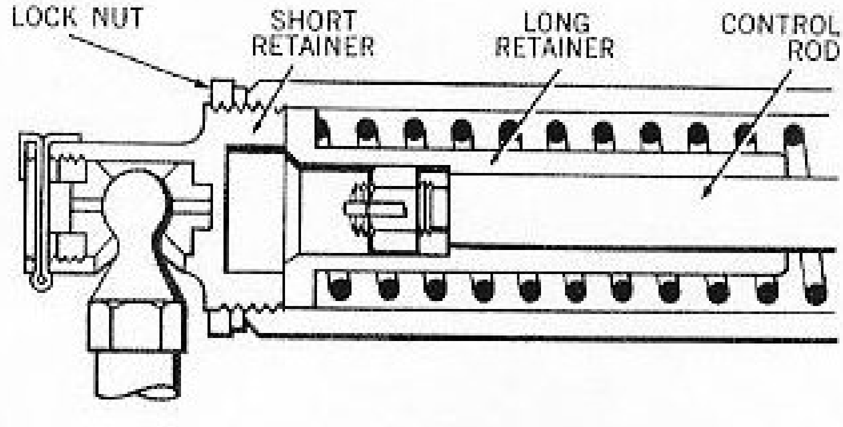


Figure 7-26. Projectile Ring Control Link Adjustment

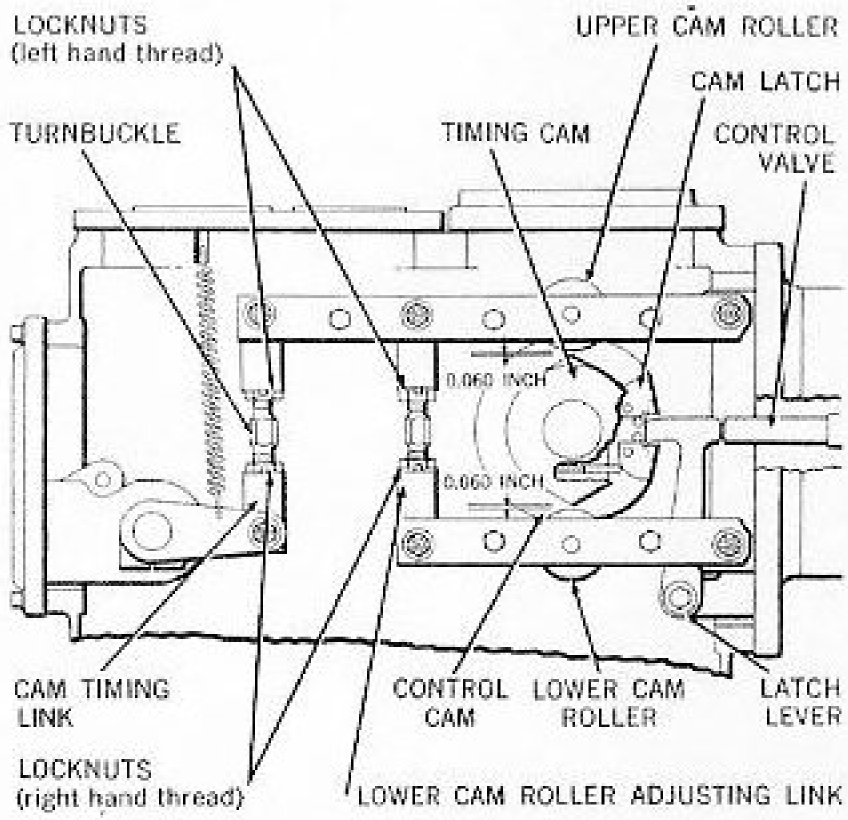


Figure 7-27. Cam Timing Link and Cam Roller Link Adjustment

3. Tighten both lock nuts to secure the adjustment.

Cam roller link adjustment (fig. 7-27). The cam roller link adjustment must be made after the cam timing link adjustment.

1. Loosen the right-hand thread lock nut and the left-hand thread lock nut of the lower cam roller link only.

2. Rotate the turnbuckle until the specified clearance of 0.060-inch is obtained between the lower cam roller and the timing cam.

3. Tighten both lock nuts to secure the adjustment.

Yoke link adjustment (fig. 7-28). Before the yoke link adjustment can be made, the control link centering spring, the cam timing link, and the cam roller links must all be properly adjusted.

To adjust the yoke link:

1. Place the hand control shaft at neutral position.

2. Loosen the two lock nuts.

3. Rotate the turnbuckle until the pump yoke is at its exact center (neutral position).

4. Tighten both lock nuts to secure the adjustment. Note: It may be necessary to readjust the yoke link in order to put the pump yoke at neutral position after starting to operate the equipment.

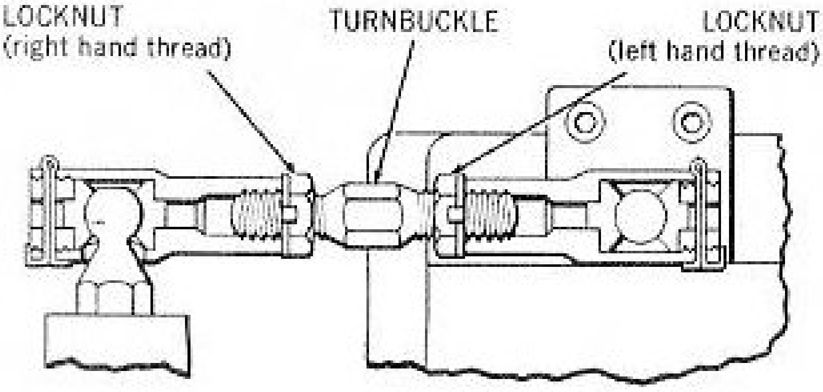


Figure 7-28. Projectile Ring Yoke Link Adjustment

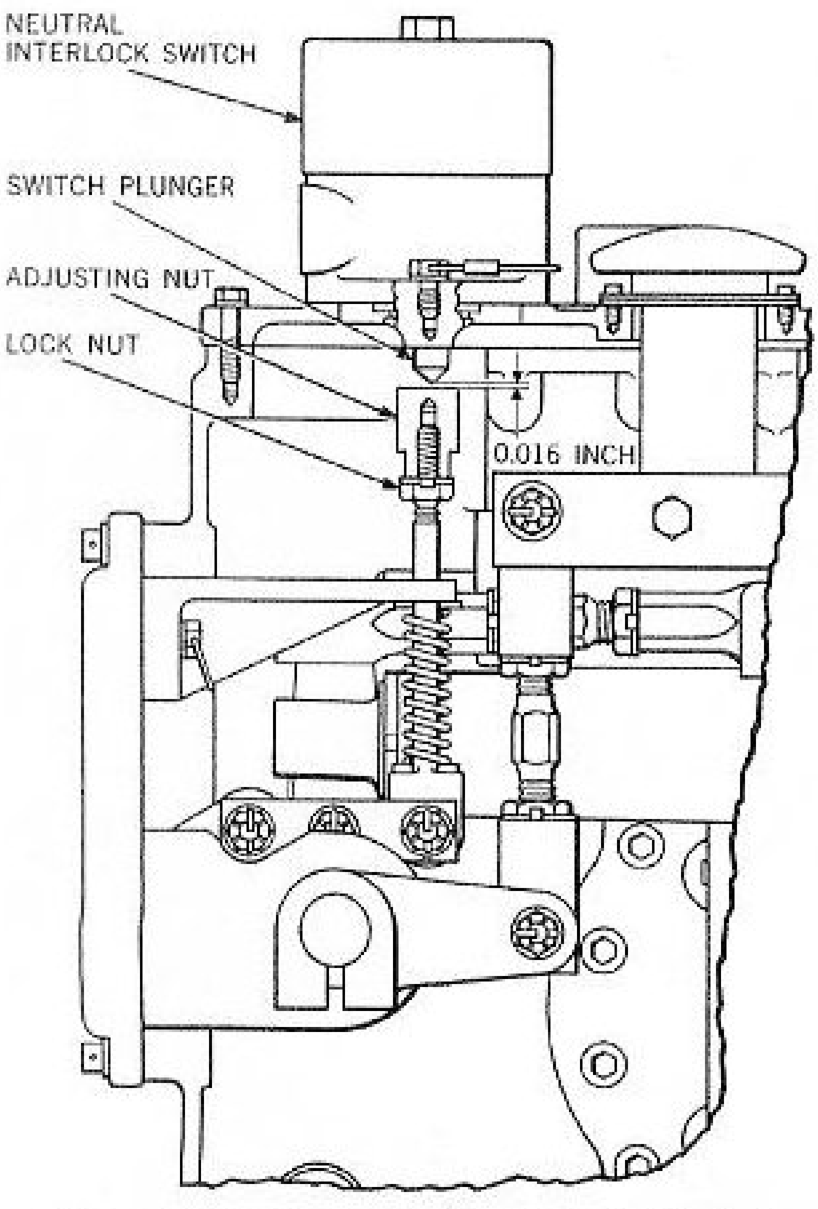


Figure 7-29. Projectile Ring Neutral Interlock Switch Link Adjustment

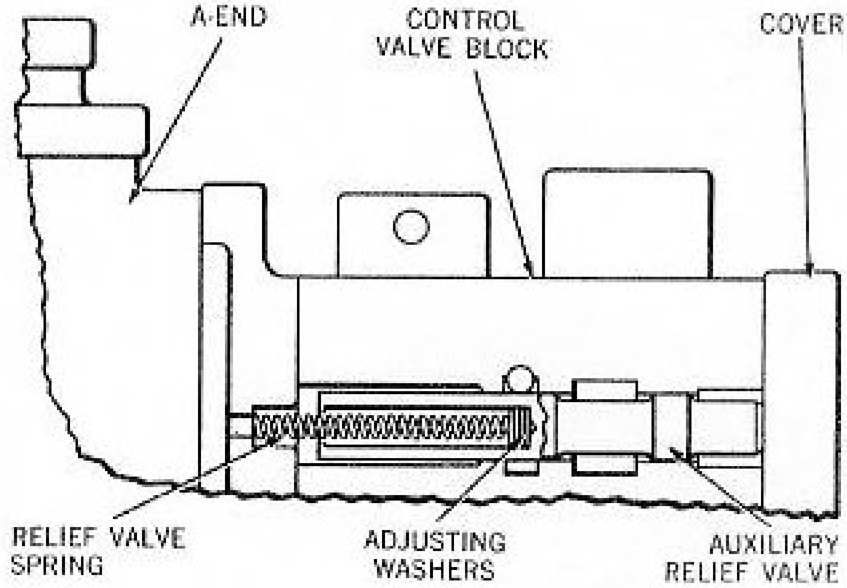


Figure 7-30. Projectile Ring Auxiliary Relief Valve Adjustment

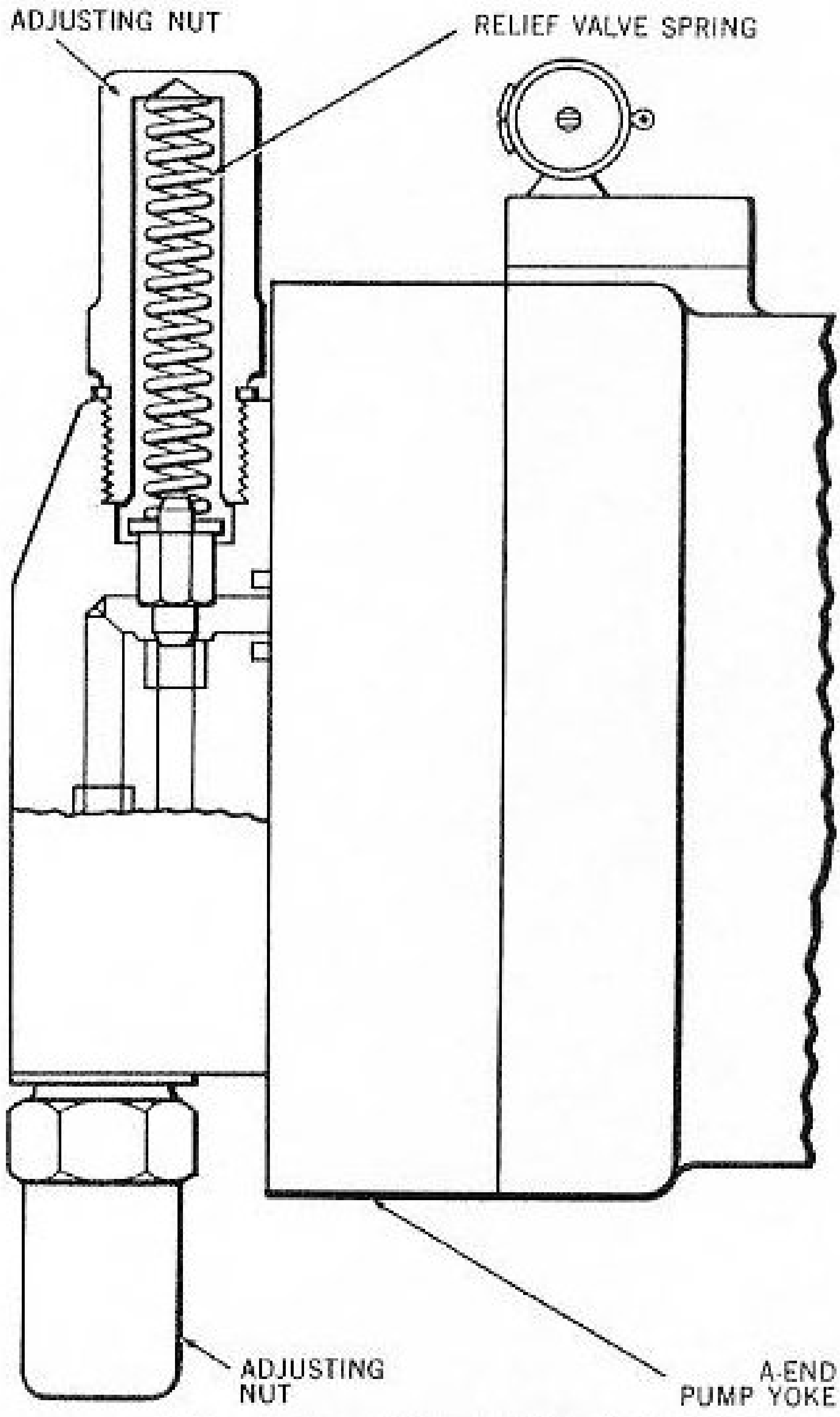


Figure 7-31. Projectile Ring Safety Relief Valve Adjustment

Interlock switch adjustment (fig. 7-29). The starting circuit neutral interlock switch linkage must be adjusted as follows:

1. Verify that the pump yoke and the hand control shaft are at neutral position.

2. Loosen the locknut.

3. Turn the adjusting nut until the specified clearance (0.016 inch) is obtained between the adjusting nut and the switch plunger.

4. Tighten the lock nut to secure the adjustment.

Auxiliary relief valve (fig. 7-30). The auxiliary relief valve is correctly adjusted at the factory to vent the auxiliary pump circuit (control pressure) to the tank when the circuit pressure exceeds 100 pounds per square inch. Initial adjustment is made by placing washers behind the valve spring. If the original washers are kept behind the spring, no further adjustment should be necessary. The auxiliary relief valve is adjusted as follows:

1. Remove the cover from the control valve block.

2. Remove the relief valve and change the number or thickness of the adjusting washers, as necessary.

3. Replace the valve and cover.

4. Place a pressure gage in line 5A, at the auxiliary pump flange, shown in figure 7-25.

5. Repeat the above procedure, if necessary, until a pressure setting of approximately 100 pounds per square inch is obtained.

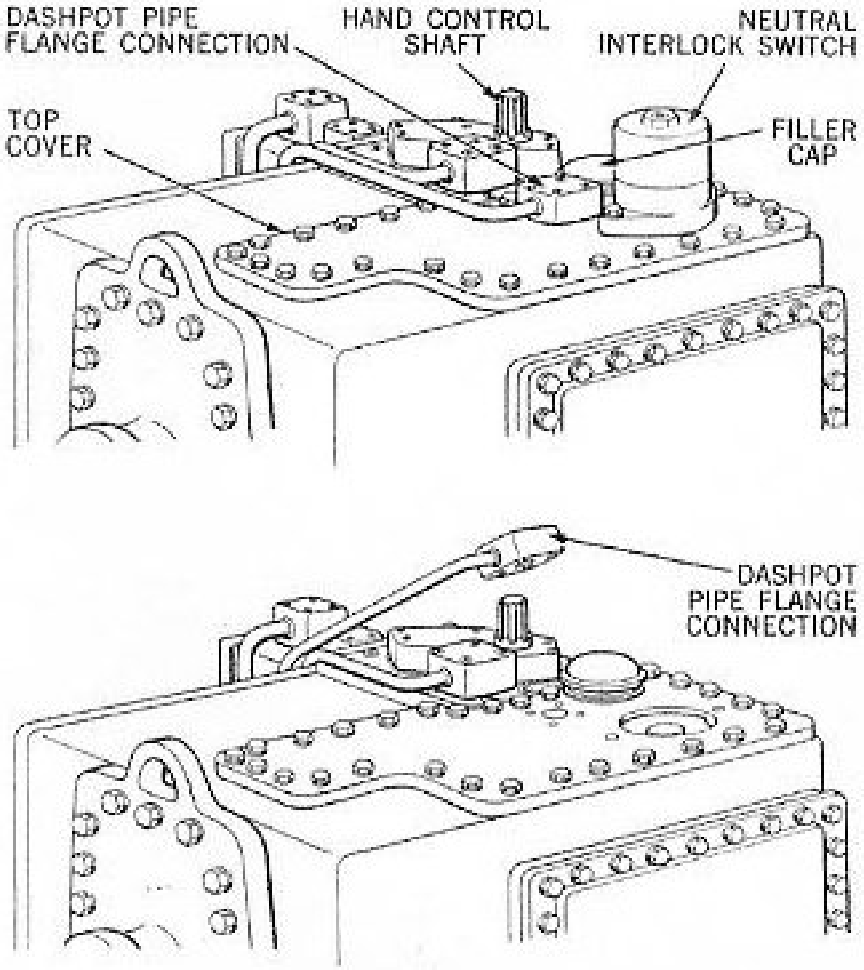


Figure 7-32. Access to Cam Timing Roller Link and Control Shaft Yoke Adjustments

Safety relief valve adjustment (fig. 7-31). The two safety relief valves V8 and V9 (in figures 7-20 to 7-24, inclusive) are properly adjusted at the factory to relieve at approximately 2200 pounds per square inch. No further adjustment should be necessary.

The valves are adjusted as follows:

1. Remove the side cover of the A-end case (complete with oil filters). This provides access to the valve on the end of the pump yoke.

2. Change the pressure relief setting. Tighten the adjusting unit to increase the pressure or loosen the nut to lower it.

Adjustment required when projectile ring stops out of phase. Whenever the projectile ring is not at a ring station, with the control and timing mechanism in stop position, the equipment has been connected up out of phase and must be adjusted.

To adjust for proper synchronization, proceed as follows:

1. Operate the equipment as necessary to place the control valve in latched position.

2. Disconnect the B-end output shaft coupling from the gear reducer worm shaft.

3. Place the B-end brake hand lever in "off" position, and manually rotate the projectile ring to place it at a ring station.

4. Connect the B-end output shaft coupling.

Access for adjustment (fig. 7-32). To adjust the timing cam link and the yoke link without dismantiling the A-end unit, proceed as follows:

1. Disconnect the dashpot pipe connection from the top cover.

2. Remove the neutral interlock switch.

The necessary adjustments can be made through the opening provided by the removal of the interlock switch.

CAUTION: Do not start the electric motor while the A-end pump yoke and handwheel are off center with the interlock switch removed.

Operating trouble diagnosis

General instructions. The following paragraphs describe the various operating troubles which may occur in the projectile ring drive with their causes. A paragraph heading indicates each symptom of improper function, and beneath the heading are listed the possible causes. The symptoms are arranged in such order as to isolate troubles by a process of elimination and thereby avoid excessive disassembly until the more simple causes have been eliminated. Whenever troubles occur immediately after installation or after maintenance operations are performed, the cause may be rags, waste, or plugs which have gotten into the hydraulic circuit. It is advisable to see that all lines are free from such obstructions before looking for other causes if malfunction occurs.

WARNING

Make sure that the electric supply circuit is open at the controller panel before working on equipment.

No electric power. The lack of current, for any of the following reasons, may cause electric motor failure:

1. Circuit breaker cut out.

2. Main line fuses blown.

3. Neutral interlock switch linkage improperly adjusted or stuck open.

Circuit breaker cuts out when starting. Tendency of the circuit breaker to cut out as the electric motor is started may be due to one of the following causes:

1. Overload relay dashpots in the controller box are set too low. Check instruction sheet inside controller cover for proper setting.

2. Insufficient or improper oil in the overload relay dashpots. Check oil in the dashpots monthly to prevent depletion due to leakage or evaporation from heating.

3. Obstruction in the line between the A-end pump and the B-end motor, (lines 1 and 2) or between the auxiliary pump and the valve block (lines 5A and 5B). Check lines for obstructions.

4. Damaged A-end pump or auxiliary pump. Check pumps for damage. If the auxiliary pump is damaged it was possibly caused by operating the electric motor in the wrong direction.

5. Excessive friction or locked rotor in auxiliary pump. Indications of this condition are poor delivery, high pitched squeal, and overheating of the pump. This condition of excessive friction or locked rotor may be due to foreign matter in the system or improper adjustment of the head shims. If a binding condition is found to exist in the auxiliary pump, the loosening of the head screws must not be considered as a correction. Remove the pump head and inspect for possible damage to the pump. The rotor vanes should be examined to see that no sheared particles of brass have become lodged in the grooves. Replace damaged parts, reassemble the pump, and adjust the head by adding shims as necessary to prevent binding of the rotor when the head is installed.

Projectile ring inoperative due to pressure failure. Inoperative condition of the projectile ring power drive units due to pressure failure may be caused by trouble in the A-end and B-end power drive transmission circuit or the auxiliary pump control circuit. When diagnosing for a pressure failure casualty, pressure gages must be placed in both circuits. Some of the probable causes are:

1. Electric motor running in the wrong direction. Check rotation with directional arrow on the motor housing.

2. Insufficient hydraulic oil in system. Check oil level at the upper trycock in the A-end case.

3. Obstruction in the auxiliary pump intake line. Remove the intake line and inspect for obstructions.

4. A-end control and timing linkage improperly adjusted. Set the pump yoke at neutral position and check for tightness and proper adjustment.

5. Safety relief valve improperly adjusted. Check safety relief valve adjustment, page 7-29 of this chapter.

6. Auxiliary relief valve, by-pass valve, check valves stuck open. Inspect valves and perform any necessary maintenance.

7. Interlock valve does not shift. Inspect valve and detent for binding or obstruction. Perform any necessary maintenance.

8. Loose or broken line in the control circuit. Inspect lines for leakage. Tighten connections or replace lines as necessary.

9. Scored valve plate in main pump or hydraulic motor. Inspect valve plates for scoring. If found, examine hydraulic oil for foreign matter and replace the valve plates.

10. Broken or distorted auxiliary pump shaft. Remove shaft and inspect. Replace as necessary.

11. Excessive internal leakage in auxiliary pump. Pump head and shims improperly adjusted. Internal parts scored by foreign matter in hydraulic oil. Check all parts and the oil and perform necessary maintenance.

Projectile ring inoperative with necessary pressure available. When pressure is available in the system but the projectile ring will not rotate, it will probably be due to one of the following causes:

1. Insufficient clearance between deceleration cams and link rollers. Check linkage for proper adjustment (fig. 7-27).

2. Excessive internal leakage in A-end pump or B-end motor. Turn ring manually to mid-cycle position. Start electric motor and place the A-end yoke in extreme offset position. If operation is possible, remove A-end and B-end and examine for scoring.

3. Binding condition of B-end output shaft or gear reducer. Disconnect the B-end output shaft coupling and remove the speed reducer pinion. Manually rotate the A-end and the speed reducer to locate and isolate the binding spot. If a binding condition is located, inspect parts for presence of foreign matter, scoring, or other defects. Disassemble, and recondition or replace damaged parts.

Projectile ring acceleration or deceleration improper. When the projectile ring operating speed lacks proper acceleration or deceleration, the causes of poor performance, described in the previous paragraph, may be responsible. An additional cause may be a replenishing check valve stuck in partly open position.

Projectile ring rotation incomplete. An incomplete rotation cycle may be caused by the reasons cited for an inoperative projectile ring, or by out-of-phase coupling and timing (page 7-29) of this chapter.

Failure of projectile ring to stop at station. If the projectile ring stops when the hand lever is returned to neutral but will not stop automatically when a ring station is reached, the control valve or the bypass valve may be stuck in depressed position or the interlock valve may be stuck in reset position. Any two or all three of these conditions may exist. Inspect the valves and perform necessary maintenance.

Projectile ring stops out of phase. Whenever the projectile ring operates through a full cycle arc but does not stop at a ring station, perform the adjustment instructions on page 7-29, of this chapter.

Projectile ring drive units overheat. The maximum permissible temperature rise for hydraulic oil is 70 degrees Fahrenheit above ambient temperature (not to exceed an equipment temperature of 180 degrees Fahrenheit). Whenever oil temperatures rise rapidly, or approach the maximum, one of the following conditions is indicated:

1. Insufficient oil in the hydraulic system. Check the oil level at the upper trycock of the A-end case. Replenish as necessary.

2. Binding condition in the B-end gear reducer. Disconnect units to isolate trouble and inspect parts for dirt, scoring, or other defects.

3. Auxiliary relief valve stuck in closed position. Check pressure in auxiliary pump circuit. Inspect valve and clean.

4. Excessive friction in auxiliary pump. Examine pump for dirt, free turning of rotor, and for proper adjustment of the pump head.

Excessive oil pressure in B-end case. External leakage and possible structural damage may result from extremely high oil pressure in the B-end case. Whenever this condition exists, one of the following conditions is indicated:

1. Obstruction in the B-end drain line (line 7).

2. Excessive internal leakage.

3. Too much oil in the A-end case.

Unusual operating noises. Whenever unusual operating noises exist, their causes should be diagnosed and corrected without delay. Refer to the installation and maintenance instructions in chapter 17. Such noises and their source are:

1. Popping and sputtering are caused by air entering the auxiliary pump through the intake line. This may be caused by inadequate size, by an obstruction, or by air leak in the pump suction line (line 6), a low oil level in the A-end case, thickened oil caused by low temperature, use of an improper grade of hydraulic oil.

2. Grinding noises may be caused by dry bearings or gears, foreign matter in the lubricant, or by improper meshing of gears due to faulty installation or assembly.

3. Hydraulic chatter or hammer may be caused by vibration of spring actuated valves, vibration of long pipe sections improperly secured, air in the hydraulic system, or a binding condition in the mechanical system.

4. Squeals or hydraulic hum may result from the auxiliary pump head being clamped too tightly against the pump rotor, or by a high frequency vibration of the auxiliary relief valve or the A-end pump safety relief valves. Relief valve noises of this nature do not indicate defects, and for all practical purposes may be ignored.

Oil leakage. Oil leakage, either internal or external, may result from the following conditions:

1. Missing, torn, or improperly fitted gaskets.

2. Scored or improperly assembled oil seals. A single surface cut or scratch may cause a slow, steady leak.

3. Worn or scored valves.

4. Worn or scored valve plates or pistons in the A-end pump or the B-end motor.

5. Scored bushings in the auxiliary pump.

DISASSEMBLY AND ASSEMBLY

General instructions

The following paragraphs contain instructions for disassembling projectile ring power drive units. In some cases a considerable part of the disassembly procedure will be apparent from reference illustrations and by studying the general arrangement drawings; therefore, only those instructions which are pertinent to the order of disassembly, and to the more complex disassembly operations are given. In general, assembly will be the reverse of disassembly. To help in the reassembly of the unit, it is desirable to mark all mating parts such as cams, gears, and adjustable linkages so that these parts will be reassembled in the same relative positions. Adoption of this practice virtually eliminates the necessity of fitting parts and will aid readjustment. When piping is removed, avoid the practice of plugging disconnected pipe openings with rags, or waste material. Always close the openings according to the instructions and with the materials specified in chapter 17. Special tools and accessories used in disassembly of the equipment are indicated in the instructions.

WARNING

Make sure that the electrical supply circuit is completely disconnected at the controller panel before beginning maintenance operations.

A-end disassembly

Disassembling the A-end unit consists of removing all assemblies and attached parts mounted on the A-end case. Proceed as follows:

Complete disassembly:

1. Drain the A-end case. Remove the drain plug from the bottom of the case.

2. Remove all external piping. Detach the flanged connections at the ends of the pipes.

3. Remove the A-end to a clear working area and disassemble in the following order:

Side cover unit (with oil filters attached)
Top cover (with interlock switch, filler cap, and control lever dashpot)
Control link and centering spring
Hand control housing with attached parts
Cam housing unit
Variable delivery pump unit
Bell crank unit

Side cover unit (with oil filters attached). To disassemble the side cover group:

1. Disconnect the piping from the filter.

2. Detach the side cover from the A-end case with the oil filters attached.

To perform periodic maintenance operations on the filter assembly, such as cleaning the elements or cleaning a fouled filter, it is not necessary to drain the A-end case or to remove any piping. Proceed as follows:

1. Unscrew the indicator lever screw and remove the indicator lever.

2. Remove the cover from the filter body and remove the two oil seals.

3. Remove the control valve (spool) from the filter body.

4. Remove the four housing screws from each element housing and detach the housings.

5. Unscrew each element to remove, and remove the element seal.

6. Unscrew each bypass valve plug, and remove the valve spring, and valve.

The filter body may be detached from the side cover without removing the side cover from the A-end case. Proceed as follows:

1. Drain oil from the A-end case until the oil level is below the bottom edge of the side cover.

2. Disconnect the piping from the filter.

3. Remove the filter body from the side cover.

Top cover with interlock switch, filler cap, and control lever dashpot. To disassemble the top cover group, perform the following operations:

1. Detach the side cover from the A-end case with the oil filters attached, as described in the previous paragraph.

2. Detach the counterbalance spring from the control shaft.

3. Detach the clevis from the hand control attaching link.

4. Detach the electrical connections and the terminal tube from neutral interlock switch.

5. Disconnect the piping from the top cover.

6. Remove the top cover from the A-end case with the interlock switch, filler cap, and control lever dashpot attached.

The neutral interlock switch may be removed from the top cover and then disassemble as follows:

1. Unscrew the cover.

2. Remove the large mounting screws and lift the switch mechanism from the case. This will permit removal of the plunger, plunger spring, and the insulator sleeves.

3. Remove the remaining screws and detach the terminal board, movable and stationary contacts, and contact spring.

4. Unscrew the stuffing box gland and remove the gland washers, packing spring, and packing.

The control lever dashpot may be removed from the top cover and then disassembled as follows:

1. Remove the front cover from the dashpot body (the cover at the clevis link end).

2. Remove the dashpot piston and piston bushings.

3. Remove the back cover from the dashpot body.

4. Remove the two check valve assemblies, composed of check valve springs, balls, and seats.

Control link and centering spring. To remove the control link and centering spring:

1. Detach the side cover from the A-end case with the oil filters attached, as described in a previous paragraph.

2. Remove the cotter pin and nut from the ball joint at each end of the control link assembly.

3. Unscrew the ball joints from the levers and remove the centering spring assembly.

The control link and centering spring may be completely disassembled as follows:

1. Remove the cotter pin and nut, and then remove the ball joint from the socket retainer at each end of the assembly.

2. Unscrew the retainer nut from the retainer, and unscrew the retainer from the tube.

3. Clamp the control rod securely in a vise and compress the spring by forcing the tube and spring retainer toward the socket retainer on the control rod lower end, and remove the nut from the control box. Gradually release the tube and remove the spring, the two spring retainers, and the tube from the control rod.

Hand control housing with attached parts. To remove the hand control housing (with attached parts):

1. Detach the side cover from the A-end case with oil filters attached, as described in a previous paragraph.

2. Unscrew the ball joint that connects the control link centering spring and dashpot piston to the hand control assembly.

3. Remove all piping from the housing.

4. Disconnect the coupling which connects the shaft of the control housing to the manual control shaft.

5. Detach the control housing and remove it from the A-end case.

The hand control housing may be completely disassembled, as follows:

1. Remove the cover from the control housing.

2. Detach the locknut and lock washer and remove the auxiliary shaft. Remove the gear segment and lever from the shaft, and the two bearings and the spacer from the housing.

3. Remove the nut and washer from the hand control shaft. The cam and pinion can now be removed. Remove the bearing from the housing.

4. Remove the hand control shaft from the housing. Remove the seal, piston, discs, spacer, plate bearing, oil seal, and bushing from the housing.

Cam housing unit. To remove the cam housing unit, proceed as follows:

1. Drain the A-end case, remove all external piping, and remove the A-end assembly to a clear working area, as described on page 7-31.

2. Remove the side cover (with oil filters attached).

3. Remove the top cover (with control lever dashpot and neutral interlock switch).

4. Disconnect the turnbuckle from the cam roller adjusting link.

5. Remove the screws and lock washers from the cover. The cam housing unit may now be removed.

The cam housing unit may be completely disassembled as follows:

1. Remove the screws and lock washers, and take off the cam housing covers with oil seal.

2. Remove the cam shaft locknut. The ball bearings, retainer, cams, and camshaft may now be removed.

Valve block unit. To remove the valve block unit:

1. Drain the A-end case until the oil level is below the valve block unit. Remove the piping attached to the valve block, side cover, and top cover.

2. Remove the side cover (with oil filters attached).

3. Remove the top cover (with control lever dashpot and neutral interlock switch).

4. Detach the timing cam roller link assembly from the valve block mounting plate.

5. Detach the mounting plate from the A-end case and remove the valve block unit.

The valve block unit may be completely disassembled as follows:

1. Remove the drain nozzle from the valve block.

2. Detach the cotter pin, nut, and bolt from the plunger guide and remove the starting valve plunger. Remove the roller pin and roller. Remove the plunger guide from the mounting plate.

3. Clamp the mounting plate to the valve block and remove the attaching screws. Loosen the clamps to permit a gradual separation between the mounting plate and the valve block until the tension of the valve springs is relieved. Remove the mounting plate and the five control valves V1, V2, V3, V4, and V5 and their springs. Remove the control valve piston and bushing from the mounting plate.

4. Remove the cover from the valve block.

5. Unscrew the two valve plugs. Remove the valve springs, replenishing valves, and valve seats.

6. Unscrew the interlock valve detent plug and remove the detent spring and detent.

Variable delivery pump unit. To remove the variable delivery pump unit, proceed as follows:

1. Drain the oil from the A-end case. Remove the oil lines from the auxiliary pump.

2. Remove the electric motor from the A-end.

3. Remove the side cover with oil filter attached.

4. Detach the piping connections from the top and bottom of the pump housing, and from the outside and inside of the end cover.

5. Unscrew the ball joint from the top of the A-end pump yoke.

6. Detach the cover from the A-end case and remove the pump and cover as a unit.

The A-end variable delivery pump unit may be completely disassembled as follows:

IMPORTANT: Handle parts with highly polished surfaces such as the valve plate, valve block, cylinder block, pintles, and pistons with special care. Any nicks or scratches on their contact surfaces will impair pump operation.

1. Remove the pump from the case and cover.

2. Remove the pump cover, gasket, and oil seal.

3. Remove the cylinder pin screw, lock washer, and plain washer from the cylinder bearing pin.

4. Place the pump on a hollow center stand so that its shaft end is pointed down.

5. Remove the valve block screws and lock washers; lift the valve block straight up from the dowel pin.

6. Lift the valve plate straight up from the dowel pin.

7. Remove the pintles. This is done by inserting a long screw in the tapped hole in the bottom of the pintle and then pulling.

8. Remove the yoke and unscrew the two stop pins and washers from the housing.

9. Remove the rotating assemblage from the housing. This is done by tapping on the splined end of the drive shaft.

10. Tilt the cylinder block slightly and carefully remove it from the pistons. As each piston is detached protect it with a cloth or paper wrapping.

11. Remove the universal link and pin assembly, detach the parts, and wrap each carefully.

12. Remove the flexible bearing retainer from the drive shaft by inserting a jacking screw in the tapped hole at the bottom of the retainer.

13. Pull the outer ball bearings from the drive shaft, then remove the snap ring to pull the inner ball bearing from the shaft.

14. Remove the yoke bearings and yoke seals from the yoke.

15. Remove the relief valve screw. Remove the relief valve spring ball, retainer, and seat.

16. Remove the fixed bearing retainer from the cylinder block as follows: Place the cylinder block on a hollow center stand with the cylinder bearing pin down. With long nosed pliers inserted in the retainer slot, grasp the snap ring. While compressing the ring into its groove, tap the cylinder bearing pin lightly on a wooden surface until the retainer is free.

17. Remove the cylinder bearing pin from the cylinder block. Remove the washer, spring, and retainer from the pin. Remove the cylinder bearing from the cylinder block.

Bell crank unit. To remove the bell crank unit:

1. Drain the A-end case until the oil level is below the lower edge of the side cover with oil filter. Remove all piping that is attached to the side cover and top cover.

2. Remove the side cover with oil filter attached.

3. Remove the top cover with control lever dashpot and neutral interlock switch.

4. Unhook each end of the counterbalance spring; remove the spring.

5. Remove the ball joint from the centering spring lever.

6. Remove the ball joint from the yoke link lever.

7. Detach the timing cam roller link clevis from the timing cam lever.

8. Remove the side cover on the opposite side from the filter, complete with attached bell crank unit.

The bell crank unit may be completely disassembled as follows:

1. Remove the interlock switch adjusting nut and guide bracket.

2. Remove the timing cam lever and centering spring lever, and keys from the ends of the shaft.

3. Loosen the securing screws of the interlock switch cam and yoke link lever and shift the control shaft as necessary to remove these parts. Remove the cam and lever keys from the shaft. Remove the ball bearings from the control shaft bracket.

4. Remove the control shaft bracket from the side cover.

A-end assembly

The A-end should be assembled in reverse order from that described previously for disassembly. All gaskets must be replaced in good condition, all locking devices must be secure, and all nuts and screws should be tight. Care must be taken not to injure oil seals. All parts must be clean and free from any foreign matter. Bearings, piston bores, and valve plate faces should be coated with an oil film immediately before assembly.

B-end disassembly

Disassembling the B-end unit consists of removing all assemblies and attached parts which are mounted in the B-end housing. Proceed as follows:

Complete disassembly.

1. Drain the B-end housing. Remove the drain plug in the bottom of the center housing segment (on the same side as the manual brake release lever). In addition, drain the A-end case.

2. Detach piping. All piping that is connected to the B-end is detached by disconnecting the pipe flanges.

3. Disconnect the response wormwheel and the output shafts. Remove the connecting couplings of these shafts after the coupling mounting bolts are removed.

4. Remove the B-end mounting bolts and move the B-end unit to a suitable working area.

5. Remove the B-end subassemblies. To completely disassemble, remove the subassemblies in the following order:

Response wormwheel shaft assembly
Brake spring housing assembly
B-end brake assembly
Output shaft assembly

Detailed instructions for removing these subassemblies are given in the following text.

These instructions are based on the assumption that the B-end unit is to be completely disassembled and that all subassemblies are to be removed. Therefore, the removal procedures are in a sequence to avoid repetition of instructions.

To remove the response wormwheel shaft assembly:

1. Drain the B-end housing, detach all piping from the B-end, disconnect the shaft couplings and move the B-end unit to a suitable working area, as described in a previous paragraph.

2. Remove the inspection cover from the side of the B-end housing opposite to the wormwheel assembly.

3. Remove the wormwheel assembly.

To remove the brake spring housing assembly, proceed as follows:

1. Remove the clamp screw and slide the collar from the output shaft.

2. Remove the bearing retainer from the flange, remove the oil seal from the retainer.

3. Remove the locknut and lock washer from the B-end drive shaft.

WARNING

> Exercise extreme care to avoid injury or damage from the compressed spring. Before beginning disassembly of the brake spring housing assembly, it is necessary to obtain special tools consisting of four assembly screws, washers, and nuts. Proceed as follows:

4. Remove four of the twelve screws and install the assembly screws. Tighten the nuts to hold the washers against the retainer.

5. Remove the eight screws that remain. The spring retainer will now be held by the four assembly screws.

6. Loosen the nuts of the assembly screws gradually, until the brake spring is no longer compressed.

7. Unbolt the flange and remove the brake spring housing assembly and B-end drive shaft bearing.

8. Remove the spring retainer and lift the piston, spring, and spacer from the flange. Remove the spacer from inside of the spring.

To remove the B-end brake assembly, proceed as follows:

1. Unbolt the hand brake shaft bearing from the housing and remove the bearing, bushings, shaft, oil seal, and hand lever as a unit.

2. Unbolt and remove the brake shaft pivot bearing from the housing. Remove the plug from the bearing and detach the spring and plunger. Pull the shaft out and remove the key.

3. Remove the brake disc retainer spacer, the yoke, brake pressure plate spacer, brake pressure plate, and the brake discs.

4. Remove the brake disc retainer.

5. Slide the brake thrust plate from the drive shaft. The worm which drives the wormwheel shaft assembly may now be removed from the drive shaft.

To remove the B-end motor assembly, proceed as follows:

1. Remove the plug and oil seal from the outer end of the valve block. Remove the screw and washers from the plug opening.

CAUTION: Handle parts with highly polished surfaces, such as the valve block, cylinder block, valve plate, pistons, and universal link, with special care. These parts must be protected from scratches and nicks with cloth or paper wrappings.

2. Unbolt and remove the valve block from the housing. Remove the valve plate.

3. Unbolt and remove the motor housing.

4. Remove the rotating assemblage from the housing.

5. Disassemble the rotating group by following a routine similar to the disassembly of the rotating group of the A-end. Refer to instructions on page 7-33 of this chapter, beginning with operation number 10.

6. Remove the output shaft ball bearing (motor end of shaft) by pressing it off the shaft.

B-end assembly

Assemble the B-end in reverse order from that described in the previous paragraphs for disassembly. All gaskets must be replaced in good condition, all nuts and screws should be tight, and all locking devices must be secure. Care must be taken not to injure oil seals. All parts must be clean and free from any foreign matter. Bearings, piston bores, and valve plate faces should be coated with an oil film immediately before assembly.

Auxiliary pump disassembly

Disassembling the auxiliary pump consists of first removing the pump from the electric motor. To remove the pump, disconnect the piping connections from the pump body and then detach the pump from the electric motor end cover.

To disassemble the auxiliary pump:

1. Detach the head from the pump body. Remove the head, shims, and oil seal.

2. Remove the cartridge assembly from the pump shaft. This assembly consists of two bushings, rotor with twelve vanes, pump ring, and locating pin.

3. Unbolt and remove the mounting flange from the pump body. Remove the oil seal from the mounting flange.

4. Remove the pump shaft from the body and slide the bearing, packing gland, and packing from the shaft.

Auxiliary pump assembly

Assemble the auxiliary pump in reverse order from that described in the previous paragraph for disassembly. Care must be taken to assemble the correct thickness of shim between the pump body and the head. This is done by assembling the head without shims and tightening the screws so that the rotor will turn without binding. Measure the clearance between the pump body and the head and assemble a shim of proper thickness from the 0.003-, 0.005-, and 0.010-inch shim pieces. Mount the shim assembly and reassemble the head on the pump body. The pump shaft should be turned while tightening the screws to ensure that the rotor does not bind. Make sure that the vanes are inserted with the chamber on the trailing edges. All gaskets must be replaced in good condition, and all nuts and screws should be tight. All parts must be clean and free from any foreign matter.

Chapter 8

PARBUCKLING GEAR

16-inch Parbuckling Gear Mark 1 Mod 0

GENERAL DESCRIPTION

The upper and lower projectile flats, described in chapter 7, are equipped with identical parbuckling gear installations. The arrangement of the parbuckling gear installations, shown in figure 8-1, is the same in all turrets of the IOWA class battleship. All parbuckling gear installations are designated 16-inch Parbuckling Gear Mk 1 Mod 0.

Purpose

The parbuckling equipment fulfills two purposes: to transfer projectiles from the outer ring to the inner ring and then to the three projectile hoists during gun operation; and to transfer projectiles from the projectile flat strike-down hatches to the stowage rings when the projectile supply is replenished.

Type

The parbuckling gear is a constant-speed, electric motor-driven, multiple capstan mechanism. It is a mechanical assembly that provides positive-type drive of six capstans from a single electric motor. The capstans, designated gypsy heads, are arranged with manual snubbing ropes, rope hooks, and snatch blocks. The snubbing ropes are used to parbuckle projectiles with the aid of the rope hooks and snatch blocks.

Components

Each parbuckling gear assembly comprises the following components:

Electric motor
Electric controller
Controller start-stop circuit
Mechanical assembly
Gypsy heads (six)

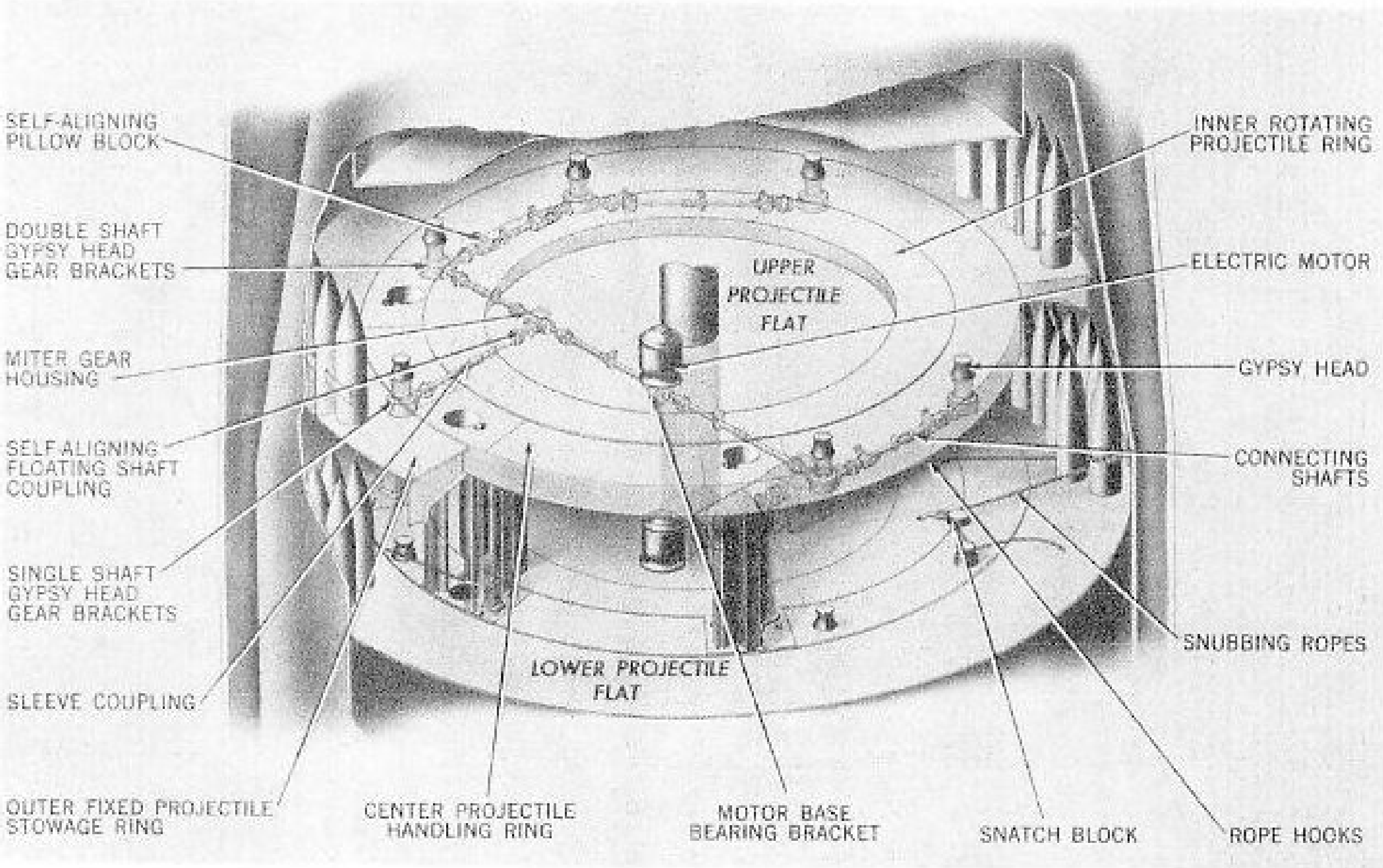


Figure 8-1. 16-inch Parbuckling Gear Mk 1 Mod 0. Upper and Lower Projectile Flats, General Arrangement

Locations

Component locations are the same for both projectile flats. The electric motor (fig. 8-1) is mounted on the floor of the machinery space of each projectile flat, adjacent to the right powder hoist trunk. The electric controller is mounted on the right powder hoist trunk above the motor. A master push-button station (start-stop control) is located at the center projectile hoist operator's station on each projectile flat. The mechanical assembly, consisting of housing-enclosed miter and bevel gears and connecting shafting, is attached to the underside of the projectile flat floor. The six gypsy heads are flange-mounted in the center ring of the projectile flat. On each flat, an emergency stop switch is located at the left and right projectile hoist operator's stations; a third emergency stop switch is located in the machinery space adjacent to the electric controller.

Mounting arrangements

The mounting arrangements of the parbuckling gear assemblies shown in figure 8-2 are the same for each projectile flat. The electric motor and the gypsy heads are mounted at floor level with their axes vertical. The mechanical assembly is bolted to the underside of the floor of the machinery space and center ring. Shafts connecting the units of the mechanical assembly are attached with floating, self-aligning couplings.

Design features

The important design features of the parbuckling gear, described in following paragraphs, are:

The multiple gypsy head arrangement which is driven by a single electric motor at a constant speed.

The positive-type drive of the gypsy heads through gear boxes and connecting drive shafts.

The adjustable slip clutch in each gypsy head.

Arrangement of drive shaft system

The drive shaft system (fig. 8-2) extends right and left from the motor base bearing bracket of the drive motor. Two gypsy heads are driven by the right-hand drive shaft through double shaft and single shaft gypsy head gear brackets. The left-hand drive shaft drives four gypsy heads through a miter gear unit provided with two output shafts. One shaft drives a single shaft gypsy head gear bracket, the other shaft drives two double shaft and a single shaft gypsy head gear bracket. Access to the system for maintenance is from the deck level immediately below the system.

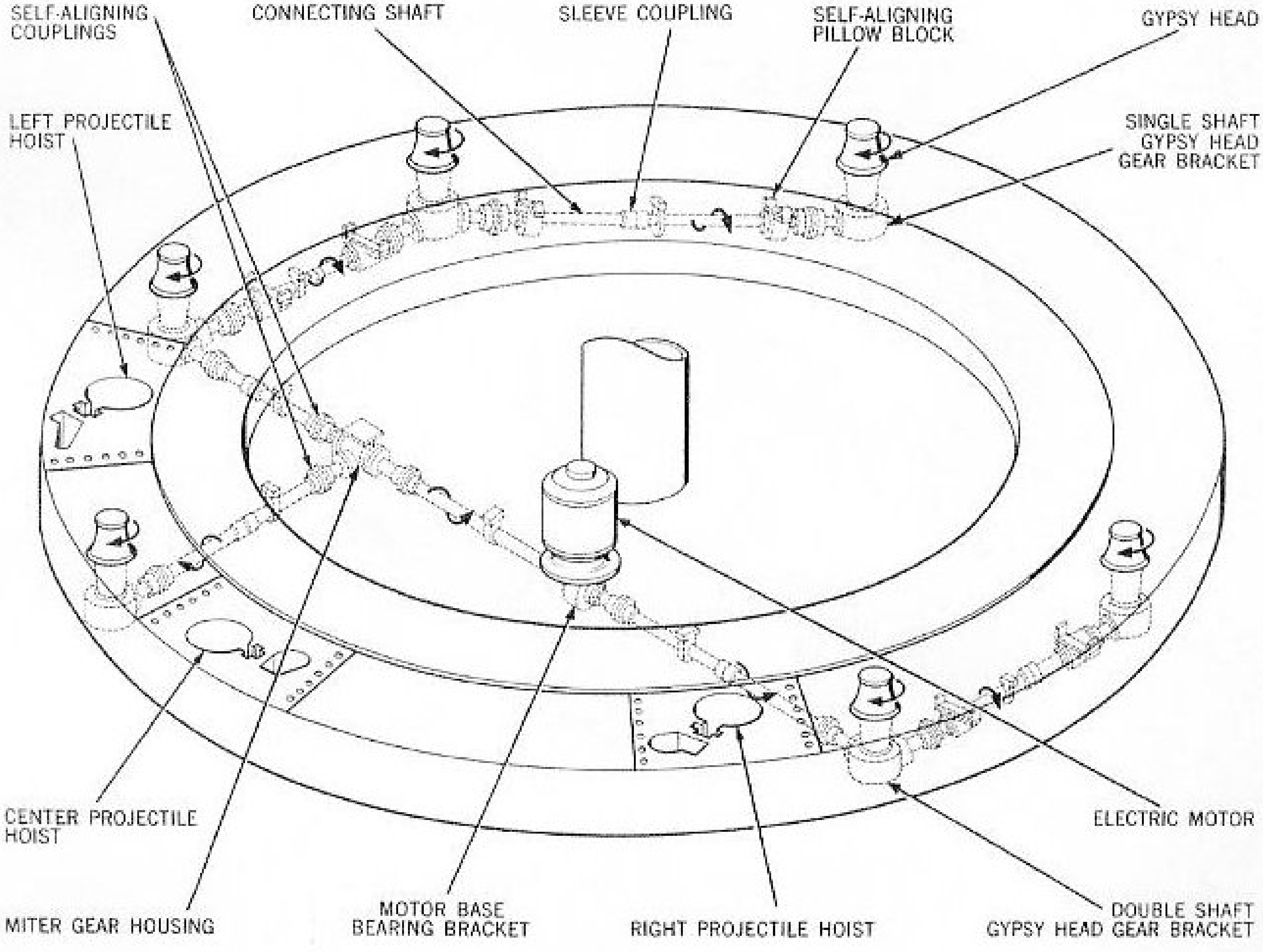


Figure 8-2. 16-inch Parbuckling Gear Mk 1 Mod 0, Schematic Arrangement

Number of gypsy heads

A gypsy head is adjacent to each projectile hoist loading aperture. This arrangement permits simultaneous transfer of projectiles from the inner ring to the three hoists. The remaining three gypsy heads are located at the forward part of the projectile flat and they provide parbuckling facilities for the transfer of projectiles from the outer, fixed stowage spaces to the inner ring. Any of the gypsy heads may be utilized to replenish the inner ring from the fixed stowage space.

Slip clutch

Each gypsy head assembly (fig. 8-8) is provided with an adjustable slip clutch, which permits the drive shaft to rotate independently of the gypsy head when an overload occurs. The slip clutch limits rope snubbing to the force permitted by the adjustment of the clutch.

Data

All gypsy heads rotate in a clockwise direction (looking down) at a speed of approximately 90 revolutions per minute. Each gypsy head clutch is adjusted for parbuckling an armor piercing projectile (2700 pounds) against 15 degrees roll of the ship.

DETAIL DESCRIPTION

Power drive

Electric motor. The electric motor used in the power drive is an induction type of commercial manufacture and is identical for each assembly. Each motor is vertically flange-mounted on a motor base bearing bracket in the machinery space of the projectile flats, as shown in figure 8-3.

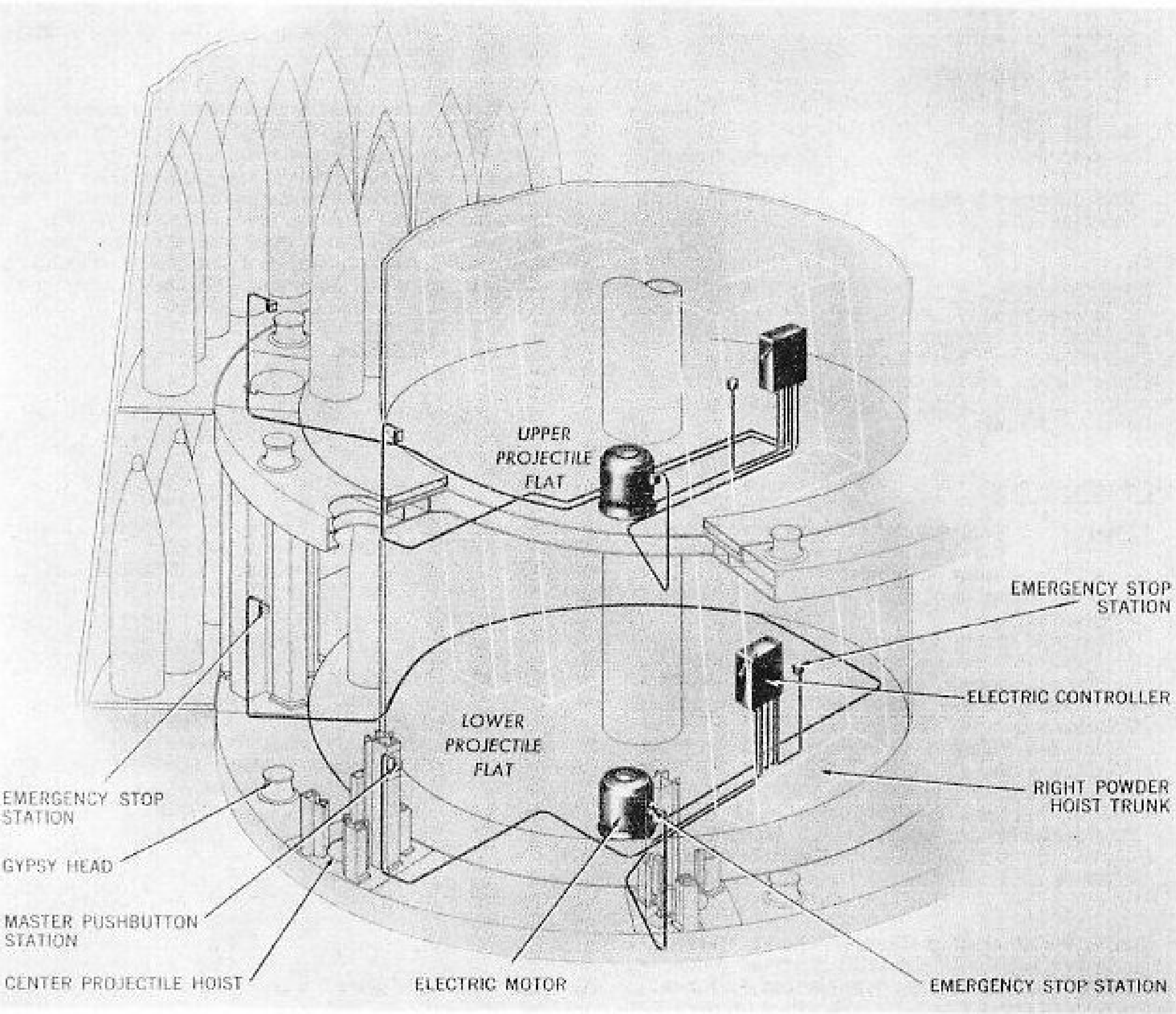


Figure 8-3. Parbuckling Gear Electric Installations, General Arrangement

The motor base bearing bracket (fig. 8-4) includes a circular cover plate beneath the motor which protects the motor from the splash of gear lubricant in the bracket housing. Other design features and specification data are listed below.

Motor data

Type	squirrel cage, induction
Design features	vertical mount, waterproof, fan cooling
Horsepower,	7.
Continuous	7.5
Intermittent	15
Revolutions per minute Synchronous	1200
Revolutions per minute, Full load	1155
Rotation (viewed from above)	counterclockwise
Speed class	constant
Voltage	440
Amperes, full load	19.9
Amperes, locked rotor	120.0
Phases	3
Cycles	60
Ambient temperature, Deg C	40
Torque class	normal
Weight, pounds	650
Manufacturer	Electro-Dynamic Works
Manufacturer's designation	AV-365-KNX
Drawing	231767

Electric controller. The electric controller (fig. 8-3) in each assembly is identical. It is of commercial manufacture, designed to control and protect the electric motor. Each controller has special starting-stopping switch controls, described in following paragraphs. Design and specification data are tabulated below.

Controller data

Type	semiautomatic, magnetic across-the-line starter controlled by remote push button
Ampere rating, full load	19.9
Protection:	
Overload thermal type:	
Adjustable range, amperes	23.6 to 28.3
Normal setting, amperes	25.0
Short circuit fuses, amperes	80.0
Undervoltage:	
Drop-out voltage	110
Sealing voltage	374
Shock rating	150
Weight, pounds	110
Manufacturer	Ward Leonard Electric Company
Drawing	231774

Controller start-stop circuit. The start-stop circuit is arranged with a master start-stop push-button switch and three stop push-button switches. The start-stop circuit is fully described on page 8-6.

Mechanical assembly. The arrangement of the parbuckling gear mechanical assembly is shown in figures 8-1 and 8-2. The mechanical assembly is composed of the following components: a motor base bearing bracket; a miter gear housing; single and double shaft gypsy head gear brackets; and connecting shafts and shaft couplings. The design features and arrangements of the mechanical assembly are indicated in the following paragraphs.

Arrangements. The components of the mechanical assembly (fig. 8-2) are mounted on the underside of the projectile flat floor beneath the machinery space and center ring. The motor base bearing bracket, mounted directly beneath the electric motor, has two output shafts. One output shaft is connected to a double shaft gypsy head gear bracket, the output shaft of which is connected to a single shaft gypsy head gear bracket. The other output shaft is connected to the miter gear housing, which has two output shafts. One output shaft of the miter gear housing is connected to a single shaft gypsy head gear bracket. The second output shaft is connected to a double shaft gypsy head gear bracket, the output shaft of which is connected to a second double shaft gypsy head gear bracket. The output shaft of the second double shaft gypsy head gear bracket is connected to a single shaft gypsy head gear bracket. The housing-enclosed miter and bevel gear units are connected by self-aligning, flexible couplings.

Motor base bearing bracket. The motor base bearing bracket (fig. 8-4) is a housing-enclosed arrangement of oil-bath-lubricated bevel gears. Mounted on the underside of the machinery space floor, this unit provides a mounting base and power transmission for the electric motor (fig. 8-1). The gearing consists of a bevel spur gear that is spline-fitted on a ball-bearing-supported stub shaft. This output shaft is splined at each end. The bevel spur gear is

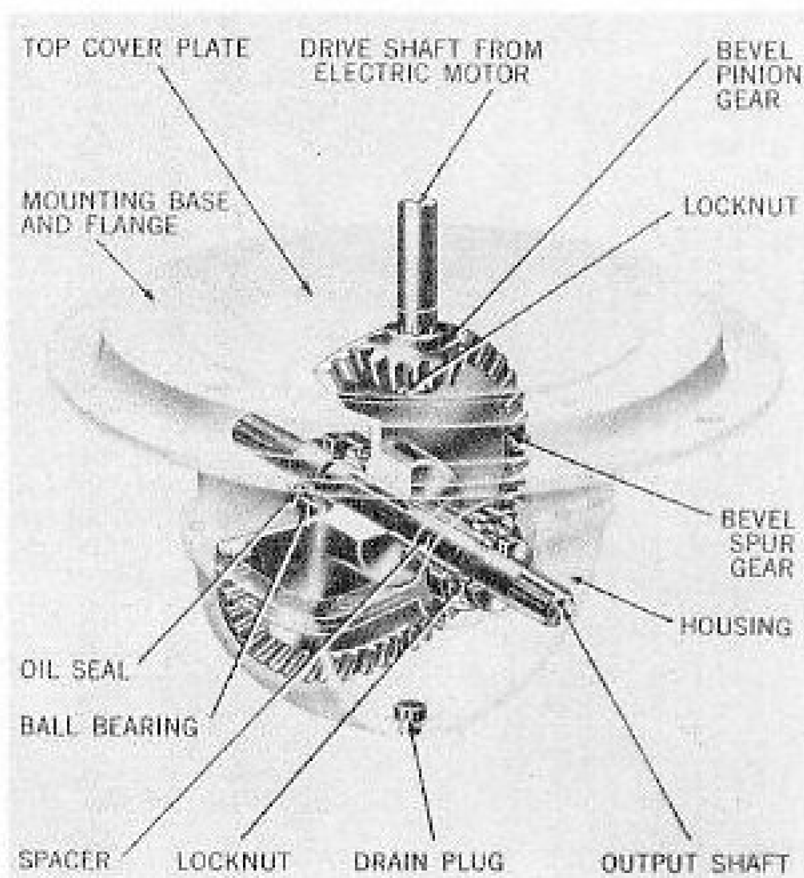


Figure 8-4. Motor Base Bearing Bracket, Sectional View

driven by a bevel pinion gear which is spline-fitted on the rotor shaft of the electric motor. Both gears are held in position on the shafts by locknuts. Oil seals, seated in retainers on each end of the output shaft, seal the lubricant within the housing. A cover-plate at the top of the bearing bracket protects the electric motor from oil splash. A plug at the bottom of the housing provides for oil drain. Fill plugs are located at the proper immersion level for the gearing.

Miter gear housing. The miter gear housing (fig. 8-5) is a housing-enclosed arrangement of oil-bath-lubricated miter gears. The housing is mounted on the underside of the machinery space floor adjacent to the center powder hoist trunk. The unit transmits power from the electric motor, through two output shafts, to four gypsy heads as shown in figure 8-2. The two output stub shafts and the input stub shaft are each ball-bearing-supported and are spline-fitted with identical miter gears, held in position on the shafts by locknuts. Oil seals, seated in retainers on each shaft, seal the lubricant within the housing. A cover plate at the bottom of the housing and the oil seal retainers provide access for maintenance. The immersion level of the gearing is limited by an oil plug hole in the housing which also provides a means for replenishing oil.

Single shaft gypsy head gear bracket. The single shaft gypsy head gear bracket (fig. 8-8) is a housing-enclosed arrangement of oil-bath-lubricated bevel gears. The three assemblies of this type are mounted on the underside of the center ring directly below their gypsy head as shown in figure 8-2. Power from the electric motor is transmitted to the gypsy heads through the single shaft gypsy head gear brackets. The input stub shafts and the drive shafts are each ball-bearing-supported and are spline-fitted with bevel gears, held in position on the shafts by locknuts. Oil seals, seated in retainers on the stub shafts seal the lubricant within the housing. A cover plate at the bottom of the housing together with the oil seal retainers provides access for maintenance. A normally plugged hole (not shown in figure 8-8) limits the immersion level of the gearing and provides a means for replenishing and draining oil.

Double shaft gypsy head gear bracket. The double shaft gypsy head gear bracket (fig. 8-6) is a housing-enclosed arrangement of oil-bath lubricated bevel gears. The three assemblies of this type are mounted on the underside of the center ring directly below their gypsy heads as shown in figure 8-2. Power from the electric motor is transmitted through the double shaft gypsy head gear brackets to the gypsy heads mounted above them and to other gypsy head gear brackets through output stub shafts. The gypsy head gear brackets at the first two locations have output stub shafts that are offset approximately 85 degrees from the input shafts. At the third location the gypsy head gear bracket has an output shaft that is offset approximately 49 degrees from the input shaft. Details of the gear housing are similar to those of the single shaft gypsy head gear bracket housing except for the additional output stub shaft in each assembly.

Connecting shafts. The stub shafts of the motor base bearing bracket, miter, and gypsy head gear bracket assemblies are connected by seven splined shafts (fig. 8-2) which are joined to the stub shafts by self-aligning, spline-fitted, flexible couplings. The shaft-and-coupling assemblies are identical except for length. The shafts, made of 1.5-inch solid-bar steel are splined at each end and cut in two at a point approximately midway between the ends. The shaft ends are reunited at this point through a sleeve-type coupling, which facilitate assembly and disassembly of the shafts in the limited space between the gear boxes. Three of the shaft assemblies are supported at each end by a Fast-type, floating, self-aligning pillow block. The shaft assemblies, with the couplings described below, provide full connections.

Shaft couplings

Sleeve type. Sleeve type couplings (fig. 8-2) located in the middle of each shaft assembly, join the ends of the cut shafts. Fitted over the shaft ends, the sleeves are keyed to both ends to ensure positive rotation of the shaft assembly. The sleeves are held in their assembled positions by taper pins which pass through the shaft and the ends of the sleeve. There are seven couplings of this type.

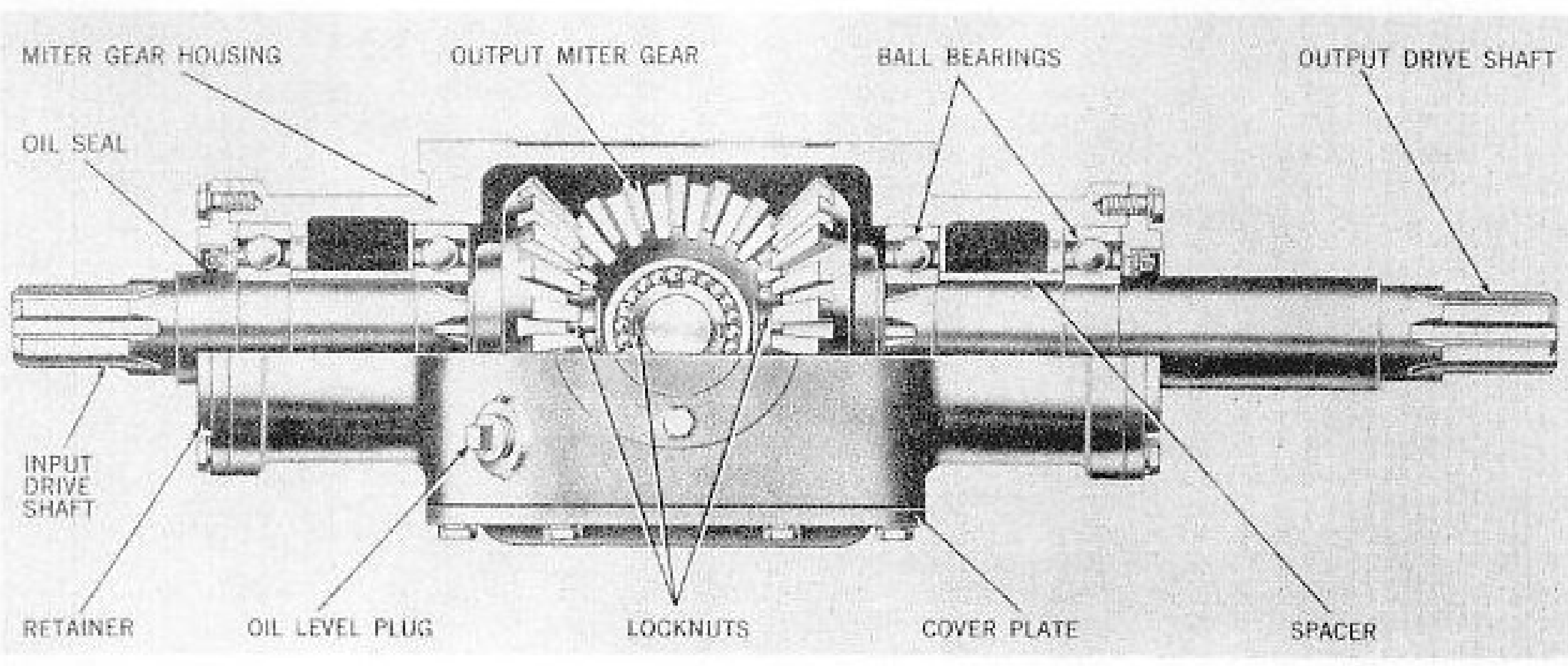


Figure 8-5. Miter Gear Housing, Sectional View

Self-aligning type. The fourteen couplings that connect the stub shafts of the gear box assemblies are floating, self-aligning, extended, fast-type couplings (fig. 8-7). Each coupling consists of a rigid half hub which connects to a flexible half sleeve. A flexible half hub has external teeth at the shaft end which mesh with the internal teeth of the flexible half sleeve. Both half hubs are spline fitted to their respective shafts. A slight clearance between the meshing teeth of sleeve and hub permits drive with small misalignment between the two shafts.

Gypsy heads. The design arrangement and mounting of the gypsy heads are shown in figure 8-8. Each gypsy head, a clutch-driven steel capstan drum, is approximately 11.0 inches in diameter at its widest part and 9.0 inches high. It is mounted on a bronze deck flange base and engaged to the gear bracket drive through a multiple-disc friction clutch. The drum is mounted on the gypsy head drive shaft upper ball bearing. An arrangement of alternately spaced steel and brass friction discs, keyed to the drive shaft and drum respectively, comprise the clutch enclosed within the gypsy head. Disc to disc pressure is maintained by a spring, adjusting nut, and a locknut mounted at the top of the gypsy head drive shaft. Adjustment settings are described on page 8-8 of this chapter. The clutch protects the power unit against overload and limits rope snubbing to the force permitted by the setting of the slip clutch.

Controls

Start-stop control. Each parbuckling gear electric motor is started and stopped through its electric controller (described on page 8-4). The controller is remotely operated from four push button stations, as described below.

Master control push-button station. The master control push-button station is located at the center projectile hoist (fig. 8-3). It comprises a two-button switch with START-EMERG and STOP pushbuttons. 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 START-EMERG button is released. In the event of a power failure, the main contactor opens and remains open until the START-EMERG button is again pressed. An overload relay opens the circuit when current demand is too great. The electric motor is stopped by pressing the master STOP button or a STOP button at one of the stations described below.

Stop push-button stations. Three stop push-button stations are located at the left and right projectile hoists and in the projectile flat machinery space adjacent to the controller cabinet (fig. 8-3). Each station has a single button switch labeled STOP. Pressing the button opens a three-pole switch and de-energizes the coil of the main contactor to stop the electric motor. The electric motor can be started again only by pressing the START-EMERG button at the master control push-button station.

OPERATION

General

Parbuckling is the operation of transferring projectiles when the projectile rings are being loaded or unloaded or when the guns are being served. For ring loading, transfer is made from the projectile flat strike-down hatches to the stowage rings. For gun serving, transfer is made from rings to hoists. Before parbuckling, the electric power drive is started by pressing the START-EMERG push button.

Parbuckling

Transfer of projectiles is performed by looping one end of the fixed snubbing rope around a projectile below its rotating band and by snubbing the other end around a gypsy head. Two snubbing loops and hand

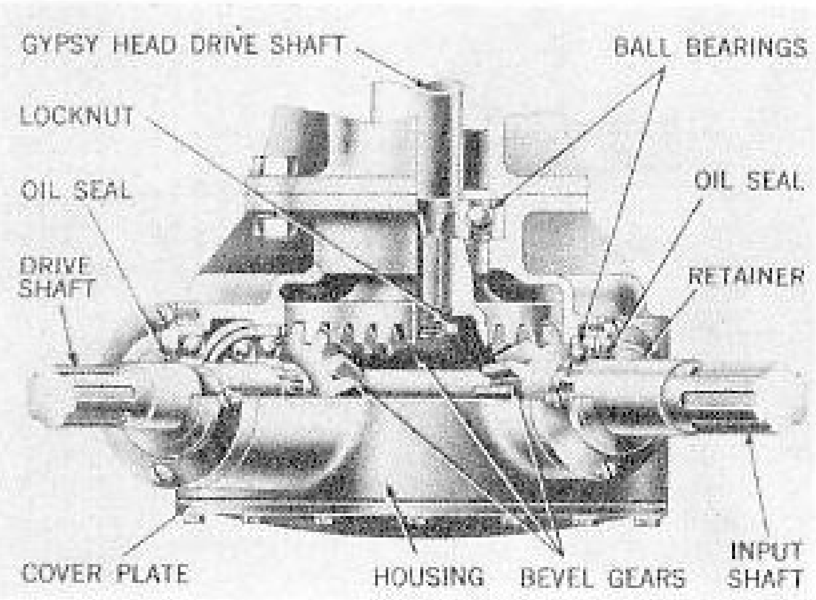


Figure 8-6. Double Shaft Gypsy Head Gear Bracket, Sectional View

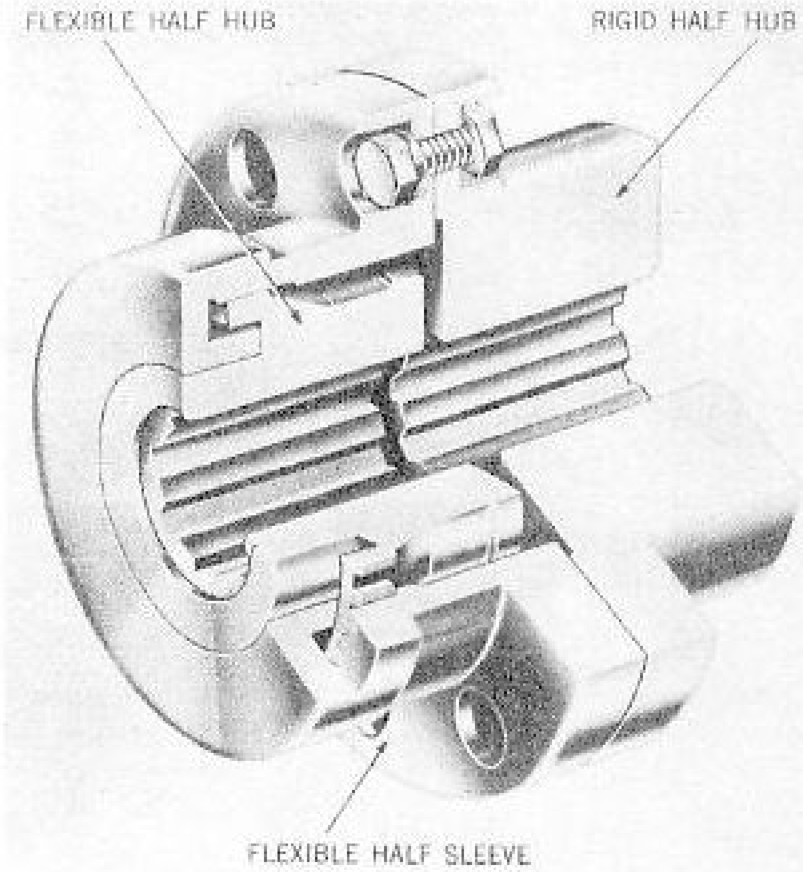


Figure 8-7. Drive Shaft Coupling, Cutaway View

pull on the free rope end provide sufficient snubbing action to slide the projectile into or out of the hoist. The operating technique for transfer of projectiles from fixed stowage to the rotating ring is similar. Hand guidance of the projectile is required.

Projectile ring movement

As the supply of projectiles on the rotating ring adjacent to the hoists is depleted, rotation of the projectile ring is required. Description of this operation is given in chapter 7.

INSTRUCTIONS

General instructions

Each parbuckling gear assembly is to be operated and maintained in accordance with the regulations of the Bureau of Ordnance Manual and the specific directions of the following paragraphs. Maintenance includes adjustment, lubrication, service check, and periodic operation necessary to keep equipment in good condition.

Operating precautions

Observe the following precautions when preparing for parbuckling and when operating the equipment to serve the projectile hoists or to stow projectiles:

1. Transfer projectiles from the rotating ring to the hoist when loading the hoists, and from the hoist to the rotating ring when unloading. Projectiles are never to be parbuckled directly from the outer ring to the hoist except in an emergency, such as failure of the projectile ring drive.

2. Turn the snubbing rope twice around the gypsy head for normal parbuckling. Never use more than three turns.

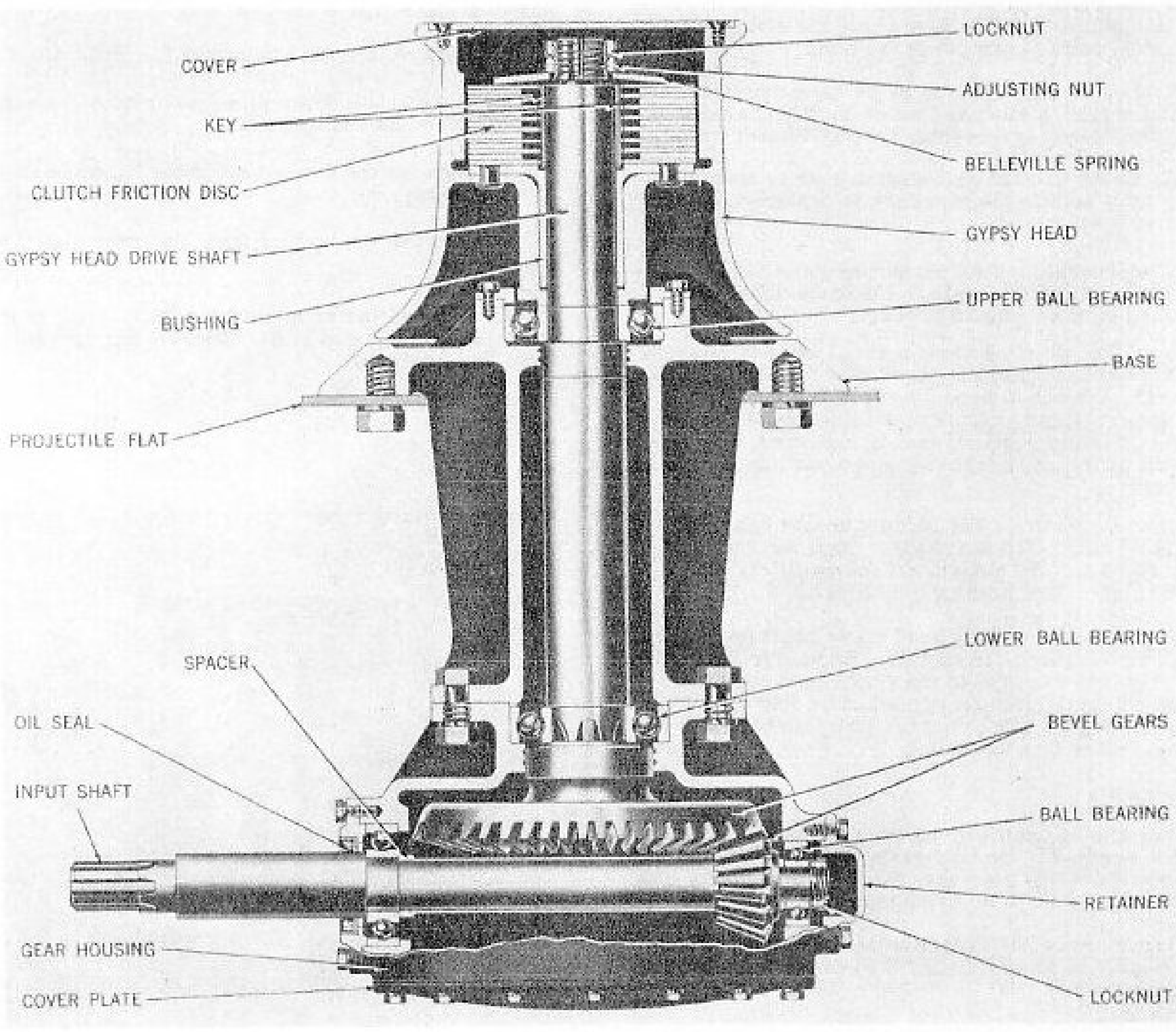


Figure 8-8. Gypsy Head Arrangement With Single Shaft Gypsy Head Gear Bracket, Cutaway View

3. Tighten the snubbing rope slowly on the gypsy head to "ease" the projectile into motion. Never start the snubbing action with a jerky, sudden movement.

4. Replenish the rotating ring as it is depleted by parbuckling from fixed stowage to the ring. Projectiles must be secured when in position.

5. Loop the snubbing rope under the copper rotating band, never above it.

6. Load the projectile hoists from the upper flat first. This is not compulsory, but is preferable.

7. Before parbuckling, make sure that the projectile hoist shutters swing freely.

8. Make certain that the loading door in the hoist is lowered before parbuckling on the upper flat. Before parbuckling on the lower flat, make certain that the hoist loading door on the upper flat is raised and secured.

9. Latch the projectile hoist shutters open before unloading a hoist. Never hold the shutters by hand when parbuckling out of the hoist.

10. Before parbuckling, make sure that each hoist operator is alert and ready to stop the hoist in an emergency by pressing the STOP push button.

11. Never use the parbuckling gear to snub auxiliary whip hoists; the assembly is designed for parbuckling only.

All parbuckling gear components are to be lubricated at the time intervals and with the lubricants specified on the lubrication chart.

Gear box units. Frequent check of gear boxes is necessary because of the possibility of lubricant loss. However, the actual need for replenishment should be infrequent. When frequent replenishment is required, a worn or faulty shaft oil seal is indicated. Replace such oil seals; do not attempt to correct the defect by shimming.

Electric motor. The electric motor bearings should be lubricated sparingly. Open the bearing drain tubes and the cage drain before filling the grease cups. Use bearing grease OS1350.

Gypsy heads. Gypsy head upper shaft bearings should be repacked bi-monthly. Access to the bearings requires removal of the gypsy head cover, the spring locknuts, and the gypsy head. Use bearing grease OS1350. The gypsy head slip clutch must be adjusted after this operation.

Adjustments

With the exception of the gypsy head clutch adjustment described in the next paragraph, all assemblies of the parbuckling gear have fixed arrangements and do not require refitting or adjustment.

Gypsy head clutch adjustment. The gypsy head clutch must be adjusted (fig. 8-9) for proper tension after lubrication.

To adjust the gypsy head clutch:

1. Reset and clean all friction discs at each lubrication. Dry discs thoroughly before reassembling.

2. Place the spring in position over the top disc and turn down the adjusting nut until the spring makes contact with the top disc.

3. Turn the adjusting nut an additional three-fourths turn for final adjustment with a new spring. Re-use of the old spring may require additional compression.

DISASSEMBLY AND ASSEMBLY

General

Instructions for disassembly of components of the parbuckling gear are contained in the following paragraphs. Assembly is the reverse of disassembly. When disassembling the gear box units, mark spacer sleeves, shafts, bearings, and pinions for reassembly in their respective housings. Oil seals are properly reassembled with the taper inward.

Disassembly of gear box units

1. Disconnect the flexible couplings of the drive shafts at the sides of the gear box.

2. Remove the gear box from the projectile flat.

3. Remove the drain plug from side of housing and drain the lubricating oil.

4. Remove the cover and gasket from the bottom of the housing.

5. Remove the locknut from the inner end of the input shaft.

6. Remove the retainer from the housing at the outer end of the input shaft. Remove the oil seal from the retainer.

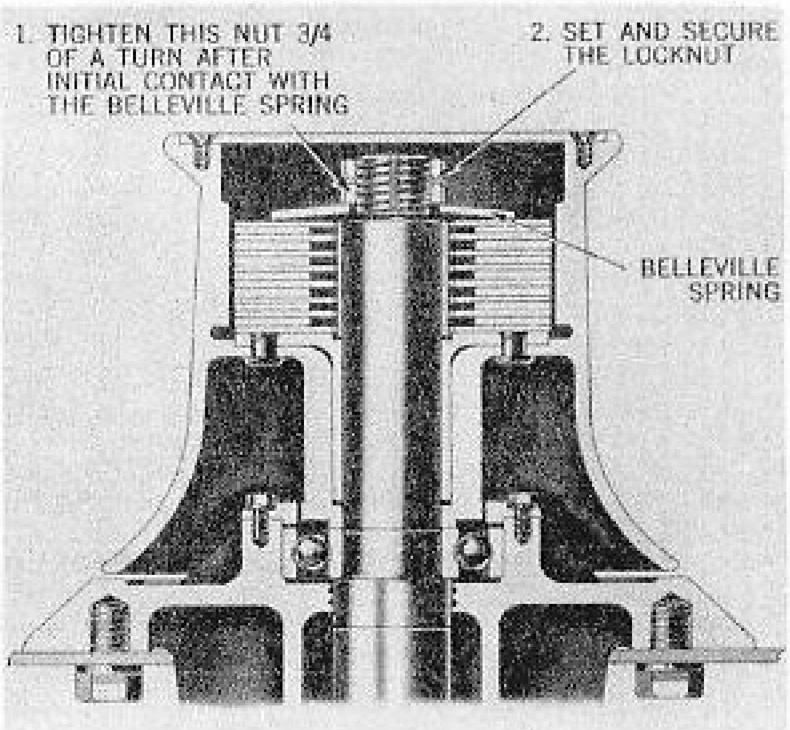


Figure 8-9. Gypsy Head Clutch Adjustment

7. Remove the locknut from the outer end of the input shaft.

8. Remove the input shaft from the housing and lift out the bevel (or miter) gear as the shaft is removed.

9. Slide the outer bearing from the input shaft.

10. Remove the output shaft by disassembling as described in operations 5, 6, 7, 8, and 9.

11. Remove bearings from the housing.

Disassembly of connecting shafts

1. Knock the taper pins out of the sleeve coupling.

2. Slide the sleeve coupling along the shaft until the shaft end is clear.

3. Remove the key from its doweled position in the shaft keyway.

4. Remove the shaft from the flexible coupling connection.

5. Open and separate the flexible coupling, if the shaft splines are seized, before attempting to force the shaft out of the coupling.

PROJECTILE HOIST

16-inch Projectile Hoist Mark 8 Mods 0, 1, and 2

GENERAL DESCRIPTION

The projectile hoist installation in each turret comprises an independent hoist assembly to serve each gun. The assemblies are virtually identical right, center, and left designs that are designated 16-inch Projectile Hoist Mk 8 Mods 0, 1, and 2, respectively. A right hoist arrangement is shown in figure 9-1.

Type

Hoists are hydraulic ram type assemblies. Each hoist assembly is a reversible, hydraulic power-driven, rack and pawl tubular lift, equipped with an independently controlled power-driven cradle assembly.

Purpose

The hoists supply projectiles to the cradle assemblies which deliver projectiles to the guns. When lowered (spanned), the cradle assemblies extend the rammer track to the gun breech as shown in figure 10-1.

Components

Each projectile hoist consists of the following principal units:

- Power drive
- Hoist components
- Cradle assembly components
- Hoist reversal system
- Controls and interlocks

Component locations

The components listed above have similar positions in the turret with respect to the guns they serve. The three hoists, located in the rear of the turret rotating structure, are shown in figure 1-6. Identically arranged, the left and right hoist courses rise vertically from the lower projectile flat to a point above the electric deck (fig. 9-1). The courses curve toward the rear and upward to the projectile cradles. Straight all the way, the center hoist course rises vertically from the lower projectile flat to the projectile cradle.

The electric motor, reduction gear, solenoid brake, and hydraulic pumps are located on the electric deck (fig. 9-2). These power drive units for the left and right hoists are located to the rear of the elevating gear units for the left and right guns. The same units for the center hoist are located to the rear of the training gear units and the left and center powder hoist trunks.

The rack operating cylinder is vertically mounted between the lower and upper projectile flats (fig. 9-2).

The hydraulic (auxiliary) pump for the dual hoist reversal and cradle system is mounted on the electric motor housing (fig. 9-2).

The components of the cradle assembly, together with the cradle operating cylinder, are aligned between the rammer and gun in the gun room compartment (fig. 9-6).

The hoist control devices are arranged in duplicate. There is a manual control operating lever with indicators and interlock devices on each projectile flat adjacent to the hoist loading aperture.

Controls for the hoist reversal mechanism and for operating the cradle are located in the gun room compartments at the cradle operator's station.

Functional arrangement

In normal operation the assembled arrangement of the hoist, power drive, and cradle assembly delivers projectiles to the gun. Hydraulic pressure is delivered by the motor driven pumps to the rack and cradle operating cylinders. Projectiles are hoisted or lowered in equal stages through the reciprocating movement of the piston of the rack operating cylinder. The total projectile lift of five stages from the lower flat (four from the upper flat) is the same in all hoists. Final movement of hoist stroke delivers a projectile into the cradle above the cradle projectile latch.

After delivery of a projectile to the cradle assembly, the cradle is lowered by the cradle operating cylinder to permit ramming the projectile into the gun. After the gun is loaded, the cradle is raised and hoisting may be resumed.

The hoist control mechanisms permit normal hoist operations to be stopped at any time with the cradle filled or empty.

The hoist reversal system, actuated through a function control valve, permits lowering projectiles.

Design differences

Hoists are of the same design, but differ in their course arrangements as described previously.

The arrangement of the electric motor, reduction gear, solenoid brake, and hydraulic pump (fig. 9-2) is identical for the left and right hoists. The same units for the center hoist are arranged in the opposite way. Shaft rotation of electric motors is clockwise for the center and left hoist power drive assemblies and counterclockwise for the right hoist assembly.

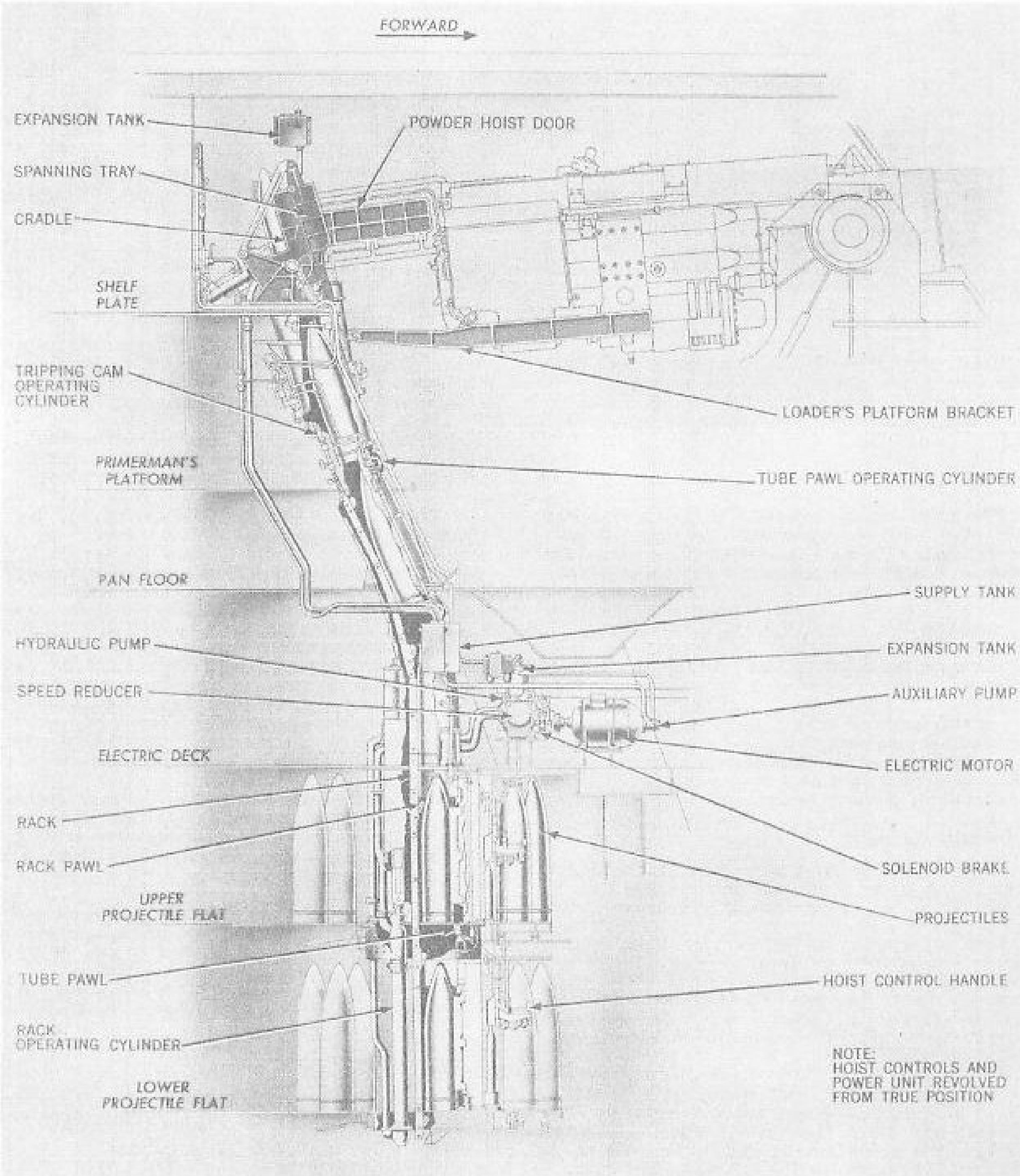


Figure 9-1. 16-Inch Projectile Hoist Mk 8 Mod 0 - General Arrangement, Sectional View

Design data

All hoists have the same projectile capacities, rate of delivery, and vertical lift of rack.

Hoist capacity	
Tube, HC or AP projectiles	5
Cradle, HC or AP projectiles	1
Rack loads, pounds	
Full load, AP projectiles	13,500
Full load, HC projectiles	9,500
Vertical lift, feet	
Upper projectile flat to the cradle opening	27.03
Lower projectile flat to the cradle opening	34.78
Spacing between rack pawls, inches	76.0
Stroke movement, inches	97.5

DETAIL DESCRIPTION

Power drive

The hoist and cradle power drive is an electric-hydraulic installation consisting of two motor driven pumps, two hydraulic operating mechanisms, and auxiliary elements for transmitting, interlocking, and controlling hoist action and for holding the rack against overhauling movement. The principal units and arrangement of a typical power drive are shown in figures 9-1 and 9-2.

Components. The power drive consists of the following:

- Electric motor
- Electric controller
- Solenoid brake
- Speed reducer
- Flexible couplings
- Rack operating hydraulic mechanism
- Cradle operating hydraulic mechanism

Electric motor. The electric motor (fig. 9-1) is mounted on a structural foundation (fig. 9-2) that raises it slightly above the electric deck. The motor is positioned horizontally and is coupled to the solenoid brake and reduction gear units through self-aligning flexible couplings.

Motor data.

Type	squirrel cage, induction
Design features	waterproof, fan cooling, horizontally mounted, reduction gear drive
Horsepower	75
Synchronous speed, rpm	1800
Full load speed, rpm	1750
Rotation (center and left hoist)	clockwise
Rotation (right hoist)	counter-clockwise
Speed class	constant
Voltage	440
Amperes, full load	95
Amperes, locked rotor	700
Phases	3
Cycles	60
Ambient temperature, deg C	40
Torque class	normal
Weight, pounds	1900
Manufacturer	Westinghouse Electric & Manufacturing Company
Manufacturer's designation	CS-FR-W-505
Drawing	268577

Electric controller. Each electric motor is powered and controlled through a cabinet enclosed, 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 remotely controlled from a master push-button station mounted adjacent to the cradle operator's station in the gun room compartment. This switch, normally open, is closed by pressing the START-EMERG button. The switch is opened by pressing the STOP button at the master push-button station. In addition, the electric motor may be stopped from either of two stop push-button stations located at the hoist control stations.

Controller data.

Type	waterproof, semiautomatic, across-the-line magnetic starter, controlled by remote push buttons
Ampere rating, full load	95
Protection: -	
Overload: - Dashpot, magnetic relay, semiauto reset	
Adjustable range, amperes	99.5 to 134.5
Normal setting, amperes	113.5
Short circuit, circuit breaker	AQB
Undervoltage: -	
Drop-out voltage	50
Sealing voltage	370
Shock rating	150
Weight, pounds	235
Manufacturer	Westinghouse Electric & Manufacturing Company
Drawing	268589

Solenoid brake. The solenoid brake consists of an actuating solenoid, brake drum, and brake band linkage. Assembled on a separate mounting base, the brake is mounted between the electric motor and reduction gear (fig. 9-2). The drum of the brake assembly is spline fitted to a shaft coupled to the motor output shaft through the input coupling described on page 9-5. Set mechanically, the brake prevents overhaul of the hoist in the event of mid-stroke power failure. When the supply circuit to the electric motor is closed, the brake is released through solenoid plunger stroke and the brake band linkage. The actuating solenoid is a 440-volt, 60-cycle, single-phase, continuous duty type. The brake develops torque of 125 pound-feet on an eight-inch brake drum.

Speed reducer. The speed reducer (fig. 9-2) is a case-enclosed unit mounted on a structural foundation of the electric deck. It is driven by the electric motor and is coupled to the main shaft of the hydraulic pump through the output coupling described on page 9-5.

Reduction gear data.

Type	enclosed worm and wormwheel
Output shaft (ratio 4.28 to 1.0), rpm	400
Rotation (output end) center and left	clockwise
Rotation (output end) right	counterclockwise
Lubrication	oil bath
Manufacturer	Michigan Tool Co.
Drawing	275600

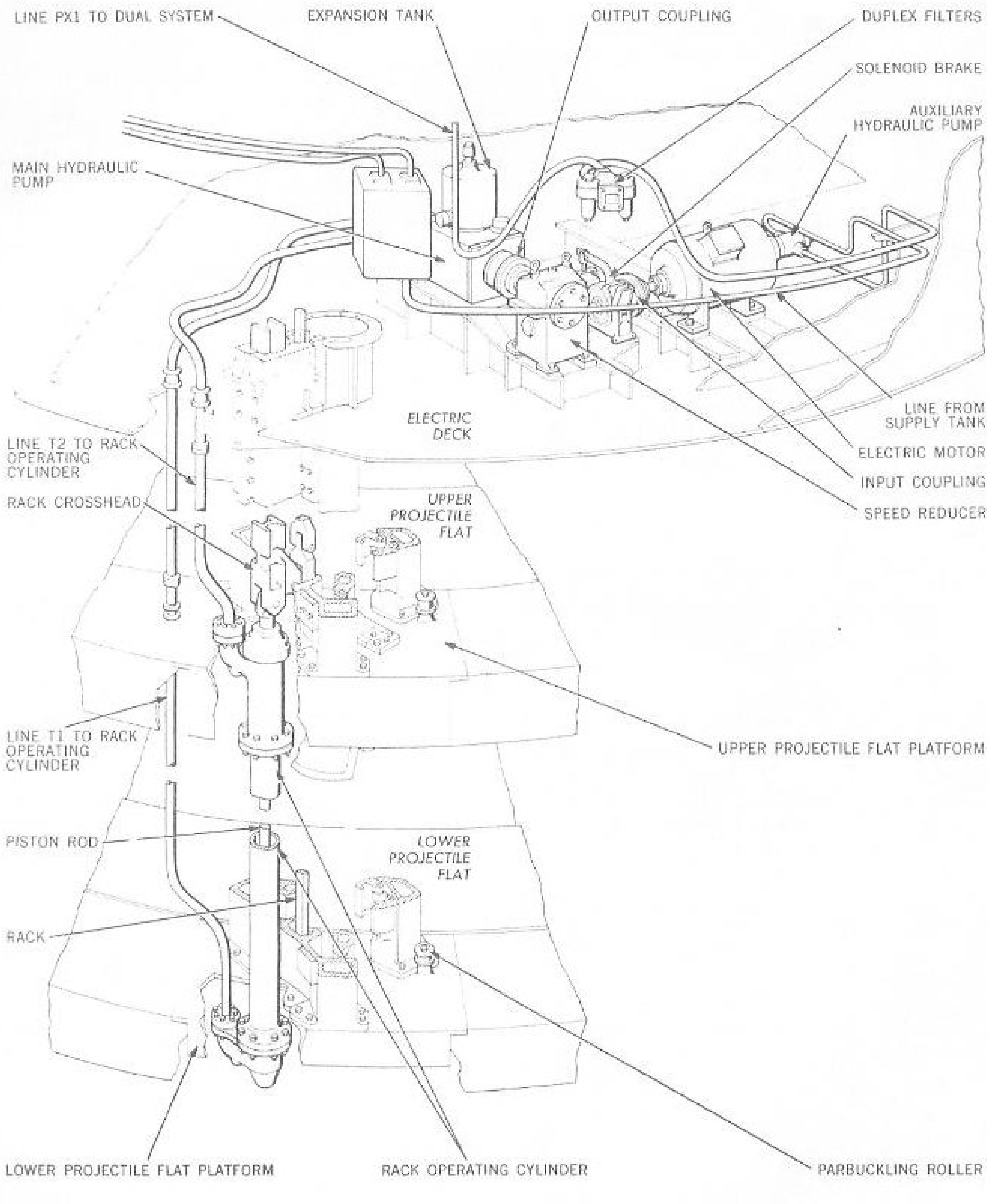


Figure 9-2. Projectile Hoist Power Drive Assembly - General Arrangement

Flexible couplings.

Speed reducer input. The coupling between the electric motor and the speed reducer input (brake drum shaft) is of commercial design and manufacture. A direct-drive, self-aligning connection, it is identical to the coupling in figure 7-17. The coupling consists of two identical hubs, male sleeve, female sleeve, sleeve gasket, and two seals and provides a flexible connection through meshing of the internal gears of hubs and sleeves. Gear lubricant is added through plugs in the outer male sleeve, and is retained by oil seals and gaskets.

Speed reducer output. The coupling between the speed reducer and the hydraulic pump is the same as the coupling between the electric motor and the speed reducer input, except that it is slightly larger.

Rack operating hydraulic mechanism. The rack operating hydraulic mechanism comprises the following:

Hydraulic pump
Rack operating cylinder

Hydraulic pump. The hydraulic pump (fig. 9-3) is a case-enclosed multi-cylinder unit. It is driven by the electric motor through the reduction gear to which it is connected by the output coupling described above. It is a type K variable displacement pump of modified commercial design.

Mounted on foundation weldments of the electric deck, the main pumps are arranged with main shaft centerlines at right angles to the electric motor shaft centerlines.

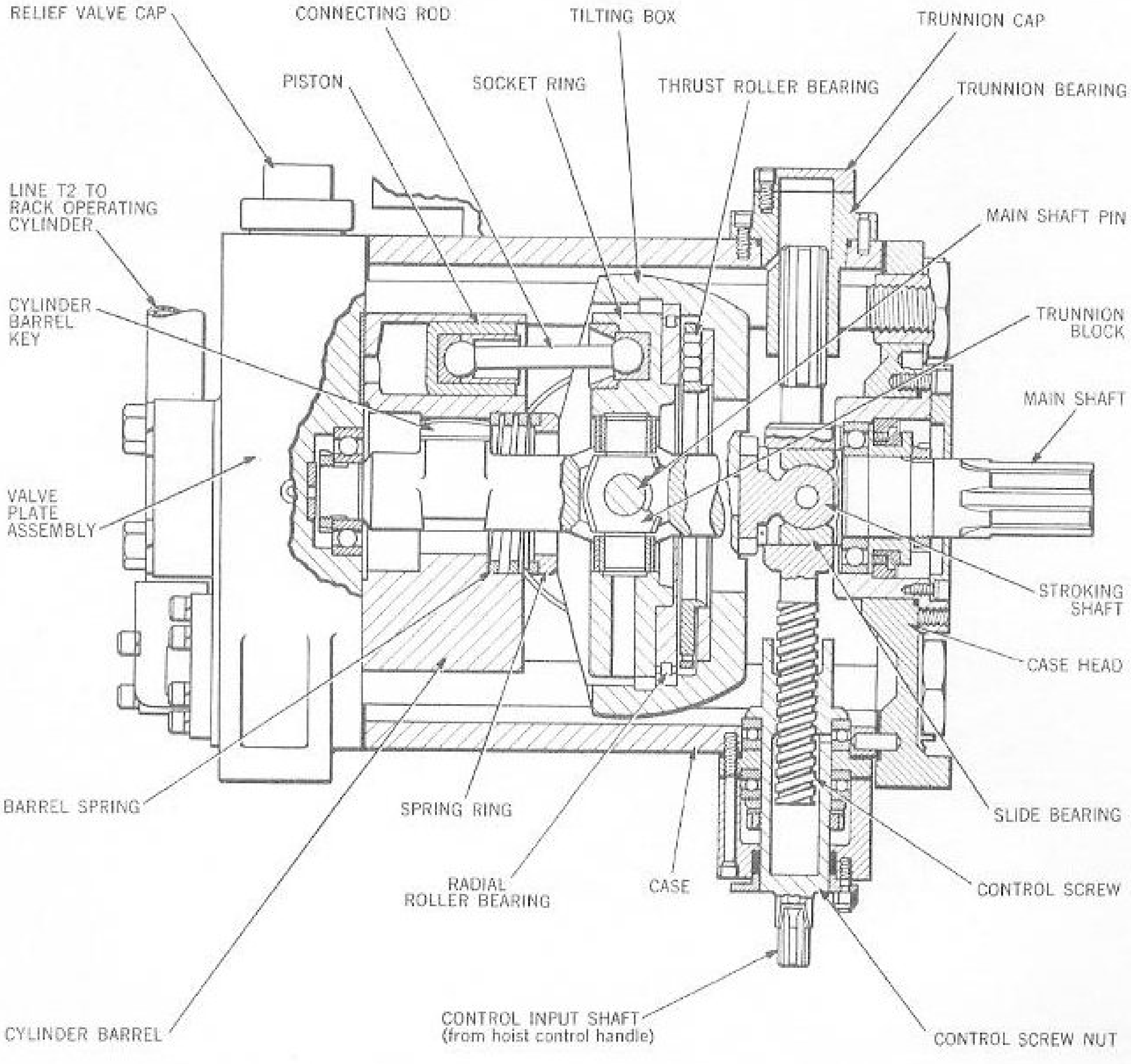


Figure 9-3. Projectile Hoist Main Hydraulic Pump - Sectional View

Case. A square, oiltight case encloses the hydraulic pump assembly. The case includes a valve plate, case head, case mounted tilting box control mechanism, trunnion cap, trunnion bearing assembly, and retainer. It forms a storage tank for hydraulic fluid in which the active parts rotate. The general arrangement of parts within the case is shown in figure 9-3. Mounting feet of the case are bolted to the pump foundation weldments.

Main shaft. The pump main shaft supports the rotating parts. At a point near the center of the pump 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, two keys are fitted in a section of the main shaft which supports the cylinder barrel. The main shaft forward end is supported by a ball bearing in the valve plate. The main shaft splined end is similarly supported by a ball bearing in the case head.

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

Pistons. Each cylinder bore is fitted with a piston ground and lapped to a smooth working fit. When the pump is delivering hydraulic fluid, 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 ends of the connecting rods.

Connecting rods. Nine connecting rods connect the 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 is drilled throughout its entire length to provide for lubrication of the ball and socket.

Socket ring. The socket ring, a circular piece, contains sockets for the other ends of the connecting rods. Each rod is retained in its socket cap, socket cap nut, and socket cap nut lock. The socket cap is split to facilitate installation and removal. The back of the socket ring has a roller track with two faces, which bear against the bearings in the tilting box. Two slots, located about the center of the socket ring and 180 degrees apart, carry the main shaft trunnion bearing blocks of the universal joint.

Universal joint. Rotation of the main shaft 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, a trunnion-mounted casting inside the pump case, varies the angle of the socket ring with relation to the main shaft, changing the length of piston stroke from zero to maximum. It contains two groups of roller bearings which take the radial and axial thrusts of the socket ring. Connected to the tilting box, a stroking shaft connects with the control screw of the control mechanism.

Valve plate. The valve plate and the case-head form the stationary ends of the pump 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 valve-plate ports, through which hydraulic fluid flows when power is being transmitted. These ports connect with the power transmission pipes between the pump and the rack operating cylinder.

Between the valve plate 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 reciprocating pistons. There is no pumping action when the cylinder bores pass over the lands. The ball bearings for the main shaft are in the center of the valve plate.

Valves. The main relief, auxiliary relief, and replenishing valves, described in the following paragraphs, are housed within the hydraulic pump valve plate. Their arrangement is shown schematically in figure 9-5.

Main relief valve. The main relief valve, located in the upper part of the valve plate, is a spring-loaded plunger-type valve, operated by a similar type pilot valve. The valve is adjusted to relieve main pump high pressure in excess of 100 pounds per square inch during the hoist strokes.

Auxiliary relief valve. The auxiliary relief valve, located in the upper part of the valve plate is adjacent to the main relief valve and is identical to it. The valve is adjusted to limit main pump pressure at 100 pounds per square inch during the lowering stroke.

Replenishing valve. There are two replenishing valves located in the lower part of the valve plate. They are identical spring-loaded plunger-type valves that replenish the hoist system hydraulic fluid through the transmission lines.

Expansion tank. The cylindrical 7.0-gallon hoist power drive expansion tank is 14.0 inches high and 12.5 inches in diameter. Mounted on top of the hydraulic pump case, it is a vented type with gravity feed connection to the replenishing valves of the hydraulic pump valve plate. Return lines lead to the tank from the main relief valve. The tank is equipped with a filler cap at its top and an inside strainer. Filled to the level indicated by the tank gages, it contains 5.0 gallons of hydraulic fluid.

Hydraulic pump data.

Driven speed, revolutions per minute	400
Oil temperatures	
Normal operating range, deg C	67-97(100-150F)
Maximum permitted, deg C	103(180F)
Displacement capacity	
Delivery, gallons per minute	200
Pressure, pounds per square inch	1000

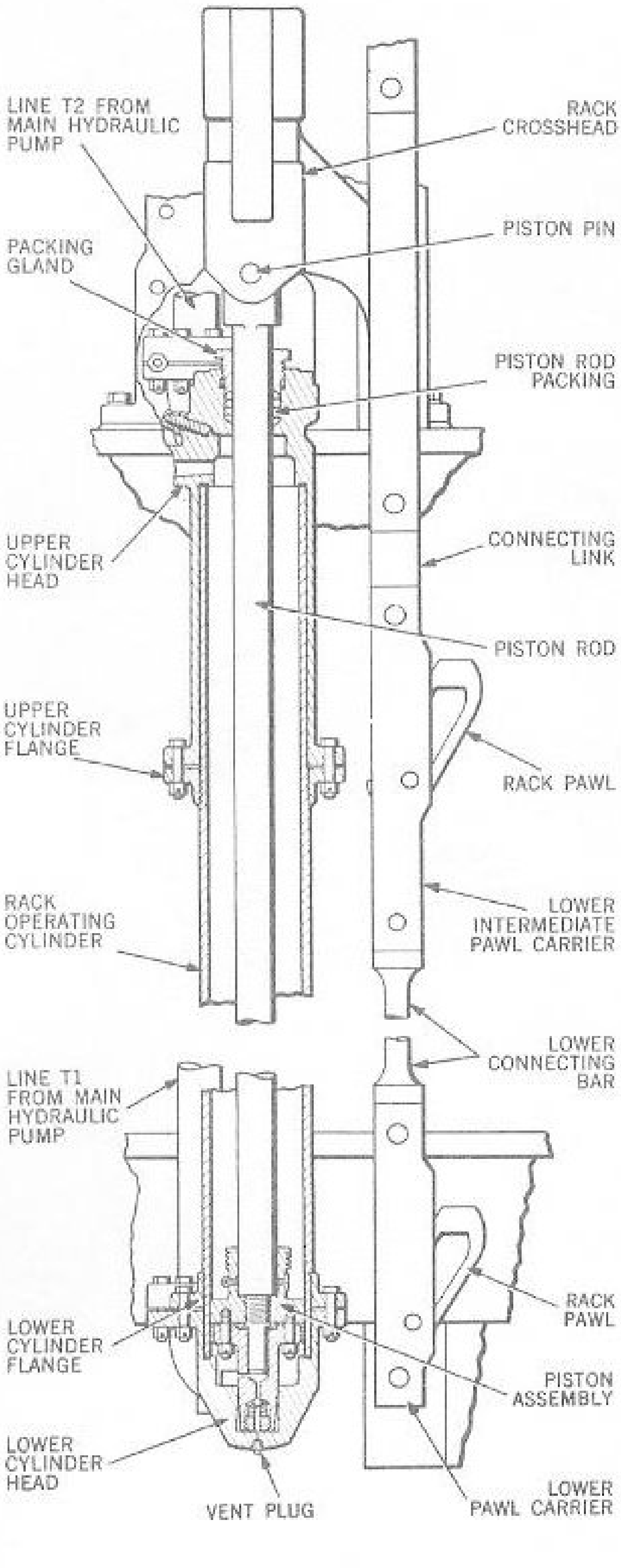


Figure 9-4. Rack Operating Cylinder and Rack-Sectional View

Rack operating cylinder. The rack operating cylinder (fig. 9-4) is a hydraulic ram of 97.5 inches stroke. It comprises a cylinder, a piston assembly, and two cylinder heads. A seamless steel tube that weighs approximately 160 pounds, the cylinder has an inside diameter of 5.875 inches and a length of 101.425 inches. At a point 5.75 inches from the lower end, the cylinder is threaded and machined to attach a cast steel flange. The upper end is also threaded and machined to attach an identical flange 21.125 inches from the top. Each cylinder flange weighs 22.5 pounds and has eight equally spaced holes for attaching the cylinder head.

Piston assembly. The piston assembly (fig. 9-5) housed within the rack operating cylinder, comprises a piston rod, piston, leather piston cup, and a piston follower. A round solid steel bar which passes through the upper cylinder head, the piston rod is 2.48 inches in diameter and 116.93 inches long. The upper end of the rod is rectangular in shape and is attached to the rack crosshead by a pin. A bronze casting 5.873 inches in diameter, the piston is threaded on the lower end of the rod. An integral grooved cylinder of smaller diameter at the top of the piston buffs the piston at the top of its stroke. The piston follower, shaped to prevent collapse of the leather piston cup, retains the cup and is bolted to the piston. Provided with a ball check valve and throttling groove, the lower end of the follower functions with an integral dashpot of the lower cylinder head to buff the piston on the downstroke.

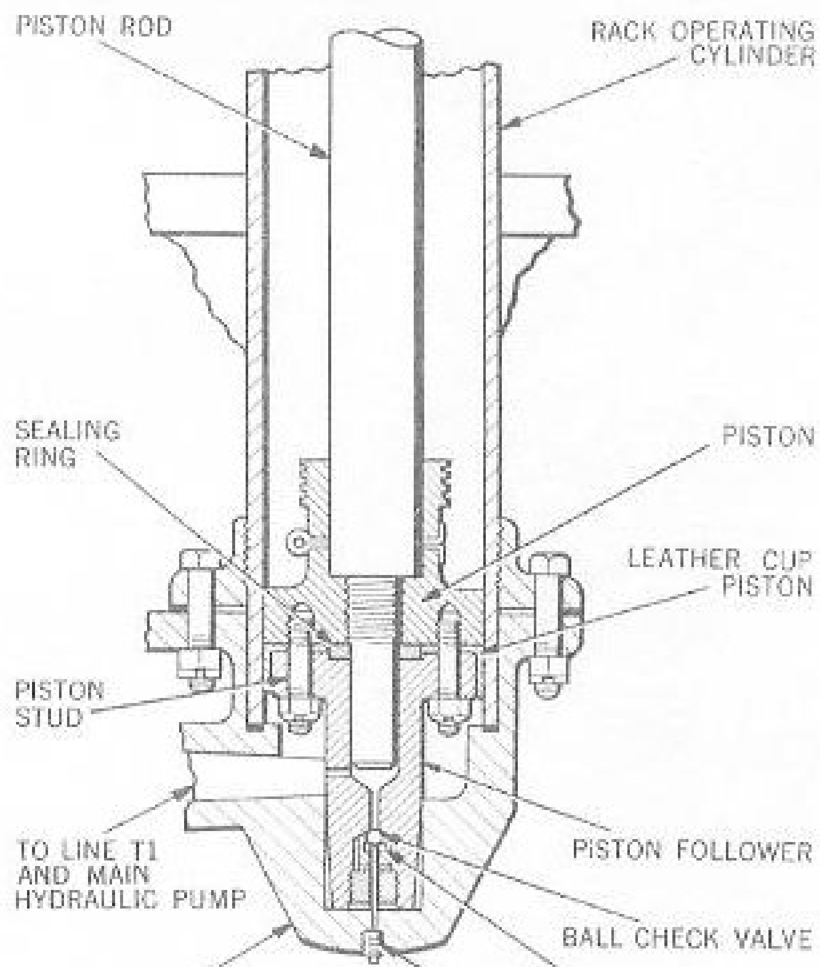


Figure 9-5. Rack Operating Piston and Cylinder-Sectional View

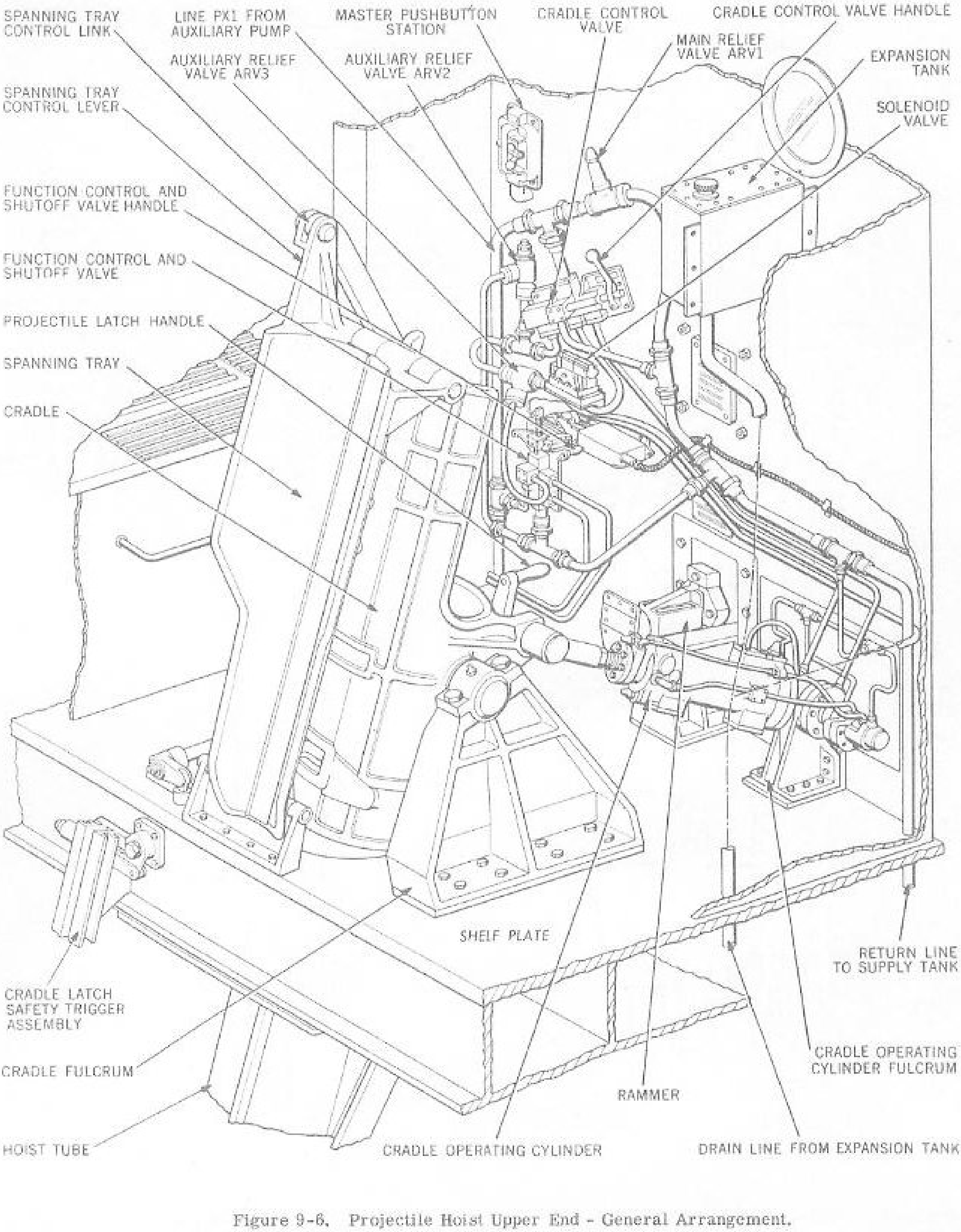


Figure 9-6. Projectile Hoist Upper End - General Arrangement.

Cylinder heads. Made of cast bronze, the cylinder heads are attached to the cylinder ends through integral head flanges. The upper cylinder head weighs 236.0 pounds. The lower head, which weighs 103.0 pounds, provides a dashpot for piston lowering movement. Both heads seat copper gaskets assembled between the cylinder and head. The piston rod passes through a garlock type packing retained in the top of the upper head by a gland nut. Both heads have pressure ports and integral mounting flanges to which the power transmission lines from the hydraulic pump are attached. There is a 0.188-inch vent hole in the upper head that is closed through a capped air valve. A similar hole in the lower head is closed with a threaded brass plug.

Cradle operating hydraulic mechanism. The cradle operating hydraulic mechanism comprises the following:

Hydraulic pump
Cradle operating cylinder

Hydraulic pump. The hydraulic (auxiliary) pump is directly driven by the projectile hoist electric motor. The rotary-gear constant displacement pump delivers hydraulic fluid at the rate of 30 gallons per minute (at varying pressures) to a dual hydraulic system described later on this page. The pump is mounted on an integral flange at the back end of the electric motor housing.

Valves. The main relief, auxiliary relief, and bypass valves, described in the following paragraphs, are arranged in the dual system as shown in figure 9-5.

Main relief valve. The main relief valve, ARV 1, located in the gun room compartment (fig. 9-6), is a spring-loaded plunger-type valve. It is adjusted to relieve auxiliary pump pressure in excess of 800 pounds per square inch during cradle lowering.

Auxiliary relief valve. The auxiliary relief valve, ARV 2, located in the gun room compartment (fig. 9-6), is a spring-loaded plunger-type valve. It is adjusted to relieve auxiliary pump pressure in excess of 400 pounds per square inch during cradle raising.

Bypass valve. The bypass valve, located in the duplex filter unit, is a spring-loaded plunger-type valve. It relieves auxiliary pump pressure in the event the filter elements become clogged.

Duplex oil filter. A pressure-type duplex oil filter, of commercial design and manufacture, is used to filter the hydraulic fluid delivered by the auxiliary pump to the dual hydraulic system. Located on the electric deck adjacent to the power drive assembly, the unit consists of two fine wire screen elements each in a filter sump attached to the unit body. For normal operation both filters should be used simultaneously. However, a control valve provided in the filter design permits the individual use of either filter. This feature makes it possible to clean a fouled filter element without stopping the power drive.

Expansion tank. The 7.0-gallon expansion tank (5.0 gallons capacity when filled to the upper trycock) for each cradle operating hydraulic mechanism is a vented type with a gravity feed connection to the supply tank. The tank, located in the gun room compartment, is at the highest point of the hydraulic system. The steel tank body is box shaped, 14.0 inches high, 14.0 inches wide, and 9.0 inches deep. It is equipped with a cover, high- and low-level trycocks, filler cap, and an oil strainer inside the tank.

Supply tank. The 22-0-gallon supply tank for each cradle operating hydraulic mechanism is a nonvented type. It has a feed connection from the expansion tank and is interposed in the return line from the cradle operating and pawl control mechanism to the auxiliary pump. The return line, which passes through the tank, has two open T fittings assembled in it at 4.0 and 18.0 inches from the tank bottom. The tank is located between the pan floor and electric deck, to the rear of the power drive components. The steel tank body is box shaped 15.0 inches square and 24.5 inches high. It is equipped with pipe flange connections for the return and feed lines, a drain plug, and a side cover plate.

Dual system. The hydraulic (auxiliary) pump supplies hydraulic pressure for operating a dual system. This system includes the hoist reversal system (described on page 9-12) and the cradle operating hydraulic mechanism.

Cradle operating cylinder. The cradle operating cylinder (fig. 9-7) is a hydraulic ram. It is mounted in the rear part of the gun room compartment (fig. 9-6) with its piston connected to the cradle through a crank pin connector and crank pin. The cylinder assembly consists of a cylinder fulcrum, a cylinder, and a piston.

Cylinder fulcrum. The cast bronze cylinder fulcrum is mounted on the shelf plate to the rear of the cradle fulcrums (fig. 9-6). It provides a mounting for the lower end of the cradle operating cylinder which is connected to the hydraulic swivel joints mounted in the fulcrum.

Cylinder. The cast bronze cradle operating cylinder (fig. 9-6) provides a 13.785-inch stroke ram, of 4.0 inches bore, and is 31.5 inches long overall. It is connected to the cylinder fulcrum through the cylinder head at its lower end. The cylinder head, together with the piston and cylinder valve port restrictions, buffs the folding action of the cradle. In the upper end of the cylinder, the piston rod passes through a chevron type packing assembly retained by a gland.

Piston. The nickel steel piston is lap fitted to the cylinder bore. It is 30.567 inches long including the dashpot plunger at its lower end. The upper end of the piston passes through the cylinder packing and gland and is attached to the cradle through a crank pin and crank pin connector.

Hoist components

The hoist components comprise the following:

Rack
Tube
Projectile flat platforms
Door and shutter brackets
Rack pawl
Tube pawl

Arrangement. The various hoist components listed above are shown in figure 9-1 and are similarly arranged for all projectile hoist installations. The hoist tubes form the courses through which projectiles are conveyed to (or lowered from) the cradle assemblies by reciprocating movement of the rack and rack pawls. Projectiles are supported at the end of a stroke by the tube pawls. The door and shutter brackets form the loading apertures for the hoist tubes. They are similarly arranged on both projectile flats with the projectile flat platforms forming the aperture bases.

Rack. The rack is an assembly of steel connecting bars, links, and pawls carriers joined end to end and connected to the crosshead. The assemblies for the left and right hoists are identical and differ slightly from the center hoist rack assembly. With curved rack casing tracks for their courses, the outboard hoist racks are 325.0 inches long. They are made up of 14 connecting bars, links, and pawl carriers with the crosshead arranged above the second pawl carrier. The center hoist rack, with a straight rack casing track for its entire course, is 318.0 inches long. It is an assembly of 9 connecting bars, links, and pawl carriers with the crosshead arranged above a connecting bar and the second pawl carrier. The crossheads, bronze castings, connect the rack to the rack operating cylinder (fig. 9-4) described on page 9-7. A connecting bar, located near the top of each rack, is arranged with a cam surface which actuates the tube pawl control valve cam mechanism described on page 9-13.

Tube. The hoist tubes (fig. 9-1) are flange bolted assemblies. The left and right hoist tube assemblies are similar but are oppositely arranged for left and right installations. The center hoist tube assembly differs from the left and right in that it is slightly shorter due to its straight course. All hoist tube cour .es are formed by cast steel sections. These have integral tracks in which the racks operate, and integral flanges through which the sections are bolted together. The assembled tube structure is supported from the lower and upper projectile platforms. It is braced, by bolted and flanged attachment, at the shelf plate, pan floor, and electric deck through cast steel brackets. These, like the tube sections, have integral tracks for the racks. The cradle unit (fig. 9-1), aligned with the tube, is mounted on the shelf plate.

Projectile flat platforms. The projectile flat platforms, shown in figure 9-1, are the foundation components for the hoist tube assemblies, the door assemblies, and the rack operating cylinders. Machined steel castings, the platforms are arranged in the handling spaces of both projectile decks. Their tops are flush with the surfaces of the rotating rings and stowage areas. Left and right hoist platforms are similar but are arranged for left and right installations.

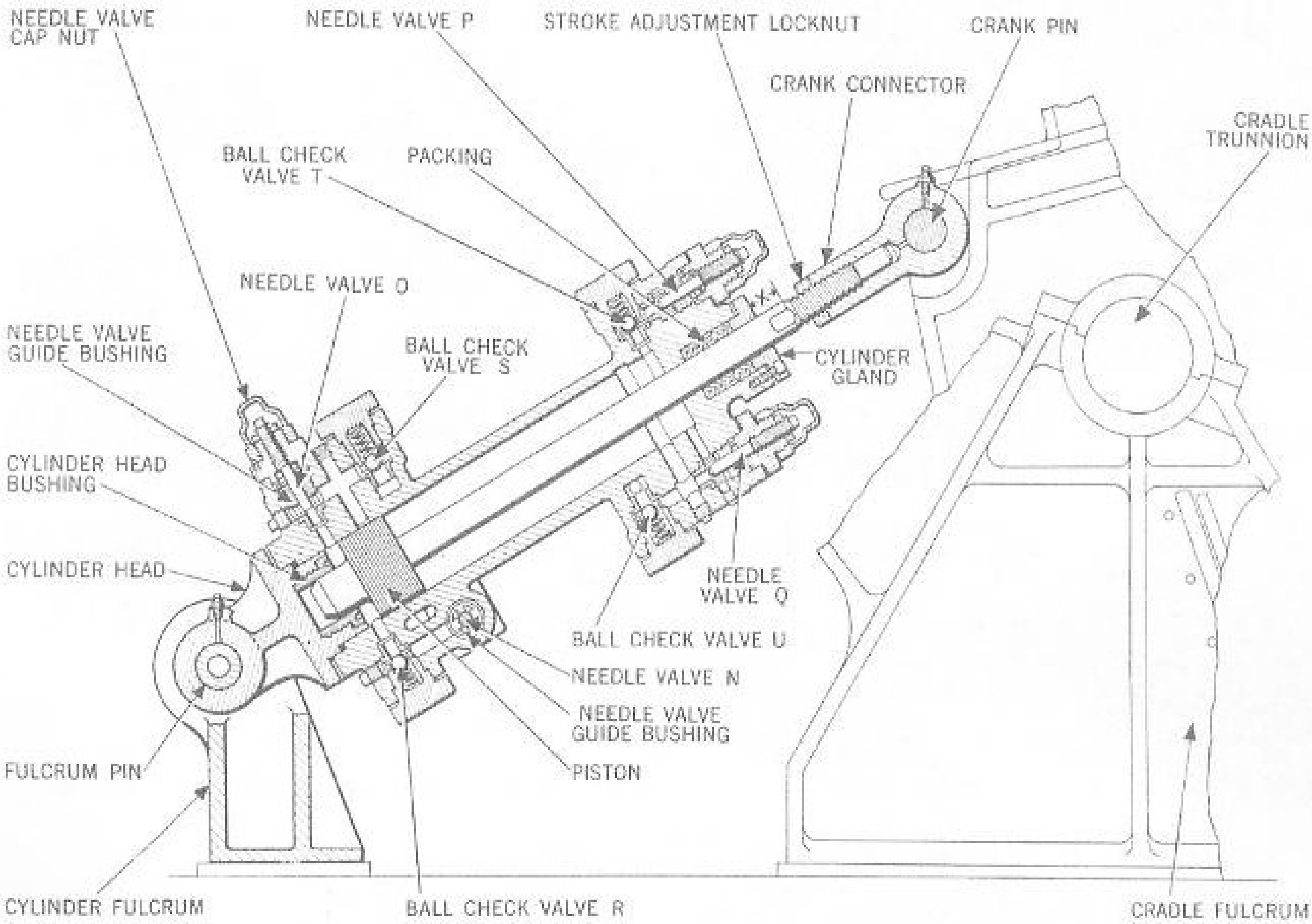


Figure 9-7. Projectile Hoist Cradle Operating Cylinder - Sectional View

Center hoist platforms differ slightly from the left and right. The upper flat platforms have integral provisions for the hoist tubes, the rack tracks, and the rack operating cylinder. The lower flat platforms differ in that they provide only for the rack track and the rack operating cylinder. All platforms are keyed to locate and secure the door and shutter brackets, hoist tube sections, and the rack operating cylinder.

Door and shutter brackets. The door and shutter brackets (fig. 9-8) help to support the hoist with its load of projectiles. Cast steel columns, the brackets are made with integral flanges through which they are secured in position to the projectile flat platforms and the electric deck bracket. The brackets are arranged vertically in the handling spaces with vertical full opening of the hoist apertures. All hoist apertures are fitted with spring-loaded doors and shutters that are hinged on the brackets (fig. 9-27).

Rack pawl. The rack pawls (fig. 9-4) are spring-loaded and pin pivoted and are seated in the pawl carriers of the rack assembly. Movement of the rack conveys projectiles, which rest on the pawls, through the hoist tube (fig. 9-26). The rack has five pawl carriers. These are the upper pawl carrier, upper intermediate pawl carrier, intermediate pawl carrier, lower intermediate pawl carrier, and lower pawl carrier. The pawls are spring-loaded to move into position for hoisting. When the rack descends after a hoisting stroke, each rack pawl is depressed by the projectile resting on the tube pawl at the next lower level.

Tube pawl. The tube pawls (fig. 9-1), spring-loaded and pin pivoted, are housed in hoist tube sections. Projectiles when lifted by the rack are supported at the end of each of the first four lifting strokes by the four tube pawls. These pawls are spring-loaded to move beneath the base of the projectile as it is hoisted on the rack pawls.

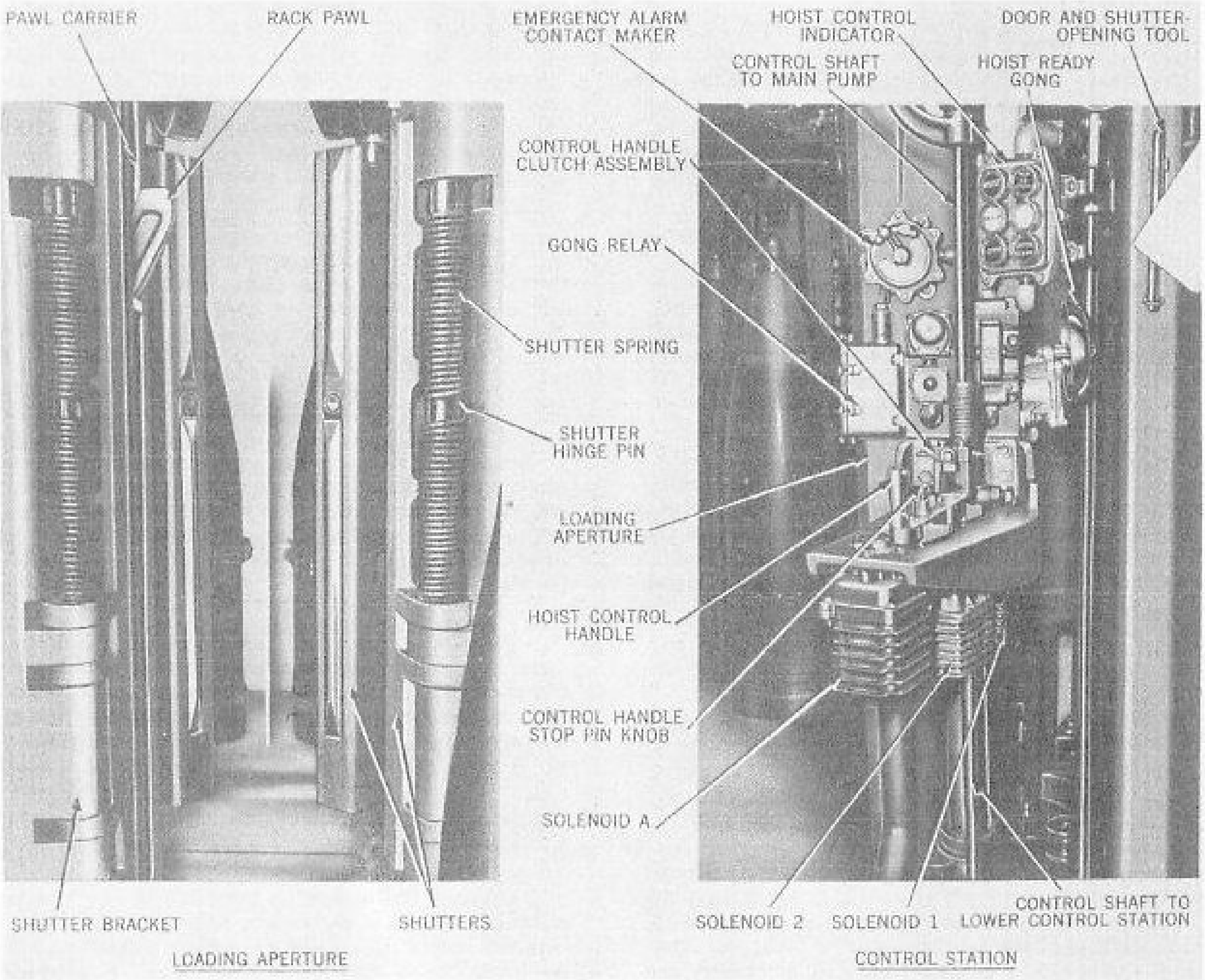


Figure 9-8. Projectile Hoist Upper Loading Aperture and Control Station - General Arrangement

Cradle assembly components

The cradle assembly comprises:

- Cradle and spanning tray
- Buffers
  - Cradle opening
  - Cradle folding
  - Spanning tray
- Cradle control valve
- Cradle solenoid valve
- Cradle latch
- Projectile indicator
  - Lever
  - Latch
  - Switch
  - Retainer

Arrangement. The cradle assembly (fig. 9-6) is mounted on the shelf plate above the hoist tube in the gun room compartment (fig. 9-1). Operated by the operating hydraulic mechanism, described on page 9-9, the cradle transfers a projectile from its vertical hoisting position to a horizontal position for ramming.

Cradle and spanning tray. The cradle and spanning tray (fig. 9-6), hinged together, are pivoted on integral trunnions of the cradle in the cradle fulcrums. A cast bronze trough 58.6 inches long with a tubular portion of 17.0 inches diameter bore, the cradle is 25.37 inches wide across its trunnions. Pivoted at the cradle bottom, the cast bronze projectile latch is spring-loaded to move beneath the base of a projectile that has been hoisted into the cradle. The spanning tray, a cast aluminum trough identical in cross section to the trough of the cradle, is connected to the cradle through the integral hinges of both castings. A control link, which connects the integral control lever of the spanning tray to the cradle fulcrum, unfolds the spanning tray when the cradle is lowered. The end of the tray opposite the hinge is tapered to enter the gun breech and extend across the screw box to the powder chamber. Machined grooves in the bottoms of the cradle and spanning trays provide a track for the rammer chain. Connected to the cradle operating cylinder through the crank connector and crank pin (fig. 9-7), the cradle and spanning tray assembly provide for delivery of projectiles to the gun by the rammer.

Buffers.

Cradle opening buffer. The cradle opening buffer is similarly mounted on the front of the cradle fulcrum in each assembly. It is a hydraulic buffer which *throttles flow* of the cylinder liquid past the plunger of the buffer piston, through grooves of variable depth in the buffer housing. Rapid return of the buffer piston to its extended operating position is ensured through a spring-loaded ball-check valve in the plunger. This valve permits the flow of liquid from the reservoir to the chamber beneath the plunger. The piston, which makes a 2.75-inch stroke with the gun at 5.0 degrees loading angle, contacts a phenol-fabric pad in the bottom of the cradle.

Cradle folding buffer. The folding action of the cradle is buffed by the cradle operating cylinder, described on page 9-9.

Spanning tray buffer. The spanning tray buffer is a rubber pad cemented in a recess in the bottom of the cradle. This pad buffs the contact between the spanning tray and cradle when the cradle assembly is folded.

Cradle control valve. The cradle control valve is flange mounted on the transverse bulkhead in the gun room compartment (fig. 9-6). It is a valve block arrangement of a spool-type, direction control valve and a valve operating lever (designated cradle control valve handle). Manually positioned, the valve directs auxiliary pump pressure to the chambers of the cradle operating cylinder. The valve is spring-loaded to return to neutral when released by the operator. The cradle control valve cannot lower the cradle to the loading position until the cradle solenoid valve (below) is operated by action of its solenoid to close a by-pass and open the hydraulic circuit to the cradle cylinder.

Cradle solenoid valve. The cradle solenoid valve is mounted as shown on figure 9-6. This valve is controlled by an internally mounted solenoid which is operated by the interlock portion of Ready Light Circuit 1R (ch. 15). The cradle solenoid valve is in the cradle operating hydraulic circuit between the cradle control valve and the cradle operating cylinder and prevents operating the cradle by by-passing pressure to the tank until the gun is in battery and the breech is open and the gun bore is clear.

Cradle latch. The cradle latch assembly (fig. 9-13) consists of a guide plate, latch, latch connection piece, connecting rod, coil spring, and yoke. Free to move up or down in a vertical slot in the cradle fulcrum, the latch is retained in the slot by the guide plate. Screwed to the latch connecting rod, the latch extends through the slot to the inside of the cradle fulcrum and is positioned to contact an integral cam lug of the cradle. The connecting rod is attached to the foot pedal assembly (described on page 9-17)through the yoke. Moved upward by the coil spring, the latch secures the cradle in the raised or lowered position until forced down and released the foot pedal.

Projectile indicator. The projectile indicator assembly is pivoted in a bracket that is mounted on the shelf plate. Actuated by movement of a projectile into the cradle and by cradle movement, the assembly illuminates a danger signal at each projectile handling level. It also prevents hoist action when there is a projectile in the cradle or when the tray is spanned. It consists of a lever, a latch, a switch, and a retainer.

Lever. The projectile indicator lever, bracket mounted in front of the cradle assembly, is spline fitted to the connecting shaft. A hook shaped cam, the lever (fig. 9-13), projects through a hole in the cradle when the cradle is folded. Displaced by the projectile as it is hoisted into the cradle, the lever actuates the indicator latch through the connecting shaft and actuating lever.

Latch. The projectile indicator latch (fig. 9-13), moved by the actuating lever and connecting rod, closes the projectile indicator switch. The latch is held in position by a retainer to keep the switch closed throughout the movement of the unfolding cradle by an arc-shaped integral cam of the cradle.

Switch. The projectile indicator switch is mounted on the side of the cradle fulcrum. The switch, when closed by the indicator latch, illuminates a danger signal at each projectile handling level and interlocks the hoist control handle against movement toward HOIST.

Retainer. The retainer is mounted on the side of the cradle fulcrum and is moved up when a projectile enters the cradle. This action permits the integral retainer cam of the cradle to move under the retainer lug while the cradle is being spanned.

Hoist reversal system

General. The rack pawls and tube pawls (described on page 9-11) are components of the hoist reversal system. They are arranged with operating mechanisms which retract the pawls alternatively for lowering projectiles. This system, a part of the dual system described on page 9-9, controls the reversing action of the rack and tube pawls. The hoist reversal system, a semiautomatic control, operates independently of the cradle operating hydraulic mechanism.

Components. The hoist reversal system consists of the following:

- Rack pawl operating cylinder
- Rack pawl tripping cam mechanism
- Tube pawl operating cylinder
- Tube pawl control mechanism
- Function control and shut-off valve
- Tube pawl control valve
- Tube pawl control valve cam mechanism

Rack pawl operating cylinder. The rack pawl operating cylinder is flange mounted on the hoist tube between the shelf plate and pan floor. Housed in a bronze casting, the cylinder assembly is a 1.25 inch stroke ram of 1.65 inch piston bore. It has hydraulic pressure connections with the function control and shut-off valve. The piston is threaded to the piston rod which passes through a chevron type packing retained by a gland in the bottom of the cylinder. Movement of the piston actuates the piston rod which is attached to the control rod linkage of the rack pawl tripping cam mechanism.

Rack pawl tripping cam mechanism. An assembly, the rack pawl tripping cam mechanism consists of a control rod linkage, tripping cams, tripping cam cranks, bearing brackets, sliding collars, and springs. The control rod linkage is mounted on the outside of the rack casing by the bearing brackets. Arranged in sets of one of each, the tripping cams and cam cranks are spline fitted on shafts mounted and pivoted horizontally in the rack casing. The cams located inside the rack casing retract the rack pawls at the bottom of the rack stroke when the hoist system is reversed to lower projectiles. The cam cranks located outside the rack casing are attached to and actuated by the control rod linkage. The cams are aligned with the four upper rack pawls when the rack is at the bottom of its stroke; they are simultaneously actuated through movement of the control rod linkage. When projectiles are lowered, the tripping cam action is such that the rack pawls are retained in retracted positions until each rack pawl (with the rack ascending) passes the base of the projectile at the next higher level.

Tube pawl operating cylinder. The tube pawl operating cylinder (fig. 9-14) is flange mounted on the hoist tube section between the shelf plate and pan floor. Housed in a bronze casting, the cylinder assembly is a 1.375-inch stroke ram of 1.75-inch piston bore. It has hydraulic pressure connections with the tube pawl control valve. The piston is attached to the piston rod which passes through a chevron type packing retained by a gland in the bottom of the cylinder. The piston rod, actuated by movement of the piston, is attached to the control rod linkage of the tube pawl control mechanism.

Tube pawl control mechanism. An assembly, the tube pawl control mechanism (fig. 9-14), consists of a control rod linkage, cranks, bearing brackets, sliding collars, and springs. The control rod linkage is mounted on the outside of the rack casing by the bearing brackets. Arranged in sets of one of each, the tube pawls and cranks are spline fitted on shafts mounted and pivoted horizontally in the hoist tube. The cranks are located outside of the hoist tube and are attached to and actuated by the control rod linkage. The tube pawls are simultaneously actuated by the cranks through movement of the control rod linkage. When projectiles are lowered, the tube pawls are retained in retracted positions while the rack is near the top of stroke (either ascending or descending). As the rack descends, the tube pawls move back into the hoistway, beneath the bases of projectiles lowered from the next higher level.

Function control and shut-off valve. The function control and shut-off valve assembly (fig. 9-9) is flange mounted, as shown in figure 9-6, on the transverse bulkhead. It is a valve block arrangement of a two-position spool-type direction control valve and a separate valve operating lever (designated function control and shut-off valve handle). Manually positioned, the valve directs auxiliary pump pressure to the rack pawl operating cylinder and the tube pawl control valve.

Tube pawl control valve. The tube pawl control valve assembly is flange mounted on the rack casing adjacent to the rack pawl operating cylinder. It is a valve block arrangement of a two-position spool-type valve. The valve passes through a packing in the lower end of the valve block and is connected to and positioned by the tube pawl control valve cam mechanism. When the function control and shut-off valve is positioned at LOWER PROJECTILES, the following action occurs:

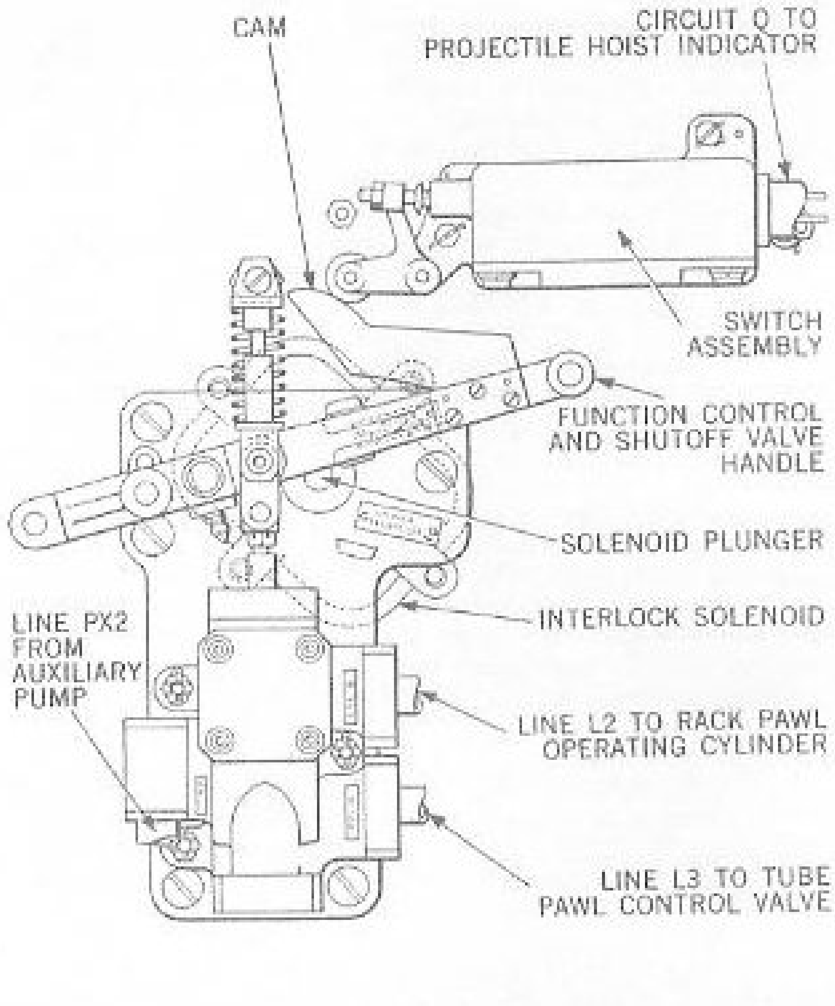


Figure 9-9. Function Control Mechanism - General Arrangement

Positioned and held up by auxiliary pump pressure, the tube pawl control valve directs auxiliary pump pressure to the top of the rack pawl operating cylinder to move the rack pawl tripping cams clear of the rack pawls.

Tube pawl control valve cam mechanism. This assembly consists of a cam lever, a cam lever bearing bracket, a control rod, and a collar. It is bracket mounted below the tube pawl control valve. Pivoted on a shaft mounted horizontally in the bearing bracket, the cam lever extends through a slotted hole in the rack casing in the way of the rack connecting bar cam. It is actuated by the rack connecting bar cam and is connected to and actuates the tube pawl control valve through the control rod.

Controls and interlocks

The projectile hoist control and interlock arrangements for each hoist consist of:

- Start-stop control
- Rack operating controls
- Hoist control indicator
- Hoist controls
- Limit switches
- Solenoid operated interlock
- Cradle operating controls
- Neutral start interlock
- Door and shutter interlock (parbuckling operation)

Start-stop control. Each projectile hoist power drive is started and stopped through its electric-power motor controller (described on page 9-3). The controller is remotely operated from three push-button stations, as described below.

Master control push-button station. The master control push-button station is adjacent to the cradle operator's station in the gun room compartment. It is a two push-button switch; 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 at this station or at either of the two stop push-button is pressed. An overload relay opens the circuit when current demand is too great.

Stop push button stations. A stop push-button station is located at each of the upper and lower projectile flat hoist operating stations. Each station comprises a single button switch labeled STOP. Pressing the STOP button at either station opens a three-pole switch and de-energizes the coil of the main contactor to disconnect power from the electric motor.

Rack operating controls. The rack operating controls comprise the hoist control handle and the function control lever interlock. The arrangements described below are similar for each hoist installation.

Hoist control handle. The projectile hoist is provided with a hoist control handle (fig. 9-8) adjacent to the hoist tube loading apertures on each projectile flat. Each control handle is an assembly that includes a clutch subassembly (fig. 9-10) mounted in the cast bronze body of the control handle. Both control handles are mounted on a common vertical control shaft. The control shaft is connected to the control handles through the clutch subassemblies and is coupled to the tilting box stroking control screw.

Function. Depending on the direction in which it is moved, the hoist control handle offsets the main pump tilting box from neutral stroke (through the control shaft and stroking control screw described above) to initiate a hoisting or lowering movement of the rack.

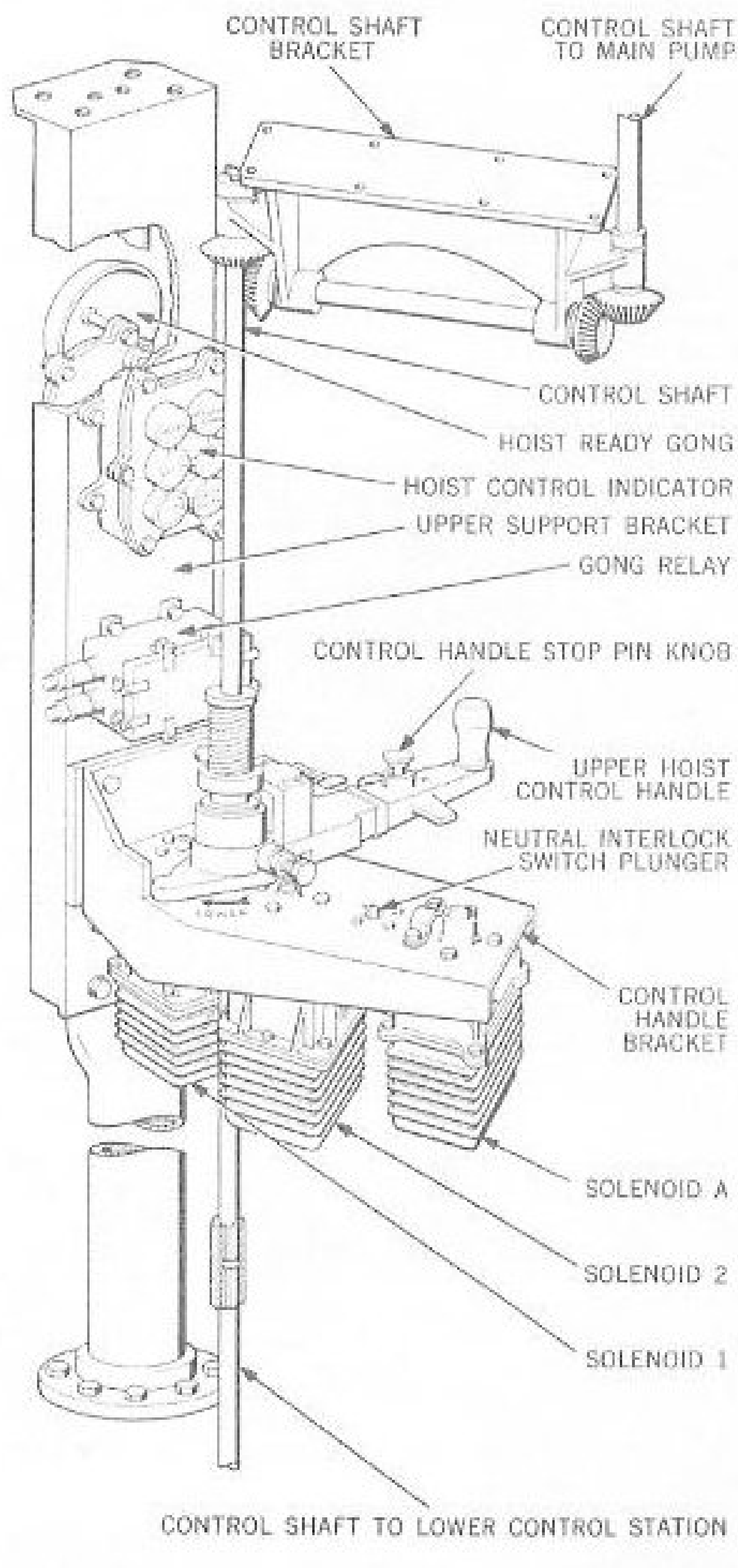


Figure 9-10. Upper Hoist Control and Interlocks

Either control handle may operate the hoist since each is independently engaged or disengaged through manually operated clutch levers (fig. 9-11).

Arrangement. The hoist control handle bracket at each hoist operating station is similarly equipped and includes an arrangement of four solenoid interlocks and an interlock switch. Stops in the bracket limit maximum movement of the control handle each side of neutral stroke. One of the solenoid plungers automatically permits restricted movement of the control handle (indicated in the table below) to lower projectiles. The other two solenoids lock the control handle at neutral stroke when a projectile is being parbuckled into or out of the hoist, and block the control handle against hoisting (but permit lowering) when a projectile is in the cradle or the cradle is open. Except when the control handle is at neutral, movement of the function control and shut-off valve to reverse the pawl mechanisms is blocked by an interlock solenoid through the interlock switch which is actuated by the control handle. The switches at both hoist operating stations, arranged in series, must be closed (by positioning the control handle at neutral stroke) in order to shift the function control and shut-off valve.

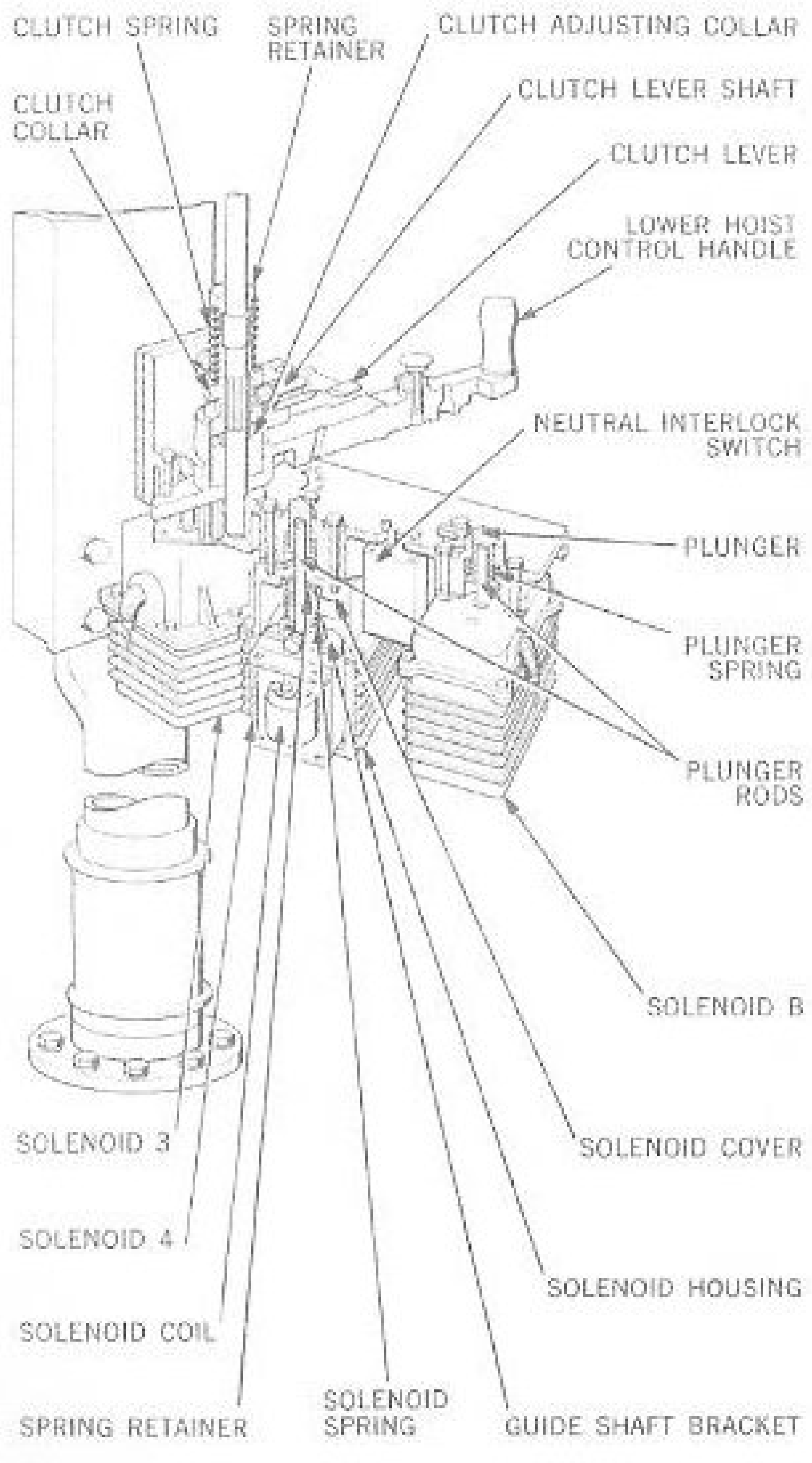


Figure 9-11. Lower Hoist Control Interlocks - Sectional View

Movement limits. The arcs of movement of the hoist control handles are identical. These movements from neutral stroke, and the equivalent tilt of the main pump tilting box, for each hoist control action are indicated below.

Hoist control handle limits

Control operation	Handle movement	Main pump tilt
Hoisting		
Rack up	62°	10° 42'
Rack down	116°	20°
Lowering		
Rack up	62°	10° 42'
Rack down	26°	4° 29'

Function control lever interlock. The function control and shut-off valve (described on page 9-13 is positioned through a separate operating lever (fig. 9-9) which is pivoted in an integral mounting flange of the valve. Provided with a spring-loaded locking pin, the valve operating lever is interlocked with the hoist control handles through an interlock solenoid.

The interlock arrangement is such that when the solenoid is de-energized, the valve operating lever is locked in its HOIST or LOWER position by the solenoid plunger. To release the valve operating lever, the solenoid is energized to retract the plunger by placing both hoist control handles at neutral stroke thereby closing the interlock switches.

Hoist control indicator. The hoist control indicator provides the projectile hoist operator with visual and audible signals which indicate safe or dangerous hoist conditions.

Visual. There are six lights in the hoist control indicator (fig 9-8) which when lighted illuminate the following legends:

HOIST. A green light. It indicates that the function control and shut-off valve handle is positioned at HOIST PROJECTILES, and that the cradle is empty and aligned with the hoist tube.

DANGER. A red light. It indicates that a projectile is in the cradle or that the cradle assembly is lowered.

LOWER. A green light. It indicates that the function control and shut-off valve handle is positioned at LOWER PROJECTILES.

TOP OF STROKE. A clear light. It indicates that the hoisting piston and rack crosshead have completed an upward stroke.

BOTTOM OF STROKE. A clear light. It indicates that the hoisting piston and rack crosshead have completed the downward stroke.

LATCH CLEAR. A clear light. It indicates that the function control and shut-off valve handle is positioned at LOWER PROJECTILES, and that the cradle projectile latch has been moved aside to release a projectile in the cradle.

Audible. The audible hoist control indicator is a single-stroke hoist-ready gong which is mounted at each hoist operating station. It sounds the instant HOIST is indicated on the visual indicator.

Hoist control clutches. Mounted with free bearing on a common vertical control shaft, the hoist control handles are engaged with the shaft through separate clutches. The clutch, a spring-loaded detent type assembly, consists of a clutch collar, an adjusting clutch collar, a spring, a spring retainer, and a clutch lever. Mounted on the hoist control shaft (fig. 9-11), the clutch is manually operated through the clutch lever which is held by a locking pin to lock the clutch in the engaged or disengaged position. Either control handle may be engaged with the control shaft and the other disengaged from the shaft to be locked at neutral stroke through the control handle locking pin.

Limit Switches. Four limit switches are installed in the projectile latch indicator system QB, for each hoist. Two of these four switches are installed on each hoist tube at the pan floor level. These switches are actuated by the crosshead when the hoist has completed its raising cycle. One switch operates the interlock solenoid on the control mechanism at the lower projectile handling level and one operates the top of stroke indicator lights. The other two limit switches are installed on the bottom of the lower projectile handling platform casting. These two switches are actuated by the rack bar when the hoist has completed its lowering cycle. One switch operates the interlock solenoid on the control mechanism at the lower projectile handling level and one operates the bottom of stroke indicator lights.

Solenoid Operated Interlocks. Each hoist is equipped with a solenoid operated interlock installed on the control mechanism at the lower projectile handling level. The solenoid operated interlock is operated by the top of stroke limit switch and the bottom of stroke limit switch upon completion of each cycle. This solenoid operated interlock locks

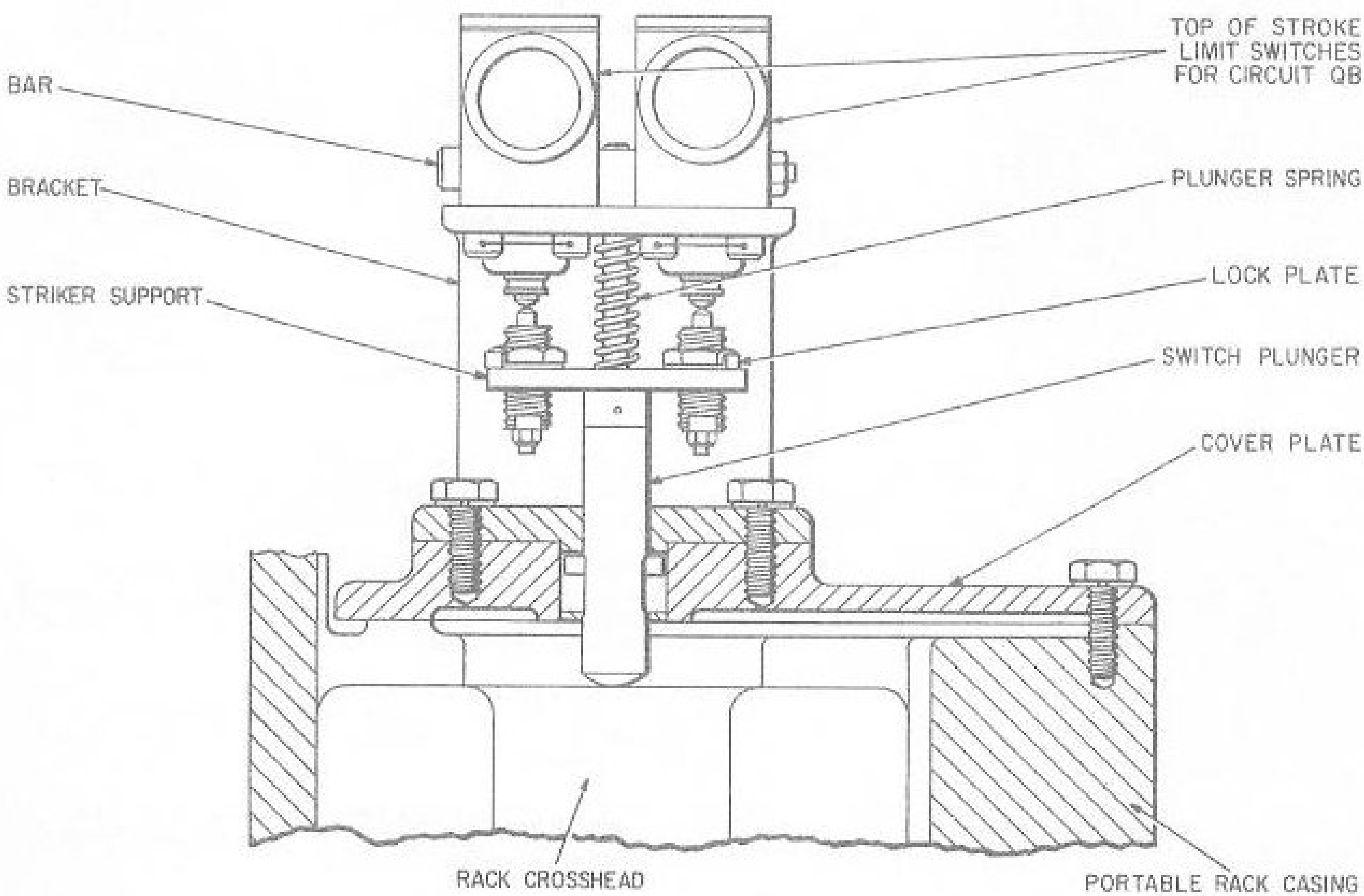


Figure 9-12. Projectile Hoist Top of Stroke Limit Switch - Sectional View

the control levers at Hoist or Lower, until the completion of the hoisting or lowering cycle. The hoist control levers cannot be moved from HOIST to LOWER, or from LOWER to HOIST, until the hoisting or lowering cycle is completed. The prevents inadvertent reversal of the projectile hoist which would cause the seating of projectiles on the nose of lower projectile.

Cradle operating controls. The cradle operating controls, similar for each hoist installation are:

- Cradle control valve handle
- Cradle latch
  - Foot pedal
  - Interlock (cradle alignment)
- Cradle and spanning tray interlock limit switch
- Projectile indicator lever
  - Interlock (projectile in cradle)

Cradle control valve handle. The cradle control valve handle, a bronze casting, is vertically pivoted in the cradle control valve mounting flange and is connected to the valve. Actuated when the valve handle is positioned toward RAISE CRADLE or LOWER CRADLE, the cradle control valve functions as described on page 9-12.

Cradle latch. The cradle latch assembly (fig. 9-13) is described on page 9-12. Located on the inside of the cradle fulcrum, it latches the cradle in a raised position through its contact with an integral cradle cam lug.

Foot pedal. The cradle latch assembly is actuated to release (unlatch) the cradle through a foot pedal. Located near the cradle operator's station, the foot pedal is connected to the latch through shafting and the latch yoke. When depressed, the foot pedal moves the latch down against spring pressure to remove the latch from contact with the cradle cam lug and permit the cradle to be raised or lowered.

Interlock (cradle alignment). The cradle latch interlock unit is mounted in the gun room compartment forward and below the cradle fulcrum. Connected by linkage to the foot pedal, the unit is arranged to interlock foot pedal operation of the cradle latch with the loading position of the gun. Locked at all other times, the foot pedal is released to unlatch the cradle when a bumper mounted on the loader's platform contacts (at five degrees elevation) a trigger pivoted in the interlock unit mounting bracket.

Cradle and spanning tray interlock limit switch. The cradle and spanning tray interlock limit switch is mounted on a bracket attached to the cradle fulcrum. The switch actuates an interlock solenoid in the elevating gear electric motor controller. A full description of the interlock limit switch and solenoid assembly is given on page 5-14 (chapter 5).

Projectile indicator lever. A hook shaped cam, the indicator lever, is displaced by a projectile as it enters the cradle. This actuates the indicator latch to close the projectile indicator switch.

Interlock (projectile in cradle). When closed by the indicator latch, the projectile indicator switch interlocks the hoist control handle against movement toward HOIST.

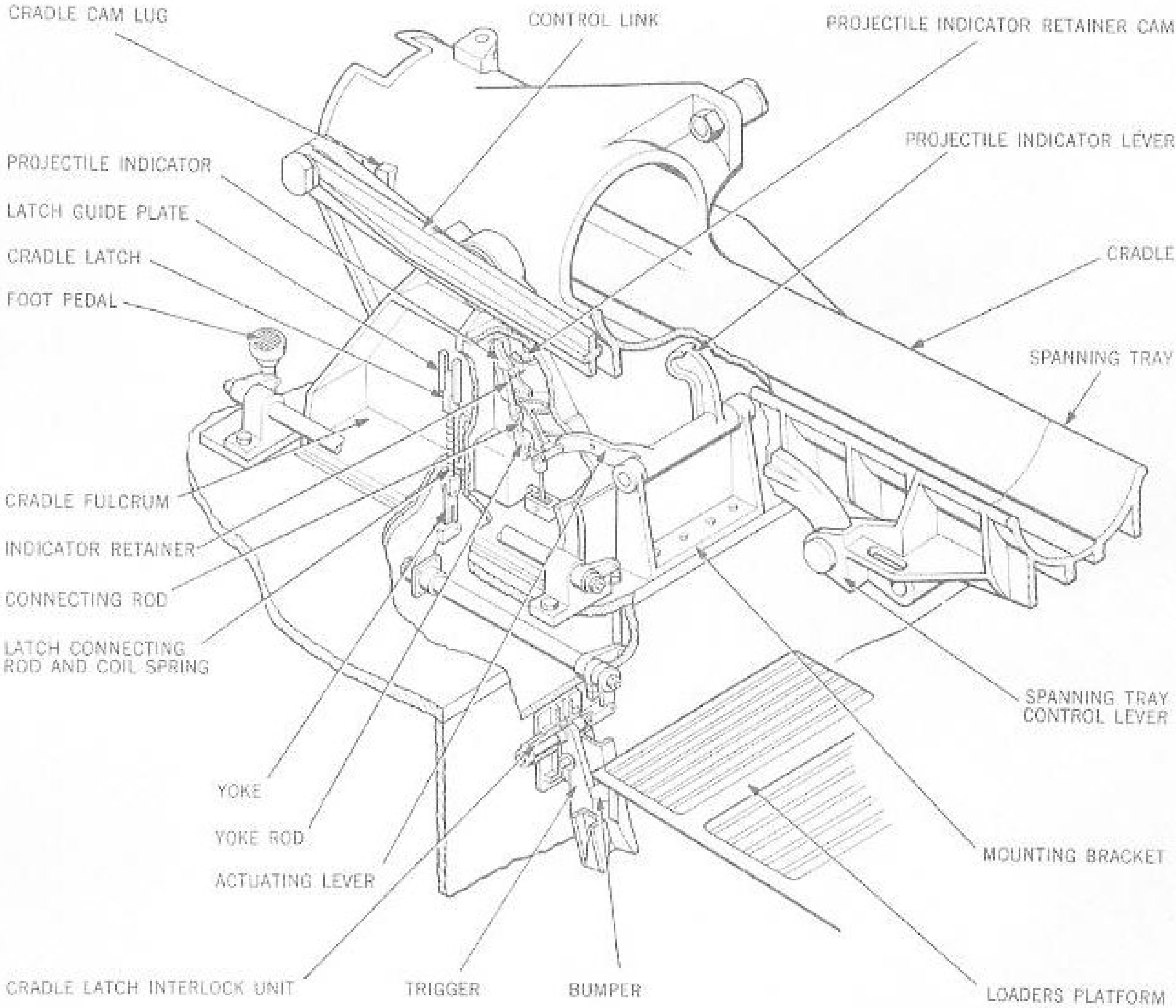


Figure 9-13. Projectile Hoist Cradle and Cradle Control Devices

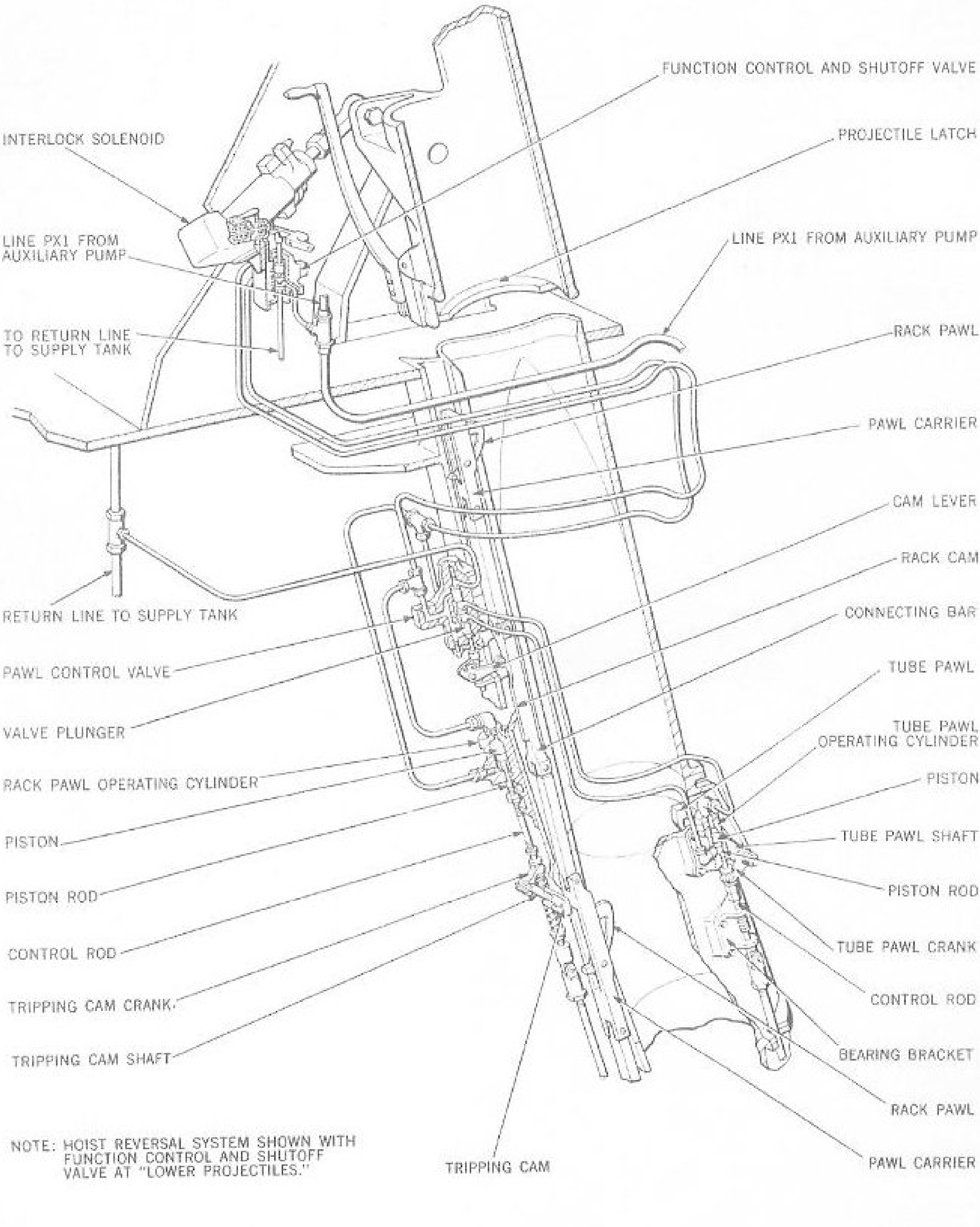


Figure 9-14. Tube Pawl and Rack Pawl Reversing Control Arrangement - Sectional View

Neutral start interlock. A neutral start interlock switch (fig. 9-19) is located on the underside of each hoist control handle bracket. It is plunger operated by a cam on the underside of the hoist control handle. The switches are connected in series in the controller starting circuit so that the proper drive motor cannot be started unless the switches are closed (by the control handles at neutral). In addition the switches are series connected with the function control and shut-off valve solenoid.

Function control and shut-off valve handle. The function control and shut-off valve handle is interlocked with the hoist control handles through a solenoid (fig. 9-19). The circuit arrangements prevent movement of the valve handle unless the hoist control handles are at neutral position. When the hoist control handles are at neutral, the neutral interlock switches are closed to energize and retract the solenoid to permit valve handle movement.

Door and shutter interlock (parbuckling operation). The projectile hoist uses eight door and shutter interlock switches, four at each loading level. Series connected, the switches open to de-energize solenoids A and B and prevent movement of the hoist control handle (fig. 9-19) when the shutters are opened and a projectile is parbuckled into the hoist. When the shutters close behind the projectile the switches close, the solenoids are energized, and the hoist control handle may be moved.

Operating handle. Located near the outer end on the underside of each operating handle (hoist control handle) bracket are the operating handle solenoids A and B (fig. 9-19). Connected in parallel, the solenoids are series-connected with the door and shutter interlock switches. When de-energized, the solenoid plungers extend upward through the handle bracket into a recess in the underside of the hoist control handle to lock it.

A solenoid operated interlock is installed on the control mechanism at the lower projectile handling level of each hoist which prevents the hoist control operating handle from being moved from HOIST to LOWER, or LOWER to HOIST, until the hoisting or lowering cycle is completed. This prevents inadvertent reversal of the projectile hoist which would cause the seating of projectile on the nose of lower projectiles. In the event of power failure, the manual retracting mechanism can be used to retract the solenoid plunger and the control operating handle may be operated.

OPERATION

General

The hoisting (or lowering) of projectiles and the raising or lowering of the cradle assembly are manually controlled, hydraulic power-driven operations. There are no provisions for manual operation of the hoist or cradle.

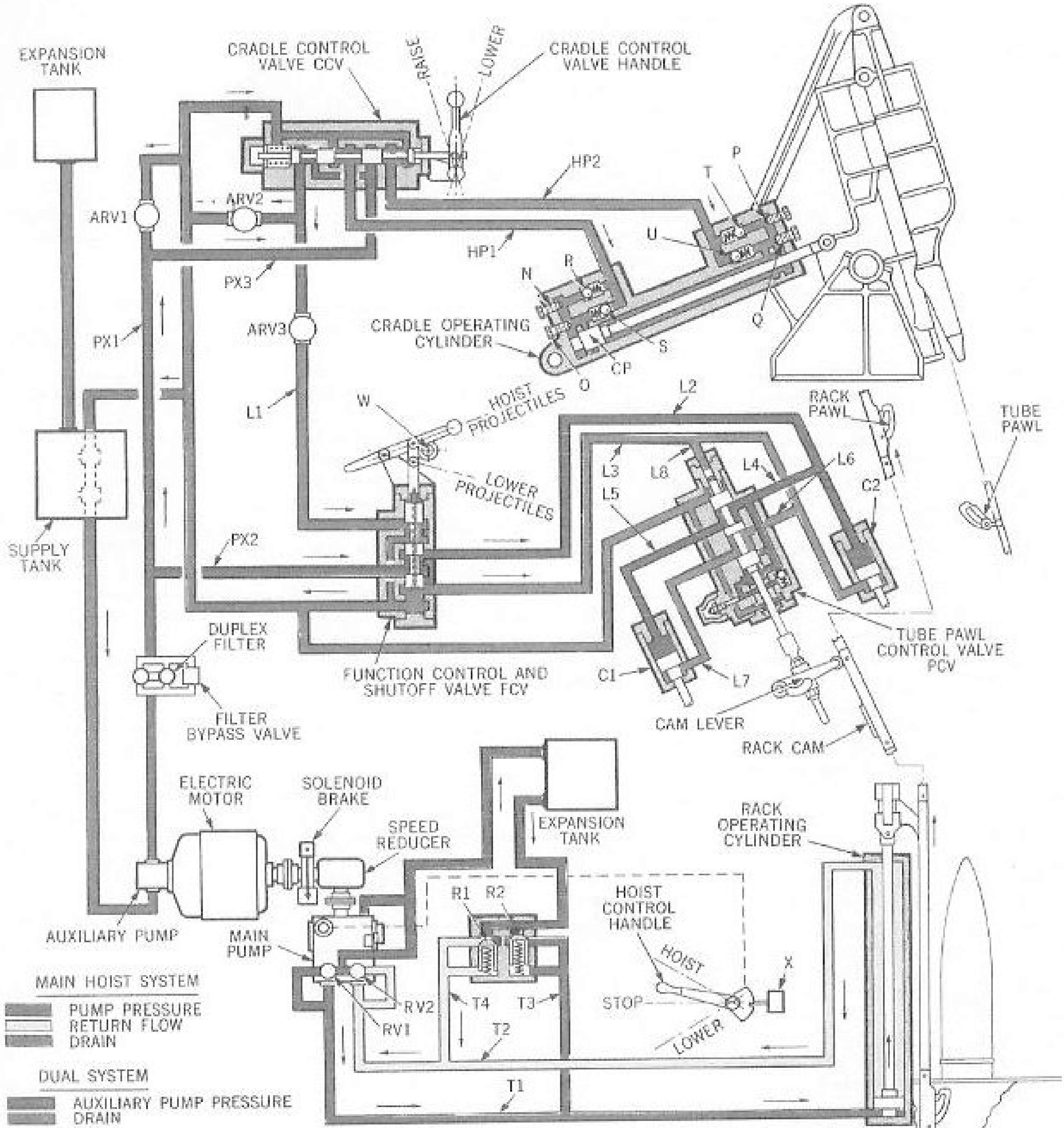
With the power on, operations of the hoist assembly are as follows:

Reciprocating action of rack. The rack, connected to the piston rod of the rack operating cylinder assembly, has a similar reciprocating action while either hoisting or lowering projectiles. As a hoisting (or lowering) cycle is begun, the rack is raised by piston action until a full stroke (as indicated by TOP OF STROKE illuminated in the hoist control indicator) is completed. The rack is then lowered by piston action until a full stroke (as indicated by BOTTOM OF STROKE illuminated in the hoist control indicator) is completed. The next hoisting (or lowering) cycle may now be begun. The alternating up and down (reciprocating) action of the piston and rack to raise (or lower) projectiles to the next level is repeated until a projectile is in the cradle (or until the hoist is emptied if lowering projectiles).

Cradle lowering and raising. After a projectile has been lifted into the cradle in the final hoist cycle (as indicated by DANGER illuminated in the hoist control indicator) the rack is lowered through a full stroke. The cradle lowering operation, actuated by the cradle operating cylinder when permitted by the cradle solenoid valve, is now begun with the gun elevated to its loading position, the breech opened, and the gun bore cleared. The cradle operator depresses the foot pedal (to unlatch the cradle) and positions the cradle control valve handle at LOWER CRADLE. The cradle operating cylinder then rotates the cradle and enters the spanning tray into the open gun breech. After the projectile and powder bags have been served to the gun by the rammer assembly (as described in chapter 10) the cradle operator positions the cradle control valve handle at RAISE CRADLE. The cradle operating cylinder then retracts the spanning tray from the gun breech and raises the cradle and spanning tray to a folded position.

Hoisting and lowering of projectiles. Projectiles are hoisted to the cradle or lowered from it by manipulation of the interrelated hoist controls. To hoist projectiles, the hoist control handle is positioned at STOP and the function control and shut-off valve handle at HOIST PROJECTILES. After a projectile has been parbuckled into the hoist, the hoist control handle is moved from STOP to HOIST. This inititates the hoist cycle and the rack is raised through a full stroke to lift the projectile to the next higher level. The hoist control handle is now moved from the HOIST to LOWER. This initiates the second half of the hoist cycle and lowers the rack so that the next hoist cycle may begin.

To lower projectiles, the hoist control handle is positioned at STOP and the function control and shut-off valve handle at LOWER PROJECTILES. This action ports auxiliary pump pressure to the hoist reversal system to cause pawl operation for lowering projectiles. The hoist control handle is then moved from STOP to HOIST; the rack moves up its full stroke to raise the projectile in the cradle just clear of the projectile latch. The projectile latch is then retracted manually to permit downward passage of the projectile. After the latch is fully retracted, the hoist control handle is moved from



ARV1, ARV2, ARV3 DUAL SYSTEM RELIEF VALVES
C1 TUBE PAWL OPERATING CYLINDER
C2 RACK PAWL OPERATING CYLINDER

VALVE, PISTON, AND ELECTRICAL SYMBOLS
CP CRADLE-OPERATING CYLINDER PISTON
N, O, P, Q CRADLE-OPERATING CYLINDER, RESTRICTIONS
R, S, T, U CRADLE-OPERATING CYLINDER, BALL CHECK VALVES

R1, R2 REPLENISHING VALVES
RV1, RV2 MAIN SYSTEM RELIEF VALVES
W, X SOLENOID-OPERATED INTERLOCKS

Figure 9-15. Projectile Hoist Schematic Diagram - Rack Beginning to Ascend; Dual System Idling.

HOIST to LOWER. This initiates the second half of the lowering cycle and lowers the projectile through a full stroke until it resets on a tube pawl. The next lowering cycle is initiated by moving the hoist control handle to HOIST to lift the projectile above the tube pawl on which it is resting. Both halves of the lowering cycle are continued until the projectile is at the desired projectile flat level and may be parbuckled from the hoist.

Starting

The hoist power drive is started as follows:

1. Place the hoist control handle at STOP.

2. Make sure that the cradle valve handle is at neutral position.

3. Place the function control and shut-off valve handle at HOIST PROJECTILES. This is not essential to starting the power drive but is a normal procedure in anticipation of following operations.

4. Press the START pushbutton.

Stopping

The hoist power drive is stopped as follows:

1. Place the hoist control handle at STOP.

2. Make sure that the cradle control valve handle is at neutral position.

3. Press the STOP push button.

NOTE: In an emergency, the power drive can be stopped immediately, regardless of hoist or cradle position, by pushing any one of the three STOP push buttons.

Serving projectiles

At both the upper and lower projectile flats, projectiles are loaded from the inner projectile rings into the hoists. Projectiles are moved from the projectile rings (chapter 7) into the hoist by parbuckling (chapter 8). The spring-loaded shutters at each loading level retain the projectiles in the hoist after they are placed within it. Projectiles are hoisted to the next level as each projectile is parbuckled into the loading level, provided the control interlocks are clear. The controls permit loading and hoisting at either projectile flat.

Filling hoist

The hoist is filled as follows: After a projectile is parbuckled into the hoist, the hoist control handle is positioned at HOIST and the projectile is automatically lifted to the next higher level. The next projectile can be parbuckled into the hoist as soon as the loading level is clear. The rack is then lowered again by positioning the hoist control handle at LOWER. As successive projectiles are parbuckled into the hoist, the manipulation of the hoist control handle is repeated as above until a projectile is lifted into (and latched in) the cradle. Interlocks then prevent the hoist from operating until the cradle is emptied and returned to its folded position. This procedure is repeated until the demand for projectiles is ended.

Hydraulic action

Hoist hydraulic arrangements are described in following paragraphs and are shown schematically in figure 9-15 to 9-18 inclusive.

Hoisting projectiles. The hoist may be filled and operated to hoist projectiles from either the upper or lower projectile flat loading level. With the hoist power drive in operation, the crosshead and rack in the bottom of stroke position (BOTTOM OF STROKE dial illuminated), position the function control and shut-off valve at HOIST PROJECTILES. This causes HOIST to be continuously illuminated in the hoist control indicators until a projectile is delivered into the cradle. As soon as the crosshead rack starts up, the BOTTOM OF STROKE dial goes out. With the control handle at the hoist control station to be used at STOP, engage the handle clutch. The hoist control handle is interlocked at STOP while the hoist shutters are held open by the projectile being loaded into the hoist; the handle is released when the shutters close. When the hoist control handle is operated to hoist projectiles and fill the hoist (described previously), TOP OF STROKE will be illuminated in the hoist control indicator at the completion of each hoist stroke. After a projectile has been delivered into the cradle, HOIST will no longer show and DANGER will be illuminated in the hoist control indicators. Also, the hoist control handle will be blocked from movement toward HOIST (by one of the interlock solenoids) but can be moved toward LOWER. The DANGER signal will be continuously illuminated until the cradle has been lowered and then raised empty to hoist position. This condition is indicated to the hoist control operator by the DANGER light going out, the gong sounding, and the HOIST light going on.

Rack ascending (fig. 9-15). With the hoist control handle (tilting box) offset to HOIST, the following conditions exist:

1. Main pump pressure at approximately 1000 pounds per square inch (controlled by relief valve RV1) is ported to the bottom of the rack operating cylinder through line T1, and the piston and rack ascent. The system is replenished through replenishing valve R1 and lines T4 and T2.

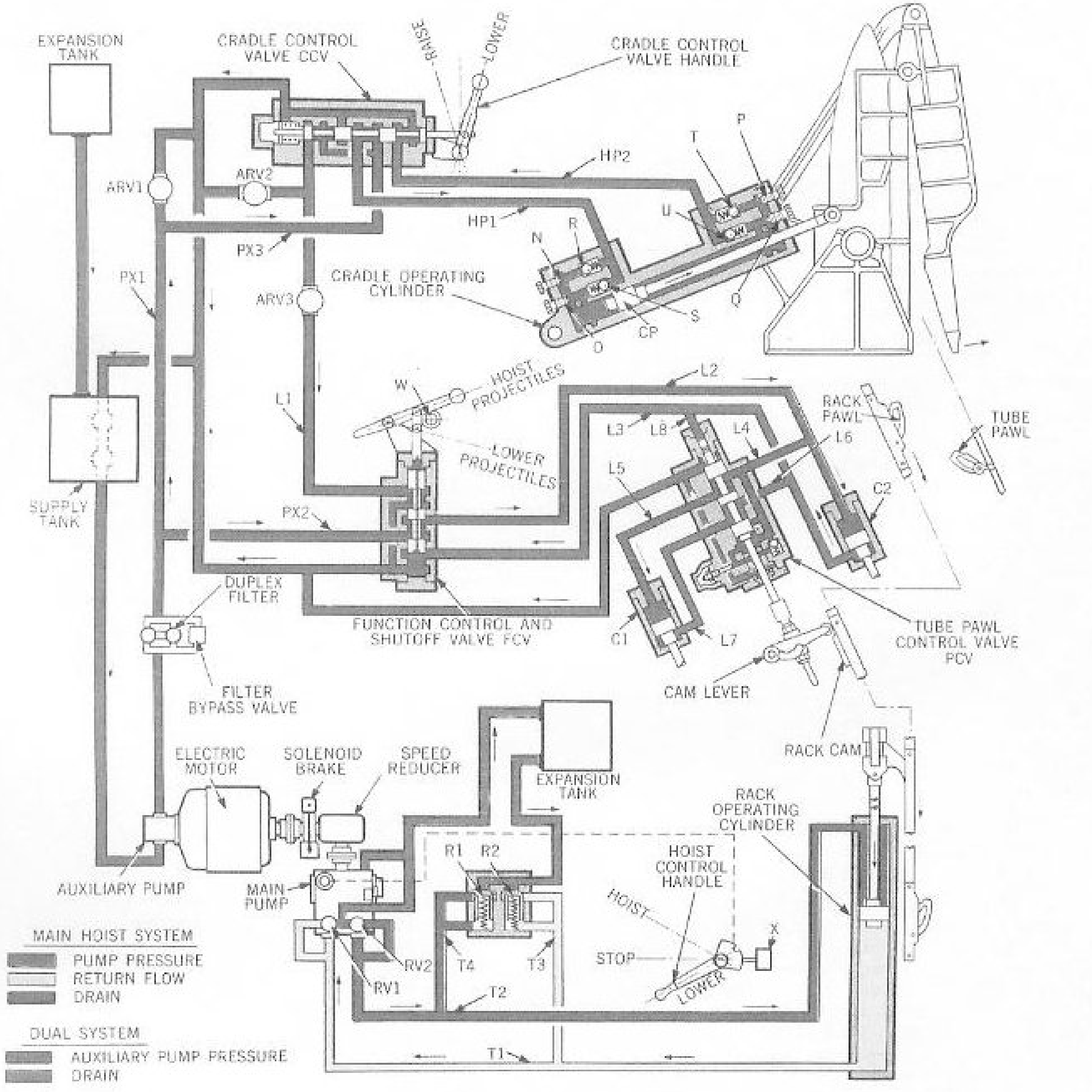
2. Auxiliary pump pressure at approximately 25 pounds per square inch (controlled by relief valve ARV3) is ported to the dual system through the duplex filter and lines, PX1, PX2, and PX3. This pressure (circulating flow) is blocked from the cradle operating cylinder and is ported to the function control and shut-off valve FCV through line 1 by the cradle control valve CCV (positioned at neutral). Positioned at HOIST PROJECTILES, FCV directs pressure from line PX2 through line L2 to the top of the rack pawl operating cylinder C2 (holding the piston down and extending the rack pawls) and through lines L2 and L4 to the tube pawl control valve PCV. PCV directs the pressure through line 15 to the top of the tube pawl operating cylinder C1 (holding the piston down and extending the tube pawls).

Rack descending (fig. 9-16). With the hoist control handle (tilting box) offset to LOWER, the following conditions exist:

1. Main pump pressure at approximately 100 pounds per square inch (controlled by relief valve RV2) is ported to the top of the rack operating cylinder through line T2, and the piston and rack descent. Relief valve RV2 by-passes rack operating cylinder differential displacement to the expansion tank. The replenishing valves R1 and R2 both remain seated.

2. Auxiliary pump pressure at approximately 800 pounds per square inch (controlled by relief valve ARV1) is ported to the dual system through the duplex filter and lines PX1, PX2, and PX3. This pressure is directed by the cradle control valve CCV (positioned at LOWER CRADLE) through line HP1 to the cradle operating cylinder. In addition CCV blocks the pressure from line L1 (blocking out relief valves ARV2 and ARV3) permitting pressure build-up in the entire dual system to 800 pounds per square inch. The function control and shut-off valve FCV, positioned at HOIST PROJECTILES, directs pressure to the tube pawl operating cylinder C1 and the rack pawl operating cylinder C2 to hold the piston down the same as when the hoist control was offset to HOIST.

3. Auxiliary pump pressure directed to the cradle operating cylinder by CCV through line HP1 holds check valve R seated. The pressure is ported through check valve S and restriction 0 to the bottom of the cradle operating cylinder. The upper end of the cradle operating cylinder is vented to the supply tank through restriction P, check valve T, and line HP2.



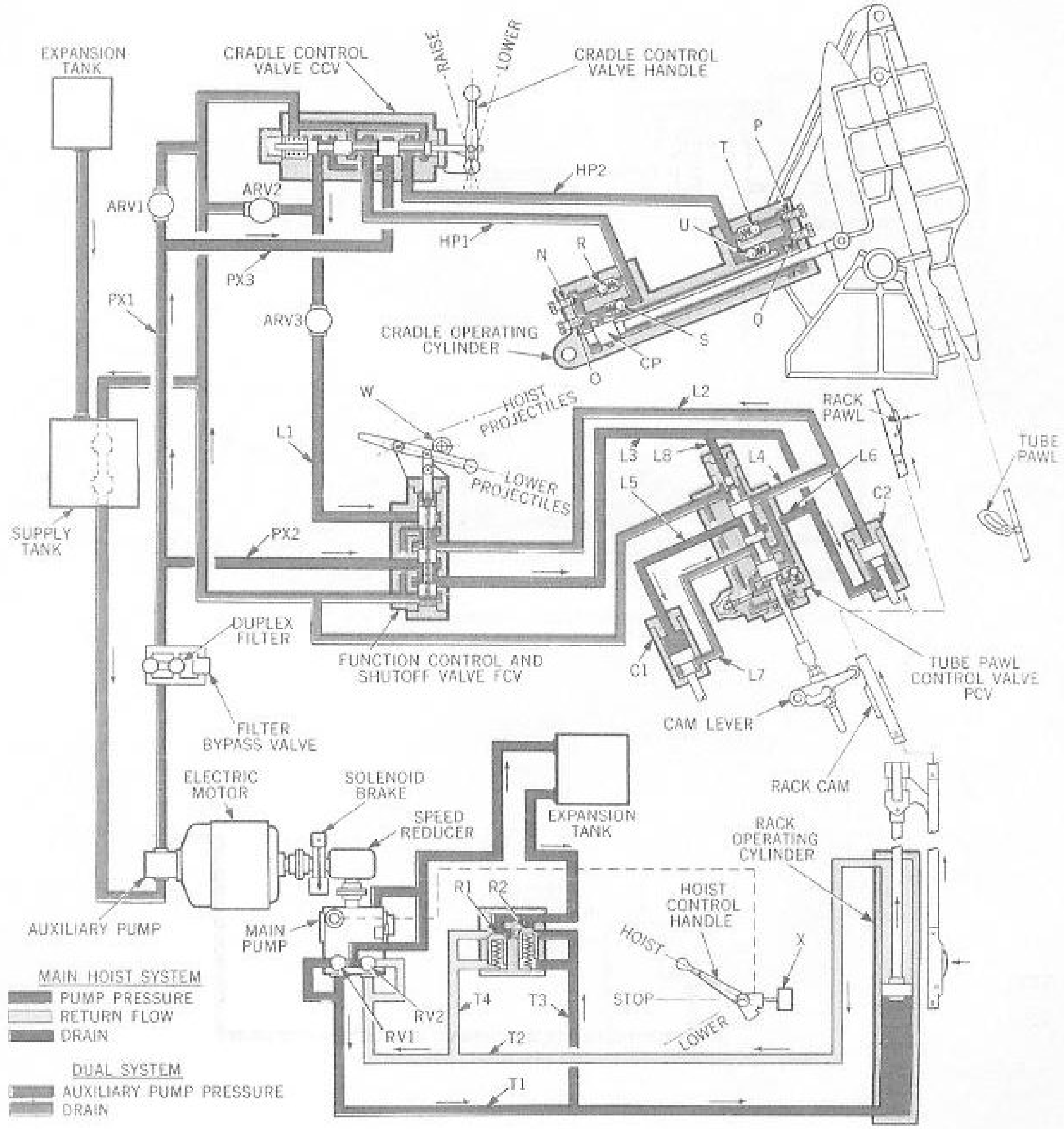
VALVE, PISTON, AND ELECTRICAL SYMBOLS

ARV1, ARV2, ARV3 DUAL SYSTEM RELIEF VALVES
C1 TUBE PAWL OPERATING CYLINDER
C2 RACK PAWL OPERATING CYLINDER

CP CRADLE-OPERATING CYLINDER PISTON
N, O, P, Q CRADLE-OPERATING CYLINDER, RESTRICTIONS
R, S, T, U CRADLE-OPERATING CYLINDER, BALL CHECK VALVES

R1, R2 REPLENISHING VALVES
RV1, RV2 MAIN SYSTEM RELIEF VALVES
W, X SOLENOID-OPERATED INTERLOCKS

Figure 9-16. Projectile Hoist Schematic Diagram - Rack Descending After Delivering Projectile to Cradle; Cradle Beginning to Lower.



VALVE, PISTON, AND ELECTRICAL SYMBOLS

ARV1, ARV2, ARV3 DUAL SYSTEM RELIEF VALVES
C1 TUBE PAWL OPERATING CYLINDER
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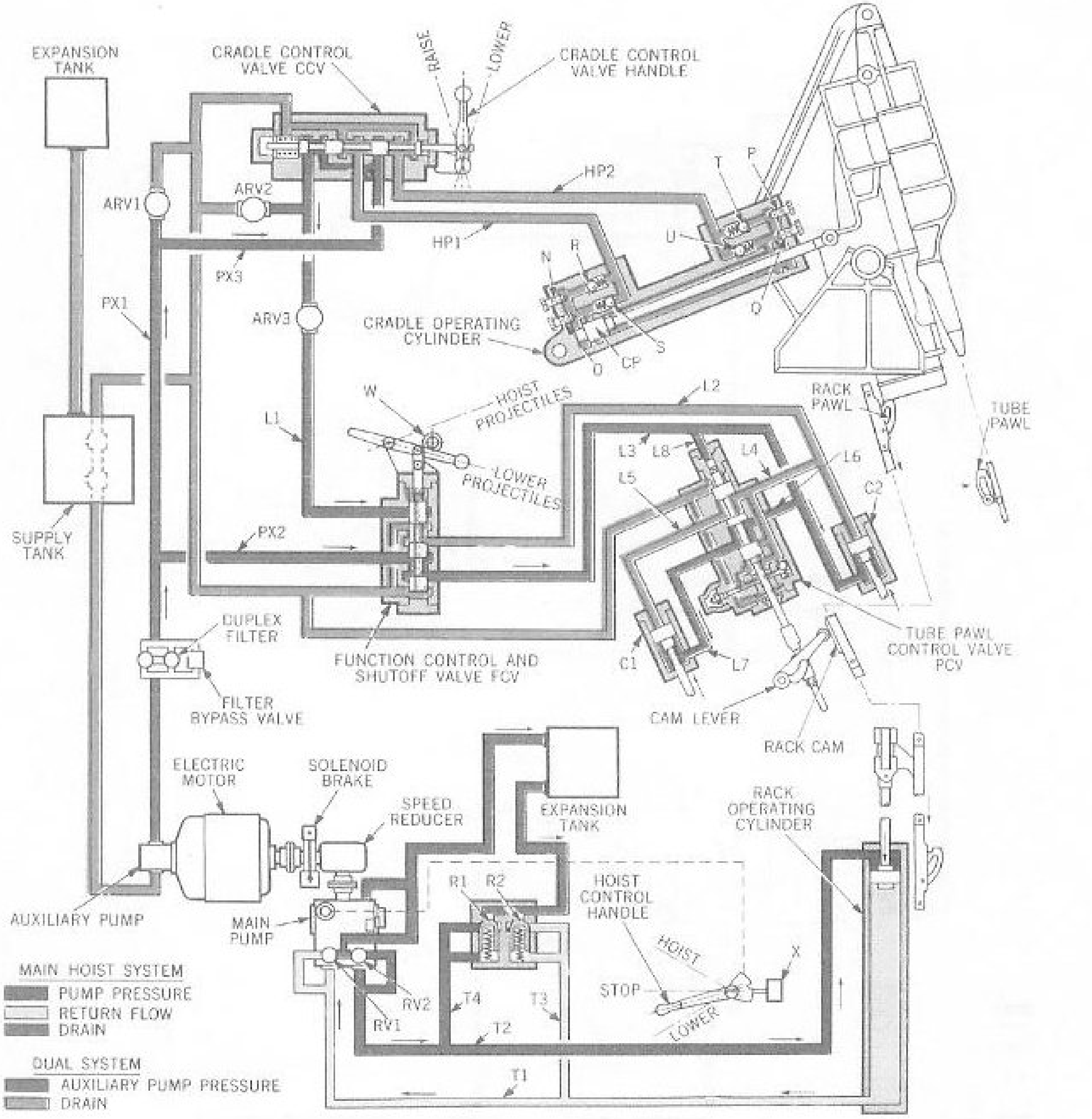
CP CRADLE-OPERATING CYLINDER PISTON
N, O, P, Q CRADLE-OPERATING CYLINDER RESTRICTIONS
R, S, T, U CRADLE-OPERATING CYLINDER, BALL CHECK VALVES

R1, R2 REPLENISHING VALVES
RV1, RV2 MAIN SYSTEM RELIEF VALVES
W, X SOLENOID-OPERATED INTERLOCKS

Figure 9-17. Projectile Hoist Schematic Diagram - Rack Ascending to Lower Projectile from Cradle; Rack Pawls Retracted.



VALVE, PISTON, AND ELECTRICAL SYMBOLS

ARV1, ARV2, ARV3 DUAL SYSTEM RELIEF VALVES
C1 TUBE PAWL OPERATING CYLINDER
C2 RACK PAWL OPERATING CYLINDER

CP CRADLE-OPERATING CYLINDER PISTON
N, O, P, Q CRADLE-OPERATING CYLINDER, RESTRICTIONS
R, S, T, U CRADLE-OPERATING CYLINDER, BALL CHECK VALVES

R1, R2 REPLENISHING VALVES
RV1, RV2 MAIN SYSTEM RELIEF VALVES
W, X SOLENOID-OPERATED INTERLOCKS

Figure 9-18. Projectile Hoist Schematic Diagram - Rack Descending with Projectile from Cradle; Tube Pawls Retracted

Lowering projectiles. The hoist may be operated to lower projectiles from either the upper or lower control station. With the hoist power drive in operation, the projectile to be lowered resting in the cradle, and the rack lowered through a full stroke, position the function control and shut-off valve handle at LOWER PROJECTILES. Clutch-engage the control handle at the hoist control station to be used.

These settings cause LOWER to be illuminated in the hoist control indicators. They also energize a solenoid to retract the interlock which blocks raising the rack, and set the interlock which limits control handle movement for lowering. When the hoist control handle is operated to HOIST to raise the rack, TOP OF STROKE is illuminated in the hoist control indicator at the completion of each hoist stroke. The cradle operator moves aside the projectile latch to close a switch and cause LATCH CLEAR to be illuminated in the hoist control indicators. These operations prepare for lowering the projectile from the cradle and the hoist control operator cam move the control handle (movement limited by interlock) to LOWER. As the projectile is lowered clear of the cradle both the LATCH CLEAR and TOP OF STROKE lights are cut out.

Rack ascending (fig. 9-17). With the hoist control handle (tilting box) offset to HOIST, the following conditions exist:

1. Main pump pressure at approximately 1000 pounds per square inch (controlled by relief valve RV1) is ported to the bottom of the rack operating cylinder through T1, and the piston and rack ascend. The system is replenished through replenishing valve R1 and lines T4 and T2.

2. Auxiliary pump pressure at approximately 400 pounds per square inch (controlled by relief valve ARV2) is ported to the dual system through the duplex filter and lines PX1, PX2, and PX3. This pressure is blocked from the cradle operating cylinder and is ported to the function control and shut-off valve FCV through line L1 by the cradle control valve CCV (positioned at neutral). Positioned at LOWER PROJECTILES, FCV directs pressure from line PX2 through line L3 to the bottom of the rack pawl operating cylinder C2 (holding the piston up and retracting the rack pawls). In addition FCV directs pressure through lines L3 and L8 to the top of the tube pawl control valve PCV, and through lines L3 and L6 to the upper groove of PCV.

3. Held down by auxiliary pump pressure in line L8, PCV directs auxiliary pump pressure from line L6 through line L5 to the top of the tube pawl operating cylinder C1 (holding the piston down and keeping the tube pawls extended into the hoistway). When the ascending rack cam contacts and forces the valve cam-lever up, PCV directs auxiliary pump pressure from line L6 through line L7 to the bottom of C1 (holding the piston up and retracting the tube pawls).

Rack descending (fig. 9-18). With the hoist control handle (tilting box) offset to LOWER, the following conditions exist:

1. Main pump pressure at approximately 100 pounds per square inch (controlled by relief valve RV2) is ported to the top of the rack operating cylinder through line T2, and the piston and rack descend. Relief valve RV2 bypasses rack operating cylinder differential displacement to the expansion tank. The replenishing valves R1 and R2 both remain seated.

2. Auxiliary pump pressure at approximately 400 pounds per square inch (controlled by relief valve ARV2) is ported to the dual system through the duplex filter and lines PX1, PX2, and PX3. This pressure is blocked from the cradle operating cylinder and is ported to the function control and shut-off valve FCV through line L1 by the cradle control valve CCV (positioned at neutral). Positioned at LOWER PROJECTILES, FCV directs pressure from line PX2 through line L3 to the bottom of the rack pawl operating cylinder C2 (holding the piston up and retracting the rack pawls). In addition FCV directs pressure through lines L3 and L8 to the top of the tube pawl control valve PCV, and through L3 and L6 to the lower groove of PCV.

3. Held up by contact of the rack cam with the valve cam-lever, PCV directs pressure from line L6, through line L7 to the bottom of C1 (holding the piston up and retracting the tube pawls). As the piston and rack descend, the rack cam disengages from the valve cam-lever and PCV is moved down by pressure in lines L3 and L8. PCV then directs pressure from line L6 through its upper groove and line L5 to the top of the tube pawl operating cylinder C1 (holding the piston down and extending the tube pawls).

Hoist action

General hoist action and operation are described in the following paragraphs.

Hoisting projectiles (fig. 9-19). The cycle of hoist actions occurring during a projectile hoisting cycle, is as follows:

1. With the hoist full (except the cradle and bottom stage), the function control and shut-off valve handle at HOIST PROJECTILES, the rack lowered, and the hoist control handle in neutral, the BOTTOM OF STROKE indicator dial and the HOIST indicator light are illuminated. As a projectile is parbuckled into the hoist the movement of the shutter, opening to admit the projectile, opens interlock switches which de-energize solenoid B at the lower hoist control station. The solenoid plunger locks the hoist control handle in neutral until the shutters are closed again.

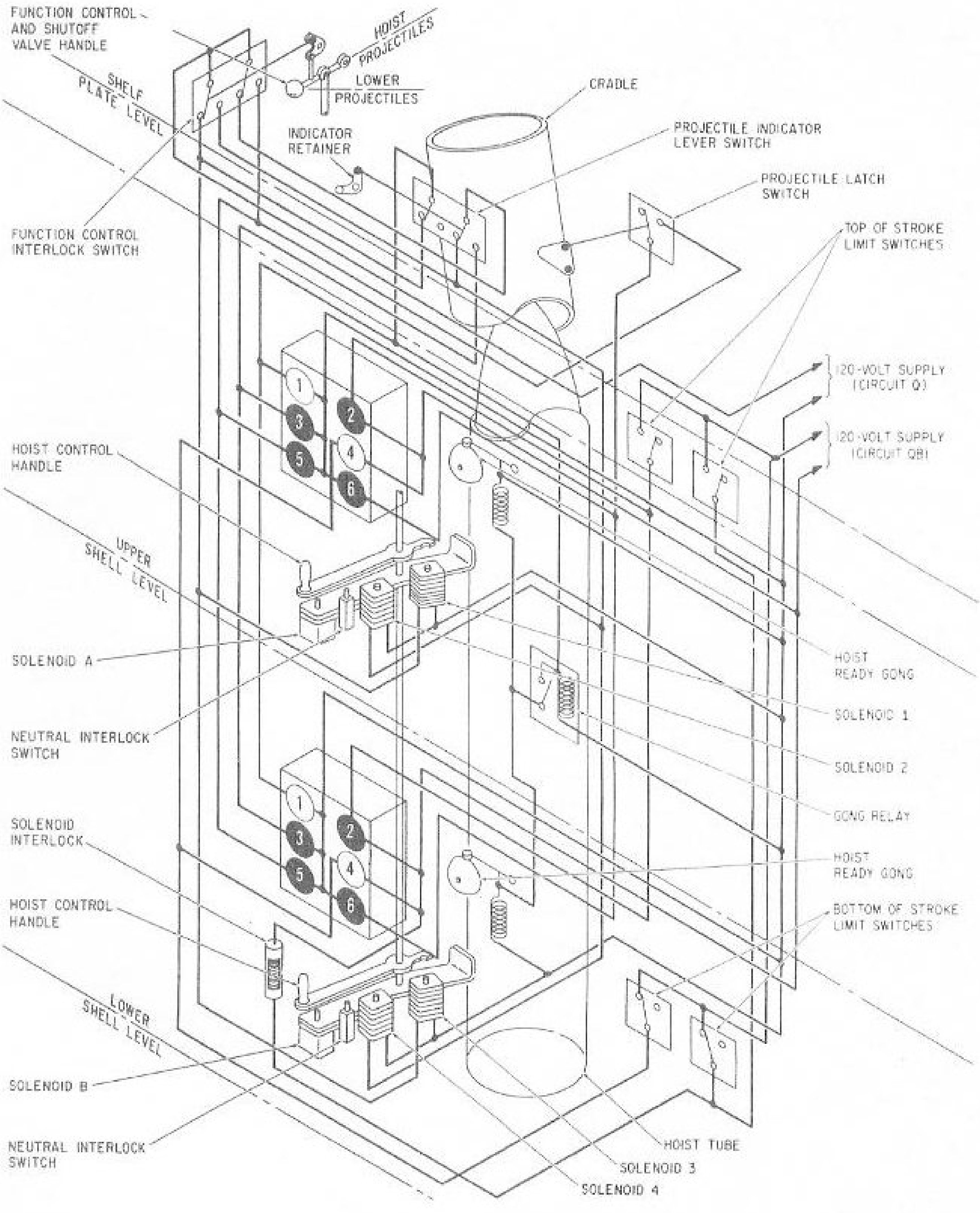
2. Movement of the hoist control handle to HOIST opens the function control interlock switch de-energizing the solenoid in the gun compartment and blocking movement of the function control and shut-off valve handle. As the rack moves upward

The BOTTOM OF STROKE indicator dial goes out.

The rack pawls engage projectiles at each tube pawl in succession from the bottom.

The ascending projectiles push the tube pawls into their respective housings.

The tube pawls move back into the hoistway as the projectile bases clear them.



1. Hoist
2. Top of Stroke
3. Danger
4. Bottom of Stroke
5. Lower
6. Latch Clear

Figure 9-19. Projectile Hoist Wiring Diagram - Hoist Position

At the top of the stroke, the crosshead indicator switch is closed (fig. 9-20), illuminating the TOP OF STROKE indicator at the hoist stations.

3. As the projectile enters the cradle (fig. 9-20), it actuates the projectile indicator lever to:

Close the projectile lever indicator switch to illuminate the DANGER indicator.

Open the projectile lever indicator switch to turn out the HOIST indicator light.

Release the indicator retainer to unlock the cradle.

Open the hoist control interlock switch (de-energizing solenoid 4) to prevent raising the rack again after it has been lowered.

The projectile latch, which is pushed back as the projectile enters the cradle, returns to its normal position as the projectile base clears it, and thus retains the projectile in the cradle.

4. When the hoist operator sees the TOP OF STROKE indicator illuminated, he moves the hoist control handle to neutral and then to LOWER. Movement of the function control handle is blocked by the solenoid plunger as when hoisting. As the rack descends:

The crosshead indicator switch opens to turn out the TOP OF STROKE indicator light.

The projectiles come to rest on the tube pawls and projectile latch.

The rack pawls are forced back against their springs as they pass the projectiles in the hoist, returning to their normal positions as they clear the projectile bases.

The rack completes downward stroke. BOTTOM OF STROKE indicator dial illuminated.

5. The rack having descended and the gun being at loading position (elevated 5^{o}) with the breech open, the cradle operator depresses the foot pedal to release the cradle latch. The operator then moves the cradle control valve handle to LOWER CRADLE thereby unfolding the cradle and entering the spanning tray into the gun breech. During this operation the DANGER indicator remains illuminated and the hoist control handle is blocked against hoisting by the hoist control handle solenoid interlock. These conditions continue throughout the operations of projectile ramming, powder transfer from car to tray, powder ramming, and return of the cradle to its folded position. During loading operations of the gun, the hoist loading operation is being repeated at the projectile handling platform. When the gun loading is completed, the cradle operator moves the cradle control valve handle to RAISE CRADLE. As the unit swings into the hoist position, the cradle latch and indicator retainer move into position to lock the cradle, and interlock switches are actuated. The hoist control handle interlock is withdrawn, the DANGER light is cut out, the HOIST indicator is illuminated, and the gong is sounded.

Lowering projectiles (fig. 9-21). The cycle of hoist actions occuring during a projectile lowering cycle, is as follows:

1. With the cradle open to receive a projectile (which is backed out of the gun), the hoist control handles are in neutral and interlocked against hoisting, and the indicator danger dial is illuminated. The cradle operator moves the cradle control valve handle to RAISE CRADLE and, as the cradle latches in folded position, shifts the function control and shut-off valve handle to LOWER PROJECTILES. This action:

Cuts out the DANGER indicator
Illuminates the LOWER indicator
Energizes the solenoid to retract the interlock which prevents raising the rack.
Positions the interlock plunger which limits hoist control handle movement.

2. When the LOWER indicator is illuminated, the hoist control operator moves the control handle to raise the rack until TOP OF STROKE is illuminated. The rack pawls are retracted as the pawl triggers contact the tripping cams, to clear projectiles in the hoist. As the rack reaches the top of its stroke, the top rack pawl lifts the projectile in the cradle clear of the projectile latch, as other projectiles are lifted clear of the tube pawls. The cradle operator then moves the projectile latch clear of the projectile, illuminating the LATCH CLEAR indicator at hoist control stations.

3. The hoist control handle is then moved to LOWER. As the rack descends, the TOP OF STROKE and LATCH CLEAR indicator lights are cut out, and the tube pawls are retracted long enough to clear the bases of the projectiles. When near the bottom of the stroke, each projectile comes to rest on the tube pawl of the stage below that from which it started. The rack completes downward stroke and BOTTOM OF STROKE indicator dial is illuminated.

INSTRUCTIONS

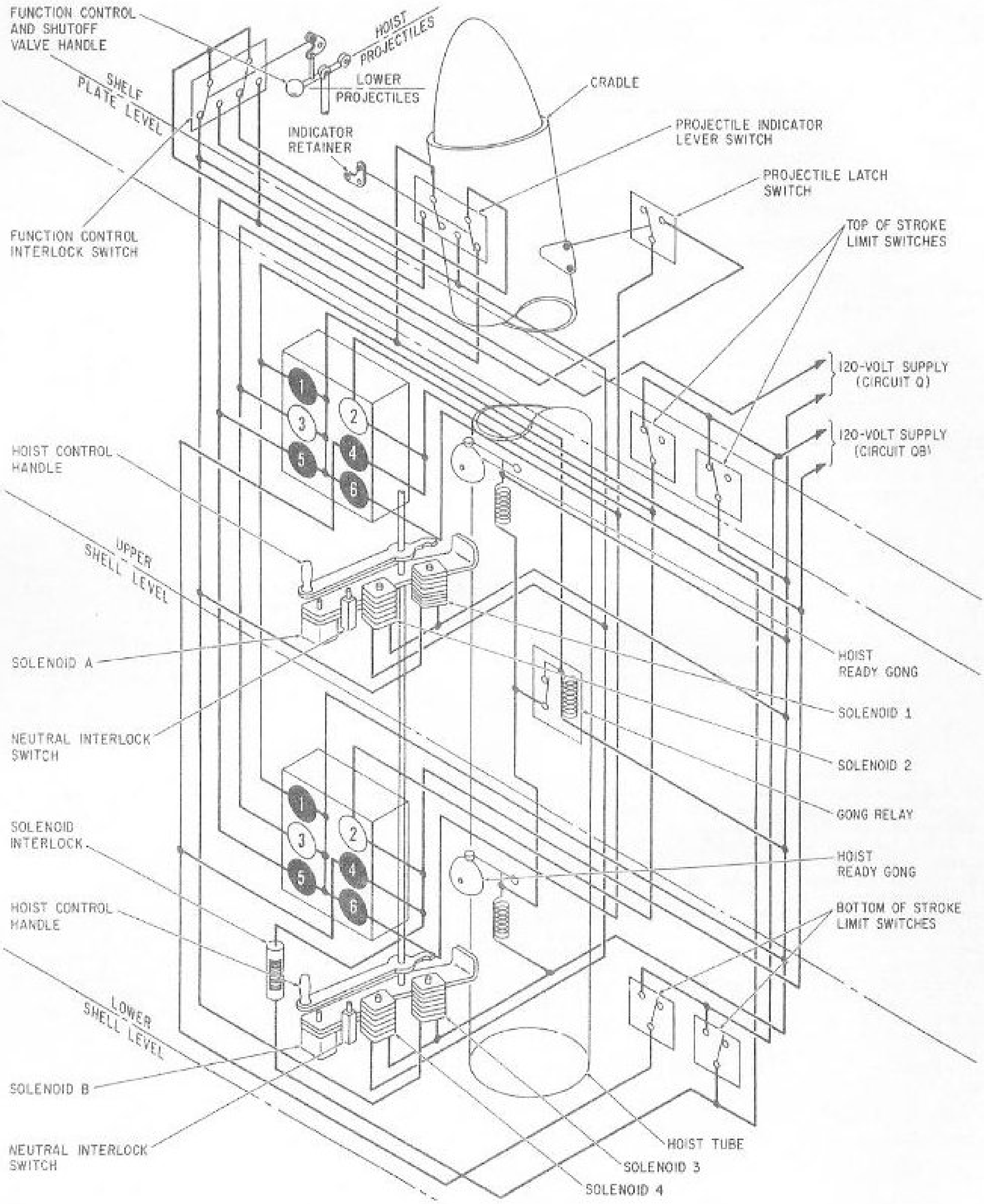
General maintenance

The projectile hoist 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.

Inspection. At installation, the projectile hoists are adjusted and checked for proper operation. They 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:

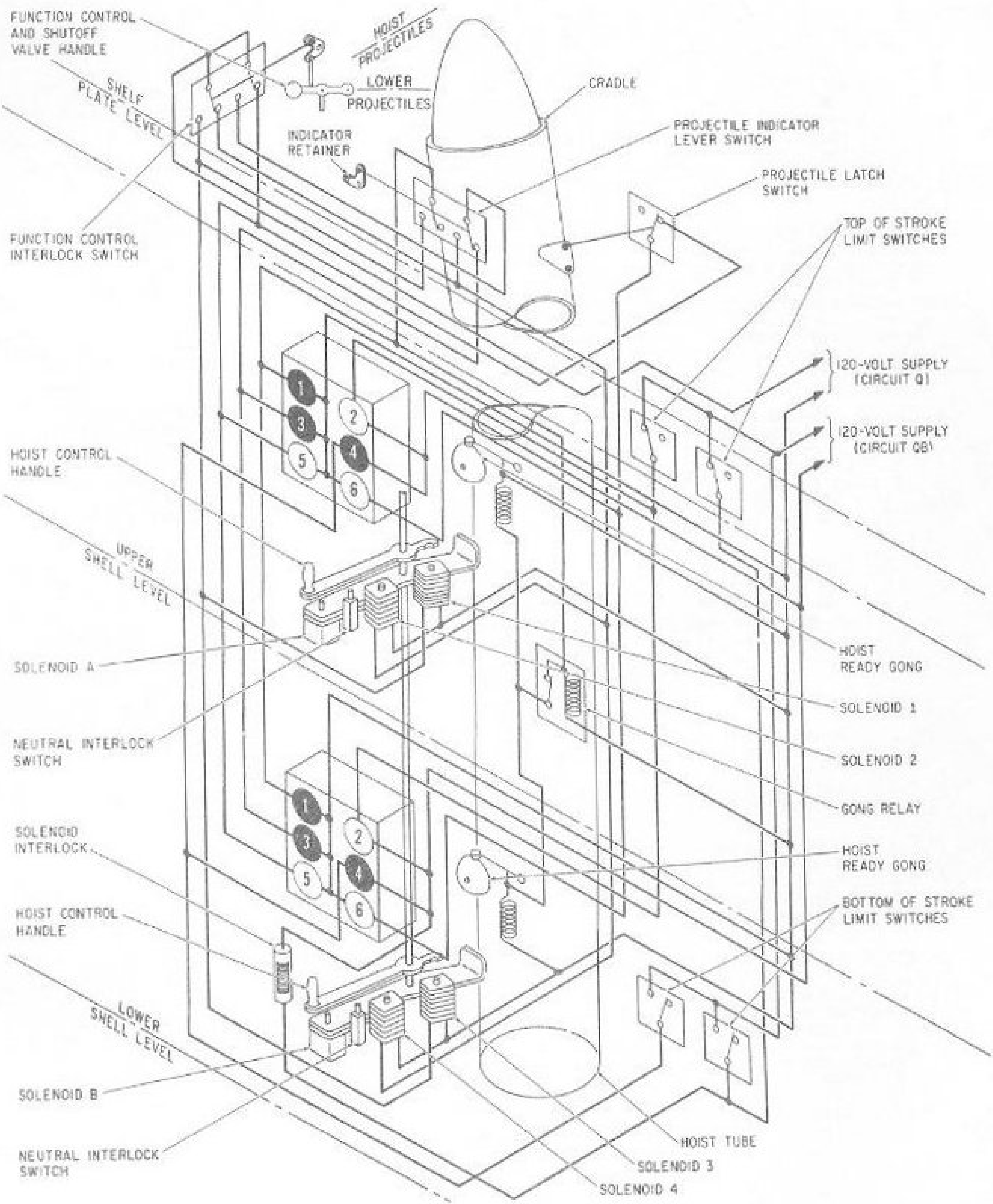
1. Alignment of shafting
2. Electric and hydraulic connections
3. Fluid level gages
4. Lubrication

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



1. Hoist	2. Top of Stroke
3. Danger	4. Bottom of Stroke
5. Lower	6. Latch Clear

Figure 9-20. Projectile Hoist Wiring Diagram - Top of Stroke Position



1. Hoist
2. Top of Stroke
3. Danger
4. Bottom of Stroke
5. Lower
6. Latch Clear

Figure 9-21. Projectile Hoist Wiring Diagram - Lower Position

Exercise operation. Operate the hoist equipment, in hoisting and lowering, and the cradle in raising and lowering, at the time of each periodic inspection. This must not be less frequent than once a week with daily exercise preferred. Exercise is essential to aid in detection of any malfunction. Frequent exercise operation also prevents the pitting and corroding that result from exposure, and keeps working parts from becoming sluggish or inoperative because of gummed lubricant, sludge, accumulation of dirt, or seizing of parts.

Lubrication. The hydraulic equipment is largely self-lubricated by the hydraulic fluid. Lubrication of the reduction gear, rack and pawls, tube pawls, cradle, shutters, and other vital parts is prescribed at definite periods, as indicated in the lubrication charts appended to chapter 18. Refer to the text of chapter 18 for information concerning alternative lubricants, substitution, and general information regarding lubrication.

Preservation. The exterior, non-rubbing surfaces of the hoist and all hydraulic units should be kept painted. Electrical components should be kept dry and clean and protected from the dripping hydraulic fluid and lubricants. Perform periodic exercise operation to keep moving parts and interior surfaces free of residue and to prevent galvanic action.

Installation instructions

When making initial or replacement installations of any parts of the hydraulic system, observe the installation instructions of chapter 17 with particular regard to the following:

1. Handle units with care.

2. Make precision line-up of pipe couplings, shafts, and connecting links of valves and cylinders.

3. Do not remove shipping adapters from any unit until ready to connect piping.

4. Unit assemblies having the same serial numbers must be used in the same hoist installation. The units comprising a drive are adjusted and tested as sets at manufacture. For maximum performance they must be installed in sets.

Operating precautions

The following operating precautions must be observed when preparing the hoist for operation and when operating. If new or overhauled hydraulic units are to be operated for the first time, make certain that all critical adjustments of linkage and mechanical parts have been made.

Refer to the adjustment paragraphs, beginning on page 9-32, for dimensions and clearances.

Before starting the electric motor.

1. Check the hydraulic fluid level in the expansion tanks. Replenish if necessary.

2. Lubricate the assembly as prescribed on the lubrication chart.

3. Check the fluid level in the cradle buffer. Replenish if necessary.

4. If the power unit is new or has been overhauled, or if any lead to the motor or controller has been disconnected, verify the direction of motor rotation.

After starting the motor and before operating to hoist or lower projectiles.

1. Run the motor until main and auxiliary system oil temperatures are normal for operation.

2. Make sure all air has been vented from the system. Refer to filling and venting procedure on page 9-31.

3. Move the hoist control handle to raise the empty rack at low speed. Lower the rack and stop the motor.

4. After an interval of five minutes, open the needle valve vent in the upper head of the rack operating cylinder. Close the vent and start the motor.

5. Operate the empty hoist, the cradle, the function control and shut-off valve, and the shutters, to verify normal operation of all indicator and interlock actions.

When operating the hoist.

To hoist projectiles:

1. Always hold the hoist control handle to HOIST position until the TOP OF STROKE indicator is illuminated.

2. While the first four projectiles are being loaded into a hoist, check the brake action. Verify the solenoid brake release movement and that the brake drum is clean and oil-free.

3. When operating the first cradle lowering movement with projectile, check the cradle buffer for normal action.

To lower projectiles:

1. The cradle operator must verify that the function control and shut-off valve is operating properly.

2. The cradle operator must not move back the cradle projectile latch until the rack is at the top of stroke.

3. When operating the first lowering cycle with projectile, check the rack pawl operating cylinder, the tube pawl operating cylinder, and the tube pawl control valve for normal, full movement.

4. Check the operating pressures in the pawl operating hydraulic circuits periodically.

5. Always hold the hoist control handle in LOWER position until the BOTTOM OF STROKE indicator is illuminated.

Hydraulic equipment servicing

Cradle buffer fluid. The fluid to be used in the cradle buffer is designated recoil cylinder liquid

MIL-G-18694. Cradle buffers should be checked for replenishment once a month, at which time they should be inspected as follows:

1. Check for 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 51F23(Ord). Use new fluid from a factory-sealed barrel only. When transferring fluid, use clean containers and funnels. When the hydraulic system is initially filled, and when replenishing, the fluid should be poured through a fine mesh wire strainer of at least 120 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 51F23(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 51F23(Ord), and refilled with fresh fluid.

Capacity. The amounts of fluid required to fill the power transmission systems are as follows:

The cradle operating and hoist reversal system requires 35 gallons of hydraulic fluid 51F23(Ord) to fill to the proper operating level.

The rack operating (main hoist) system requires 25 gallons of hydraulic fluid 51F23(Ord) to fill to the proper operating level.

Draining the system. The hydraulic system, including the supply and expansion tanks, is drained by removing the drain plugs according to the instructions of chapter 17. While draining the system, it is necessary to start-stop the motor at intervals to completely drain.

Proceed as follows:

1. Drain the power drive expansion tank through the one-inch pipe extending over the edge of the main pump case at the base of the expansion tank.

2. Drain the main pump case through the one-inch socket type pipe plug located on the same side of the pump as the tank drain pipe.

Filling and venting. The hydraulic system, including the tanks, is filled according to the instructions of chapter 17. Proceed as follows:

1. Fill the system at its respective supply tank.

2. Immediately after filling operate the system at slow speed.

3. Vent the system.

4. Check and fill the system to the proper level as indicated by the fluid level gage (or trycock).

The cradle operating and hoist reversal systems are self venting.

The rack operating (main hoist) system is vented through a needle valve in the upper cylinder head.

Cleaning dual oil filters. The oil filter is equipped with a directional valve sleeve to control the flow of fluid through either one, or both, filter elements. An instruction plate, mounted on top of the filter body, indicates the direction of fluid flow through the unit. By directing the flow through one filter element, the inoperative element can be removed and cleaned while the hydraulic equipment is being operated.

To clean, proceed as follows:

1. Turn the directional valve sleeve toward one of the filter elements.

2. Unscrew and remove the filter cap from the other element.

3. Lift out the filter spring and filter element.

4. Clean the filter element with dry cleaning solvent, Navy Specification P-S-661, and compressed air.

5. Remove socket type pipe plug from bottom of filter container to drain sludge and sediment.

6. Flush out filter container and replace socket type pipe plug. Reassemble filter element, spring, and cap.

7. Turn directional valve sleeve toward cleaned filter element and repeat cleaning operations on the other element.

8. Turn valve sleeve to center position so that both elements are being used.

Replacing gaskets and shims. Whenever gaskets or shims are defective and must be replaced, be sure to check the thickness of the original part. Install a new gasket or shim of the same thickness as the original. Close tolerances in the design of this equipment prevent indiscriminate use of gaskets and shims.

Operating trouble diagnosis

The causes of various troubles which may occur in the projectile hoist assemblies 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 the position of the hoist control handle. If the control handle is in a stroke position, the handle interlock switch will be open. The starting circuit cannot be closed until the control handle is placed at 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.

3. Check the 10-ampere fuse in the projectile hoist control interlock (circuit Q). Check for shorts if fuses are blown. Install new fuses.

Drive inoperative due to system pressure failure. If there is no pressure in the hydraulic system, the hydraulic equipment will be inoperative. Check the following possibilities:

1. Wrong rotation of the electric motor shaft. Check shaft rotation. Arrow on motor housing indicates correct rotation. Switch the lead wires to correct shaft rotation.

2. Insufficient hydraulic fluid in the system. Check the fluid level gages. Replenish if necessary.

3. Excessive leakage due to loosely connected or damaged pipes or oil seals. Check all lines and flanges in the hydraulic system. Tighten loose lines and flanges. Replace defective lines and oil seals.

4. A failure of auxiliary pump pressure may be caused by a damaged auxiliary pump, a sheared pump shaft, or a broken or leaking line. Loosen the flange fitting on the pump discharge line and operate the motor for 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.

Adjustments

General. Most elements of the projectile hoist are installed with fixed settings, determined when factory-supervised functional tests were completed. Resetting of adjustable parts is described in the following paragraphs. The positions and movements described must be periodically verified by operating tests, measurements, and gage readings. Certain adjustable and nonadjustable parts are adequately lubricated. Clean and lubricate all parts thoroughly before attempting adjustment.

Brake adjustment. The solenoid brake assembly is adjustable for brake action, brake release, and band position. Refer to drawing 231727.

Brake action. Brake torque is adjusted through the main spring pressure adjusting screw.

To adjust the brake action:

1. Loosen the locknut 231727-54.

2. Turn the adjusting screw 231727-55 in to increase the brake action. Turn the adjusting screw out to decrease the brake action.

3. Tighten locknut 231727-54 (after adjustment is completed) against the spring yoke 231727-53.

NOTE: This brake is intended only to hold the A-end and reduction gear worm against overhaul in case of power failure with the full hoist load. It is not a motor brake.

Brake release. The brake release is adjusted to permit the band to ride clear of the drum (after the band position is adjusted as described in the next paragraph).

To adjust the brake release (power on):

1. Loosen the two hex nuts 231727-35.

2. Position the eyebolt 231727-34 in the adjusting yoke 231727-36 so that the band 231727-30 rides clear of the drum 231727-62.

3. Tighten the two hex nuts 231727-35.

NOTE: The brake release movement must permit the solenoid plunger to "bottom." A suspended plunger will cause the solenoid coil to burn out.

Band position. The band is centered and adjusted to ride clear of the drum by postioning the band support yoke with the brake released.

To adjust the band position:

1. Turn the hex head adjusting cap screw 231727-48 in or out to center the band support yoke 231727-27. Properly adjusted, the band should have the same clearance all around the outer drum surface.

Tube pawl operating mechanism adjustment. The tube pawl operating mechanism is adjusted to retract the tube pawls during the first part of the rack lowering stroke when the hoist is operating to lower projectiles and to prevent the tube pawls from "sticking" in the retracted position. Adjustments are made at the upper and upper intermediate pawls, the intermediate pawl, and the lower intermediate and lower pawls. Before attempting to make the adjustment:

1. Check the length of all operating rods, from clevis pin to clevis pin, for conformity with dimensions on the detail drawings.

2. Proper operation of the tube pawl operating mechanism requires the stroke of the tube pawl operating cylinder piston to be 1.375 inches. Verify the stroke by starting the motor and placing the function control and shut-off valve handle at LOWER PROJECTILES. This will cause the operating cylinder piston to "bottom" in the cylinder. Hoist the empty rack to top of stroke to bring the piston to its uppermost position. The rack may be kept in this position until the measurement is obtained.

3. Check the chordal position of each tube pawl actuating crank center with the dimensions on the detail drawings. Take the measurements with the tube pawl operating cylinder piston "bottomed" and the pawls fully extended into the hoist tube, (crank center 0.6875-inch below centerline of tube pawl shaft for the upper, and upper intermediate pawls and 1.49 inches above the tube pawl shaft for the lower intermediate and lower tube pawls).

All tube pawl adjustments are made with the tube pawl operating cylinder piston "bottomed" in the cylinder. The tube pawls must be fully extended into the hoist tube. There must be operating pressure in the tube pawl operating system. The function control and shut-off valve handle must be positioned at HOIST PROJECTILES. Under these conditions, there is a slight pressure on the top of the operating cylinder piston to hold it at "bottom."

To adjust the upper and upper intermediate pawls (fig. 9-22). Refer to drawings 236561 and 236562.

Upper pawl adjustment, proceed as follows:

1. Loosen hex nut 12-Z-9-9 on piston rod 231121-3.

2. Position adjusting nut 231118-2 on piston rod 231121-3 until there is a gap of 0.125 inch between the sliding collar 231118-1 and the adjusting nut.

3. Tighten hex nut 12-Z-9-9.

Upper intermediate pawl adjustment, proceed as follows:

4. Loosen hex nut 12-Z-9-9 on control rod 233130-3.

5. Position adjusting nut 231118-2 on control rod 233130-3 until there is a gap of 0.125 between the sliding collar 23118-1 and the adjusting nut.

6. Tighten hex nut 12-Z-9-9.

To adjust the lower intermediate and lower pawls (fig. 9-23). Refer to drawing 236564.

1. Back-off the left-hand thread hex nut 23117-6 from the clevis 231066-4 at the upper end of the lower control rod 233128-4.

2. Turn the lower control rod 233128-4 in a direction to make a gap of 0.125 inch between the upper end of the elongated slot in the clevis 231066-2 and the clevis pin 231068-5.

3. Tighten hex nut 231117-6 against the clevis 231066-4.

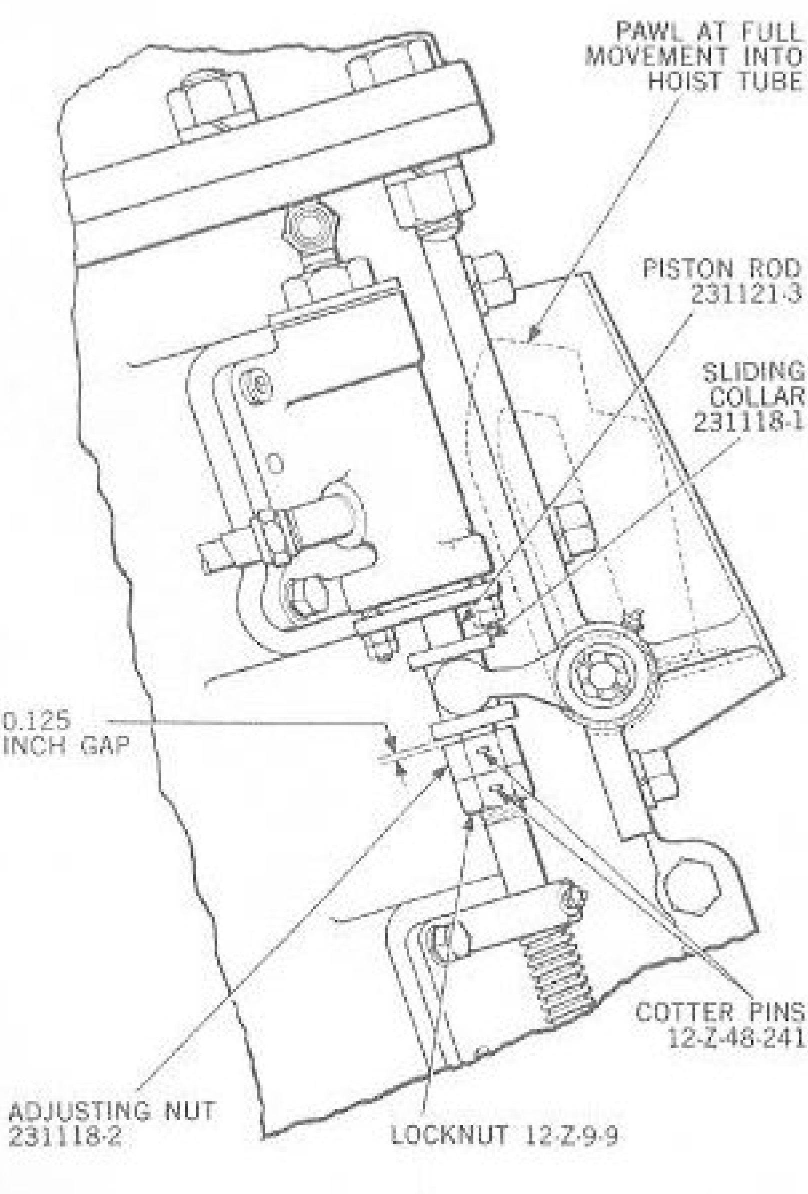


Figure 9-22. Projectile Hoist Tube Pawl Mechanism-Adjustment at Upper and Upper Intermediate Pawls

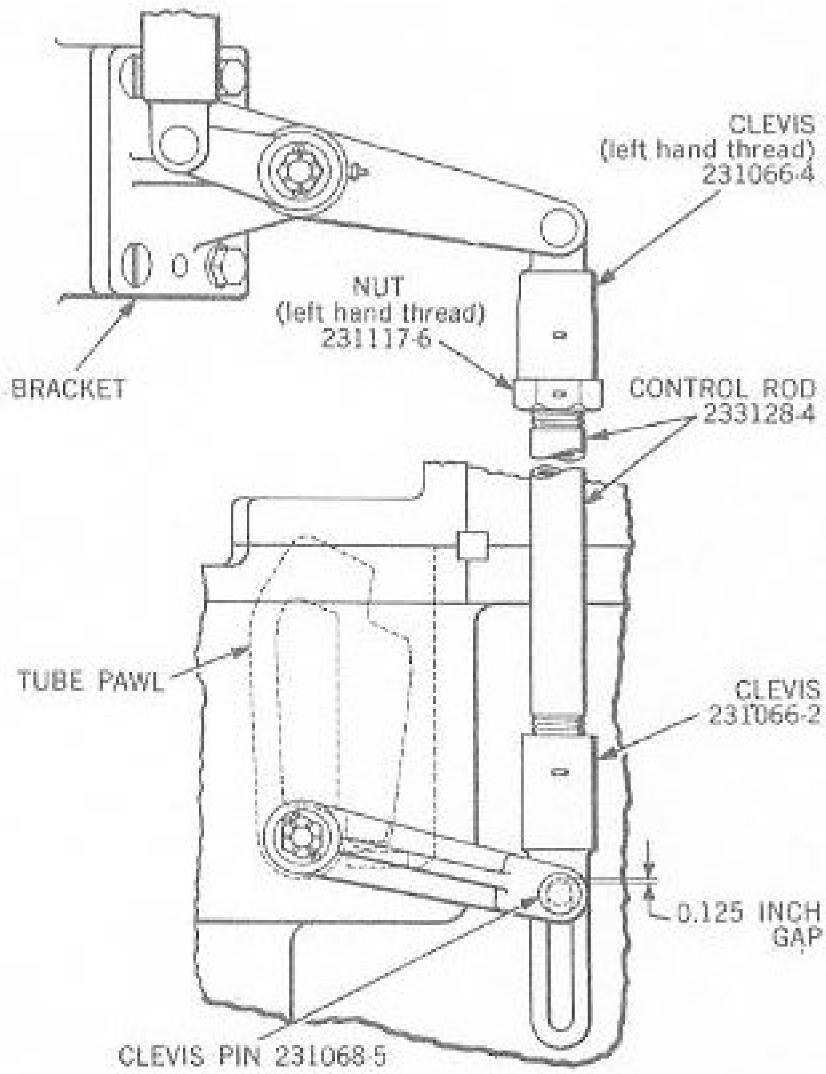


Figure 9-23. Projectile Hoist Tube Pawl Mechanism - Adjustment at Lower Intermediate and Lower Pawls

Place the function control and shut-off valve handle at LOWER PROJECTILES and operate the empty rack to verify the operation of the tube pawls. If the operation is satisfactory, secure all nuts and clevises with cotter pins as shown on the drawings.

Tripping cam mechanism adjustment. The tripping cam mechanism is adjusted so that the tripping cams retract the rack pawls during the first part of the hoisting stroke when lowering projectiles. Pawl retraction must be rapid and positive so that each rack pawl clears the base of the projectile immediately above it as the rack is raised. Adjustments are made at the upper and upper intermediate tripping cams and at the lower intermediated and lower tripping cams.

To adjust the upper and upper intermediate tripping cams (fig. 9-24). Refer to drawing 236555.

1. Position the function control and shut-off valve handle at LOWER PROJECTILES. Start the motor.

This action causes the piston 231123-5 to move up through its full stroke of 1.25 inches and seat against the cylinder head 231123-1.

2. Loosen hex nut 12-Z-9-8 on the lower end of control rod 233126-2.

3. Back off adjusting nut 231062-1 until there is a slight gap between the sliding collar 231062-2 and the adjusting nut. This adjustment is made after the tripping cam is brought to its limit stop by spring 231063-4.

4. Tighten hex nut 12-Z-9-8 to lock adjusting nut 231062-1.

To adjust the lower intermediate and lower tripping cams (fig. 9-25). Refer to drawing 236559.

1. Position the function control and shut-off valve handle at LOWER PROJECTILES. Start the motor.

2. Loosen hex nut 12-Z-9-8 on the lower end of control rod 233122-5.

3. Back off adjusting nut 233122-2 until there is a slight gap between the collar 233122-6 and the adjusting nut.

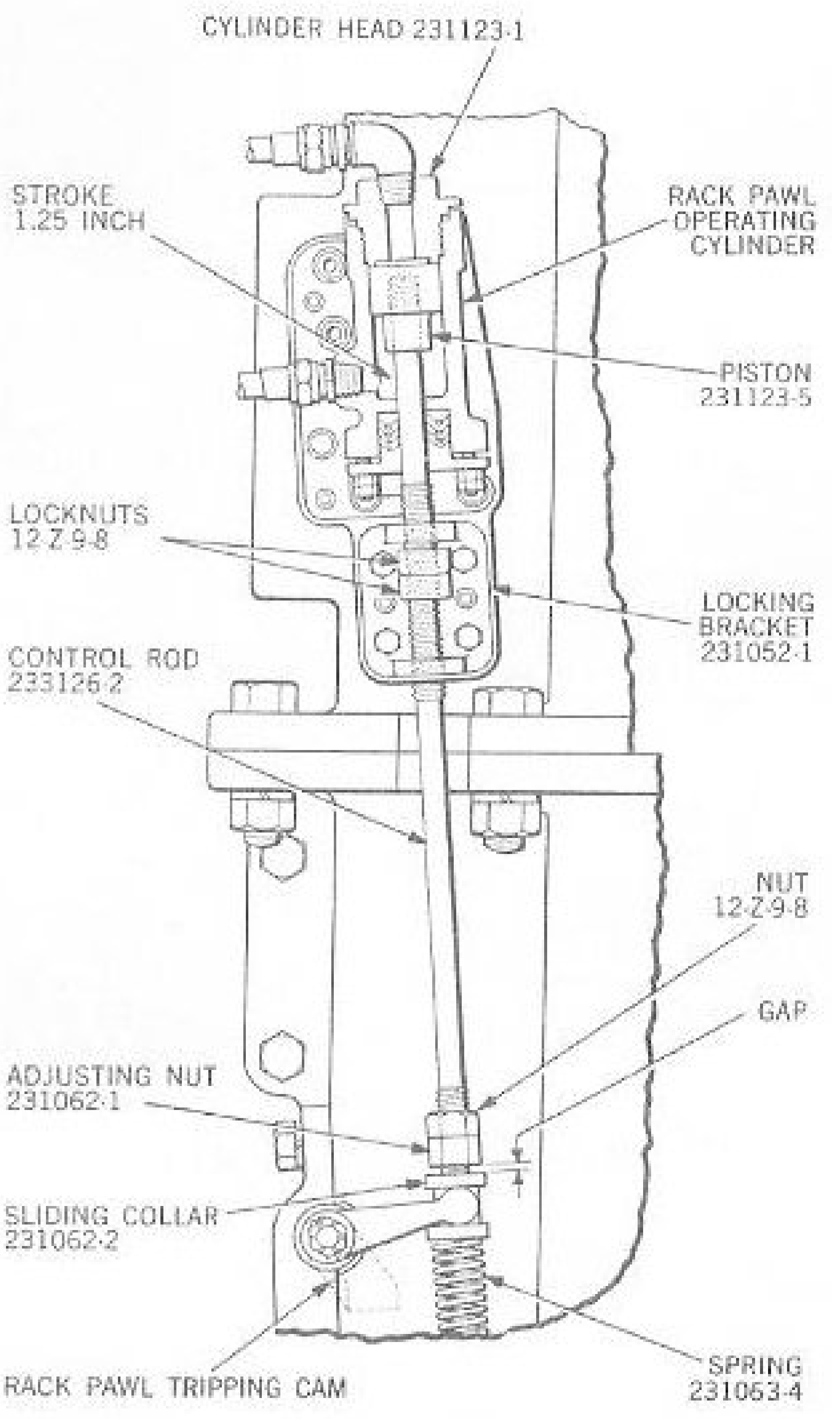


Figure 9-24. Projectile Hoist Upper Tripping Cam Adjustment

This adjustment is made after the tripping cam is brought to its limit stop by spring 233122-4.

4. Tighten hex nut 12-Z-9-8 to lock adjusting nut 233122-2.

To check the adjustments:

1. Position the function control and shut-off valve handle at LOWER PROJECTILES and then at HOIST PROJECTILES. Measure the stroke of the operating cylinder piston rod. Proper operation of the tripping cam mechanism requires a stroke of 1.25 inches.

2. Secure nuts 12-Z-9-8 on piston rod 233126-2 so that there will be clearance between the nuts and the lugs on control rod locking bracket 231052-1 (fig. 9-24) when the piston rod is stroked downward.

3. Position the function control and shut-off valve at LOWER PROJECTILES and bring the adjusting nut 231062-1 in contact with sliding collar 231062-2 (fig. 9-24). Bring nut 12-Z-9-8 in contact with sliding collar 233122-6. The tripping cams should be against their stops.

Cradle operating cylinder piston adjustment. The cradle operating cylinder piston must be so coupled to the cradle that the piston will not "bottom" or cover the starting port.

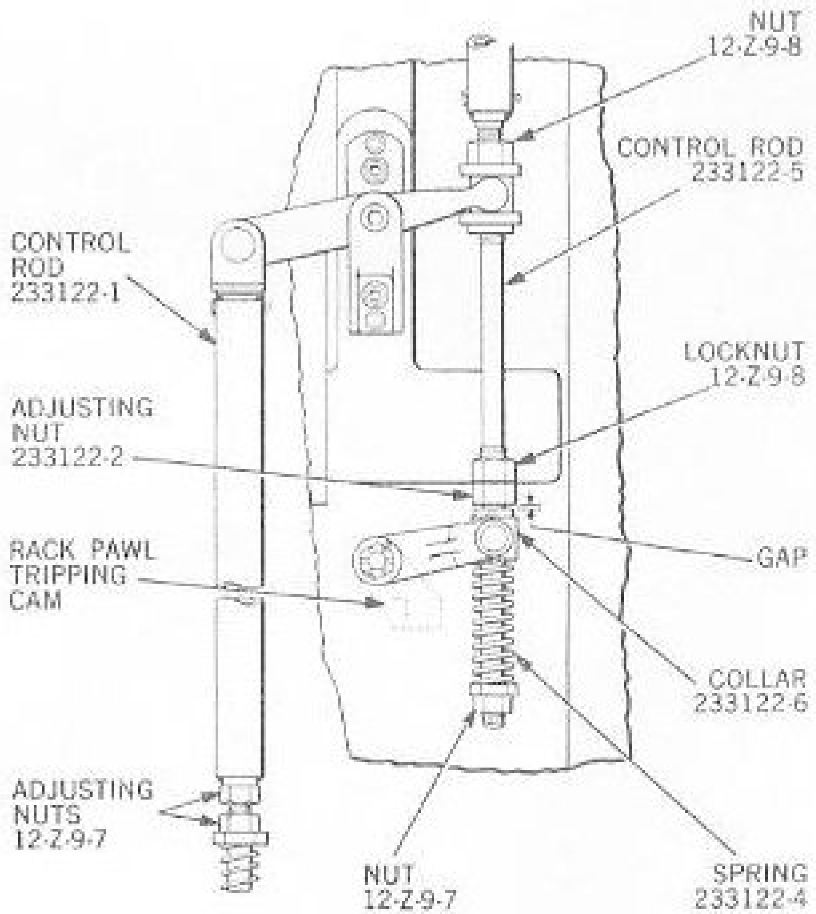


Figure 9-25. Projectile Hoist Lower Tripping Cam Adjustment

To adjust the cradle operating cylinder piston (fig. 9-7), (refer to drawing 236586):

1. Loosen stroke adjustment lock nut 232469-6 on the upper end of piston rod 232469-2.

2. Slip open-end wrench (part number 12-Z-707-10) over the parallel flat surfaces of the upper end of the piston rod.

3. Turn the piston rod in or out of the crank connector 232469-3 until the measurement of dimension X (fig. 9-7) at the piston rod upper end is as follows:

Outboard hoist assemblies, inches 1.5
Center hoist assembly, inches 2.135

4. Tighten lock nut 232469-6 against the crank connector to secure the adjustment.

Projectile latch switch adjustment. The projectile latch switch is adjusted to close (and indicate LATCH CLEAR on the hoist control indicators) when the projectile latch is moved to its maximum position to clear a projectile.

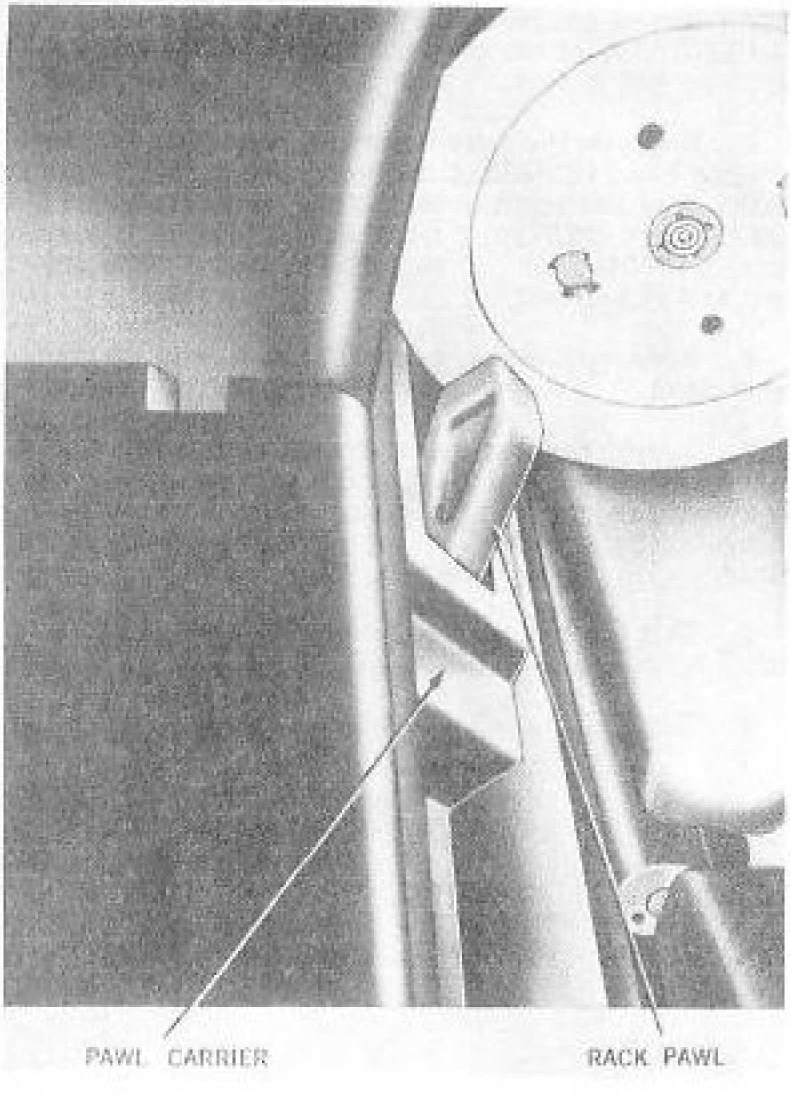


Figure 9-26. Rack Pawl Raising Projectile in Hoist

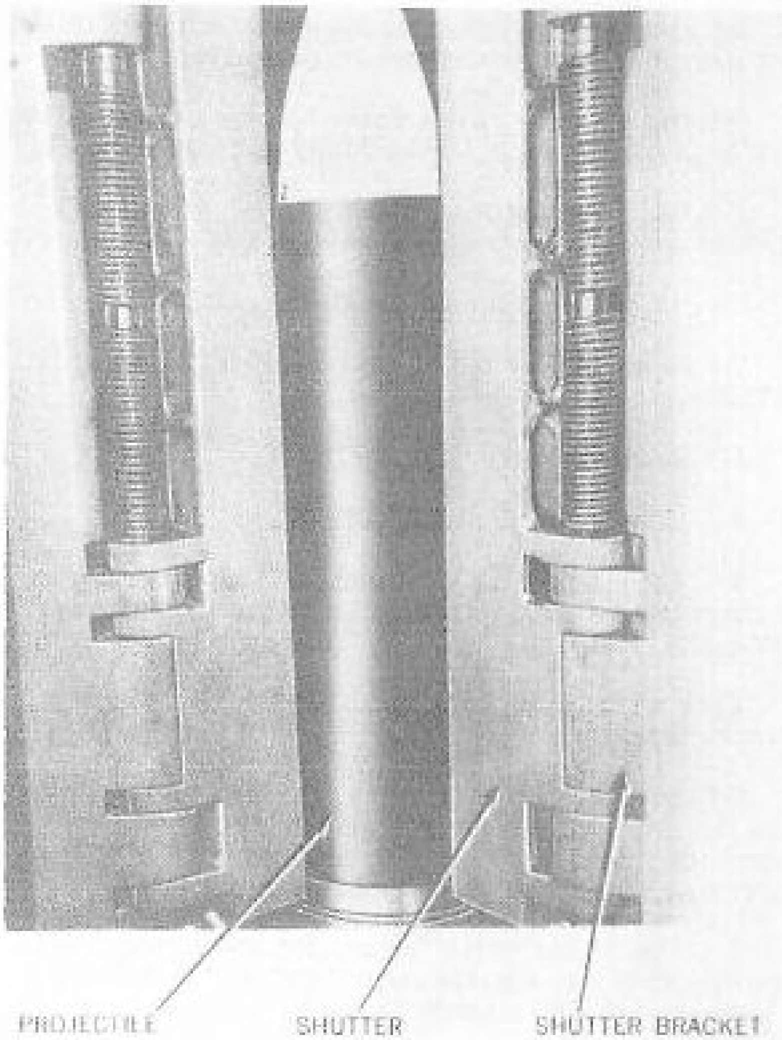


Figure 9-27. Projectile in Hoist, Upper Projectile Handling Flat

To adjust the projectile latch switch (refer to drawing 34401):

1. Turn adjusting screw 344338-2 in or out of the switch plunger lever 344338-1 so that maximum movement of the projectile latch will depress the switch plunger 344338-6 0.15 inch to close the switch.

2. Drill hole through switch plunger lever and adjusting screw.

3. Insert pin 12-Z-49-9 to lock adjusting screw in position.

Indicator retainer adjustment. The indicator retainer is adjusted so that a projectile entering the cradle will displace the indicator actuating cam, and the retainer will be moved upward enough to permit the cradle retainer cam to move under the lug on the retainer.

To adjust the indicator retainer (refer to drawing 232311):

1. Loosen the hex nut on the upper end of the connecting rod.

2. Turn the connecting rod in or out of the yoke rod until the indicator retainer is properly positioned.

3. Tighten the hex nut on the connecting rod.

Adjustment of main system oil pressure. Main system oil pressure is controlled by the adjusted spring loads of the identical high pressure (hoisting) and low pressure (lowering) relief valves.

Set the hoisting relief valve to by-pass main system high pressure at 1000 pounds per square inch.

Set the lowering relief valve to by-pass main system low pressure at 100 pounds per square inch.

Do not increase these pressure settings.

To adjust the relief valve (refer to drawing 297129):

1. Remove valve cap 297162-2.

2. Remove lock pin 297161-8.

3. Turn adjusting coupling 297161-2 clockwise to increase setting, counterclockwise to decrease setting.

This adjustment may be made while the pump is operating.

Adjustment of pawl control system relief valves. The dual system pressures are controlled by two pressure relief valves. The adjustments of these valves are apparent. Refer to drawing 297139.

1. The relief valve for cradle operations (also pawl control system operations) is set to relieve at a pressure of 800 pounds per square inch.

2. When the cradle control valve is at neutral, the pawl control system operates at a pressure of 400 pounds per square inch, controlled by the second relief valve.

DISASSEMBLY AND ASSEMBLY

General instructions

Disassembly and assembly of the projectile hoist electric-hydraulic equipment must only be performed by personnel familiar with the procedure and equipped with the standard and special tools necessary for the job.

Disassembly and assembly of most hoist components is readily apparent after examination of the general arrangement and detail drawings. In general, assembly will be the reverse of disassembly. To help in the reassembly of the unit, it is desirable to mark all mating parts such as cams, gears, and adjustable linkages so that these parts will be reassembled in the same relative positions. The following paragraphs contain references and instructions for disassembly of the main pump and the hoist hydraulic cylinder. These operations are not readily apparent after examination of the equipment and pertinent general arrangement and detail drawings.

Main pump

The main pump is disassembled according to the disassembly instructions for the similar elevating gear A-end unit, described in chapter 5.

Removal and disassembly of hydraulic cylinder

The instructions in this paragraph give the sequence of operations for removal and disassembly of the hydraulic cylinder. Because of its size, position, and arrangement, removal is difficult. Cylinder removal, however, is possible without disturbing any of the hoist castings. Study drawings 232309, 232310, and 216379 carefully.

Proceed as follows:

1. Disconnect pipe flange 216383-2 from the upper cylinder head 216381-1 of the center and left hoists, 216381-2 of the right hoist.

2. Disconnect pipe flange 216383-2 from the lower cylinder head 216382-1.

3. Remove set screw 12-Z-24-150 from upper end of piston rod 216380-2.

4. Knock out piston pin 216384-2 from the crosshead 230700-1 of the center hoist, 230701-1 of the right and left hoists.

5. Remove the four bolts and secure the upper cylinder head (216381-1 of the center and left hoists, 216381-2 of the right hoist) to the intermediate rack casings (230711-1 and 230719-1 of the center hoist, 217294-1 or -2 and 216295-1 or -2 of the right and left hoists).

6. Remove the two keys 216384-4 from the upper head.

7. Lower the hydraulic cylinder approximately 30.0 inches so that the upper cylinder head will clear the upper projectile handling platform 230702-1 of the center hoist, 230723-1 or -2 of the right and left hoists.

8. Tilt the hydraulic cylinder to the side for the center hoist, to the rear for the right and left hoists.

9. Remove the upper cylinder head.

Chapter 10

RAMMER

16-inch Rammer Mark 5 Mods 0, 1, and 2

GENERAL DESCRIPTION

The ramming gear, shown in figure 10-1, is used in turrets of the IOWA class battleships. The rammer assembly for the right gun is designated 16-inch Rammer Mk 5 Mod 0, for the center 16-inch Rammer Mk 5 Mod 1, and for the left 16-inch Rammer Mk 5 Mod 2. All three assemblies are identically powered and controlled, differing only in the position and arrangement of some components, to seat projectiles in and to serve powder bags to the guns.

Type

16-inch Rammer Mk 5 is an electric-hydraulic mechanism that drives a folding chain through ramming and withdrawing movements. The mechanism is manually controlled from the rammer operator's station.

Design features

The three rammer assemblies of the turret are independently controlled by the rammer operators and have no interconnection. The assemblies have the same strokes, speeds, and degree of selective control.

The controls include automatic stops at the limits of chain movement which are adjusted to function ahead of positive limit stops. Ramming and withdrawing movements are manually controlled between the limit stops.

The A-end tilting box, manually offset to begin a ram or withdraw stroke, is automatically restored to neutral at the end of a withdraw stroke and at the end of a ram stroke when no projectile or powder is being served to the gun.

Components

The components of each rammer assembly are:

- Power drive
  - Electric motor
  - Controller
  - Speed reducer
  - Coupling
  - A-end (hydraulic pump)
  - Coupling
  - Auxiliary pump
  - Stroking control mechanism
  - B-end (hydraulic motor)
  - Limit stop mechanism
  - Supply tank and filter assembly
- Rammer
  - Casing
  - Sprocket
  - Sprocket bearings
  - Sleeve coupling
  - Chain buffer
  - Chain
  - Head link buffer
  - Rammer switch
- Controls
  - Start-stop control
  - Hand control gear
  - Stroking control
  - Neutral interlock switch

Component locations

The components have similar locations in the installed arrangements of the three rammer assemblies. The assemblies (fig. 10-1) are located to the rear of the transverse bulkhead of the turret officer's compartment. They are mounted on foundation weldments attached to the shelf plate over-hang, together with the casings of the folding rammer chains which are aligned with their respective guns. The operating hand lever (rammer operator's station) is just forward of the transverse bulkhead in the gun room compartment. The motor controllers are located in the machinery space of the lower projectile flat, with the master pushbutton switch located in the gun compartment at the rammer operator's station.

Functional arrangements

The power drive is an electrically driven hydraulic transmission. It drives the folding chain through a sprocket to ram projectiles to seated positions in the band slope and gun bore. The installed arrangement of the power drive is shown in figure 10-1.

The transmission is operated to ram or withdraw through the manually operated control linkage (fig. 10-10) which actuates the stroking control unit (fig. 10-5). The stroking control is a dual-purpose unit that provides for manually positioning the tilting box (fig. 10-2) and for automatically restoring the tilting box to neutral at the end of a ram or withdraw stroke.

Design differences

The left and center gun rammer assemblies are identical, except for the arrangement of some hydraulic pipes and the positions of components of the hand control gear. In the center gun installation, the linkage of the hand control gear is arranged to conform to the left side ram operator's position. For the left gun installation, the linkage is arranged for direct connection to the stroking control unit from the right side ram operator's position.

The right gun rammer assembly differs from the left and center installations as follows: the electric motor and A-end and the B-end are mounted in the opposite way from like units of the left and center installations, and the hydraulic pipes are rearranged to conform to this mounting. The linkage of the hand control gear is arranged for direct connection to the stroking control unit from the left side ram operator's position.

Performance data

The data are the same for all rammer installations.

Travel measurements:

Projectile travel, in.	226.43
Chain-to-projectile travel, in.	7.925
Chain-to-breech travel, in.	108.025

Weight of projectile:

AP Projectile Mk 8, lb	2700

Rammer chain speed:

Acceleration, full power, ft/sec/sec	22.2
Maximum velocity, fps	13.9
Time of ram stroke, sec	1.7

DETAIL DESCRIPTION

Power drive

Components. The components of each rammer assembly are:

- Electric motor
- Controller
- Speed reducer
- Coupling
- A-end (hydraulic pump)
- Coupling
- Auxiliary pump
- Stroking control mechanism
- B-end assembly
- B-end (hydraulic motor)
- Limit stop mechanism
- Supply tank and filter assembly

Electric motor. The electric motor is a squirrel-cage induction type. It is mounted on a structural foundation (fig. 10-1) that raises it slightly above the shelf plate. The motor is horizontally aligned with its integrally housed, flange-mounted speed reducer directly coupled to the A-end.

Motor data:

Type	squirrel cage, induction
Design features	waterproof, fan cooling, horizontally mouned, reduction gear drive
Horsepower	60
Revolutions per minute, synchronous	1800
Revolutions per minute, full load	1750
Revolutions per minute, reduction output, full load	501
Rotation (reduction output)	counterclockwise
Speed class	constant
Voltage	440
Amperes, full load	83.5
Amperes, locked rotor	560.0
Phases	3
Cycles	60
Ambient temperature deg C	40
Torque class	normal, low starting current
Weight (including reduction gear), lb	1750
Manufacturer	Reliance Electric Engineering Co.
Manufacturer's designation	Type AA
Drawing	231523

Contactor. 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 operated from a master push button at the rammer operator'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.

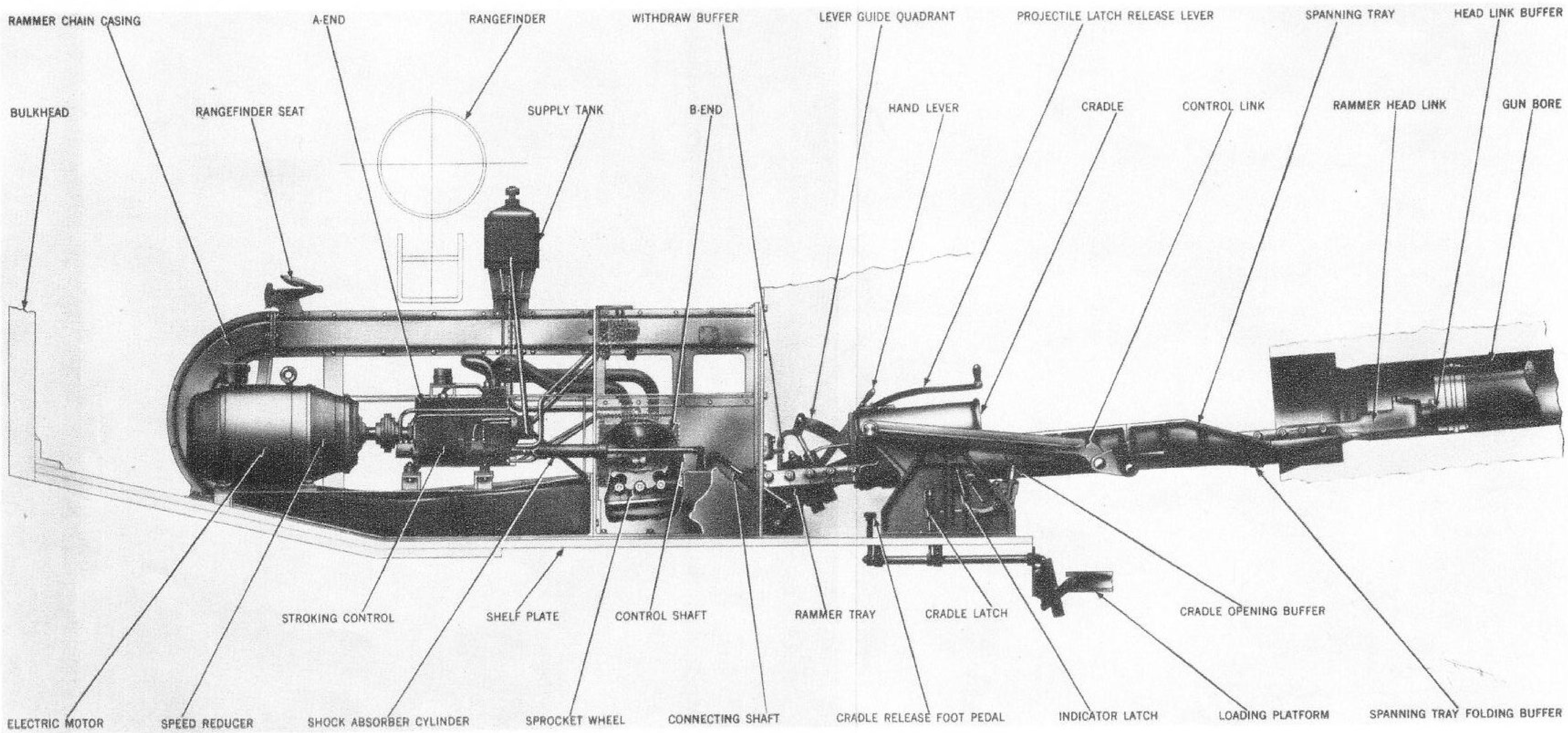


Figure 10-1. 16-inch Rammer Mk 5 Mods 0, 1, 2 - General Arrangement

Controller data.

Type . . . . waterproof, semiautomatic across - the - line starter, controlled by remote push button
Ampere rating, full load 83.5
Protection
  Overload, thermal type
    Adjustable range, amp . . . . 78 to 95
    Normal setting, amp 92
Short circuit, circuit breaker AQB, amp . . 675
Undervoltage
  Drop-out voltage 44
  Sealing voltage 352
Shock rating 50
Weight, lb 165
Manufacturer . . . . Cutler-Hammer
Drawing 273545

Speed reducer. The speed reducer is directly driven by the electric motor and is bolted to the motor case through an integral flange of the speed reducer housing. The housing encloses a spur gear train which is immersed in an oil bath for lubrication. The unit requires 1.5 gallons of mineral oil, Navy Symbol 2250, for proper lubrication. The speed reducer output shaft is connected through a flexible coupling to the A-end

Coupling. The speed reducer-to-A-end coupling, designated Falk size 12FAS, serves as a flexible direct drive connection between the shafts of these two units. Similar to the coupling shown in figure 7-9, it 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 design gives drive connection through the grid spring, which is engaged in grooves milled in the outer flanges of the two hubs splined to the shafts. The hubs and grid spaces are packed with lubricant confined within the two shells by grease seals.

A-end assembly.

Components. The A-end (hydraulic pump), shown in figure 10-2, consists of the following:

Case
Main shaft
Cylinder barrel
Pistons
Connecting rods
Socket ring
Universal joint
Tilting box
Valve plate
Main valves

The A-end is a case-enclosed, multicylinder, type K, variable-displacement hydraulic pump of modified commercial design. It is connected to and is driven by the speed reducer through the

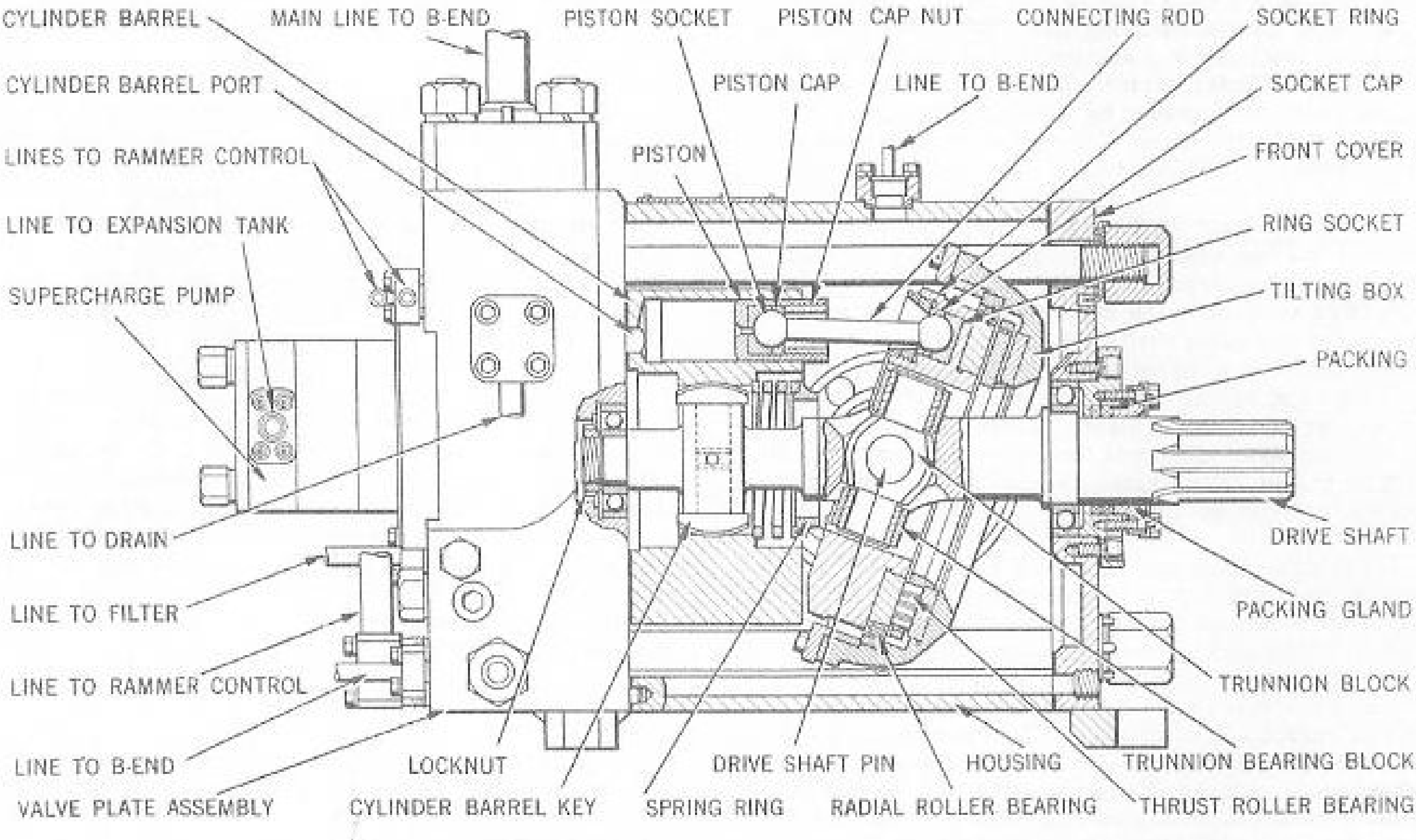


Figure 10-2. Rammer A-end, Sectional View

flexible coupling described in a previous paragraph.

Mounting. The A-end (fig. 10-1) mounted on a foundation weldment of the shelf plate overhang, is directly forward of its electric motor. These units are located on the right side of the rammer chain casings for the left and center gun installations, and on the left side of the casing for the right gun installation. The A-ends and electric motors are aligned with their common centerlines parallel to and 18.625 inches from the centerlines of the casings.

Pressure and tank connectings. In addition to the pipe connections of the main system, the A-end has a tank pressure connection with the B-end case. This connection functions for the circulation and drain of hydraulic fluid from the A-end to the B-end. There is also a connection from the tank to the supercharge pump which discharges through duplex filters to the A-end valve plate.

Case. A square oiltight case comprising a valve plate, case head, stroking control mechanism, trunnion cap, trunnion bearing assembly, and retainer encloses the A-end assembly. Forming 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 general arrangement of parts within the case is the same as the training gear A-end shown in figure 6-5.

Main shaft. 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, two keys are secured in a section of the shaft 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.

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

Pistons. 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 ends of the connecting rods.

Connecting rods. Eleven connecting rods connect the 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 is drilled throughout its entire length to provide for lubrication of the ball and sockets.

Socket ring. The socket ring is a circular piece that contains the sockets for the other ends of the eleven 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 back of the socket ring has a roller track with two faces which bear against the bearings in the tilting box. Two slots, located about the center of the socket ring and 180 degrees apart, carry the main shaft trunnion bearing blocks of the universal joint.

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 the piston stroke.

Tilting box. The tilting box, a trunnion-mounted casting inside the A-end case, varies the angle of the socket ring with relation to the main shaft, changing the length of piston stroke from zero to maximum. It contains two groups of roller bearings which take the radial and axial thrusts of the socket ring. A shaft from the tilting box extends through a hole of the A-end case and is spline fitted to the control arm of the stroking control mechanism.

Valve plate. The valve plate, together with the casehead, form the stationary ends 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 valve-plate ports, through which hydraulic fluid flows when power is being transmitted. These ports connect with the power transmission pipes between the A- and B-ends.

Between the valve plate 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 reciprocating pistons. There is no pumping action when the cylinder bores pass over the lands. The ball bearings for the main shaft are in the center of the valve plate. Two replenishing valves and a two-way relief valve are housed by the valve plate.

Main valves.

Replenishing valves. Each of two replenishing valves, a spring-loaded plunger type, is connected with a semiannular port of the valve plate. The valves operate under supercharge pressure to separately supply each port of the closed system (whichever is the suction port) with fluid to replace that lost by seepage.

Two-way relief valve. The main system twoway relief valve (fig. 10-3) is located in the top of the A-end valve plate. A spring-loaded plunger type valve, it is operated by a spring-loaded plunger type pilot valve within the main plunger. The main valve, unseated when main system high pressure exceeds the pilot valve adjustment, bypasses the high pressure transmission line to the low pressure transmission line.

Coupling. The supercharge pump (fig. 10-4) is directly coupled to the end of the A-end main shaft through a flexible coupling. This unit, housed within the A-end valve plate, consists of two jaw flanges, a center member, and four bearing strips. The floating center member, mounted between the jaw flanges, is constrained to slide across the face of one flange on a line passing through the center, and across the face of the second flange in a direction at right angles to the first. The coupling has removable graphite impregnated bearing strips mounted between the center member and the flanges, together with a grease reservoir in the center member, to provide lubrication. The coupling is similar to the one shown in figure 7-16.

Auxiliary pump (supercharge pump).

Purpose. The auxiliary pump (supercharge pump), in addition to replenishing hydraulic fluid in the A- and B-end cases, provides forced circulation of fluid through the supply tank. This dissipates heat and keeps the temperature of the fluid nearly constant. The supercharge pump (fig. 10-4) is a constant-displacement, gear-type pump which discharges through a duplex filter to the supercharge relief and supercharge valves.

Mounting. The supercharge pump is flange-mounted to the A-end valve plate as shown in figure 10-2.

Relief valve. The supercharge pump relief valve is a spring-loaded, pressure-operated safety relief valve. It is interposed between the duplex filters and the supercharge valves to maintain a supercharge pressure of 50 pounds per square inch.

Stroking control mechanism. The rammer stroking control mechanism (fig. 10-5), a housing-enclosed unit, is mounted on the side of the A-end case as shown in figure 10-1. It is a dual-purpose unit through which the tilting box is positioned at stroke and which also acts to restore the tilting box automatically to neutral at the end of a ram or withdraw

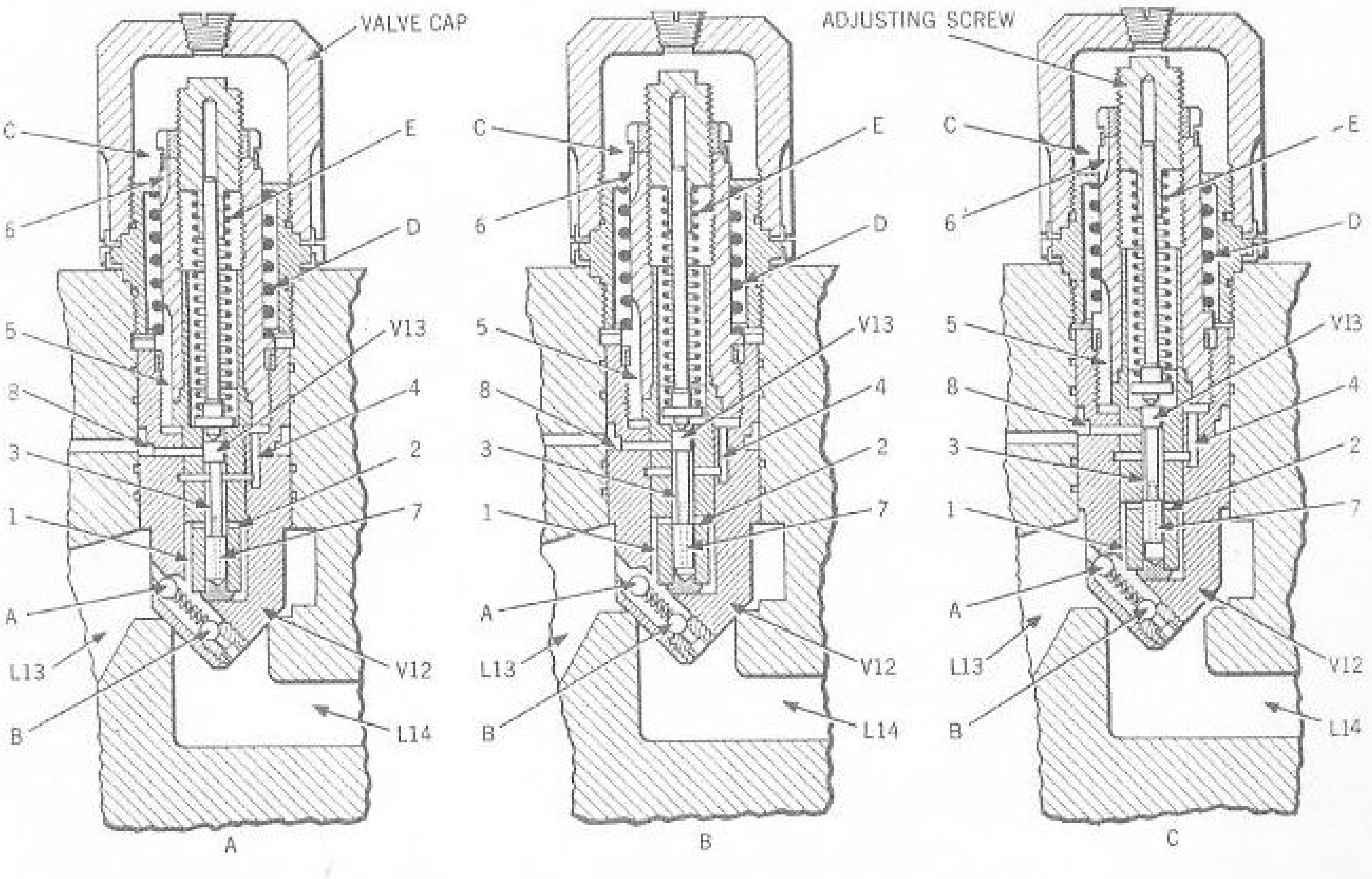


Figure 10-3. Two-way Main System Relief Valve, Sectional View

stroke. The stroking control mechanism is described in full detail on page 10-14, this chapter.

B-end (hydraulic motor).

Components. The B-end (hydraulic motor) consists of the following:

Case
Main shaft
Rotating group
Angle box
Valve plate

The B-end (fig. 10-6) is a case-enclosed, multi-cylinder, type K, fixed-displacement hydraulic motor of modified commercial design. It connects to, and drives, the rammer chain through the sprocket wheel described on page 10-10.

Mounting. The B-end, mounted on a foundation weldment of the shelf plate overhang (fig. 10-1), is forward of its electric motor and A-end. It is located on the left side of the rammer chain casings for the left and center gun installations, and on the right side of the casing for the right gun installations. Aligned parallel to and 29.0 inches from the transverse bulkhead of the turret officer's booth, the B-end centerlines are at right angles to the centerlines of the chain casings.

Pressure and tank connections. In addition to the pipe connections of the main system, the B-end has tank pressure connections with the A-end case and the supply tank.

Case. The valve plate and angle box of the B-end (fig. 10-6) 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 main shaft differs from the A-end shaft only in dimensions. An intershaft 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 thirteen pistons and connecting rods, and the socket ring.

Angle box. The angle box in which the socket ring rotates forms an end plate of the B-end and is permanently tilted at an angle of 20 degrees. It forms an end plate of the B-end. The pistons and connecting rods therefore reciprocate through one full stroke each time the main shaft makes one full revolution. The socket ring rotates in a radial and thrust roller bearing assembly. The angle box holds the roller bearing assembly in which one end of the main shaft rotates.

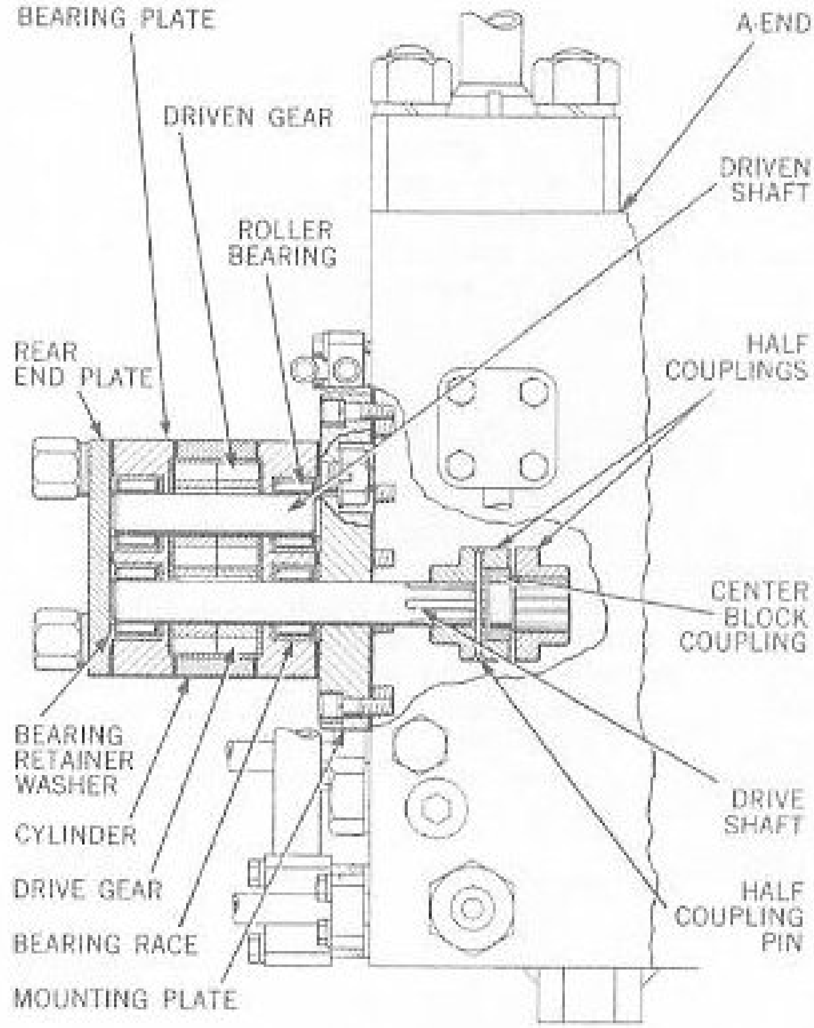


Figure 10-4. Supercharge Pump, Sectional View

Valve plate. The valve plate forms the other end plate for the B-end. It contains semiannular valve plate ports (similar to those of the A-end) which connect with the two power transmission pipes from the A-end, and it holds the roller bearing assembly in which the other end of the main shaft rotates. The cylinder barrel is held against the valve plate by a spring which backs up against a flange and spring ring on the main shaft. Hydraulic fluid is admitted into or is discharged from each cylinder through the two semiannular valve plate ports. In addition, the B-end valve plate contains the limit stop mechanism.

Limit stop mechanism. The rammer limit stop mechanism is shown in figure 10-7. It is built into the lower part of the B-end valve plate and is driven by the B-end drive shaft. The limit stop mechanism is a gear-driven, valve porting device that stops the rammer just ahead of its mechanical limit stops at the end of the ram stroke and at the end of the withdraw stroke.

Components. The limit stop mechanism consists of the following:

Driven gear	Decelerate valves (two)
Driving gear	Reverse check valves (two)
Rocker arm	Flow cutoff valve
Striker pin	
Striker block	

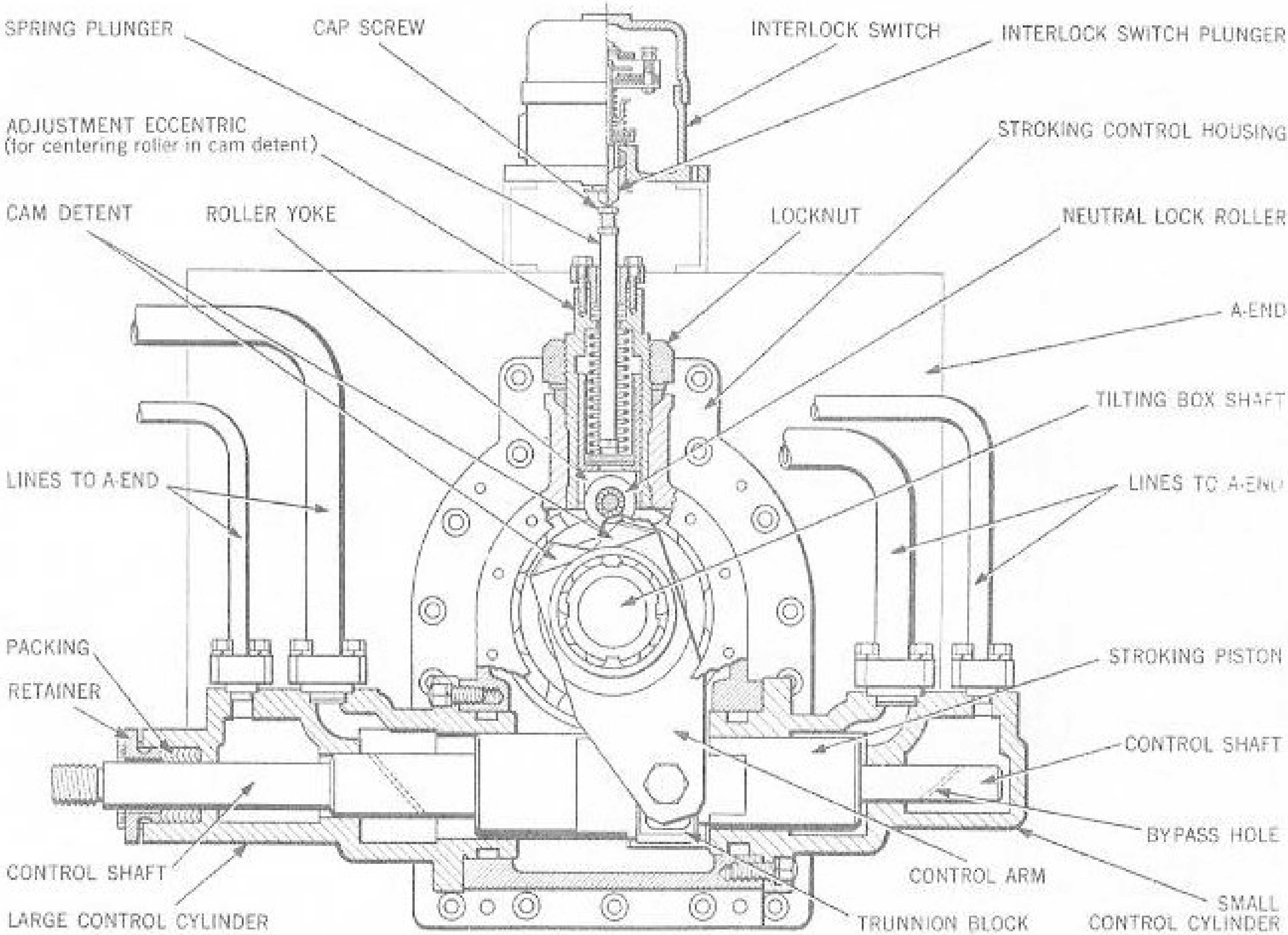


Figure 10-5. Rammer Stroking Control, Sectional View

Driven gear. The driven gear of the limit stop mechanism is an assembly that comprises a gear hub, a ring-gear with external teeth, a flat retainer plate, and six spring-loaded plungers. These components (fig. 10-7) are mounted in the gear hub which is keyed to a ball-bearing-mounted driven stub shaft. The spring-loaded plungers, equally spaced and arranged radially in the gear hub, fit into six detents in the internal surface of the ring-gear. The external surface of the ring-gear has 81 equally spaced teeth which are meshed with the driving gear of the B-end drive shaft. The ring-gear and plungers are retained in position on the gear hub by a flat, circular retainer plate which fits into a recess of the gear hub and is bolted to it. The assembled arrangement described above acts as a safety overload device to permit the ring-gear to be rotated by the B-end drive shaft while the gear hub is held stationary by the rocker arm and striker pin.

Driving gear. B-end rotation is transmitted to the driven gear through the drive gear to actuate the limit stop mechanism. The driving gear (fig. 10-7) of the limit stop mechanism is an integral section of the B-end drive shaft. This shaft section has 14 teeth, equally spaced around its circumference, which mesh with the teeth of the driven gear.

Rocker arm. The rocker arm, a steel casting pivoted in a bronze bushing, has a pivot point that is in vertical alignment with and at a point midway between the driving gear and the driven gear stub shaft. At each end of the rocker arm and fastened to it is a striker block (fig. 10-7) which contacts either the ram or withdraw decelerate valve, depending on the direction of stroke. Movement of the rocker arm to contact a decelerate valve is actuated by rotation of the driven gear.

Striker pin. The striker pin (fig. 10-7) is mounted in the gear hub of the driven gear assembly. The pin, moved through an arc of 360 degrees by B-end rotation of the driven gear, makes contact with the striker block of the rocker arm. The rocker arm, depressed by the striker pin, actuates a decelerate valve depending on the ram or withdraw direction of stroke to initiate the limit stop action.

Striker block. The striker block, a hardened steel contact plate mounted on the rocker arm, is directly in the path of the arc of the striker pin.

There are two other striker blocks (fig. 10-7) which are mounted in the toes at each end of the rocker arm. The blocks provide a hardened steel

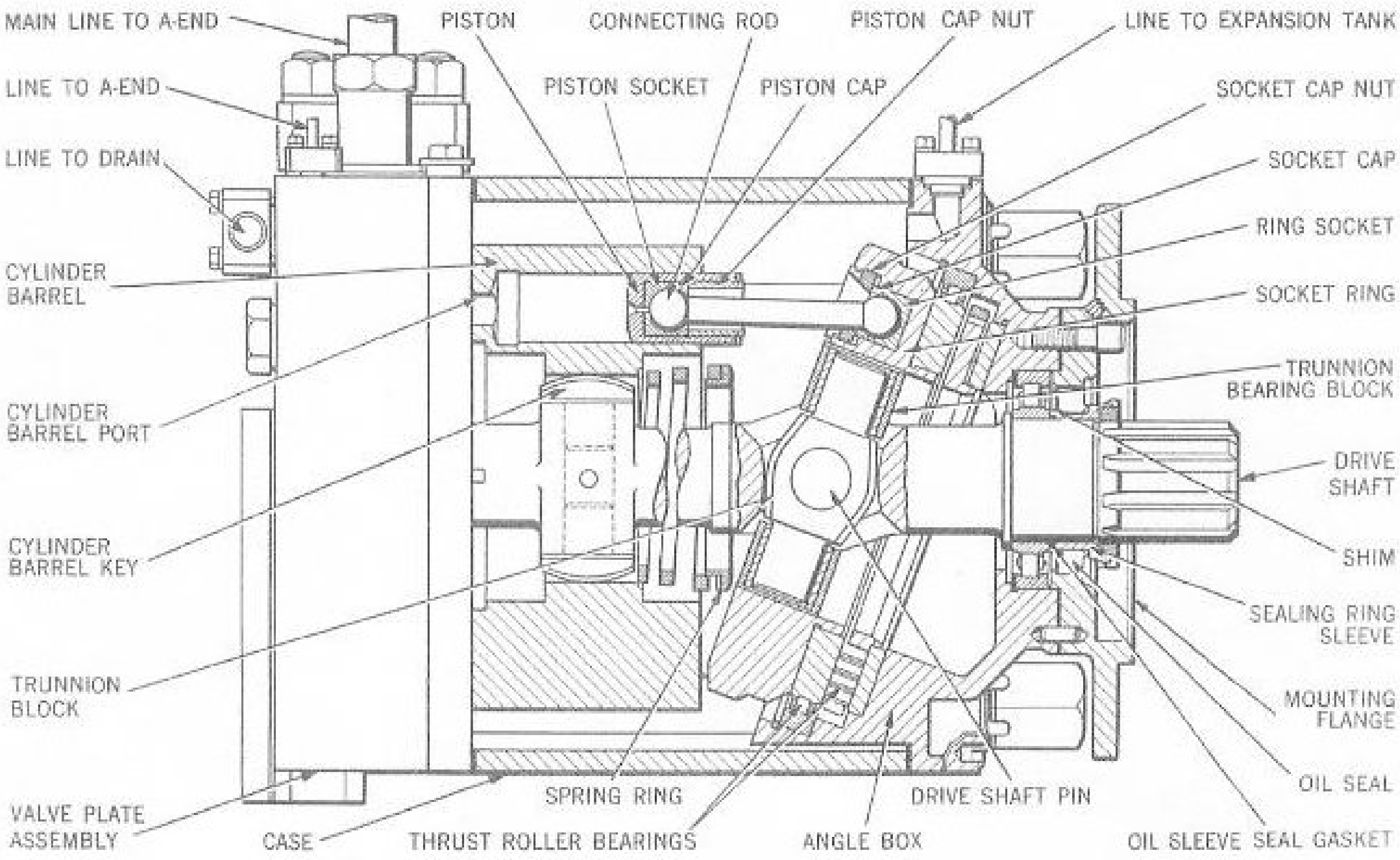


Figure 10-6. Rammer B-end, Sectional View

contact surface between the rocker arm and the decelerate valves.

Decelerate valves. There are two decelerate valves, one valve to control the deceleration of each of the ram and withdraw strokes. The valves are identical spool-type units. The lower wide land of each valve has a 0.828-inch taper per foot at the upper part. This taper provides the desired gradual deceleration toward the end of a stroke. The valves, spring loaded, are vertically positioned (fig. 10-7) with the lower end of each in the path of a striker block in the end of the rocker arm. The timing of the limit stop action is adjustable through a valve core which is threaded into the decelerate valve body. The decelerate valve assembly, held down in an open position by a spring, is closed by contact of the rocker arm to throttle the B-end discharge.

Reverse check valves (two). Each of the two main transmission lines is provided with a reverse check valve (fig. 10-7) which is a spring-loaded ball. The check valves permit hydraulic fluid to pass in order that the B-end may rotate at the start of a ram or withdraw stroke when the respective decelerate valve is closed.

Flow cutoff valve. The spring-loaded flow cutoff valve is mounted in the top part of the B-end valve plate adjacent to the decelerate valve. It is held down in operating position by a valve cap (fig. 10-19). With the valve cap removed, the valve prevents loss of hydraulic fluid from the B-end case when a decelerate valve cap is removed to adjust the decelerate valve core.

Functional arrangements. The assembled arrangements of the components of the limit stop mechanism function together to decelerate and stop the movement of the rammer chain at its limits of ram and withdraw movement. The B-end rotates the driving gear which is meshed with the driven gear. The driven gear, with its attached striker pin, is turned by B-end rotation through 360 degrees for each full ram or withdraw stroke. Actuated by the driven gear, the striker pin contacts the striker block of the rocker arm, which in turn is actuated to contact a decelerate valve. The decelerate valve is closed against tension of its spring to cut off B-end discharge. Because of the tapered section of the valve, B-end rotation is brought to a gradual, decelerated stop.

Movement data.

Rammer chain movement	
To forward limit stop, full movement, inches	238.9
B-end shaft rotation	
Full rammer chain movement, number of turns	5.97
Decelerate valve, start	start of valve movement
Ram	in final 90 degrees
Withdraw	in final 90 degrees

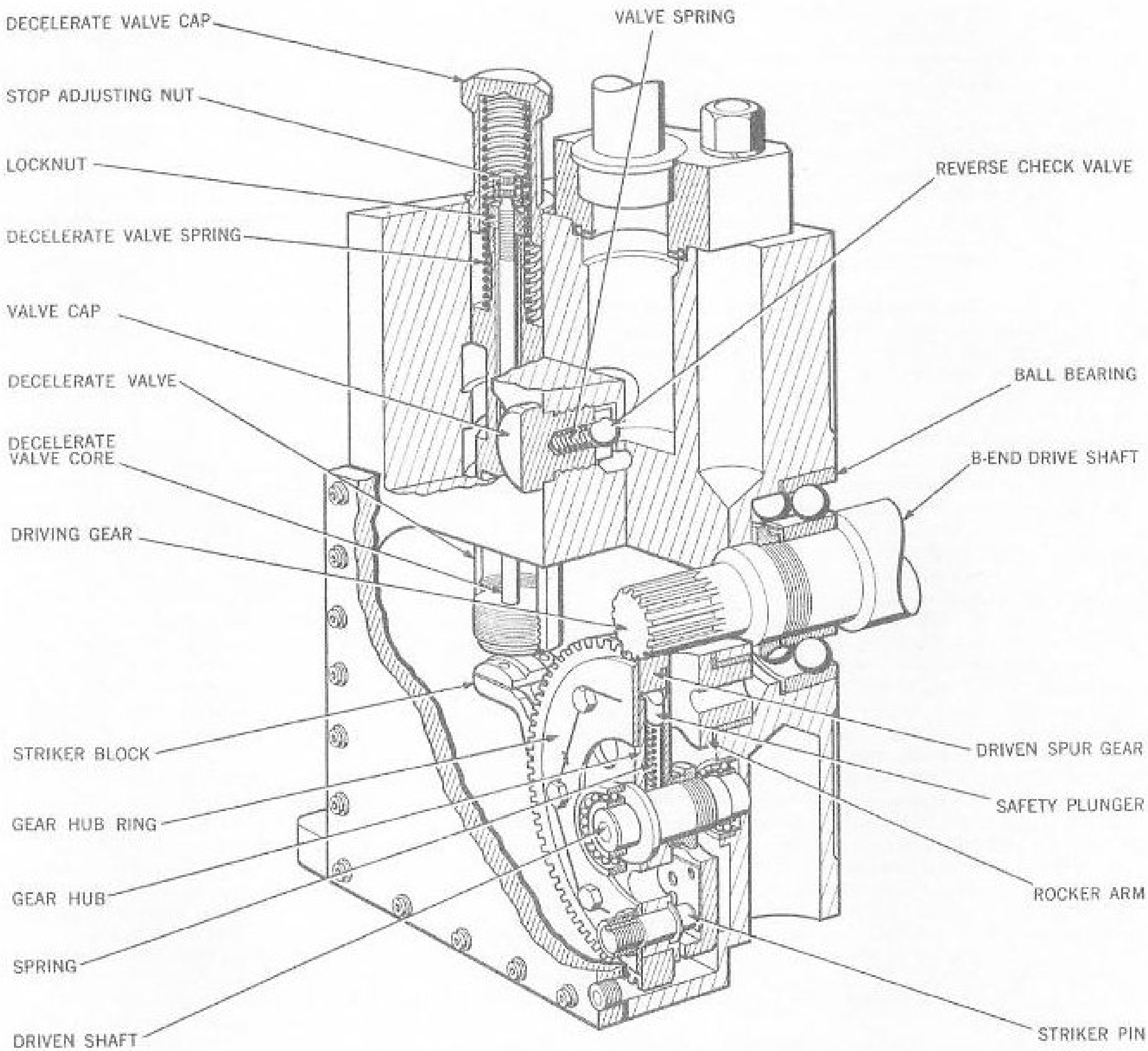


Figure 10-7. Rammer Limit Stop, Sectional View

Supply tank and filter assembly. The supply tank, a square-shaped container with a rounded dome-like top, is mounted on top of the rammer chain casing as shown in figure 10-1. The tank body, 10.5 inches high and 12.375 inches wide and deep, is mounted on a pedestal that is 7.0 inches high. The tank is drained through a plug at the bottom and filled through a vented filler cap on top. Full tank capacity is 7.0 gallons and tank capacity to the proper level as indicated on the tank gage is 5.0 gallons. Hydraulic fluid is supplied to the main transmission and supercharge circuits by the tank.

The duplex filters, a separate assembly, are mounted on the rammer chain casing adjacent to the supply tank. The filters are connected in the hydraulic line between the supercharge pump and the supercharge pump relief valve. The assembly removes foreign matter from the hydraulic fluid as it is recirculated to replenish the power drive from the supply tank.

Rammer

The rammer is the folding chain and chain housing assembly that is driven by the power drive unit. It consists of the following:

Casing	Chain buffer
Sprocket	Chain
Sprocket bearings	Head link buffer
Sleeve coupling	Rammer switch

Casing. The casing is a cast steel housing formed by five pairs of flange-bolted sections. It provides an enclosed U-course roller track for the chain link rollers. The casing, mounted on the shelf plate as shown in figure 10-1, is looped around structural elements of the rangefinder stand foundation. The forward sections of the casings enclose a bronze chain link guide, the sprocket and sprocket bearings, and the chain buffer. Circular covers, bolted to the casing over openings in the side, carry and cover the sprocket bearings, provide an opening for the drive shaft of the B-end, and receive any thrust from the drive shaft.

Sprocket. The chain is driven by a double-wheel sprocket which straddles the chain and meshes with the chain rollers, as shown in figure 10-9. It is an integral forged steel sprocket wheel and hub made with eight teeth with a chord of 4.87 inches on a pitch diameter of 12.73 inches. The hub is mounted in roller bearings enclosed within the sprocket bearing covers bolted to the casing. The drive coupling arrangement is a close-coupled, semi-floating quill type, driven through a splined sleeve coupling fitted into female splines of the hollow hub. This design, in addition to providing close coupling and self-adjustment for any slight-misalignment, also facilitates coupling adjustment of chain position with respect to drive limit stops. The sprocket weighs 87 pounds and is 10.625 inches wide at the hub.

Sprocket bearings. The sprocket bearings are assemblies composed of three-piece cast bronze cages with specially hardened steel rollers. The outer diameter of the cage assembly is 8.85 inches, and it contains 30 equally spaced rollers. Two roller bearing assemblies (fig. 10-9) for each sprocket are arranged with an assembly seated in each sprocket bearing cover. The bearings are accessible by removing the portable sections of floorplate on either side of the casing and immediately to the rear of the transverse bulkhead. It is not necessary to remove the portable sections to lubricate the bearings. A grease manifold block, together with copper tubing leading to the sprocket bearing covers, has been provided for this purpose. The block mounted on the chain casing above the floor plates, has a grease fitting for each bearing.

Sleeve coupling. The sprocket is driven through a chrome-vanadium steel alloy sleeve coupling, as shown in figure 10-9. The sleeve is provided at one end with 10 male splines that fit into matching female splines of the sprocket hub. At its opposite end, the sleeve is provided with 10 female splines that fit onto the B-end drive shaft. The sleeve is 10.625 inches long and weighs 26.5 pounds.

Chain buffer. The chain withdraw buffer (a hydraulic type), mounted in the casing in front of the sprocket and above the chain link guide, is aligned with its plunger in the way of a lug on the chain head link (fig. 10-10). The buffer functions in the final three inches of chain withdrawing movement. Three throttling grooves of varying depths provide for graded fluid displacement from the rear to the front of the plunger piston. The plunger is restored to normal position by a coil spring within the buffer housing. There are two rawhide positive stops in the front face of the housing which prevent metal-to-metal contact. When the power drive assembly is properly adjusted, the withdraw limit stop device should stop the chain 0.75 inch from the rawhide stops. The plunger packing consists of three rows of graphite packing beneath a threaded gland, and is accessible at the front of the buffer. The filling hole (fitted with a plug) is placed at the top front of the buffer to permit servicing through the chain port.

Chain. The rammer chain, shown in figures 10-9 and 10-10, is a hinged-link, roller-type chain which extends from the driving sprocket as a rigid column. The chain, an assembly 297.25 inches long, is composed of a rammer head, head link, 26 male links, 25 female links, 53 link coupling pins, 108 rollers, washers, and a tail link. The head link, a leather-faced head, spring and hydraulic buffer assembly, has a buffer stroke of 2.5 inches. The tail link, a positive stop link, is designed to jam at the sprocket in the event of limit stop failure. When this occurs, the face of the head link extends 13.89 inches beyond the position of the base of a seated projectile. The chain rollers are arranged in pairs, one on each outer end of the link coupling pin. The rollers have free rotation on the pin, roll in engagement with the sprocket, and each roller is retained on its pin by a washer which is secured by peening over the pin rivet (except for the tail link pin). The male and female links are each 5.0 inches from pin center to pin center, and weigh approximately six pounds each.

Chain removal and replacement is provided by arrangements that give access to the tail link and tail link pin. A casing end cover plate, accessible in the gun compartment, and two small covers accessible in the turret officer's compartment provide access to these parts.

Head link buffer. The head link buffer assembly (fig. 10-10) is a fixed piston type that buffs the rammer chain as a projectile is seating. The head link, made of cast bronze, is 33.56 inches from the end of the buffer body to the pin center. The assembly acts to buff through compression of a coil spring and the throttled flow of fluid through three grooves of varying depth in the head. The plunger packing consists of three rows of graphite packing beneath a threaded gland. Buffer fluid is replenished through a normally plugged hole located at the top of the rammer head.

Rammer switch. Limit Switch Mk 6 Mod 1 with actuator and mounting bracket are bolted to the turret officer's bulkhead as shown in figure 10-8. This microswitch has one pair of normally open and one pair of normally closed contacts. The switch is positioned to be actuated when the rammer head link moves to within four inches of its fully retracted position. When the switch is actuated during the ramming stroke it energizes the coil of a Mk 5 Mod 1 relay. When the switch is actuated during the return stroke it closes its portion of Ready Light Circuit 1R (ch. 15) through the relay contacts to energize the powder door valve solenoid (ch. 11) and permit opening the powder unloading door.

Controls

The independent rammer control arrangements for all three installations of a turret consist of:

Start-stop control
Hand control gear
Stroking control

Start-stop control. Each rammer power drive is started and stopped through its electric-power motor controller (pages 10-2 and 10-3). The controller

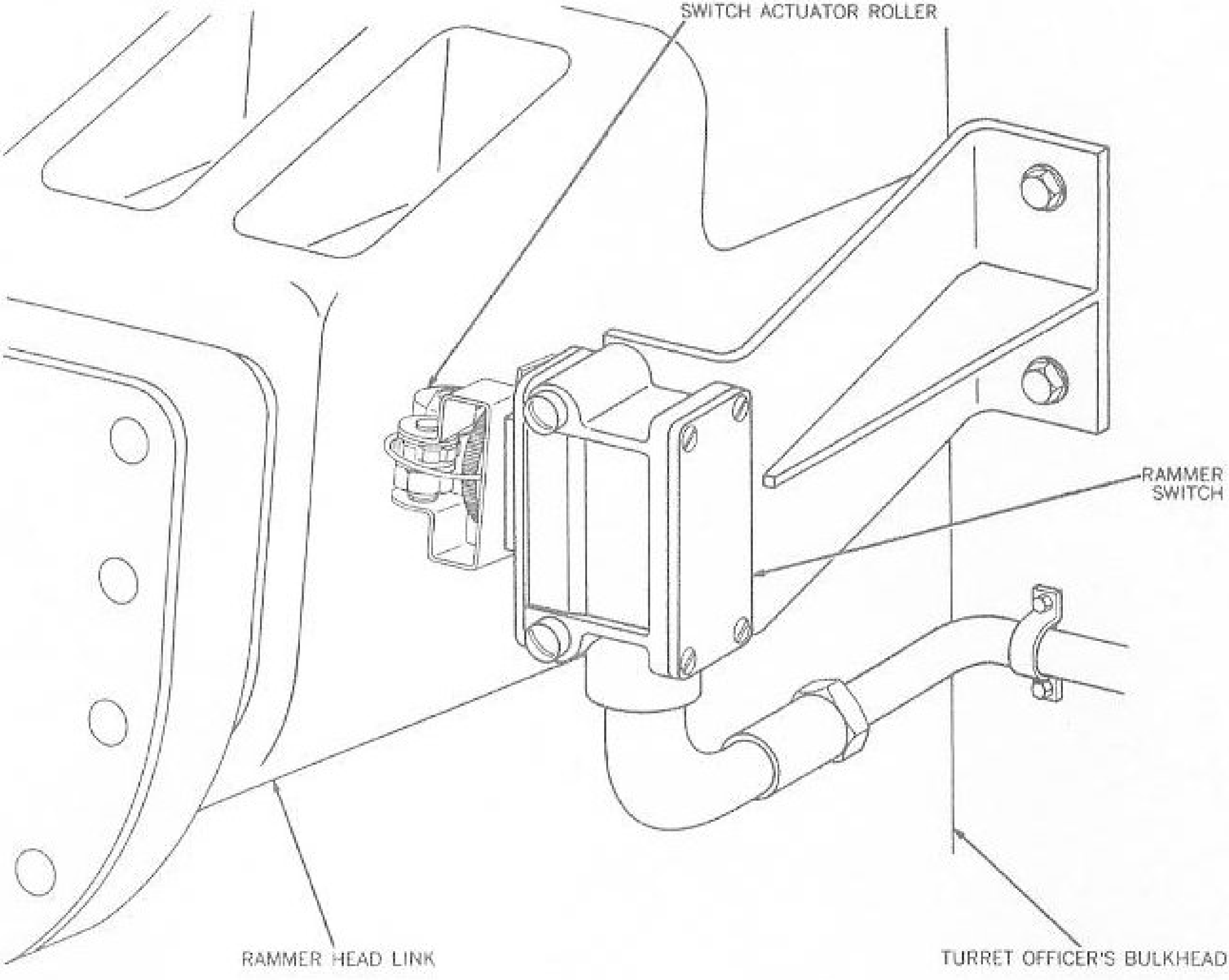


Figure 10-8. Rammer Switch and Actuator

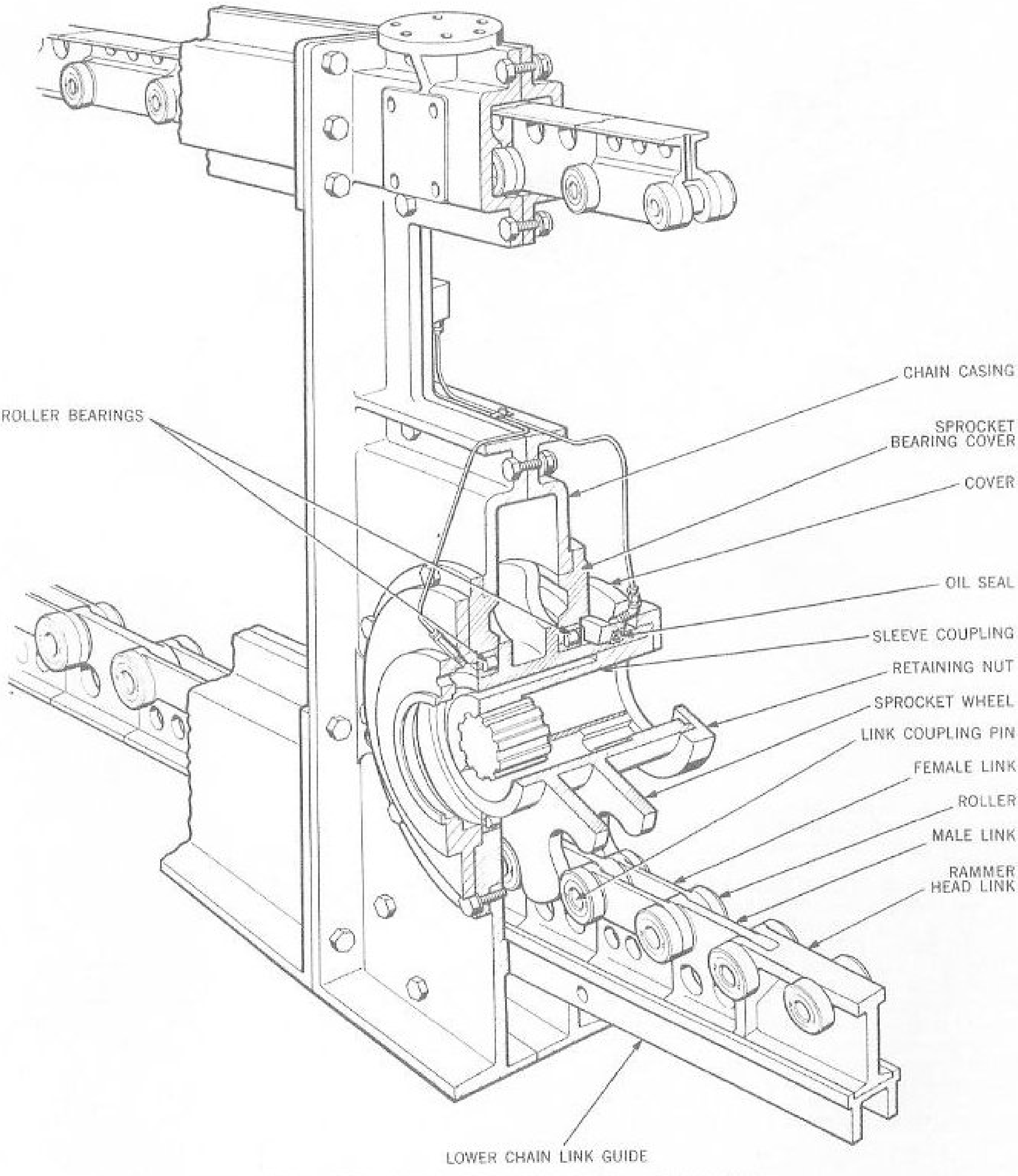


Figure 10-9. Rammer Sprocket Coupling, Sectional View

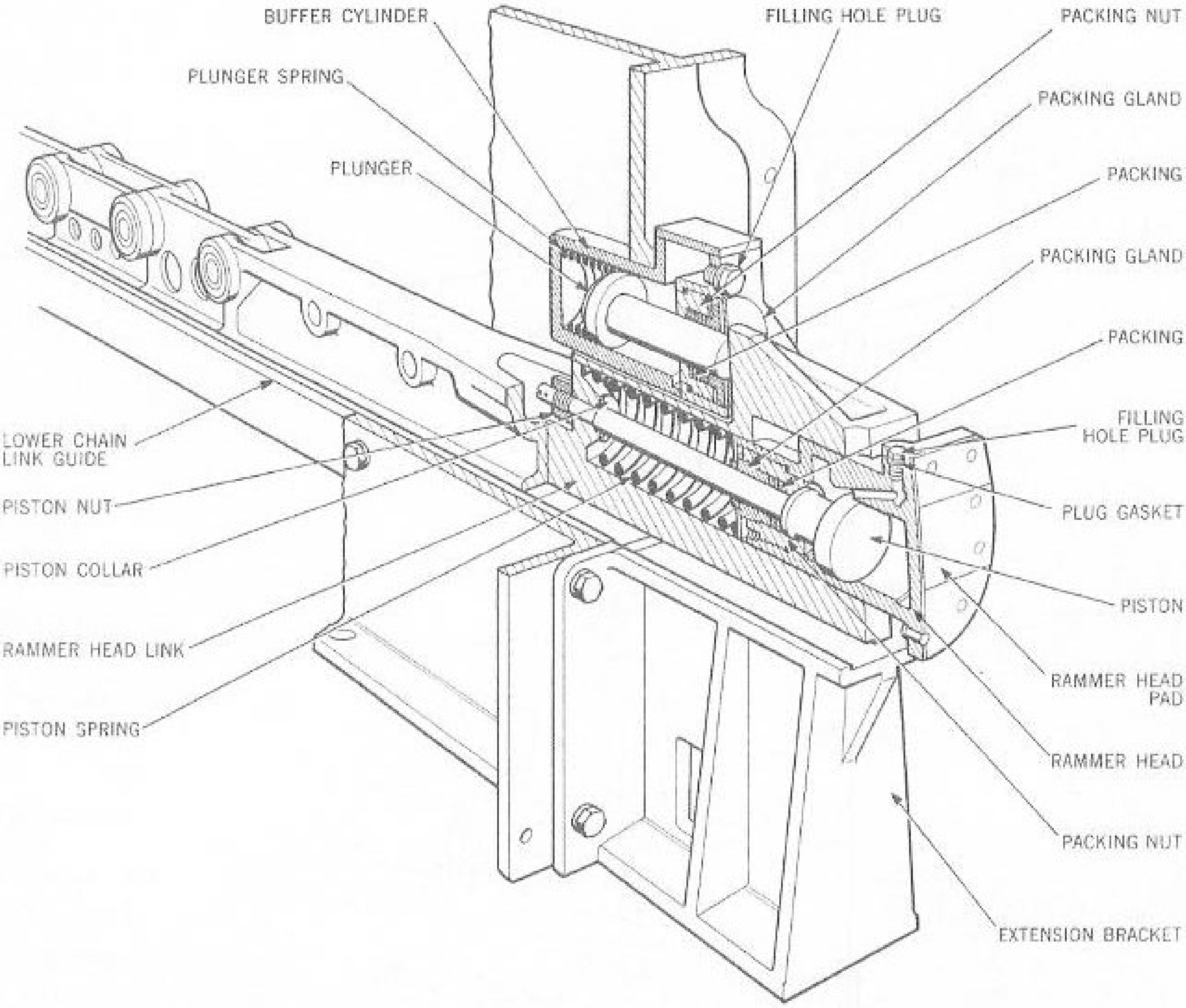


Figure 10-10. Rammer Chain, Head Link, and Withdraw Buffer, Sectional View

is remotely operated by two push buttons adjacent to the rammer operator'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. In the event of power failure, the main contactor opens and remains open until the START-EMERG button is depressed. 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.

Hand control gear. The installed arrangement of the hand control gear is shown in figure 10-10. Its components are:

Hand lever
Lever pivot
Lever guide quadrant
Brackets
Shock absorber cylinder
Shaft linkage
Coupling

Hand lever. The hand lever, a flat steel bar approximately 33 inches long and 0.50-inch thick, is shaped and drilled for attaching a handle at its upper end and a lever pivot at its lower end. Mounted in the gun room compartment (fig. 10-1), the hand lever is the device which actuates the stroking control to initiate a ram or withdraw stroke. A spring detent, mounted on the upper end of the hand lever just below the handle, locates and retains the lever at neutral. It is an assembly consisting of a detent guide, a spring -loaded detent, and a roller mounted in the detent, which contacts the lever guide quadrant.

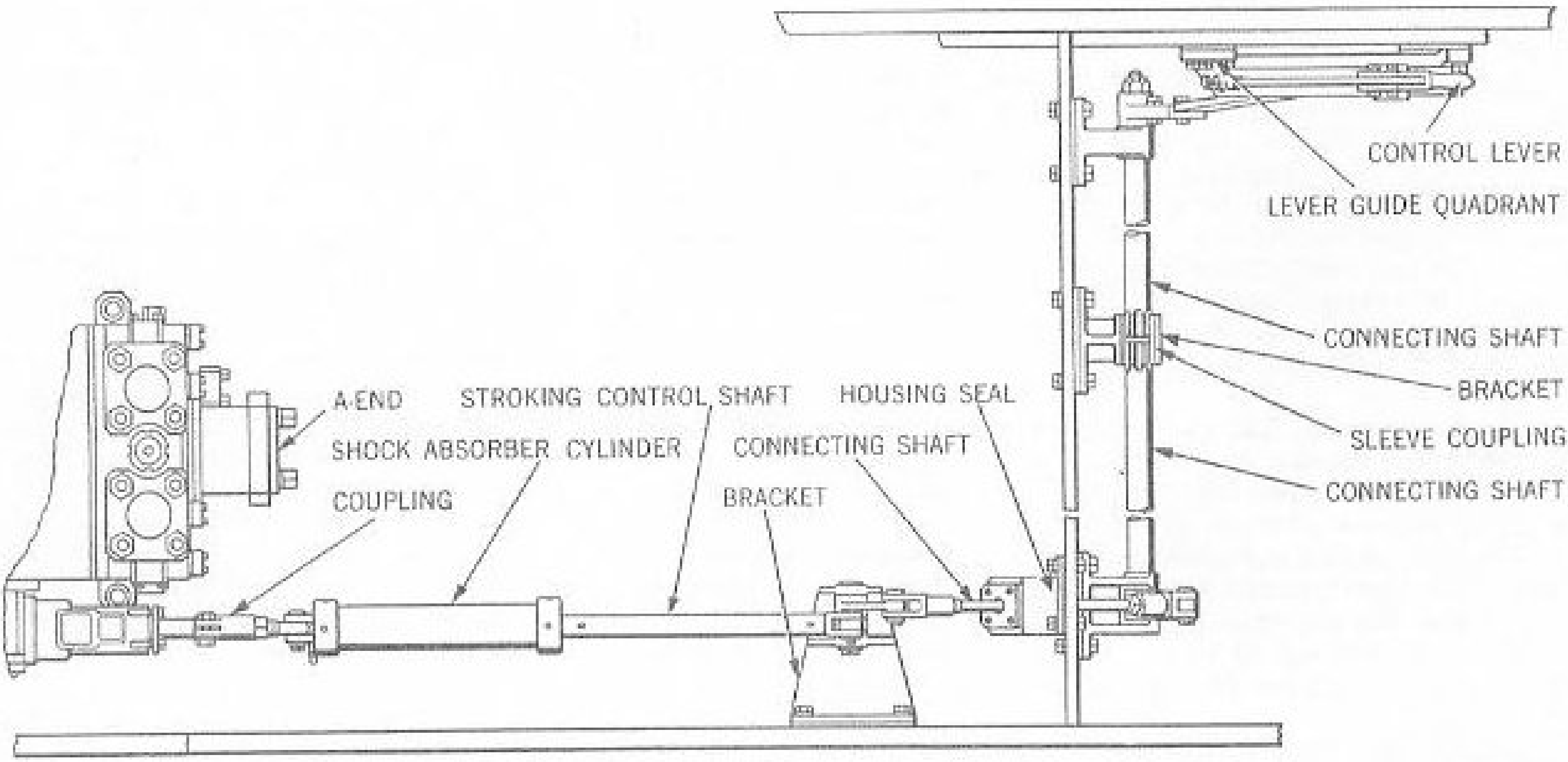


Figure 10-11. Hand Control Gear, Center Rammer, Plan View

Lever pivot. There are two lever pivots used for the turret rammer assemblies. The lever pivot for the outboard rammer assemblies, attached to the lower end of the hand lever, is a steel casting 10.875 inches long. At its lower end it is connected to the hand control linkage and is pivoted at a point 5.0 inches above this connection. The lever pivot for the center rammer assembly, attached to the lower end of the hand lever, is a steel casting 5.875 inches long. It is pivoted at its lower end and is connected to the hand control linkage at a point 5.0 inches above this connection. Through both arrangements, movement of the hand lever to RAM or WITHDRAW actuates the linkage to offset the tilting box.

Lever guide quadrant. The lever guide quadrant, attached to the gun room compartment bulkhead at the rammer operator's station, is a bronze casting approximately 23.3 inches long. It provides the arc on which the spring detent rides and a groove into which the detent roller drops to position the hand lever at neutral. There are adjustable stop bolts at each of the quadrants through which the limits of lever movement are adjusted. The lever movement, 17 degrees 33 minutes for outboard rammers and 17 degrees 26 minutes for the center rammer, is equivalent to 1.5 inches displacement of the linkage coupling or full tilt of the tilting box. RAM and WITHDRAW, together with arrows, are clearly inscribed on the quadrant to indicate lever movement for these actions.

Brackets. The hand control shaft linkage is supported and secured in proper alignment by brackets which are bolted to the turret structure. The brackets, all castings, are made of a copper silicon alloy. A special bracket, used only in installations for the center gun, encloses a sleeve-type shaft coupling (fig. 10-11) which is lubricated by a grease fitting in the bracket.

In each installation, where the linkage passes through the transverse bulkhead, a linkage housing seal provides flameproof protection for the turret officer's compartment.

Shock absorber cylinder. The shock absorber cylinder (fig. 10-11), a double-acting spring device, forms the connecting link between the control shaft and the coupling of the hand control gear. It acts to absorb the kick of the hand lever when the A-end stroking control positions the tilting box at neutral. The device consists of a tube with an end piece threaded on each end of the tube. Within the tube, a spring compressed between two retainers fits over a control rod which passes through one end piece and threads onto the control shaft. The device is approximately 18 inches long at rest.

Shaft linkage. The operating components of the hand control gear are connected to the stroking control through an assembly of shaft linkage. The linkage differs for the outboard and center gun rammer installations. For the similar outboard gun installations, there is a direct linkage connection from the stroking control unit to the hand lever. An adjustable connecting shaft secured with a clevis pin at each end connects the lever pivot with a bracket-mounted bellcrank. The bellcrank is connected by a clevis pin to the control shaft which is threaded onto the control rod of the shock absorber cylinder. The center gun installation (fig. 10-11) differs in that the hand lever is on the opposite side of the chain casing from the stroking control unit, and the linkage must therefore provide for this offset arrangement. The lever pivot is spline fitted to a bracket mounted transverse connecting shaft. This shaft, joined near its center through a sleeve-type coupling is connected to the adjustable connecting shaft by a clevis pin. The remainder of the center gun linkage assembly is the same as the outboard assemblies with the exception of the bellcrank.

Coupling. The shock absorber cylinder is connected to the stroking control unit through a threaded sleeve coupling (fig. 10-11) and an eyebolt. The coupling, a steel casting split at one end, is threaded onto the control shaft of the stroking control unit and is locked in position through a bolt which passes through the split end. The eyebolt, threaded into the coupling, is locked in position through a locknut. The eyebolt is secured to the shock absorber cylinder head through a connecting pin.

Stroking control. The rammer stroking control (fig. 10-5) is a housing-enclosed mechanism mounted on the side of the A-end (fig. 10-1). It is coupled to the tilting box described on page 10-4 and to the hand control gear as described in the previous paragraph. The stroking control mechanism is a dual-purpose unit through which the tilting box is positioned at stroke, and which also restores the tilting box to neutral at the end of a ram or withdraw stroke.

Components. The stroking control unit comprises the following:

- Housing
- Cylinder
- Control arm
- Control shaft
- Trunnion block
- Neutral lock roller
- Adjustment eccentric

Housing. An oil-tight housing encloses the stroking control mechanism. The housing, a steel casting, consists of a cover and integral flanges for mounting the stroking control mechanism to the pump case and for mounting the control cylinders (fig. 10-5). The housing and cover each contain integral shoulders which seat ball bearings for the tilting box shaft. Within the housing are a control arm, piston, control shaft, and a spring plunger with neutral lock roller.

Cylinder. There is a cylinder flange mounted on each end of the housing. These cylinders, designated large and small control cylinders, provide a hydraulic discharge port and chamber, and a dashpot at each end of the housing. The inner arrangement of the housing, cylinder, and piston assembly provides a double-acting hydraulic piston combined with dashpot areas. The dashpots balance movement toward neutral and center the tilting box when it is hydraulically restored to neutral at the end of a ram or withdraw stroke.

Control arm. The control arm, spline fitted on the tilting box shaft, is located within the stroking control housing. The arm, a steel forging, is the connection between the stroking piston and the tilting box. The lower end of the arm is connected to the piston (fig. 10-5), and the upper end of the arm provides a cam detent for the tilting box follower to drop into.

Control shaft. The control shafts, integral parts of the stroking piston, extend into the outer chambers of both control cylinders. One control shaft passes through a packing and packing retainer (fig. 10-5) at the end of the large control cylinder. The end of this shaft is threaded for attaching the coupling of the hand control gear described previously. The control shafts and the outer chambers of both control cylinders form dashpots which balance the stroking piston movement and center the tilting box at the end of ram or withdraw strokes.

The by-pass holes (fig. 10-5), drilled in the ends of the control shafts, are located in such positions that they will by-pass hydraulic fluid from one end chamber to the other of the control cylinders. The holes by-pass fluid if the tilting box is slightly off neutral when the control lever is in its neutral position. The fluid flows from one end chamber to the other by way of either hole and a supercharge valve, depending upon the position of the tilting box. This action makes precise neutral location of the tilting box unnecessary to prevent creep of the rammer chain.

Trunnion block. The trunnion block (fig. 10-5) forms the connecting link between the stroking piston and the control arm. The block fits into a recess at the center of the piston and is restrained against horizontal movement. The block, attached to and moved by the control arm, is free to move vertically.

Neutral lock roller. The neutral lock roller (fig. 10-5) is a component of the neutral lock device of the stroking control unit. The other components of the device are a spring plunger which is attached to a roller yoke. The yoke provides a ball-bearing mounting for the neutral lock roller. These components, through an adjustment eccentric, are located vertically above the cam detent of the control arm and below the interlock switch plunger. The neutral lock device is mounted on the top of the stroking control housing.

Adjustment eccentric. The neutral lock device, described above, is mounted within the adjustment eccentric. The eccentric is a rotatable eccentric sleeve with a locknut. It provides for centering the neutral lock roller in the cam detent at neutral positions of the tilting box.

Neutral interlock switch. The neutral interlock switch is an enclosed plunger-type electric switch that is used in the electric motor starting circuit. The switch, bracket-mounted from the A-end case, locates the switch plunger vertically above the interlock plunger. The switch opens the starting circuit during the first 1/4-inch offset movement of the plungers when the tilting box moves either side of neutral. The purpose of the switch is to prevent starting overload on the electric motor when the power drive is at a midcycle position with the tilting box offset from neutral stroke.

OPERATION

General

The starting, stopping, speed, and ram or withdraw action is controlled by the direction and degree of hand lever movement. The position of the control and limit stop mechanism is shown in figure 10-11. The schematic diagrams illustrate in sequence the phases of circuit flow conditions and resultant movement of components during a complete operating cycle as described in the following paragraphs.

Starting

Perform the following operations when starting the rammer electric motor:

1. Place the controller circuit breaker lever at ON.

2. Place the hand lever at neutral stroke position.

3. Press the START-EMERG button.

Stopping

When stopping the rammer power drive, perform the following operations:

1. Move the hand lever to WITHDRAW and fully retract the rammer.

2. Place the hand lever at neutral stroke position.

3. Press the STOP button.

Circuit operations

Controls neutral (fig. 10-12). With the rammer stopped at the end of a withdraw stroke and the hand lever at neutral, the following condition exist:

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 withdraw deceleration valve A is held closed by the rocker arm actuated by pin B.

VALVE AND PISTON SYMBOLS

A WITHDRAW DECELERATE VALVE
B1, B2 BALL CHECK VALVES
F RELIEF VALVE (SUPERCHARGE)
FV FILTER BYPASS RELIEF VALVE
G, H SUPERCHARGE VALVES
K RELIEF VALVE (MAIN SYSTEM)
M STROKING CONTROL PISTON
QQ RAM DECELERATE VALVE
SS, ZZ STROKING VALVES
S, T, W, X PORTS
EE, FF, GG, JJ CHAMBERS
1 THROUGH 16 HYDRAULIC LINES

MECHANICAL SYMBOLS

B DECELERATE VALVE ACTUATING PIN
C GEAR WHEEL (DRIVEN)
D GEAR WHEEL (DRIVING)
I TILTING BOX FOLLOWER
J STROKING ARM
L SPRING
V ECCENTRIC ADJUSTMENT

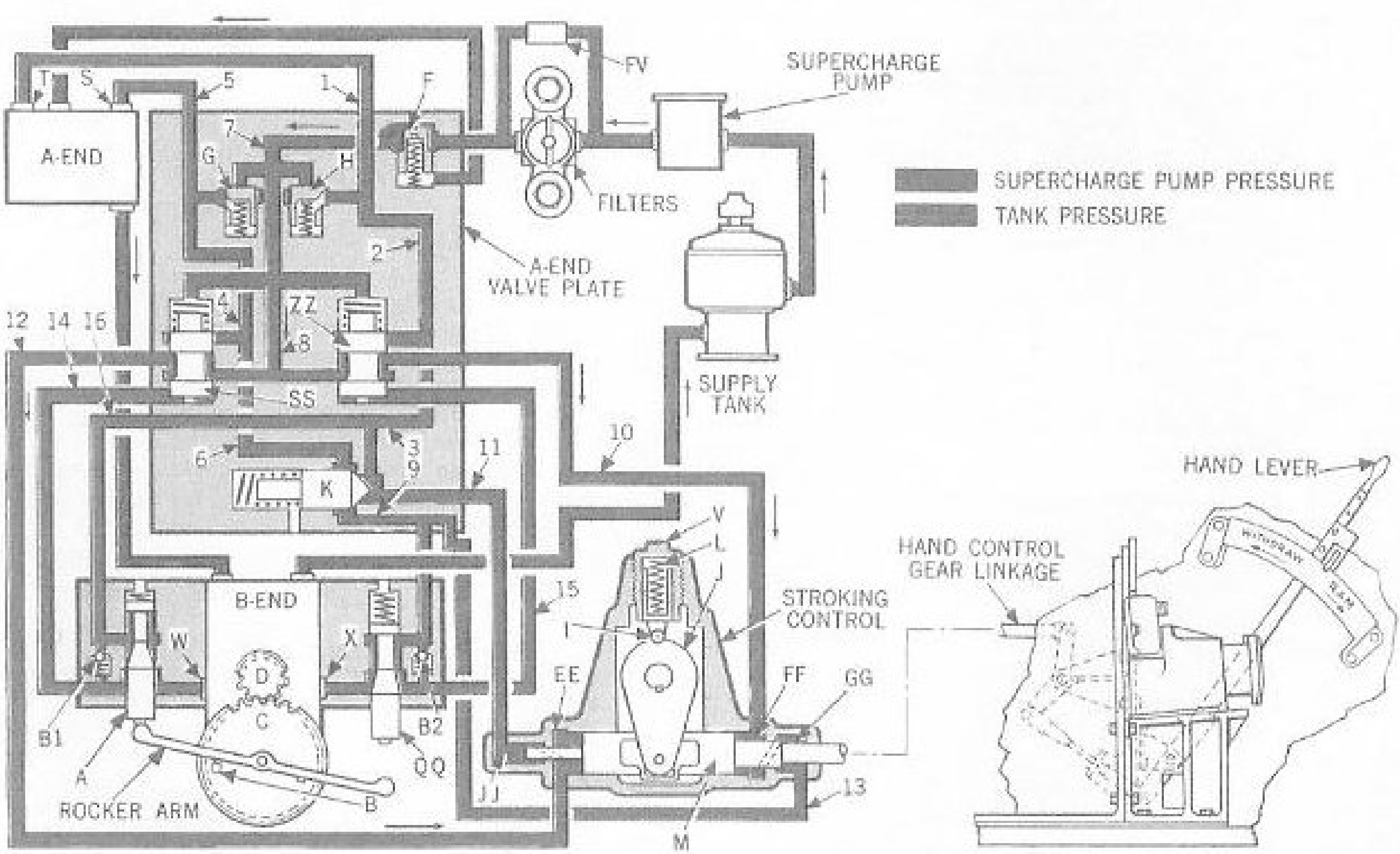


Figure 10-12. Rammer Hydraulic Schematic - Controls Neutral, End of Withdraw Stroke

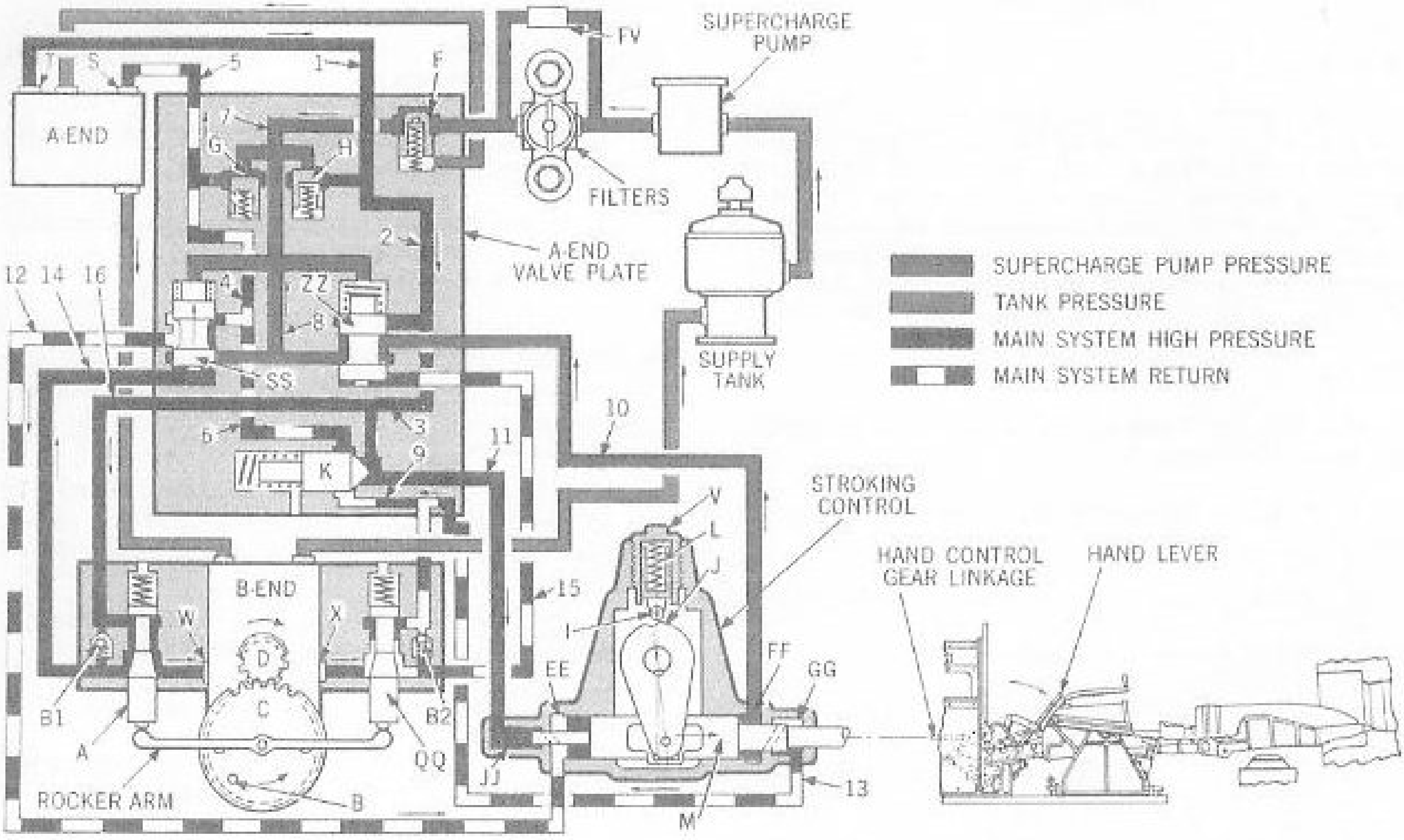


Figure 10-13. Rammer Hydraulic Schematic - Starting to Ram

3. Hydraulic fluid is delivered by the supercharge pump (at supercharge pressure) through the duplex filters to supercharge relief valve F to the tops of supercharge valves G and H, and to the stroking valves SS and ZZ. From SS and ZZ, supercharge pressure is delivered through line 12 to chamber EE and through line 10 to chamber FF of the stroking control piston M.

4. The ram deceleration valve QQ is open.

5. The tilting box is held in neutral position by the tilting box follower I, which rests in the detent of stroking arm J.

Starting to ram (fig. 10-13). When the hand lever is moved to RAM:

1. Hand lever motion, transmitted through the hand control gear linkage (fig. 10-13), moves the tilting box to stroke. As the tilting box moves to stroke, stroking arm J forces tilting box follower I out of the arm J detent. To permit free movement of piston M, chamber GG is open to the B-end discharge line 9 and chamber FF is open to the control pressure portion of the system (to which chamber EE is also open) through valve ZZ.

2. Main system high pressure is delivered from the A-end through port T to the B-end through lines 1, 2, and 2, through ball check valve B1, and around valve A to port W of the B-end to start rotation of the rammer sprocket. High pressure is also ported to chamber JJ to assist in moving the A-end to full stroke. The B-end discharge is ported back to the A-end through lines 9, 6, 4, and 5. Movement of withdraw stroking valve SS by system high pressure has no effect on the system during the ram stroke.

3. After a few degrees rotation of the B-end, pin B is disengaged from the rocker arm. Withdraw deceleration valve A is then opened by its spring to permit free flow of hydraulic fluid at main system high pressure to the B-end.

4. Normal leakage in the main system is replenished through line 7 and replenishing valve G into main system return line 5.

Rammer stalled, projectile seating (fig. 10-14). With the hand lever remaining at RAM and the projectile seated, the rammer stalls and the B-end cannot rotate. Main system high pressure builds up above the setting of relief valve K, unseats the valve and bypasses to part A of the A-end through lines 6, 4, and 5.

Main system relief valve. The main system relief valve is shown in figure 10-3A as it would appear when operating conditions are normal. If pressure in port L13 rises above 800 pounds per square inch, check valve A in the plunger V12 is unseated (fig. 10-3B). Fluid under excessive high pressure flows through passages 1, 2, 3, 4, 5, and 6 into chamber C at the top. This excessive high pressure at the top of the valve together with spring D keeps the plunger V12 seated against the force of fluid under high pressure beneath V12. Simultaneously, fluid

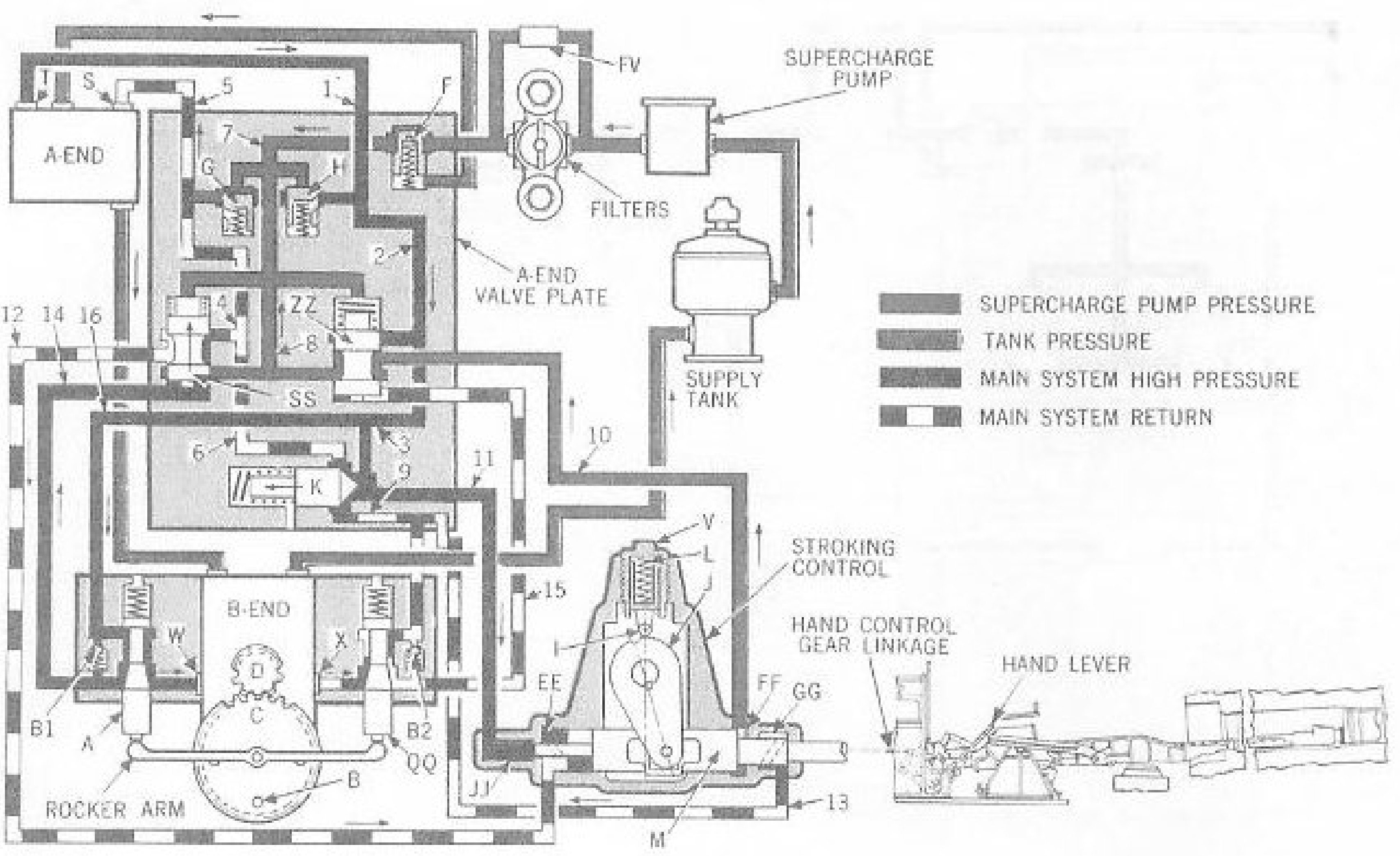


Figure 10-14. Rammer Hydraulic Schematic - Rammer Stalled, Projectile Seated

under high pressure flows through passage 7 and forces the pilot plunger V13 up against spring E until the upper shoulder of V13 opens the pressure port to passage 8 (fig. 10-3C). This releases the pressure in chamber C. Excessive high pressure on the lower end of V12 unseats V12 and permits flow of excessive high pressure from port L13 to port L14. Unseated momentarily only, V12 seats as soon as main system pressure drops below 800 pounds per square inch. The effective areas of V12 in ports L13 and L14 are equal; therefore the valve has identical operation for high pressure relief in both drive pipes.

Limit stop control during ramming (fig. 10-15). With the rammer stopped at the end of a ramming stroke by the limit stop mechanism, the following conditions exist:

1. Rammer sprocket rotation, which drives gear C through rotation of gear D, causes pin B to depress the rocker arm thereby closing valve QQ and gradually cutting off main system discharge through QQ into line 9. The closing of valve QQ decelerates sprocket rotation. Main system return pressure build-up in line 15 opens stroking valve ZZ before QQ is fully closed.

2. When opened, valve ZZ directs system pressure to chamber FF of piston M to move the tilting box back to neutral. As the tilting box approaches neutral, the pressure in chamber FF drops and the rate of tilting box movement toward neutral lessens However, a return of the tilting box to stroke position is impossible because of the reduced main system pressure in chamber FF.

3. Hydraulic fluid, displaced by piston M from chamber EE, is delivered to port S of the A-end (through line 12, valve SS, and lines 4 and 5) to replace main system fluid which entered chamber FF.

Manual stop control (fig. 10-16). While a ram stroke is being performed, chamber GG is open to the B-end discharge line 9 and chamber FF is open to the control pressure portion of the system (to which chamber EE is also open) through valve ZZ. The rammer is stopped manually, before the end of a ram stroke, by moving the hand lever toward neutral. The following conditions exist:

1. When the hand lever is moved toward neutral (in the direction indicated by the arrow), fluid in chamber EE is ported to the A-end through line 12, valve SS, and lines 4 and 5.

2. Fluid in chamber JJ is forced back into the high pressure side of the main system through line 11. Main system return fluid is ported to chamber GG from the B-end through valve QQ and line 13. Hand lever movement toward RETRACT is possible after a ram stroke has been initiated.

Starting to retract (fig. 10-17). When the hand lever is moved to WITHDRAW:

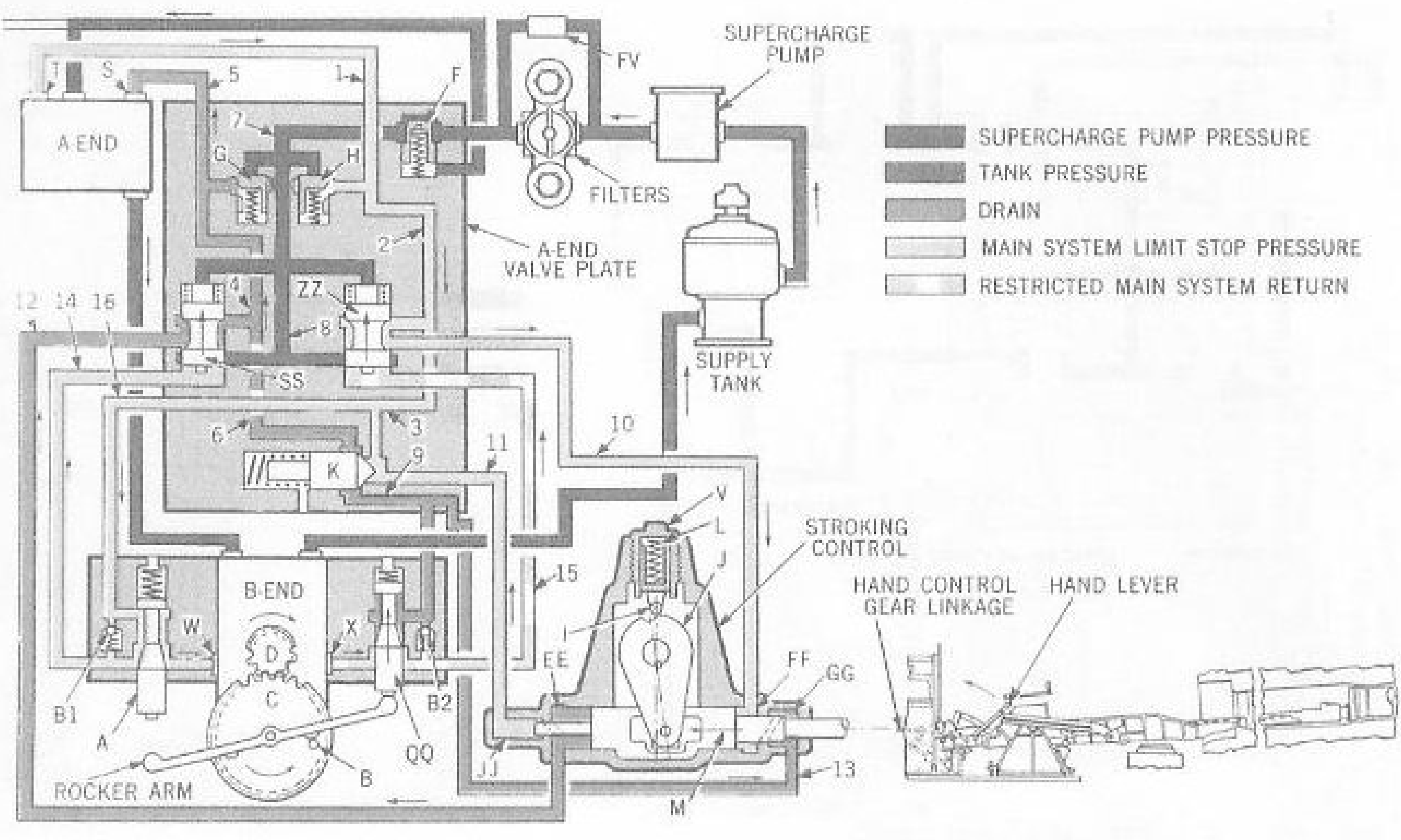


Figure 10-15. Rammer Hydraulic Schematic - Limit Stop Control During Ramming

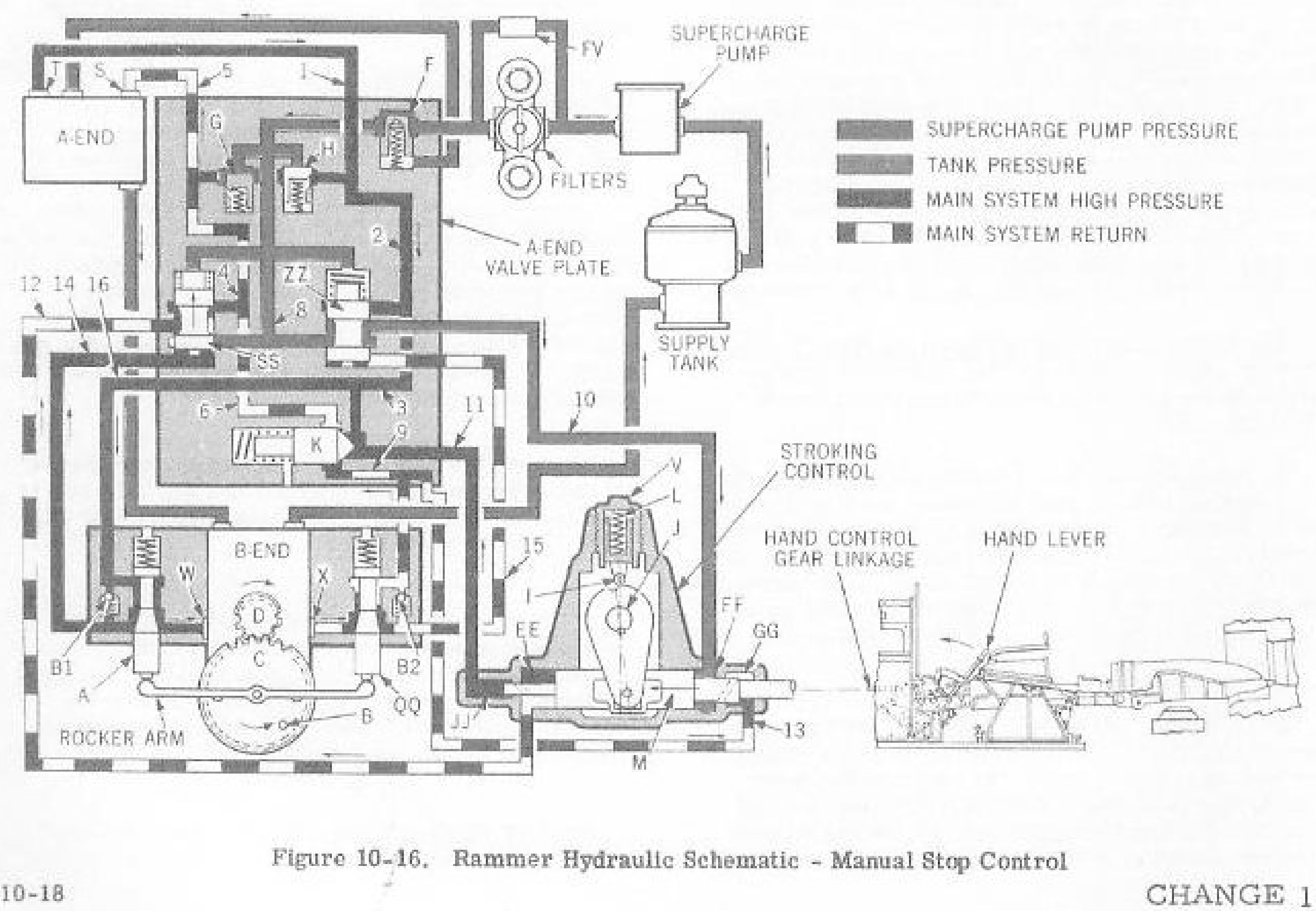


Figure 10-16. Rammer Hydraulic Schematic - Manual Stop Control

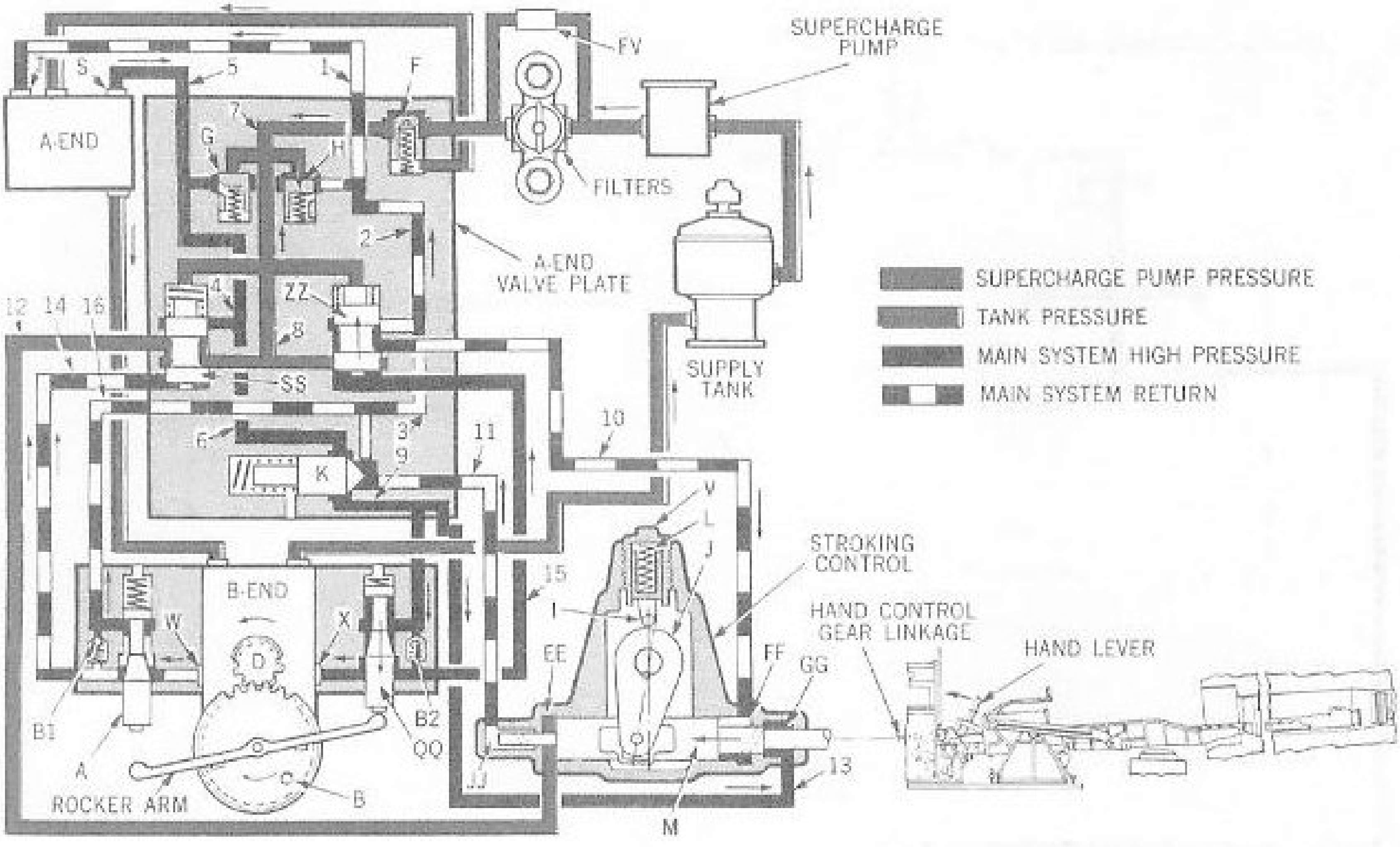


Figure 10-17. Rammer Hydraulic Schematic - Starting to Withdraw

1. Hand lever motion, transmitted through the hand control gear linkage, moves the tilting box to stroke. As the tilting box moves to stroke, stroking arm J forces follower I out of the arm J detent. To permit free movement of piston M, chamber JJ is open to the B-end discharge through line 11 and chamber EE is open to the control pressure portion of the system (to which chamber FF is also open) through valve SS.

2. Main system high pressure is delivered from the A-end through port S to the B-end through lines 5, 4, 6, and 9, through ball check valve B2 and around valve QQ to port X of the B-end to start rammer sprocket rotation. High pressure is also ported to chamber GG to assist in moving the A-end to full stroke. The B-end discharge is ported back to the A-end through lines 16, 2, and 1. Movement of valve ZZ by system high pressure has no effect on the system during the ram stroke.

3. After a few degrees rotation of the B-end, pin B is disengaged from the rocker arm. Valve QQ is then opened by its spring to permit free flow of hydraulic fluid at main system high pressure to the B-end.

4. Normal leakage in the main system return line 1 is replenished through line 7 and replenishing valve H.

Rammer withdraw stroke relief (fig. 10-18). With the hand lever remaining at WITHDRAW and the limit stop mechanism out of adjustment, the withdraw stroke is completed, the rammer stalls, and the B-end connot rotate. Main system high pressure builds up above the setting of relief valve K, unseats the valve and bypasses to port T of the A-end through lines 5, 4, 6, 3, 2, and 1.

INSTRUCTIONS

General maintenance

The rammer 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 hydraulic system maintenance instructions in chapter 17.

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

Except for the controller overload safety device, check all elements of the rammer power and control assembly for normal operation by operating through ram and withdraw strokes and by obtaining gage readings of supercharge pressure. Make these test at frequent intervals, and always prior to firing. Make the tests with hydraulic fluid at normal operating temperature and after observing the operating precautions on page 10-20. To make supercharge pressure tests, connect pressure gage 265851-7 at either of the main transmission line air vent holes.

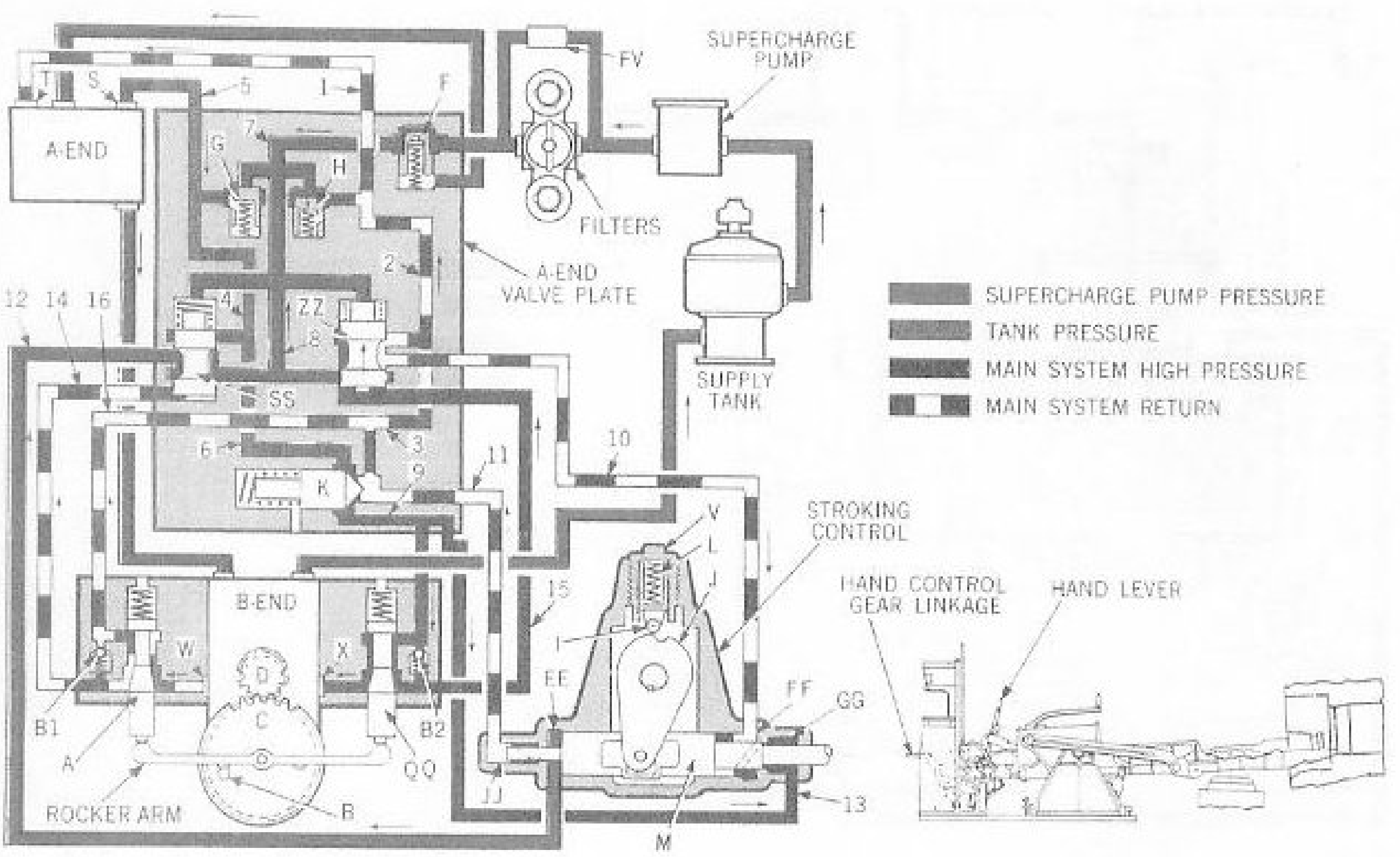


Figure 10-18. Rammer Hydraulic Schematic - Withdraw Stroke Relief Action

With the power drive operating, move the hand lever slightly from neutral and check the lowest pressure reading. The reading should be between 35 and 100 pounds per square inch. If the pressure is less than 35 pounds per square inch, plunger 265809-20 (shown on drawing 265781) should be removed and cleaned. If the pressure is over 100 pounds per square inch, the filter is clogged and must be cleared.

Lubrication. All hydraulic power units are self-lubricating. Other elements of the rammer assemblies, such as the electric motor, hand control linkage, and couplings, are to be lubricated in accordance with the instructions on the lubrication charts.

Operating precautions

The following precautions must be observed before operating the rammer assemblies:

1. Check the fluid level at the supply tank to make sure that there is sufficient hydraulic fluid in the system. Check the fluid level immediately after starting the electric motor and at intervals thereafter. Replenish if necessary.

2. Lubricate the assembly using the lubricants specified on the lubricating chart. Check the chain roller pin, for sufficient lubricant.

3. Inspect the withdraw and the rammer head buffers. Check the liquid level. Replenish if necessary as described on page 10-21.

4. Check the electric motor and A-end for correct direction of rotation.

5. Check the neutral interlock switch adjustment. Move the tilting box off neutral and verify that the starting circuit opens. Return the tilting box to neutral.

6. Check and clear the hydraulic system filter cartridge as described on page 10-21.

7. Start the power drive and gun until the system temperature is about 75 degrees F. With the gun, projectile hoist cradle, and spanning tray at loading position, move hand lever for a slow ram stroke to the limit stop. Check the shock absorber cylinder and lever actions for normal operation, as described on page 10-19.

8. Check the system temperature frequently when used frequently. The power drive should not be operated when fluid temperatures exceed 170 degrees F.

9. The hand lever must be fully returned to its neutral detent position when it is returned from a ram stroke. If not, the B-end may continue to rotate until the decelerate valve is jammed shut and the detent plungers jump out of the driven gear of the limit stop mechanism. This action will throw the system out of timing and permit the decelerate valve to open and jam the tail link before the limit stop acts. When this occurs, a full withdraw stroke must be made to allow the plungers to reseat in the detents. The chain should not overrun sufficiently to allow the

plungers to drop in the next detents; if this should happen, adjust as described on page 10-22.

Hydraulic equipment servicing

Buffer fluid. The fluid to be used in the withdraw and rammer head buffers is recoil cylinder liquid, NAVORD OS 1914. The buffers should be checked for replenishment once a month, at which time they should be inspected as follows:

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

2. Check the condition of the plunger packings.

Observe the following instructions on the caution plate:

CAUTION

BUFFERS TO BE FILLED IN 5° OPERATING POSITION ONLY. WITH PLUNGER EXTENDED REMOVE FILLING HOLE PLUG. FILL TO OVERFLOWING WITH RECOIL CYLINDER LIQUID, THEN REPLACE FILLING HOLE PLUG.

Hydraulic oil. Power transmission fluid 51F23 (Ord) is to be used in the hydraulic system. When the hydraulic system is initially filled, and when replenishing, the fluid should be poured through a fine mesh wire strainer of at least 120 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 51F23(Ord) and refilled with fresh fluid. A test inspection and analysis of a fluid 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 51F23(Ord), and refilled with fresh fluid. The total amount of fluid required to fill each system, when completely vented, is approximately 25 gallons for a center rammer and 26 gallons for an outboard rammer.

Draining the system. When the system is to be drained, remove the plugs from the bottoms of the A-end and B-end cases and from the B-end valve plate cover. To completely drain the B-end valve plate, refer to drawing 297388 and remove, in order, the valve screw 265832-67, the decelerate valve cap 265832-9, the decelerate valve spring 265831-4, the decelerate valve assembly 265831-38, and valve 265832-65. To completely drain the A-end valve plate, refer to drawing 297360 and remove the two stroking valves 265810-32. The stroking valves have threaded holes for the insertion of 1/4-20NC thread pulling screws.

Filling and venting. When filling or replenishing the system, pour the hydraulic fluid into the supply tank through a funnel with a strainer as described above. This procedure is important because the tank strainer is only adequate to prevent entrance of coarse foreign matter. Proper procedure for filling is as follows:

1. Remove the filler cap from the supply tank and fill to proper level as indicated on the gage.

2. Start the electric motor and allow it to run for several minutes.

3. Stop the electric motor and replenish the supply tank if necessary.

4. Open all air vents in the hydraulic pipes and start the electric motor.

5. Run the motor until fluid that is free of air flows from the vents. Stop the motor.

6. Turn the filter handle two complete turns and replenish the fluid in the supply tank to the proper level.

Oil filter maintenance. Clean the filter cartridge by rotating the handle one complete turn. Clean the filters periodically, depending upon the frequency and extent of operation, to prevent cartridge clogging. If the handle is difficult to turn, work it back and forth until the cleaners free themselves. A wrench or other tool must not be used to turn a plugged filter. If the handle cannot be worked freely, remove the cartridge, wash in solvent, and air dry.

Operating trouble diagnosis.

The following paragraphs describe operating troubles that may occur in the rammer power drive and their causes. The power drive is designed so that more than adequate forces are available to move all valves. Any trouble that may develop will be due to dirt or other foreign matter in the system. Possible sources of such trouble and their remedies are indicated in the following paragraphs.

B-end fails to deliver full torque. Failure of the B-end to deliver full torque when the A-end is stroked indicates that the main system relief valve is sticking open. Correct this condition as follows:

Remove and clean the two-way relief valve assembly and its pilot valve assembly.

Limit stop not functioning properly. Failure of the rammer to deliver a full ram or withdraw stroke (or if it tends to overtravel) is probably due to a sticking decelerate valve. Correct this condition as follows:

1. Remove the valve cap and spring.

2. Tap on the end of the valve with a soft hammer to loosen.

3. Work the valve up and down until it slides freely.

4. Do not lift the upper land of the valve above the valve plate for large fluid loss will result.

5. Reassemble before operation.

Adjustments

Rammer chain-limit stop adjustment. These instructions provide for the maximum ram stroke cut-off position which provides for chain travel to compensate for gun erosion.

The parts of the rammer assembly that are adjustable for obtaining correct limit stop positions or for varying the length of chain stroke are:

1. Chain

2. Sprocket and coupling

3. Withdraw stroke decelerate valve

At installation, these components are positioned in the process of adjusting the limit stop positions. Subsequent adjustment to vary or increase the chain stroke only requires readjustment of the ram stroke decelerate valve.

The adjusted positions of the chain, sprocket and coupling, and withdraw decelerate valve at initial assembly for a new gun are described in following paragraphs.

Chain. Clamp the chain at the withdraw limit stop position. This position locates the rammer head at 0.75 inch from full withdraw position (with the rammer head buffer plunger lug 0.75 inch from the rawhide stops).

Sprocket and coupling. Position the chain as described above, and position the B-end shaft as described in the next paragraph. The assembly will be properly adjusted if the splines of the coupling and shaft are aligned to engage. If the splines to not engage, reposition the sprocket or the B-end shaft, or both, to correct for the misalignment. Sprocket rotation of 4.5 degrees is equal to 0.5-inch displacement of the chain. Proceed as follows:

If the misalignment is 4.5 degrees or less:

1. Unclamp the chain from the position described above.

2. Move the chain in or out, as necessary, to engage the splines.

If the misalignment is more than 4.5 degrees:

1. Unclamp the chain from the position described on page 10-

2. Disengage the chain from the sprocket.

3. Rotate the sprocket one or more teeth and again engage with the chain and clamp in position.

This shift of sprocket engagement is based on the values of coupling misalignment as given in the tabulation on page 10-23.

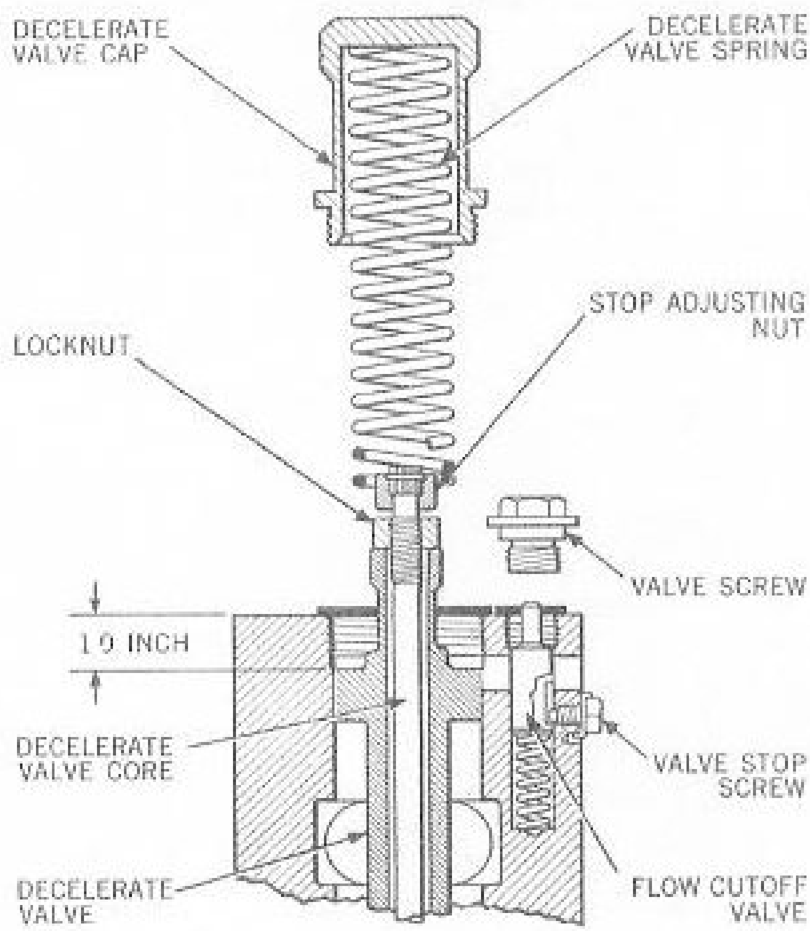


Figure 10-19. Withdraw Decelerate Valve, Limit Stop Adjustment

Withdraw stroke decelerate valve. Before engaging the coupling described in the previous paragraph, position the B-end at withdraw limit stop position. In this position the withdraw decelerate valve and the rocker arm are adjusted as follows:

1. Remove the flow cutoff valve cap.

2. Remove the decelerate valve cap and spring.

3. Turn the valve core counterclockwise for its full movement and back off 3/4 turn.

4. Rotate the B-end shaft in withdraw direction until the rocker arm lifts the top land of the valve one inch below the top surface of the B-end (fig. 10-19).

5. Replace the spring and valve caps.

This position of the B-end shaft and decelerate valve is the desired B-end position for coupling when the chain is positioned as described previously. If, due to spline misalignment, the chain has been moved from this position by 4.5 degrees or less to couple, the decelerate valve core must be readjusted an equivalent amount. The relationship of the valve adjustment is: 3/4 turn is equal to 0.5-inch chain displacement.

With the withdraw stroke limit stop adjusted as above and the B-end coupled to the sprocket, the ram stroke limit stop position is obtained by operating the rammer at slow speed until the face of the rammer head is 249.11 inches from the rawhide stops. Adjust the ram stroke decelerate valve as follows:

1. Remove the flow cutoff valve cap.

2. Remove the decelerate valve cap and spring.

3. Turn the valve core down until the top land of the valve is one inch below the top surface of the B-end.

4. Replace the spring and valve caps. The forward limit stop position may be advanced to compensate for gun erosion as follows:

Adjust the ram decelerate valve to delay cut-off movement; the additional chain travel (maximum) is equal to 4 inches.

Tabulation

Coupling Misalignments and Equivalent Adjustments

Coupling misalignment (degrees)	= Tooth change	+ Valve adjustment (degree)
18	2	0
17	2	1
16	2	2
15	2	3
14	2	4
13	1	4
12	1	3
11	1	2
10	1	1
9	1	0
8	1	1
7	1	2
6	1	3
5	1	4
4	-	4
3	-	3
2	-	2
1	-	1

Control lever adjustment. When the tilting box and the control shaft are in neutral positions, the hand lever must lock in its detent. This position, adjusted at the clamp coupling between the stroking control shaft and the shock absorber cylinder (fig. 10-11), is adjusted as follows:

1. Start the electric motor.

2. Run the chain part of the way out. Slowly bring the lever back toward neutral until the chain is motionless.

3. Adjust the coupling until the detent locks.

At the completion of this adjustment the rammer must not creep when the hand lever is locked at neutral.

Tilting box control movement. The hand lever and linkage give the desired maximum B-end speed when the hand lever arcs of movement are adjusted as tabulated below. Stop bolts on the lever guide quadrant must prevent lever movements from exceeding these arcs.

Rammer	Control movement from neutral
Right	$17^\circ 33'$
Center	$17^\circ 26'$
Left	$17^\circ 33'$

Two-way relief valve adjustment. The main system relief valve is adjusted to relieve high pressure in either main transmission pipe as follows:

1. With the electric motor stopped, remove the valve cap.

2. Turn the adjusting screw in to raise the pressure relief setting; turn out to lower the setting.

3. Replace the valve cap after making sure that the valve screw (fig. 10-19) is in place.

Rammer switch adjustment. The rammer switch is adjusted as shown on figure 10-20. The switch actuating lever is positioned to close the normally open switch when the rammer head link is four inches from the fully retracted position. A switch overtravel of 1/16 inch is provided.

DISASSEMBLY AND ASSEMBLY

General instructions

The following paragraphs contain instructions for disassembling units of the rammer power drive. In some cases a considerable part of the disassembly procedure will be apparent from reference illustrations and by studying the general arrangement drawings. Therefore, only those instructions which are pertinent to the order of disassembly and to the more complex disassembly operations are given. In general, assembly will be the reverse of disassembly. To help in the reassembly of a unit, mark all mating parts such as cams, gears, and linkages so that these parts will be reassembled in the same relative positions If this is done, individual parts will not need to be fitted to each other and readjustment will be easier. When piping is removed, do not plug disconnected pipe openings with rags or waste material. The openings must be closed according to the instructions and with the materials specified in chapter 17. Special tools and accessories used in disassembly of the equipment are indicated in the instructions.

Rammer chain removal

To remove the rammer chain, study drawings 233150 and 216401. Two methods of chain removal are described. Perform the following operations:

1. Remove the portable floor plate sections in the turret officer's compartment adjacent to the rammer chain to be removed.

2. Remove the two covers from the chain casing, accessible in the turret officer's compartment, that read "remove cover to extract tail link pin."

3. Drive out the tail link pin and remove the two rollers.

4. Remove the sprocket bearing covers.

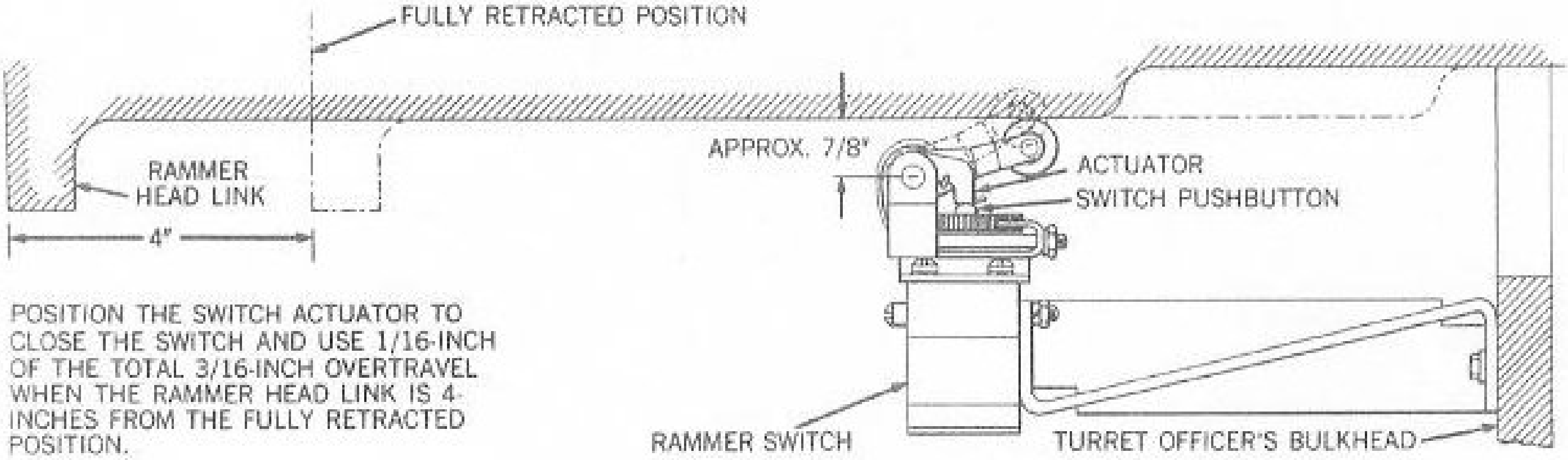


Figure 10-20. Rammer Switch and Adjustment.

5. Remove the sprocket coupling sleeve. This frees the sprocket from the B-end shaft.

6. Remove the chain by manually drawing it out until it is free.

Operations 1 through 6 above are convenient for outboard rammer installation. For the center rammer installation the alternative method of limit stop control overtravel is used. Proceed as follows:

1. Perform operations 2 and 3 of the instructions above.

2. Open the vents in the main transmission lines.

3. Remove the chain by manually drawing it out until it is free.

This action causes the driven gear to rotate beyond its limit stop control position - the six spring-loaded plungers and the gear hub being held by the rocket arm and striker pin - with the plungers slipping from their detents in the ring-gear. When the chain is reassembled, the driven gear must be similarly displaced at the other extreme of chain movement and the stop controls readjusted.

Disassembly of the A-end

To disassemble the A-end, refer to drawing 297359 and perform the following operations:

1. Remove the screws and washers which secure the packing gland (265802-57) to the front end of the A-end case.

2. Remove the packing gland, gasket and rotary oil seal.

3. Remove the stud nuts (265794-52) that secure the case head to the case.

4. Remove the long case bolts (265794-46).

5. Place the A-end assembly, with its valve plate up, on a hollow center stand with the main shaft down in a vertical position.

6. Remove the valve plate assembly.

7. Place the tilting box at neutral.

8. Screw eyebolt into top end of main shaft.

9. Remove the rotating group from the case with suitable hoist.

10. Remove the cylinder barrel (265801-43) and cylinder barrel keys (265800-39).

11. Remove the barrel spring (265800-38) and the spring ring (265800-37).

12. Remove the socket cap nut locks (265793-12).

13. Remove the socket cap nuts with socket cap nut wrench (265851-1).

14. Remove the connecting rod sockets (265793-4) and the connecting rods.

To disassemble the universal joint, refer to section ZZ of 297359, and proceed as follows:

15. Remove the taper pins (12-Z-49-104) by driving out with a punch.

16. Rotate the bearing block 90 degrees, and remove the universal joint with the bearing block from the socket ring.

17. Remove retaining pin (265794-19) from the trunnion block.

18. Remove the trunnion pin.

To disassemble the stroking control unit, refer to drawing 265782, and proceed as follows:

19. Remove the control cylinders (265814-8 and 265814-12).

20. Remove the cover from the housing.

21. Remove the locknut (265813-43) and the eccentric sleeve with its associated parts.

22. Remove the locknut from the tilting box shaft and the end ball bearing.

23. Remove the stroking arm, using jack-screws in the threaded holes.

24. Remove the unit housing.

25. Remove nut (265843-7) and pin (265851-5) and remove blocks (265812-3). Mark the blocks to aid in reassembly.

26. Refer to drawing 297359 and remove the trunnion cap (265802-72).

27. Remove the tilting box.

28. Remove the nuts that secure the supercharge pump to the valve plate.

29. Remove the supercharge pump and mark the gaskets so that they will be reassembled in the same position as removal.

30. Disassemble the valve plate, drawing 297360.

31. Remove valve plungers by inserting a long screw in the valve end.

Assembly of the A-end

Assembly the A-end in reverse order of the disassembly procedure above.

Replace all gaskets in good condition.

Tighten all nuts and screws, and make sure that all locking devices are locked.

Keep the components free at all times of foreign matter.

Cover all bearings, piston bores, valve plate, cylinder barrel and valves with a film of oil immediately before assembly to provide lubrication the instant the unit is started.

Adjust the stroking control unit after reassembly and after it is vented and filled with fluid. Proceed as follows:

1. Loosen locknut (265813-43).

2. Rotate the eccentric sleeve so that the tilting box is on neutral.

3. Tighten the locknut.

4. Adjust screw (265853-101) so that there is from 0.002- to 0.010-inch clearance below the interlock switch plunger when the tilting box is on neutral.

Disassembly of the B-end

To disassemble the B-end, refer to drawing 265785, and perform the following operations:

1. Remove the B-end from the rammer chain casing.

2. Remove the screws and washers which secure the packing gland to the front end of the B-end case.

3. Remove the packing gland and oil seal.

4. Remove the mounting flange and roller bearing assembly.

5. Remove the stud nuts that secure the case head to the case.

6. Remove the long case bolts.

7. Remove the valve plate.

8. Place the B-end with its valve plate end down.

9. Remove the angle box.

10. Screw eyebolt into end of main shaft.

11. Remove the rotating group.

12. Remove the cylinder barrel and cylinder barrel keys.

13. Remove the barrel spring and the spring ring.

14. Remove the socket-cap nut locks.

15. Remove the socket cap nuts with socket cap nut wrench (265851-1).

16. Remove the connecting rod sockets and the connecting rods.

To disassemble the universal joint, proceed as follows:

17. Remove the taper pins by driving out with a punch.

18. Rotate the bearing block 90 degrees, and remove the universal joint with the bearing block from the socket ring.

19. Remove the retaining pin from the trunnion block.

20. Remove the trunnion pin.

21. Disassemble the valve plate (drawing 297388). Remove the cover plate.

22. Remove the retainer plate (265836-15) from the driven gear assembly.

23. Wrap a strong cloth around the assembly before removing the ring-gear (265836-41) in order to catch the spring-loaded safety plungers (265836-32). These will be thrown out of their holes by the springs when the ring-gear is removed from the gear hub (297387-4). The safety plungers and springs are interchangeable.

24. Remove the driven gear hub and its shaft.

25. Remove the rocker arm (297392-4).

Assembly of the B-end

Assemble the B-end in reverse order of the disassembly procedure above.

Replace all gaskets in good condition.

Tighten all nuts and screws, and make sure that all locking devices are locked.

Keep the components free at all times of foreign matter.

Cover all bearings, piston bores, valve plate, cylinder barrel, and valves with a film of oil immediately before assembly to provide lubrication the instant the unit is started.

To assemble the safety plungers and springs in the driven gear assembly, proceed as follows:

1. Insert 3/16-inch-diameter steel pins into the the drilled holes of the gear hub and on top of the safety plunger springs (265841-33).

2. Remove these steel pins after the ring-gear (265836-41) is in place.