GENERAL DESCRIPTION OF THE TURRET

Four ships, the U.S.S. IOWA, U.S.S. NEW JERSEY, U.S.S. MISSOURI, and U.S.S. WISCONSIN comprise the IOWA class battleships. These ships have main batteries consisting of three 16-inch 3-gun turrets.

Main battery ordnance of each ship comprises nine 16-inch 50-caliber turret-mounted guns which are chambered for bagged powder charges and are equipped with carrier-type breech mechanisms. The guns, which may be fired at the rate of two rounds per minute, have a maximum range of approximately 41,000 yards (refer to ballistics data, chapter 3, page

All three turrets of each ship are located on the centerline, two forward and one aft of the superstructure. The gun house of turret II extends above the level of the first superstructure deck. The turret III gun house is higher above the main deck than the gun house of turret I. Turret distances from the ship's bow and from the base line to the gun trunnion axes are listed in the turret emplacement data below. Turret positions and the large arcs of train provide fire concentration of nine guns on either beam, six forward, and three astern.

Purpose

The main battery ordnance design provides for accurate firing of either armor piercing or high capacity projectiles at targets which include surface ships and shore installations. Armor piercing projectiles are capable of penetrating up to 16 inches of armor plate. High capacity projectiles, fired at ships and shore installations, are fuse-set to detonate on contact or at a predetermined time.

Ship class

The IOWA class battleships have an overall length of 888 feet, a beam of 108 feet, and a maximum draught of 34.6 feet. Ships of this class have a standard displacement of 45,000 tons (approximately 57,250 tons full load displacement) and are capable of a speed in excess of 32 knots. Extensive hull belt and deck armor protect the turrets and engine room spaces below the main deck level.

Emplacement data

Distances of the turret centers (turret vertical axes) from the ship's bow, and the gun trunnion axes above the base line (34.6 feet below the waterline) are tabulated below. The limits of gun elevation and depression and of turret train are given in chapters 5 and 6 respectively.

TURRET EMPLACEMENT DATA

Turret Number	Vertical Axis (feet from bow)	Trunnion Axis (feet above base line)
I	224	60.75
II	296	69.25
III	642	63.00

Turret arrangements and differences

Virtually identical, each turret comprises a gun house and rotating structure, a barbette and fixed structure, magazines, and ordnance installations. These differ only in minor details, adapting each turret to its ship location and the fire control plan. The gun house, 50.63 feet long with a maximum width of 36 feet, is mounted above and attached to the rotating structure. Cylindrical and conical in section, with a maximum diameter of 35 feet, the rotating structure is supported by a roller path and consists of six floor levels. Turret II has a seventh floor level which is a part of the fixed structure.

The rotating structure, protected on top by heavy armor plate of the gun house, is enclosed within the upper and lower barbette sections. Cylindrical and made of heavy armor plate, the upper barbette and armor deck plates protect the rotating structure, roller path, and foundation. The three upper barbettes, each 37.25 feet in diameter, have different heights because of trunnion axis elevation differences. Conical and made of heavy steel plate, the lower barbette is a supporting structure for the upper and differs in height for each turret.

Components

Each turret consists of the structural units and equipment installations listed below and described in following paragraphs of this chapter.

List of design components:

- Structural assembly
  - Rotating structure
  - Suspended structure
  - Turret roller bearing
  - Fixed structure
- Ordnance installations
  - Gun and slide assemblies
  - Gun laying equipment
  - Projectile stowing and handling equipment
  - Ammunition hoist and gun loading equipment
  - Fire control equipment
- Auxiliary installations
  - Power supply
  - Illumination supply
  - Ventilating system
  - Sprinkling system
  - Sprinkling system, electrical
- Communications
  - Depression and train stop signal system (circuit DS)
  - Intra-turret emergency alarm (circuit RA)
  - Train warning signal system (circuit TW)
  - Turret announcing system (circuits MC)
  - Battle telephone system (circuits JA)
  - Supplementary telephone system (circuit XJ)
  - Sound powered telephone and voice tube call bell system (circuit E)
  - Ship's service telephone system (circuit J)

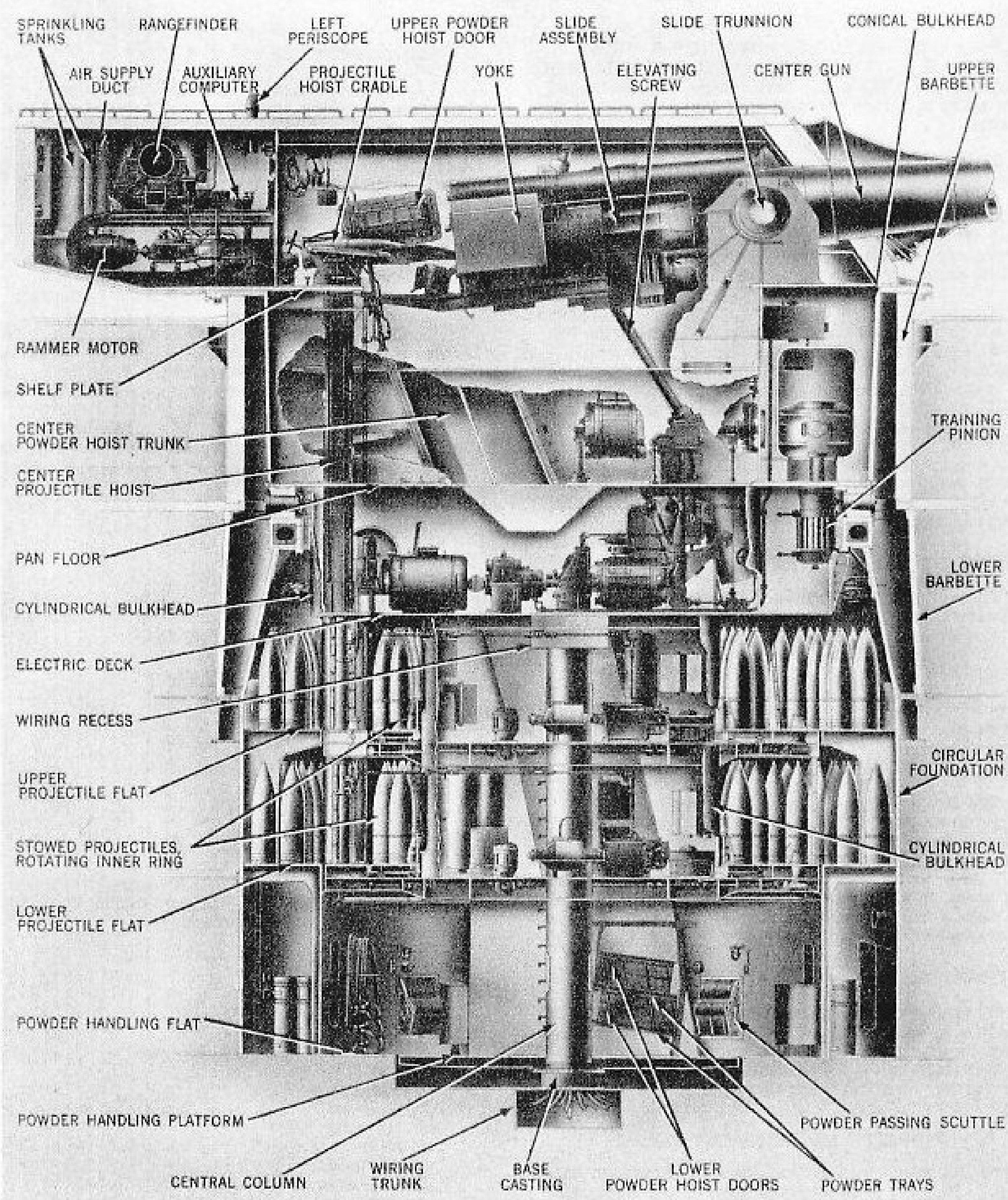


Figure 1-1. Turret General Arrangement - Longitudinal Section

Illumination

- General turret illumination
- Instrument illumination
- Rangefinder de-icing
- Gas ejector supply

Structural assembly

The structural assembly comprises the fixed structure, the turret roller bearing, and the rotating and suspended structures. Rotable, the two latter structures are attached to each other and are supported by the fixed structure. These two structural members bear directly on the turret roller bearing which is between the fixed and rotating structures.

The fixed structure, described on page 1-7 consists of parts built into the ship to support and protect the rotating structures. These parts are the foundation bulkhead, barbette, and other fixed elements.

The turret roller bearing, described on page 1-6 is the movable support for the rotating parts.

The rotating and suspended structures, described in the following paragraphs, are the parts that seat on the roller bearing. Ordnance and auxiliary installations are mounted in and are enclosed by these rotating parts which include the gun house and the structure beneath it.

Rotating structure. The rotating structure (fig. 1-1) is an assembly of steel weldments that weighs over 2000 tons with ordnance and auxiliary units installed. It is a six-level structure erected in the form of a rectangular gun house above a cylindrical assembly of five levels. The height of the structure from the powder handling platform to the top of the gun house is 53.75 feet for turret I, 62.25 feet for turret II, and 51.25 feet for turret III.

The six deck levels of the rotating structure are identified as follows: the shelf plate at the bottom of the gun house, the pan floor at the bottom of the gun pits, the electric deck (machinery floor) beneath the gun pits, two levels called the upper and lower projectile flats, and the powder handling platform at the lowest level. These deck levels are joined together by cylindrical and conical bulkheads, and gun girder weldments between the shelf plate and electric deck. Below the electric deck another cylindrical bulkhead extends to the lowest projectile flat. A central column within the latter cylindrical bulkhead extends from the machinery floor to the powder handling platform. The column, the conical bulkheads, and the outer edges of all deck plates below the shelf plate are concentric with the turret center of rotation. This arrangement - together with the welded construction of all plates, girders, and bulkheads - ties the entire rotating structure together in one rigid unit. It divides the turret into its principal functional spaces of gun compartments, machinery compartments, and ammunition handling compartments. The following overall measurements include these spaces:

Dimensions, Rotating Structure

Vertical distances, feet	
Powder handling platform to lower projectile flat	
Turret I	11.10
Turret II	19.60
Turret III	8.60
Lower projectile flat to upper projectile flat	7.75
Upper projectile flat to machinery floor (electric deck)	6.40
Machinery floor to pan floor	7.25
Pan floor to shelf plate	11.25
Shelf plate to turret roof	10.00
Gun house length, feet	50.62
Gun house width, feet	39.95
Pan floor diameter, feet	34.58
Electric deck diameter, feet	29.67
Upper projectile flat diameter, feet . .	28.12
Lower projectile flat diameter, feet. .	28.12
Cylindrical bulkhead between machinery floor and lower projectile flat, diameter, feet	17.00
Powder handling platform diameter, feet	19.50
Central column inside diameter, feet .	2.50

Gun house structural plan. The space between the gun house roof and the pan floor is subdivided by portable plates, flame barriers, and structural members. Comprising the turret officer's compartment, the sight stations, and the gun room compartments, this space is 21.25 feet high and is formed and subdivided by the following design arrangements.

Gun pit details. Extending vertically above and supported by the pan floor are five major components of the turret (fig. 1-5). These are the enclosing conical bulkhead and the four gun girders. Longitudinally parallel and vertical, the gun girders divide the gun pit into three gun pockets.

Each gun pocket is six feet wide and is 15.5 feet deep from the trunnion centerline to the pan floor. There is an 8.25-foot long trough-like depression in the pan floor parallel to and aft of the turret transverse centerline. A part of the gun pocket, this is 2.75 feet deep and provides clearance space for the loader's platform when the gun is at full elevation. Varying in length within the curving end walls, the approximate lengths of the gun pockets are 22 feet for the wing guns and 25 feet for the center gun. The gun girders that form the parallel sides of the pockets are different design types. The outer, or wing, girders are plate structures and the center units are box girder weldments.

Wing girders isolate two small spaces, which form ventilation trunks, between their outboard sides and the conical bulkhead. In each space vertical plates transversely placed and welded between the bulkhead and the wing girder stiffen the girder and the pan floor.

Each box girder is a unit consisting of two parallel plates with web bracing and vertical plates transversely placed and welded between the parallel plates; In the spaces between the parallel plates, the powder hoist trunks rise to the gun room compartments. Both box girders have provisions for access to the powder hoist machinery spaces and the trunnion bearings.

All four gun girders, covered with cap plates, extend 4.25 feet above the shelf plate. Portable vertical plates above the cap plates provide flame barriers and access for powder hoist machinery removal. Two parallel structural members of the forward portion of each box girder extend toward the turret roof to positions immediately behind the front plate. A structural member of the forward end of each wing girder extends to a similar position behind the front plate. These structural members are aligned to locate the positions of the deck lugs as described on page 4-1, chapter 4.

The four gun girders have six vertical structural members that extend rearward horizontally above the shelf plate to the gun house rear plate. These structural members, parallel cantilever beams which are connected to each other by vertical web bracings, provide attachment for the shelf plate.

Gun house details. The shelf plate, attached to the above-described gun pit structure, rests on the conical bulkhead. It extends beyond the conical bulkhead, overhanging slightly at the front and sides and 14.50 feet at the rear. Cut away in the area between the wing girders and conical bulkhead to provide a clear opening above the gun pits, the shelf plate extends 5.40 feet into the rear of the enclosure of the conical bulkhead. Flat throughout most of its area, the shelf plate forms a floor in the sight control stations and is bent up 13 degrees and 8 minutes along a line parallel to and 24.46 feet aft of the turret transverse centerline.

Parallel to the flat portion of the shelf plate and 2.80 feet above it, are the floor plates which form a flooring in the turret officer's and wing gun room compartments. This flooring has both fixed and portable sections and is broken to provide for installation of the rammer assemblies and rangefinder carriage.

Under the floor plates the cantilever beams and braces, together with the shelf plate, form a rigid box structure. This structure is designed to receive and support the gun house armor at its outer edges, and, in the space between shelf and floor plates, to accommodate units of the ventilating system (fig. 1-12).

The gun house roof plates are supported 6.25 feet above the floor plates by four 10-inch transverse beams. These are supported by three transverse webs and the gun house transverse bulkhead, all of which rise vertically from the shelf plate. With the shelf plate and armor plates, the webs, beams, and bulkhead constitute the gun house structure.

Armor. The armor plates consist of eleven pieces shaped, fitted, and bolted together to form an integral structure. Their identities and thicknesses are:

Front plate, inches	17.00
Front side plates, right and left, inches	9.50
Rear side plates, right and left, inches	9.50
Rear plate, inches	12.00
Roof plates, inches	
Front	7.25
Front intermediate	7.25
Center	7.25
Rear intermediate	7.25
Rear	7.25

The gun house outside arrangements include attached foot and hand rails, ladders, and platforms. These attachments differ for the three turrets. The armor front and side plates slope inward at the top; the rear plate is vertical.

The armor openings of the three turrets vary somewhat. Each turret has 11 virtually identical openings - three gun ports, two access openings, four sight hood openings, and two periscope openings. Turrets II and III, however, each have two additional openings for the rangefinder hood. In addition, on all ships of the class Turret III has a hole in its rear roof plate for electrical cables to the antiaircraft mount on its top; on some ships of the class Turret II also has a hole for a similar mount. Access openings in all turrets are located in the shelf plate overhang. These and all other openings are fitted with gasket seals or bucklers which make the gun house a weather and gas sealed enclosure.

Gun ports. Arrangements for sealing the three gun ports comprise fixed and moving parts (fig. 1-2). These consist of a weldment of splinter plates on the rear side of the front plate, shield plates on the gun slide, and a buckler (made of three-ply rubberized fabric) on the outside.

Attachment of the buckler to the front plate is provided for by a frame angle which encircles and is bolted to the gun port in the front plate. The buckler, clamped to the frame angle by a galvanized steel band, is distended by three expansion tubes (one at the top, two at the bottom). The inside of the buckler has arrangements for lashing it to the tubes which are free to move as the gun elevates or depresses. An additional clamping band attaches the front end of the buckler to the forward end of the gun slide cylindrical gun cover.

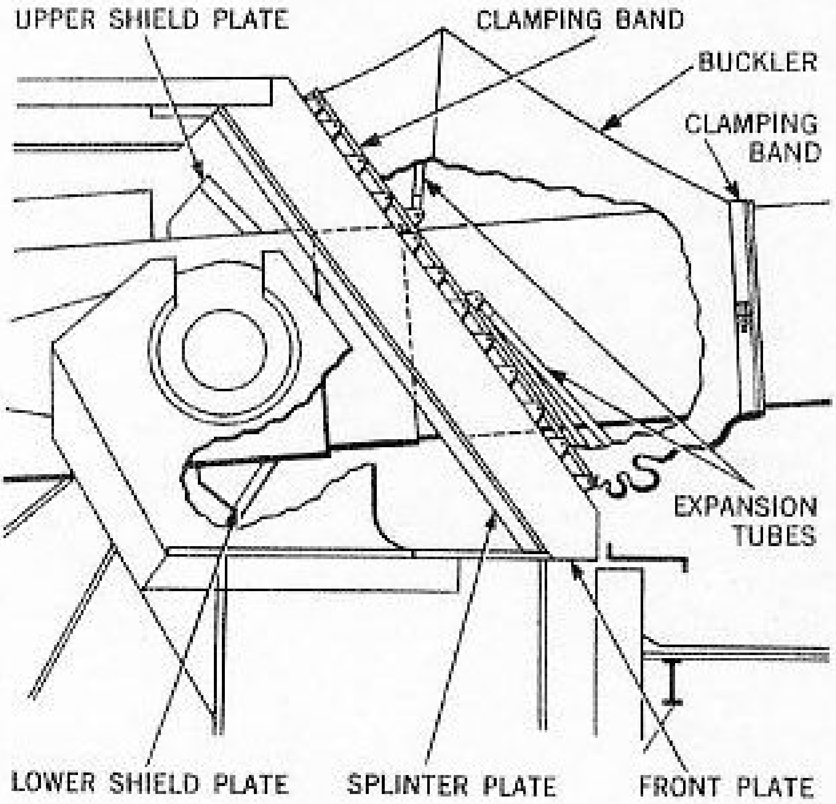


Figure 1-2. Gun Port Arrangement

Gun house subdivisions. The gun house interior is subdivided into six compartments (fig. 1-6) by interior arrangements which include the transverse bulkhead and webs, the plates and flame barriers above the gun girders, and the access doors in these structures. These gun house interior arrangements also isolate the powder hoist trunk and machinery spaces, and the hoist operators' stations.

The turret officer's compartment is formed by the transverse bulkhead 17.0 feet aft of and parallel to the turret transverse centerline and by the armor side and rear plates. Forward of the transverse bulkhead the three gun room compartments are formed by the gun house side plates and the plates, flame barriers, and transverse webs that rise vertically to the gun house roof above the gun girders and shelf plate. The two sight control stations are separate compartments, isolated from the wing gun rooms by the transverse webs between the side plates and the plates above the wing gun girders.

Access to these six compartments is provided by the following arrangements. The turret officer's compartment is accessible through a hatch in the bottom of the overhang. Six doors in the transverse bulkhead permit entrance into the three gun room compartments and the three powder hoist operators' stations. An additional door in each transverse web provides access to the sight control stations. Ladders at the rear of the gun pits permit passage to the pan floor level.

Suspended structure. The rotating structure that extends below the pan floor is a suspended structure that is isolated from the gun house and gun pits except for three flame tight hatches, one in each gun pit. Comprising the four lower levels of the turret, the structure is suspended from the pan floor and the upper roller path.

Upper roller path. The upper roller path (fig. 1-5) is a forged steel ring, 34.50 feet in diameter, secured to the pan floor beneath the conical bulkhead. Concentric around the train axis with the conical bulkhead, the upper roller path is the upper race of the turret roller bearing. The bottom face of the upper roller path is a machined horizontal bearing surface 16.0 feet below the gun trunnion axis. The suspended structure of turret I hangs 32.0 feet from this bearing surface to the level of the powder handling room (40.50 feet in turret II; 29.50 feet in turret III).

Suspended structure details. The suspended structure comprises the following units: the electric deck and enclosing cylinderical bulkhead, the upper and lower projectile flats and circular bulkhead, the central column, and the powder handling platform.

The central column is a continuous steel column fastened to and supporting the electric deck at its upper end. It passes through the powder handling platform and both projectile flats and supports these structures in addition to the electric deck. Between the lower projectile flat and the electric deck, a circular bulkhead provides additional support for the three floor structures it connects. On the projectile flat levels the bulkhead has cutaway sections which provide access to the projectile flat machinery spaces from the projectile handling spaces. The powder handling platform, supported by the central column, provides support for the lower ends of the powder hoist trunks. These rise upward to the gun room compartments and pass through both projectile flats (within the circular bulkhead), the electric deck, and the pan floor.

Both the upper and lower projectile flats are identical in compartment subdivisions and space arrangements. Each projectile flat is separated into two compartments, inner and outer, by the circular (cylindrical) bulkhead. Enclosed within the circular bulkhead, the 17.0-foot diameter inner compartment is the projectile ring power drive machinery space. The outer compartment is subdivided into three concentric, ring-shaped platforms with the outer ring attached to the fixed turret foundation. The inner ring, which may be rotated independently in either direction, is mounted on rollers that are supported by the turret rotating structure. A part of the turret rotating structure, the center ring is the projectile handling platform and provides support for the three projectile hoist tubes. The top surfaces of all rings are flush with each other. Each inner ring (called projectile ring) is an integral platform weldment with a low cylindrical coaming mounted around the inner edge. The platform provides sufficient space for stowing two concentric rows of projectiles and is arranged with chain lashings and other details shown in figure 7-1.

A cross web of cantilever I-beams, passing through the circular bulkhead, supports the inner compartment floor plates and the inner and center rings of each projectile flat. It is a heavy duty structure, cross braced by other beams and stiffened by the platform plates. This portion of the suspended structure is designed to carry the great weight of stowed projectiles and loaded projectile hoist tubes without apparent deflection. The upper and lower projectile flat construction is similar, the only differences being the sizes and locations of the powder hoist trunk and projectile hoist tube apertures.

The circular bulkhead between the pan floor and electric deck encloses a space 29.67 feet in diameter. This space is vertically subdivided into five compartments by the gun girders and a transverse bulkhead within the cylindrical bulkhead. Longitudinally arranged, the electric deck compartments comprise a void compartment in addition to one compartment for each elevating gear and training gear power drive. Access to these compartments is provided by cutaway sections and arches in the gun girders and by ladders to adjacent floor levels. The transverse bulkhead, 10.50 feet forward of and parallel to the turret transverse centerline, isolates the training pinions from the electric deck compartments. This is a rigid structure braced with a circular intercostal girder that is concentric within the cylindrical bulkhead.

Vertical portable ladders in the forward part of the projectile flat center ring give access from one projectile flat to the other. Steel rings attached to the rear of the central column permit passage to the powder handling room from either projectile flat. All hatches are of the raised non-flame-tight type except the hatch between the lower projectile flat and powder handling room. This is a raised flame-tight type hatch. The removal and installation of equipment in lower turret spaces is provided for by portable plates in the inner projectile flat compartments. These are arranged in vertical alignment.

Skirt plate. A cylindrical plate extends from the bottom of the pan floor into the electric deck space. Called the circular skirt plate, it is a tight fit within the enclosing cylindrical bulkhead of the electric deck. A structural element, it provides for riveted attachment of the suspended structure to the rotating structure.

Turret roller bearing. The rotating structure turns on the roller bearing assembly (fig. 1-3). This unit is supported on a lower roller track unit of the fixed structure described on page 1-9.

Bearing components. The turret roller bearing comprises 72 rollers assembled in 12 cage sectors of 6 rollers each. Attached together by inner and outer ring butt straps, the sectors form a 360 degree bearing ring with an outside diameter of approximately 35 feet.

Rollers. All rollers are identical steel forgings made with integral flanges. Each is 22.70 inches long across the flanges with a roller track contact surface between flanges of 17.58 inches in length. These are tapered rollers with maximum diameters across the inner and outer flanges of 14.25 and 15.19 inches, respectively. Weighing 546 pounds, each roller is drilled, bushed, and fitted with a spindle bolt which locates and retains the roller in a precisely allotted position in the cage sector.

Cage sectors. The cage sectors are identical in their construction, but differ as to the assembled positions of the six rollers retained by each. This difference applies to variations in the spaces between the axes of the 18 rollers in each of four identical quadrants. In each quadrant of three 30-degree sectors, the spaces between rollers vary by increasing increments that are constant for each sector but differ in value for the three sectors (fig. 1-4). In sector number 1, the distances between rollers increase clockwise by increments equal to four minutes of arc, in sector number 2 by six minutes of arc,

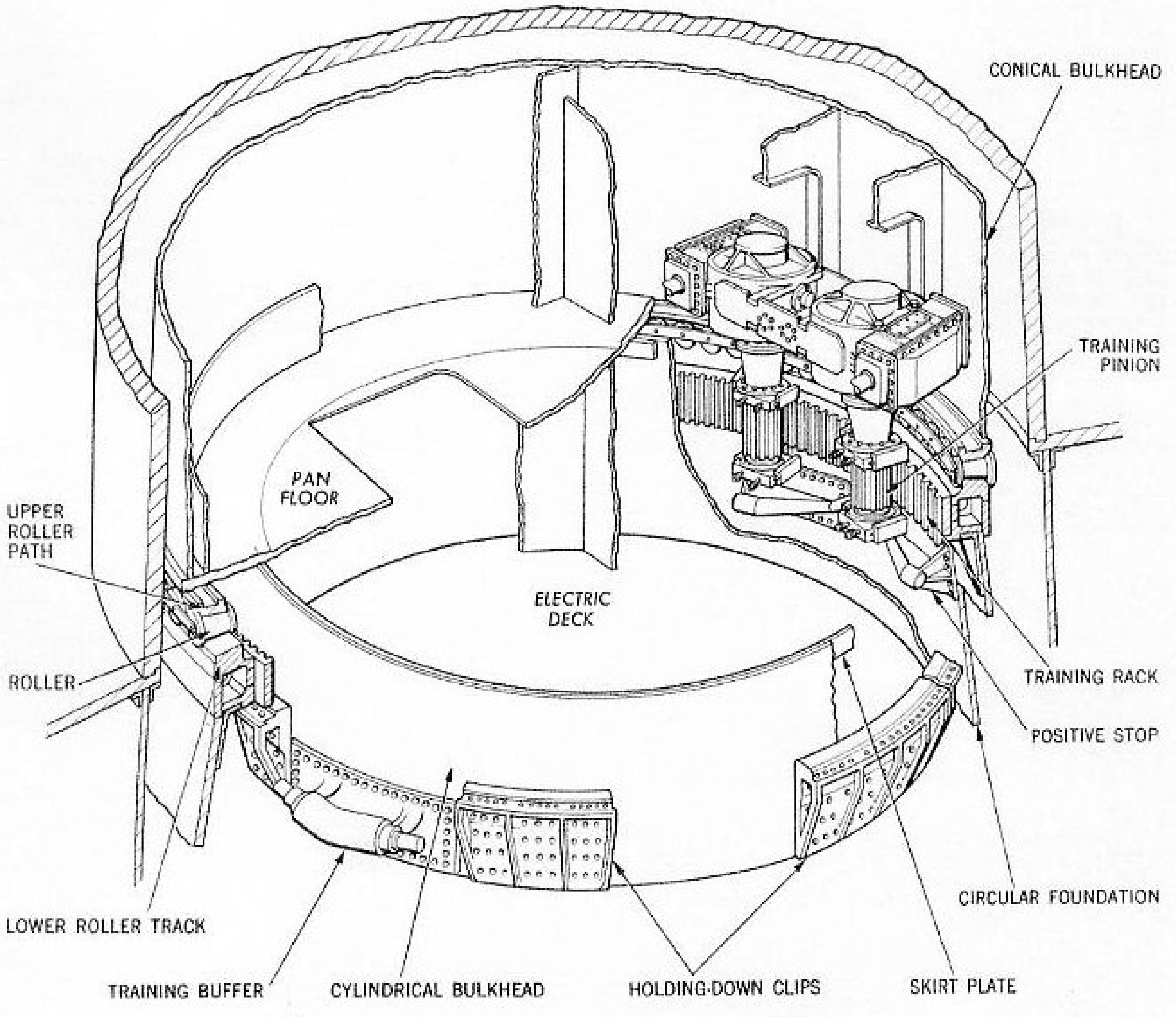


Figure 1-3. Turret Roller Carriage Arrangement

and in sector number 3 by eight minutes of arc. This design arrangement is to prevent roller path deformation from developing at the points of roller contact — a condition that would develop under firing and seaway load stresses if the roller spaces were equal.

Roller access. The cage sector and turret structure arrangements provide for inspection, lubrication, and replacement of rollers without dismantling the turret. Openings in the cylindrical bulkhead (enclosing the electric deck space) permit access to any and all rollers from inside of the electric deck space, by training the turret. To remove a roller the turret must be trained to one of six different angles (depending upon which sector the roller is to be removed from) to line up the desired sector with the access openings in the cylinderical bulkhead. The inner ring of the sector is removed through an access opening after the roller spindle bolts and the inner ring bolts of the left and right separators are removed. The rollers above the portable section of the lower roller track are then separated and the track section removed. Number 3 roller may be removed and removal of the remaining rollers follows without disturbing the outer ring.

Fixed structure. The fixed, or non-rotating, turret structure comprises the turret circular foundations, powder handling flat, lower roller track, base casting, and barbette. These components are shown in figures 1-1 and 1-5.

Turret circular foundations. Turret circular foundations differ for the three turrets. Each is a cylindrical and conical steel weldment, 37.25 feet in diameter at the bottom, which tapers to a 34.10-foot diameter at the top. The weldment is supported and secured at the ship's third platform deck in turrets I and II, and at the second platform deck in turret III. The weldment extends upward 29 feet above the third platform deck in turret I and 38.50 feet in turret II. In turret III the weldment extends upward 27.50 feet above the second platform deck.

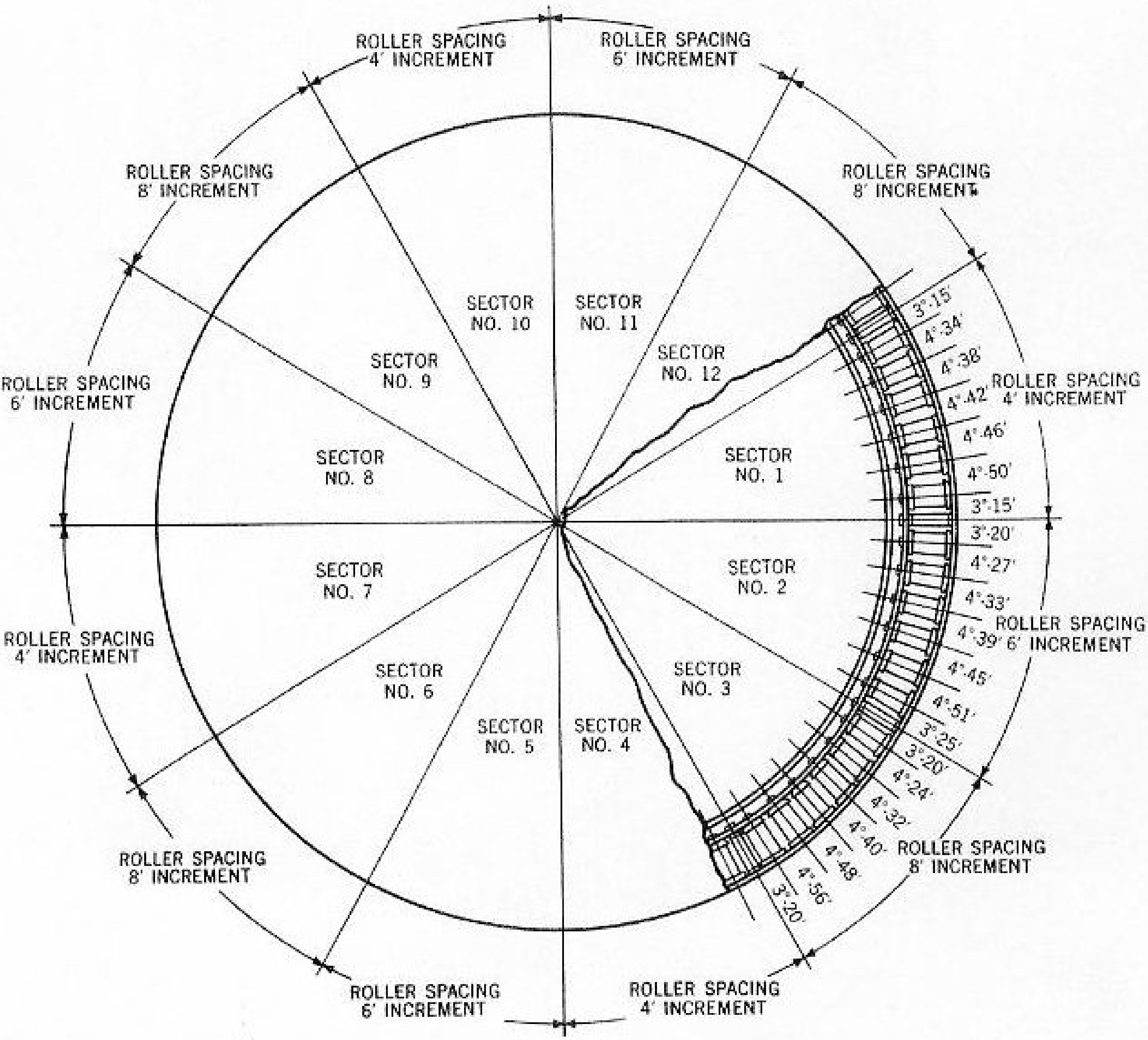


Figure 1-4. Cage Sector and Roller Spacer Details

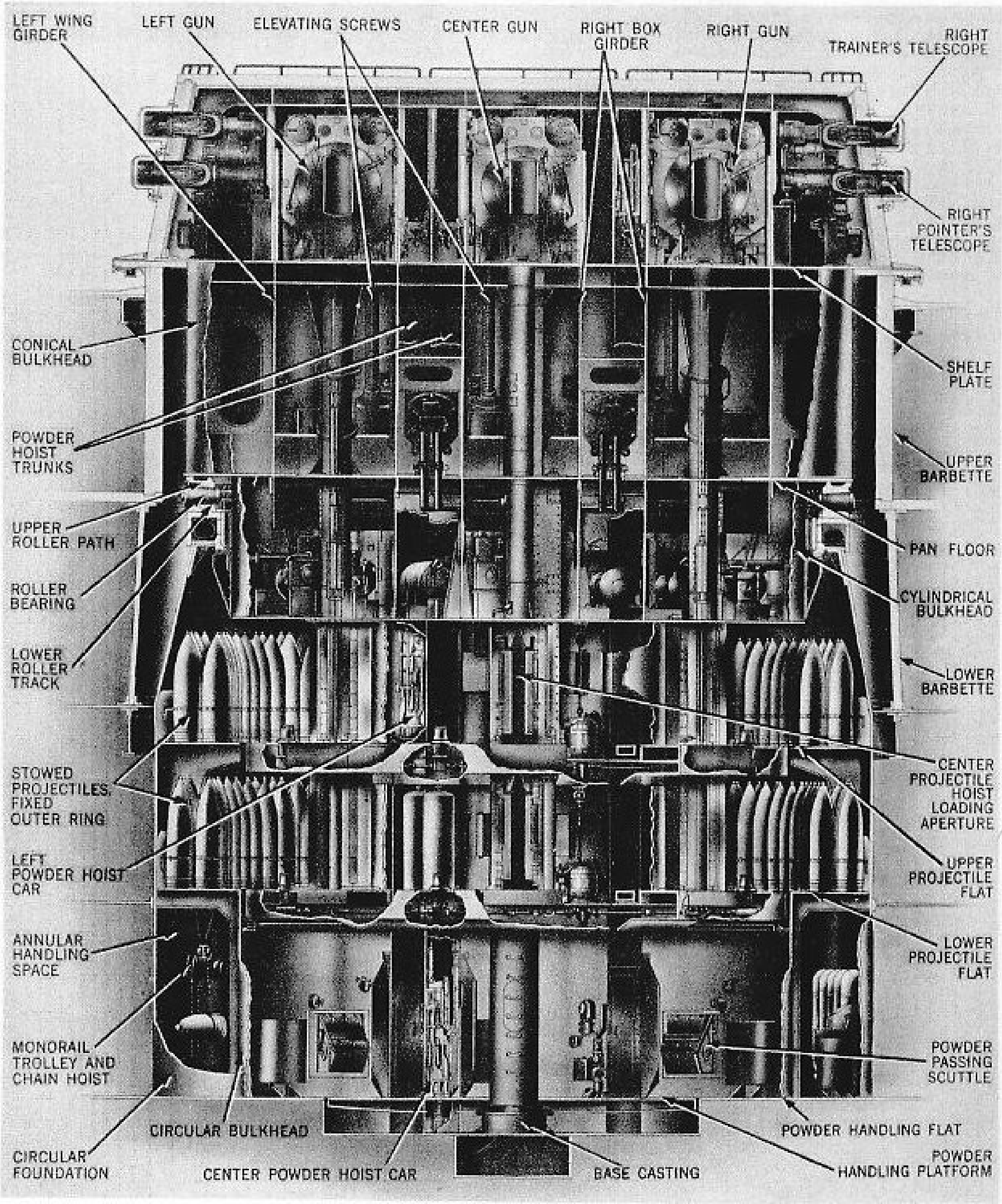


Figure 1-5. Turret General Arrangement - Transverse Section

Each circular foundation is a stand for the lower roller track (described below). In addition, it is an enclosing bulkhead for the projectile flats and the annular handling space. It also provides attachment for the training stops, flame seals, and powder scuttles.

There are two positive training stops. These are located near the top of the circular foundation (fig. 1-3) in the way of the training buffer.

The flame seal, located beneath the lower projectile flat, isolates the powder handling room from the rest of the turret. The seal, an angle bracket formed into a complete ring, is mounted on the concentric circular bulkhead enclosing the powder handling room. The ring mates with a complementary ring at the bottom of the lower projectile flat to provide a mechanical barrier. This arrangement permits free turning of the turret.

There are six powder passing scuttles in the lower part of each circular foundation (four scuttles in turret I) that align with similar scuttles in the powder handling room circular bulkhead. In addition, there are two watertight doors in each circular foundation that align with similar doors in the circular bulkhead. These arrangements provide access and communications between the powder handling room and magazines. The scuttles are manually rotated, horizontally positioned cylinders. They transfer powder bags (singly) from the magazines to the annular handling space and from this handling space to the powder handling room. During this transfer procedure a mechanical seal is maintained between the turret and magazine compartments.

Powder handling flat. At the bottom of the circular foundation, a ring-shaped floor structure forms the powder handling flat. The floor plates of the flat, flush with the powder handling platform of the rotating structure, form a working area 4.50 feet wide in front of the scuttles.

Lower roller track. The lower roller track is a ring-shaped weldment of box-section (fig. 1-3) which is attached to the top of the circular foundation. Machined after installation, the top of the roller track is a bearing surface of the same form, finish, and size as the similar surface of the upper roller path (34.50 feet in diameter). The inner face (roller flange surface) is a true cylindrical surface concentric with the roller paths and the axis of the rotating structure. Six portable roller track sections, keyed and tapped for accurately seating and securing to the weldment, provide for roller bearing access and removal. The weldment is also keyed and tapped for accurately seating the six segments of the annular training gear power drive, is a 360-degree of 210 teeth and 359.29-inch pitch diameter.

Base casting. The lowest element of the fixed structure is the base casting. This is a flanged and hollow pintle of 48-inch diameter, 15 inches high, that is secured below the platform level of the powder handling room. Accurately centered beneath the turret center of rotation, it is a dual purpose component that aligns the rotating structure and leads in the communications, power, and air supplies. The casting extends into and provides a radial bearing for the lower end of the central column. A ring-shaped insulation bushing horizontally placed at the bottom prevents the electrical cables from chafing.

Barbette. The barbette is made in two sections. The upper barbette is an assembled cylinder of heavy armor plate comprising seven cylindrical segments in turret I, twelve segments in turret II, and eleven segments in turret III. These segments, joined by a special welding procedure, form a built-in unit that encloses the turret above the second deck. With an inside diameter of 37.25 feet, the upper barbette extends vertically upward through the main deck to a plane two inches below the shelf plate. The ship's three upper barbettes have different heights because of the different heights of circular foundations. This dimension of the barbette is 142.16 inches for turret I, 253.03 inches for turret II, and 178.03 inches for turret III. Armor plate thicknesses vary from a standard 17.30 inches for all turrets to 11.60 inches at the front and rear sides. Upper barbettes are supported at their lower edges by the 4.75-inch thick second deck armor and the lower barbette.

The lower barbette is an assembled conical cylinder of heavy steel plate comprising eight cylindrical segments. These segments, joined by tapered keys, form a built-in unit that encloses the turret between the second and third decks. With an outside diameter of 40.50 feet at the bottom (39.67 feet at the top), the ship's three lower barbettes have different heights because of the different heights of circular foundations. This barbette dimension (maximum) is 140.08 inches for turret I, 118.88 inches for turret II, and 109.88 inches for turret III. With a plate thickness of approximately three inches, the lower barbettes are supported at their lower edges by the third deck.

Ordnance installations

The ordnance installations mounted in the turret rotating structure (described on page 1-3) comprise the units shown in figures 1-1 and 1-5 and in the turret floor plans (figs. 1-6 to 1-10 inclusive). These installations are of the following types and design identities.

Ordnance types. Each turret ordnance assembly comprises units of the following types:

- Gun and slide assemblies
- Gun laying equipment
- Projectile stowing and handling equipment
- Ammunition hoist and gun loading equipment
- Fire control equipment

Ordnance design identities. Ordnance equipment of the above types include one or more units of the following 16-inch design identities.

GUN AND SLIDE ASSEMBLIES, 16-INCH

- Gun Mk 7 Mod 0
- Beech Mechanism Mk 4 Mod 0
- Firing Lock Mk 14 Mod 0
- Gas Ejector Mk 5 Mod 0
- Yoke Mk 5 Mod 0
- Slide Mk 6 Mod 0
- Deck Lug Mk 7 Mod 0

GUN LAYING EQUIPMENT, 16-INCH

- Training Gear Mk 2 Mod 0
- Train Receiver-Regulator Mk 18 Mods 5, 6, and 7
- Elevating Gear Mk 5 Mods 0, 1, and 2
- Elevation Receiver-Regulator Mk 10 Mod 0

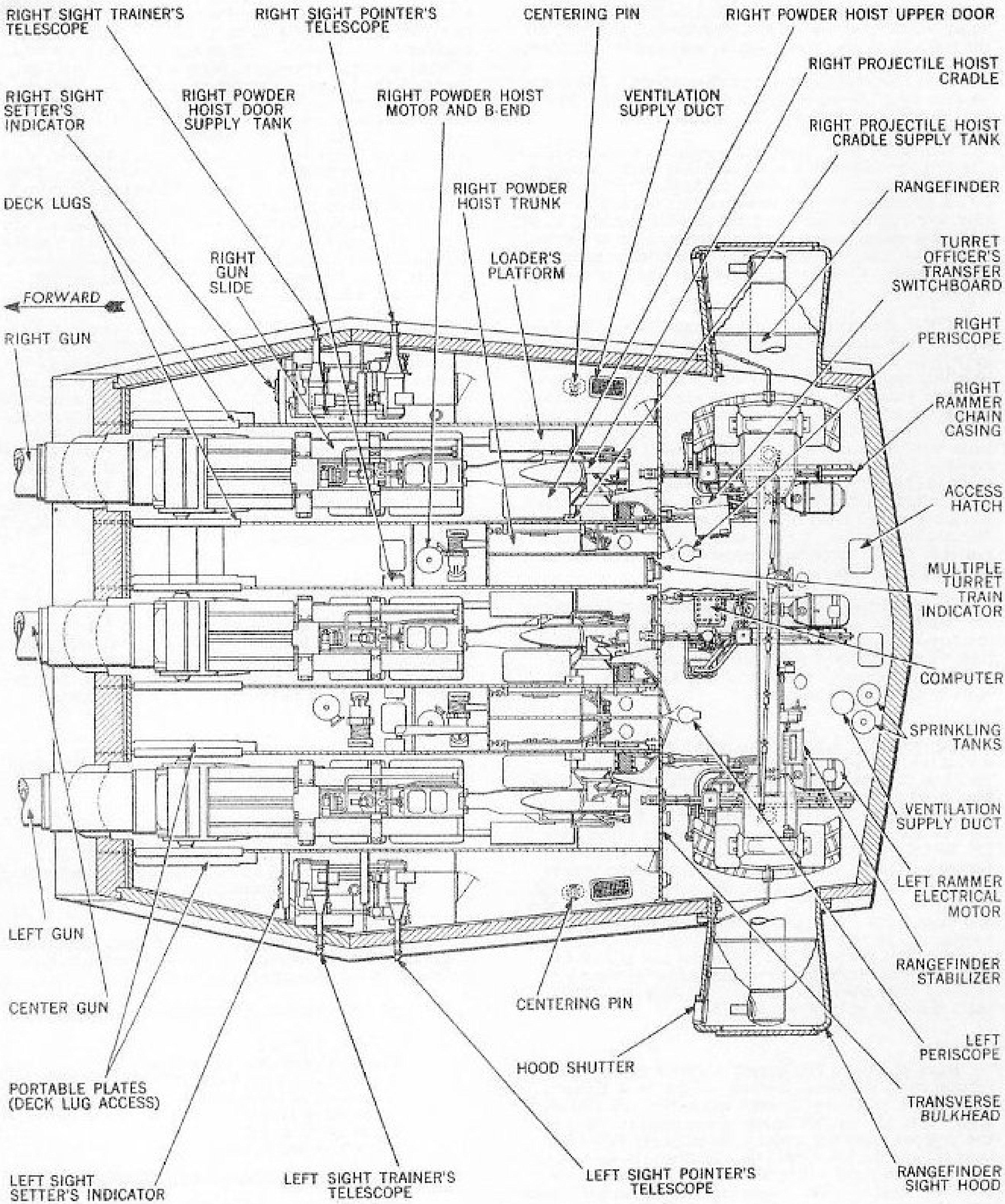


Figure 1-6. Ordnance Equipment in Gun House - General Arrangement - Plan View

PROJECTILE STOWING AND HANDLING EQUIPMENT, 16-INCH

Projectile Ring Mk 2 Mod 0
Parbuckling Gear Mk 1 Mod 0

AMMUNITION HOIST AND GUN LOADING EQUIPMENT, 16-INCH

Projectile Hoist Mk 8, Mods 0, 1, and 2
Rammer Mk 5 Mods 0, 1, and 2
Powder Hoist Mk 9 Mods 0 to 8 inclusive

FIRE CONTROL EQUIPMENT

16-inch Sight Mk 4 Mods 2 and 3
Sight Setters Indicator Mk 3 Mods 2, 3, 4, and 5
Gun Elevation Order Transmitter Mk 2 Mods 0 and 1
Gun Elevation Indicator Mk 33 Mods 3 and 4
Turret Train Indicator and Transmitter Mk 37 Mods 4, 5, and 6
Multiple Turret Train Indicator Mk 12 Mods 5, 6, 7, and 9
Computer Mk 3 Mod 2
Rangefinder Mks 52 and 53 Mod 0 *
Rangefinder Stand Mk 52 Mod 0 *
Firing Circuit Mk 3 Mod 0
Lighting Circuit Mk 3 Mod 0
Telescope Mk 66 Mod 0
Battle Order Indicator Mk 28 Mod 0

Turret ordnance assembly references. The exact number and identity of each of these turret assembly components are listed in the tabulations of 16-inch Turret Assemblies appended at the back of this book. These lists include references identifying the Fire Control Equipment Lists of Drawings of Assemblies and the Turret Ordnance Equipment Lists of Drawings of Assemblies for every turret installation of the IOWA class.

Turret ordnance location arrangements. All ordnance items listed above and on page 1-9 are mounted in the rotating structure as indicated in the following description of the turret floor levels.

Gun house ordnance arrangement. The location arrangement of the gun house ordnance equipment is shown in figure 1-6. In addition, the positions and relative sizes of some elements of the ventilating and sprinkling systems (pages 1-18 and 1-19) are shown.

In the gun house are located all units of all three guns (except the forward portions of the (barrels), the rammers, projectile cradles, and the upper doors of the powder hoists. In addition, this space encloses components of the fire control equipment. These are grouped in three locations as follows: The turret officer's compartment and identical left and right sight control stations. The latter two each have a sight setter's indicator, a pointer's and a trainer's telescope, and a gun elevation order transmitter. In the turret officer's compartment are the rangefinder, multiple turret train indicator, turret officer's and turret captain's indicator panels and periscopes, auxiliary computer, transfer switchboard, and communication facilities. These are identified in the descriptions of the fire control arrangements (page 1-16).

*Turrets II and III only

Within the box girder weldments are the powder hoist power drives and the hoist operators' stations.

Access to the gun house is provided by the large hatch toward the rear of the gun house overhang. The small hatch is for emergency use.

Pan floor ordnance arrangement. The location arrangement of the pan floor ordnance equipment is shown in figure 1-7. In the pan floor spaces (gun pockets) are the elevating gear B-ends and oscillating bearings. Within the box girder weldments and above the pan floor level are the training gear B-ends and brake assemblies. The wormwheel and pinions are in a separate compartment forward of the center gun pit together with training and elevating gear expansion tanks. The powder hoist trunks are enclosed and rise within the box girder weldments. The upper portion of the projectile hoists and the primerman's platforms are in the rear part of each gun pit.

Electric deck (machinery floor). The location arrangement of the pan floor ordnance equipment is shown in figure 1-8. In the electric deck spaces between the wing gun girders and box girder weldments are left and right gun elevating gear and projectile hoist power drive components and left and right gun layers' stations. The space between the two box girder weldments contains training gear power drive components and the main pump of the center projectile hoist. Within the right box girder (accessible through archways) are the center gun elevating gear power drive components and gun layer's station, and the right powder hoist trunk. Within the left box girder are components of the center projectile hoist power drive. The projectile hoist tubes rise through the rear part of each space between gun girders.

Fire control equipment in the electric deck spaces includes the elevation indicators, turret train indicator and transmitter, and other accessories at the gun layers' and train operator's stations.

Upper projectile flat ordnance arrangement. The location arrangement of the upper projectile flat ordnance equipment is shown in figure 1-9. In the projectile flat space within the circular bulkhead are the projectile ring power drive components, the powder hoist trunks, parbuckling gear motor, power drive electric controllers, and the central column and wiring recess. The projectile flat space between the circular bulkhead and circular foundation is divided into three concentric rings (two projectile stowage rings and a handling ring). The handling ring has six gypsy heads of the parbuckling gear, and three projectile hoists and loading apertures. In addition there are projectile ring and hoist control stations and an access hatch. The projectile rings are fixed and rotating stowage areas, the rotating (inner) ring being provided with a centering pin. Projectiles stowed on the rings are lashed in position.

Lower projectile flat ordnance arrangement. The arrangement of the lower projectile flat ordnance equipment is similar to that of the upper projectile flat with respect to the ammunition hoists, parbuckling gear, and projectile ring power drive installations. Projectile stowage is the same on the inner rings of each. Outer ring projectile stowage is different for the three turrets as described in chapter 7.

Within the circular bulkhead, the arrangement of power drive electric controllers differs from that of the upper deck.

Powder handling flat ordnance arrangement. The location arrangement of the powder handling flat ordnance equipment is shown in figure 1-10. In the rotating platform are the lower ends of the three powder hoist trunks with their lower doors and loading trays. The central column passes through the center of this platform which is centered within a fixed platform. A part of the fixed turret structure, this platform is enclosed within a circular bulkhead which is equipped with powder passing scuttles. The fixed platform also has powder bag immersion tanks. Additional powder passing scuttles are arranged in the circular foundation to align with those in the circular bulkhead.

Ordnance designs

The turret ordnance designs listed on page 1-9 have the following design features and characteristics.

Gun and slide assemblies. The assembled arrangements of a gun and slide assembly are shown in figures 3-1 and 4-4. This assembly comprises the following:

- Gun
- Breech mechanism
- Firing lock
- Gas ejector
- Yoke
- Slide
- Deck lug

Gun. The gun is a rifled light weight type 16-inch, 50-caliber design. Built-up, it consists of a liner, tube, jacket, hoops, locking rings, a liner locking ring, and a yoke ring. The gun is chambered for a bag charge and is equipped with a carrier-type breech mechanism.

Breech mechanism. The breech mechanism is of the rotating plug and swinging carrier type with closure of the breech by a breech plug and obturator unit assembly. The breech plug and mating screw box liner are segmented with stepped screw threads.

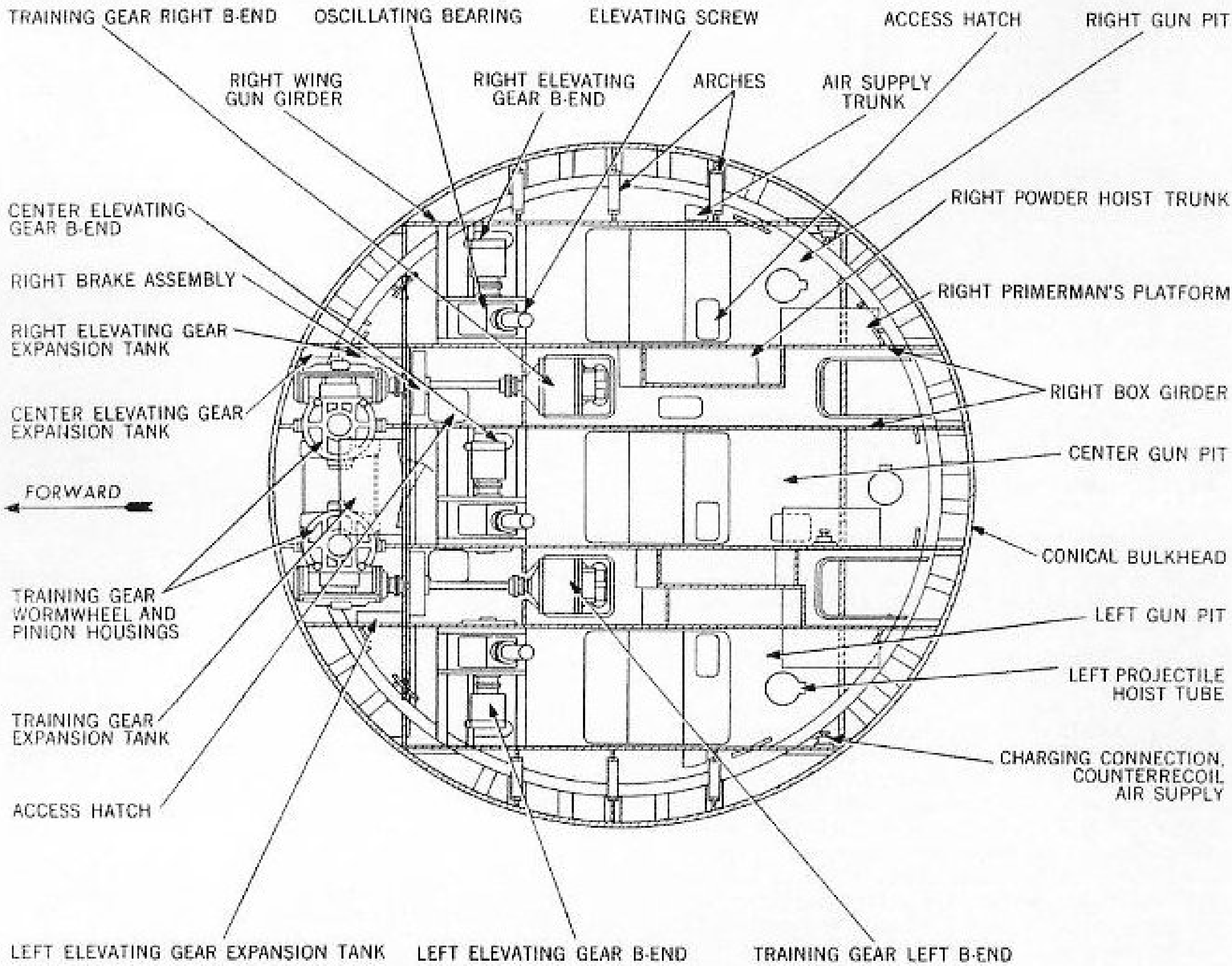


Figure 1-7. Ordnance Equipment on Pan Floor - General Arrangement - Plan View

Firing lock. The firing lock is a hand-primed wedge type automatically actuated by crosshead linkage of the breech mechanism. Normally the primer is fired electrically; however, the firing lock design provides for percussion firing in emergency.

Gas ejector. The gas ejector is an automatic, low-pressure air porting system which clears the bore when the breech is opened after a round has been fired. The system also provides air for the breech closing cylinders.

Yoke. The gun yoke is a large counterbalancing unit, mounted on the gun shoulder, that provides integral lug seats for the recoil cylinder piston rod and the counterrecoil cylinder yoke rods.

Slide. The slide is a large trunnion-pivoted assembly in which a single gun is mounted. A gun-supporting structure, the slide is also a gun recoil brake and a gun counterrecoil mechanism. In addition, the slide assembly has devices that secure the gun in battery position and the slide in stowed position.

Deck lug. The deck lug is a bearing block and roller bearing assembly that provides for frictionless elevating movement of the slide gun. Each deck lug is arranged with a bearing block and roller bearing assembly on either side of each slide.

Gun laying equipment. The gun laying equipment comprises the turret turning mechanism and gun elevating drives and their controls. These units consist of the training gear electric-hydraulic drive units and the train receiver-regulator, and three elevating gear electric-hydraulic drive units and receiver-regulators. In addition, there is sight control station equipment for train and elevation.

Training gear. The training gear is an annular stationary gear rack type with pinion gears driven by an electric-hydraulic power drive, through twin worms and wormwheels.

The power drive consists of a 300-horsepower electric motor coupled to a reduction gear which drives an A-end pump assembly. The pump valve plate is hydraulically connected by a system of pipe manifolds to two B-end motors each of which drives a pinion gear through a worm and wormwheel assembly.

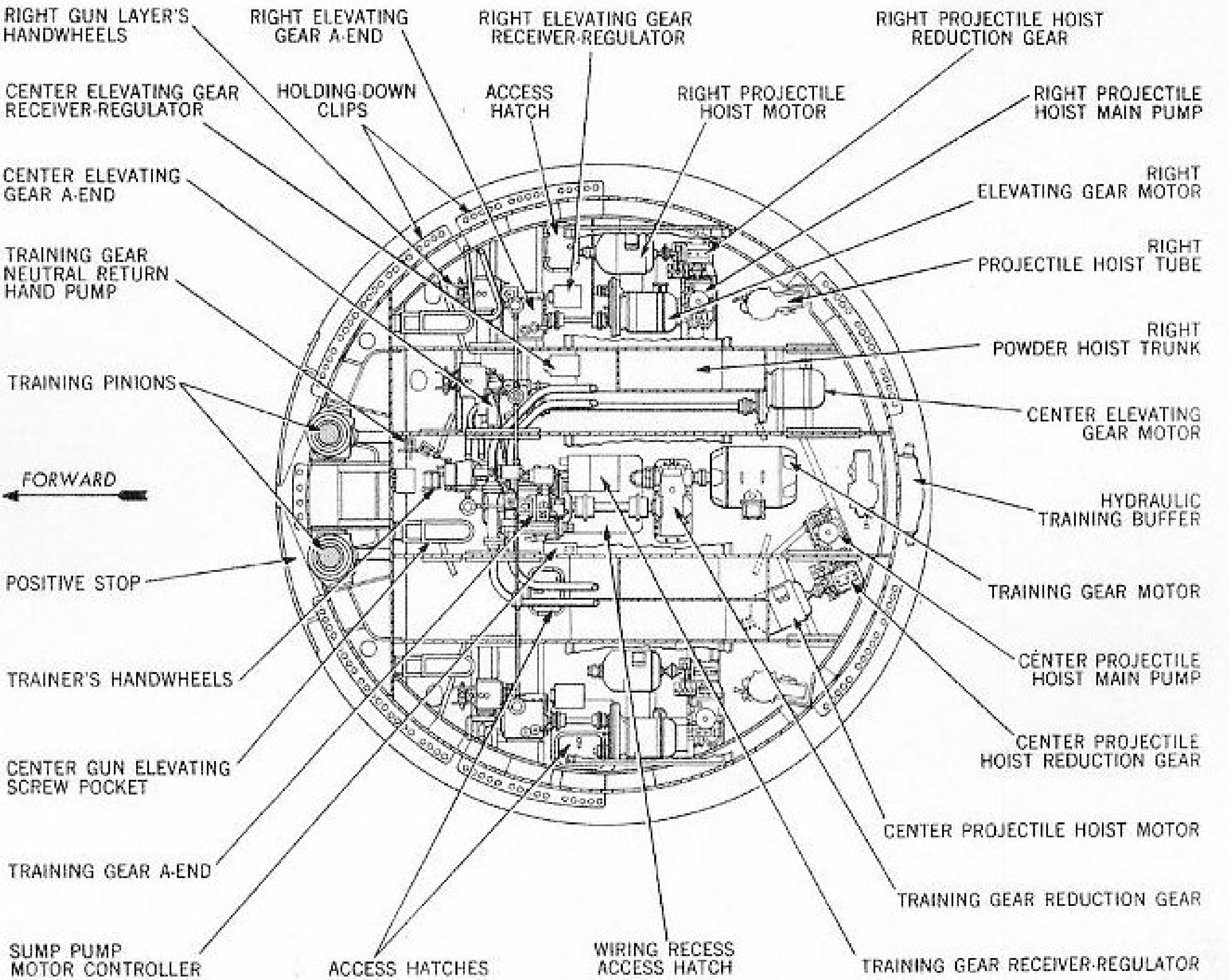


Figure 1-8. Ordnance Equipment on Electric Desk - General Arrangement - Plan View

Training gear control. Hydraulic fluid delivery to the B-end motors is controlled by varying the A-end pump displacement by an arrangement of hand and automatic servo controls. A control selector permits control selection of turret train either automatically from a remote station or by hand from a local trainer's station. The control method is selected by the train operator.

Train operator's control equipment. Control devices at the train operator's station enable him to start and stop the power drive, to select the method of control, and to control turret train in HAND control. The manner in which these devices are employed in the different control methods is explained in chapter 2.

Elevating gear. The turret elevating gear consists of three independent mechanisms. Each elevating gear is an electric-hydraulic power drive with an elevating-screw and oscillating-bearing type of final drive.

The power drive consists of a 60-horsepower electric motor directly coupled to a speed reducer, the output shaft of which drives an A-end pump assembly. The pump valve plate is hydraulically connected to a B-end hydraulic motor by two pipes, and the B-end output shaft is coupled to the elevating screw.

Elevating gear control. Hydraulic fluid delivery to the B-end motor is controlled by varying the A-end pump displacement by an arrangement of hand and automatic servo controls. The independent control selector for each gun permits control selection of gun laying from a remote station or hand control of gun laying from a local pointer's station. The control method is selected by the gun layer.

Gun layer's control equipment. Control devices at each gun layer's station enable him to start and stop the power drive, to select the method of control, and to control gun elevation in HAND and LOAD control. The manner in which these devices are employed in the different control methods is explained in chapter 2.

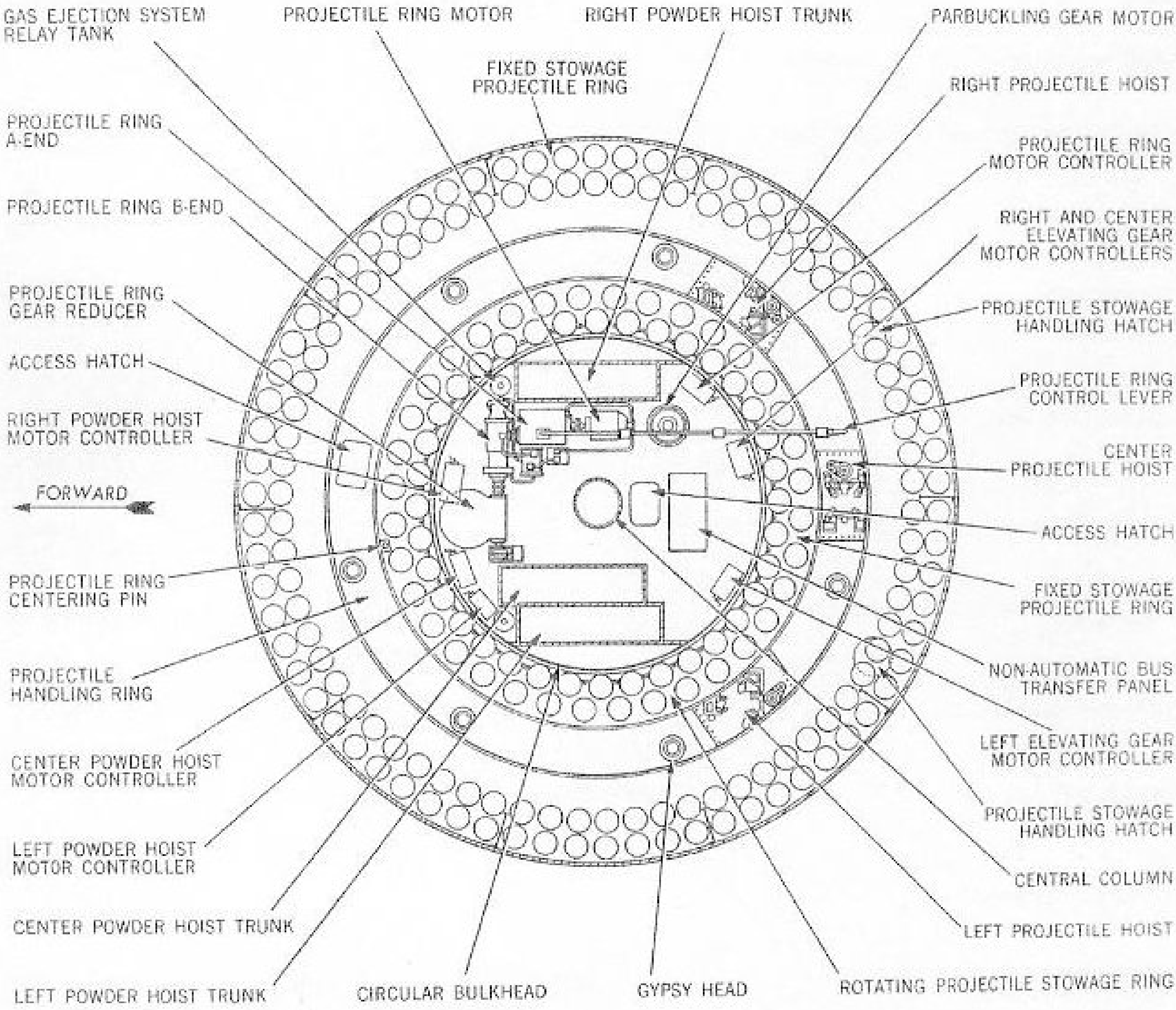


Figure 1-9. Ordnance Equipment on Projectile Flat - General Arrangement - Plan View

Projectile stowing and handling equipment. The two groups of equipment for stowing and handling projectiles include four power-driven assemblies installed in the projectile flats. These units are two projectile ring drives and two parbuckling gears.

Projectile ring drive. Each projectile ring has an attached annular rack which is driven by a spur pinion through a worm gear speed reducer and an electric hydraulic power drive. The ring, power drive, and control arrangements permit the ring to be driven clockwise or counterclockwise.

Identical installations, each power drive consists of a 40-horsepower electric motor, an A-end pump and control assembly, a B-end hydraulic motor and brake mechanism, and a manual control mechanism.

The A-end is a variable displacement pump with an automatic cycling control. This control device is a manually initiated type that operates the ring for a short arc of movement and then automatically decelerates, stops, and locks the ring.

The manual control mechanism is an arrangement of a hand lever, gears, and shafts coupled to the A-end control input. The direction of hand lever movement is the same as ring rotation.

Parbuckling gear. The two parbuckling gear installations are identical. Each consists of a 7.5-horsepower motor which drives a system of gear boxes and shafts that operate six gypsy heads. Three are located adjacent to the loading apertures of each projectile hoist; the other three gypsy heads are located at the forward part of the projectile flat. Driven at constant speed, all gypsy heads are in the center projectile flat ring.

Ammunition hoist and gun loading equipment. The projectile cradle and spanning tray for each gun are served with projectiles and powder bags by two separate ammunition hoists. The gun must be brought to a fixed loading position to permit delivery of the ammunition to the gun. The turret ammunition hoists are three similar projectile hoists and three similar powder hoists. Ammunition delivery (gun loading) is by three similar rammer installations.

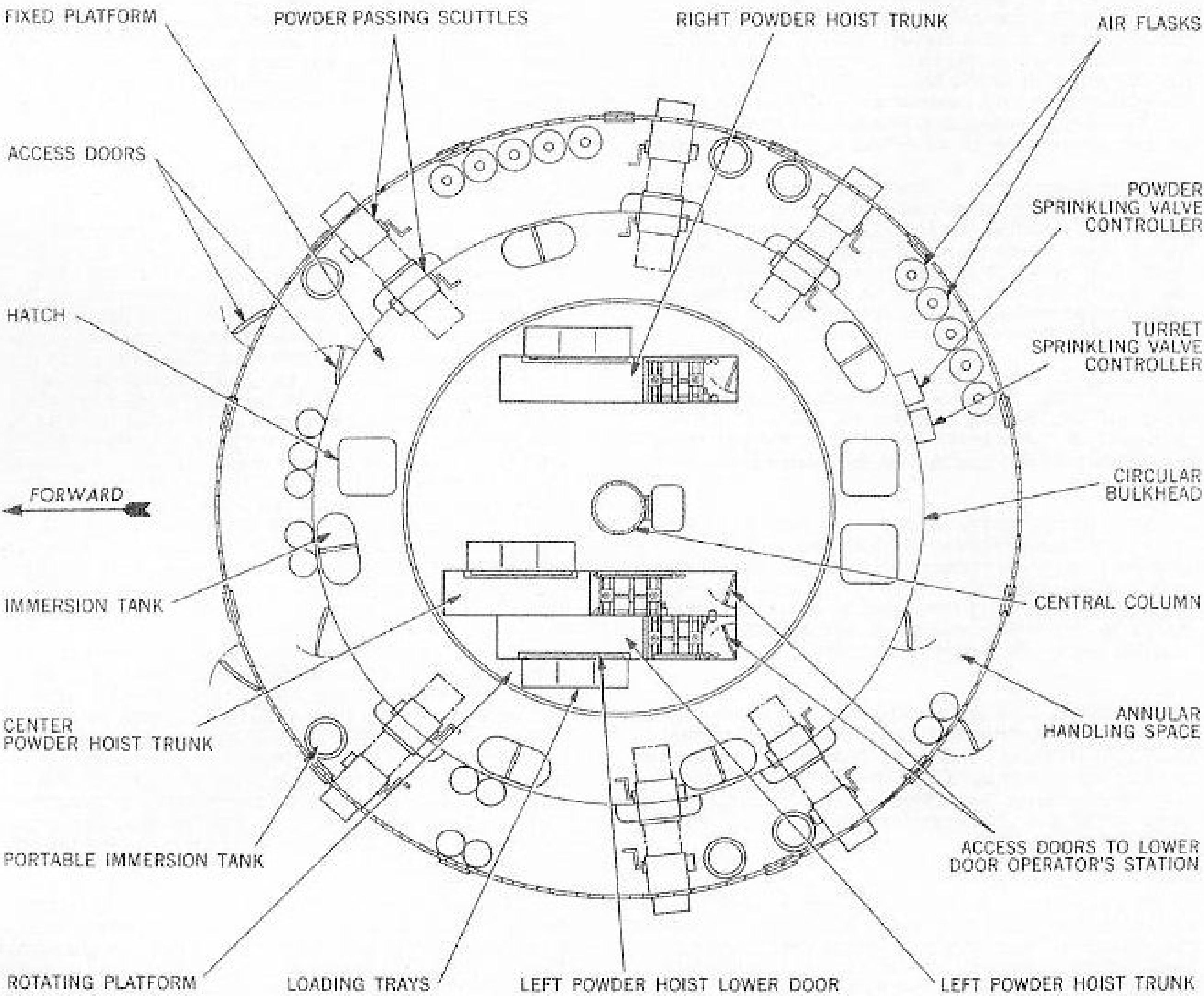


Figure 1-10. Ordnance Equipment on Powder Handling Flat - General Arrangement - Plan

Projectile hoists. Each projectile hoist assembly is a reversible rack and pawl tubular lift electric-hydraulically power driven. It is equipped with an independently controlled, hydraulic power-drive cradle assembly. The hoist supplies a projectile to the cradle assembly which aligns the projectile with the gun. When lowered (spanned), the cradle assembly extends the rammer track to the gun breech.

The tubular hoist courses, extending from the lower projectile flat to the projectile cradles, are each equipped with four stationary tube pawls. These tubular courses have integral tracks to guide the vertical movement of the rack which is equipped with five pawls. Projectiles when lifted by the rack are supported at the end of each of the first four lifting strokes by the tube pawls. The fifth lifting stroke places a projectile in the cradle.

At each projectile flat there is a loading aperture with shutter and control devices.

Hoist controls. An arrangement of hydraulic valves controls the actions of the hoist and cradle and reverses the pawls to lower the projectiles. Hoisting action control devices are arranged in duplicate, there being a manual control operating lever with indicators and interlock devices on each projectile flat adjacent to the hoist loading aperture. Cradle spanning control devices and controls for the hoist reversal mechanism are located in the gun room compartment at the cradle operator's station.

Hoist power drive. The hoist power drive consists of a 75-horsepower electric motor coupled to brake and reduction gear units. The reduction gear output shaft drives the main pump assembly, the valve plate of which is hydraulically connected to the upper and lower ends of the rack operating cylinder by two pipes. This arrangement is a hydraulic ram which raises or lowers the rack.

Rammer. The rammer is an electric-hydraulic mechanism that drives a folding chain through ramming and withdrawing movements. Manually controlled from the operator's station in the gun room compartment, the mechanism delivers ammunition to the gun.

Each power drive, identical for each gun, consists of a 60-horsepower electric motor directly coupled to a speed reducer, the output shaft of which drives an A-end pump assembly. The pump valve plate is hydraulically connected to a B-end hydraulic motor by two pipes with the B-end output shaft coupled to the chain driving sprocket.

Hydraulic fluid delivery to the B-end motor is controlled by varying the A-end pump displacement through a stroking control mechanism. A limit stop mechanism that is built into the B-end valve plate 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.

Powder hoist. A functionally independent assembly, each powder hoist delivers a full service powder charge (of six bags) to a gun during each hoisting cycle. It is a vertical lift, electric-hydraulically driven, which raises or lowers a powder car confined within the spaces of a trunk. The car is loaded through the trunk lower doors and is unloaded in two stages through the trunk upper door.

The power drive consists of a 100-horsepower electric motor which is coupled to and drives an A-end pump assembly. Two pipes hydraulically connect the pump valve plate to a B-end motor. The B-end output shaft is connected to a hoisting drum which winds or unwinds the powder car hoist rope to raise or lower the car.

Hydraulic fluid delivery to the B-end motor is controlled by varying the A-end pump displacement by an arrangement of hand and servo controls the selection of which is made by the hoist operator. The hoisting and lowering acceleration and deceleration rates are controlled by B-end cams.

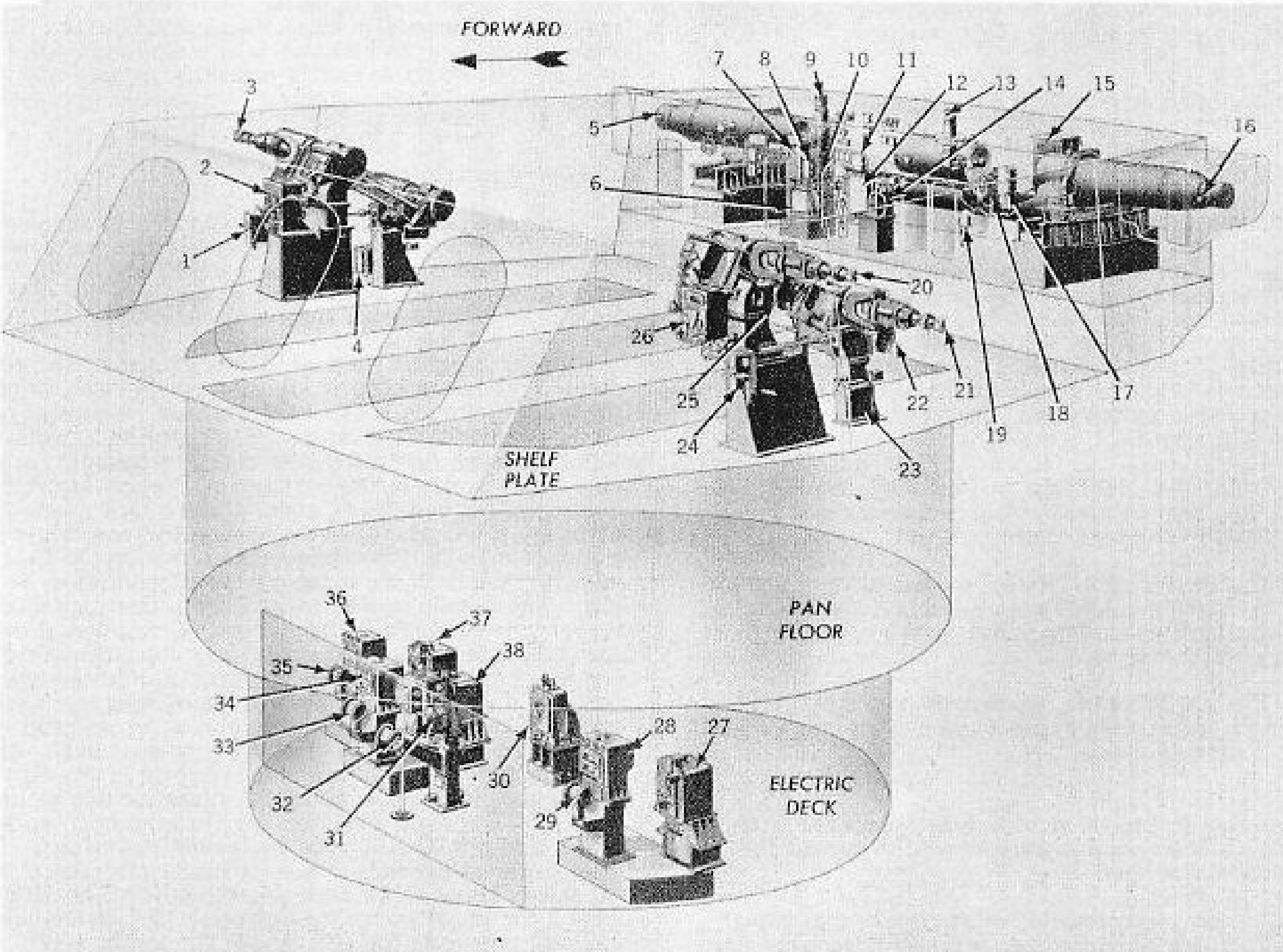
Fire control equipment. The sights and gun attachments, control instruments, and rangefinder listed on page 1-11 comprise the turret fire control equipment (fig. 1-11). This is supplemented by switching and communication devices and an extensive system of wire circuits of Bureau of Ships design and cognizance.

Sights and gun attachments. Turret local fire control arrangements comprise two interconnected sight assemblies and attached or associated instruments. The design is a carriage sight arrangement which functions as a directing type fire control assembly. Control may be selectively arranged to direct gun laying and turret train from either sight station.

Each sight station is a pedestal and bracket mounted arrangement of a sight trainer's and sight pointer's line-of-sight optic with a sight setter's indicator. The lines of sight are mechanically connected for simultaneous offset in deflection and sight angle from the sight setter's input. All lines of sight move together in response to the sight pointer's handwheel movement as the controlling sight pointer manipulates his handwheels to hold his telescope on the target. Sight angle and sight pointer's movements are transmitted electrically to instrument dials at the gun layer's stations. They are gun order directing movements and do not position the gun laying controls. Sight train is selectively arranged so that the sight trainer's handwheels may be clutched to the servo control of the training gear power drive. The mechanical system of gun order transmission extends transversely between the two sight stations and connects line-of-sight and sight setter outputs to all indicating instruments. Interconnected with manually operated, interlocked, synchronized selectors, either sight station can quickly assume control of gun direction.

Manual input movements at the sight setters' indicators (made in response to synchro-received, dial-indicated orders) offset the lines-of-sight in deflection and depression from parallelism with the guns. These values (sight deflection and sight angle) are transmitted mechanically to and simultaneously move the sight trainers' and sight pointers' optics. Transmitted mechanically to the gun elevation indicators, sight angle value is one of the factors used in computing erosion correction; the other factor being initial velocity loss.

Trainer's station. The optic at this station has deflection and depression controlled by the sight setters' indicator as described in the previous paragraph. This arrangement keeps the sight trainer on the target in elevation as the pointer elevates or depresses the guns. However, the trainer is compelled to operate his handwheels to train the turret for every change in sight deflection input or change in ship's course.



1. SIGHT ANGLE SYNCHRONIZING CLUTCH AND INTERLOCK
2. RIGHT SIGHT SETTER'S INDICATOR
3. RIGHT SIGHT TRAINER'S TELESCOPE
4. GUN ELEVATION ORDER TRANSMITTER
5. RANGEFINDER SIGHT
6. MULTIPLE TURRET TRAIN INDICATOR
7. TURRET OFFICER'S INDICATOR PANEL
8. TURRET OFFICER'S SELECTIVE SWITCH
9. TURRET OFFICER'S PERISCOPE
10. TURRET OFFICER'S TRANSFER SWITCHBOARD
11. REPRODUCER
12. TRANSMITTER CONTROL BOX
13. TURRET CAPTAIN'S PERISCOPE
14. AUXILIARY COMPUTER
15. RANGEFINDER STABILIZER CONTROL PANEL
16. RANGEFINDER SIGHT
17. TURRET CAPTAIN'S INDICATOR PANEL
18. RANGEFINDER STABILIZER
19. SHIP'S SERVICE TELEPHONE
20. LEFT SIGHT TRAINER'S TELESCOPE
21. LEFT SIGHT POINTER'S TELESCOPE
22. LEFT SIGHT POINTER'S HANDWHEELS
23. GUN ELEVATION ORDER TRANSMITTER
24. SIGHT ANGLE SYNCHRONIZING CLUTCH AND INTERLOCK
25. LEFT SIGHT TRAINER'S HANDWHEELS
26. SIGHT SETTER'S INDICATOR
27. LEFT GUN ELEVATION RECEIVER-REGULATOR
28. LEFT GUN ELEVATION INDICATOR
29. LEFT GUN LAYER'S HANDWHEELS
30. TRAIN RECEIVER-REGULATOR
31. TURRET TRAIN INDICATOR AND TRANSMITTER
32. TRAIN OPERATOR'S HANDWHEELS
33. CENTER GUN LAYER'S HANDWHEELS
34. CENTER GUN ELEVATION INDICATOR
35. RIGHT GUN LAYER'S HANDWHEELS
36. RIGHT GUN ELEVATION INDICATOR
37. RIGHT GUN ELEVATION RECEIVER-REGULATOR
38. CENTER GUN ELEVATION RECEIVER-REGULATOR

Figure 1-11. Turret Fire Control Installation - General Arrangement

Pointer's station. Similar to the optic at the sight trainer's station, the pointer's optic has deflection and depression controlled by the sight setter's indicator as described previously. This arrangement compels the sight pointer to manipulate his handwheels to hold his line-of-sight on the target as the ship rolls or the sight angle is changed. Because of the offset value of the sight angle, the sight pointer is constantly holding the gun in correct range position.

Turret officer's control equipment. The turret officer's control equipment are optical, mechanical, and electrical devices for visual observation of fall of shot, for local communication, for local solution of firing problems, and for selection of alternative control methods.

The equipment is arranged with the ship's director system so that the turret may be operated in any one of several basic types of control and their variations. These control methods are designated: PRIMARY, SECONDARY, and LOCAL. The master selector for all controls is the large cabinet called the turret officer's transfer switchboard. Through this unit the turret is placed in:

PRIMARY CONTROL, so that the gun and turret drives are remotely controlled (automatically or by indicating) by the main battery directors; or,

SECONDARY CONTROL, so that the gun and turret drives are remotely controlled (automatically or by indicating) by another turret or the secondary battery directors; or,

LOCAL CONTROL, so that the gun and turret drives are controlled by the local gun sights, rangefinder, and computer.

Alternatives to these switching selections are included in the transfer switchboard to permit the following variations:

In "primary automatic" or "primary indicating" control, either selection can be controlled from Forward Plot or After Plot, using the forward or after main battery director.

In "secondary automatic" or "secondary indicating" control, either selection can be controlled from another turret or from Forward Plot or After Plot, using secondary battery directors.

Turret local control methods include sight control, rangefinder control, periscope control, and combinations of these. All use the local computer for solution of external ballistics.

Gun firing control. The firing lock and primer designs provide for electrical or percussion firing, with safety devices and special arrangements included in the electrical system. This is a selective firing control that interlocks with the gun loading and gun laying actions and permits local or remote firing. Safety features of the electrical circuit (in addition to automatic danger zone cutout switches) include manually operated firing stop switches accessible to the turret officer, each gun captain, each gun layer, each sight pointer, and the train operator.

Rangefinder equipment. Turrets II and III are equipped with rangefinder mount equipment located and arranged at the rear of the turret. The rangefinder is mounted on a stand which supports the rangefinder horizontally in a carriage which pivots the instrument for both elevation and azimuth movements. The instrument rotates in carriage bearings for elevation of the lines-of-sight (movement counter to roll of ship). For azimuth movement, the entire carriage and instrument pivot in deflection through slight arcs centered at the mid-point of the carriage beam. Elevating movement is automatically stabilized by the rangefinder stabilizer or is manually operated by hand gear. The azimuth movement is manually operated.

Auxiliary installations

Turret auxiliary installations, which include power supply, illumination supply, ventilating systems, and sprinkling systems are described in following paragraphs. These facilities are units of Bureau of Ships design and cognizance.

Power supply. Normal, alternate, and emergency electric power is supplied to each turret from two of the ship's four main 440-volt, 3-phase, 60-cycle twin turbo-generators. This power is supplied to each turret through flexible feeder cables originating at connection boxes in the wiring trunk below the base casting of the central column. Cables lead upward through spacer blocks in the central column to a wiring recess at the top of the column, just below the electric deck. Slack in the cables at the bottom of the column permits the cables to twist and flex during turret rotation. From the wiring recess, the normal and alternate cables are routed to a manual bus transfer panel located in the machinery space of the upper projectile flat. The panel is equipped with switches and indicator lights for selection of either normal or alternate power supply. From the manual bus transfer panels power is supplied to five circuit breaker power panels. These comprise three for gun equipment (one for each gun), one for training gear equipment, and a miscellaneous equipment power panel. These circuit breaker power panels supply power to all power drive controllers and the several auxiliaries, except for the illumination system. The emergency cable is routed to the I.C. and F.C. power panel located in the electric deck.

Illumination supply. Power for the illumination system is supplied to each turret form the 120-volt, 60-cycle ship's electric service system. The power is supplied to the turret by flexible cable, through the central column, similar to the arrangements described in the preceding paragraph. From the wiring recess at the top of the central column, the cable is routed to two automatic bus transfer panels located on the electric deck and pan floor. The panels automatically transfer the 120-volt supply from normal to emergency, or visa versa, when required.

Ventilating system. Eight self-contained ventilating systems (fig. 1-12) supply fresh air under forced draft to all turret levels and spaces, except the powder handling room. All systems have fresh air intake through the gun house overhang and are provided with two-speed remote push-button operating controls. Each system comprises an electric motor-driven fan set and necessary air supply ducts. The fan sets are equipped with three- or four-horsepower motors and supply air (at the rate of 4000 or 6000 cubic-feet-per minute respectively) as follows:

4000 Cubic Feet Per Minute Sets

Set 1 supplies air to the turret officer's booth through a vertical supply duct located near the rear armor plate, left of the turret center line. The system intake and supply trunk is at the rear of the gun house with an air supply passage directly below the fan set and duct. The ON-OFF and speed selection push-button control is located in the turret officer's booth on the transverse bulkhead (left end).

Set 2 supplies air to the left gun chamber through a horizontal duct with exhaust into the passage to the left sight control station. The system intake and supply trunk is at the left, rear corner of the gun house with an air supply passage leading to the fan set and duct. The ON-OFF and speed selection push-button control is located in the left gun chamber adjacent to the gun captain's station.

Set 3 supplies air to the right gun chamber through a horizontal duct with exhaust into the passage to the right sight control station. The system intake and supply trunk is at the right, rear corner of the gun house with an air supply passage leading to the fan set and duct. The ON-OFF and speed selection push-button control for this system is located in the right gun chamber adjacent to the gun captain's station.

Set 4 supplies air to the center gun chamber through a horizontal duct with exhaust in the rear of the gun chamber below the shelf plate. The system intake and supply trunk is at the rear of the gun house (right of the turret center line) with an air supply passage leading to the fan set and duct. The ON-OFF and speed selection pushbutton control for this system is located in the center gun chamber adjacent to the gun captain's station.

6000 Cubic Feet Per Minute Sets

Set 1 supplies air to the right side of the electric deck, and the right side of the upper and lower projectile flats. The system intake and supply trunk is forward of the right, rear corner of the gun house with a vertical air passage aft of the fan set. The ON-OFF and speed selection push-button control for this system is located in the turret officer's booth on the transverse bulkhead (right end).

Set 2 supplies air to the righ sight control station, right powder hoist and hoist power drive spaces, training gear right B-end, and the right side of the electric deck and upper and lower projectile flats. The system intake and supply trunk is forward of the right, rear corner of the gun house (common with the intake and supply trunk for Set 1). The ON-OFF and speed selection push-button control for this system is located in the turret officer's booth on the transverse bulkhead (right end).

Set 3 supplies air to the left side of the electric deck, and the left side of the upper and lower projectile flats. The system intake and supply trunk is forward of the left, rear corner of the gun house with a vertical passage aft of the fan set. The ON-OFF and speed selection push-button control for this system is located in the turret officer's booth on the transverse bulkhead (left end).

Set 4 supplies air to the left sight control station, left and center powder hoists and hoist power drive spaces, training gear left B-end, and the left side of the electric deck and upper and lower projectile flats. The system intake and supply trunk is forward of the left, rear corner of the gun house (common with the intake and supply trunk for Set 3). The ON-OFF and speed selection push-button control for this system is located in the turret officer's booth on the transverse bulkhead (left end).

In addition to the intake and supply trunks, and the fan sets described above, the ventilation systems have other equipment described below.

There are intake and exhaust holes in the shelf plate (overhang). Arranged between the intake and supply trunks, and the system air supply passages, the intake holes permit air circulation while providing less armor protection. Exhaust holes permit regulated air escape from exhaust passages.

An air circulation duct in each sight station aids in circulating air through the sight station.

A manually-operated airtight cover over the turret officer's booth exhaust opening provides for regulation of air pressure build-up and for wet weather closure of the exhaust opening.

Air circulation and exhaust holes in the foundation and electric deck bulkheads aid in keeping air in motion.

A gas and air seal between the powder handling room and lower projectile flat maintains air pressure in the upper turret spaces.

Pressure relief and automatic exhaust shutters in the powder hoists and box girders prevents excessive air pressure build-up in these spaces.

Exhaust shutters in the gun chambers and powder hoist operators' stations maintain air pressure at these stations.

The ventilating systems maintain air pressure slightly in excess of 1.0 pound per square inch. This is controlled by exhaust arrangements which include spring- and weight-loaded automatic shutters. Manually-operated doors in intake and exhaust ducts prevent entrance of water in heavy weather.

Electrical components of the ventilating systems, described in chapter 15, include eight motors provided with individual controllers, and push-button stations. Each push-button station is labeled with a designation of the system it operates.

Sprinkling system. The turret sprinkling system (fig. 1-13) is designed to provide a quick and efficient means of sprinkling all ammunition in the turret -- whether in transit via the ammunition hoists, ready for transit in the loading trays, or ready for loading into the gun. It is a mechanically and hydraulically operated system which permits selective or overall control of sprinkling from both local and remote stations within the turret, as well as from a station outside the turret.

The sprinkling system includes a primary source of water from the ship's firemain, and two sprinkling tanks for water storage within the gun house. In addition the system has an air supply to maintain water pressure in the tanks and an assortment of control and operating valves, and associated nozzles, piping, and tubing described in chapter 16.

LEGEND FOR FIGURE 1-12

4000 Cubic Feet per Minute Sets

Set 1 From turret overhang (rear, left of centerline) to turret officer's booth

4. Intake and supply trunk
5. Fan set and air supply duct

Set 2 From turret overhang (left rear corner) to left gun chamber and left sight station passage.

11. Intake and supply trunk
15. Air supply duct

Set 3 From turret overhang (right rear corner) to right gun chamber and right sight station passage.

1. Intake and supply trunk
55. Air supply duct

Set 4 From turret overhang (rear, right of centerline) to center gun chamber

2. Intake and supply trunk
53. Fan set and air supply duct

6000 Cubic Feet per Minute Sets

Set 1 From turret overhang (forward of the right, rear corner), to right side of electric deck and upper and lower projectile flats

44. Air supply ducts, lower projectile flat
45. Air supply duct, upper projectile flat
46. Air supply duct, electric deck
48. Fan set
52. Air passage opening
56. Intake and supply trunk

Set 2 From turret overhang (forward of the right, rear corner) to right sight control station, right powder hoist, powder hoist and training gear power drive spaces, and right side of electric deck and upper and lower projectile flats

7. Air supply duct, hoist operator's station
13. Automatic air supply shutter
23. Air supply duct, right sight station
24. Air supply duct, powder hoist machinery space
35. Air supply duct, training gear right B-end
36. Air supply duct, center gun layer's station
37. Air supply duct, right gun layer's station
38. Air supply duct, machinery space upper flat
41. Air supply duct, lower projectile flat
42. Air supply duct, machinery space lower lower flat
47. Fan set
52. Air passage opening
56. Intake and supply trunk

Set 3 From turret overhang (forward of the left, rear corner) to left side of electric deck and upper and lower projectile flats

12. Intake and supply trunk
17. Air passage opening
25. Air supply duct, electric deck
26. Fan set
31. Air supply duct, upper projectile flat
39. Air supply duct, lower projectile flat

Set 4 From turret overhang (forward of the left, rear corner) to left sight control station, left and center powder hoists, powder hoist and training gear power drive spaces, and left side of electric deck and upper and lower projectile flats

9. Air supply duct, center hoist operator's station
10. Air supply duct, left hoist operator's station
12. Intake and supply trunk
14. Automatic air supply shutter
16. Air supply duct, left and center powder hoist machinery space
17. Air passage opening
19. Air supply duct, left sight station
20. Automatic air supply shutter
21. Air supply duct, left powder hoist machinery space
22. Air supply duct, center powder hoist machinery space
27. Fan set
30. Air supply duct, left gun layer's station
32. Air supply duct, training gear left B-end
33. Air supply duct, train operator's station
34. Air supply duct, upper projectile flat
40. Air supply duct, upper projectile flat

Allied Equipment

3. Intake holes in overhang
6. Exhaust holes in overhang
8. Manually operated airtight cover (exhaust opening) turret officer's booth
18. Air circulation duct, left sight station
28. Air circulation holes
29. Air exhaust holes in foundation bulkhead
43. Gas and air seal
49. Pressure relief shutters from powder hoists
50. Automatic exhaust shutters in right and left box girder weldments
51. Air circulation duct, right sight station
54. Exhaust shutters from powder hoists and gun chambers

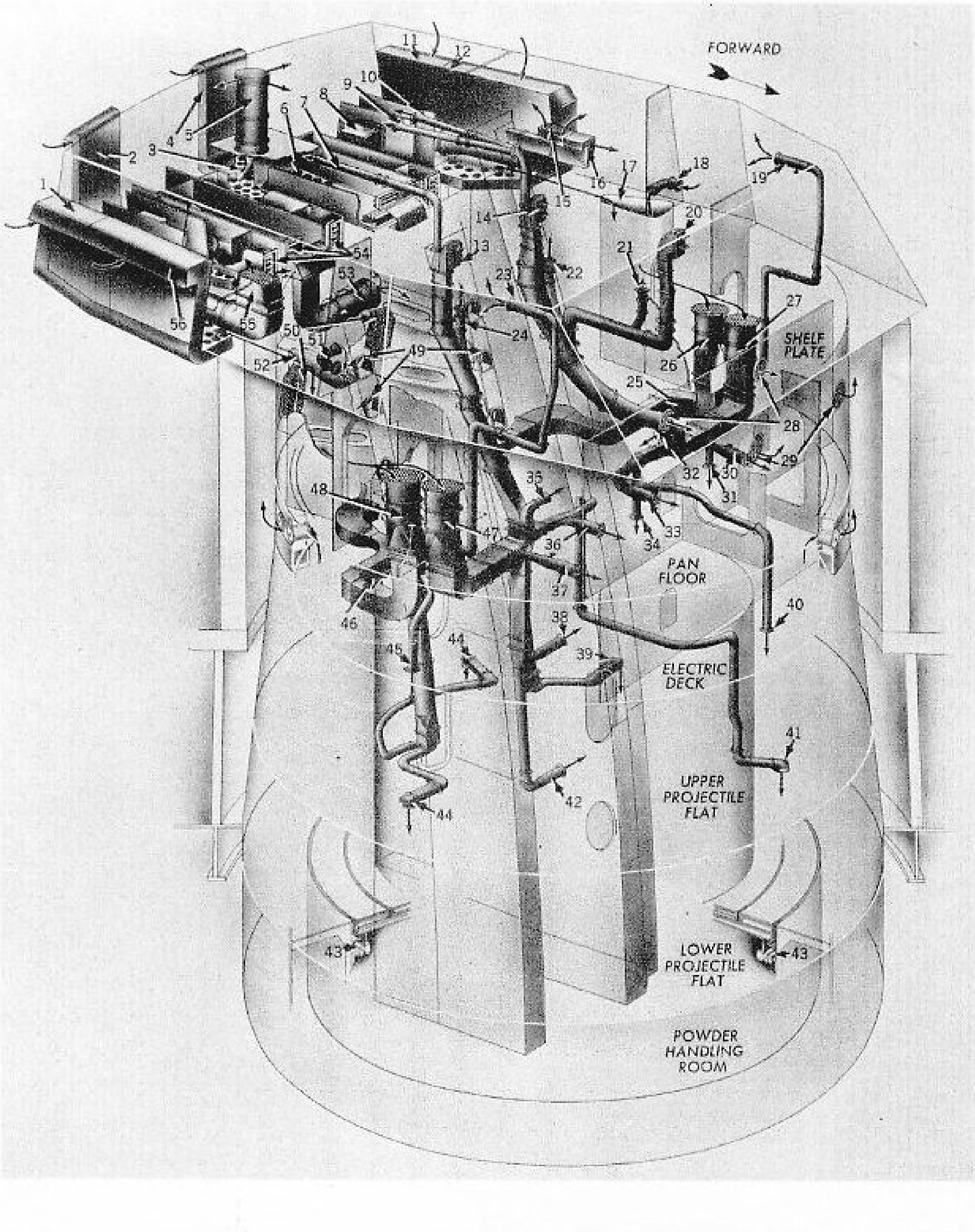
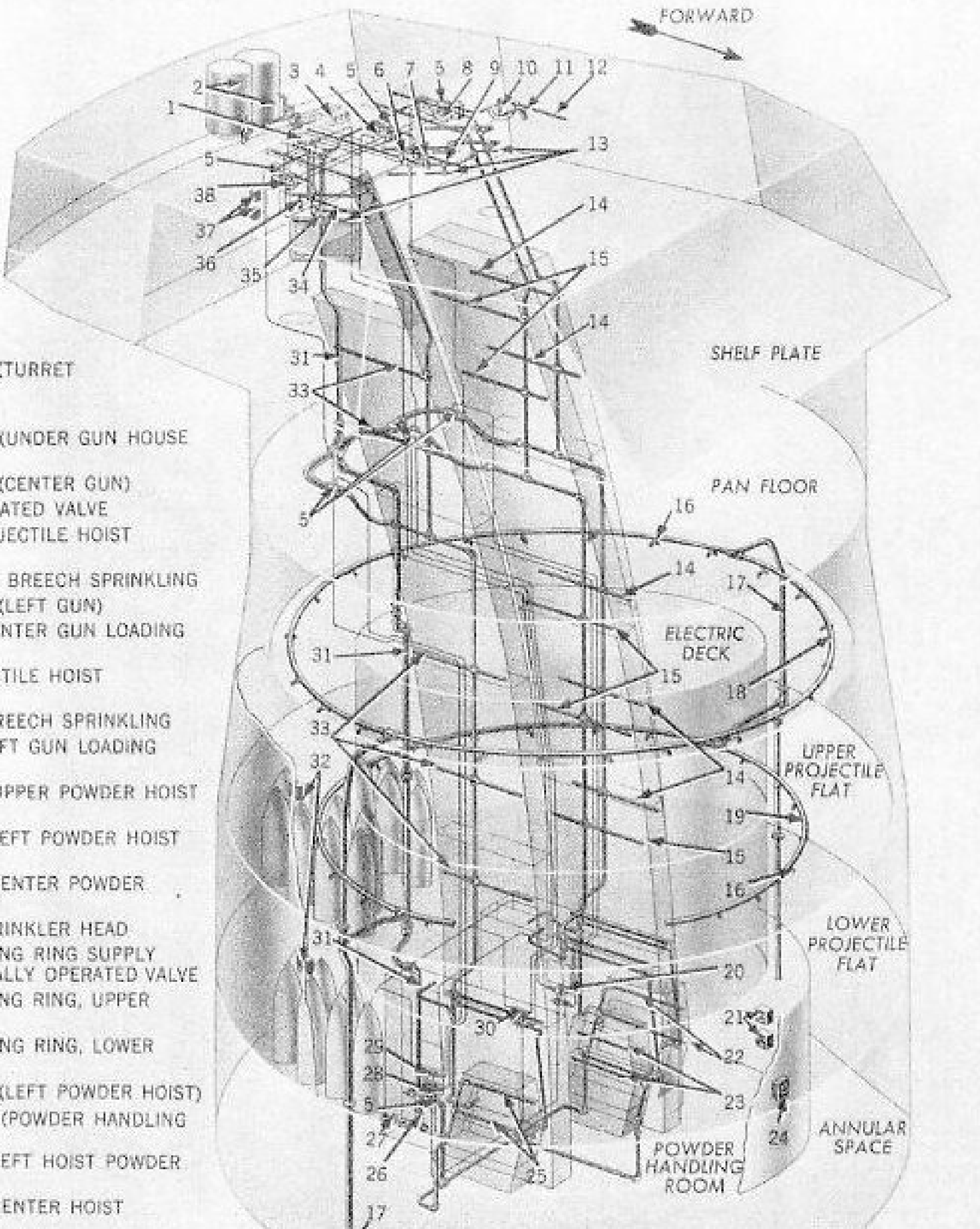


Figure 1-12. Turret Ventilating Systems - General Arrangement



1. CONTROL STATION A (TURRET OFFICER'S BOOTH)
2. SPRINKLING TANKS
3. CONTROL STATION B (UNDER GUN HOUSE OVERHANG)
4. CONTROL STATION C (CENTER GUN)
5. HYDRAULICALLY OPERATED VALVE
6. NOZZLE, CENTER PROJECTILE HOIST SPRINKLING
7. NOZZLE, CENTER GUN BREECH SPRINKLING
8. CONTROL STATION C (LEFT GUN)
9. PERFORATED PIPE, CENTER GUN LOADING TRAY SPRINKLING
10. NOZZLE, LEFT PROJECTILE HOIST SPRINKLING
11. NOZZLE, LEFT GUN BREECH SPRINKLING
12. PERFORATED PIPE, LEFT GUN LOADING TRAY SPRINKLING
13. PERFORATED PIPES, UPPER POWDER HOIST DOOR SPRINKLING
14. PERFORATED PIPES, LEFT POWDER HOIST TRUNK
15. PERFORATED PIPES, CENTER POWDER HOIST TRUNK
16. SPRINKLING RING SPRINKLER HEAD
17. PROJECTILE SPRINKLING RING SUPPLY PIPE FROM ELECTRICALLY OPERATED VALVE
18. PROJECTILE SPRINKLING RING, UPPER PROJECTILE FLAT
19. PROJECTILE SPRINKLING RING, LOWER PROJECTILE FLAT
20. CONTROL STATION E (LEFT POWDER HOIST)
21. CONTROL STATION G (POWDER HANDLING ROOM)
22. PERFORATED PIPES, LEFT HOIST POWDER TRAYS
23. PERFORATED PIPES, CENTER HOIST POWDER TRAYS
24. CONTROL STATION F (ANNULAR SPACE)
25. PERFORATED PIPES, RIGHT HOIST POWDER TRAYS
26. GLOBE VALVE, FIREMAIN SUPPLY
27. HOSE CONNECTION, FIREMAIN SUPPLY
28. CONTROL STATION D (POWDER HANDLING ROOM)
29. CONTROL STATION E (RIGHT POWDER HOIST)
30. CONTROL STATION E (CENTER POWDER HOIST)
31. FIREMAIN SUPPLY
32. CONTROL STATION H (PROJECTILE FLAT)
33. PERFORATED PIPES, RIGHT POWDER HOIST TRUNK
34. PERFORATED PIPE, RIGHT GUN LOADING TRAY SPRINKLING
35. NOZZLE, RIGHT GUN BREECH SPRINKLING
36. NOZZLE, RIGHT PROJECTILE HOIST SPRINKLING
37. CONTROL STATION I (TURRET OFFICER'S BOOTH)
38. CONTROL STATION C (RIGHT GUN)

Figure 1-13. Turret Sprinkling System - General Arrangement

Turret sprinkling control stations. Selective control of the turret sprinkling system is provided at both local and remote control stations. These are designated alphabetically, and consist of stations A to I inclusive, arranged as shown in the following table:

Control Station	Location	Manual Control Valve	Controls Sprinkling Of
A	Turret officer's booth	1	Powder hoists
		2	Gun rooms
B	Beneath the turret overhang	1	Powder hoists
		2	Gun rooms
		3	Annular space
C	Station C in each gun room	1	Gun room (local)
		2	Powder hoist (adjacent)
D	Powder handling room	1	Powder trays
E	Station E on each powder hoist trunk in powder handling room	1	Powder hoist (adjacent)
F	Annular space (powder handling room)	1	Annular space
G	Powder handling room	1	Projectile flats
		2	Annular space
H	Station H on each projectile flat	1	Projectile flats
		2	Projectile flats
		3	Projectile flats
I	Turret officer's booth	1	Annular space
		2	Projectile flats

Sprinkling system - electrical. An electrically operated valve system provides turret sprinkler control from a number of locations within the turret, from outside the turret on the overhang, or from related damage control stations. The system provides controlled sprinkling of the projectile stowage areas of each flat and the powder passing scuttles of the powder handling room. It is a separate system, separately controlled, and is not part of the mechanically and hydraulically operated system which provides sprinkling protection at each gun breech, loading tray, projectile hoist, and powder hoist trunk. The electrical sprinkling system (described in chapter 15) has sprinkling control of specific areas as indicated in figure 15-71.

Communications

The primary circuits which provide various types of communications within each turret, between turrets, and between the turrets and other ship stations are listed below. A brief description of each circuit follows the listing. Circuit extent and arrangements are shown in figures 1-14 and 1-15.

SYSTEM	CIRCUIT IDENTITY
Depression and train stop signal	DS
Intra-turret emergency alarm	RA
Train warning signal	TW
Turret announcing:	
Turret I	11 MC
Turret II	12 MC
Turret III	13 MC
Battle telephone	JA
Supplementary telephone	XJ
Sound-powered telephone and voice tube call bell	E
Ship's service telephone	J

Depression and train stop signal system (circuit DS). Circuit DS is an arrangement of a three-dial and three one-dial indicators located at the train operator's and gun-layers' stations respectively. The circuit is interconnected with six switches which are located as described on page 6-19 (chapter 6). Circuit DS opens the firing circuit of individual guns, and warns (by the indicator lights) when a gun's line of fire approaches the ship's superstructure.

Intra-turret emergency alarm system (circuit RA). Circuit RA is an arrangement of nine electrically operated sirens, strategically located throughout the turret, which are activated whenever serious danger exists or serious casualty has occurred. Control stations for the siren contact makers are located within the turret, on the various levels.

Train warning signal system (circuit TW). At times other than general quarters, the train warning signal system is used to warn ship's personnel on deck that the turret is about to train. It consists of a watertight warning bell, mounted on the exterior of the turret (under the turret overhang), which is energized by a normally open push-button within the turret officer's compartment.

Turret announcing system (circuits MC). The turret announcing system permits the turret officer to communicate with all principal stations within the turret. A transmitter control box within the turret officer's compartment provides communication with any or all stations, or a combination of stations. The system comprises an amplifier, 16 reproducers, and a portable microphone. Reproducers are of two types, one with a talk-back switch, and one without a talk-back switch.

Battle telephone system (circuits JA). The battle telephone system provides telephone connections between certain key personnel within the turret, and the ship's main battery plotting rooms. Push-to-talk button handsets and headsets with breastplate support and push-button controlled transmitters are used.

Supplementary telephone system (circuit XJ). The supplementary telephone system for the turret officer, comprises six local telephone circuits. Telephone equipment used is identical to that used for circuit JA. The circuits link the turret officer with the pointer's circuit (sight control station personnel, gun layers, and train operator), ammunition circuit (gun captains, projectile flats, powder handling room, and outside turret safety watch), subcaliber circuit, and the three powder hoist circuits which have connections with the gun captains.

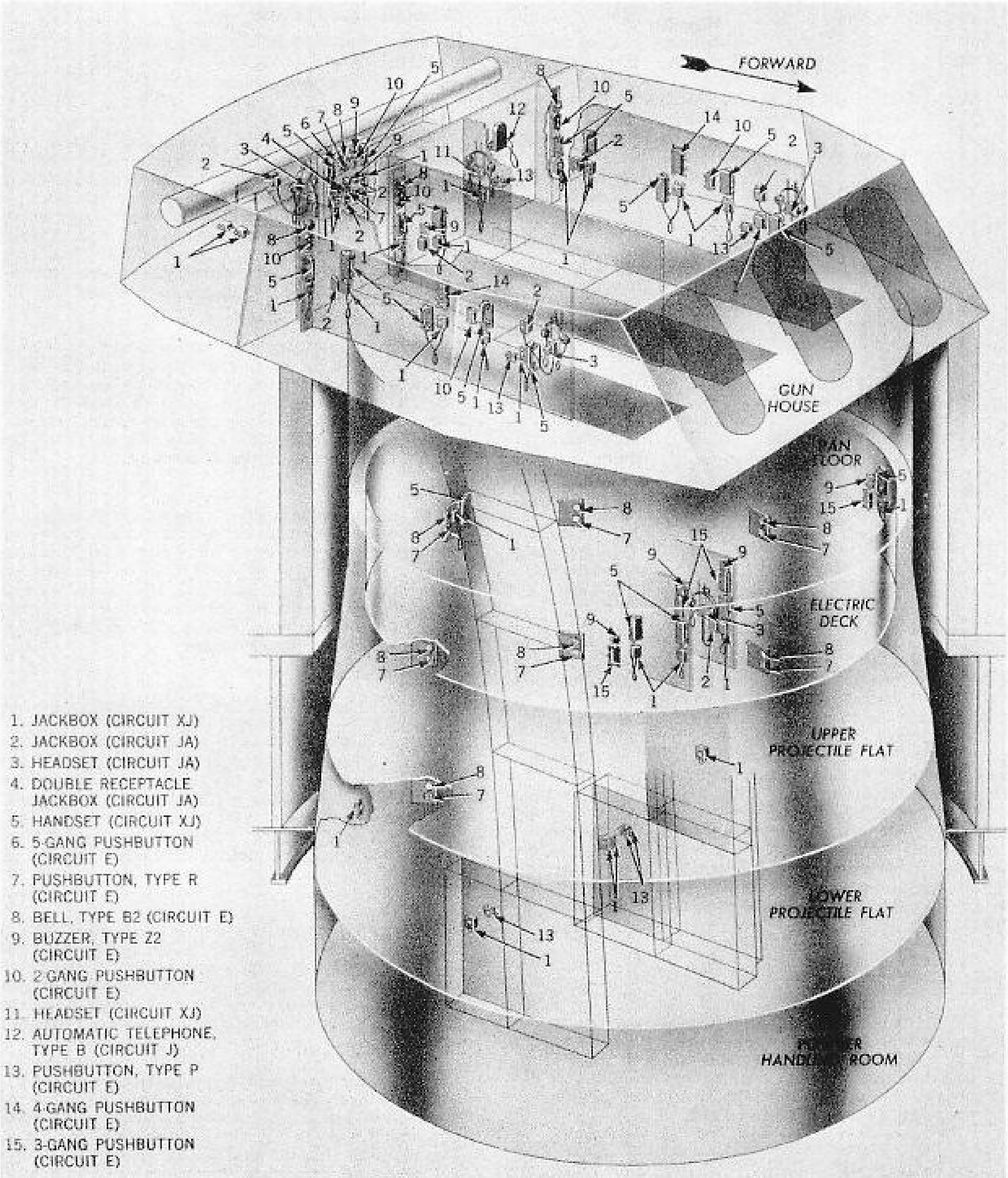


Figure 1-14. Turret General Communications System - General Arrangement

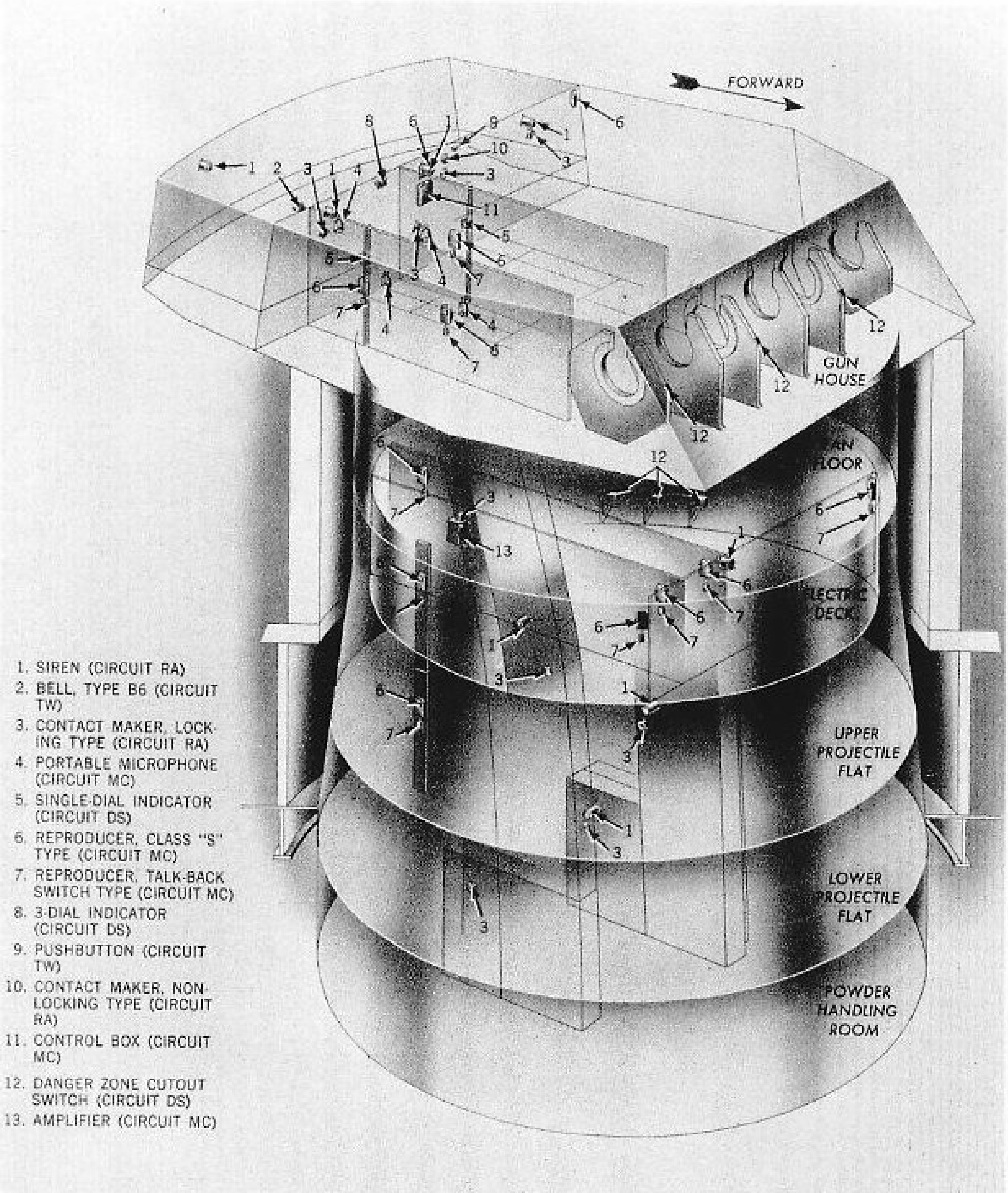


Figure 1-15. Turret Interior Communications System - General Arrangement

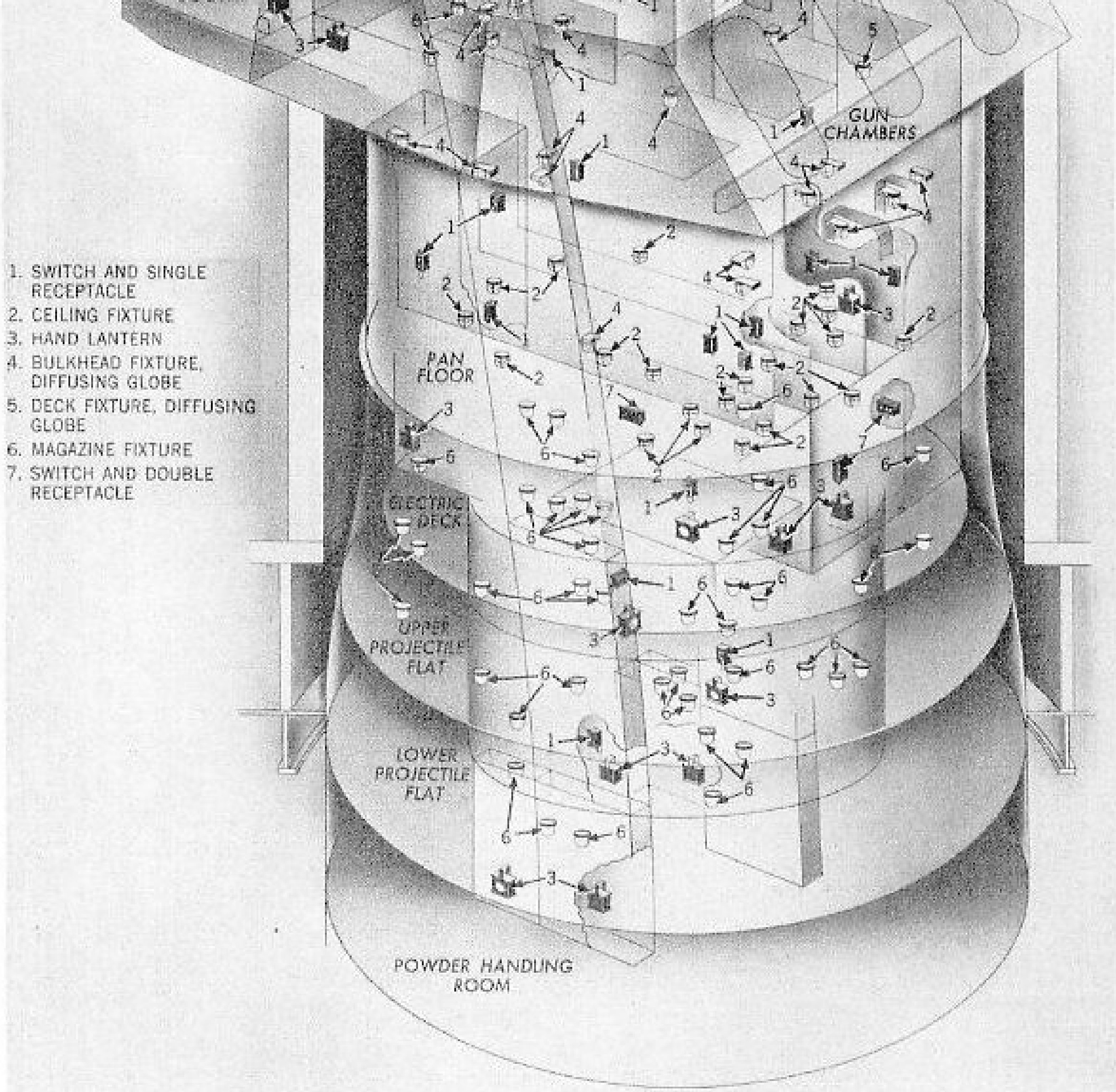


Figure 1-16. Turret Illumination - General Arrangement

Sound powered telephone and voice tube call bell system (circuit E). The sound powered telephone and voice tube call bell system comprises an audible call system which parallels most circuits of the turret officer's telephone system (XJ circuits) and most voice tubes. It includes bells and buzzers and associated push-buttons.

Ship's service telephone system (circuit J). The ship's service telephone system is a dial-type telephone system which connects the turret, through a central switchboard, to any similar dial telephone in the ship. Two telephones are located in the turret, one in the turret officer's compartment, and one in the electric deck space.

Illumination

Turret illumination in each turret comprises a general turret lighting system and a battle or instrument lighting system. In addition there is rangefinder de-icing equipment.

General turret illumination. The general turret lighting system comprises lighting fixtures, switch and receptacle units, hand lanterns, branch boxes, distribution boxes, and associated wiring (fig. 1-16). Normal and emergency power supply for the system is derived from the 120-volt, 60-cycle ship's service system through the automatic bus transfer panel. This equipment automatically switches from normal to emergency power (or vice versa) should there be failure in either power supply.

General illumination throughout the turret is provided by fixtures of the deck, bulkhead, or magazine type. Combination switch and receptacle units which provide an outlet source for trouble lights and various electrically operated portable devices are installed at convenient locations in each turret level. Hand lanterns, energized by self-contained dry-cell batteries, are located at convenient locations in the turret to provide emergency lighting.

Instrument illumination. The system that provides instrument illumination is a 6-volt circuit designated 16-inch Lighting Circuit Mk 3 Mod 0. This is a three division circuit (fig. 1-17) that controls lamp wells and reticle lamps which illuminate indicating dials and telescope crosslines. Two of these divisions illuminate instruments in the gun rooms and sight stations and the various reference marks, scales, and reticles of the rangefinder. The third division provides instrument lighting on the electric deck at gun layers' and train operator's stations.

The circuit is arranged to be supplied from a transformer or storage battery. Its components are two transformers, two storage batteries, two snap switches, six rheostats, branch boxes, and connection boxes.

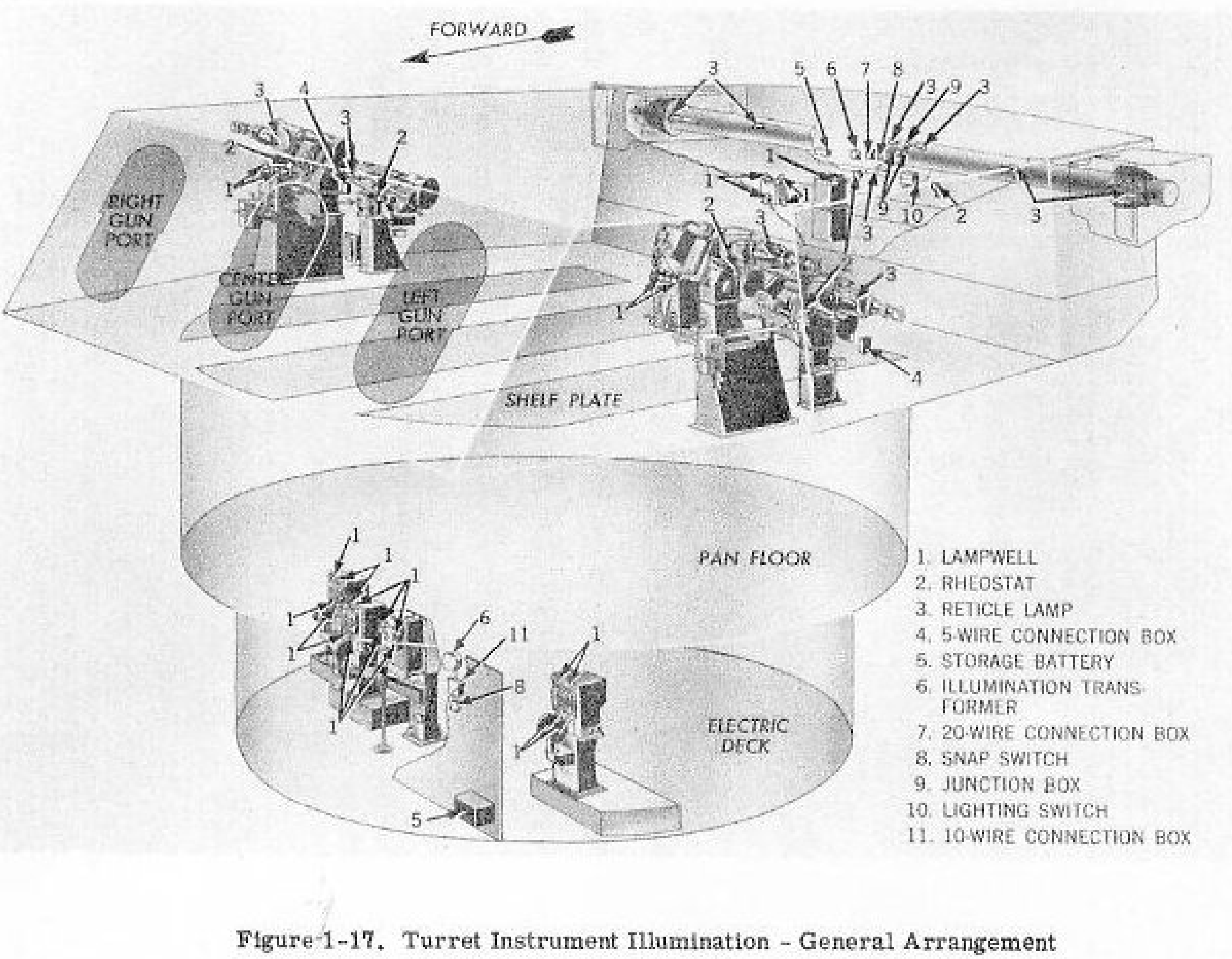
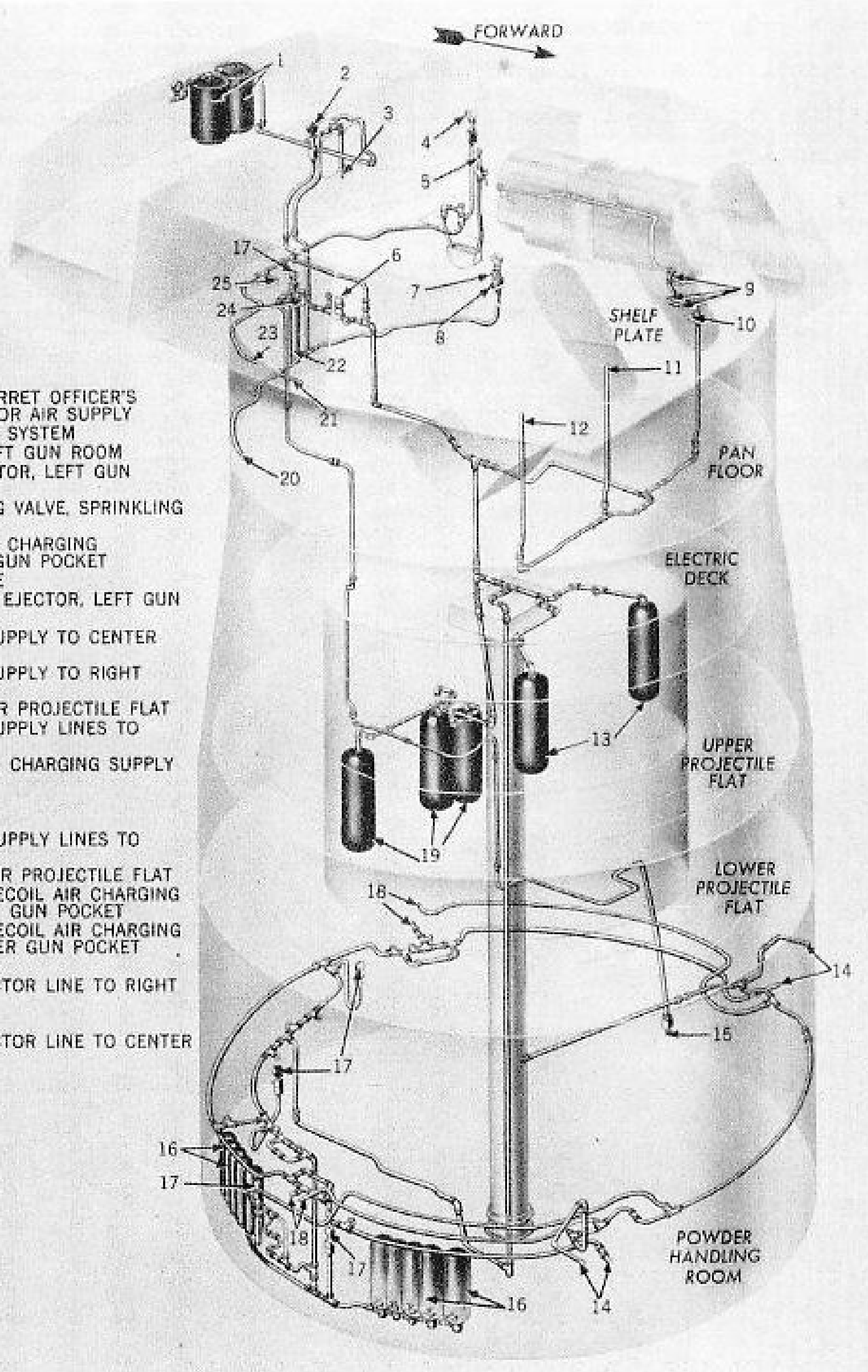


Figure 1-17. Turret Instrument Illumination - General Arrangement



1. SPRINKLING TANKS
2. PRESSURE GAGE, TURRET OFFICER'S STATION, GAS EJECTOR AIR SUPPLY
3. LINE TO SPRINKLING SYSTEM
4. PRESSURE GAGE, LEFT GUN ROOM
5. AUXILIARY GAS EJECTOR, LEFT GUN ROOM
6. PRESSURE REDUCING VALVE, SPRINKLING SYSTEM
7. COUNTERRECOIL AIR CHARGING CONNECTION, LEFT GUN POCKET
8. AIR CHARGING VALVE
9. SWIVEL JOINTS, GAS EJECTOR, LEFT GUN
10. GATE VALVE
11. GAS EJECTOR AIR SUPPLY TO CENTER GUN
12. GAS EJECTOR AIR SUPPLY TO RIGHT GUN
13. RELAY TANKS, UPPER PROJECTILE FLAT
14. GAS EJECTOR AIR SUPPLY LINES TO TURRET I
15. COUNTERRECOIL AIR CHARGING SUPPLY LINE
16. AIR FLASKS
17. PRESSURE GAGE
18. GAS EJECTOR AIR SUPPLY LINES TO TURRET III
19. RELAY TANKS, LOWER PROJECTILE FLAT
20. LINE TO COUNTERRECOIL AIR CHARGING CONNECTION, RIGHT GUN POCKET
21. LINE TO COUNTERRECOIL AIR CHARGING CONNECTION, CENTER GUN POCKET
22. SEPARATOR
23. AUXILIARY GAS EJECTOR LINE TO RIGHT GUN ROOM
24. STRAINER
25. AUXILIARY GAS EJECTOR LINE TO CENTER GUN ROOM

Figure 1-18. Gas Ejector and Counterrecoil Air Supply Pipe System. Turret II - General Arrangement

Rangefinder de-icing. Each rangefinder telescope is provided with de-icing mechanism which blows jets of heated air over the exposed window at each outer end of the rangefinder. Electrical components of this equipment are two rotary vane type electric motor driven blowers and two nichrome wire type heater elements. One blower is mounted on each end of the rangefinder tube. Power supply is 120-volt, single phase, 60-cycles, derived from the general lighting system.

Gas ejector supply

Air for the gas ejector supply is furnished by the ship's air compressors. The general arrangement of this system, together with the counterrecoil air supply replenishing pipe system is shown in figure 1-18.

The gas ejector supply pipe line enters the turret beneath the powder handling platform through a 2-inch pipe fitted with a swivel joint beneath the base casting. At this point a vertical 2-inch pipe extends upward through the exact center of the central column wiring tube. Within the wiring recess at the top of the central column the pipe is fitted with a 90 degree ell fitting which extends the pipe line horizontally rearward on the longitudinal centerline of the turret, to the exterior of the wiring recess. At this point the pipe line turns toward the left where, interconnected with three T fittings the pipe line extends to five relay tanks (two on the upper projectile flat, three on the lower projectile flat), and upward to a point below the center gun pocket. Here the pipe line has two branches, one leading rearward to the air supply connections for the auxiliary gas ejector and sprinkling system and the other leading forward to three 1-1/2-inch branch lines. These lead upward through the forward ends of the right, center, and left gun pockets where they terminate at 1-1/2-inch gate valves, which provide local cutoff of the gas ejector air supply. Connection of this supply to the gas ejector valve on the gun is described in chapter 3. Relay tanks each have a capacity of approximately 7.5 cubic feet.

The counterrecoil air supply replenishing pipe enters the turret through the foundation bulkhead into the annular powder handling space where it connects to a bank of air flasks. These are connected to a turret pipe system (by a portable pipe connection) which leads upward to a separator in the rear part of the center gun pocket.

The separator, which has three branch lines leading to air charging connections in the gun pockets, is provided with a pressure gage graduated from 0 to 3000 pounds per square inch. Gun pocket air charging connections are provided with similar pressure gages.

TURRET OPERATION

INTRODUCTION

This chapter, a guide to turret operation, is arranged to be an aid in organizing the turret crew. Each station is separately described, and the equipment used and the duties of the station are defined. The duties are explained or identified with respect to the functional activities of equipment - a station or compartment - and with respect to methods of control of equipment and of the turret. In the instance of certain key stations, the duties include alternative activities concerning different methods of control or emergency or casualty operations.

It is not intended that ships' officers consider the descriptions of duties of turret personnel to be rigid or definitive. Variations therefrom are within the discretion of officers in charge, provided existing regulations are observed.

Station activities and turret control methods

Classes of operations. All station activities are associated with one of four functional classes of operations. These are:

- Ammunition service to the guns
- Gun operation
- Gun laying
- Controlling gun fire

Ammunition service to the guns from projectile flats or magazines is the same in all methods of turret operation.

Operation of the gun (breech mechanism, firing lock, and gas ejector) is the same in all methods of turret operation.

Gun laying (and turret train) is controlled either from a remote control station or from a local sight control station.

There are three basic types of fire control selections designated:

- Primary
- Secondary
- Local

Primary control is turret control by a main battery director in combination with main battery plotting room equipment. It has two types of operation: "Automatic" and "Indicating." In "Automatic" control, the turret and its guns are automatically positioned by the receiver-regulators through signals received from plot. In "Indicating" control, the turret and its guns are positioned by the turret crew in follow-the-pointer operation. The firing station in both types of control is normally the stable vertical in either plotting room.

In secondary control, a turret acts as a controlling director, in combination with main battery plotting room equipment, to control either or both of the other turrets and their guns. This is an auxiliary method of director control, and has two types of operation: "Automatic" and "Indicating," which are identical to the similar types of primary control.

Local control is independent turret control, deriving target bearing and range locally. It is control in which the sight control stations, rangefinder, and auxiliary computer control the turret and gun positions. Guns are fired by designated local switch or switches.

Objectives. In all operations and in each method of control, the purpose of the turret design is to provide for rapid and accurate fire with safety. Speed and safety design features of the ammunition hoists, projectile rings, guns, and gun laying devices are dependent on crew teamwork and alertness, smart operation, and good maintenance. These personnel factors are best obtained by understanding the station equipment, the turret installations, and the crew arrangement. Each member of the crew must be drilled in his duties.

Firing cycle

The importance of teamwork in ammunition handling is shown in figure 2-1. In continuous fire, each of the turret's three guns is firing every 30 seconds, approximately. During this time interval many ammunition service actions and gun loading actions take place. Most of these actions depend upon completion of a prior action. The final action, gun firing, is dependent upon smooth coordination and rapid completion of all actions. Any lag or delay in these actions will stop or retard gun firing.

Personnel organization

The turret personnel organization is tabulated in figure 2-2. For 3-gun operation, a minimum crew of 77 men is required. Forty-six men are stationed below the electric deck and in the top of the powder hoist trunks to serve ammunition to the guns. Twelve others, stationed in the gun compartments, maintain gun operations. These 58 men are identically employed in all methods of turret control.

The remainder of the organization comprises three gun layers and a train operator on the electric deck, three men in each sight control station, and nine turret controlmen in the gun house. These 19 men have varying duties, depending on the method of turret control. All are engaged when the turret is operated in HAND under LOCAL control (except the three men in the stand-by sight control station). When the turret is operated in AUTOMATIC under PRIMARY control, one sight setter and the three gun layers (for automatic load operation only) are actively engaged. All others are at stand-by operation.

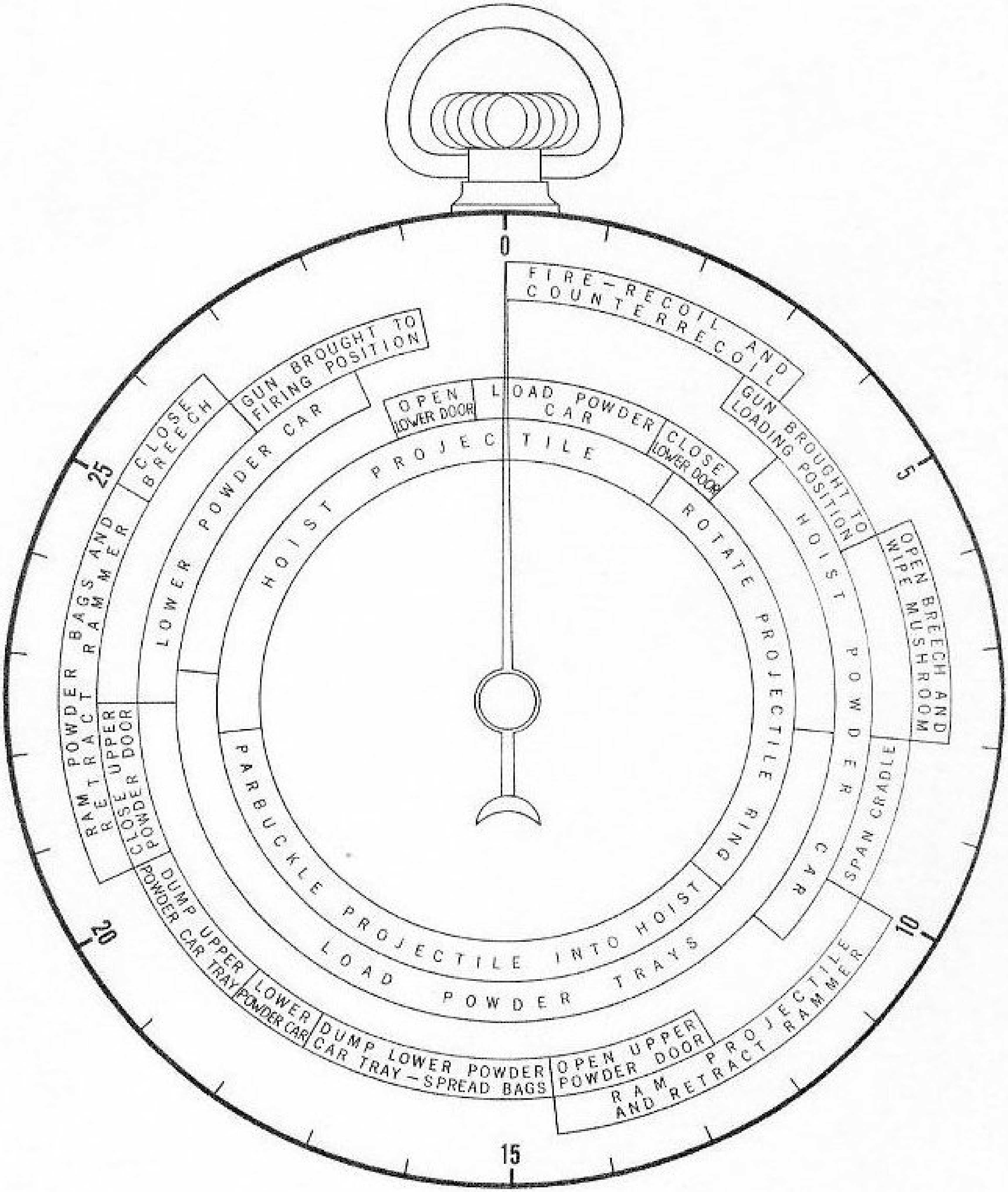


Figure 2-1. Firing Cycle Operations

CREW NAME	STATION	LOCATION
TURRET OFFICER	TURRET OFFICER'S BOOTH (RIGHT)	TURRET OFFICER'S COMPARTMENT
TURRET OFFICER'S TALKER	TURRET OFFICER'S BOOTH (RIGHT)	TURRET OFFICER'S COMPARTMENT
TURRET CAPTAIN	TURRET OFFICER'S BOOTH (LEFT)	TURRET OFFICER'S COMPARTMENT
COMPUTER OPERATOR	COMPUTER	TURRET OFFICER'S COMPARTMENT
COMPUTER OPERATOR-TALKER: JW (RANGEFINDER OPERATOR TO COMPUTER)	COMPUTER	TURRET OFFICER'S COMPARTMENT
RANGEFINDER OPERATOR-TALKER: JW	RANGEFINDER	TURRET OFFICER'S COMPARTMENT
RANGEFINDER POINTER	RANGEFINDER	TURRET OFFICER'S COMPARTMENT
RANGEFINDER TRAINER	RANGEFINDER	TURRET OFFICER'S COMPARTMENT
TALKER: JE (COMPUTER TO SIGHT SETTERS)	COMPUTER	TURRET OFFICER'S COMPARTMENT
POWDER HOIST OPERATOR, RIGHT	RIGHT HOIST CONTROL, TOP OF TRUNK	TURRET OFFICER'S COMPARTMENT
POWDER HOIST OPERATOR, CENTER	CENTER HOIST CONTROL, TOP OF TRUNK	TURRET OFFICER'S COMPARTMENT
POWDER HOIST OPERATOR, LEFT	LEFT HOIST CONTROL, TOP OF TRUNK	TURRET OFFICER'S COMPARTMENT
SIGHT POINTER	SIGHT POINTER'S HANDWHEEL	RIGHT SIGHT STATION
SIGHT TRAINER	SIGHT TRAINER'S HANDWHEEL	RIGHT SIGHT STATION
SIGHT SETTER	SIGHT SETTING INDICATOR	RIGHT SIGHT STATION
SIGHT POINTER	SIGHT POINTER'S HANDWHEEL	LEFT SIGHT STATION
SIGHT TRAINER	SIGHT TRAINER'S HANDWHEEL	LEFT SIGHT STATION
SIGHT SETTER	SIGHT SETTING INDICATOR	LEFT SIGHT STATION
GUN CAPTAIN	LOADER'S PLATFORM	RIGHT GUN COMPARTMENT
CRADLE OPERATOR	PROJECTILE HOIST CRADLE	RIGHT GUN COMPARTMENT
RAMMER OPERATOR	RAMMER CONTROL	RIGHT GUN COMPARTMENT
PRIMERMAN	PRIMERMAN'S PLATFORM	RIGHT GUN COMPARTMENT
GUN CAPTAIN	LOADER'S PLATFORM	CENTER GUN COMPARTMENT
CRADLE OPERATOR	PROJECTILE HOIST CRADLE	CENTER GUN COMPARTMENT
RAMMER OPERATOR	RAMMER CONTROL	CENTER GUN COMPARTMENT
PRIMERMAN	PRIMERMAN'S PLATFORM	CENTER GUN COMPARTMENT
GUN CAPTAIN	LOADER'S PLATFORM	LEFT GUN COMPARTMENT
CRADLE OPERATOR	PROJECTILE HOIST CRADLE	LEFT GUN COMPARTMENT
RAMMER OPERATOR	RAMMER CONTROL	LEFT GUN COMPARTMENT
PRIMERMAN	PRIMERMAN'S PLATFORM	LEFT GUN COMPARTMENT
GUN LAYER	RIGHT ELEVATING CONTROL HANDWHEEL	ELECTRIC DECK
GUN LAYER	CENTER ELEVATING CONTROL HANDWHEEL	ELECTRIC DECK
GUN LAYER	LEFT ELEVATING CONTROL HANDWHEEL	ELECTRIC DECK
TRAIN OPERATOR	TRAIN CONTROL HANDWHEEL	ELECTRIC DECK

CREW NAME	STATION	LOCATION
PROJECTILE HOIST OPERATOR	RIGHT PROJECTILE HOIST CONTROL	UPPER PROJECTILE FLAT
PROJECTILE HOIST OPERATOR	CENTER PROJECTILE HOIST CONTROL	UPPER PROJECTILE FLAT
PROJECTILE HOIST OPERATOR	LEFT PROJECTILE HOIST CONTROL	UPPER PROJECTILE FLAT
PROJECTILE RING OPERATOR	PROJECTILE RING CONTROL	UPPER PROJECTILE FLAT
SHELLMEN (2)	GYPSY HEAD ADJACENT TO RIGHT PROJECTILE HOIST	UPPER PROJECTILE FLAT
SHELLMEN (2)	GYPSY HEAD ADJACENT TO CENTER PROJECTILE HOIST	UPPER PROJECTILE FLAT
SHELLMEN (2)	GYPSY HEAD ADJACENT TO LEFT PROJECTILE HOIST	UPPER PROJECTILE FLAT
SHELLMEN (3)	GYPSY HEAD IN FORWARD PART OF FLAT	UPPER PROJECTILE FLAT
ELECTRICIAN	INNER MACHINERY SPACE	UPPER PROJECTILE FLAT
PETTY OFFICER IN CHARGE (TALKER - XJ CIRCUIT)	PROJECTILE HANDLING SPACE	UPPER PROJECTILE FLAT
PROJECTILE HOIST OPERATOR	RIGHT PROJECTILE HOIST CONTROL	LOWER PROJECTILE FLAT
PROJECTILE HOIST OPERATOR	CENTER PROJECTILE HOIST CONTROL	LOWER PROJECTILE FLAT
PROJECTILE HOIST OPERATOR	LEFT PROJECTILE HOIST CONTROL	LOWER PROJECTILE FLAT
PROJECTILE RING OPERATOR	PROJECTILE RING CONTROL	LOWER PROJECTILE FLAT
SHELLMEN (2)	GYPSY HEAD ADJACENT TO RIGHT PROJECTILE HOIST	LOWER PROJECTILE FLAT
SHELLMEN (2)	GYPSY HEAD ADJACENT TO CENTER PROJECTILE HOIST	LOWER PROJECTILE FLAT
SHELLMEN (2)	GYPSY HEAD ADJACENT TO LEFT PROJECTILE HOIST	LOWER PROJECTILE FLAT
SHELLMEN (3)	GYPSY HEAD IN FORWARD PART OF FLAT	LOWER PROJECTILE FLAT
ELECTRICIAN	INNER MACHINERY SPACE	LOWER PROJECTILE FLAT
PETTY OFFICER IN CHARGE (TALKER - XJ CIRCUIT)	PROJECTILE HANDLING SPACE	LOWER PROJECTILE FLAT
POWDER DOOR OPERATOR	RIGHT HOIST, BOTTOM OF TRUNK	POWDER HANDLING ROOM
POWDER DOOR OPERATOR	CENTER HOIST, BOTTOM OF TRUNK	POWDER HANDLING ROOM
POWDER DOOR OPERATOR	LEFT HOIST, BOTTOM OF TRUNK	POWDER HANDLING ROOM
FIRST POWDERMAN, RIGHT	RIGHT POWDER HOIST	POWDER HANDLING ROOM
SECOND POWDERMAN, RIGHT	RIGHT POWDER HOIST	POWDER HANDLING ROOM
THIRD POWDERMAN, RIGHT	MAGAZINE SCUTTLE	POWDER HANDLING ROOM
FIRST POWDERMAN, CENTER	CENTER POWDER HOIST	POWDER HANDLING ROOM
SECOND POWDERMAN, CENTER	CENTER POWDER HOIST	POWDER HANDLING ROOM
THIRD POWDERMAN, CENTER	MAGAZINE SCUTTLE	POWDER HANDLING ROOM
FIRST POWDERMAN, LEFT	LEFT POWDER HOIST	POWDER HANDLING ROOM
SECOND POWDERMAN, LEFT	LEFT POWDER HOIST	POWDER HANDLING ROOM
THIRD POWDERMAN, LEFT	MAGAZINE SCUTTLE	POWDER HANDLING ROOM
PETTY OFFICER IN CHARGE (TALKER - XJ CIRCUIT)	POWDER HANDLING SPACE	POWDER HANDLING ROOM

Figure 2-2. Turret Personnel Organization

Crew stations

In normal turret operation (in all methods of control) crew stations are manned in all levels of the turret except the pan floor. All levels are isolated with all intercommunicating hatches closed and secured. This divides the manned spaces into compartments located on five levels with personnel arrangements as shown in figures 2-3 to 2-6. The upper and lower projectile handling flats are identically manned.

PERSONNEL DUTIES

Turret officer

Duties. The turret officer, as the supervisor of turret operations, directs the entire crew. He is responsible for organizing and training the operators of all stations for performance of their duties in all types of control. Turret operations as related to fire control are directed by the control officer except when battle damage has isolate the turret from all control stations. The turret transfer switchboard and other necessary control devices, for the different control methods, are set by the turret officer as directed by the control officer. His main duty is: general supervision of turret operation, coordinating and directing the work of the turret crew. He takes control, in the event of director control failure, to direct firing after shifting to local control.

In local control, the turret officer assumes full control of turret fire, designating the target and directing and coordinating all turret operations. He observes the fall-of-shot through the periscope and constantly gives spot correction orders to the computer operator.

Equipment used. The turret officer's control station and the equipment used by him both at the station and adjacent to it are shown in figures 2-7 and 2-8. The major piece of equipment is the turret officer's transfer switchboard. This has 16 rectangular panels arranged across its front with 21 rotary disc-type switches mounted in 14 panels (the remaining two panels serve miscellaneous purposes). The switches provide ON-OFF and transfer switching facilities for most of the turret fire control circuit. In local control, the turret officer uses his periscope to observe the target and fall-of-shot. He has a selective switch which is set either to include the director firing key in the firing circuit or to bypass it for local control of firing. This switch also connects the firing circuit either to the alternating current ship supply or to the local storage battery. When positioned to DIRECTOR, this switch also closes a circuit to light a "turret ready" light in plot and in the turret officers' panel. This panel also has indicating lights to show when the other two turrets are ready to fire plus a "plot ready" light. He has an indicator panel which indicates when the trainer is ready to fire, when the other turrets are ready, and when plot is ready. The indicator panel also provides the turret officer with individual firing key cutout and cut in switches. In addition the turret officer has at his disposal: a two-dial transfer signal indicator which indicates (from plot) whether transfer switches are to be set at FWD or at AFT; a three-dial danger sector indicator which indicates when the line of fire of any of the guns closely approaches ship's structure; a multiple turret train indicator which indicates turret train order, the actual angle of turret train, and the angle of train of the adjacent turret (except turret III). The turret officer also has: sprinkling system control valves for selective control of sprinkling of gun breeches, ammunition hoists, and projectile stowage spaces; various types of equipment for communications with personnel of the plotting rooms, control stations, and other ship's stations, and with personnel within the turret.

Turret captain

Duties. The turret captain, as the assistant supervisor of turret operations, helps to organize and train all turret personnel. He complies with the orders of the turret officer, assisting him in the setting of controls and in intraturret communications. The turret captain is the overseer of gun operations, directing and coordinating the work of the three gun captains. He takes over turret supervision in event of incapacity of the turret officer.

Immediately after all stations are manned, the turret captain (assisted by the gun captains) checks the electric gun-firing circuit by connecting a test lamp between the firing lock and the firing circuit lead at each gun. Individual firing keys, cut-in through the turret officers' indicator panel switches, are then closed on salvo circuit signal.

The turret captain observes the fall-of-shot through his periscope and gives spot corrections to the computer operator when directed by the turret officer.

Equipment used. The turret captain's control station and the equipment used by him are shown in figure 2-7. His equipment includes: the left periscope; an indicator which is identical to the turret officers except that it has no switches; an emergency alarm contact maker which, when held open, stills the alarm sirens; a train warning pushbutton which, when held closed, sounds the train warning bell; and elements of the sprinkling system, and interior communications equipment.

Computer operators

Duties. The computer operators (an operator and an operator-talker) are responsible for the operation of the auxiliary computer (fig. 2-30). They are at stand-by duty in primary and secondary control (unless the turret is acting as a director). They take over computation of the fire control problem, when turret control is switched to local. While in stand-by duty, if range can be received from the rangefinder operator, the operators compute the fire control problem as an exercise and check.

In local control, the computer operators compute sight angle and deflection. They introduce 13 manual inputs into the computer which, along with three electrical inputs, produce the required values. These values are indicated in the computer and are transmitted orally (via the computer operator-talker) to the sight setter.

Equipment used. The computer operators use the auxiliary computer and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

Talker

Duties. Stationed in the turret officer's compartment (fig. 2-3), the talker receives information (sight deflection and sight angle) from the computer operator. He orally transmits this information to the sight setters.

Equipment. The talker uses a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

Rangefinder operator (Turrets II and III only)

Duties. The rangefinder operator is responsible for the operation of the turret rangefinder (fig. 2-29). He is at stand-by duty in primary and secondary control (unless the turret is acting as a director). He supplies target range orally to the computer operators when turret control is switched to local and at other times as an exercise.

Equipment used. The rangefinder operator uses the rangefinder operator's handwheels, and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

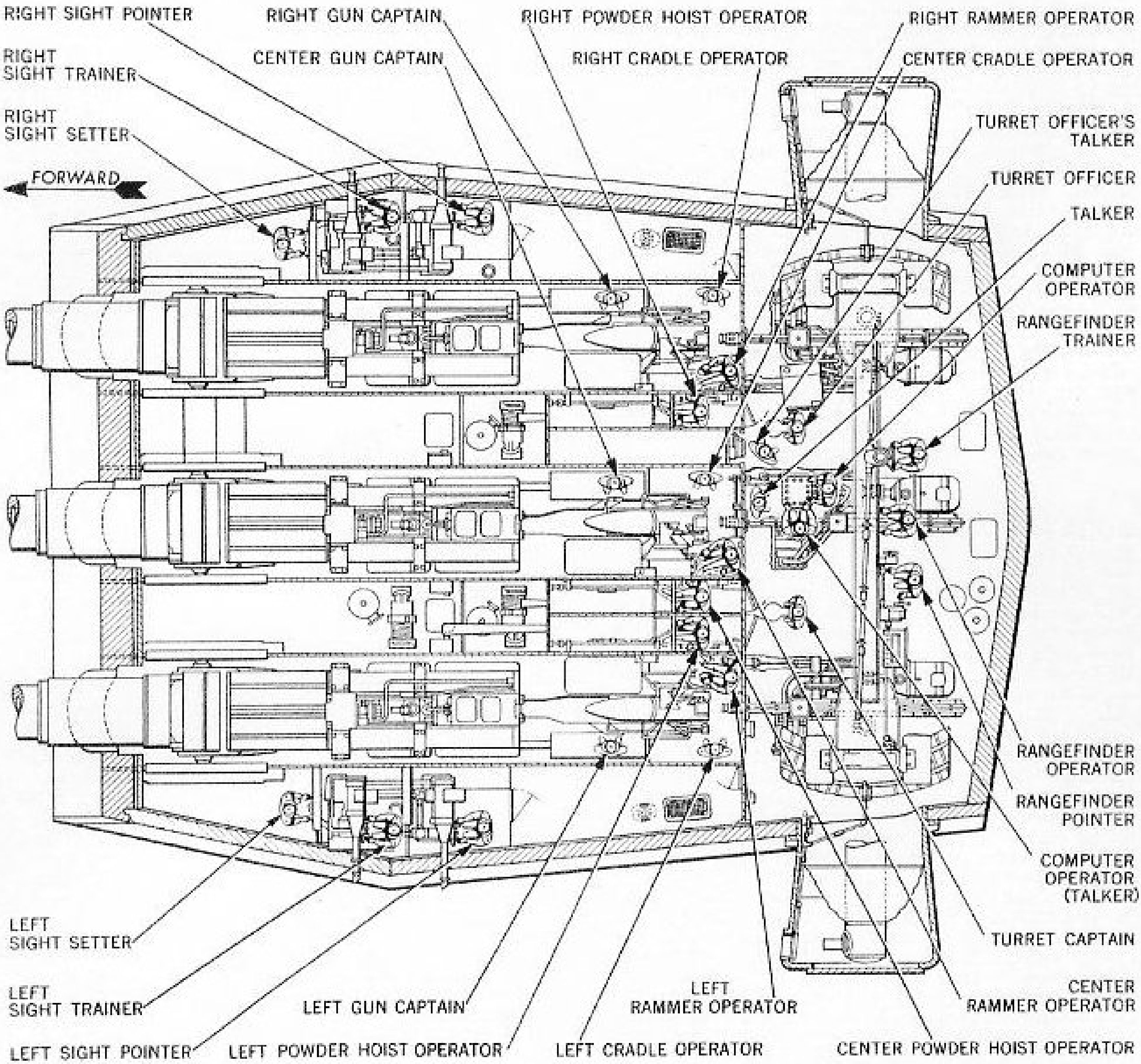


Figure 2-3. Turret Personnel Arrangement. Gun House Stations

Rangefinder pointer

Duties. The rangefinder pointer (fig. 2-3) is responsible for keeping the rangefinder lines of sight, in altitude or elevating and depressing motion (to follow the roll of the ship), on the target. He performs this duty whenever the rangefinder operator takes the target range.

Equipment used. The rangefinder pointer uses the rangefinder pointer's handwheels and an automatic elevating drive (stabilizer) which holds the rangefinder lines of sight horizontal.

Rangefinder trainer

Duties. The rangefinder trainer (fig. 2-3) is responsible for keeping the rangefinder lines of sight, in deflection or azimuth motion (to modify turret train movements), on the target. He performs this duty whenever the rangefinder operator takes the target range.

Equipment used. The rangefinder trainer uses the deflection handwheel and the deflection setting and indicator assembly.

Sight trainers (right and left)

Duties. The sight trainers (fig. 2-3) are at stand-by duty in primary and secondary control. One of them assumes control of turret train (in local control) when directed by the turret officer. They maintain communications with each other, with the sight pointers, and with the turret officer (through his talker). The sight trainer in control (fig. 2-13) is responsible for keeping the turret's vertical crosslines on the target. By turning his handwheels, the sight trainer offsets the hydraulic transmission A-end of the training gear to train the turret.

Equipment used. Each sight trainer uses: a telescope; handwheels; a telephone headset with breastplate-supported and pushbutton-controlled transmitters; and a foot-operated ready switch, which, when closed, illuminates TRAIN READY dials at the turret officer's, turret captain's, and sight station indicators.

Sight pointers (right and left)

Duties. The sight pointers (fig. 2-3) are at stand-by duty in primary and secondary control. When ordered by the turret officer, one of them turns his handwheels to keep the horizontal crossline on the target. By doing this, the sight pointer transmits gun elevation orders to the gun elevation indicator of each of the three gun layers. The sight pointers maintain communications with each other, with the sight trainers, and with the turret officer (through his talker).

Equipment used. The sight pointers use: the sight pointers' telescopes and handwheels; firing keys which are mounted on the handwheels; telephone headsets with breastplate-supported and pushbutton-controlled transmitters; and synchronizing clutches (for synchronizing the handwheels with the gun elevation indicators) and clutch indicators (which indicate the relative position of the opposite sight pointer's clutch).

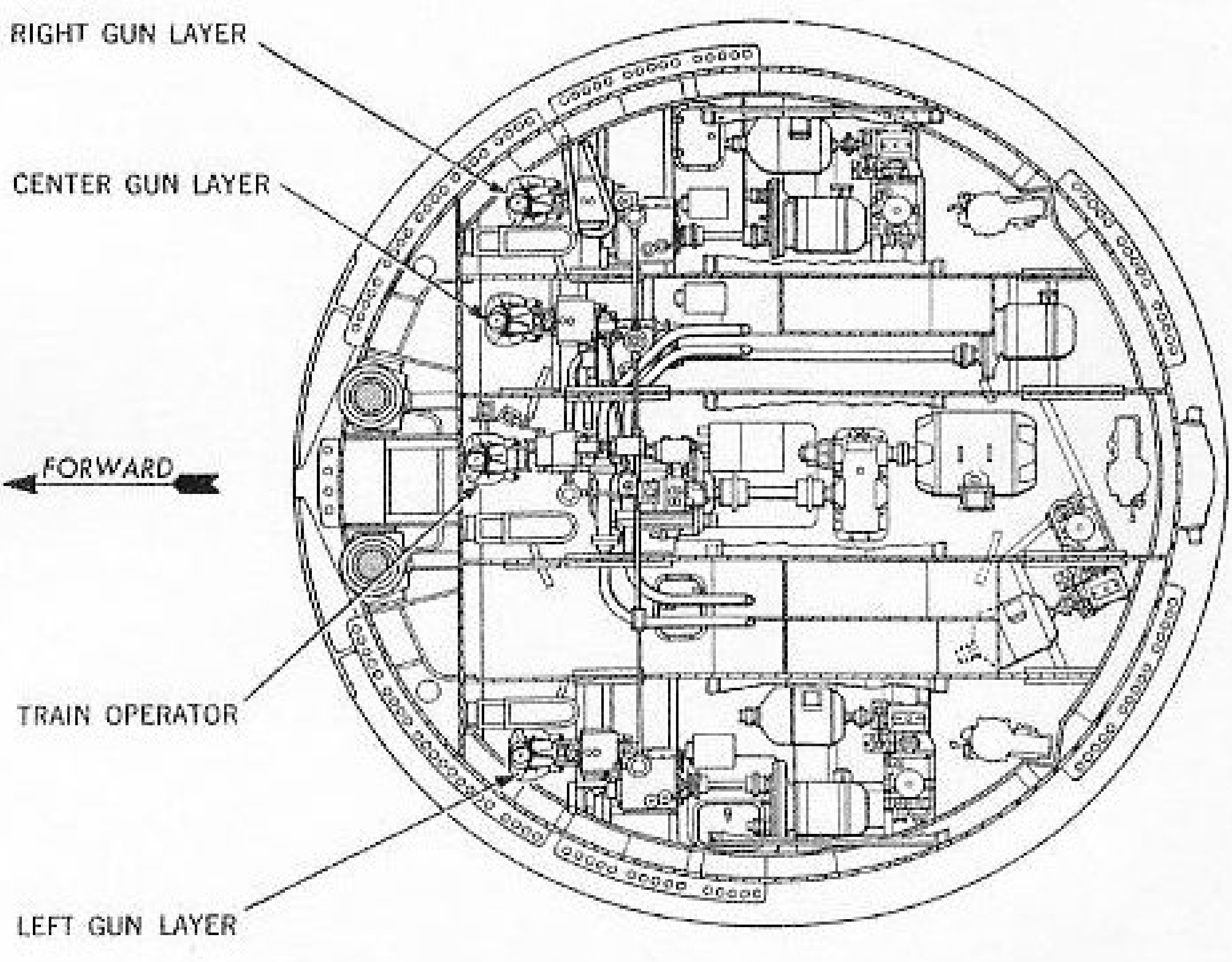


Figure 2-4. Turret Personnel Arrangement. Electric Deck Stations

Sight setters (right and left)

Duties. The two sight setters have identical duties. One of them (designated by the turret officer) performs these duties in all methods of turret control. They maintain communications with the computer operator and with the turret officer (through his talker). The sight setter selected (fig. 2-9) must clutch-engage his indicator with the sight angle cross-shaft system. He is then responsible for manually entering mechanical values that offset the lines of sight and correct gun orders. He operates the indicator hand cranks in response to electrically received dial-actuated orders (in primary control and secondary control) or according to data received by telephone (in local control, or in secondary control, when the turret acts as a director). These values are for offset depression of the lines of sight from parallelism with the guns (sight angle), azimuth offset of the lines of sight (sight deflection), and turret train offset for difference in target bearing at the director and the guns (parallax range). In performing these follow-the-pointer duties, he is entering corrections to the gun orders and off-setting the pointer and trainer lines of sight.

Equipment used. The sight setters use: the sight setters' indicators; telephone headsets with breastplate-supported and pushbutton-controlled transmitters; and synchronizing clutches (which provide for correct engagement of the sight angle cross-shaft system) and clutch indicators (which indicate the relative positions of both sight setters' clutches).

Gun captains

Duties. Each of the three gun captains is directly responsible for supervision of a gun. He directs the activities of his gun crew (fig. 2-31, primerman not shown) in all of their duties. He directs the starting of the projectile hoist power drive and has emergency stop control of gun laying for his gun.

The duties of the three gun captains are identical and include checking of the removal of tompions (or muzzle covers), releasing the slide securing pins, and releasing the gun locking device, and assists the turret captain when he checks the electric gunfiring circuit. He personally verifies the charges of the counterrecoil and recoil mechanisms. In addition to these duties, the right and left gun captains are responsible for releasing the turret centering pins.

During gun firing operations, the gun captain positions his ready switch at SAFE, opens the breech, verifies that the gun bore is clear and depresses the bore clear switch momentarily, closes the gas ejector valve, and wipes the mushroom clean of burning powder bag fragments. He indicates to his crew when they are to span the cradle and spanning tray, ram the projectile, prime the firing lock, and open the powder door. He indicates to the powder hoist operator when he is to dump the first powder car tray, lower the car, and dump the second powder car tray. He spreads the powder bags and indicates to his crew when they are to ram the powder bags, close the powder door, and raise the cradle. The gun captain closes the breech and, after

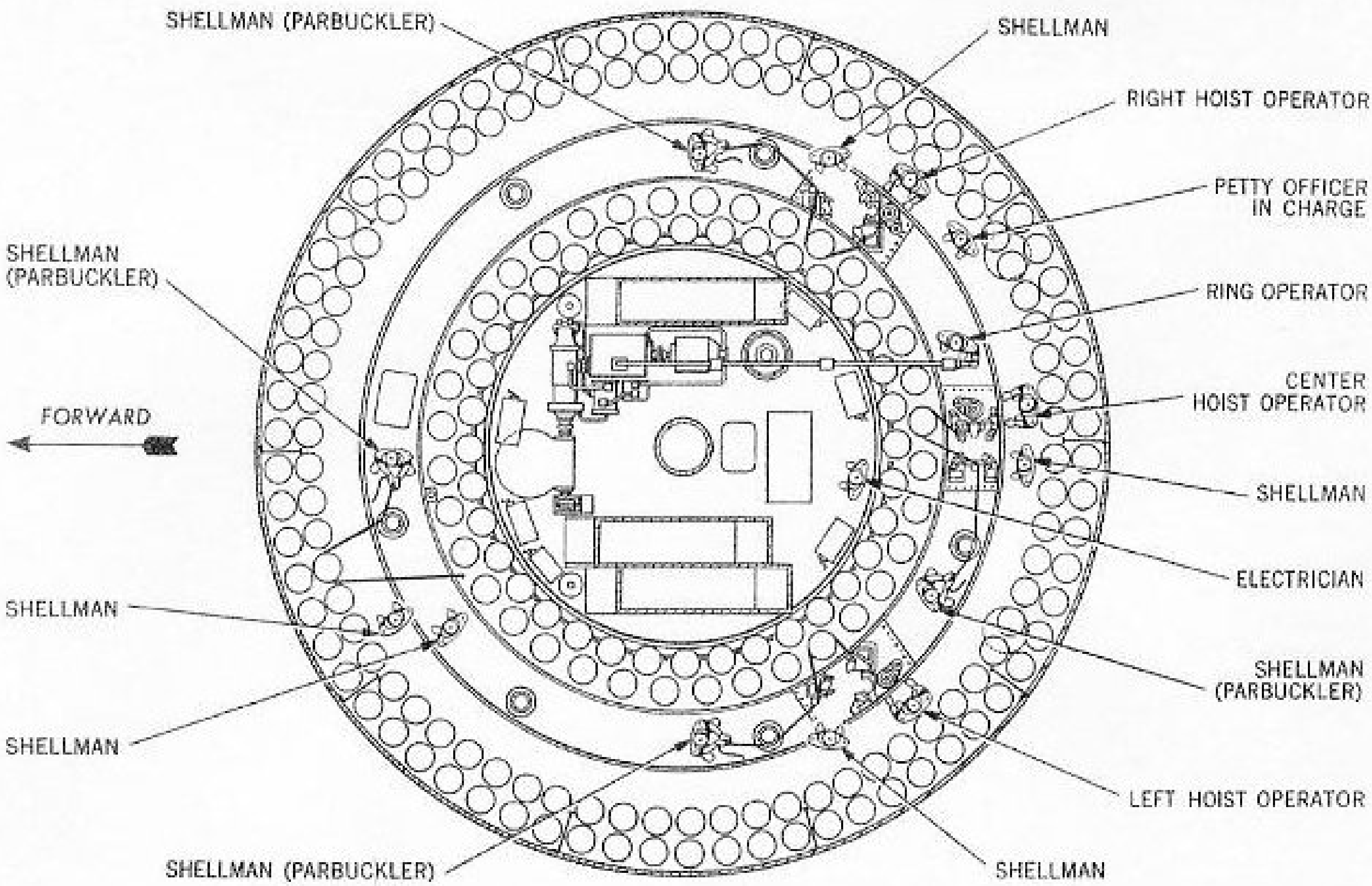


Figure 2-5. Turret Personnel Arrangement. Projectile Flat Station.

he and his crew are in safe positions, he positions his ready switch to READY. After the gun has fired and he returns the ready switch to its SAFE position, the gun captain verifies that the gun has returned to battery before beginning the next load operation.

The gun captain has facilities for communicating with the turret officer and with the powder hoist and projectile hoist operators.

After firing operations are completed, the gun captain and his crew help to clean and stow the gun units and unload the ammunition hoists.

Equipment used. Each gun captain uses push-to-talk button telephone handsets and the instrument panel at his station (fig. 2-10).

Cradle operator

Duties. Each of the three cradle operators has identical duties, all of which are performed under direct supervision of the gun captain.

The cradle operator (fig. 2-31) starts or stops the power drive. During gun firing operations, he spans the cradle and spanning tray, helps the gun captain spread the powder bags as they are dumped into the spanning tray, and raises the cradle after the gun is loaded and the rammer retracted. He performs these duties on indications by the gun captain.

When high capacity projectiles are fired, the cradle operator (acting as fuze setter) communicates with the secondary battery computer fuze follow-up operator and sets projectile fuzes as ordered.

After firing operations are completed, the cradle operator assists in cleaning and stowing the gun units. He sets the projectile hoist function control mechanism to lower projectiles in the hoist.

Equipment used. Each cradle operator uses a telephone headset with breastplate-supported and pushbutton-controlled transmitter, and the control devices at his station.

Rammer operator

Duties. Each of the three rammer operators has identical duties, all of which are performed under direct supervision of the gun captains.

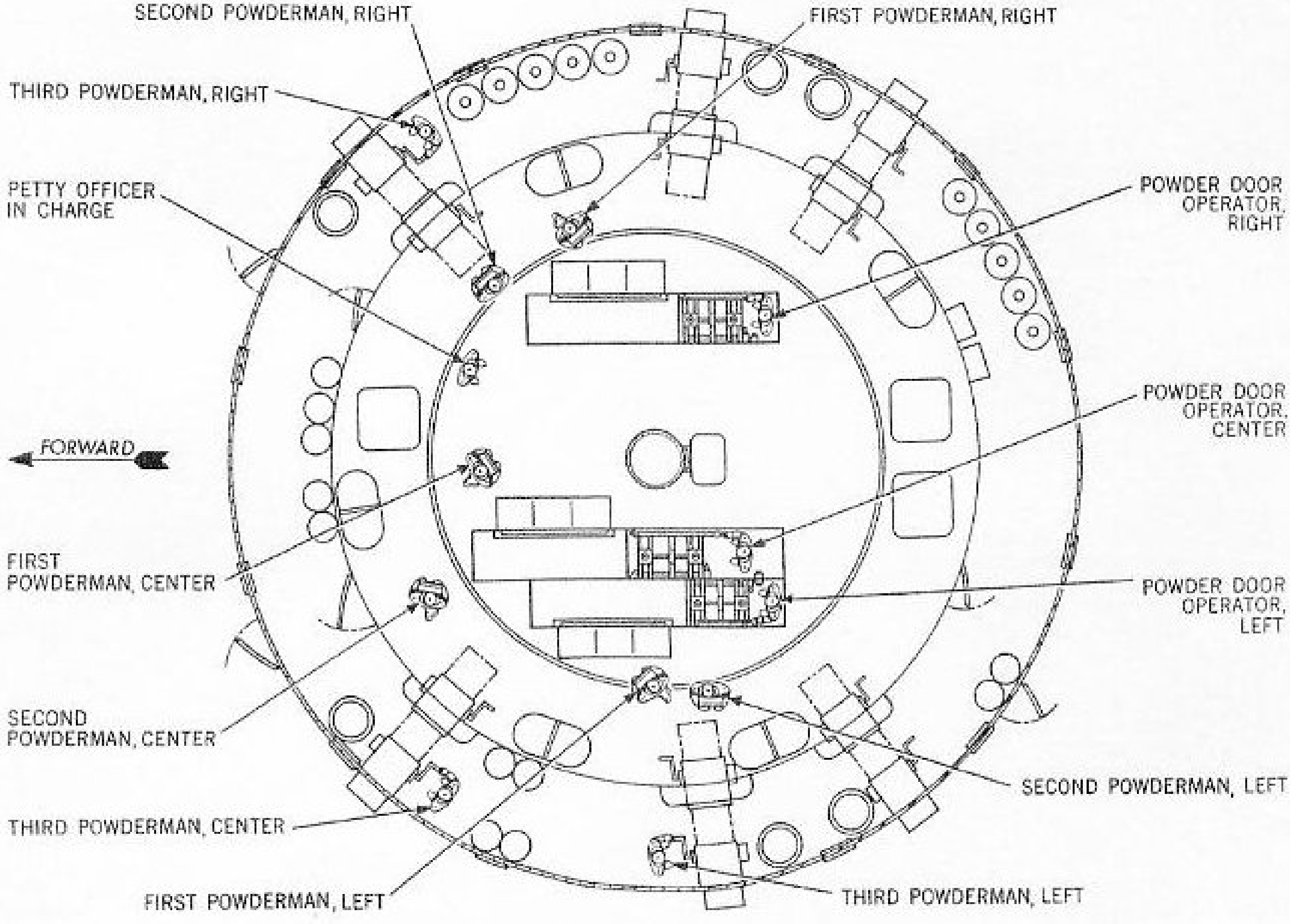


Figure 2-6. Turret Personnel Arrangement. Powder Handling Room Stations

During gun firing operations the rammer operator (fig. 2-31) operates the rammer to seat the projectile in the gun and to retract. He opens the powder door, operates the rammer to ram the powder bags into the gun and to retract, and closes the powder door. He performs these duties on indications by the gun captain.

After firing operations are completed, the rammer operator assists in cleaning and stowing the gun units.

Equipment used. Each rammer operator uses the control devices at his station.

Primermen

Duties. Each of the three primermen has identical duties all of which are performed under direct supervision of the gun captain.

During gun firing operations, the primerman (who is stationed on a platform below the shelf plate) inspects the primer seat and mushroom stem hole after each round is fired. He inserts a loaded primer into the firing lock.

Equipment. No equipment other than primers is used.

Powder hoist operators

Duties. Each of the three powder hoist operators has identical duties, some of which are performed on indications by the gun captain.

The powder hoist operator (fig. 2-32) has telephone communication with the turret officer (through his talker) and with the lower powder door operator. There is also a visual signal system between the lower powder door operator (fig. 2-11) and the hoist operator. Manually operated by the lower powder door operator, this system indicates to the hoist operator that he may hoist the car. A window in the bulkhead between the hoist operator and the gun room allows the operator to see signals made by the gun captain.

For the first load, "Control" orders the turret officers to "bring up powder." This order is relayed by the turret officers' talkers to the powder hoist operators. Until "Control" orders the turret officers to "cease fire" and to "return powder to magazine" the action is controlled by the hoist operators or gun captains.

The powder hoist operator's duties include starting or stopping the hoist power drive and operating it to hoist or lower the powder car when ordered to do so by the turret officer (through his talker). The hoist operator dumps the powder car trays at the car's two unloading stations when ordered to do so by the gun captain.

Equipment used. Each powder hoist operator uses the hoist and powder car control devices, and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

Gun layer

Duties. Each of the three gun layers is responsible for the operation and control of the elevating gear of his gun. He starts or stops the power drive and operates the devices (some of which are shown in fig. 2-12) by which the control method of gun elevation is selected.

The gun layer maintains communications with the turret officer (through his talker) who designates when the power drive is to be started or stopped, and the method of gun elevation control to be used. In starting or stopping operations the gun layer verifies that the tilting box is at neutral and the control selector lever is at HAND. With the gun in HAND control, he elevates the gun to correspond with the gun elevation order (shown on his indicator) before shifting to AUTO (automatic) control. In AUTO control the gun layer may bring the gun to its loading position from any angle of elevation by positioning the control selector lever at LOAD. He may return the gun to automatic control by positioning the control selector lever at AUTO. (Normally, the guns are brought to loading position and returned to AUTO control by the gun captain's ready switch). In AUTO control, the gun layer is at stand-by duty. He watches the indicator dials to check that gun position agrees with gun order. When ordered, he resumes HAND control of gun elevation.

When the elevating gear is operated in HAND control, the gun layer observes the gun order signal indicated by the pointers (dials) in the elevation indicator and compares that signal with the indicated position of the gun. If there is a "matching error" in the pointers, he operates his handwheels in a direction and at a speed calculated to "match pointers." The gun layer has a firing key that may be used to fire the guns (through switches on the turret officer's indicator panel) when directed by the turret officer.

Equipment used. The gun layer uses: pedestal mounted handwheels; a gun elevation indicator which is mounted on top of the handwheel pedestal; a firing key which is mounted on the handwheels; a control selector with a synchro power indicator light; gun elevation ready and gun ready indicator lights; a foot-operated ready switch which illuminates dials at the turret officer's, turret captain's, train operator's, gun captain's, and sight stations' indicators to indicate that the gun is ready; and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

Gun train operator

Duties. The train operator (fig. 2-33) is responsible for the operation and control of the turret training gear. He starts or stops the power drive and operates the devices by which the control method of gun train is selected.

The train operator maintains communications with the turret officer (through his talker) who designates when the power drive is to be started or stopped and the method of gun train control to be used. In starting or stopping operations the train operator verifies that the tilting box is at neutral

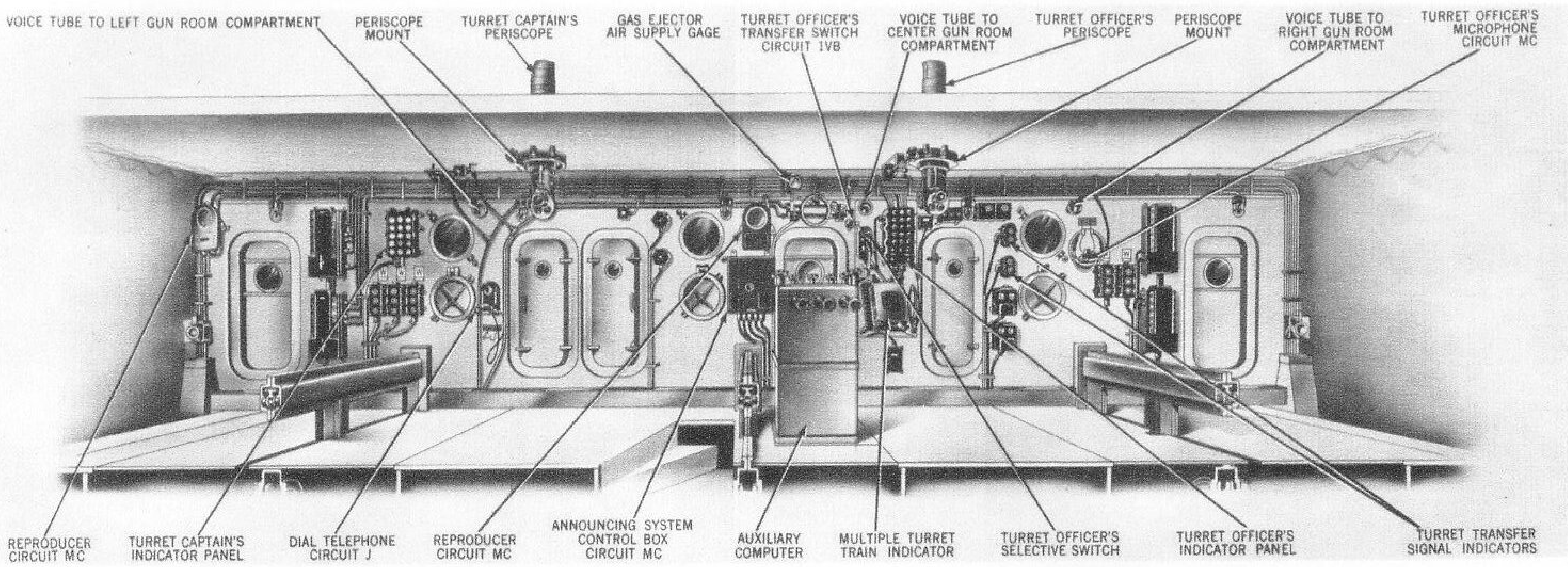


Figure 2-7. Turret Officer's Booth, Looking Forward

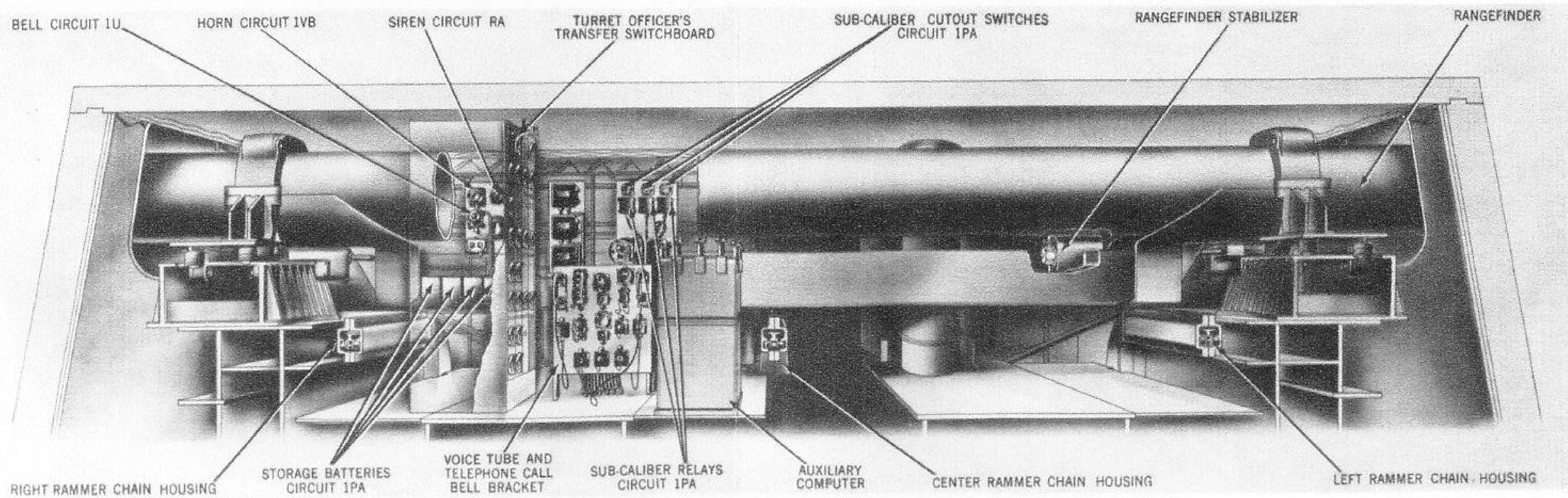


Figure 2-8. Turret Officer's Booth, Looking Aft

(indicated by the neutral-start indicator light being lit) and that the control selector lever is at HAND. With the turret in HAND control, he trains the turret to correspond with the gun train order (shown on his indicator) before shifting to AUTO (automatic) control. In AUTO control, the train operator is at stand-by duty. He watches the indicator dials to check that turret position agrees with gun train order. When ordered, he resumes HAND control of gun train.

When the training gear is operated in HAND control, the train operator observes the train order signal indicated by the pointers (dials) in the train indicator and transmitter and compares that signal with the indicated position of the turret. If there is a "matching error" in the pointers, he operates his handwheels in a direction and at a speed calculated to "match pointers."

The train operator has a firing key that may be used to fire the guns (through switches on the turret officer's indicator panel) when directed by the turret officer.

The train operator also turns the parallax-range handcrank to match pointers on the range dials of his indicator and transmitter.

Equipment used. The train operator uses: pedestal mounted handwheels; a turret train indicator and transmitter which is mounted on top of the handwheel pedestal; a firing key which is mounted on the handwheels; a control selector with a synchro power indicator light; gun elevation and train ready indicator lights; a foot-operated ready switch which illuminates dials at the turret officer's, turret captain's, train operator's, and the sight station's indicators to indicate that turret train is ready; and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

Projectile hoist operators (each level)

Duties. Each projectile hoist may be filled and used to hoist projectiles from either the uppor or lower projectile flat. The hoist control stations and the hoist operator's duties are identical for each hoist on each level. The hoist operator is responsible for the operation of the projectile hoist and has emergency stop control of the hoist from the level on which he is stationed.

The projectile hoist operator performs his duties under direct supervision of the petty officer in charge. He operates the hoist control handle in accordance with the visual and audible signals and warnings of the dial indicators and gong.

Equipment used. The projectile hoist operator uses: the hoist control handle; the power drive stop button; the indicator dials and gong; and a turret alarm contact maker, circuit RA (center hoist only).

Projectile ring operator (each level)

Duties. Each projectile ring operator is a controlman for ammunition delivery to the shellmen. He is responsible for the operation of a projectile ring which he controls by manually rotating the hand lever (fig. 2-13). The ring operator's control stations on each level are identical.

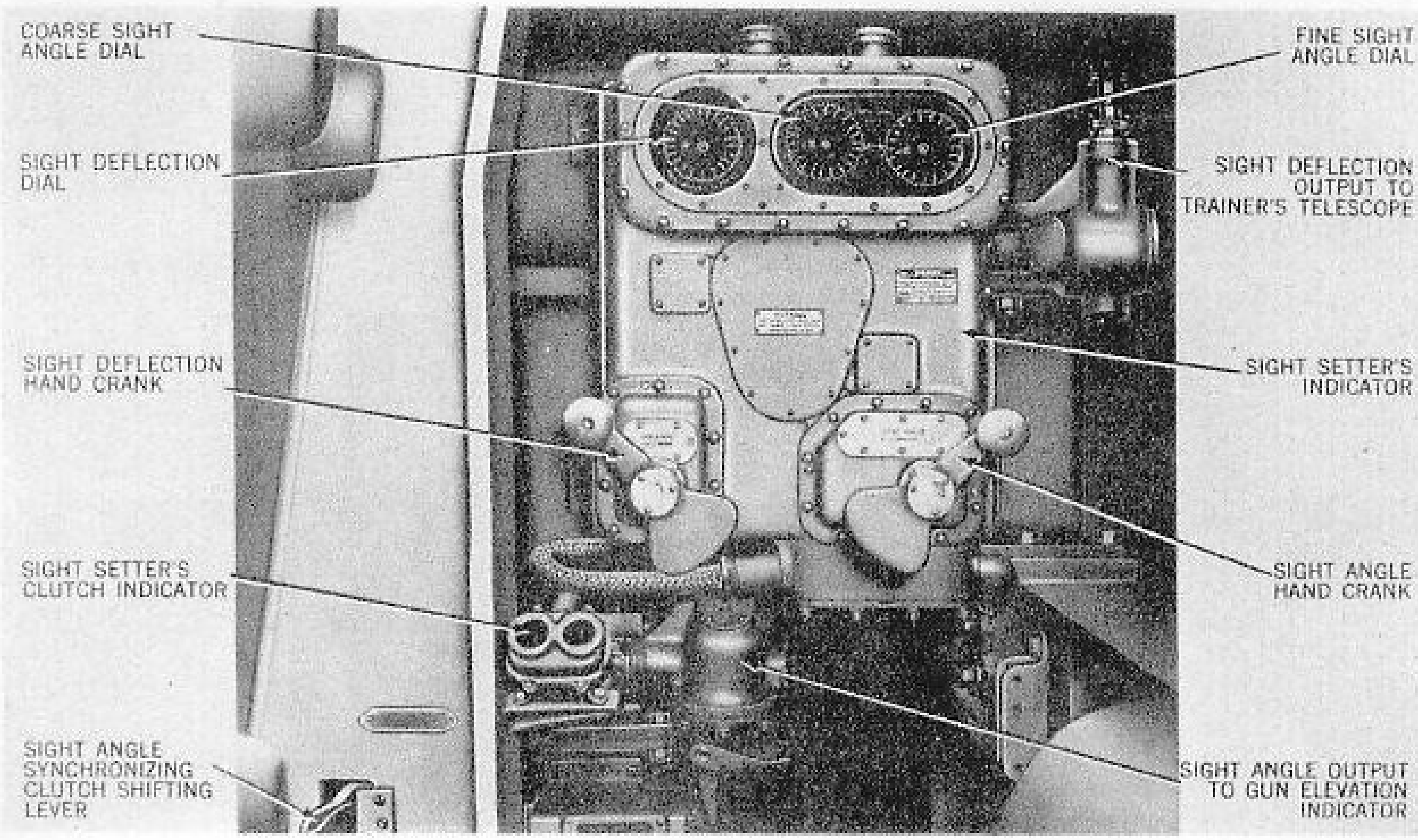


Figure 2-9. Sight Setter's Station, General Arrangement

The duties of the two ring operators are identical and include casting loose and securing the ring centering pins, and assisting the hoist operators and shellmen when directed to do so by the petty officer in charge.

The ring operator controls starting or stopping of the ring power drive. He controls speed and direction of ring rotation by the degree and direction of hand movement. When a ring station is reached (at the end of a rotation cycle) the projectile ring stops automatically with three projectiles in positions adjacent to each hoist loading aperture. Because he cannot observe parbuckling operations at all hoists, the ring operator must observe a three-dial indicator which, when illuminated, notifies him that the ring may be rotated in its next cycle.

Equipment used. The projectile ring operator uses: the control handlever; power drive start-stop pushbuttons; a three-dial indicator, circuit RP.

Shellmen (each level)

Duties. There are nine shellmen on each projectile flat and all are under direct supervision of the petty officer in charge. The duties and stations of shellmen are not rigidly defined; however they are usually divided into four teams comprising three two-man teams (next to each projectile hoist), and a three-man team in the forward part of the projectile flat. Each man in a team should be able to perform the duties of another team member.

The two-man teams at the projectile hoists act as hoist loaders and take projectiles from the rotating inner ring. The three-man team in the forward part of the projectile flat replenishes the projectile supply on the inner ring from the fixed stowage area. One man in each team acts as a parbuckler while the other team members unlock projectile lashing chains, apply the snubbing rope around the projectile to be moved (below its rotating band), and steady the projectile as it slides across the projectile flat floor plates.

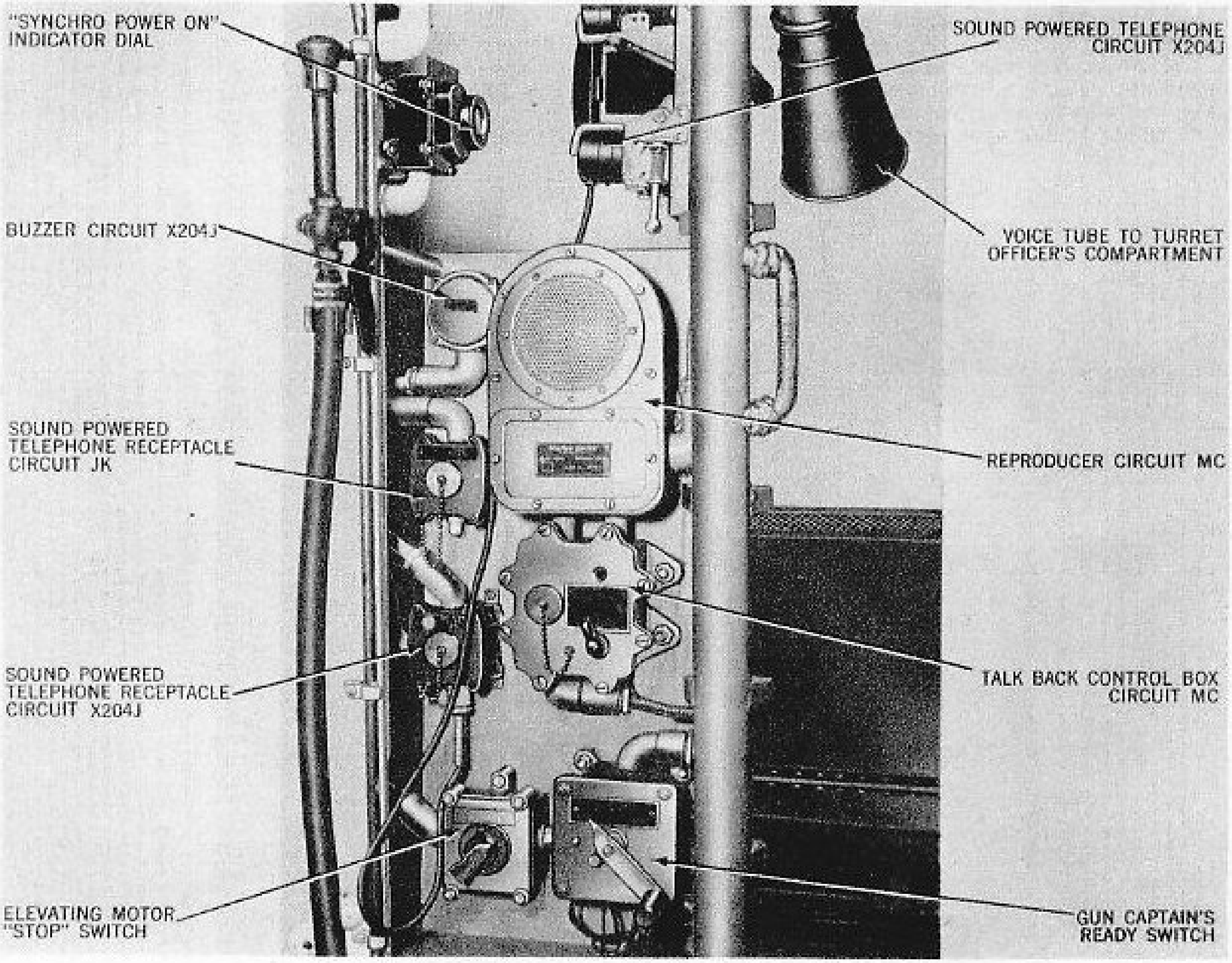


Figure 2-10. Gun Captain's Station, General Arrangement

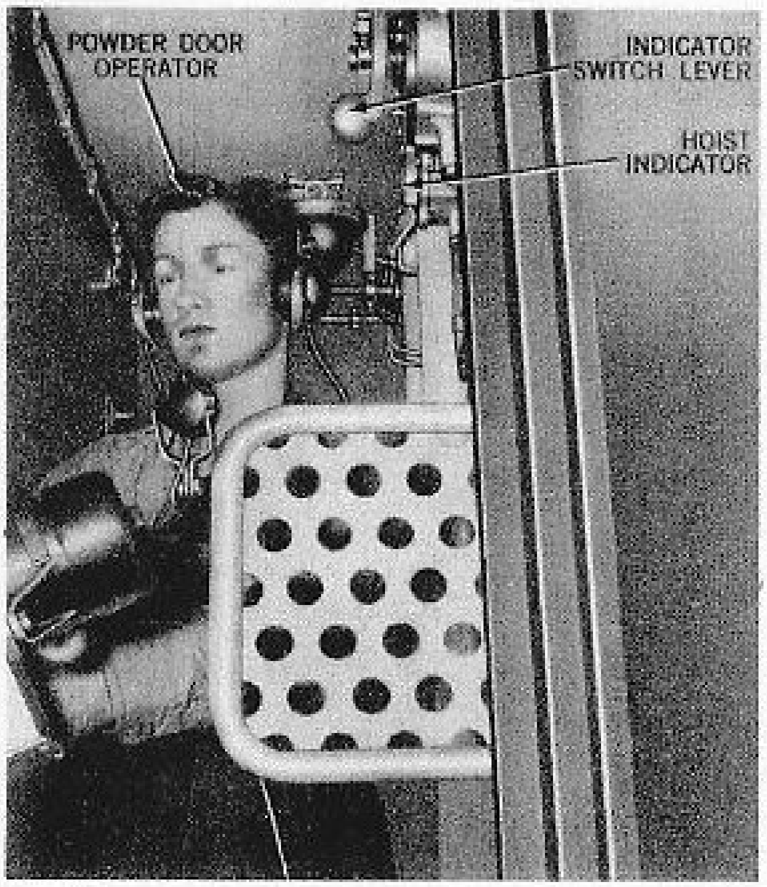


Figure 2-11. Powder Hoist Lower Door Operator's Station, Manned

The shellman of a team employed as a parbuckler (fig. 2-36) is responsible for smoothly moving the projectiles onto the rotating ring or into the hoist. His parbuckling work consists of taking one or two turns of his snubbing rope around a gypsy head and applying hand pull to the rope to move a projectile.

The shellmen (or projectile hoist operators) close contact makers at each projectile hoist operator's station to illuminate dial indicators at the ring operator's station. This notifies the ring operator that he may rotate the ring.

Equipment used. The shellmen use: the snubbing ropes and gypsy heads in the projectile handling space of each flat; and the contact makers for the projectile ring ready lights, circuit RP.

Electrician (each level)

Duties. The electrician in the machinery space of each projectile flat performs a number of miscellaneous duties. He is primarily concerned with the turret power drive electric controllers, supply panels, and other electrical equipment in the machinery space. During operation, he acts as a roving trouble-shooter. He makes circuit continuity checks, replaces fuses and indicator lamps, and repairs and replaces electrical elements in instances of malfunction or failure. His roving battle station includes servicing of all turret electircal installations.

Equipment used. The electrician uses tools and accessories of his electrical test and service maintenance outfits.

Petty officer in charge (projectile handling deck, each level)

Duties. The petty officer in charge of each projectile flat performs a number of duties, the most important of which is supervision of safe projectile transfer. Under the turret officer, he organizes his crew of shellmen, hoist operators, and ring operator and trains the men to be skillful in operating their equipment when serving the projectile hoists. If service to a hoist lags he assists that team or directs a member of another team (replenishing team) to assist.

The petty officer in charge has telephone communication with the turret officer (through his talker) and reports to him any equipment malfunction or casualty resulting in ammunition service lag.

If any fire hazard is indicated or occurs, he operates sprinkling controls.

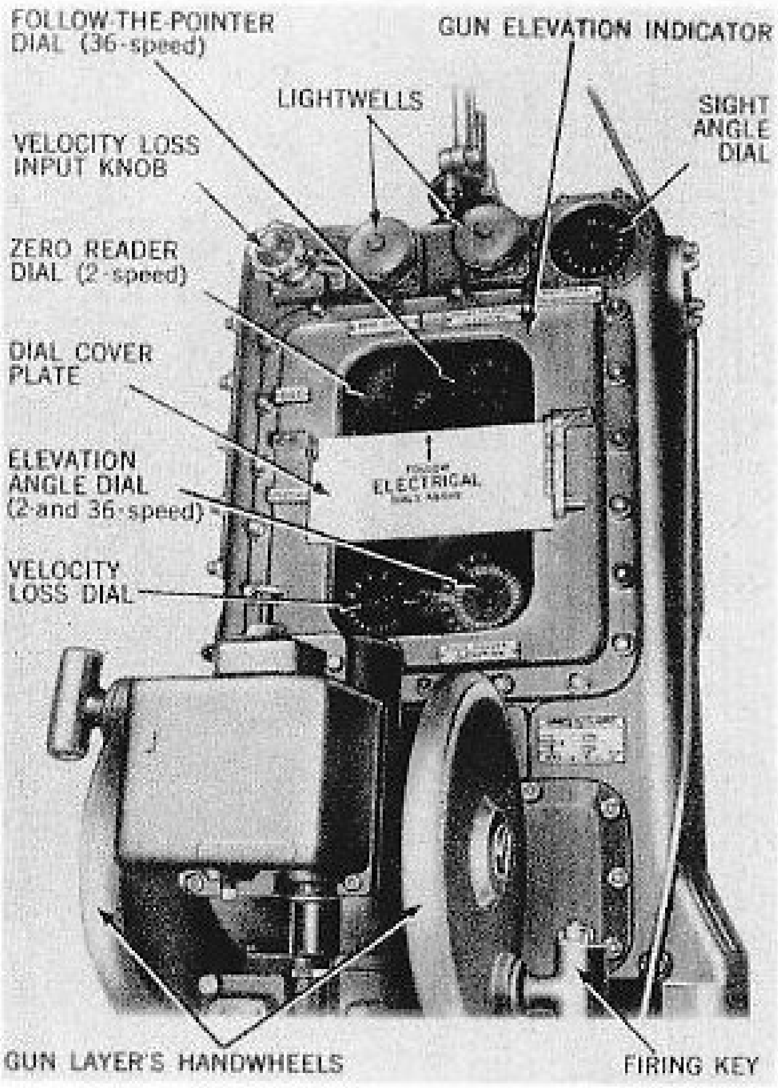


Figure 2-12. Gun Layer's Station, General Arrangement

Equipment used. The petty officer in charge (projectile handling deck) uses: communications units located in the projectile flat; the controls of sprinkling station H; and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

Lower powder door operators

Duties. A member of the powder handling room crew, each of the three lower powder door operators (fig. 2-11) has identical duties. Primarily these are to open and close the loading doors at the lower end of the powder hoist trunk. He has emergency stop control of the hoist power drive and telephone and visual communications with the hoist operator.

When the powder hoist is operated to serve powder to the gun, the powder door operator manually opens the lower doors after operating his foot pedal to unlatch them (when the car is at the loading station). He closes the doors when ordered to do so by the powder passers. He manually positions his indicator switch lever vertically when the car is loaded and the doors are closed.

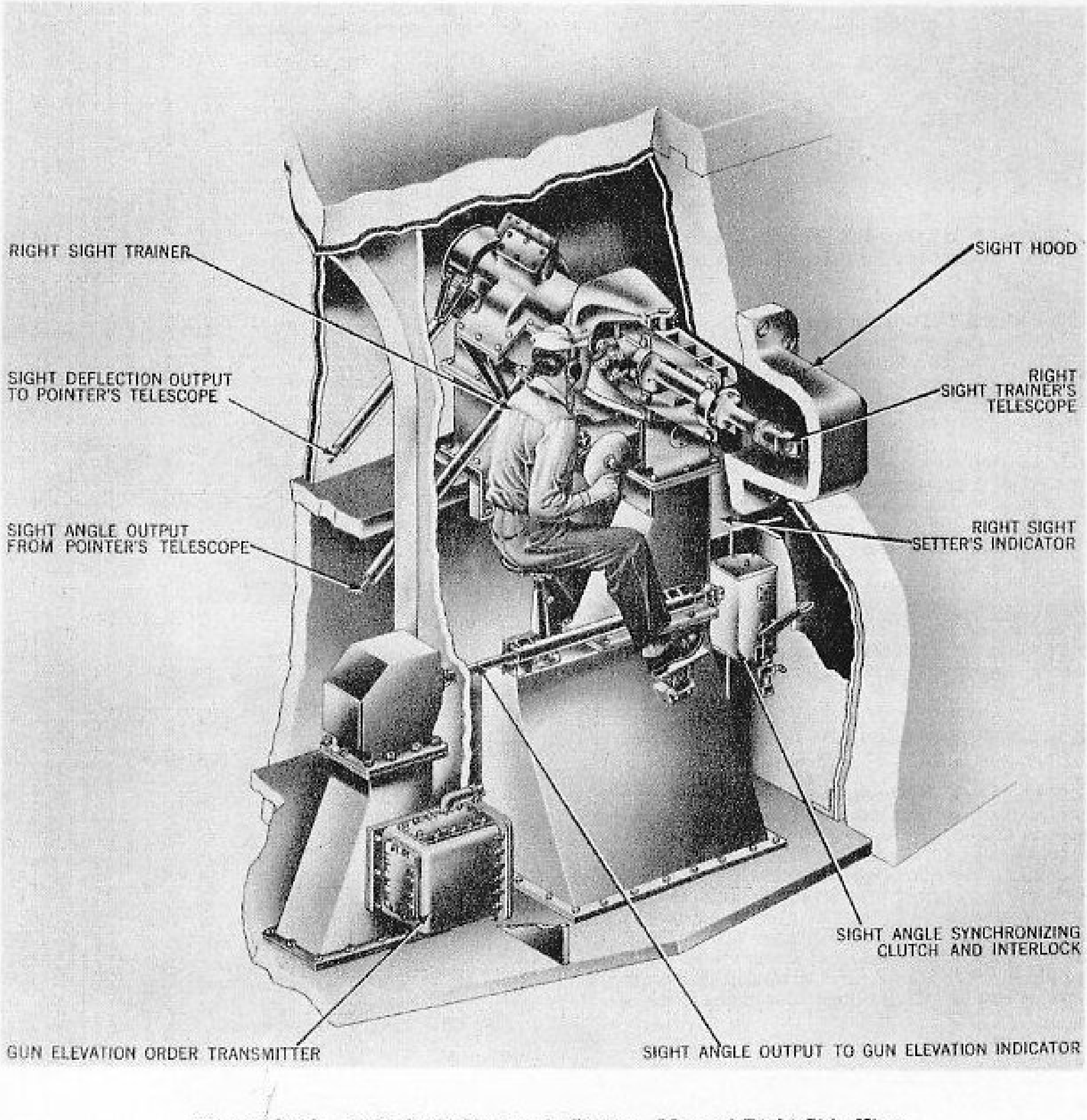


Figure 2-13. Right Sight Trainer's Station, Manned Right Side View

This causes the HOIST light to be illuminated at the hoist operator's station.

Equipment used. The powder door operator uses: the door operating and control devices, and indicator controls at his station; and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

Powdermen (powder passers)

Duties. The nine powdermen in the powder handling room crew are divided into three three-man teams, each team comprising first, second, and third powdermen. The teams have identical duties; however the duties of individual team members differ.

All powdermen perform their various duties under supervision of the petty officer in charge of the powder handling room. Team members designated first and second powderman are responsible for removing powder bags from the handling room scuttles, placing the bags (with the red colored ignition ends toward the rear) in the powder hoist trunk loading trays, and loading the powder car. The team member designated third powderman is stationed in the annular powder handling space and is responsible for passing the powder bags from the magazine scuttle to the handling room scuttle.

During powder service operations the first powderman of a team rotates the handling room scuttle (fig. 2-39) and removes the powder bag. He carries the bag to the loading tray of the powder hoist he is assigned to. In this time interval the second powderman rotates the same scuttle, removes the bag, and places it in the same loading tray. Each powderman repeats this procedure three times to place a total of six bags in the two levels of the loading tray. When the powder car is lowered and the lower doors are opened, the first and second powdermen roll the six bags into the car (fig. 2-35) and notify the door operator to close the doors.

Each time that the powder handling room scuttle is emptied, the third powderman of a team rotates the magazine scuttle (fig. 2-38) and passes a powder bag into the handling room scuttle. He then turns a mechanical indicator device to notify the magazine crew to fill the magazine scuttle. He repeatedly rotates and empties the magazine scuttle and passes powder bags to the handling room scuttle while there is a demand for powder.

Equipment used. The powdermen use: first and second powdermen use the handling room scuttle and hoist loading tray; the third powderman uses the magazine scuttle and mechanical indicator. Water filled tanks for powder submergence are adjacent to all personnel in the event that a powder bag breaks in transit.

Petty officer in charge (powder handling room)

Duties. The petty officer in charge of the powder handling room has a number of duties, the most important of which is supervision of safe powder transfer to the powder cars. Under the turret officer, he organizes the powder room crew, and trains the men to be alert, careful, and skillful in their various duties. He directs their movements to prevent traffic confusion, orienting the three hoist crews so that they move between the scuttles and loading trays without interference. If the service to a hoist lags, he assists that crew.

The importance of his duty as traffic director and coordinator is best appreciated by referring to figure 2-1 and noting the comparatively short interval in which the powder trays must be loaded.

He and his crew must be alert to prevent transfer of loose powder or a torn powder bag. This would result in powder being spilled during hoisting or gun loading operations and subsequent delay in the firing cycle. If powder spills during the handling room transfer operation, he directs the crew in the handling of the spilled powder so that hoist service can be safely resumed.

If any fire hazard is indicated or occurs, he must operate one or both of his sprinkling controls.

The petty officer in charge has telephone communication with the turret officer (through his talker).

Equipment used. The petty officer in charge (powder handling room) uses: communications units located in the projectile flat; the controls of sprinkling stations D and E; and a telephone headset with breastplate-supported and pushbutton-controlled transmitter.

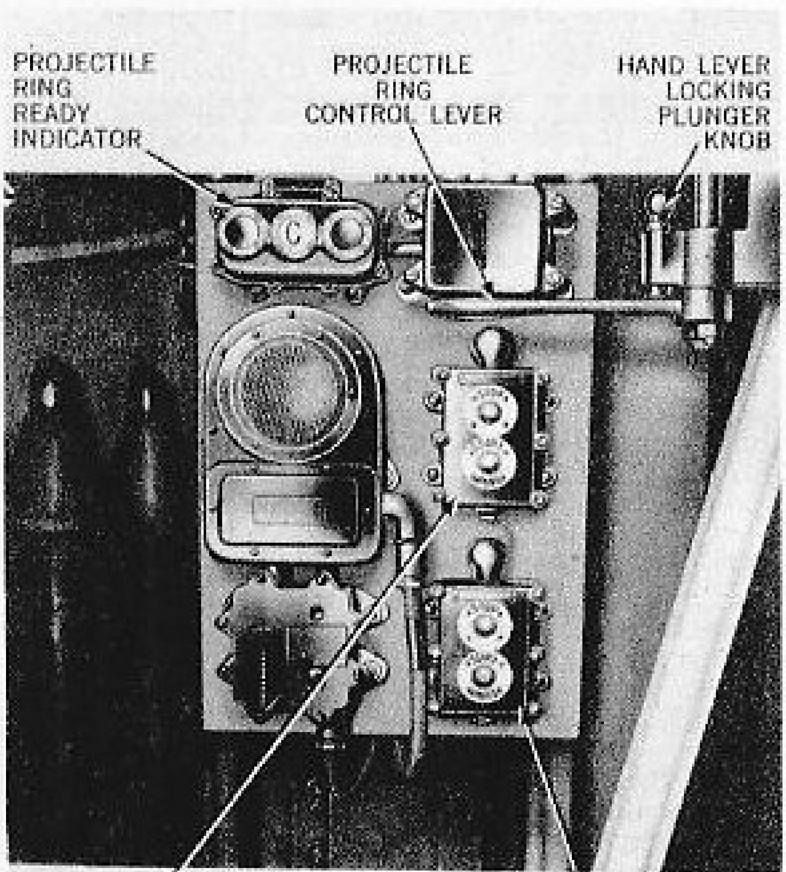


Figure 2-14. Projectile Ring and Parbuckling Gear Control Station

PREPARATION FOR OPERATION

After stations are manned, a considerable number of manually performed operations are required to cast loose, start the power drives, and fill the ammunition hoists of a secured turret. These activities not only require time, but many of them depend on other time-consuming features of the equipment that delay firing until system temperatures and pressures can build up. It is important that necessary preparations be coordinated by dividing duties among the crew and establishing a duty-sequence for each man. Design arrangements for access, turret exterior operations, work priority, and locations of controls must be considered by the turret officer.

Manning stations

Personnel access to the turret is through three doors: the center door in the bottom of the gun house overhang and the two doors in the turret foundation at the powder handling room level. The right door in the bottom of the gun house overhang is used as an emergency escape hatch and should be closed and secured at all other times.

The turret crew may be routed through the three doors by any of several alternatives, but the recommended routes are based on secured left and right gun-pit hatches. This requires all stations below the electric deck to be manned through the turret foundation doors, while the gun house and electric deck personnel use the door in the bottom of the gun house overhang.

Starting operations

Three classes of manually performed operations are involved in starting turret operations. These are:

Auxiliary service operations
Casting loose
Establishing communications

Auxiliary service operations. All auxiliary service operations are starting activities within the turret and are "first" duties for the crew. Location arrangements and crew assignments for accomplishing them as follows:

LIGHTING. Mounted on the gun house transverse bulkhead, two adjacent to each the right and left hand sides (fig. 2-7), are four 12-circuit distribution boxes. Switches on the boxes (normally operated by the turret officer and turret captain) provide selective control for closing all lighting and portable electrical equipment circuits within the gun house compartments, the gun pockets, and the pan floor spaces.

Two 12 circuit and two 6-circuit distribution boxes are mounted in the left box girder above the pan floor between the left and center gun pockets. Switches on the boxes (operated by designated electric deck personnel) provide selective control of lighting and receptacle circuits in the powder handling room.

Two 12-circuit distribution boxes are mounted in the left box girder above the electric deck between the left and center gun pockets. Switches on the boxes (operated by designated electric deck personnel) provide selective control of lighting and receptacle circuits in the electric deck spaces.

Two 12-circuit distribution boxes are mounted on the circular bulkhead in the machinery space of each projectile flat. Switches on the boxes (operated by the electrician stationed in that space) provide selective control of lighting and receptacle circuits in the respective projectile flat.

INSTRUMENT ILLUMINATION. A snap switch mounted in the center of the gun house rear plate (in the turret officer's compartment) provides control of illumination of instrument dials and sight crosslines for certain equipment in the gun house and electric deck spaces. It has four positions labeled: OFF (2 positions), BATTERY, and ILLUM. TRANS. The switch is usually positioned at ILLUM. TRANS. which steps-down the 110-volt, 60-cycle, ship's service supply to the 6-volt current required for instrument illumination. When the switch is positioned at BATTERY the 6-volt current for instrument illumination is supplied by storage batteries. Rheostats in the circuit at the various equipment provide dimming control for each circuit.

VENTILATION. Mounted on the gun house transverse bulkhead, two adjacent to the right and three adjacent to the left-hand side (fig. 2-7), are five ventilation pushbutton controls. There is an additional pushbutton control in each gun room. Each pushbutton is plainly marked with the designation of the fan set it controls. The pushbuttons (operated by the turret officer, turret captain, and gun captains) provide high and low speed, and stop control. Air exhaust is automatically regulated to maintain the desired pressure within the turret.

AIR SUPPLY, GAS EJECTOR SYSTEM. Ordinarily, the gas ejector air supply will always be open and under pressure. Either the turret officer or the turret captain may observe the pressure gage at their station to check system pressure. Additional gas ejector system gages are located in the gun rooms and are checked by the gun captains. Should system pressure not be indicated at the gages, it is necessary to check and open the valves of the six gas ejector storage tanks located on both projectile flats, and to check the system piping. This is done by designated men on the respective levels, as directed by the turret officer or turret captain.

AIR TO SPRINKLING TANKS. In ordinary turret drill operations, sprinkling tanks are filled with water at all times, but are not under air pressure. In preparing for battle conditions or target practice, air pressure is placed on the water in the tanks as follows. The turret officer opens a valve in the air supply line to the sprinkling tanks and then sets the air control cock to vent. After water appears at the overflow, the cock is kept at vent until both tanks are free of air. The air control cock is then set to supply air to the tanks.

HEATING. A total of 15 heaters, located in the turret officer's compartment, the two sight control stations, and the electric deck control stations, provide heat for turret personnel.

Four distribution boxes, each equipped with an ON-OFF snap switch, control the power supply of all heaters. Each heater is provided with an adjacently mounted ON-OFF snap switch.

Casting loose. Casting loose operations consist of opening covers, such as the sight hood shutters, periscope hood covers, rangefinder optic shutters, and muzzle covers; and of releasing the various securing devices on the gun, slide, turret, and projectile rings.

Opening sight hood shutters. The right and left sight pointers and sight trainers are each provided with a telescope within a sight port and enclosed by a sight hood assembly. Mounted on the gun house side armor plate, all sight hoods are similarly arranged with a bullet-proof steel door. This door slides horizontally to open or close and is operated by a double screw and link operating mechanism which secures it in either position. The mechanism has an operating handwheel within the side armor at the sight port.

Personnel designated by the turret officer open the periscope hood covers which are reached from the exterior top of the gun house. The covers are secured closed by a wing nut, and after being swung open are secured open by another wing nut.

The rangefinder pointer and trainer are each provided with an optic within a sight port and enclosed by a sight hood assembly. Mounted on the gun house side armor plate, both sight hoods are similarly arranged with a door similar to that of the sight hood assemblies. This door slides horizontally to open or close and is operated by a shaft and screw mechanism which secures it in either position. The mechanism has an operating handcrank within the side armor at the sight port.

Tompions, muzzle covers. Personnel designated by the turret officer remove the tompions or muzzle covers. Removing a tompion requires that the tompion clamping bolt be loosened with a proper wrench and the tompion then lifted out.

Releasing turret centering pins. Two turret centering pins are provided, one in each wing gun room in the rear outboard corner. An operating wrench for each pin is mounted on the transverse bulkhead adjacent to the pin which is usually released by the gun captain or one of his crew (fig. 2-15). The wrench is used to turn the screw bolt of the centering pin, a clockwise motion screwing the bolt into and raising the centering pin from the tapered centering hole in the upper barbette. The turning motion is indicated on a nameplate secured to the top of the deck plate mounted in the gun room floor plate. Travel distance of the pin is 4.25 inches.

Releasing slide securing pins. When directed by the turret officer, the gun captains or their crew release the slide securing pins (fig. 2-16).

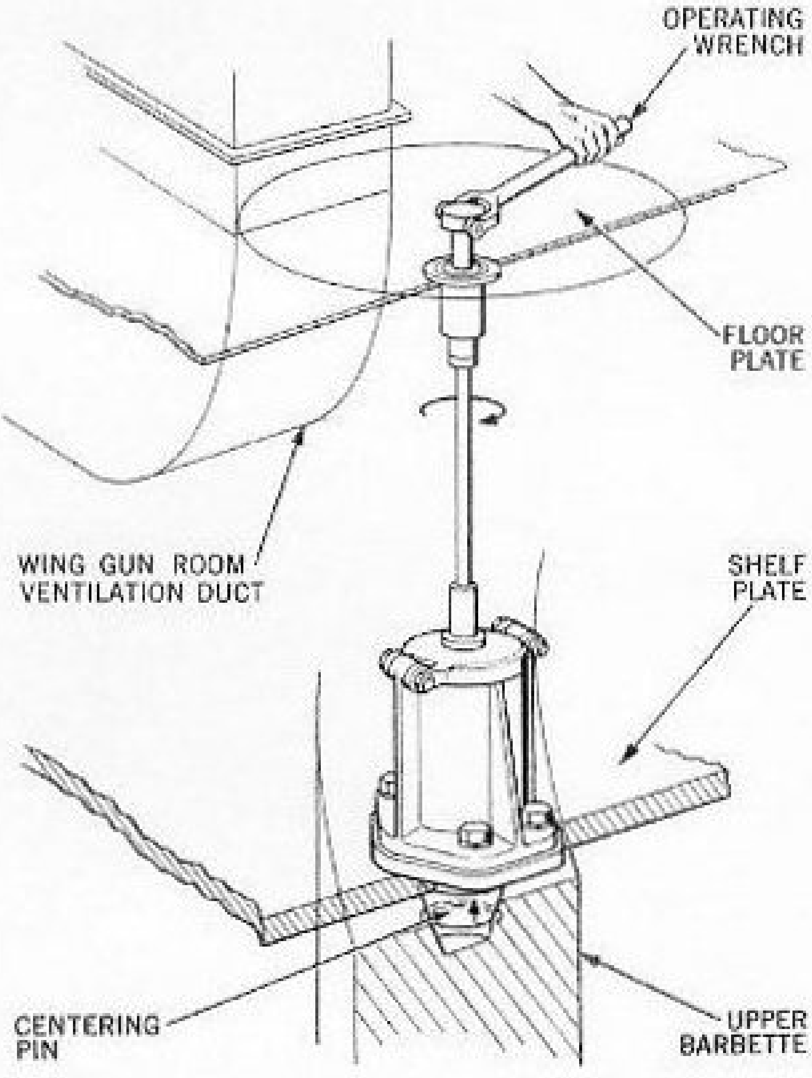


Figure 2-15. Releasing Turret-Centering Pin

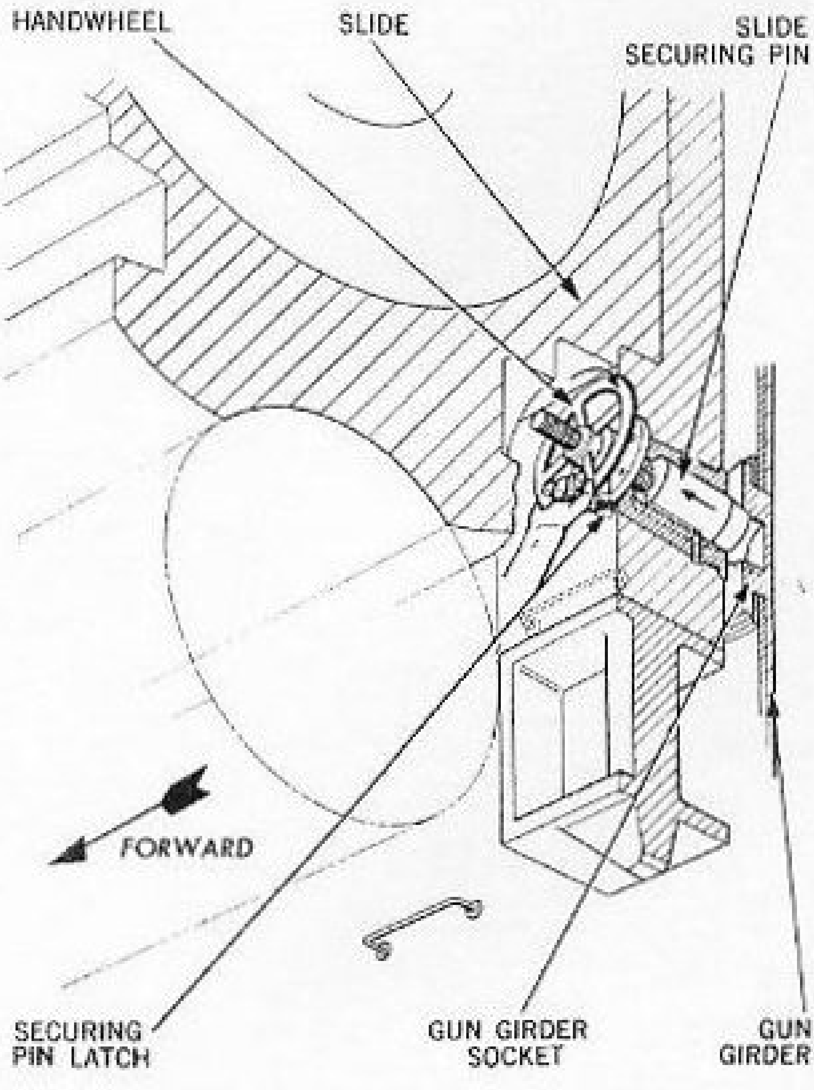


Figure 2-16. Releasing Slide-Securing Device

These are similar hand-operated screw-type mechanisms mounted on the opposite side of each slide to the loader's platform bracket. By turning the respective handwheel clockwise and holding the securing pin latch down, the pin is withdrawn from its socket in the gun girder.

Releasing gun locking device. Each gun is provided with a gun locking device which secures the gun and yoke assembly to the slide assembly. When directed by the turret officer, the gun captains or their crew release the device by loosening the knurled locknut and pivoting the threaded safety link and nut up to the stowed position (fig. 2-17). The nut is then turned clockwise and tightened until the device is secured in the stowed position.

Releasing projectile ring pins. Each projectile ring is provided with two retractable screw-type centering pins, which fit into sockets in the projectile flat recess. A special socket wrench is stowed in a clip at each pin station. A member of the projectile flat crew, designated by the petty officer in charge, retracts the ring pins using the special wrench (fig. 2-18) and turning in a clockwise direction.

Establishing communications. Simultaneously with the preceding starting activities and during performance of certain of the ordnance equipment control setting operations described below, it is imperative that communications be established throughout the turret. None of the mechanisms should be operated until control members of the crew have received reports that the casting-loose operations and inspections have been completed and that the gun pits, slides, projectile rings, and other hazardous areas are clear of personnel, tools, accessories, and supplies. "Ready" reports should be coordinated by clearing them through the turret captain.

Communications employed in this phase of the starting operations (and subsequently) are the public address and telephone systems. A minimum of 27 crew members must be equipped with telephone

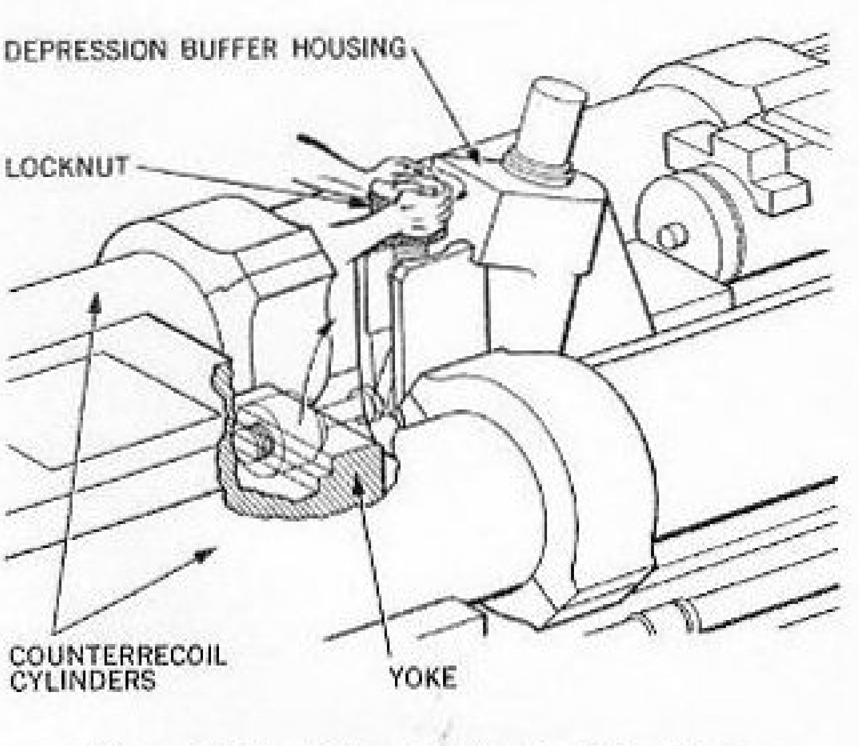


Figure 2-17. Releasing Gun Locking Device

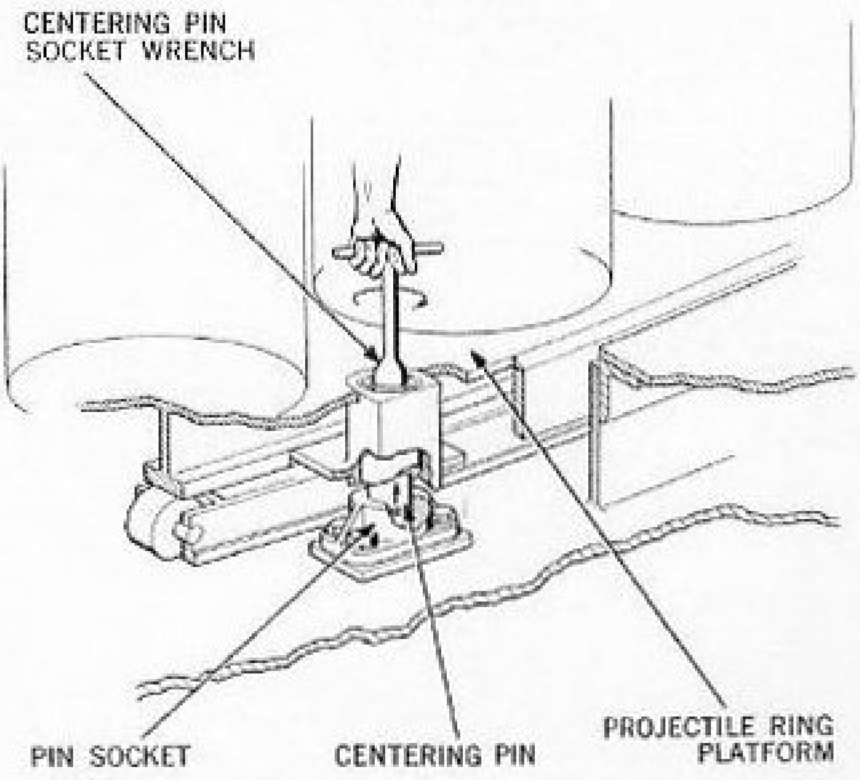


Figure 2-18. Releasing Projectile Ring Centering Pin

headset receivers and talk-back microphones. These 27 crew members are: the turret officer, turret captain, rangefinder operator, computer operator, talker, sight station personnel (6), gun layers and train operator (4), gun captains (3), powder hoist operators and door operators (6), and the petty officers in charge on the projectile decks and powder handling room (3).

Ordnance equipment preparations and starting operations.

Starting operations, described in the following paragraphs, include safety checks, operating precautions, and operating tests as well as the turning on of turret primary power, starting drives, and setting controls.

Safety checks, operating precautions, and tests. Personnel must be fully cognizant of the necessary operating precautions and safety checks. All ordnance assemblies require periodic maintenance and inspection. When preparing for operation and before starting any of the electric motors, it is necessary to verify that: proper lubrication has been performed; hydraulic fluid and oil levels, and high and low air pressures, are adequate and available; the equipment has been cast loose; and all personnel are clear. These and many other detailed precautions, tests, and checks are noted in other chapters and should be performed by the personnel directly controlling the various assemblies or by personnel designated by the turret officer.

Energizing main power circuit. A manual bus transfer panel, in the machinery space of the upper projectile flat, provides two external switches for controlling normal and alternate power for major electrical installations in the turret. Power from the bus transfer panel is transferred to five circuit breaker power panels in compartment and electric deck ventilating systems; and the turret heating system. Each panel cut-off switch is normally turned to the ON position. A mechanical indicator plate above the operating handle in a small circular window indicates when power is on or off.

Located in the projectile flat machinery spaces are 17 motor controllers which control starting and stopping of power drive motors. On the upper projectile flat are three elevating gear motor controllers, three powder hoist motor controllers, one projectile ring motor controller, and one parbuckling gear motor controller. On the lower projectile flat are the training gear motor controller, three rammer motor controllers, three projectile hoist motor controllers, one projectile ring motor controller and one parbuckling gear motor controller. Each controller is equipped with a main line disconnect circuit breaker or switch, interconnected with the door so that the door can be opened only after the handle has been positioned at OFF. The ON or OFF position of the handle is indicated by a name plate on the controller cabinet. Ordinarily the handle is left in the ON position.

Starting drives. The following paragraphs contain the necessary instructions for starting the drive units for all power-driven ordnance assemblies within the turret.

Starting elevating gears. The master pushbutton switch for each elevating gear motor controller is located adjacent to the respective gun layer's station. It is a watertight unit with two pushbuttons, one labeled START-EMERG and the other STOP. The starting circuit contains two series connected neutral start interlock switches which prevent starting the elevating gear motor unless the A-end tilting box and the servo control valve are at neutral. In addition the control selector lever must be placed in the HAND position before the elevating motor is started.

If the elevating motor does not start when the START-EMERG button is pressed, either the handwheels or the tilting box are not in their neutral positions. Rotate the handwheels in both directions, counting the turns between limits, and position the handwheels at neutral midway between these limits. To position the tilting box at neutral operate the neutral return device hand-lever on top of the A-end control case. Tilting box neutral position is mechanically indicated by a pointer.

After the elevating gear motor is started, allow it to run until the hydraulic fluid is at normal operating temperature. Verify that the power-off control valve is energized and that the lubricating system is pumping oil. Operate the elevating gear in HAND to both limits of gun movement.

To switch control from HAND to AUTO verify: that the synchro power indicating light in the control selector is lighted and that the gun captain's switch is positioned at READY. Rotate the handwheels until gun elevation matches gun elevation order, as shown on the gun elevation indicator. When these match, place the control selector lever in the AUTO position.

Starting training gear. The master pushbutton switch for the training gear motor controller is located adjacent to the train operator's station. It is a watertight unit with two pushbuttons, one labelled START-EMERG and the other STOP. There is a neutral start indicator light assembly connected to the adjacent master switch. The starting circuit contains two series connected neutral start interlock switches which prevent starting the training gear motor unless the A-end tilting box and the servo pilot valve are at neutral. This condition is indicated by illumination of the neutral start indicator light. The control selector lever must be placed in the HAND position before the training gear motor is started.

If there is no illumination in the neutral start indicator, either the handwheels or the tilting box are not in their neutral positions. Rotate the handwheels in both directions, counting the turns between limits, and position the handwheels at neutral midway between these limits. The tilting box neutral position is mechanically indicated by a pointer on top of the A-end case. To position the tilting box at neutral operate the neutral return hand pump located near the train operator's station.

After the training gear motor is started, by pressing the START-EMERG button, allow it to run until the hydraulic fluid is at normal operating temperature. Verify that the power-off solenoid is energized and that the brakes are released. Operate the training gear in HAND to both train limit stops.

To switch control from HAND to AUTO, verify that the synchro power indicating light in the control selector is lighted. Operate the handwheels until the turret position matches gun train order, as shown on the train indicator. When these match, place the control selector lever in the AUTO position.

To switch to local control (in HAND) by either the left or right sight trainer, the train operator: disengages his handwheels by positioning the clutch lever on the left side of his handwheel pedestal at neutral; engages the handwheels of the selected sight trainer by positioning the clutch lever (located on the overhead at his station) at LEFT or RIGHT.

Starting rammers. The master pushbutton switch for each rammer motor controller is located at the rear of each gun room at the respective rammer operator's station. It is a watertight unit with two pushbuttons, one labeled START-EMERG and the other STOP. The starting circuit contains a neutral start interlock switch which prevents starting the rammer motor unless the A-end tilting box is at neutral. To start the motor, the rammer operator presses the START-EMERG pushbutton.

Starting projectile hoists. The master pushbutton switch for each projectile hoist motor controller is located at the rear of each gun room adjacent to the respective cradle operator's station. It is a watertight unit with two pushbuttons, one labeled START-EMERG and the other STOP. The starting circuit contains a neutral start interlock switch which prevents starting the projectile hoist motor unless the hoist control handle is placed at neutral. To start the motor, the projectile hoist operator presses the START-EMERG pushbutton.

Starting powder hoists. The master pushbutton switch for each powder hoist motor controller is located at the hoist operator's station.

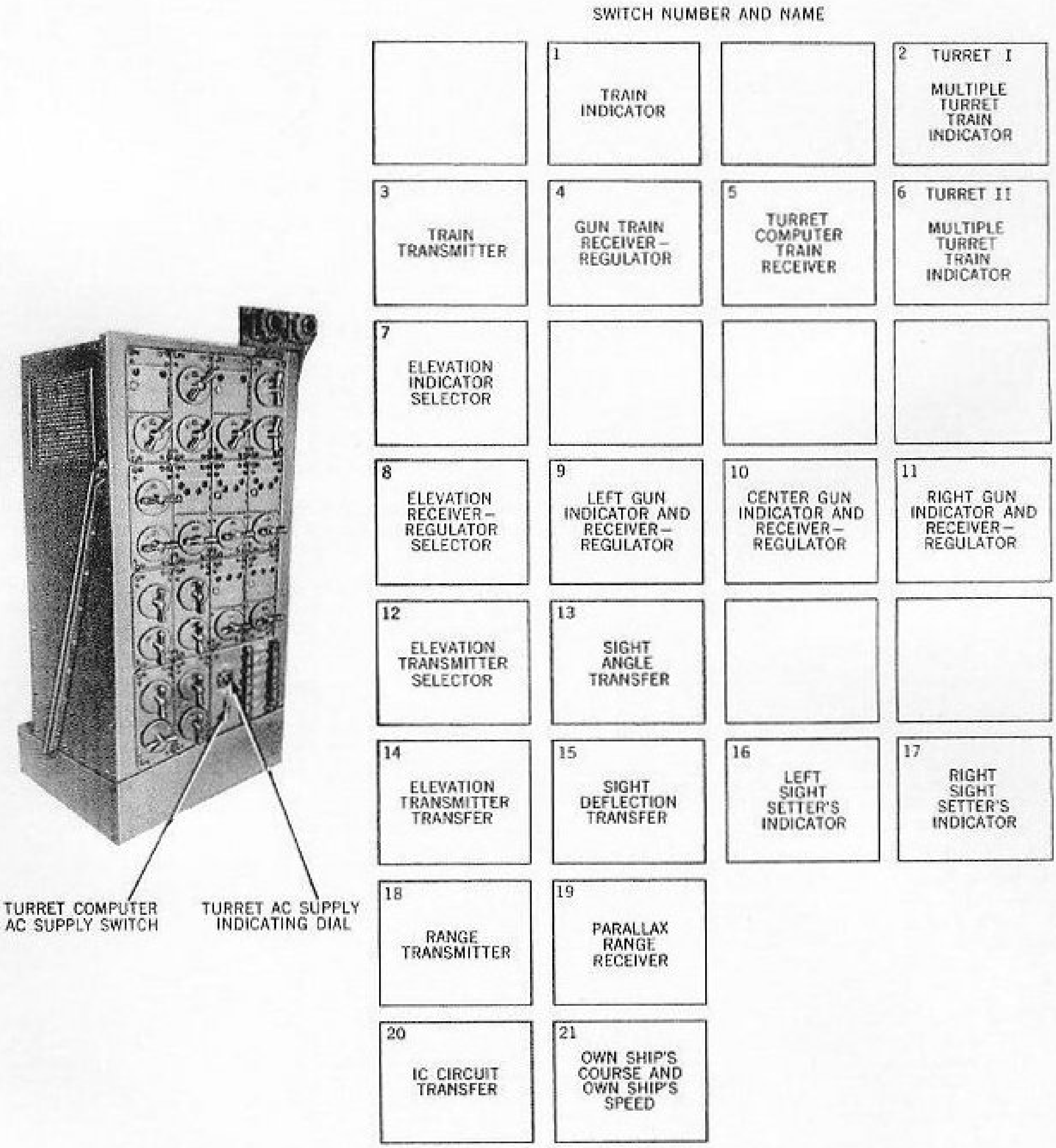


Figure 2-19. Turret Officer's Transfer Switchboard, Turret II. General Arrangement

It is a watertight unit with two pushbuttons, one labeled START-EMERG and the other STOP. The starting circuit contains a neutral start interlock switch which prevents starting when the pump yoke is offset from the neutral position. To start the motor the hoist operator places the hoist control lever at neutral and presses the START-EMERG button.

Starting projectile rings. The master pushbutton switch for each projectile ring motor is located at the center projectile hoist at respective upper and lower projectile flats. It is a watertight unit with two pushbuttons, one labeled START-EMERG and the other STOP. The starting circuit contains a neutral start interlock switch which prevents starting when the pump yoke is offset from neutral position. To start the motor, the ring operator places the hand control lever at neutral and presses the START-EMERG button.

Starting parbuckling gears. The master pushbutton switch for each parbuckling gear motor is located at the center projectile hoist at respective upper and lower projectile flats. It is a watertight unit with two pushbuttons, one labeled START-EMERG and the other STOP. To start the motor, the parbuckler presses the START-EMERG pushbutton.

Setting controls; energizing the control circuit. Two classes or groups of controls must be closed when starting turret operations. These are the ordnance equipment controls and the turret officer's controls described below.

Ordnance equipment control setting. The automatic elevating and training gear receiver-regulator (AUTO) control devices are not placed in operation by the power drive starting operations (page 2-17). These control devices are energized by setting certain turret officer controls.

Turret officer controls. All fire control signals and communications transmitted to the gun layers and train operator, the elevation and train receiver-regulators, the personnel of both sight stations, the computer, and personnel in the gun rooms (acting as fuze setters) are routed through controls set by the turret officer. They are electric switching controls compactly arranged in the turret officer's transfer switchboard (fig. 2-7). Switchboards for turrets I, II, and III are virtually identical. Panel details of the switchboard for turret II are shown in figure 2-19.

Primary control. The 21 transfer switches on the switchboard panel are set as follows for primary control.

Switch Number	Switch Position
1	PLOT FWD
2	FWD
3	PLOT FWD
4	PLOT FWD
5	TURRET 2
6	FWD
7	PLOT FWD
8	PLOT FWD
9	AUTO AND IND
10	AUTO AND IND
11	AUTO AND IND
12	OFF
13	FWD
14	OFF
15	FWD
16	SIGHT ANGLE AND DEF
17	SIGHT ANGLE AND DEF
18	FWD
19	FWD
20	PLOT FWD
21	FWD

All transfer switches that may be positioned at at either FWD (PLOT FWD) or AFT (PLOT AFT) must be positioned similarly (all at FWD or all at AFT). There is a two-dial indicator (dials marked F and A) which shows the selected FWD or AFT position for transfer switches through which control circuits are actuated from either plotting room.

In addition to the transfer switches, the turret officer also operates the turret officer's selective switch, mounted on the transverse bulkhead at his station. This switch assembly consists of a pair of rotary switches. Controlled by a pointer type knob, the upper switch has three positions, labeled DIRECTOR - OFF - LOCAL. The lower switch, controlled by a pointer-handle, also has three positions, labeled AC SUPPLY - OFF - BATTERY. By rotating these switches, the turret officer selects local or remote firing, and the source of power to energize the firing circuit. Battery power can be used only for local turret firing.

Secondary control. The transfer switches are set as follows for secondary control.

Switch Number	Switch Position
1	OFF
2	LOCAL
3	OWN TUR COMP
4	OFF
5	OFF
6	LOCAL
7	TURRET II
8	TURRET II
9	IND
10	IND
11	IND
12	TURRET II
13	
14	OFF
15	
16	OFF or SIGHT ANGLE AND DEF
17	OFF or SIGHT ANGLE AND DEF
18	
19	
20	OFF
21	

The switches are set as above for turret II when it acts as a director in secondary control, and the switches in turrets I and III are set as follows.

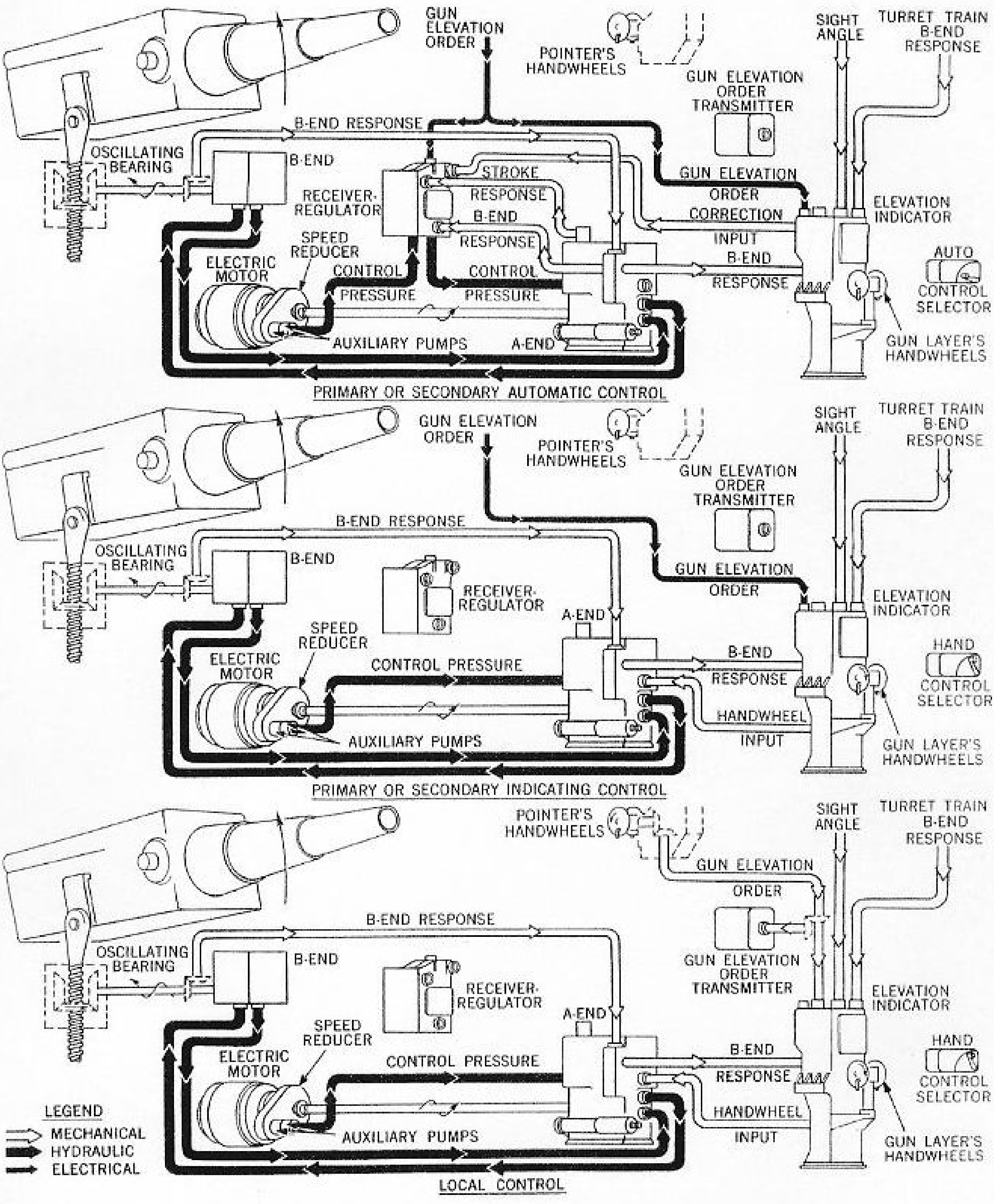


Figure 2-20. Elevating Gears and Controls. Functional Diagrams

Switch Number	Switch Position
1	TURRET II
2	LOCAL
3	TURRET II
4	TURRET II
5	TURRET II
6	LOCAL
7	TURRET II
8	TURRET II
9	AUTO or IND
10	AUTO or IND
11	AUTO or IND
12	TURRET II
13	
14	OFF
15	
16	SIGHT ANGLE AND DEF
17	SIGHT ANGLE AND DEF
18	
19	
20	OFF
21	

Local fire control. The transfer switches are set the same for local fire control as they are set when the turret acts as a director in secondary control.

FIRING OPERATIONS

First round

In preparing for the first round, the turret officer designates which projectile flat will serve the hoists and whether armor piercing or high capacity projectiles will be used. The hoist operators on the designated flat clutch engage their hoist control handles and the petty officer in charge, or a crew member, starts the parbuckling gear and projectile ring drive.

Serving hoists. When the preceding operations are completed, the shell men and parbucklers on the designated flat begin serving the projectile hoists. The powder handling room crew begin serving the powder hoists.

A shell man and parbuckler work as a team to parbuckle projectiles into the hoist aperture. The shell man puts the hook on the end of the parbuckler's snubbing rope into a convenient hole or eye on the projectile flat provided for the purpose. He steadies and guides the projectile as it moves. The parbuckler operates the snubbing rope, looping the free end of the rope twice around a gypsy head and pulling it tight enough to move the projectile into the hoist aperture. Spring-loaded shutters at the hoist aperture retain the projectile in the hoist after it is placed within it. The projectile ring operator operates his handlever every three rounds (each hoist) to position the projectile ring so that the shell men teams may reach the projectiles in rotating stowage.

Three powdermen work as a team to load each powder hoist. Two men operate the powder handling room scuttles, carry powder bags to the hoist loading trays, and load the powder cars. The third powderman of each team operates a magazine scuttle. The first and second powdermen must each make three trips to load six powder bags into the loading trays. When the trays are loaded they stand by, waiting for the door operator to open the hoist lower doors so that they can roll the bags into the powder car. After this is done the powdermen load the trays in preparation for the next round.

Filling hoists. After a projectile is parbuckled into the projectile hoist, the hoist control handle is positioned at HOIST (and held there until the TOP OF STROKE indicator is illuminated at the hoist operator's station) 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 hoist rack is then lowered 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.

After the powder bags have been rolled into the powder car and the hoist lower doors are closed, the control lever is positioned at HOIST and the powder car with six bags is hoisted to the upper unloading station.

Breech opening. The gun captain opens the breech, wipes the mushroom, and looks through the bore to make sure that there are no gases or burning remnants from the preceding round left in the gun or breech. He then announces "bore clear," depresses the bore clear switch momentarily, and trips the gas ejector valve. For the first load, the gun captain must manually disengage the salvo latch.

Priming. As soon as "bore clear" is announced, the primerman inserts a live primer into the firing lock.

Cradle opening. After a projectile has been lifted into (and latched in) the cradle and the bore clear switch has been depressed, the cradle operator depresses the foot pedal (unlatching the cradle) and positions the cradle control valve handle at LOWER CRADLE. The cradle then rotates to lower and to enter the spanning tray into the open gun breech. The cradle cannot be lowered until the bore clear switch has been depressed because of the cradle interlock portion of Ready Light Circuit 1R.

Projectile ramming. After the cradle assembly is spanned (containing a projectile), the rammer hand lever is moved toward RAM and the projectile is rammed into and seated in the gun. The hand lever is then moved toward WITHDRAW. The upper powder door is opened simultaneously with these ram and withdraw movements.

Powder transfer. After the rammer has been withdrawn, the powder car hoisted, and the hoist upper door opened, the hoist operator dumps the lower car tray. The upper powder door cannot be opened, because of the powder door interlock portion of Ready Light Circuit 1R, until the rammer has been withdrawn after projectile ramming. The three powder bags roll down the open door (which forms a shelf between the powder hoist trunk and the spanning tray) and are guided into the spanning tray by the gun captain and cradle operator. These men spread the bags (two forward and one aft) to make a space wide enough for the three bags still in the powder car. These remaining bags are then dumped by the hoist operator (who has lowered the powder car) and are guided into position in the spanning tray to be rammed into the gun's powder chamber.

Powder ramming. After all six powder bags have been transferred to the spanning tray, the rammer hand lever is moved toward RAM and the bags are rammed into the gun's powder chamber. The handlever is then moved toward WITHDRAW. The upper powder door is closed simultaneously with these ram and withdraw movements. As soon as the rammer is fully withdrawn and the upper powder door is closed, the cradle control valve handle is positioned at RAISE CRADLE. The cradle then raises and retracts from the gun. The gun captain then closes the breech and positions his ready switch at READY.

Firing. When the breech is closed and the gun captain's ready switch is positioned at READY, the firing circuit closed within the turret, and the turret officer's selective switch turned to DIRECTOR, the gun can be fired electrically by remote control. During recoil and counterrecoil, the salvo latch is tripped automatically and the breech can be opened. The preceding loading procedure is repeated for the second and subsequent rounds.

Gun laying, firing

Turret control methods of gun laying and firing include primary or secondary automatic control, primary or secondary indicating control, and local control. Each method is described in following paragraphs.

Automatic control. In primary or secondary automatic control, gun laying and firing are accomplished entirely by remote control. Electrical signals (gun orders) to lay the guns in elevation and train the turret are relayed from either of the plotting rooms (forward or aft), or from another turret (acting as a director) and pass through the turret officer's transfer switchboard to the elevation and train receiver-regulators. The transfer to automatic control is completed when each gun layer and the train operator positions the lever of his control selector at AUTO.

Inputs to the elevating gear and to the training gear in the various methods of control are shown in figures 2-20 and 2-21.

Sight deflection and sight angle orders are relayed through the turret officer's transfer switchboard to the sight setter's indicator. The sight setter matches the sight angle order by hand and transmits this order mechanically to the sights and the gun elevation indicators (as a factor in correcting for gun erosion). The sight setter also matches the sight deflection order by hand and transmits this order mechanically to the sights.

Parallax range orders are relayed through the turret officer's transfer switchboard to the turret train indicator and transmitter. The train operator matches the parallax range order by hand and transmits this order mechanically to the indicator and transmitter and to the train receiver-regulator.

Corrections for roller path inclination, velocity loss, and gun erosion are combined in a differential gearing in the elevation indicator. These corrections are mechanically transmitted through a shaft to each elevation receiver-regulator from the respective elevation indicator.

Train response is mechanically transmitted from the right B-end (training gear) to the turret train indicator and transmitter, and to all elevation indicators (to correct for roller path inclination). Train response is mechanically transmitted from the train indicator and transmitter to the train receiver-regulator.

Gun elevation (B-end) response is mechanically transmitted from the B-end (elevating gear) to the respective elevation indicator and receiver-regulator.

Stroke response (elevation and train) is mechanically transmitted from elevating and training gear A-end control boxes to the respective elevation and train receiver-regulators.

Indicating control (primary). In primary (indicating) control, gun laying is accomplished locally. Gun firing is accomplished either by remote control or from a designated local station. Electrical signals (gun orders) to lay the guns in elevation and train the turret are relayed from either the forward or aft plotting room and pass through the turret officer's transfer switchboard to the gun elevation indicator and turret train indicator and transmitter. The gun layers and train operator observe their indicator dials and manipulate their handwheels to follow-the-pointer and directly control gun elevation and turret train. Each gun layer and the train operator positions the lever of his control selector at HAND.

Sight deflection and sight angle orders are relayed through the turret officer's transfer switchboard to the sight setter's indicator, and from this instrument to the elevation indicator and sights as in automatic control.

Parallax range orders are relayed through the turret officer's transfer switchboard to the turret train indicator and transmitter. The train operator matches the parallax range order by hand and transmits this order mechanically to the indicator and transmitter.

Roller path inclination, velocity loss, and gun erosion corrections are combined in a differential gearing in the elevation indicator.

Train response is mechanically transmitted from the right B-end (training gear) to the turret train indicator and transmitter, and to all of the elevation indicators (to correct for roller path inclination).

Gun elevation (B-end) response is mechanically transmitted from the B-end (elevating gear) to the respective elevation indicator.

Indicating control (secondary). In secondary (indicating) control, gun laying is accomplished locally. Gun firing is accomplished either by remote control or from a designated local station. Electrical signals (gun orders) to lay the guns in elevation and train the turret are relayed from another turret (acting as a director) and pass through the turret officer's transfer switchboard to the gun elevation indicator and turret train indicator and transmitter.

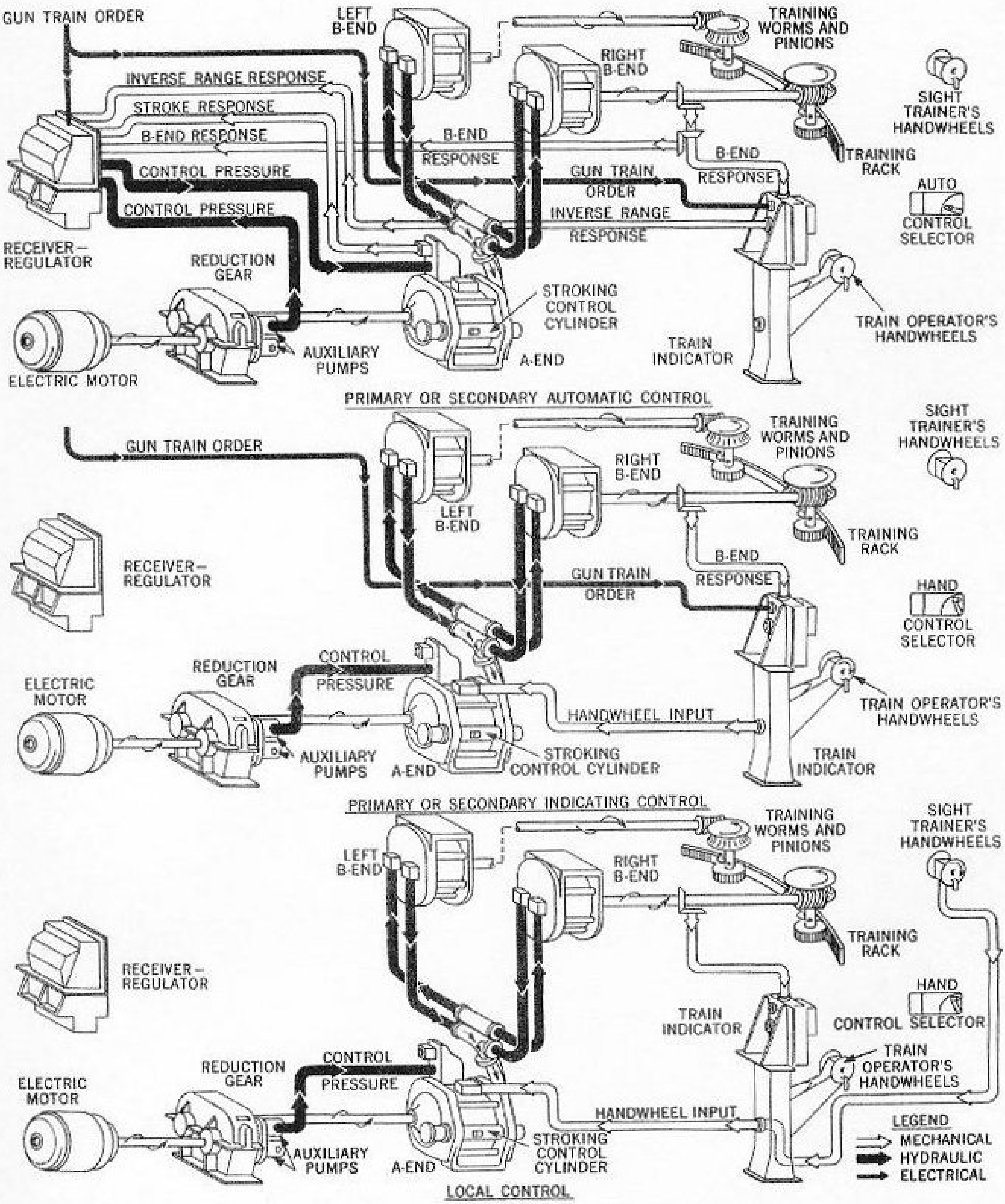


Figure 2-21. Training Gears and Controls. Functional Diagrams

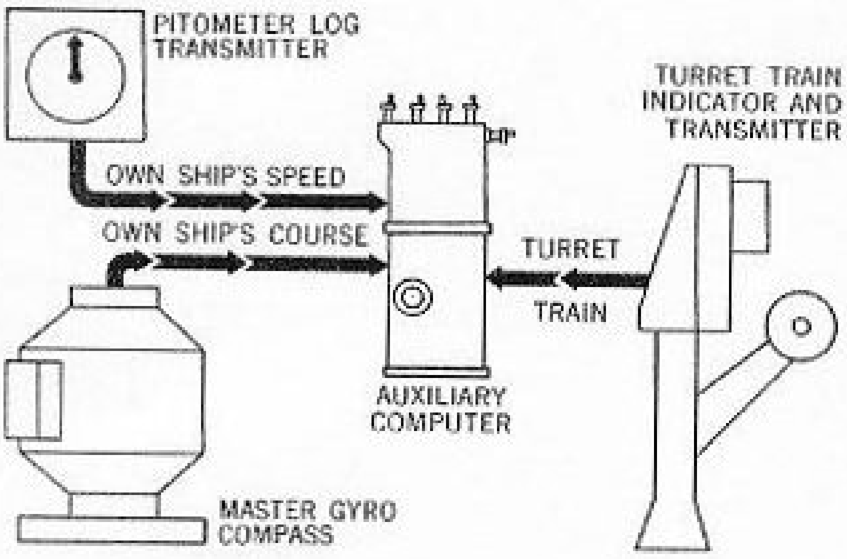


Figure 2-22. Auxiliary Computer Operation, Automatic Inputs

The gun layers and train operator observe their indicator dials and manipulate their handwheels to follow-the-pointer and directly control gun elevation and turret train. Each gun layer and the train operator positions the lever of his control selector at HAND.

Sight deflection and sight angle orders are relayed through the turret officer's transfer switchboard to the sight setter's indicator and from this instrument to the elevation indicator and sights as in automatic control.

Parallax range orders are relayed through the turret officer's transfer switchboard to the turret train indicator and transmitter. The train operator matches the parallax range order by hand and transmits this order mechanically to the indicator and transmitter.

Roller path inclination, velocity loss, and gun erosion corrections are combined in a differential gearing in the elevation indicator.

Train response is mechanically transmitted from the right B-end (training gear) to the turret train indicator and transmitter, and to all of the elevation indicators (to correct for roller path inclination).

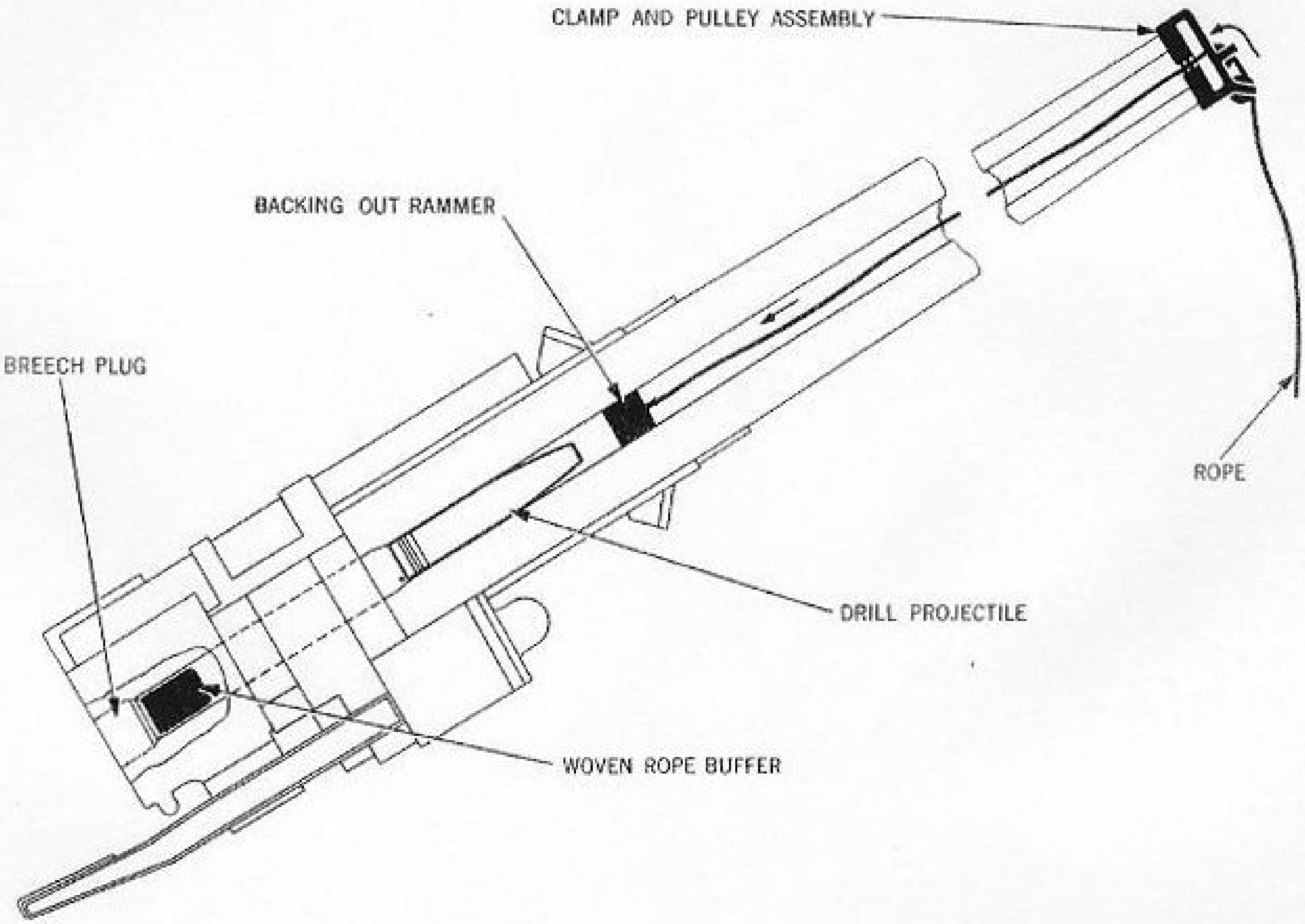


Figure 2-23. Use of Backing Out Rammer

Gun elevation response is mechanically transmitted from the B-end (elevating gear) to the respective elevation indicator.

Indicating control (local). In indicating control (local control), gun laying is accomplished locally and gun firing is accomplished by designated local switch or switches. Mechanical signals (gun orders) to lay the guns in elevation are transmitted through shafting from a sight pointer's handwheels to the elevation indicators. The gun layers manipulate their handwheels to follow-the-pointer and control gun elevation. Mechanical signals to train the turret are transmitted through shafting directly from either sight trainer's handwheels to the training gear A-end. The turret officer's transfer switchboard is set as described on page 2-3 for local control. Each gun layer and the train operator positions the lever of his control selector at HAND.

Target range and the fire control problem are computed by the turret rangefinder and auxiliary computer respectively. Sight deflection and sight angle orders are orally transmitted from the computer to the sight setter's indicator. The sight setter adds these values to his instrument by hand and transmits the sight orders to the pointer's and trainer's sights.

Loading

The gun can be brought to its loading position of five degrees elevation while in either automatic or hand control as selected by positioning the control selector lever at AUTO or HAND, respectively.

Automatic control. Automatic (loading) control is control action by the elevation receiver-regulator which moves the gun automatically from any angle of elevation to the loading position. This action occurs either when the control selector lever is positioned from AUTO to LOAD or when the gun captain's ready switch is turned to SAFE (provided synchro power is available, as indicated by an illuminated dial marked SYNCHRO POWER ON at the gun layer's station).

Hand control. Hand (loading) control is control action initiated by the gun layer who turns his handwheels to move the gun to the loading position. He does this when the gun captain's ready switch is turned to SAFE, in which position a dial marked LOAD is illuminated at the gun layer's station.

Sighting

Sight setting. The sight setter sets the sights by turning his hand cranks to match dials in the sight setter's indicator. The hand cranks set the sights by mechanically transmitting sight angle and sight deflection orders to shift the lines-of-sight of the sight pointer's and sight trainer's telescope. The indicator also supplies sight angle to the gun elevation indicators where it is used as one of the factors for computing erosion correction (for transmission to the receiver-regulator, AUTO control).

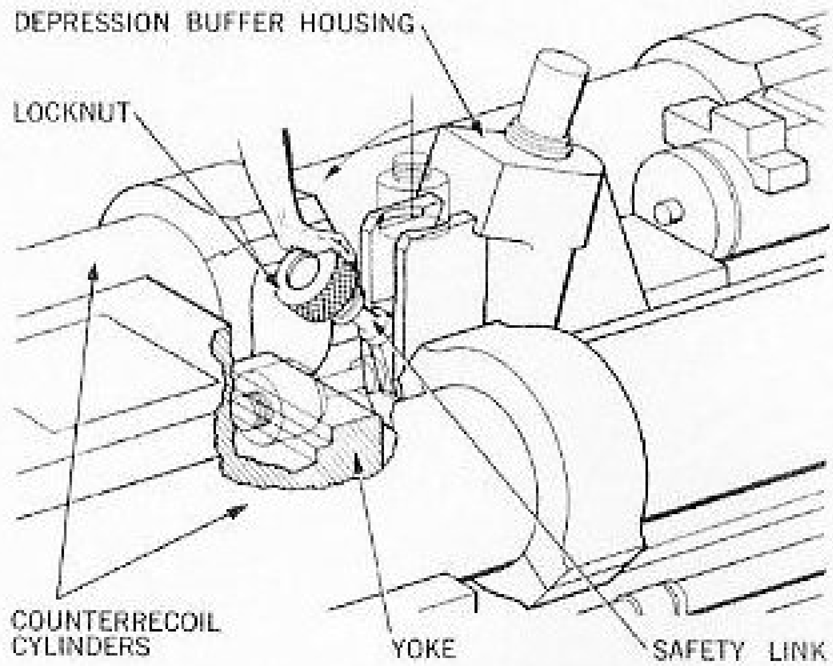


Figure 2-24. Securing Gun-Locking Device

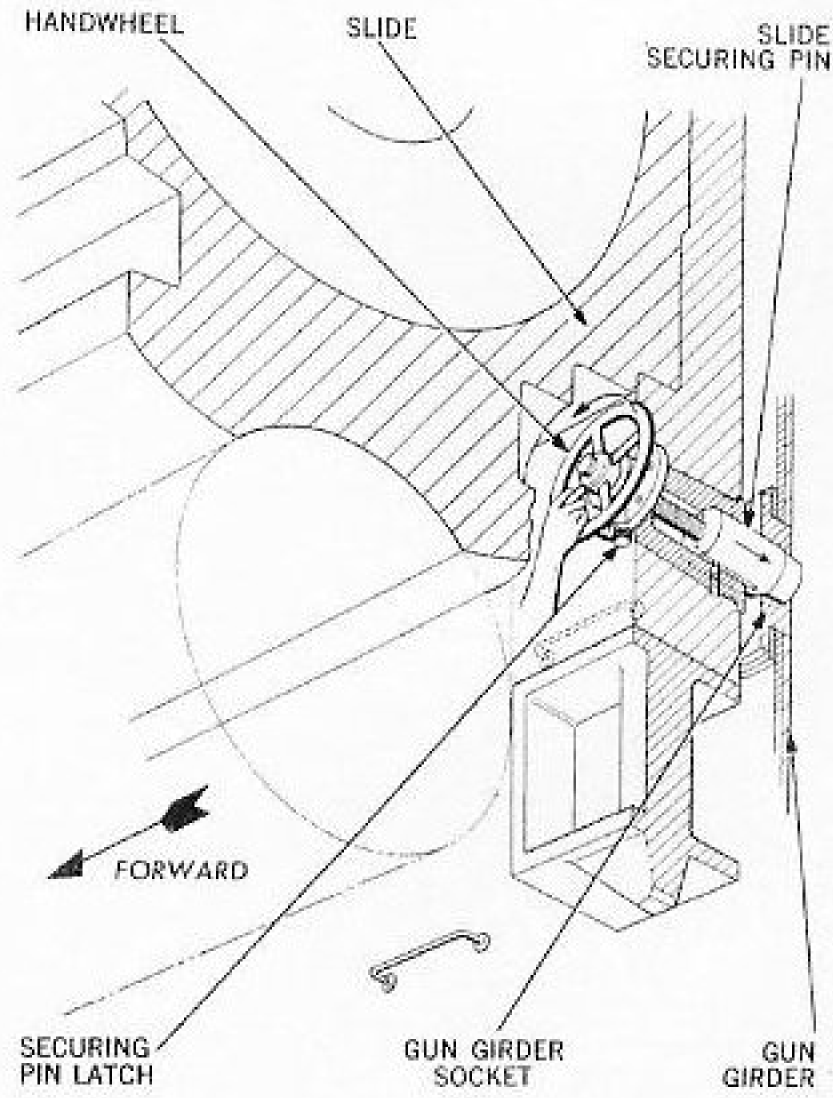


Figure 2-25. Securing Slide Securing Device

Pointer's sight operation. The sight pointer (in local control or when the turret is used as a director in secondary control) lays his horizontal crossline on the target by turning his handwheels, thereby developing gun elevation order. This value is transmitted to the gun elevation indicators and the gun layers turn their handwheels to lay the gun by matching dials.

Trainer's sight operation. The sight trainer (in local control or when the turret is used as a director in secondary control) lays his vertical crossline on the target by turning his handwheels, thereby training the turret to the proper position.

Range estimating

Computing data. The turret computer is used by the computer operator in local control to solve the fire control problem.

Three electrical synchro inputs are received in the computer (fig. 2-22). These are own ship's speed and own ship's course, received from the ship's gyro compass and Pitometer log via the plotting room; and turret train, received from the local turret train indicator and transmitter.

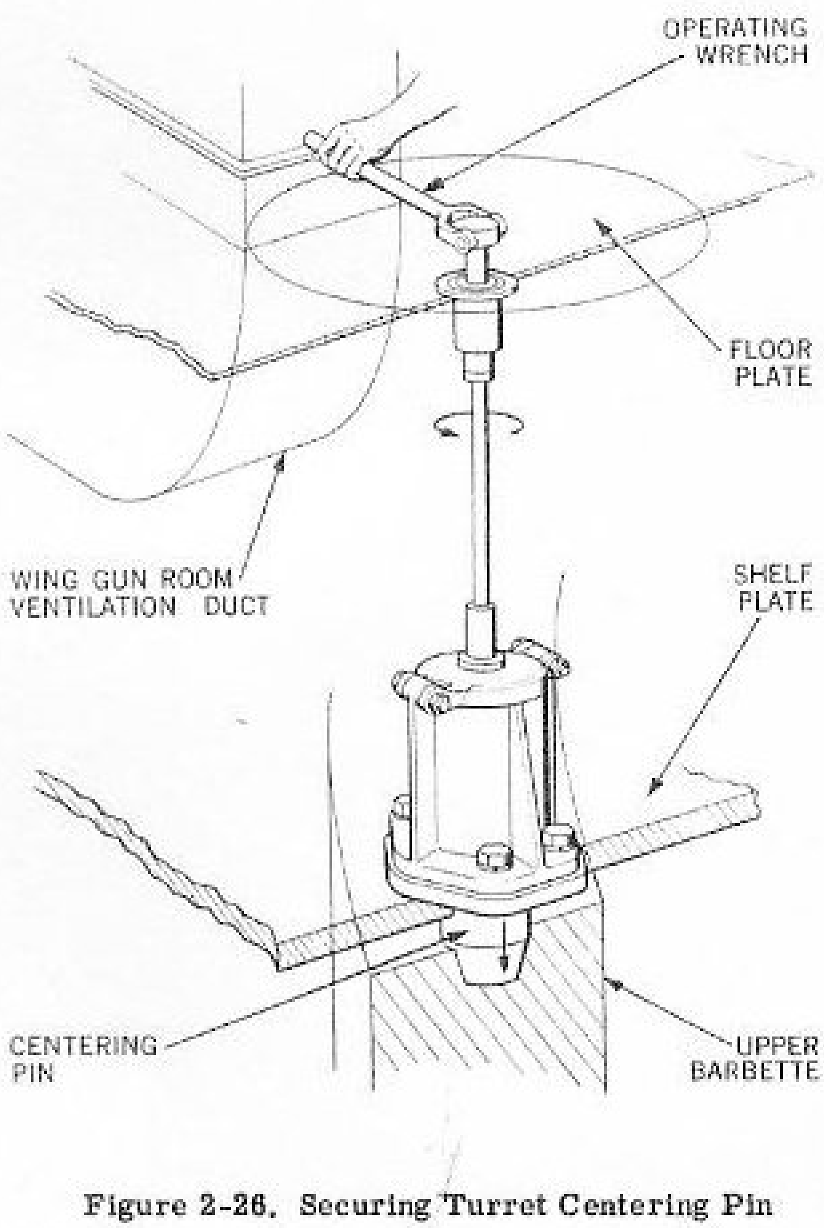


Figure 2-26. Securing Turret Centering Pin

Thirteen inputs are manually introduced. These are: projectile, initial velocity, target angle, wind angle, wind speed, true target bearing, own ship's speed, deflection correction, present range, range correction (shot), time, target speed, and turret train follow-up. Three of these hand inputs are identical to the electrical inputs - true target bearing (when own ship's course electrical does not function), turret train follow-up, and own ship's speed. The first two are for emergency use when the corresponding electrical input or the respective follow-up is inoperative. The electrical input for own ship's speed operates a dial but does not set the mechanism. Setting must be done by hand.

The outputs of the computer are sight deflection and sight angle, indicated on dials or counters at the computer and transmitted by telephone to the sight setters.

GUN CASUALTY OPERATION

Misfire operation

Misfires are usually caused by a break in the electrical firing circuit, the weakest portion of which is the primer. To avoid misfires, handle primers carefully to prevent damage of the electrical contact within the primer.

In the event of a misfire a series of operations must be performed by the gun captain (with assistance from his gun crew) to correct the malfunction quickly and resume normal fire. Teamwork is necessary because of the number of operations, the urgency, and the work involved.

The normal procedure is quickly performed, but it requires a number of control, unloading, and loading actions. These actions interrupt gun laying, extract the misfired primer, and load a new primer, as described in the next paragraph.

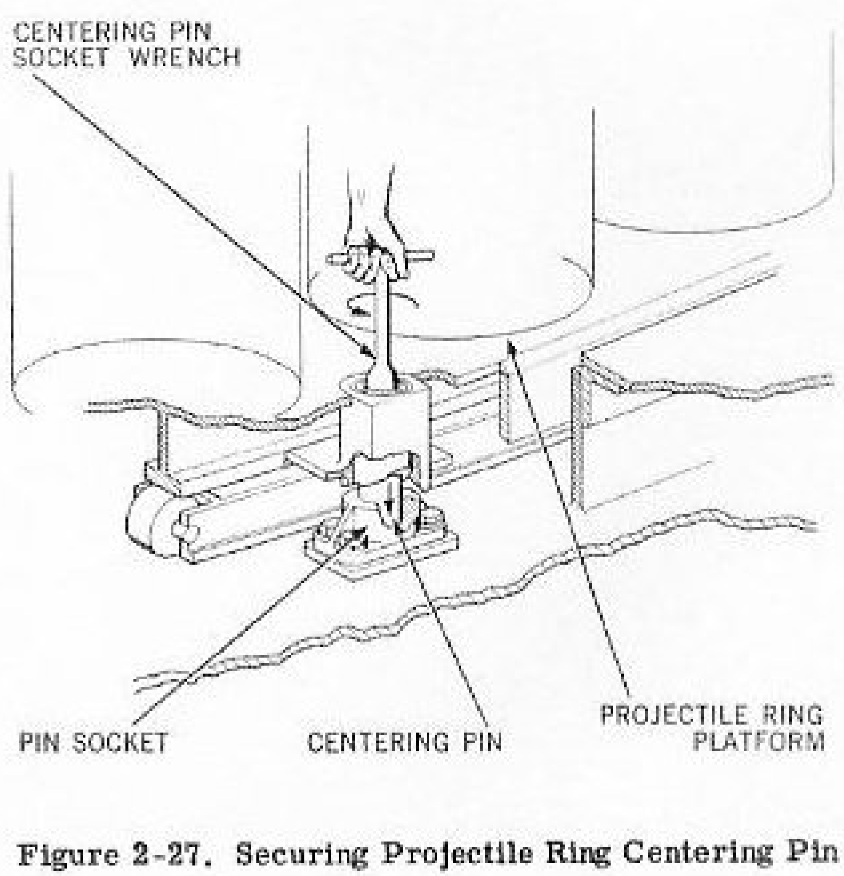


Figure 2-27. Securing Projectile Ring Centering Pin

Suggested operating procedure for misfire correction. When misfire occurs, the malfunction is corrected as follows:

The gun captain immediately positions his ready switch lever to SAFE, after pulling the PULL TO RELEASE button on the switch to release the lever lock (fig. 15-22). This action opens the respective gun firing circuit, and either automatically brings the gun to its five degrees loading position or notifies the gun layer (by indicator light) to do so.

The gun captain notifies the turret officer of the misfire and receives permission to extract the misfired primer from the firing lock. This action may be done without opening the breech* (see NAVORD INSTR. 5100.1 as quoted) or removing the firing lock (unlatch the wedge retracting lever and rotate it rearward independently of the breech operating lever).

The gun captain inserts a new primer into the firing lock (using the re-priming tool) and rotates the wedge retracting lever to close the firing lock wedge.

The gun captain then notifies the turret officer that the gun is reprimed and awaits orders from the turret officer to position his ready switch to READY. The turret officer must check to see that the firing circuit is open.

The gun captain positions his ready switch to READY upon orders from the turret officer, and gun laying and normal firing may be resumed.

If the firing malfunction persists after the above procedure, it may be necessary to resort to percussion firing until the electrician can check the firing circuit.

*NAVORD INSTRUCTIONS 5100.1, Safety Precautions, III - 26:

"The possibility of a serious accident due to opening the breech of a gun too soon in the case of a hangfire demands the constant exercise of the utmost prudence and caution. A hangfire must be assumed to exist when:

(1) An unsuccessful attempt has been made to fire the gun.

(2) A charge remains in a bag gun, with the possibility of ignition by an undetected ember from the previous round.

(a) The following procedure shall be followed in the cases noted above:

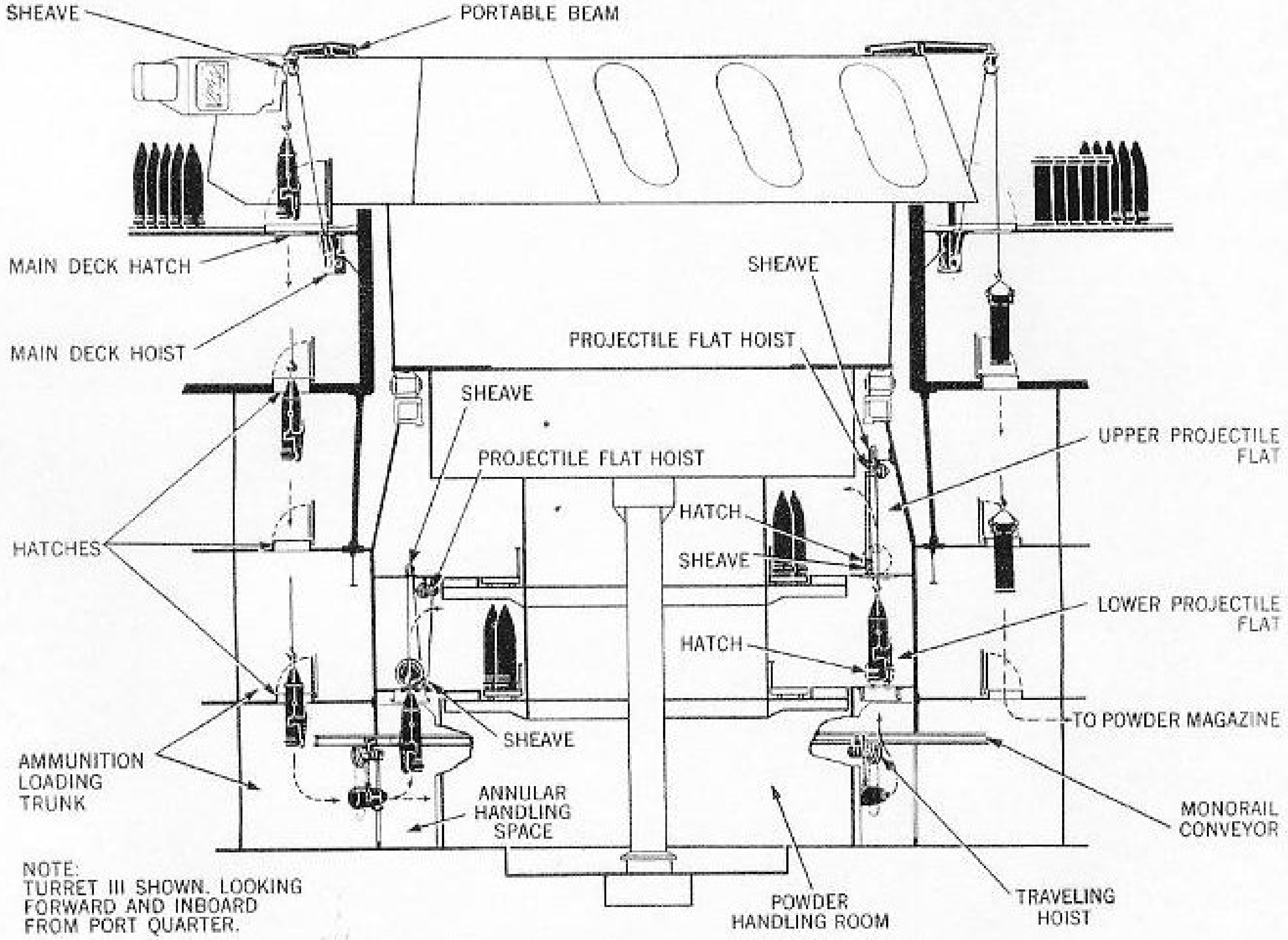


Figure 2-28. Ammunition Stowage into the Turret

(1) Keep the gun pointed and trained in a safe direction.

(2) Keep the breech mechanism fully closed.

(3) Continue attempts to fire, if desired, repriming bag guns provided such efforts do not involve any movement tending to open the breech.

(b) If the gun is not fired under the above conditions:

(1) Open the firing key and break the firing circuit elsewhere.

(2) Unhook the firing lanyard, if detachable.

(3) Remove the primer from the lock of a bag gun, using the primer tools supplied for this purpose, taking care to avoid danger from recoil or blowback. For this purpose, or for shifting primers, do not leave the firing lock open longer than necessary.

(4) Do not open the breech for 30 minutes (10 minutes for field and landing guns on shore) after the last attempt to fire. This, at the discretion of the commanding officer, is not obligatory in time of action; nor is it obligatory or advisable with a hot gun if an instruction of the Bureau of Ordnance to prevent a projectile "cook-off" recommends earlier opening of the breech when the gun cannot otherwise be cleared by firing it.

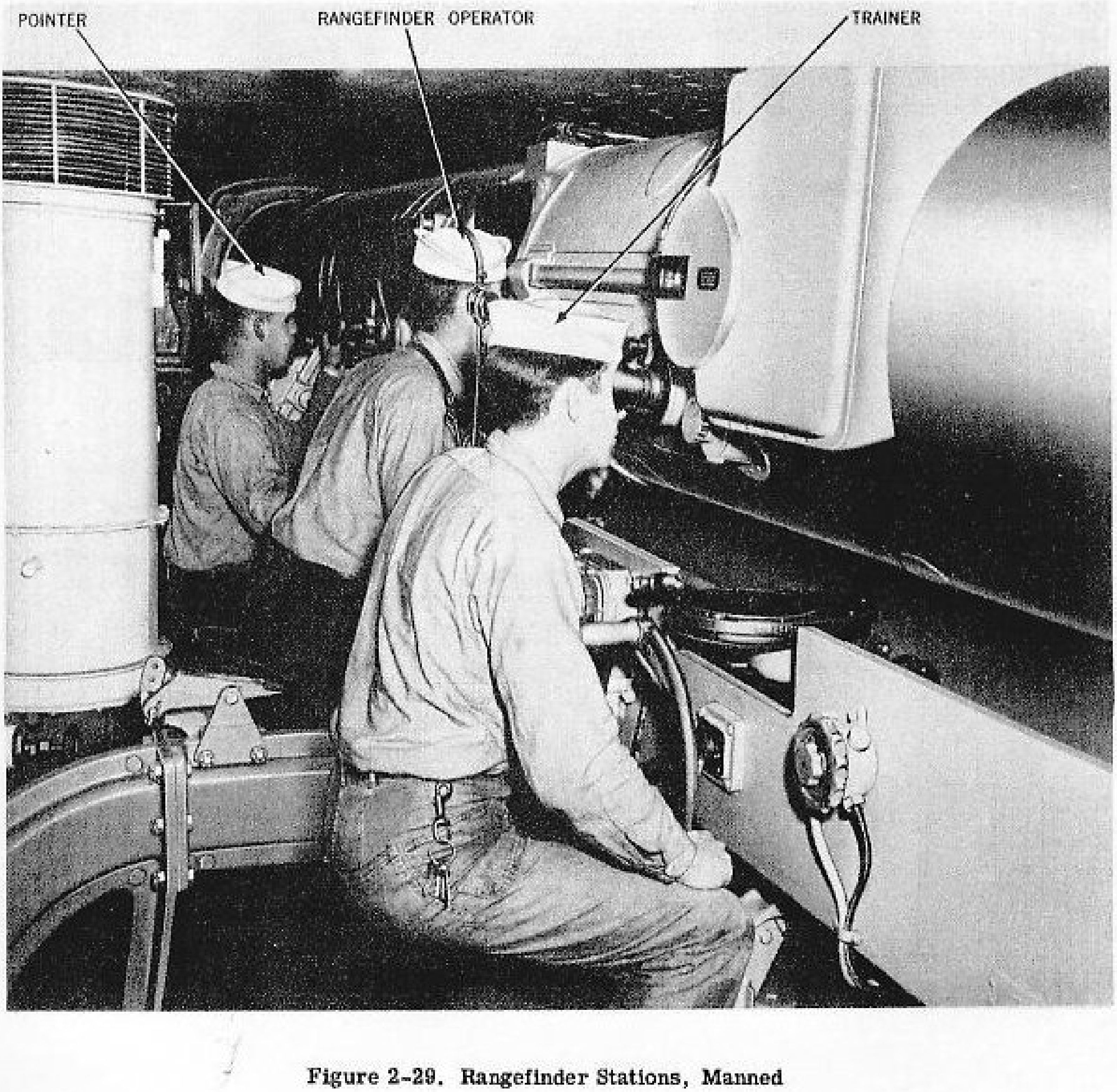


Figure 2-29. Rangefinder Stations, Manned

(c) The crew shall never leave a loaded gun until the precautions in (a) and (b) (1) to (3) above have been carried out.

(d) Ammunition removed from a loaded gun shall be disposed of in accordance with current instructions of the Bureau of Ordnance."

Manual projectile extraction

A backing-out rammer outfit consisting of a ram, a rope, a clamp and pulley assembly, and a woven rope buffer is used to remove drill projectiles from the gun. The buffer is placed in the powder chamber (to protect the mushroom when the projectile breaks loose and falls back) and the breech is closed. The ram with rope attached, and the clamp and pulley assembly are installed with the rope led through the pulleys. While the ram is held at the muzzle end of the gun, the gun is elevated as shown (fig. 2-23). The ram is dropped on the projectile and raised by the rope and pulleys. This operation is repeated until the projectile is unseated and falls back against the buffer. See 'Backing-out precautions," chapter 3.

SECURING OPERATIONS

At conclusion of firing operations, many duties must be performed to stow and secure the ordnance assemblies, auxiliary equipment, and turret stations. The work includes conventional gun cleaning and preservation as defined by the Ordnance Manual, inspections and system replenishing services, closing down power units, shifting controls, and securing operations. These activities are generally the reverse of the casting-loose and starting preparations described previously in this chapter. They are duty assignments that include all members of the turret organization.

This work comprises three general classes of activities:

Stopping equipment
Conditioning for stowing
Securing

Stopping equipment

All power-driven ordnance equipments are stopped by depressing master pushbutton stop control switches.

The electric control systems of the elevating and training gears are stopped by opening signal circuits and supply switches of the turret officer's transfer switchboard and selective switch.

Ventilating units designated by the turret officer are stopped by depressing master pushbutton stop control switches.

Heaters are cut off by opening supply switches adjacent to each unit.

The power-supply manual disconnect switches of all Ordnance controllers are opened, and supply switches are opened at all power equipment panels except the miscellaneous equipment panel.

Certain of these operations are deferred when the "Cease fire" order is received, in order to unload the hoists, to condition units for stowing, or to move them to securing positions.

Hoist unloading operations. The power drives of the hoists must be in operation to move ammunition from the projectile cradle and powder car to the projectile flats and powder handling room.

At "Cease fire" the gun captain directs the cradle operator to position the function control and shut-off valve handle at LOWER PROJECTILES.

WARNING

If powder has been exposed in the gun chamber, no projectiles are to be lowered until the powhas been returned to the powder car and the powder car returned to the bottom of its hoistway. The only flame-proofing within the projectile hoists is provided by the projectiles in it.

The hoist operator then positions the hoist control handle at HOIST and the hoist rack is lifted until the TOP OF STROKE indicator is illuminated at the hoist operator's station. This action lifts the projectile above the cradle projectile latch.

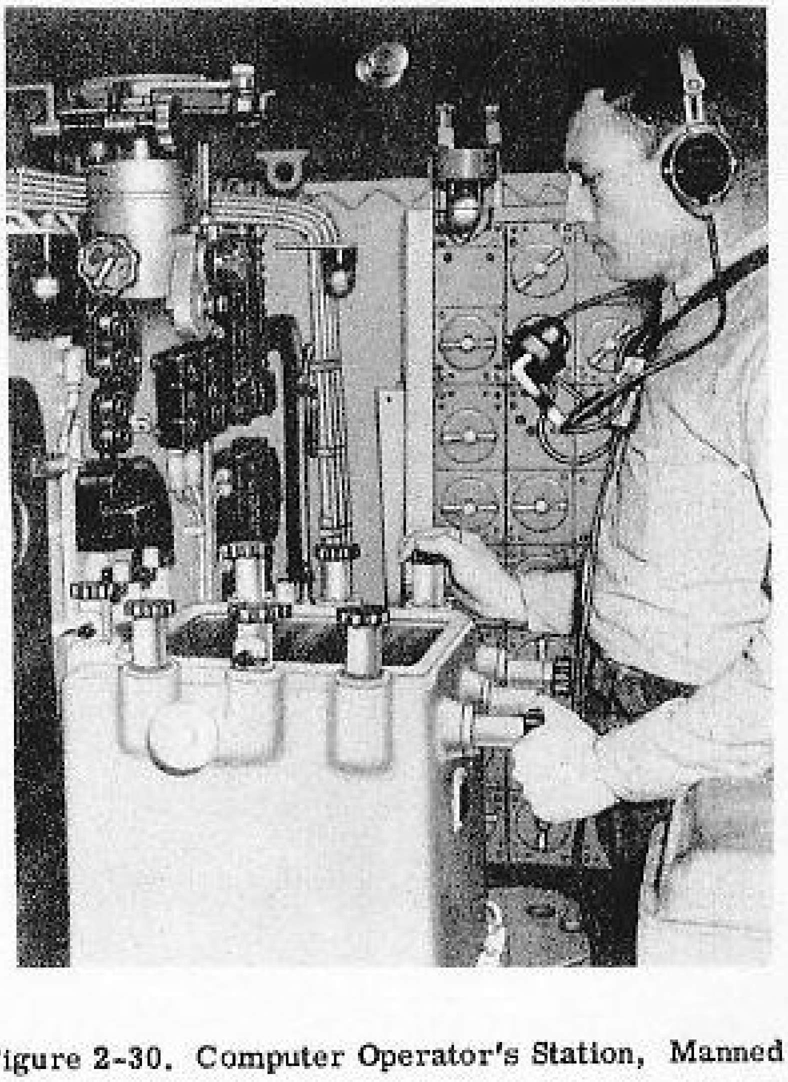


Figure 2-30. Computer Operator's Station, Manned

The cradle operator must move the latch back to permit downward passage of the projectile when the hoist operator positions the hoist control handle at LOWER (after the LATCH CLEAR indicator is illuminated). When this occurs the projectile is lowered from the cradle to the next lower stage, and the projectile flat crew parbuckles the projectile at their level from the hoist. As successive projectiles are parbuckled from the hoist, the use of the hoist control handle is repeated as above until the hoist tube is empty.

At "Cease fire," the power hoist operator lowers his loaded powder car to the hoist loading station in the powder handling room. The lower door operator dumps the car trays to roll the powder bags into the loading trays. The first and second powdermen carry the bags from the loading trays to a powder handling room scuttle. They rotate the scuttle each time they place a bag in it to return all bags to the magazine via the magazine scuttle which is operated by the third powderman.

WARNING

A loaded powder car must not be unloaded nor the lower powder door opened until all exposed powder in the handling room has been returned through the scuttles to the magazines. Unload and return powder to the magazine from one car before opening the lower door of another hoist.

Conditioning for stowing

Preparations for stowing the equipment consist of cleaning and inspecting all assemblies, performing "After Operation" lubrication as prescribed by the lubrication charts, and servicing counterrecoil bottles and hydraulic system tanks to replenish depleted air and fluid volumes.

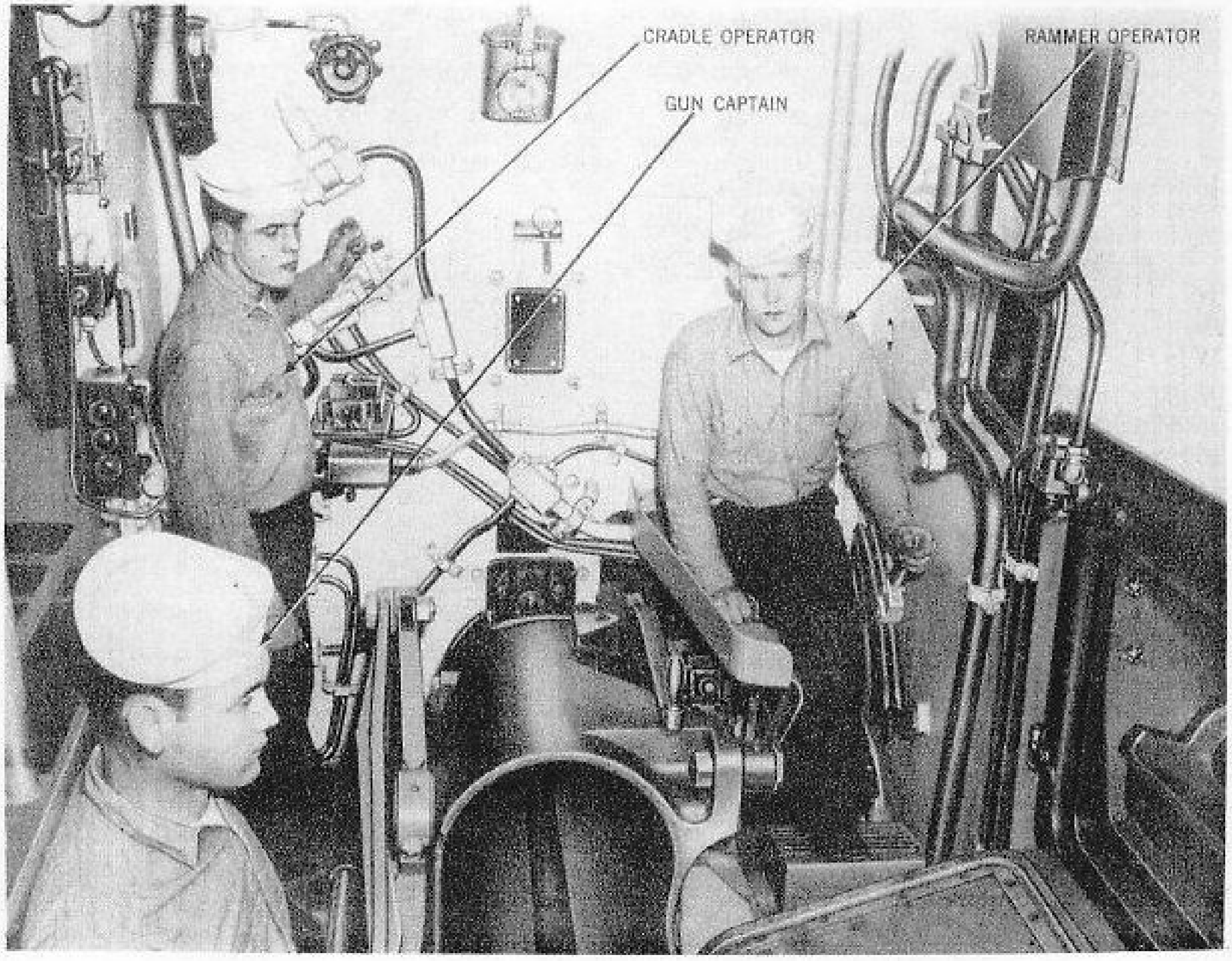


Figure 2-31. Right Gun Chamber Stations, Manned

Lamp replacements. The inspection work must include complete check-off of all ready-lights, light-well illumination, and other battle illumination, replacing all defective lamps.

Cable check. Cable loops of the firing circuit at the gun breeches and firing keys, and all other wiring exposed to chafing and twisting action must be examined for kinks, insulation breaks, or other defects.

Securing

The principal securing operations are illustrated and are described in the following paragraphs.

Securing the guns. The gun locking device is connected (fig. 2-24) with the threaded safety link and locknut lowered to the locked position in the yoke recess. The nut is then tightened until the device is secured in the locked position. After cleaning, bore gage tests, and preservation treatment, the tompion or muzzle cover is installed and the breech is closed.

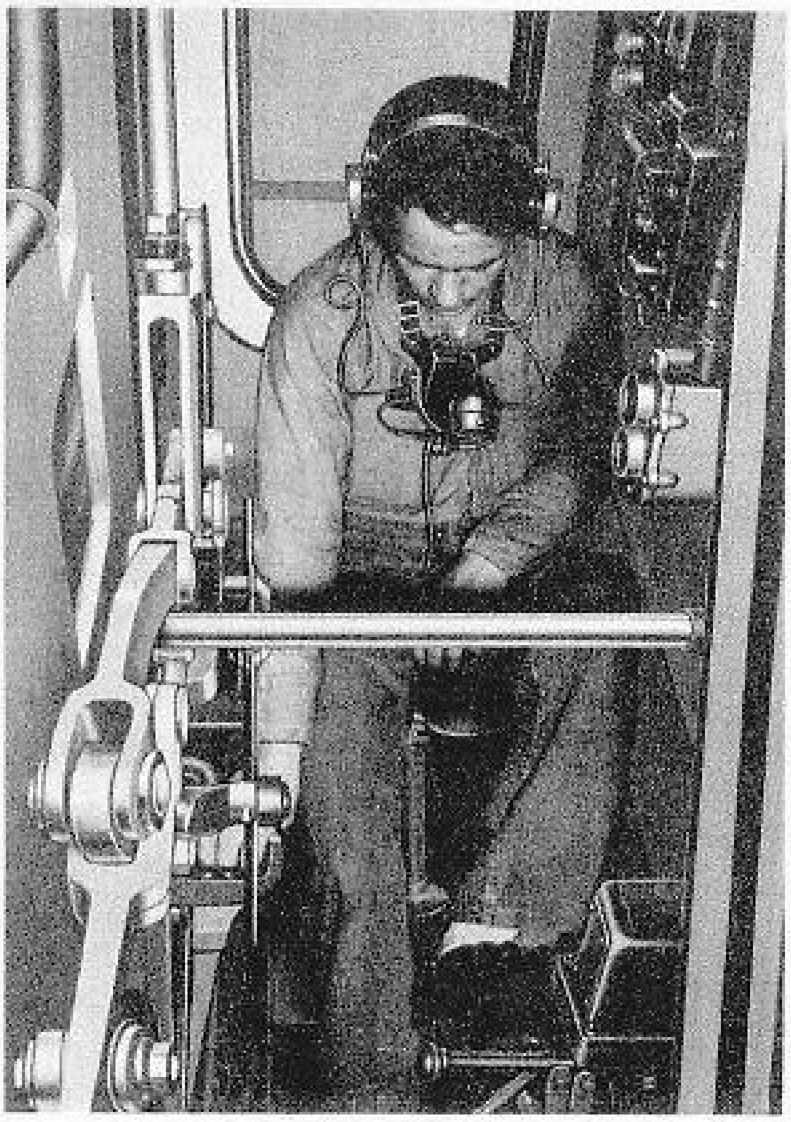


Figure 2-32. Powder Hoist Operator's Station, Manned

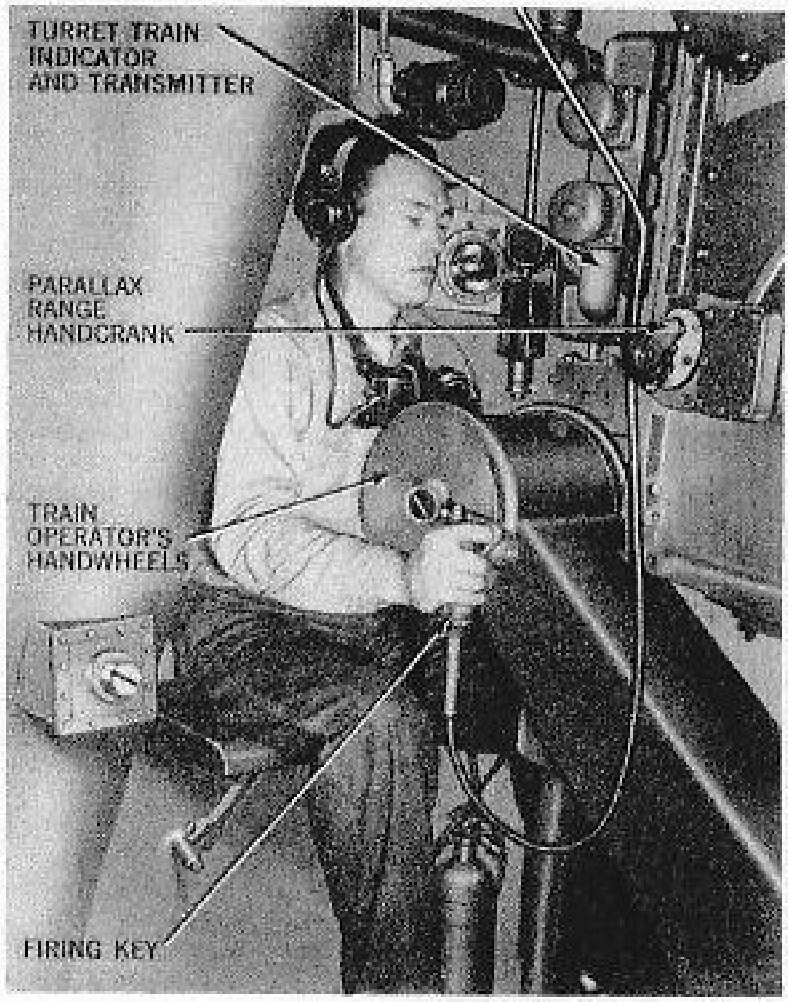


Figure 2-33. Gun Train Operator's Station, Manned, Left Side View

Securing the slides. Slides are secured by elevating the gun to zero degrees elevation in order to align the securing pin with its gun girder socket (fig. 2-25). By turning the respective handwheel counterclockwise and holding the securing pin latch down, the pin is run into its socket.

Securing the hoists. Each ammunition hoist must be stowed empty. Projectile hoists are to be stowed with racks fully lowered and control handles at neutral. Function control and shut-off valve handles are to be positioned at HOIST PROJECTILES. Powder hoists are to be stowed with the car fully lowered and all doors closed.

Securing the elevating gear. The elevating gear is locked against backlash action and seaway stress when the slide securing pin is in secured position. Controls are secured when the gun layer stops handwheel rotation at neutral position and the control selector lever is at HAND position. The drive motor is then stopped.

Securing the training gear. The training gear is secured by training the turret slowly until the two centering pins align with their holes in the upper barbette. This position is zero degrees train for turrets I and II, and 180 degrees train for turret III. Both pins must be run out until each is tight (fig. 2-26). This operation is essential to prevent seaway stress in the roller carriage, "brinelling" in the roller track, and backlash chatter in the pinions and training rack.

Controls are secured when the train operator stops handwheel rotation at neutral position (indicated by the neutral-start indicator light being illuminated) and the control selector lever is at HAND position. The drive motor is then stopped.

Securing the projectile rings. The projectile rings are secured by operating each ring from its "Cease fire" position in repetive power drive cycles until the centering pins and sockets align. The pins are then run out until each is tight (fig. 2-27).

All projectile lashings are inspected to verify secured position of each toggle link. Lashings of expended ammunition should be tied to the coaming.

Each projectile ring control hand lever is secured at STOP detent position and the drive motor is then stopped.

Securing the parbuckling gear. The two parbuckling gear assemblies are stopped, and the snubbing ropes are neatly coiled and hung in convenient locations in the projectile flats.

Securing the sights. The turret optics should be positioned with offsets removed when securing. The sight setter handcranks should be at 2000 minutes sight angle, 500 miles deflection. The rangefinder should be positioned at zero degrees elevation and azimuth, and the periscopes at zero degrees azimuth.

The rangefinder is secured by operating the handcrank mechanism to closè the hood door and making sure that it latches shut.

Each periscope is secured by seating the azimuth movement plunger and releasing the cover from its open position, moving it to its closed position, and running the wing nut tight.

Sight telescopes are secured, after wiping sight objectives with lens paper, by operating the sight hood door mechanism to close the door tightly.

Securing the turret officer's controls. The turret officer's transfer switches, selective switch, and firing key switches are positioned as follows when securing:

Transfer switches: All switches having an OFF position to be positioned at OFF, all other switches at their primary control position.

Selective switch: Pointer knob and pointer handle at OFF with the stop secured.

Firing key switches: All switches at OFF position.

Securing the sprinkling system. The air pressure control valve to the sprinkling tanks is closed. The system air pressure is relieved.

The firemain cut-off valve in the powder handling room is closed.

Securing the ventilating system. Ventilating fan sets are stopped as designated by the turret officer.

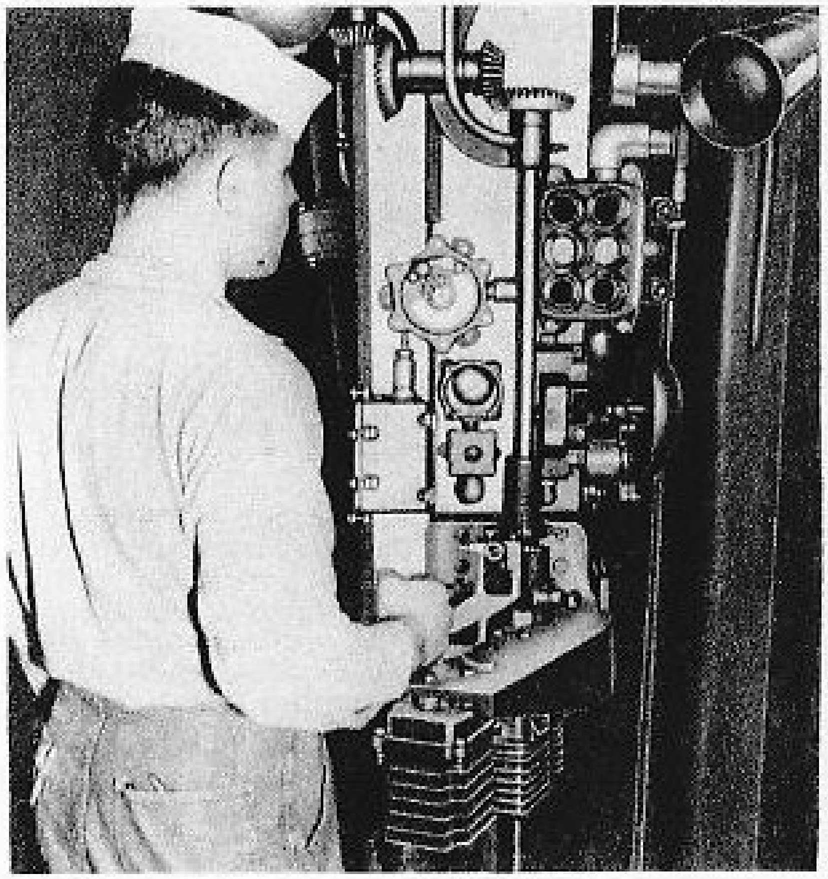


Figure 2-34. Projectile Hoist Operator's Station, Manned

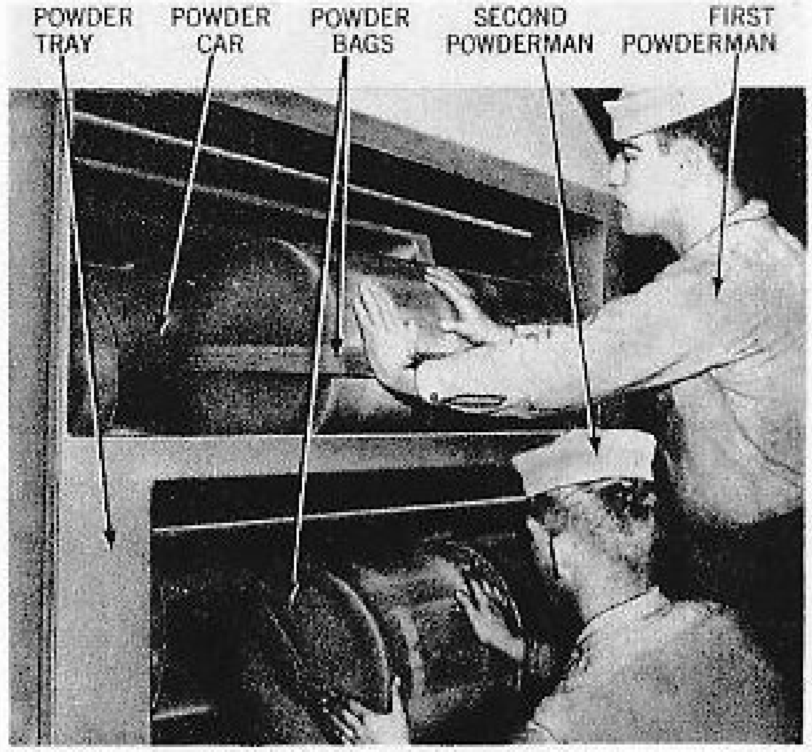


Figure 2-35. First and Second Powdermen Loading Powder Car

STOWING AMMUNITION

Ship and turret design arrangements permit two separate routes to be utilized for moving ammunition from the main deck outside the turret to stowed positions in the magazines and projectile flats. A separate stowage route is located on each side of the turret as shown in figure 2-28. The routes (or ammunition loading trunks) are formed by hatch openings in each deck, each opening being located directly below the main deck hatch.

Stowage procedure

Ship and turret arrangements for ammunition 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 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. These angles of train are: turret I, 266 degrees; turret II, 230 degrees; and turret III, 193 degrees. After the turrets are trained to these positions, portable beams are bolted to the tops of the gun house structures. Each portable beam suspends a sheave and hoisting hook directly over a trunk.

Structural arrangements for the ammunition stowage handling routes are the trunks and annular handling space. In addition, there are hatch arrangements within the turret for projectile stowage handling. These latter arrangements 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, located in the rear part of each fixed stowage ring, 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.

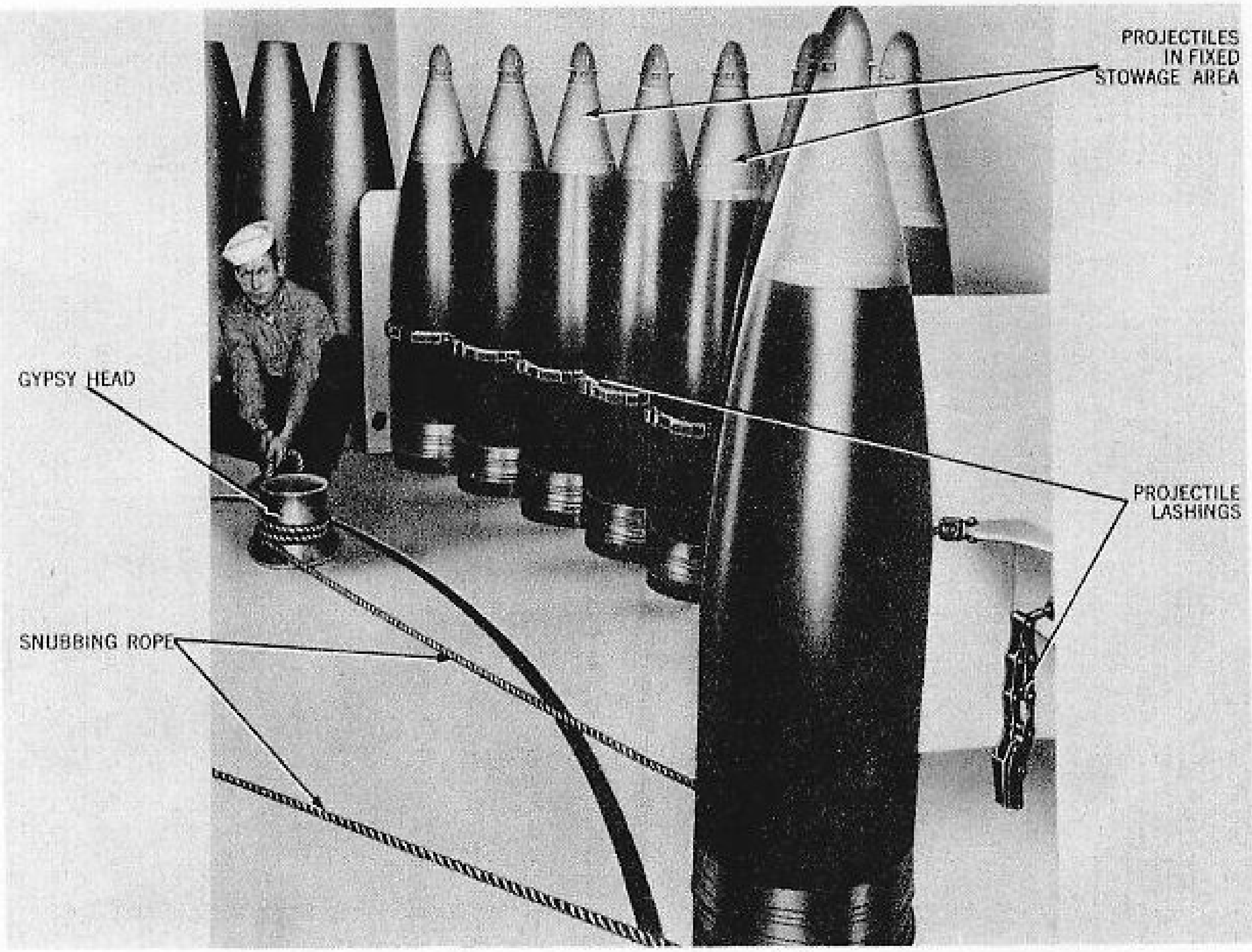


Figure 2-36. Shellman Parbuckling Projectile

Each stowage route is provided with hoist equipment which includes a main deck hoist, a projectile flat hoist, and the monorail conveyor traveling hoist at the magazine level. The main deck hoist is electric-motor-driven with remote start-stop controls located at the main deck hatch. The hoist motor rotates a drum and is 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 the sheave in the outer end of the portable beam. This hoist is used for stowing projectiles and powder into the turret.

The projectile flat hoist is electric-motor-driven with remote start-stop controls located on the turret foundation bulkhead adjacent to the round projectile flat hatch. Mounted on the projectile flat overhead, the hoist is adjacent to and above the round hatch opening in the floor below the hoist. The hoisting chain is lead downward from the hoist through a sheave that is secured to the floor alongside of the round opening. From the floor sheave, the chain is lead upward to a second sheave that is secured to the overhead directly over the center of the round hatch opening in the projectile flat floor. This hoist is used only for transferring projectiles from the magazine level to the upper and lower flats.

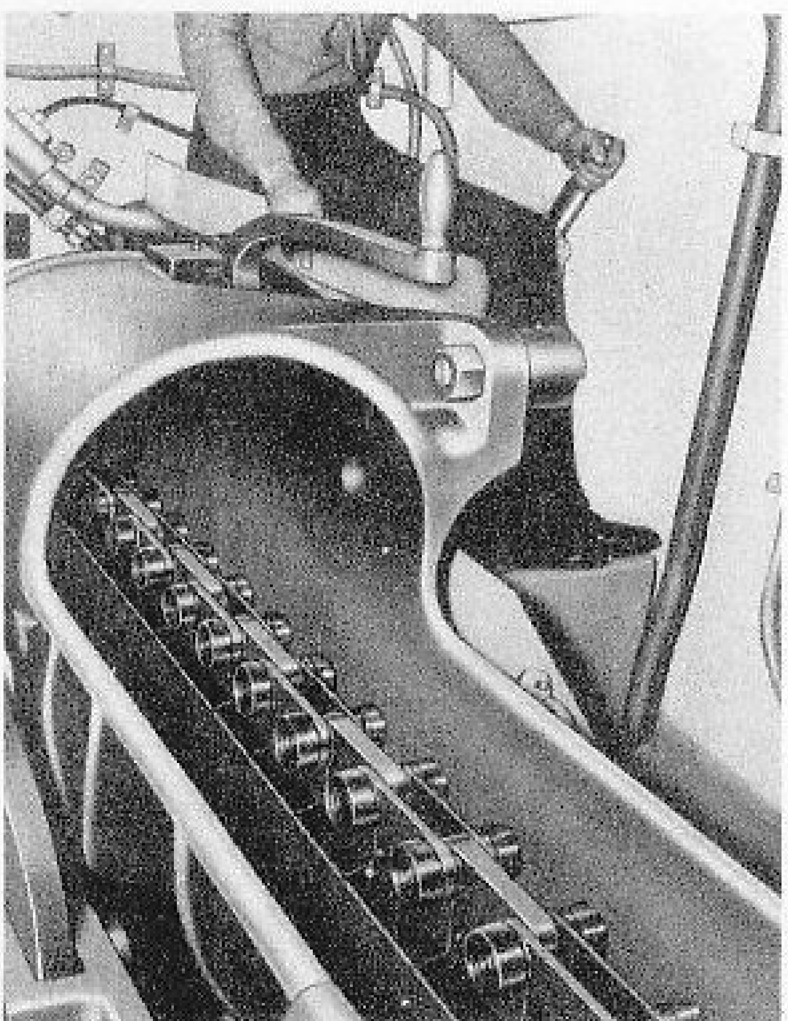


Figure 2-37. Rammer Operator's Station, Manned

The monorail conveyor traveling hoist at the bottom of the ammunition trunk is an overhead trolley with a manually operated chain hoist. This hoist is used to transfer projectiles from the main deck hoist to the projectile flat hoist. The hoist is also used in transferring powder or stowing powder in the magazines.

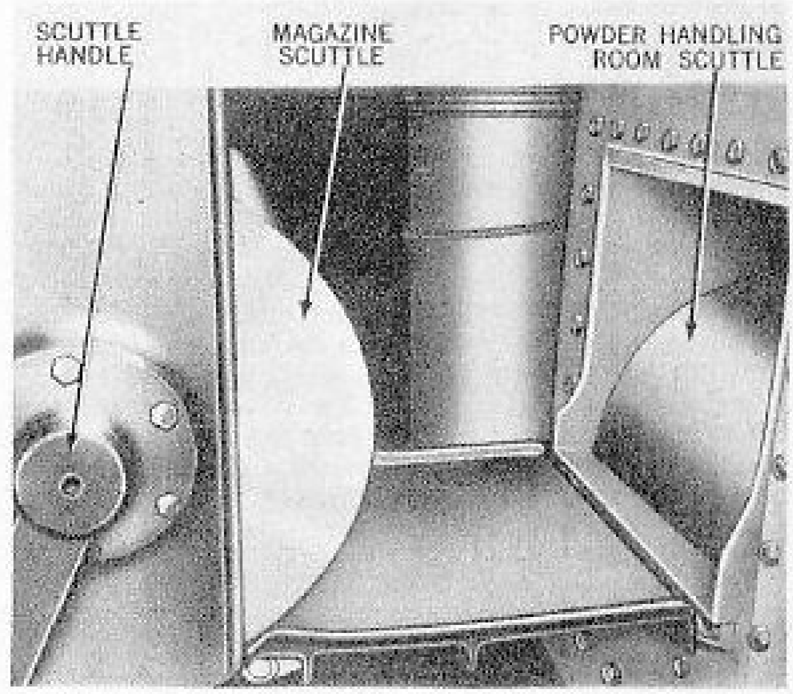


Figure 2-38. Magazine and Powder Handling Room Scuttles. Powder Handling Space

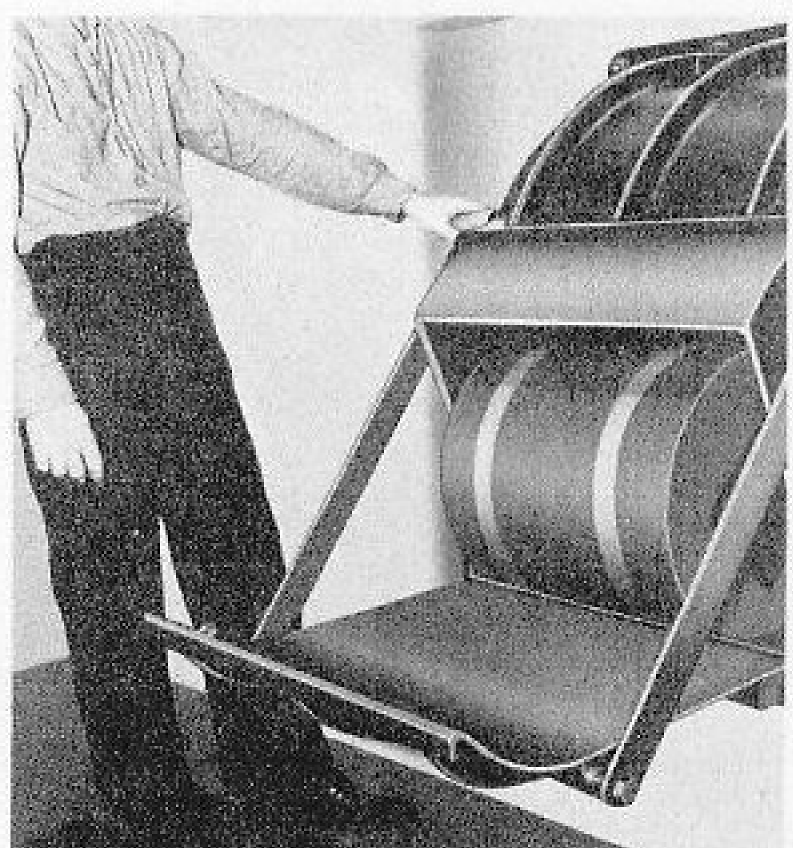


Figure 2-39. Powder Handling Room Scuttle, Manned. Powder Handling Room

Projectiles are handled by a projectile carrier which is a projectile holding yoke and base stirrup with a wire rope sling and becket. A two-position carrying design, the carrier is used to carry projectiles in the horizontal position as well as vertical. It is removed from each projectile after the projectile is delivered in a vertical position at the bottom of the trunk. A similar carrier is then installed on the projectile, and the first carrier is hoisted empty to the main deck. Projectiles are transported in a horizontal position through the annular handling space, by the second carrier and the overhead trolley-conveyor, to a position beneath the projectile flat hatches. Projectiles are hoisted in a vertical position through these hatches to the projectile flats. Stowing of projectiles on the inner and outer rings is performed by parbuckling.

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. Projectiles are secured by special chain lashings. The outer row of projectiles on the outer ring fit into notches in a flange, and are chained to the flange. The inner row of projectiles are secured similarly. All securing chains are equipped with pelican-type fasteners, which permit rapid and separate unlashing of the projectiles.

Powder tanks are handled by a powder tank carrier, which is two short lengths of wire rope joined by a steel ring and equipped with a spring-loaded latch fitting on each end. The hook of the main deck hoistsfits through this ring when the carrier is latched to the upper powder tank flanges. It is a one-position carrying design used to carry powder tanks in a vertical position through the ammunition loading trunks or annular handling space.

After the powder tank has been hoisted into a magazine, it must be secured in position. Powder tanks are secured by stacking them horizontally in bins (between the magazine floor and overhead). The tanks are held in position by their flanged and grooved ends (which are interlocked), and by vertically placed portable battens (which prevent the stacked tanks from shifting). Stacking of tanks in the topmost rows is facilitated by powder handling cars (gravity actuated) within the magazine. These cars hoist powder bags singly, thereby enabling the stowage crew to empty a powder tank, stack it in position, and then fill it by hoisting the bags.

Chapter 3

GUN ASSEMBLIES

16-inch Gun Mark 7 Mod 0

16-inch Breech Mechanism Mark 4 Mod 0

Firing Lock Mark 14 Mod 5

16-inch Gas Ejector Mark 5 Mod 0

16-inch Yoke Mark 5 Mod 0

GENERAL DESCRIPTION

The 16-inch, 50-caliber gun assemblies (fig. 3-1) of each turret are right, center, and left installations. Each gun assembly consists of a 16-inch Gun Mk 7 Mod 0, a 16-inch Breech Mechanism Mk 4 Mod 0, a Firing Lock Mk 14 Mod 5, a 16-inch Gas Ejector Mk 5 Mod 0, and a 16-inch Yoke Mk 5 Mod 0. The right and center gun assemblies are identical right-hand arrangements. The left gun differs in that the air-line piping to the reduction valve is located at the left side of the breech together with the closing valve. The tripping levers for releasing the holding-down linkage of the breech and for operating the closing valve are also located at the left side of the breech.

The gun (fig. 3-2) is a lightweight type, mounted in an individual slide, with its own elevating gear. The gun is chambered for a bag charge and is equipped with a carrier-type breech mechanism.

The breech mechanism (figs. 3-3 and 3-4) is of conventional design with closure of the breech by a breech plug and obturator unit assembly.

A ~~slave~~ SALVO latch prevents opening of the gun breech, in the case of an unnoticed misfire or hangfire when the guns are fired in salvo. The salvo latch is automatic and positive in action.

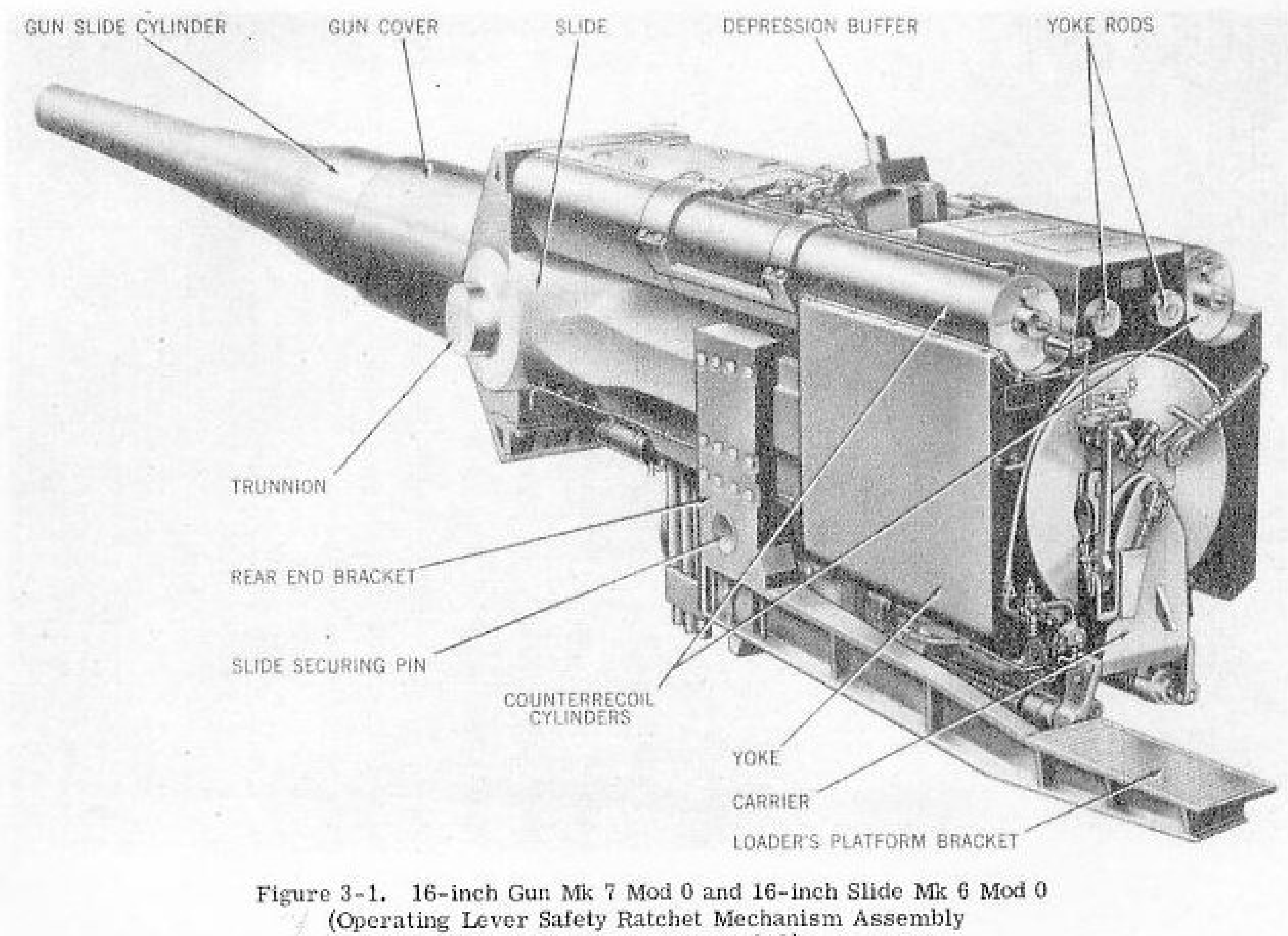


Figure 3-1. 16-inch Gun Mk 7 Mod 0 and 16-inch Slide Mk 6 Mod 0 (Operating Lever Safety Ratchet Mechanism Assembly Not Shown; See Figure 3-3)

The firing lock is a hand-primed wedge type with provision for either electric or percussion firing of the primer when the breech is completely closed.

The gas ejector is an automatic, low-pressure air porting system which clears the bore when the breech is opened after a round has fired. The system also provides air for the breech closing cylinders.

Yoke. The gun yoke is a large counterbalancing unit, mounted on the gun shoulder, that provides integral lug seats for the recoil cylinder piston rod and the counterrecoil cylinder yoke rods.

Components

Each gun assembly comprises the following principal units and subassemblies:

- Gun
- Breech mechanism
  - Screw box liner
  - Breech plug and obturator unit
  - Operating mechanism
  - Firing mechanism
- Salvo latch
- Firing lock
- Gas ejector

Assembly arrangements

Each of the right, center, and left gun assemblies consists of the above components and each is mounted in a separate gun slide (ch. 4). The three gun slides are pivoted horizontally on trunnions whose axes are in the same straight line. The common trunnion axis is above the shelf plate and forward of the turret transverse centerline. (See data, page 3-3.)

Each gun and slide assembly is located in its own turret subdivision. This provides separate gun room compartments that are isolated (by bulkheads and hatches) from adjacent guns, the turret officer's booth, the sight stations, the electric deck below the gun pits, and the powder hoist trunks.

Assembly differences

The gun assemblies are virtually identical in arrangement. The design of the left gun differs in that the holding down linkage trip lever and the

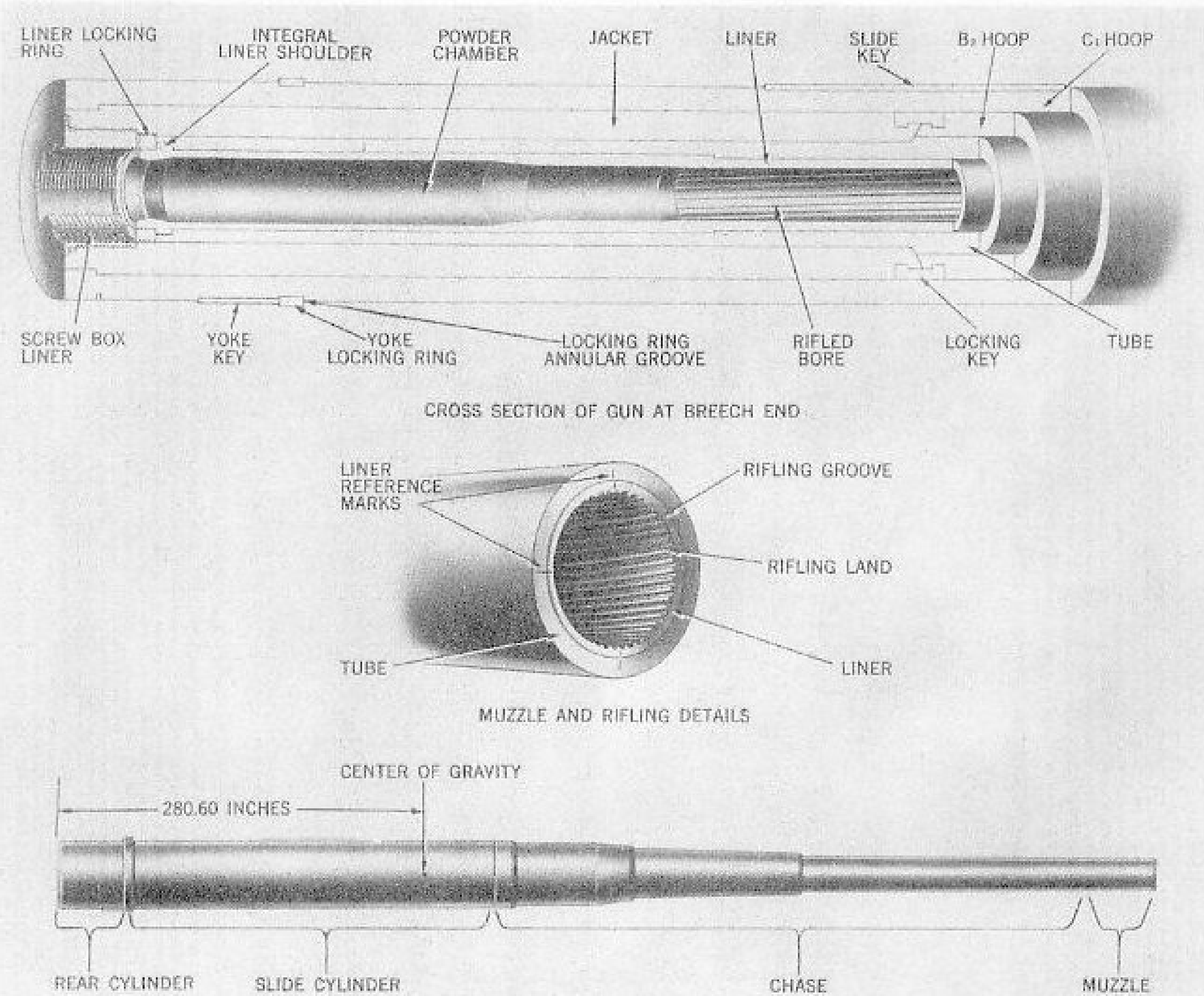


Figure 3-2. 16-inch Gun Mk 7 Mod 0, General Arrangement, Details and Profile

closing valve and the reduction valve. The elevating screw of the left gun attaches to a bracket at the right side of the gun slide. Otherwise, the left gun assembly is identical to the right and center assemblies.

Data

Weight and dimensions of the gun assemblies, the positions of the guns in the turrets, and other gun data are tabulated below. The data are the same for all turret installations.

Turret position

Bore axes, center	Turret centerline
Bore axes (right and left guns) from centerline, inches	122
Gun trunnion axis (above the plane of axes of roller path rollers), inches	198
Gun trunnion axis (forward of turret transverse centerline), inches	132

Gun dimensions

Over-all length (muzzle to breech), inches	816.0
Maximum diameter slide cylinder, inches	49.0
Maximum width of yoke, inches	66.0
Maximum height of yoke, inches	95.25

Weights

Gun, with screw box liner, lb	239,156
Gun, with recoiling parts, lb	292,000
Yoke weight, lb	38,500

Ammunition

16-inch AP Projectile	Mk 8, Mod 0
Weight, pounds	2700
Length, inches	72
Radius of ogive (windshield), cal	9 (144 in.)
16-inch, HC Projectile	Mk 13 Mod 0
Weight, pounds	1900
Length, inches	64
Radius of ogive, cal	9 (144 in.)
Powder charge (service)	
Number of bags	6
Total weight of charge, lb	650

Ballistics

Muzzle velocity, 16-inch AP Projectile Mk 8 Mod 0, fps	2425

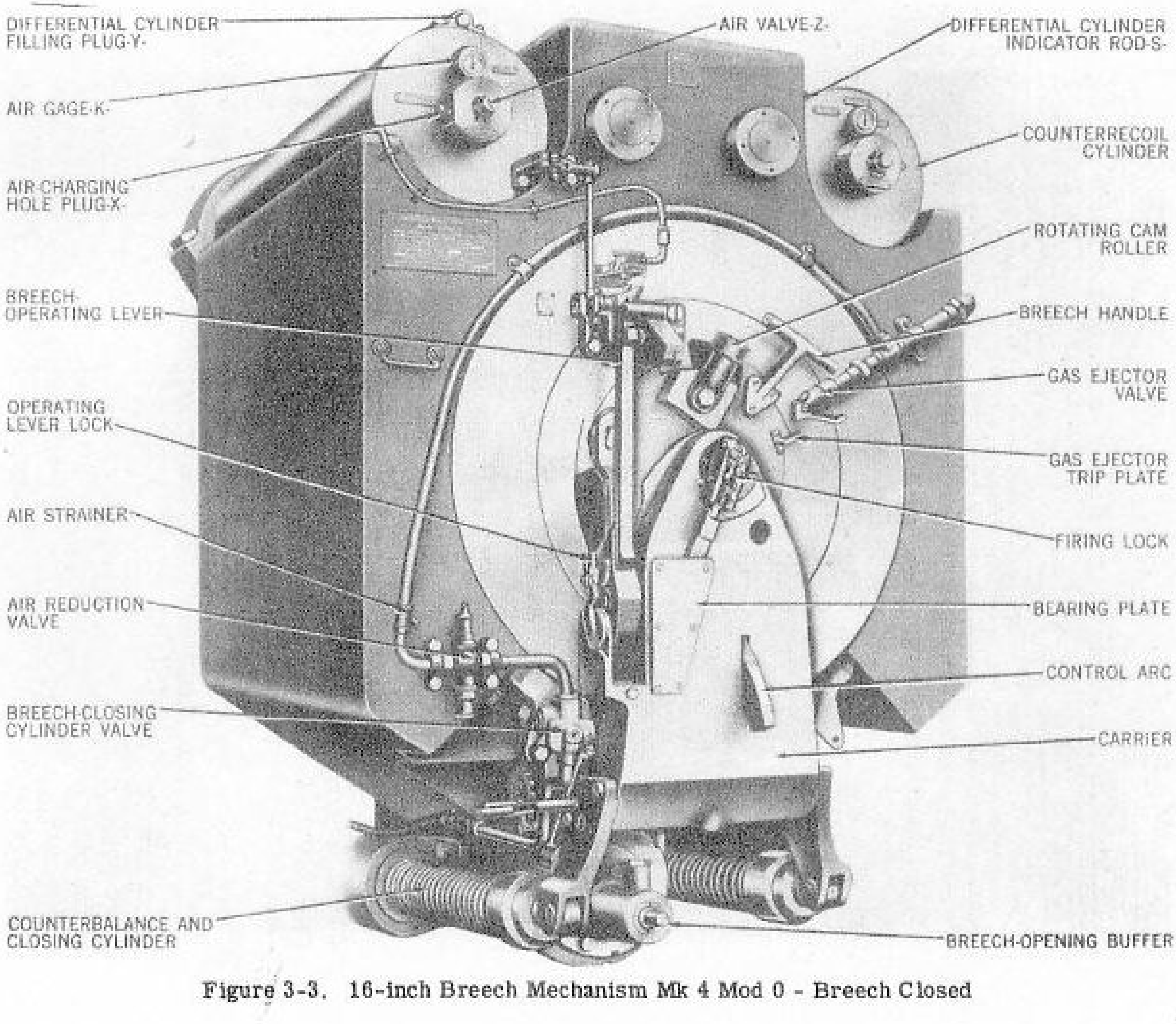


Figure 3-3. 16-inch Breech Mechanism Mk 4 Mod 0 - Breech Closed

Muzzle velocity, 16-inch HC Projectile 13 Mk 13 Mod 0, fps 2690
Range, 16-inch AP Projectile Mk 8 Mod 0, yd 40,185
Range, 16-inch HC Projectile Mk 13 Mod 0, yd 41,622
Rate of fire, rounds per minute 2
Range table, 16-inch AP Projectile Mk 8 Mod 0 . . . . OP 1457
Range table, 16-inch AP Projectile Mk 13 Mod 0 . . . . OP 1100

DETAIL DESCRIPTION

Gun

Type. The built-up type gun consists of the following forged steel components:

Components. The gun comprises a liner, tube, jacket, hoops, locking rings, a liner locking ring, and a yoke ring.

Design features. The liner, tube, jacket, and hoops are tube-shaped cylinders. They are assembled by heating and expanding each piece before slipping it into position over the tube. The pieces that are united end-to-end over the tube are held together by the locking rings. The liner is inserted into the tube, jacket, and hoop assembly from the breech end until its shoulder engages the breech end of the tube. A tight, single unit is formed when the heat-expanded components cool and shrink. The liner is locked in the tube by the liner locking ring, which threads into the jacket and is screwed up tight against the liner shoulder and tube. The liner lock-

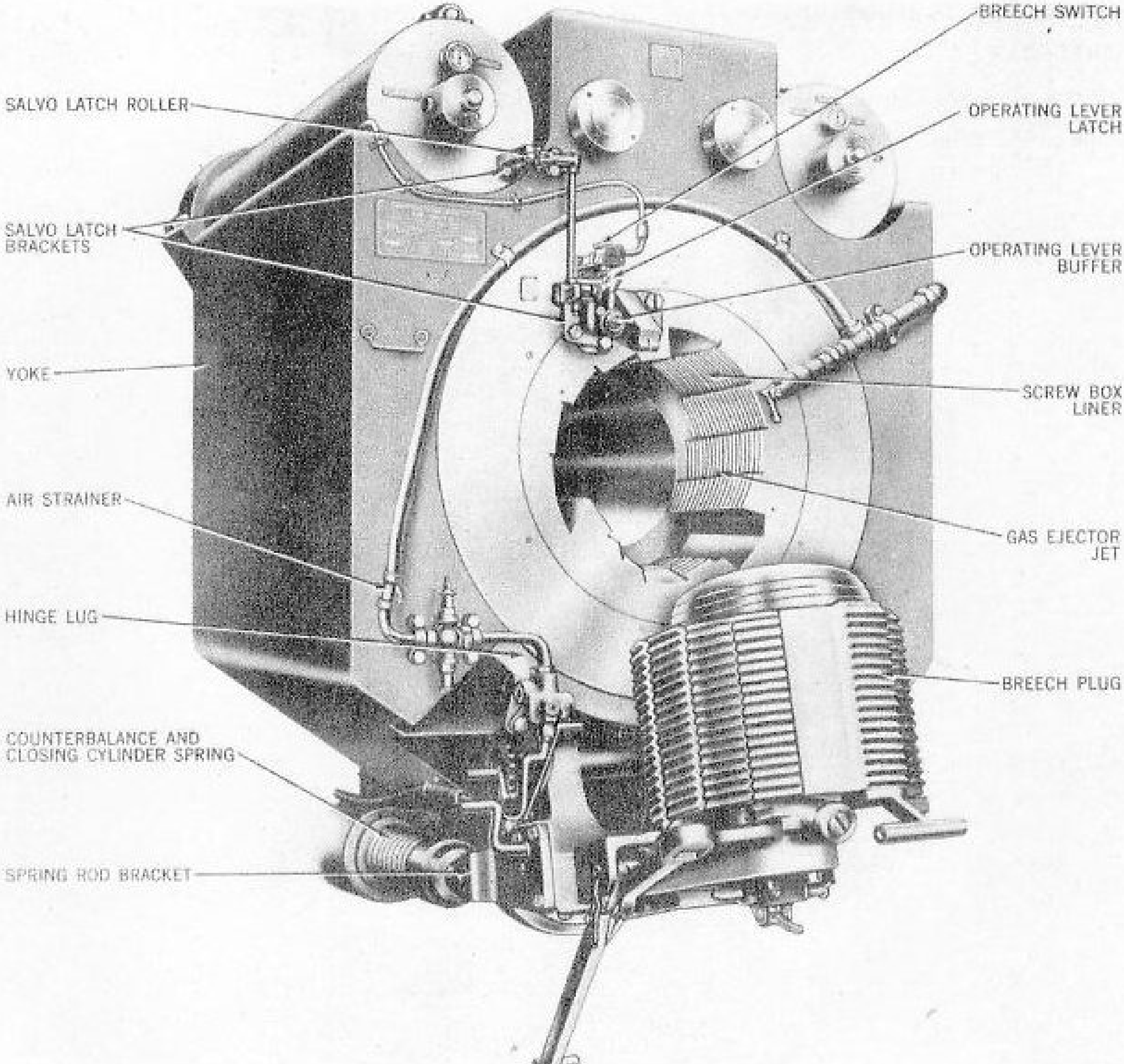


Figure 3-4. 16 inch Breech Mechanism Mk 4 Mod 0 - Breech Open (Operating Lever Safety Ratchet Mechanism Assembly Not Shown; See Figure 3-3)

ing ring prevents expansion of the gun liner toward the screw box liner when the gun is fired. Seated in the annular groove of the gun shoulder, the two-piece yoke ring attaches the yoke to the gun. The gun profile (fig. 3-2) is a straight slide cylinder 337.0 inches from the breech shoulder with a stepped and tapered chase to a straight muzzle cylinder. The gun profile, slide cylinder, and yoke are designed to facilitate gun removal from the slide and turret (through the gun port) without dismantling the turret.

Ballistic data tabulation. Gun data are tabulated below:

Length of gun, inches	816.00
Outside diameters:	
Rear cylinder, inches	49.00
Slide cylinder, inches	23.00
Muzzle, inches	23.50
Liner at muzzle, inches	18.46
Liner at rear, inches	22.10
Slide cylinder length, inches	337.00
Bore diameter, inches	16.00
Bore length, inches	800.00
Powder chamber:	
Choke diameter, inches	17.50
Bore diameter, inches	18.35
Length, inches	1105.82 ?
Volume, cubic inches	27,000
Rifling:	
Grooves	96
Length, inches	632.46
Length of plating, inches	690.00
Depth of grooves, inches	0.15
Twist	Uniform, right hand, one turn in 25 calibers
Weight (with screw box liner), pounds	239,156
Center of gravity, from breech, inches	280.6

Breech mechanism

Type. The breech mechanism (fig. 3-5) is of the rotating plug and swinging carrier type. Screw box liner and breech plug are segmented with stepped screw threads.

Design variations. The design is the same for the right and center guns of each turret. The left gun differs in the location of the levers for releasing the holding-down linkage and operating the closing valve.

Components. Each breech mechanism comprises the following principal units and subassemblies:

- Screw box liner
- Breech plug
- Obturator unit
- Carrier
  - Carrier hinge lug and bearings
  - Carrier holding-down latch
- Breech opening buffer
- Counterbalance and closing cylinder
  - Reducing valves
  - Control valve
  - Air strainer
- Breech operating mechanism
  - Operating lever
  - Operating lever safety ratchet mechanism assembly
  - Rotating cams
  - Firing mechanism
- Salvo latch
- Breech switch
- Firing lock
- Gas ejector

Screw box liner. The screw box liner is an adapter, made of nickel steel, threaded into the breech end of the gun. It provides an internal stepped thread to receive the breech plug. The liner has an outside diameter of 31.2 inches with right-hand buttress-type male threads, 0.50-inch pitch, for seating in the breech end of the gun. It is locked in position by the lower rotating cam and control arc and two lock screws. The rotating cam and control arc fits into a matching recess in the liner and gun. The internal surface of the screw box liner is divided into 15 sectors of 24 degrees each. These form three symmetrical groups, 120 degrees each, of five stepped sectors; the radius of each sector in each group decreases clockwise. The first sector is the largest radius and is blank. The succeeding four sectors are with buttress-type female threads, with 0.90-inch pitch. The breech plug locks with 24 degrees rotation of the plug after the threads engage. There are clearance cuts, of varying radii, in the blank and threaded sectors of the liner. These cuts provide clearance for the entering and withdrawing movements of the plug. An annular groove near the breech end of the screw box liner forms an annular air duct space between the liner and the gun. The space is part of the gas ejector system and is sealed with a plastic compound to prevent loss of air. Three holes are drilled from the air duct space through the screw box liner. These holes are fitted with nozzles to direct gas ejector air forward and toward the center of the gun bore. The face of the screw box liner is drilled and tapped so that the holder for a 16-inch Boresight MK 2MOD 0 may be mounted.

Breech plug. With the obturator unit (fig 3-6) mounted on its forward face, the breech plug is mounted to rotate on the carrier spindle. The plug is arranged with stepped, threaded sectors that engage with the screw box liner and close the breech of the gun. The surface of the plug is machined and is divided into three symmetrical groups, 120 degrees each, of five 24 degree sectors. Each group has four stepped screw thread sectors and a blank sector, decreasing in radii clockwise. These groups mate with similar groups of stepped screw thread sectors and blank sectors in the screw box liner, and close the breech by 24 degrees rotation. The buttress-type threads are right hand with 0.90-inch pitch. The breech plug is bored through, from front to rear, to receive the carrier spindle. The plug bore, at its forward part, forms a bearing surface for the carrier spindle. At its rear part, the plug bore is threaded with 0.90-inch pitch, square threads. These threads mate with similar threads that form the outer surface of the plug adjusting nut (figs. 3-5 and 3-6). This nut is an adapter that is threaded on the carrier spindle. It is used to compensate for movement of the gun hoop and hinge lug; it is fully described under "adjustments". The bearing portion of the plug bore is lubricated from an oil hole in the upper blank sector; the threaded portion is lubricated from an oil hole in the plug face. The face of the plug is drilled to receive the plug ball pin (figs. 3-6 and 3-12) and the breech handle (fig. 3-3), and is provided with slots for dovetail assembly of the rotating cam rollers.

Obturator unit. The obturator unit (fig. 3-6) is assembled in the breech plug and carrier; it consists of a mushroom, gas check pad, and two steel split rings. This unit prevents the escape of gases from the breech of the gun when it is fired. The mushroom is a nickel steel forging, machined to a mushroom and stem appearance. It covers the inner forward face of the breech plug, with its stem extending rearward through the plug and carrier. Between the mushroom head and breech plug are the gas check pad and two split rings. The gas check pad is composed of alternate vulcanized layers of oil-resistant rubber and fiber-glass cloth previously coated with an adhesive. The pads fit the forward face of the plug. One split ring is at the rear of the pad, the other is at the forward side; both rings serve as a protection for the gas check pad. The mushroom is keyed to the carrier and held tightly against the pad by a split nut and compressed spring. The mushroom stem, to the rear of the split nut, has a bayonet-type joint to which the firing lock is attached, and it is made to receive the primer seat bushing. A hole is bored from the primer seat bushing through the mushroom face. This hole provides for igniting the gun charge when the firing lock mechanism detonates the primer. When the gun is fired, the gas check pad is distended by the force of the gases of combustion. This distention seals the gun breech and prevents escape of the gases. Directions for checking the thickness of the gas check pad are given in the Instructions section of this chapter, page 3-20. Directions for lubrication of the pad are given in the chapter on Lubrication.

Carrier. The carrier (figs. 3-5 and 3-6) is a steel casting with an integral spindle at its upper part on which the breech plug is pivoted. The carrier is mounted on the hinge lug, which is bolted to the gun shoulder. The breech plug is mounted to rotate on the carrier, which also provides a fulcrum point for the operating lever to rotate the plug. The firing lock operating bar, the firing mechanism, and spring rod brackets of the counterbalance assembly are all mounted on the carrier. The integral hollow spindle of the carrier, fitted with a bronze bushing at its forward end, forms the plug bearing.

Carrier hinge lug and bearings. The cast steel carrier hinge lug (figs. 3-5 and 3-7) provides two hinge projections for the carrier hinge pin, a lug for the closing latch lever, and a lug at either side for the closing valve. The hinge lug, shaped to fit the gun shoulder, is centered in position by a cover plate retained dowel and is bolted to the bottom of the gun shoulder. The two lugs for the carrier hinge bearings are provided with adjustable eccentric bushings. Inside the eccentric bushings, between the bushings and the hinge pin, are roller bearings which are retained by the hinge pin, nut, and carrier. The hinge pin fits the carrier and rotates with it in the hinge lug bearing.

Carrier holding-down latch. The holding-down latch (figs. 3-7 and 3-8) is a stiff leg or toggle between the hinge lug and the carrier; it locks the carrier down in a breech open position. A crank extends through the spring rod brackets and the carrier to act as a pivot pin for one lever of the stiff leg. It is keyed to that lever so that the crank, when depressed, pulls the holding-down latch past center and collapses it. While the breech is opening, the hinge spring straightens the holding-down latch and brings it past center to its locked position to secure the breech in an open position. To close the breech, the latch operating crank (or lever) is depressed by foot from the gun loader's platform.

Breech opening buffer. The breech opening buffer (fig. 3-9) is mounted on the recoil cylinder piston rod, below the breech. It contacts an integral raised pad of the carrier to buff the last 14 degrees of carrier opening rotation. The buffer is of the piston and cylinder type with three throttling grooves in the cylinder wall. An expansion chamber in the filler cap allows for the volume of liquid displaced by the piston rod, which extends through a Garlock type packing and packing gland. When the breech is closed, the piston is returned to the released position by a spiral spring.

Counterbalance and closing cylinder. The counterbalance and closing cylinder (fig. 3-5) is a dual

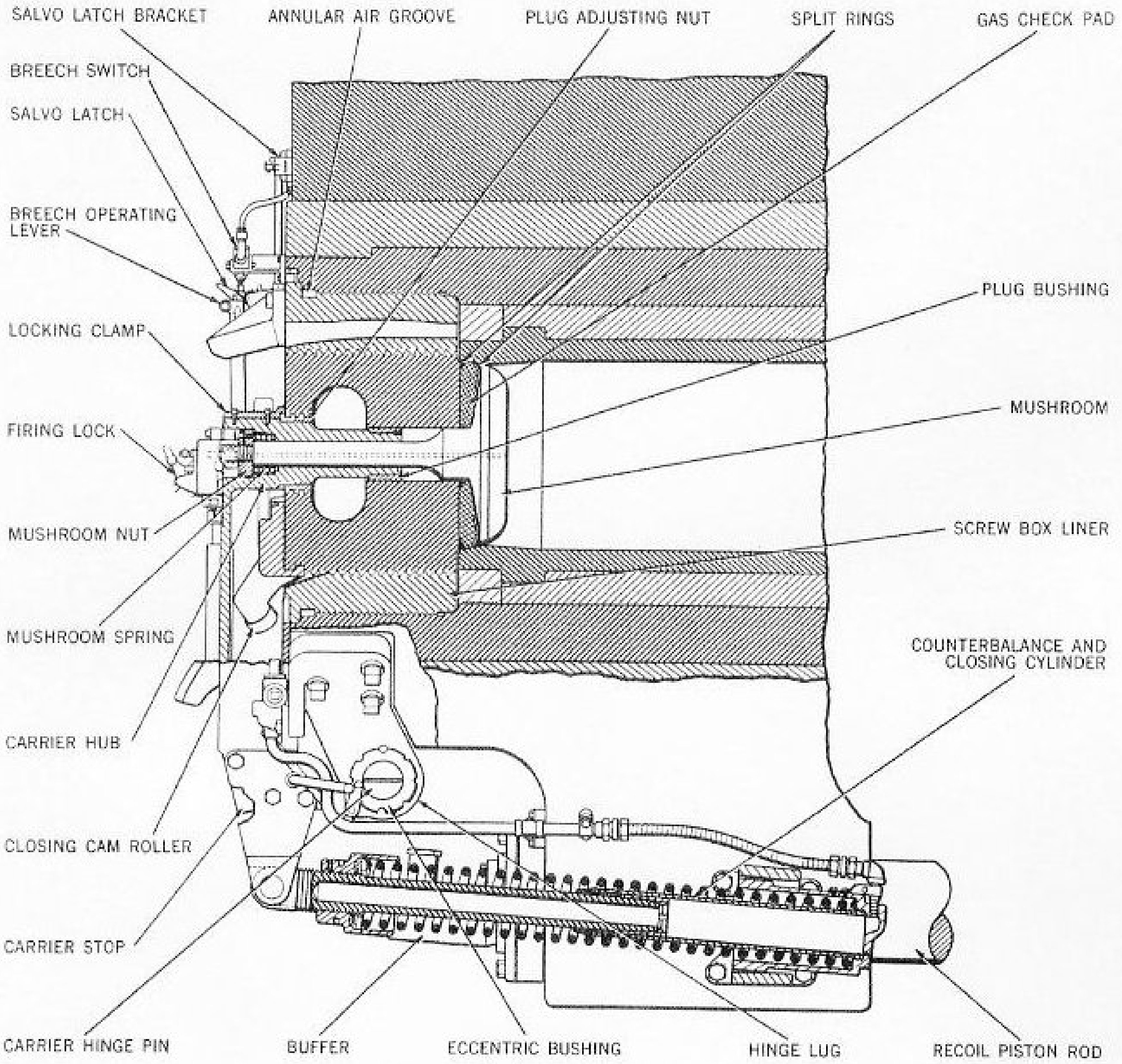


Figure 3-5. 16-inch Breech Mechanism Mk 4 Mod 0 - Sectional View

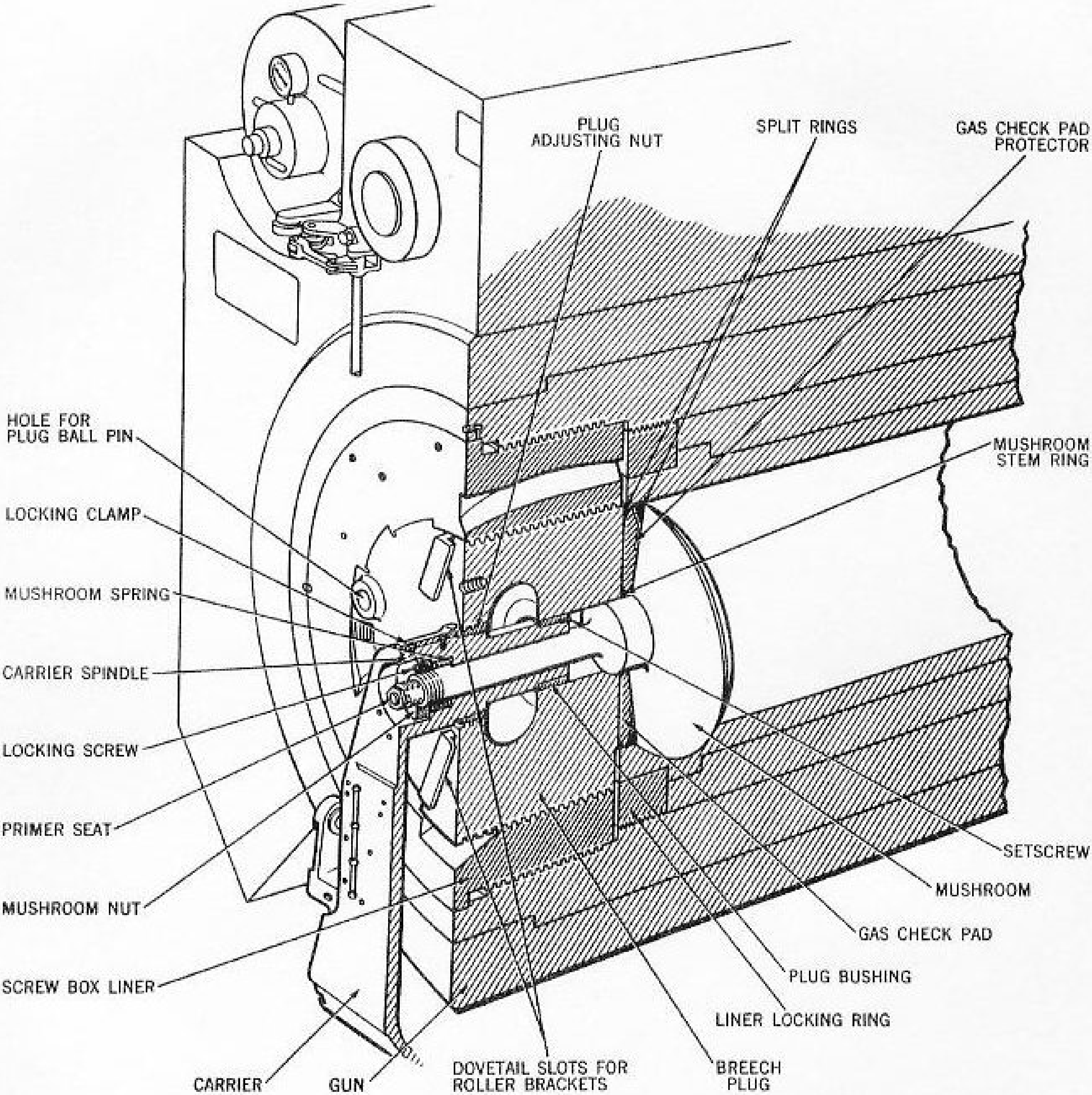


Figure 3-6. Breech Plug Obturator Assembly

arrangement for balancing the weight of the breech assembly in opening and for swinging the carrier upward in closing the breech. It is a spring and pneumatic type mechanism. The closing cylinder bracket is mounted on the yoke and provides bearings for the journals of oscillating bearings. These bearings permit oscillation of the assembly in opening and closing the breech, and provide spring seats and caps for the closing cylinders. Each air cylinder screws into its oscillating bearing. With the piston and spring, the air cylinder extends through the spring to the spring rod brackets and attaches to the carrier. The spring compresses between the oscillating bearing on one end, and a ball bearing washer within the spring adjusting nut at its other end. The spring is adjusted on both cylinders so that their combined action will prevent the breech down swing from being stopped with damaging shock, and yet allow the holding-down latch to secure the breech in the open position.

The air supply for operating this mechanism comes from the air supply of the gas ejector system. The gas ejector air pressure, from 150 to 200 pounds per square inch, is reduced to approximately 40 pounds per square inch by an adjustable air reduction valve. The desired air pressure for normal closing action is obtained by adjustment of a square-headed screw at the top of the reduction valve. The piping, at the outlet side of the reduction valve, directs the reduced air pressure to the closing control valve. The control valve ports air to the breech closing cylinders and is operated manually to open. When the control valve is opened, breech closing movement is started.

Reducing valve. The adjustable reduction valve, installed in this breech closure system, is a commercial product, either Mason or Foster type. Each is described below:

Mason type. The Mason type air reducing valve (fig. 3-11) is pilot valve controlled. The pilot valve, controlled by reduced gas ejector air pressure, is spring-held against a diaphragm. As the diaphragm is moved against the pressure of an adjusting spring by the reduced air pressure, it moves the pilot valve with it. The pilot valve controls the opening of the main valve by porting gas ejector air pressure through an air passage in the valve body to the stem of the piston. The piston, forced up by the gas objector air pressure, contacts the spring loaded main valve to unseat it and thus permit a flow reduced air pressure to the breech closing valve. Pressure in the outlet air pipe enters the chamber beneath the diaphragm, through an air port in the valve body, and controls the pilot valve. In action, the valves, the diaphragm, and the piston are constantly in motion, seating and unseating; thus the air pressure that is ported from the reducing valve is delivered to the breech closing valve at a pressure that is regulated

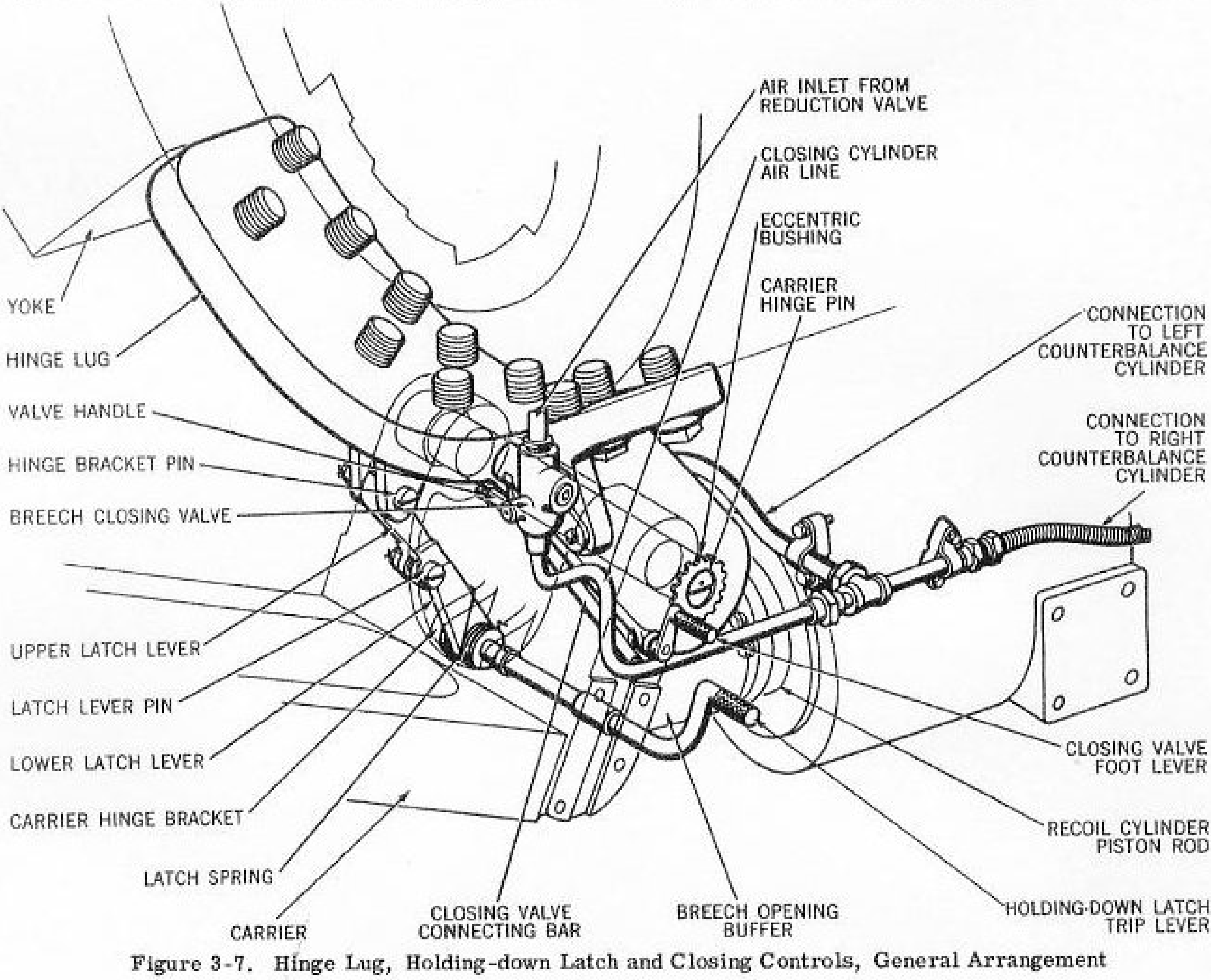


Figure 3-7. Hinge Lug, Holding-down Latch and Closing Controls, General Arrangement

by the setting of the adjusting screw. The piston is prevented from chattering by an integral dashpot arrangement. This valve assembly and the Foster valve are both 3/4 inch reducing valves with union connections to the air pipes, and both are secured to the face of the yoke by pipe clips.

Foster type. The Foster valve is used alternately as a reducing valve for the closing cylinder system. It functions, as does the Mason valve, to control air pressure. It consists of a valve, controlled by a spring-loaded diaphragm, between closing cylinder pressure and atmospheric pressure. The main valve is a faced plunger, spring-held against a funnel-shaped piece that extends through the valve port and connects to the diaphragm. The main valve operating piece extends through the diaphragm. It is held against the main valve by spring pressure and moved away from the main valve by ported closing cylinder pressure to allow the main valve to close. The amount of air pressure depends upon the spring pressure behind the diaphragm and is adjustable by a spring pressure adjusting screw on top of the valve.

Control valve. The rotary type breech-closing cylinder control valve (fig. 3-10) is manually opened by a lever on the hinge lug, adjacent to the holding-down latch trip lever. The valve is automatically closed when the carrier reaches the breech closed position. The actuating foot lever of the control valve is located so that it can be operated simultaneously with the trip lever of the holding-down latch. The control valve is bolted to the hinge lug.

Air strainer. The air line piping, at the inlet side of the reduction valve, is equipped with an air strainer. This insures filtered air in the breech operating air line.

Breech operating devices. The breech mechanism has operating devices for manually rotating the plug in opening. Other devices interlock the breech against opening until the gun has fired. Still other elements provide firing lock action which parallels the breech opening and closing movements. A description of the breech operating devices follows:

Operating lever. The steel breech-operating lever is pivoted on the side of the carrier (fig. 3-12). Motion of the operating lever about its pivot point moves the connecting rod to rotate the breech plug through 29 degrees. The operating lever contacts a rawhide bumper at the end of its opening swing. In closing, the swing of the operating lever is stopped by a buffer in the salvo latch bracket. The operating lever is secured in the salvo latch (when the breech is closed) by a spring-plunger type beveled catch in the lever handle.

Operating lever safety ratchet mechanism

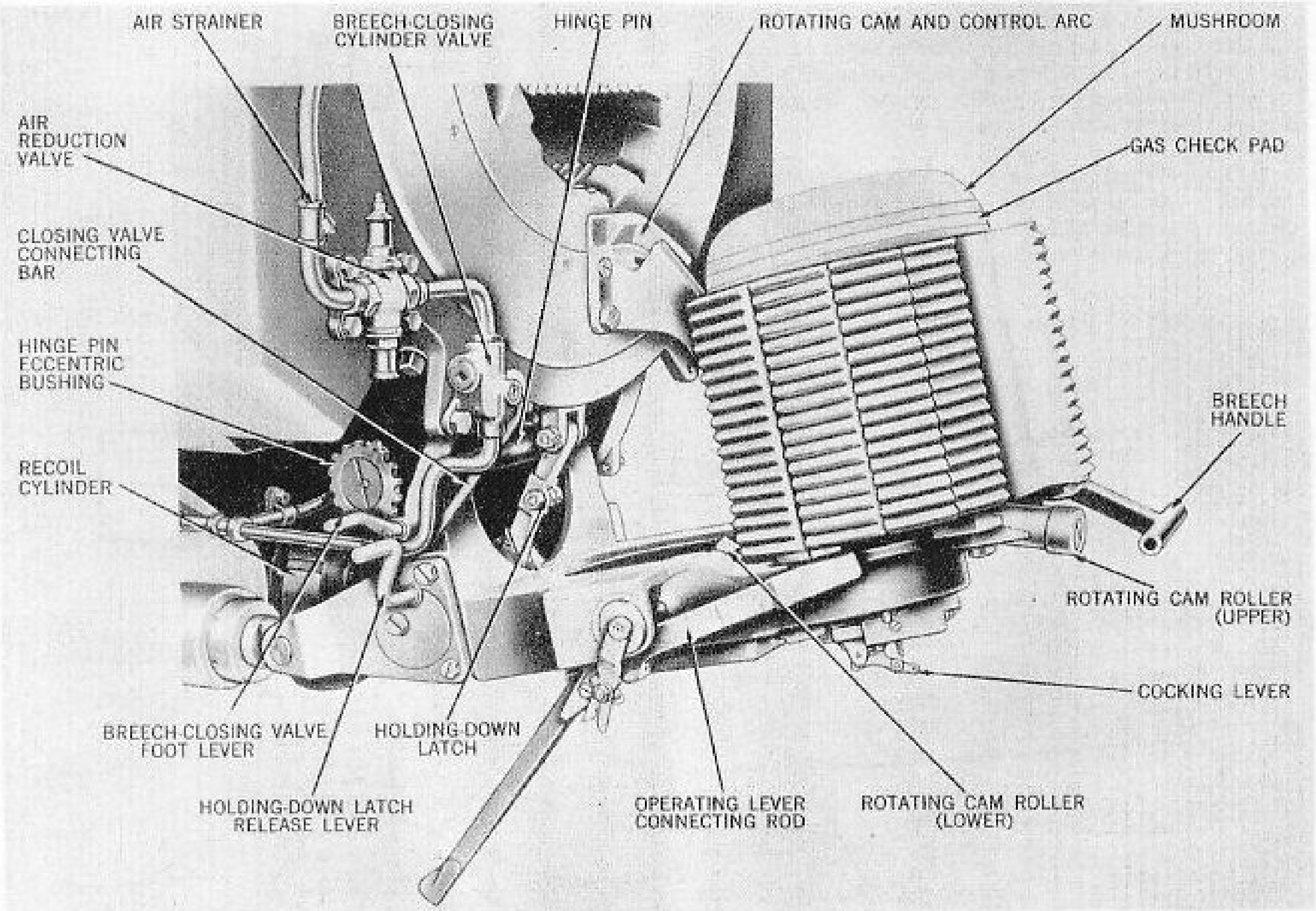


Figure 3-8. 16-inch Breech Mechanism Mk 4 Mod 0 - Breech Open Showing Holding-down Latch (Operating Lever Safety Latch Mechanism Assembly Not Shown; See Figure 3-3)

assembly. This assembly prevents the manual breech operating lever from reversing direction in the event it has not been fully latched during the breech closing operation. The assembly is composed of two subassemblies: the pawl and bracket assembly mounted on the operating lever, and the safety ratchet and ratchet bracket plate assembly mounted on the carrier. The pawl (attached to the operating lever) rides over the ratchet teeth (attached to the carrier) when the breech plug is opening. When the plug is fully retracted, the pawl returns to the neutral position. During the closing operation, the pawl engages the ratchet teeth. When the breech is fully closed and the handle in the latched position, the pawl swings free to the neutral position.

Connecting rod. The operating lever connecting rod extends from a pivot on the lever (2.75 inches from the lever pivot point) to a plug pin in the breech plug rear face. The connecting rod is joined to the operating lever by a pin. The breech plug end of the connecting rod has split socket bronze bearing into which the ball of the plug pin is fitted. This forms a universal-type joint between the breech plug and connecting rod.

Plug pin. The plug pin is a solid, cylindrical piece of steel, with a ball-like knob at its outer end. The ball of the plug pin is fitted to, and secured in, the split socket bronze bearing of the connecting rod. The stem of the plug pin fits into the outer face of the breech plug. The plug pin is secured by a locking pin that passes horizontally through the plug pin stem and screws into the breech plug.

Wedge retracting lever catch. The wedge retracting lever catch (fig. 3-14) is fastened to the breech mechanism operating lever. It connects the operating lever to the firing mechanism.

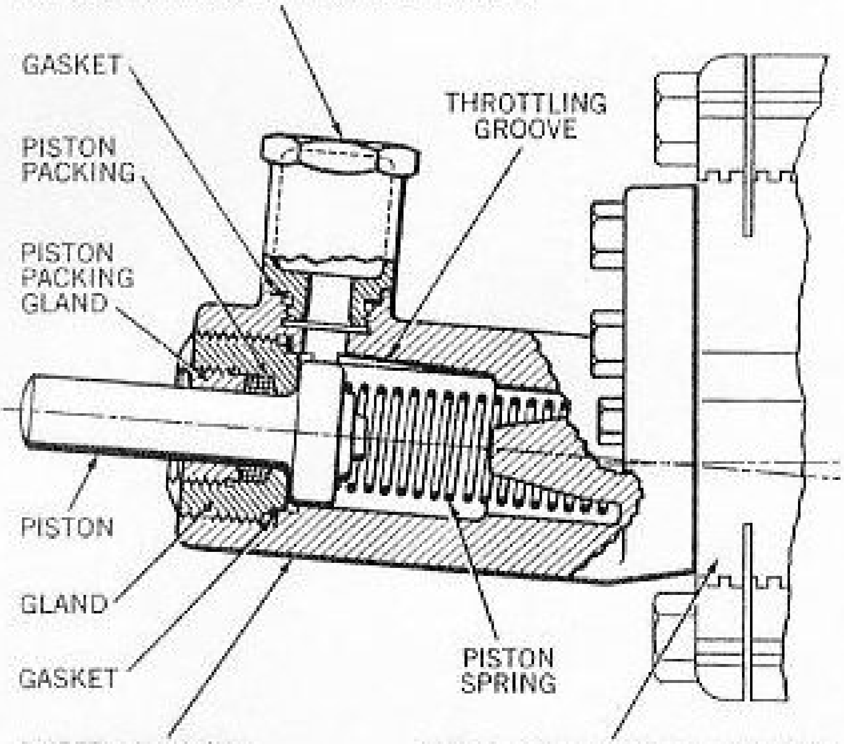


Figure 3-9. Breech-opening Buffer, Sectional View

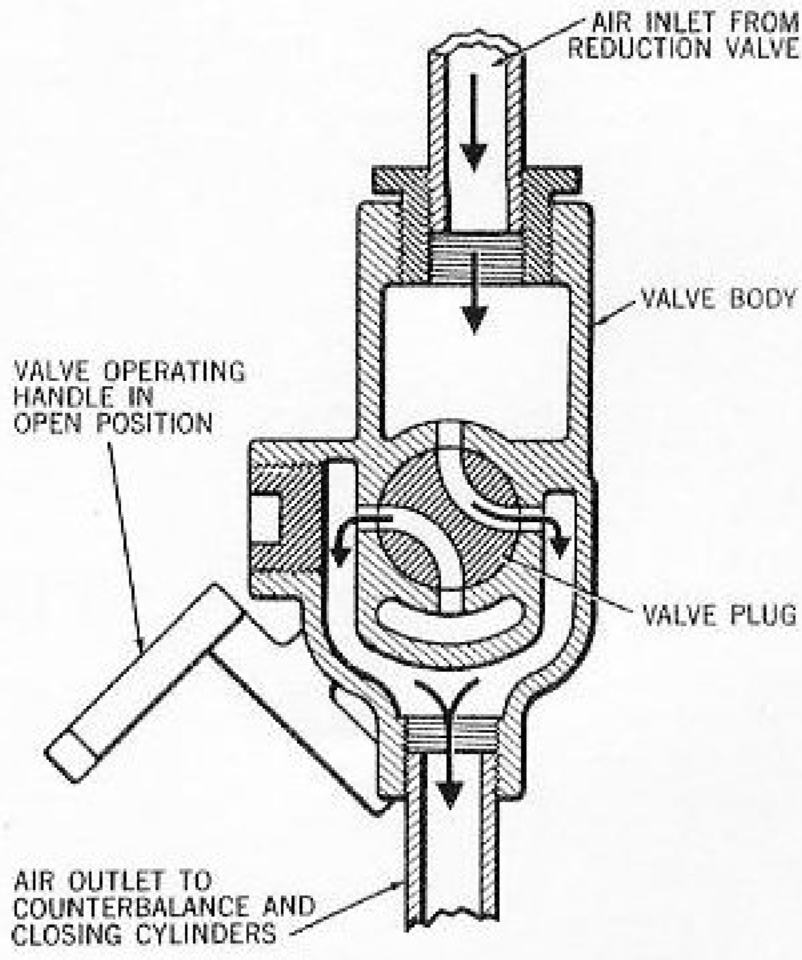


Figure 3-10. Breech-closing Cylinder Valve, Sectional View

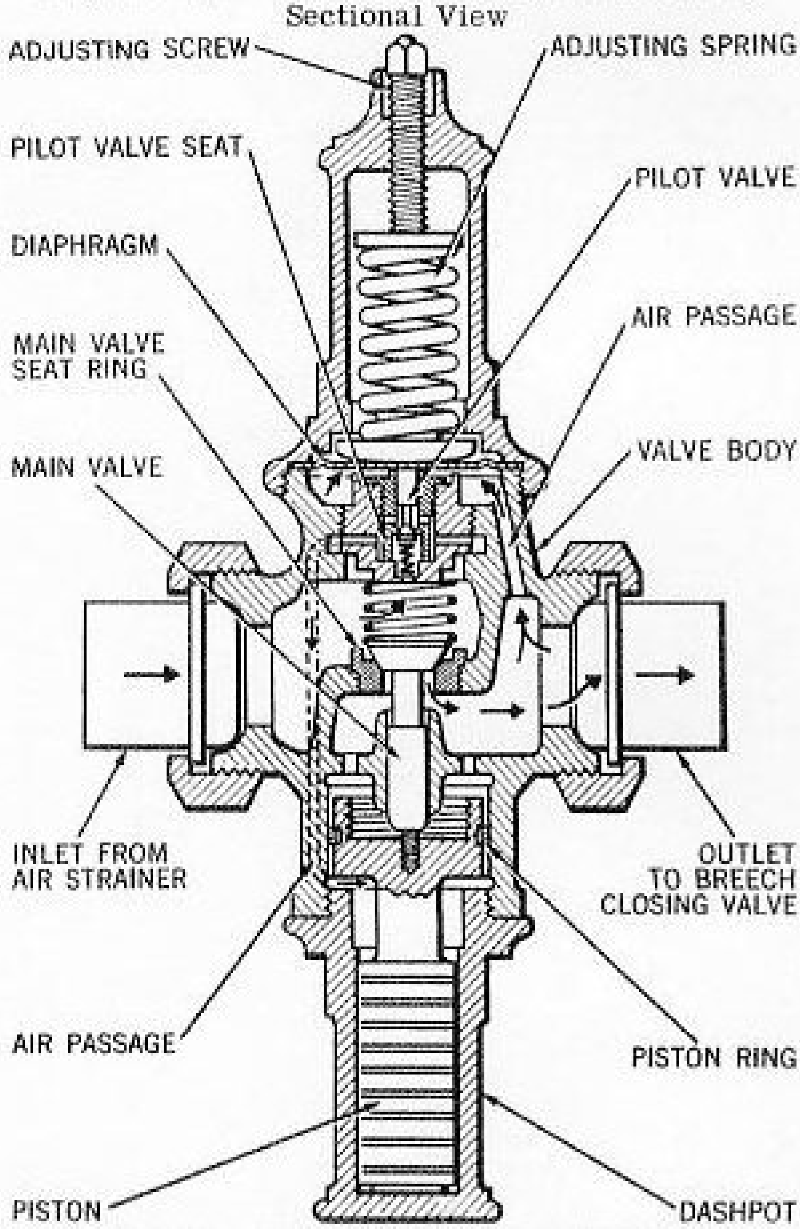


Figure 3-11. Breech Mechanism Air Reduction Valve, Mason Type, Sectional View

Rotating cams. When the breech is closed, plug and carrier swinging motion is changed to plug rotation by cam rollers (on the plug) in contact with stationary cams (on the breech). The stationary upper and lower cams, attached to the breech, are called rotating cams. The upper cams (fig. 3-12), secured to the screw box liner by two bolts, is further held by the lower salvo latch bracket, which fits into an undercut in the side of the cam flange. The lower cam (fig. 3-8) is fitted into a recess cut in the gun and screw box liner; it is secured with four bolts.

The upper and lower brackets for the cam rollers fit into dovetail slots (fig. 3-6) in the rear face of the breech plug and are each secured by a bolt. The rollers (fig. 3-12) are pin-mounted on the brackets.

After the plug has been completely rotated to open, a control arc retains the plug in its rotated position. The control arc, an integral part of the lower cam, is made on a radius about the carrier hinge center. With the breech closed, the control arc projects through the carrier.

The cams and cam rollers are carefully set at manufacture. Because of the exact position requirements, they are not provided with adjustment.

Firing mechanism. The firing mechanism (fig. 3-14) is a mechanical linkage between the firing lock and the breech operating lever. During breech opening movement, the firing mechanism acts to eject the empty primer case. The breech operating lever is connected to the wedge retracting lever by the wedge retracting lever catch. The crank shaft of the wedge retracting lever extends through the pivot end of the operating lever to the crank-operated crosshead. The crosshead slides in a vertical slot in the carrier. The crosshead is connected to the firing lock operating bar by a bearing block that is attached to the crosshead and slotted to the lock operating bar. This mechanism changes the rotation of the wedge retracting lever to vertical movement of the crosshead and lateral movement of the lock operating bar. The crosshead and the lock operating bar are retained in position by the bearing plate. A groove, machined in the bearing plate,

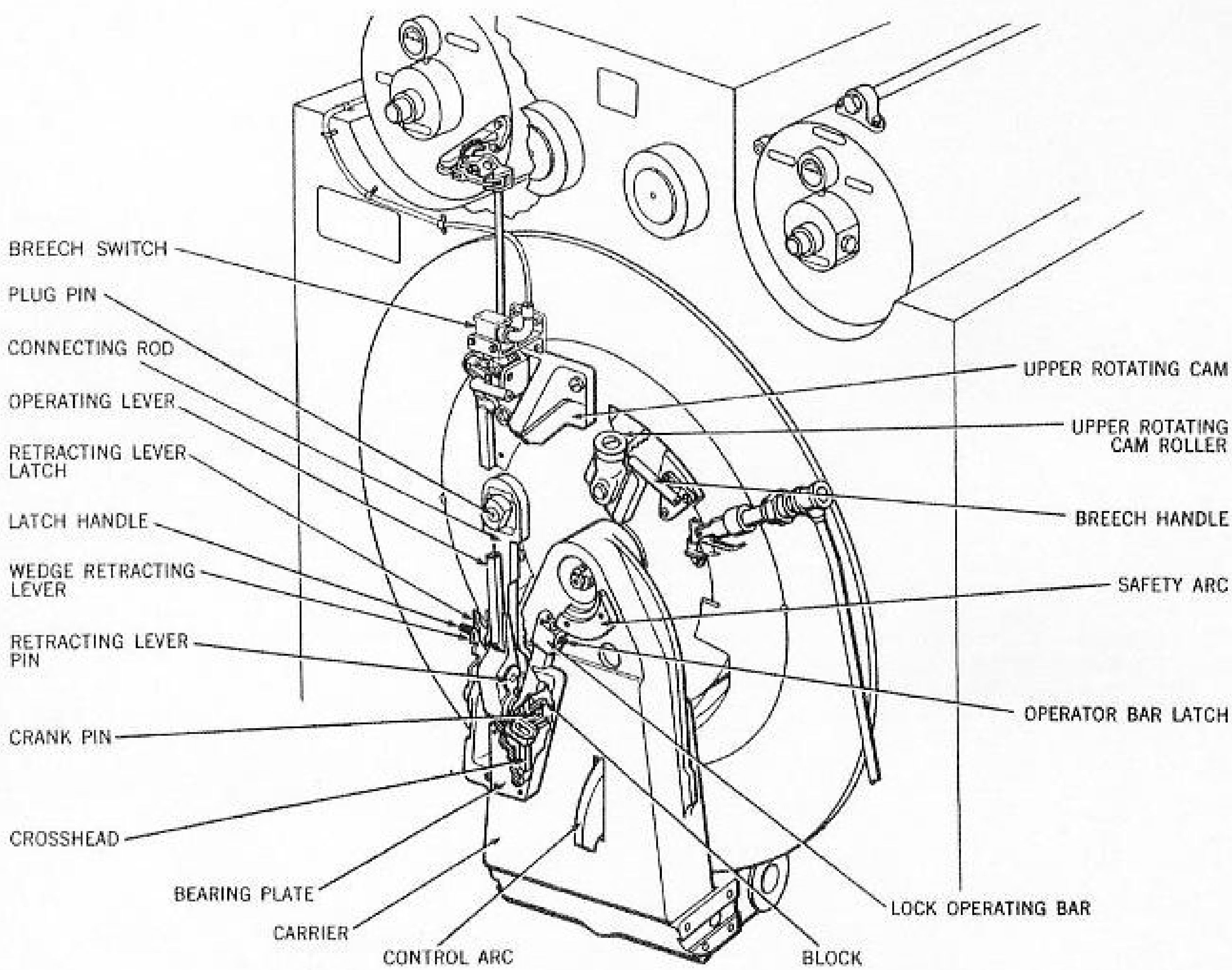


Figure 3-12. Breech Opening Mechanism, General Arrangement

receives the lock operating bar. In opening the breech, rotation of the wedge retracting lever causes the lock operating bar to retract the firing lock wedge and eject the used primer. In the case of a misfire, the wedge retracting lever can be unlatched and rotated independently of the breech operating lever to retract the wedge without opening the breech. Also, the firing lock can be removed without opening the breech.

The salvo latch is an automatic latching device which prevents opening the breech of a loaded gun. The salvo latch (fig. 3-13) prevents lifting of the operating lever latch when the breech is closed. Gun recoil operates the salvo latch to release the lever latch.

A lower salvo latch bracket is mounted on the gun. The salvo latch lever shaft, with the salvo latch lever cam at its upper end, extends from the lower latch bracket to the upper salvo latch bracket. The latch lever cam is positioned so that it contacts a cam roller mounted on a bracket on the left air bottle of the counterrecoil system. When the gun recoils, the cam roller moves aside the latch lever cam and rotates the latch lever shaft to displace the latch locking arm. Displacement of the latch locking arm allows the salvo latch catch (not visible in fig. 3-13) to rise and prevent the latch locking arm from returning to the lock position. The latch locking arm, attached to the lower end of the latch lever shaft, is positioned in the way of an integral lug of the operating lever latch; the lug prevents lifting of the lever latch. When the latch locking arm is held in its displaced position by the latch catch, the operating lever latch can be raised and the operating lever moved. When the operating lever is raised, it compresses the spring of the latch catch and allows the latch locking arm to be repositioned over the latch catch and in the way of the lug of the operating lever latch.

A deliberate act is required to defeat the purpose of the salvo latch. The operating lever cannot be released to open the breech until the gun has recoiled. However, if the latching arm is moved aside, the operating lever latch remains unlocked until it is lifted to release the operating lever. This action depresses the latch catch and resets the mechanism. The latch locking arm can be secured in its unlocked position for drill purposes by securing the latch locking pin in hole B in the lower salvo latch bracket. Immediately after drill, the latch locking pin must be removed from hole B and returned to the turret officer's booth.

The salvo latch caution plate is fastened to the gun at the left side of the lower salvo latch bracket. It reads:

CAUTION

SCREW PIN IN HOLE "B" FOR DRILL ONLY. AT ALL OTHER TIMES IT MUST BE KEPT IN TURRET OFFICER'S BOOTH.

Integral with the lower salvo latch bracket is the cylinder and expansion chamber of the operating lever buffer. The buffer is of the plunger type and is filled with recoil cylinder fluid. The buffer is filled to the level of the filling plug and, with the plug in place, contains sufficient air for operation.

Breech switch. Limit Switch MK 6 MOD 1 is mounted on the breech face of the gun as shown on figures 3-1 and 3-13. This microswitch is closed when the breech operating lever is latched. When closed, the breech switch, with closed blade contacts and with the recoil switch in battery position (ch. 4), retracts the gun captain's ready switch control solenoid and permits the switch to be moved to the READY position. It also illuminates a BREECH CLOSED indicator light adjacent to the gun captain's panel. The breech switch is part of Ready Light Circuit IR, described in chapter 15.

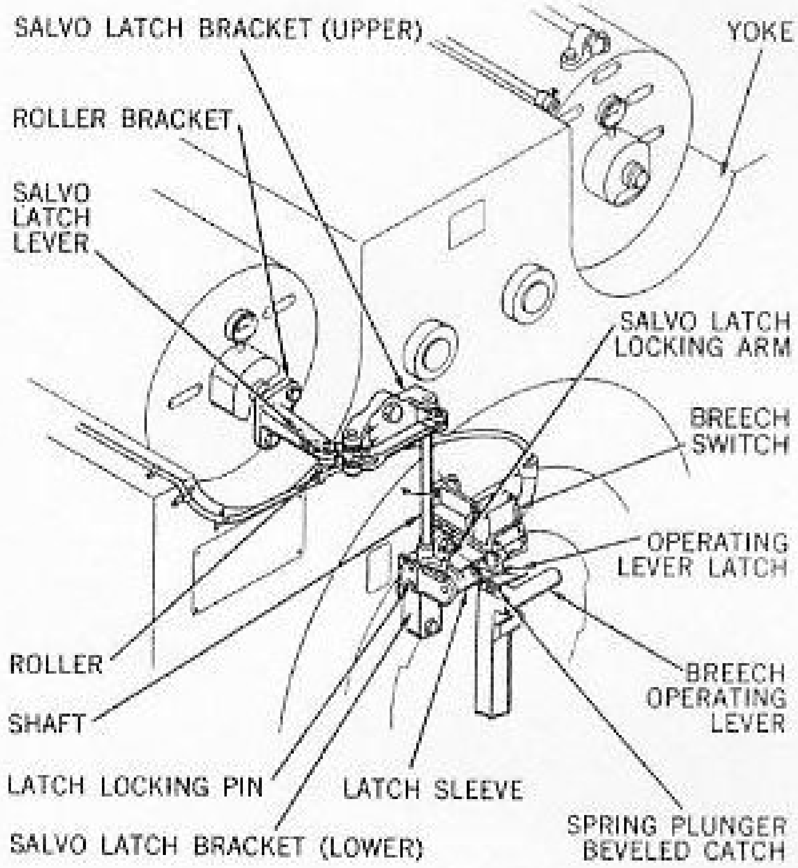


Figure 3-13. Breech Mechanism Salvo Latch

Firing lock

The firing lock, as shown in figures 3-15 and 3-16, fires the primer to ignite the powder charge in the gun. Normally, the primer is fired electrically; however the firing lock design provides for percussion firing in emergency. The firing lock is mounted on a bayonet-type joint at the breech end of the mushroom stem. The receiver, the main structural component of the lock, contains a wedge that slides back and forth to close or open the recess in which the primer is seated. This wedge, operated by the firing mechanism, is connected to the breech firing mechanism by a spring latch in the end of the lock operating bar. The receiver has a catch that retains the primer after it is inserted and an extractor that ejects the primer case after firing. The wedge contains an insulated firing pin which carries the electric current to the primer bridge for firing. For percussion firing, a hammer, firing spring, and cocking lever attached to the wedge delivers a blow to the same firing pin that is used for electric firing.

For safety, the firing lock is constructed so that the primer cannot be fired either electrically or by percussion until both the breech and the lock are fully closed. The clearance to be maintained between the firing lock and the carrier is given in the instructions section of this chapter, page 3-20.

Components. The Firing Lock MK 14 MOD 5 consists of the following components:

- Receiver
- Wedge
- Firing pin assembly
- Cocking lever
- Hammer
- Contact piece
- Hammer guide block
- Primer retaining catch
- Extractor and extractor cam
- Extractor stop screw

Receiver. The receiver (fig. 3-15), approximately rectangular in shape, is milled out to receive the wedge. Secured to the breech mechanism by means of a bayonet-type joint on the end of the mushroom stem, the receiver is prevented from rotating by the

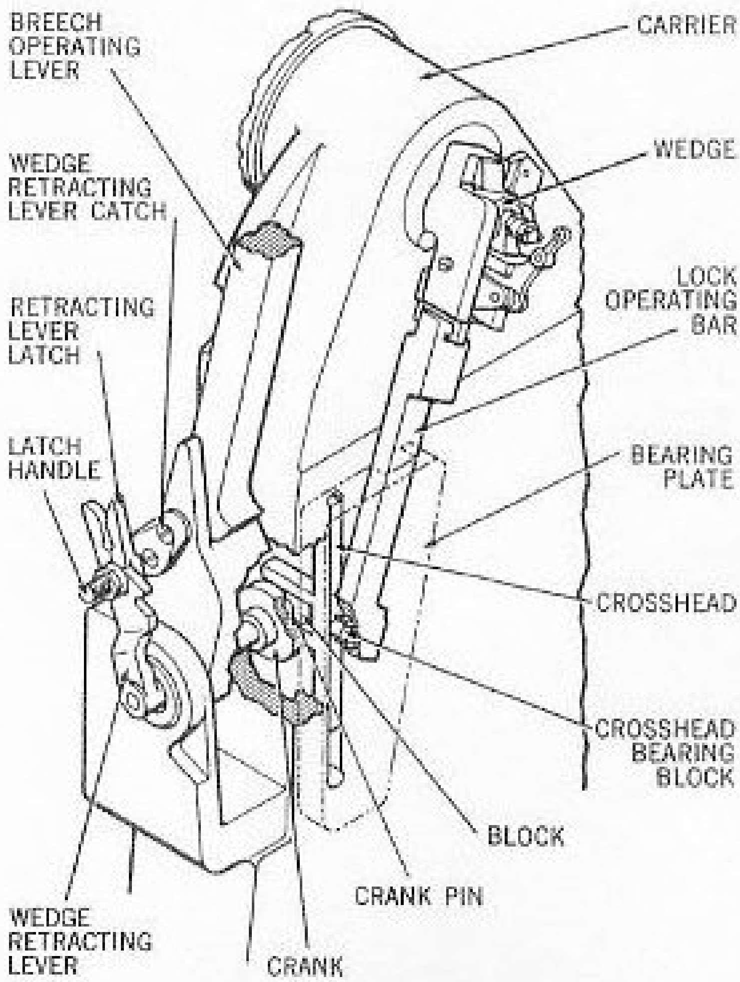


Figure 3-14. Breech Mechanism Firing Mechanism

lock operating bar, which is connected to the wedge. The receiver is drilled for the extractor pin and the necessary clearances are milled for the extractor. There is a slot on one side of the receiver into which a lug on the hammer slides. This lug prevents the hammer from being pulled back for percussion firing after the wedge has started to retract.

Wedge. The wedge (figs. 3-17 and 3-18), the operating component of the firing lock, slides in the receiver when it is actuated by the lock operating bar of the breech firing mechanism. A yoke on the end of the operating bar straddles the wedge and is secured to it by a pin. The opening in the wedge through which this pin passes is elongated to provide for the movement of the mushroom stem at the time of firing. Lost motion between the wedge and the operating bar is taken up by a spring and plunger.

The wedge stop screw (fig. 3-15) projects through the receiver into a slot in the wedge to prevent the wedge from being entirely withdrawn from the receiver.

The wedge face plate (fig. 3-17) is made of hardened steel with a hole through which the end of the firing pin passes. The face plate is dovetailed in the wedge. The center part of the face plate is insulated to prevent a short circuit in the firing system should the firing pin point come in contact with the face plate. The face plate takes the thrust of the primer when it is fired.

Firing pin assembly. The firing pin assembly (fig. 3-18) is held in position in the wedge by means of the firing pin bushing, a small steel sleeve threaded into the wedge where it bears against a shoulder on the firing pin sleeve. A small spring which surrounds the firing pin sleeve returns the pin to its normal position after firing.

The assembly of the firing pin, firing pin insulation sleeve, and firing pin sleeve are completely assembled during manufacture and are supplied only as a complete unit.

Cocking lever. The cocking lever (fig. 3-15) pivots on its axle, which is supported between two lugs that extend from the wedge. Incorporated within the cocking lever is a torsion spring that tends to move the lever toward the lock. One end of this spring engages a recess in its housing in the cocking lever, while the other end is engaged by a hole in the torsion washer, which functions as a bearing for the lever as well as a cover for the spring housing.

The cocking lever lug is on the right side of the cocking lever and extends toward the face of the wedge. This lug acts as a latch to engage the hammer catch when the hammer is pulled back for percussion firing. The cocking lever lug is of such a length that, when the cocking lever is in the normal (uncocked) position, it bears against the wedge and transmits any accidental blow directly to the wedge instead of through the hammer and firing pin.

Hammer. The hammer is pivoted on an axle (fig. 3-17) supported by the same two lugs on the wedge as is the cocking lever. A spring-operated hammer catch is fitted in the hammer and projects from the right side. This catch is engaged by the latch on the cocking lever and rides on it when the cocking lever is pulled back by the lanyard for percussion firing. When the lever has been pulled back

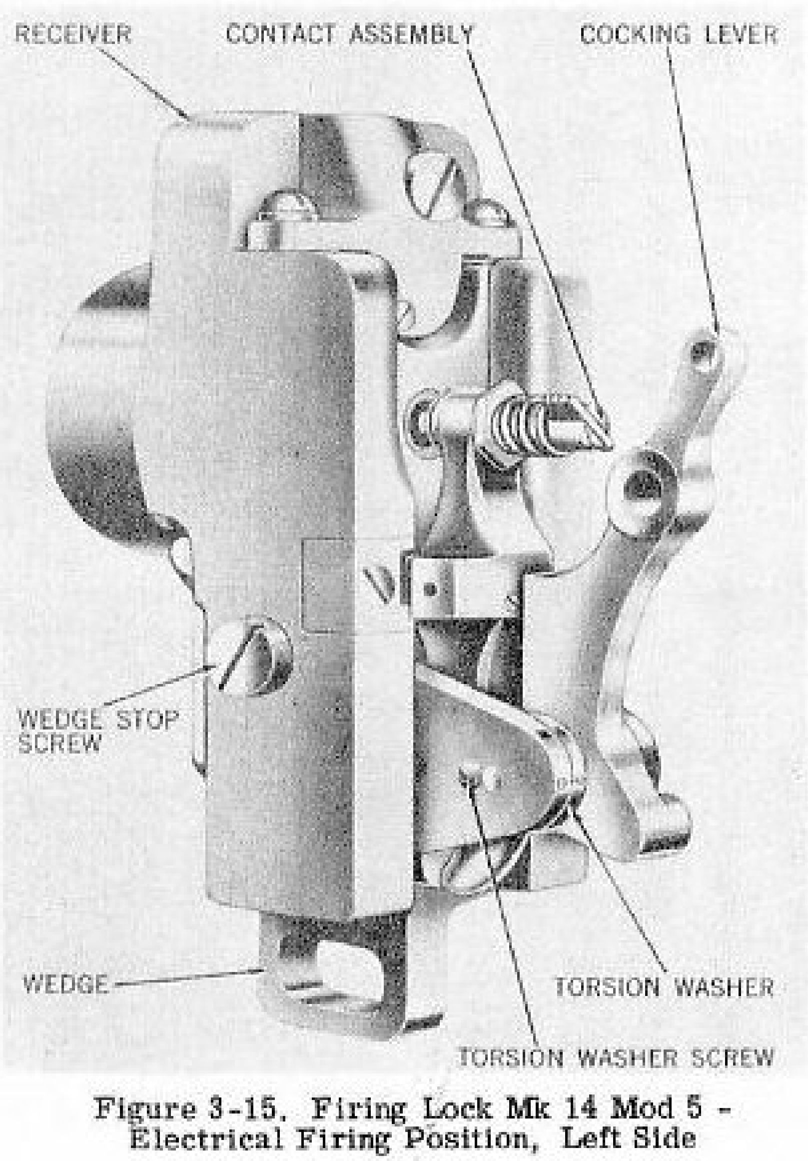


Figure 3-15. Firing Lock Mk 14 Mod 5 - Electrical Firing Position, Left Side

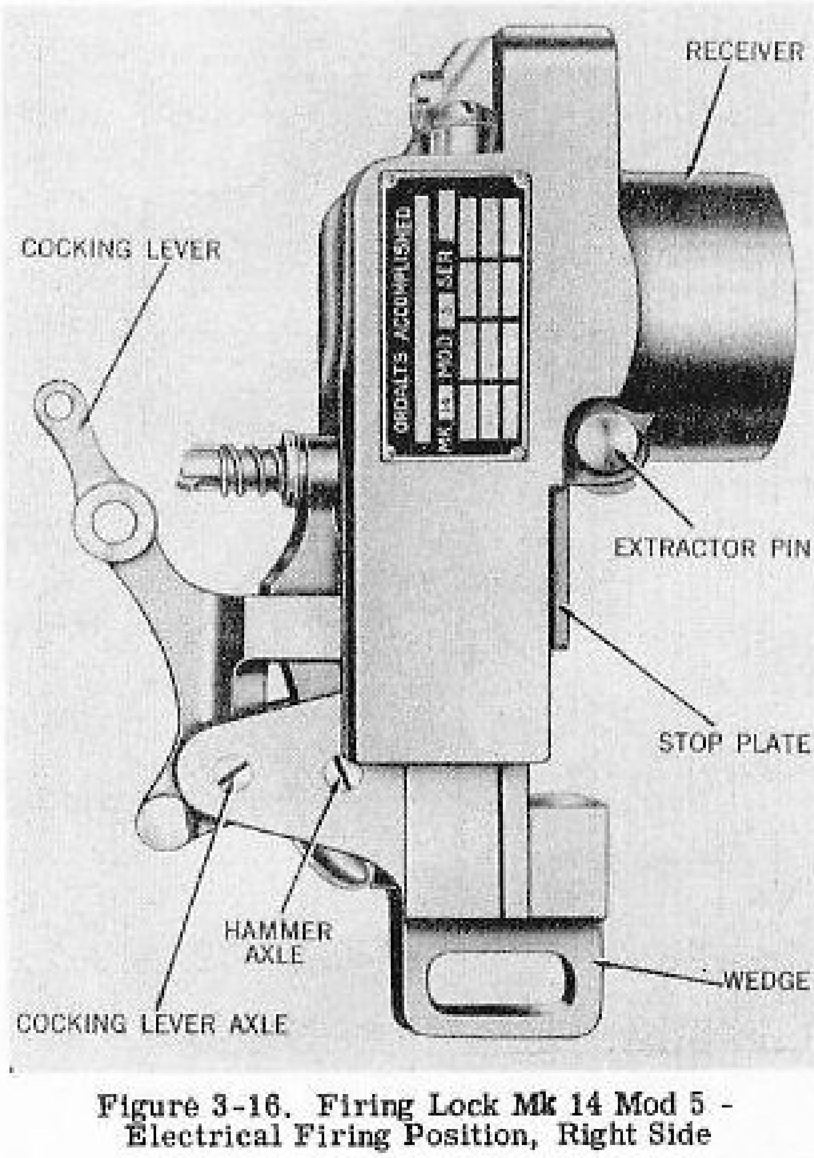


Figure 3-16. Firing Lock Mk 14 Mod 5 - Electrical Firing Position, Right Side

far enough, the hammer catch is released; the firing spring (fig. 3-18) acts through the hammer thrust pin to force the hammer to strike the firing pin sharply. When the lanyard is released, the cocking lever moves forward under its spring action, and the latch again engages the hammer catch.

Contact piece. The forward end of the contact piece rests upon the firing pin when the firing lock is closed. The contact piece is housed in, but insulated from, the upper end of the hammer. At the rear of the contact piece is a provision for quick positive connection of the electric firing cable.

Hammer guide block. The hammer guide block is fitted into the front face of the receiver on the side with the slot. This block is aligned with the slot to allow the hammer to be cocked only when the wedge is fully closed.

Primer retaining catch. The primer retaining catch (fig. 3-18) is a separately assembled unit bolted to the receiver. The unit consists of a housing, the catch, a catch retaining spring, and a guide screw that limits the outward movement of the catch. As the primer is pushed into position in the mushroom stem, the rim of the case first seats in a recess in the rear face of the extractor and then pushes the extractor forward until the rear of the primer has passed the primer retaining catch. The catch then moves down behind the primer to hold it in place until the wedge closes. The tapered cut on the wedge then completes the priming operation by pushing the primer case home. The wedge comes up against a stop plate, secured to the inner face of the receiver, to prevent the wedge overrunning and coming into contact with the primer retaining catch housing.

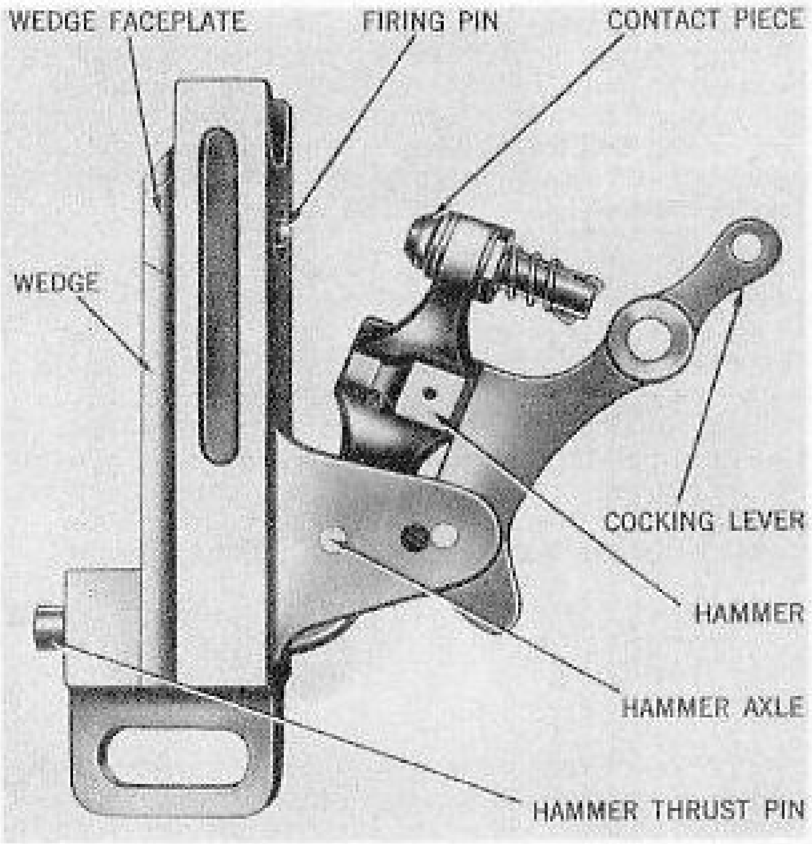
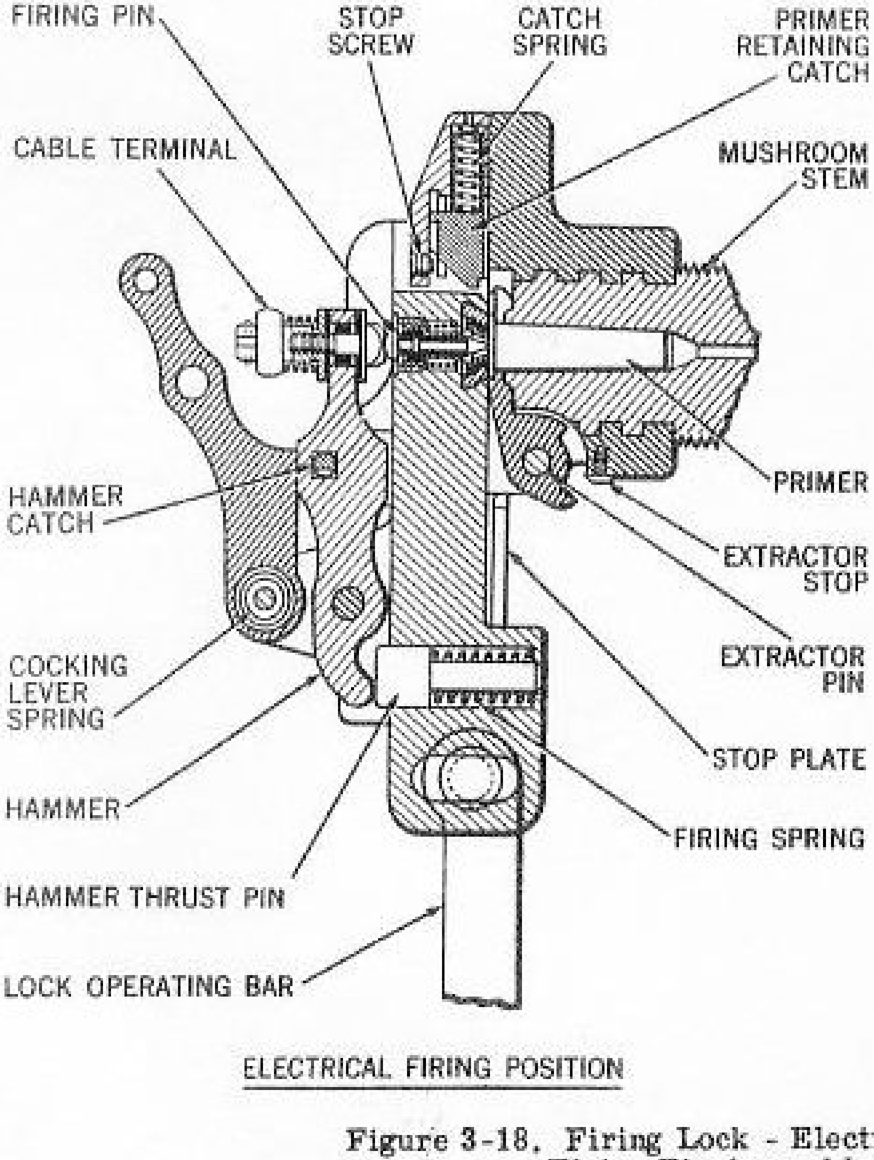
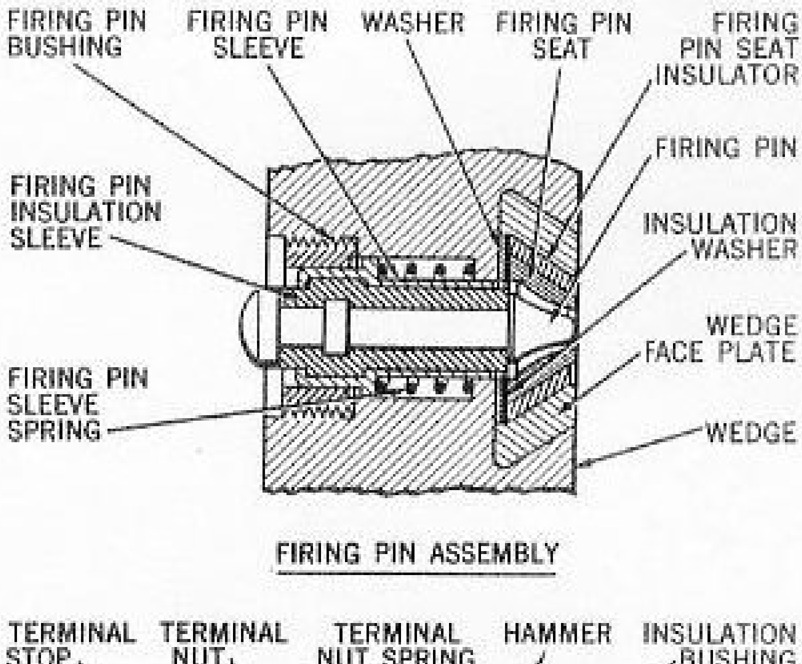


Figure 3-17. Wedge - Cocked Position, Left Side

Extractor and extractor cam (figs. 3-19 and 3-20). The extractor and extractor cam are both pivoted on the extractor pin which passes through the receiver. The extractor cam is actuated by a





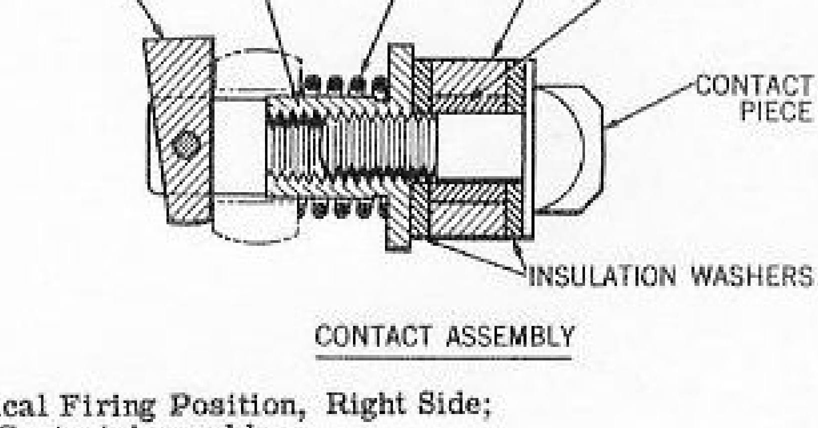


Figure 3-18. Firing Lock - Electrical Firing Position, Right Side; Firing Pin Assembly; Contact Assembly

lug on the wedge face plate to operate the extractor. Fitted between the wedge and the mushroom stem, the arms of the extractor engage the primer case on two sides. When the wedge is retracted, the lug on the wedge strikes the extractor cam; this causes the extractor to move to the rear, push the primer retaining catch out of the way, and extract the primer case. A torsion spring returns the extractor cam to its original position.

Extractor stop screw. The extractor stop screw (fig. 3-20) limits the movement of the extractor.

Safety appliances. The following safety features are included in Firing Lock Mk 14 Mod 5:

1. The primer cannot be fired either by electricity or by percussion until the breech is completely closed.

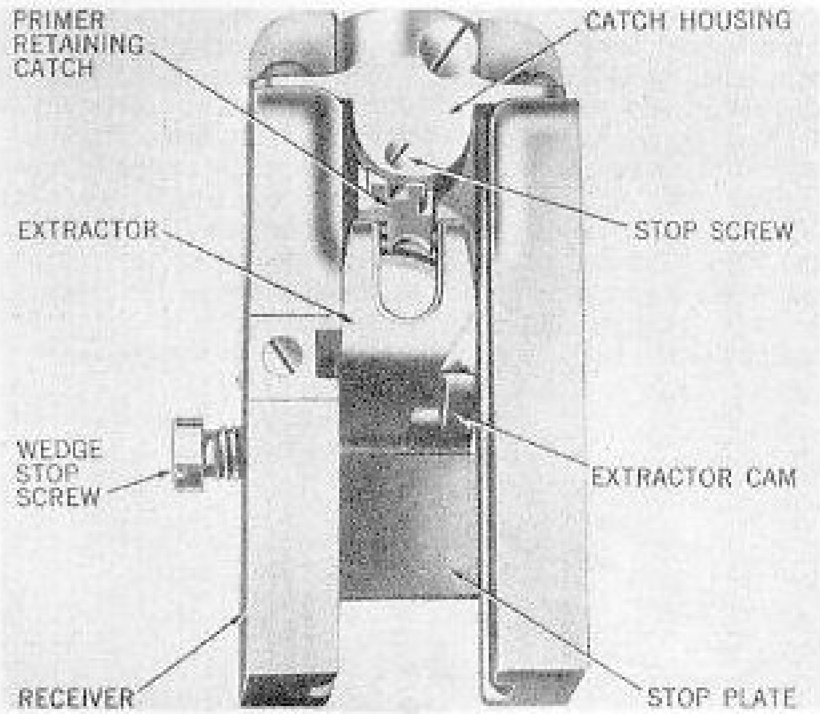


Figure 3-19. Firing Lock Mk 14 Mod 5 - Wedge Removed

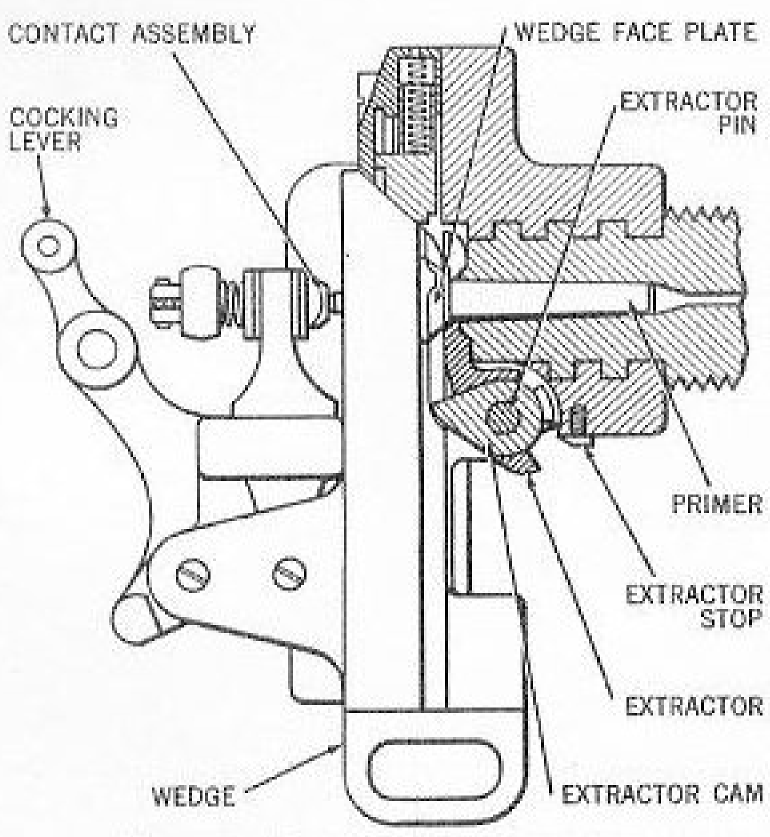


Figure 3-20. Firing Lock, Right Side, Sectional View - Wedge Closed

2. As the wedge is opened, lug on the hammer engages in a milled recess in the receiver to lift the hammer so as to break contact and prevent electric firing.

3. The same lug also prevents the hammer from being drawn back for percussion firing except when the wedge is closed.

4. A stop plate is secured to the receiver to prevent the wedge from over-riding and hitting the primer retaining catch housing.

5. A pin, screwed into the carrier and fitted against the receiver, prevents the firing lock from being turned in the wrong direction during disassembly or when the lock is being disengaged from the operating bar.

6. An arc plate secured to the face of the carrier prevents the lock from being turned until the wedge is retracted. It also prevents the wedge from being closed until the lock is in its proper position.

7. If the pin that locks the operating bar to the wedge is disengaged, the arc plate on the carrier automatically withdraws the wedge from the firing position. This prevents jamming and puts the wedge in the safe position so that the gun cannot be fired.

8. When the lock is in the closed position with the wedge disengaged from the operating bar, and the breech mechanism is open, the wedge is prevented from closing by a shoulder on the end of the breech mechanism in front of the wedge.

Gas ejector

16-inch Gas Ejector Mk 5 Mod 0 (fig. 3-21) is an automatic, low-pressure, air porting system. It is composed of an assembled air line with valves and a connection to an automatically opened valve mounted on each gun breech. The purpose of the gas ejector is to expel powder gases and burning fragments through the gun muzzle to clean the bore without fouling the gun room compartment. When the breech plug is opened, an attached trip plate automatically opens the gas ejector valve to direct jets of compressed air into the gun bore through orifices in the screw box. The valve is held open by a detent until closed manually.

The gas ejector delivers the ship's compressed air supply to the main and auxiliary gas ejector systems and furnishes the air supply for the breech closing system. Air, at 150 to 200 pounds per square inch pressure, is brought into the turret through the central column and is stored in five relay tanks located on the projectile handling decks. From the tanks, air is piped to swivel joints below the right slide trunnion of each gun. From the swivel joints at each gun, the air passes through pipe lines and an expansion joint to the gas ejector valve at the breech of the gun (fig. 3-21).

A 1-1/2-inch gate valve, below and adjacent to the swivel joints, permits local cut off of the gas ejector supply.

From a T-fitting below the gun pocket pan deck, a second air line extends upward to two storage tanks at the rear of the turret officer's booth. Air lines from these tanks deliver air to each gun room to a manually operated auxiliary gas ejector system that is used in case of a main system failure.

The auxiliary ejector, a hose fitted with a brass nozzle, is stowed overhead at the gun captain's station, adjacent to the breech.

Gas ejector valve. The valve unit (fig. 3-22) is a poppet type, arranged for semi-automatic operation. The valve is similarly located on each gun breech. The position of the valve in the valve port of the screw box liner is oriented for correct tripping by a cam bearing pin that seats in a reamed hole in the face of the liner. The valve cam is designed so that contact with the trip plate rotates the cam through an arc of 90 degrees. This raises and holds the poppet in open detent position, until a lanyard pull returns the cam and permits spring closure and air cut-off.

Air demand. Gas ejector air-supply pressure and air consumption data are:

System pressure, average sustained, psi	175
Free air demand:	
Each gun, cu ft per second	14.5
Each gun cu ft per round	25

Auxiliary gas ejector systems have substantially greater free air demand. With either system, the bore clearing performance is improved and the air demand is decreased when the turret is closed and the ventilating fans are on.

Yoke

16-inch yoke Mk 5 Mod 0 (fig. 3-1) is a large, cast steel, counterbalancing unit. It mounts on the gun shoulder and provides integral lug seats for the recoil cylinder piston rod and the counterrecoil cylinder yoke rods.

The yoke is mounted on the gun shoulder and secured to it with the yoke ring. This ring, made in semicircular halves, seats in an annular groove in the gun shoulder and engages a shoulder in the yoke bore. The yoke and yoke ring are locked to each other and to the gun shoulder by a yoke locking ring that is threaded into the forward face of the yoke and secured by a lock plate. The gun is prevented from rotating in the yoke bore by a key that is centered in the bottom of the bore and in the gun shoulder.

The yoke contour provides clearance spaces or attachment lugs for the breech mechanism and for elements of the gun slide. Two pockets in the top center of the yoke provide for lead balance weights. Below the pockets are two horizontally bored holes which receive the yoke rods of the counterrecoil cylinders. At either side of the yoke top are spaces for clearance of the counterrecoil cylinders. A slot at the top, forward part of the yoke receives the nut of the yoke locking device. At the bottom of the yoke, a large integral lug houses the end of the recoil cylinder piston rod. The lower section of the yoke is

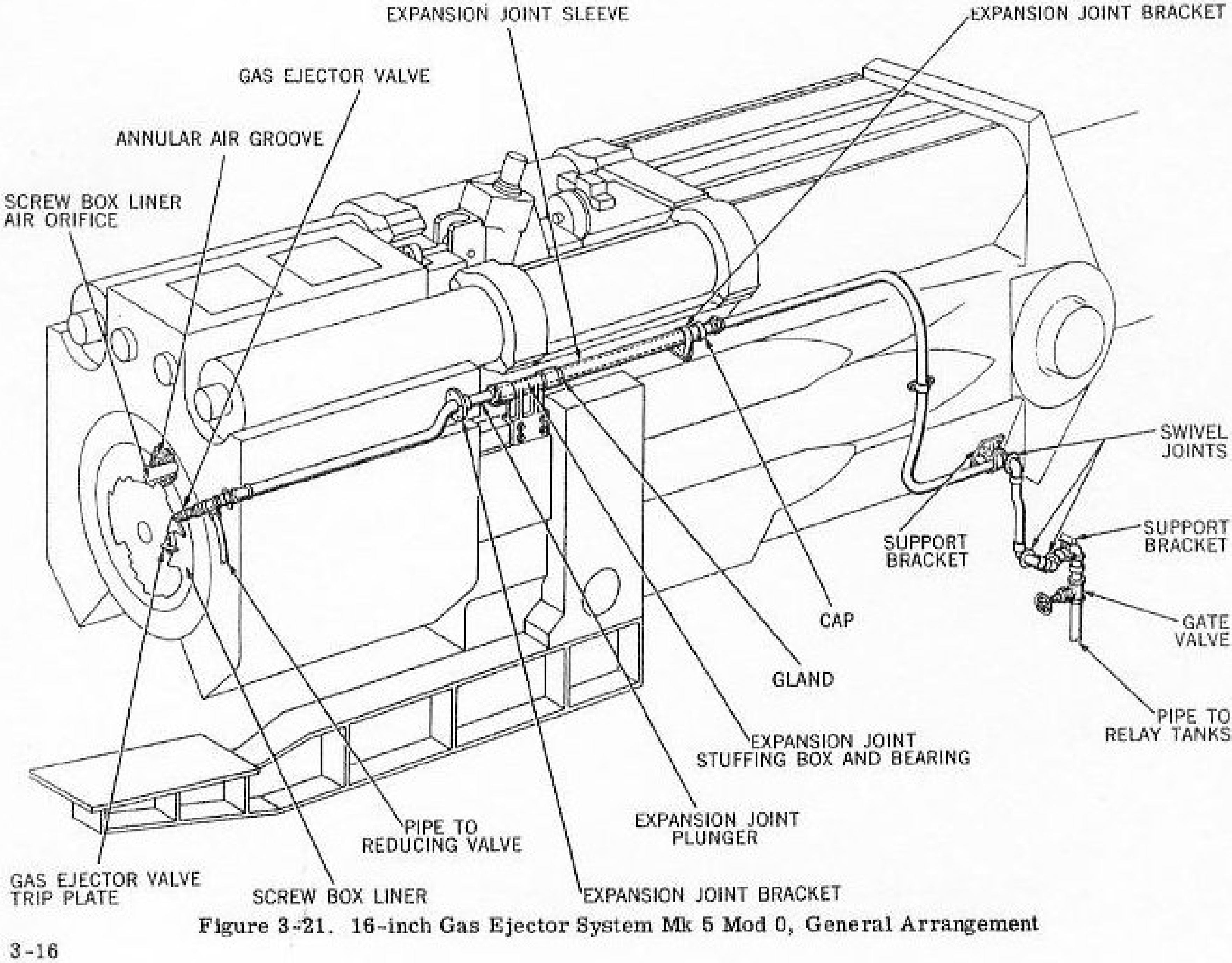


Figure 3-21. 16-inch Gas Ejector System Mk 5 Mod 0, General Arrangement

cut away rearward from the recoil piston rod seat to provide clearance for the carrier hinge lug and the breech opening buffer. The gas ejector air line is housed in a slot cast in the right side of the yoke.

OPERATION

General

The guns can be fired either electrically or by percussion. Gun operation consists of a series of manually initiated breech mechanism, gun, and gas ejector actions. Loading operations are performed at the LOAD position (five-degree elevation), after which the gun is laid on target either automatically or through gun layer's handwheel motion. The sequence of gun firing operations, starting with the gun ready to fire and continuing through one complete cycle, is described below. In addition, instructions on replacing a misfired primer, percussion firing, and non-firing operation are also included.

Firing operation

Ready to fire. The gun is ready to fire (fig. 3-23) after: (1) the salvo latch locking pin is not in hole "B", (2) the yoke locking device is released, (3) the primer is inserted into the firing lock receiver,

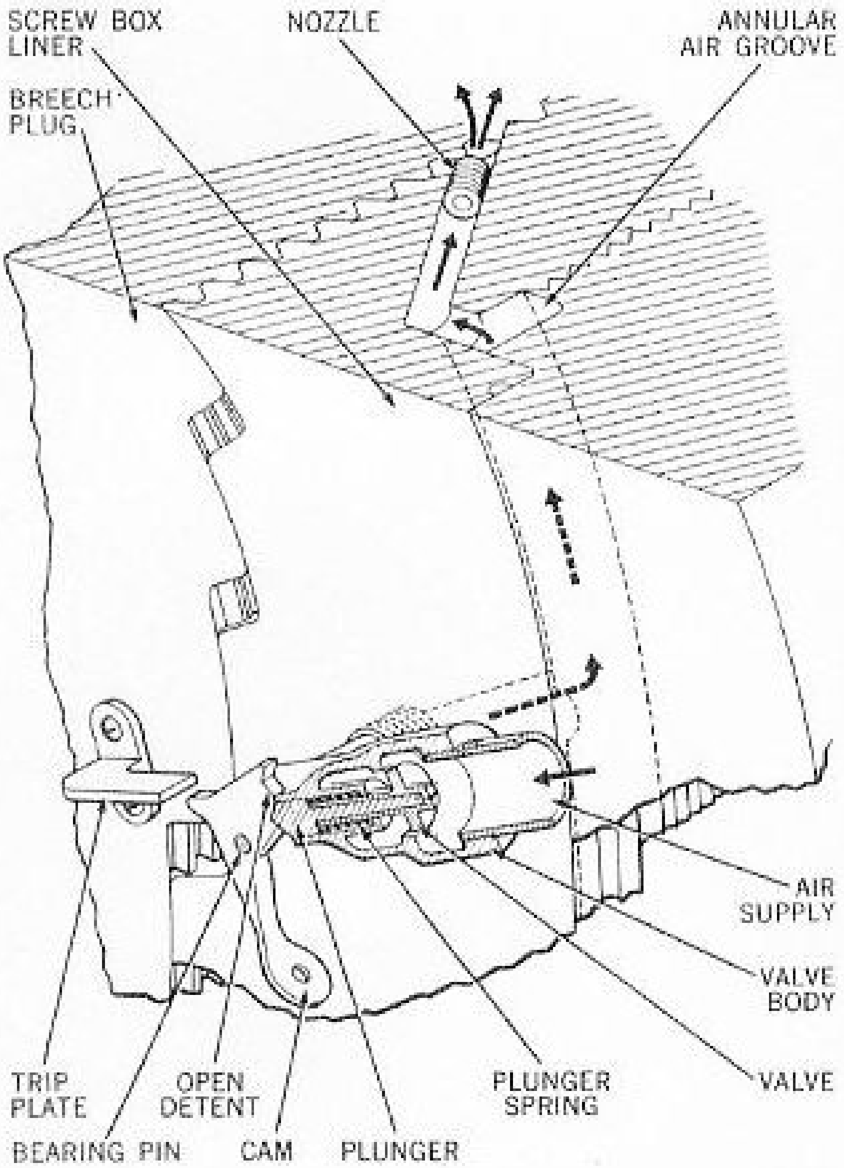


Figure 3-22. Gas Ejector Valve

(4) the projectile and six powder bags are rammed, (5) the breech is closed and latched, (6) the gun is on target.

Gun recoil and counterrecoil action. Upon firing (fig. 3-23A) the ignited powder causes the projectile to leave the bore and the gun to recoil. Recoil energy is expended (fig. 3-23B) in the recoil cylinder by forcing hydraulic fluid through the piston ports against the obstructing action of the throttling rods. The recoil action compresses air in the counterrecoil system. The hydropneumatic counterrecoil mechanism (fig. 3-23C) returns the gun back to battery (as explained in ch. 4). The buffing action of the recoil cylinder, shown on figure 3-23D, occurs during the last part of the counterrecoil movement.

Salvo latch actuation. The salvo latch lever cam (fig. 3-23E) is rotated clockwise by gun recoil. This movement rotates the locking arm to release the operating lever latch, permitting reopening of the breech for a new cycle of operation. If misfire occurs, it is evident by the locked position of the salvo latch arm and, therefore, the operating lever cannot be actuated to open the breech.

Breech opening. To open the breech for initial round loading only, the salvo latch locking arm is manually thrust aside and the operating lever latch is lifted. The released lever is then pulled rearward and down (fig. 3-23F). Motion of the breech operating lever rotates the plug to unlock and retract it and opens the breech. Opening rotation of the plug opens the gas ejector valve (fig. 3-23G). The valve ports compressed air through the gun bore. As the plug swings open and the operating lever swings downward, the crankshaft, actuated by operating lever movement, rotates in a clockwise direction (fig. 3-23H). This lowers the cross-head and, therefore, the lock operator bar to retract the firing lock wedge. As shown in figure 3-23I, when the wedge is retracted, the lug on the wedge strikes the extractor cam. This action causes the extractor to move to the rear, pushing the primer retaining catch out of the way and extracting the spent primer.

In case of misfire, the wedge is retracted, without opening the breech, by unlatching the wedge retracting lever from the breech operating lever (figs. 3-23G and 3-23H).

During breech opening, the carrier-mounted plug swings to the rear and down, through a vertical arc, compressing the counterbalancing springs. The breech-opening buffer, during final movement, retards and stops the carrier. The holding-down latch then moves into a stiff-leg position and secures the fully opened carrier.

During this time, compressed air from the gas ejector system has been entering the gun powder chamber and bore through three holes in the screw box liner (fig. 3-23J). The gun captain wipes the mushroom with his special sleeve and verifies that the bore is clear (fig. 3-23K). He then depresses the bore clear switch momentarily, and manually shuts off the gas ejecting air supply by tripping the valve closing cam (fig. 3-23L).

Gun loading. The projectile cradle and spanning tray are lowered to the gun loading position. The spanning tray enters the open gun breech. The projectile is rammed, rammer retracted, and then the powder charge is rammed (figs. 3-23M and 3-23N). Then the cradle and tray are withdrawn. During this period, the primerman, using a special tool, inserts a primer into the receiver of the firing lock (fig. 3-23O).

Breech closing. With the gun loaded, the holding-down latch is foot operated to release the carrier (fig. 3-23P). The foot lever of the closing valve is operated at the same time to open the valve and port air pressure to the closing cylinder, as shown in figure 3-23Q. The carrier and plug swing up under spring load and air pressure. A guide aligns the cam rollers with the rotating cam. As the plug's forward thread contacts the stop thread of the screw box, the cams cause rotation and locking of the plug to close the breech. In this final movement the operating lever is actuated, by plug rotation of its pivot, to swing upward until it is almost to its latch. The operating lever is then latched by hand (fig. 3-23R). The operating lever safety ratchet mechanism acts to prevent the operating lever from reversing its direction in the event it has not been fully latched during the breech closing operation. In conjunction with plug rotation, the crank shaft is rotated to raise the wedge back into firing position.

Replacing misfired primer. In the case of misfire, the deficient primer can be removed without opening the gun breech. The primer is extracted by unlatching the wedge retracting lever from the operating lever and pulling it down (fig. 3-23S). A new primer is inserted; the lock is closed; the wedge retracting lever is re-latched; and firing is repeated.

Percussion firing. In the event of casualty to the gun-firing electrical circuit, the loaded gun can be fired by percussion. A hammer, contact piece, and cocking lever attached to the wedge (fig. 3-23T) function to deliver a blow to the firing pin. This is accomplished by drawing back the cocking lever by means of a lanyard. The cocking lever pulls the hammer back with it until a catch on the cocking lever releases the hammer. As the hammer is drawn back, the hammer spring is compressed. When the hammer is released, this spring drives it forward making the contact piece strike the firing pin, which transmits the blow to the primer to fire the gun.

Non-firing operation

For a non-firing breech operation the procedure is as follows: The firing lock is mounted in position only if a drill is planned, and is never mounted during maintenance. The slide securing pin is retracted and the gun elevated to its loading position of five degrees. When the breech is to be opened for a drill or for maintenance the salvo latch locking pin should be in hole "B", as directed by the salvo latch caution plate. However, the latch locking arm can be manually thrust aside to unlock the operating lever latch each time the breech is opened. The breech is opened and closed in the same manner as described previously. Upon securing from drill or completion of maintenance, the salvo latch locking pin must be removed from hole "B" and returned to the turret officer's booth. The gun is returned to five degrees elevation and the slide securing pin is run into its seat.

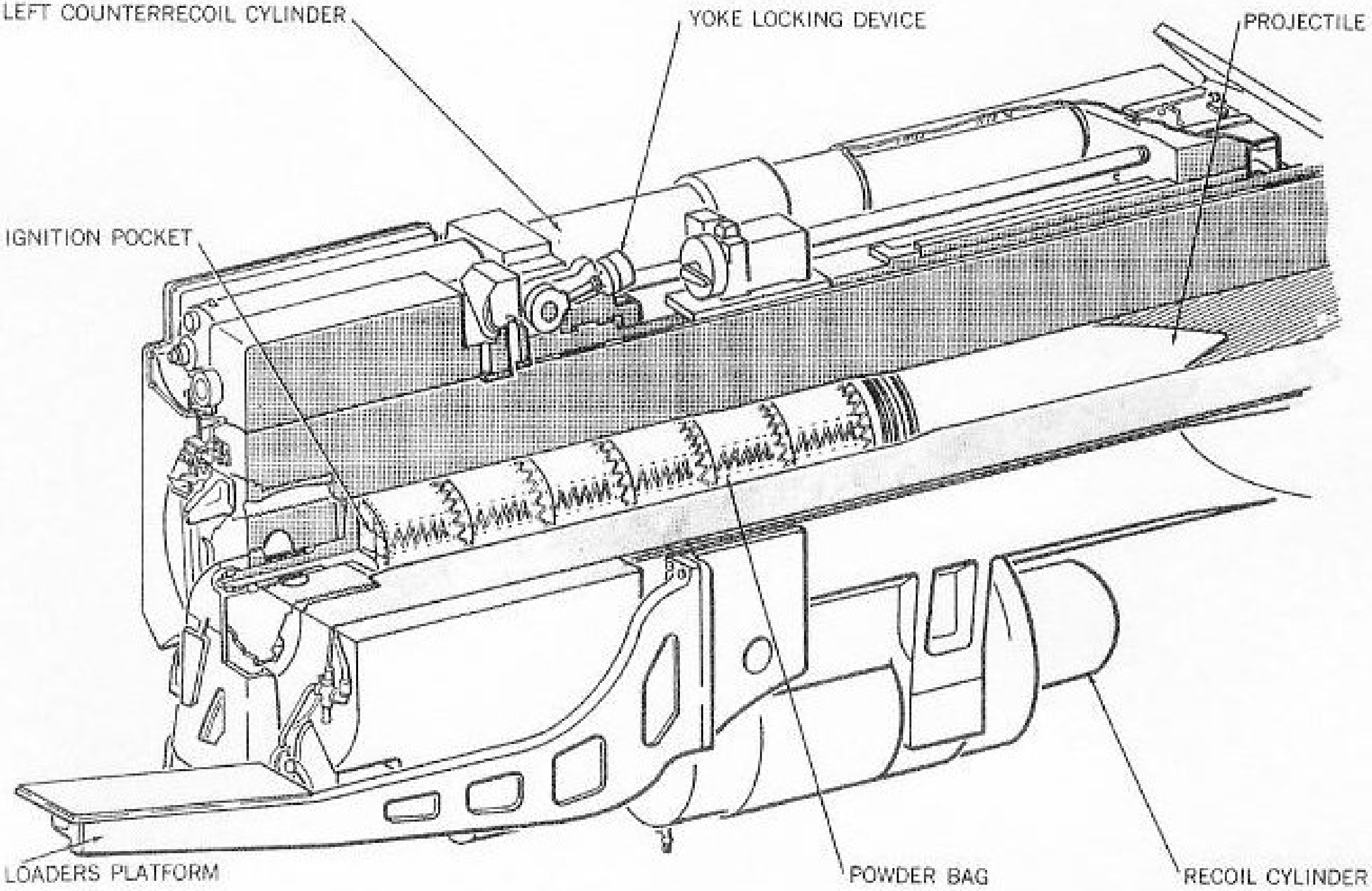


Figure 3-23. 16-inch Gun Assemblies. Gun Ready for Firing.

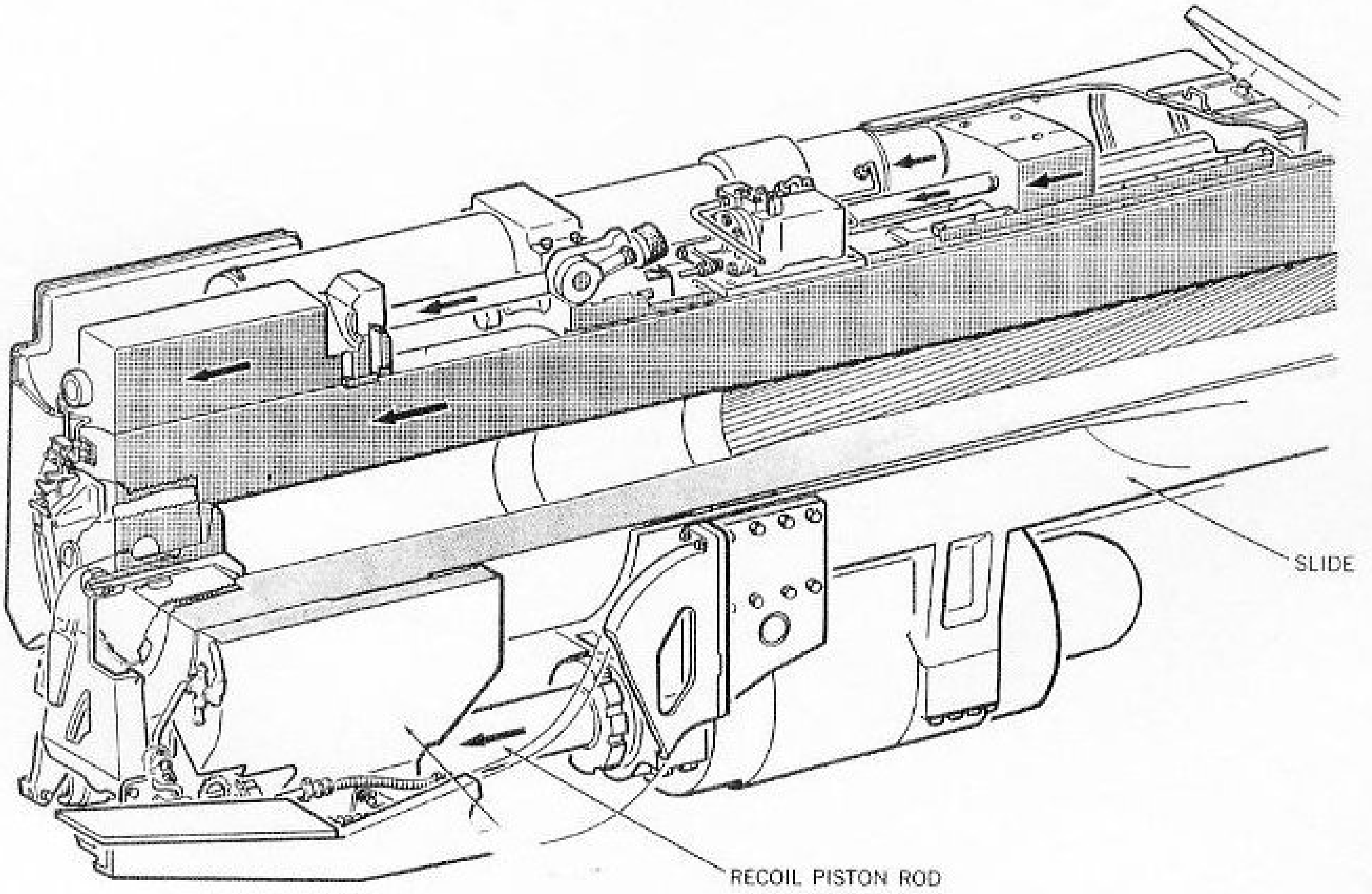


Figure 3-23A. 16-inch Gun Assemblies. Firing Gun Recoiling.

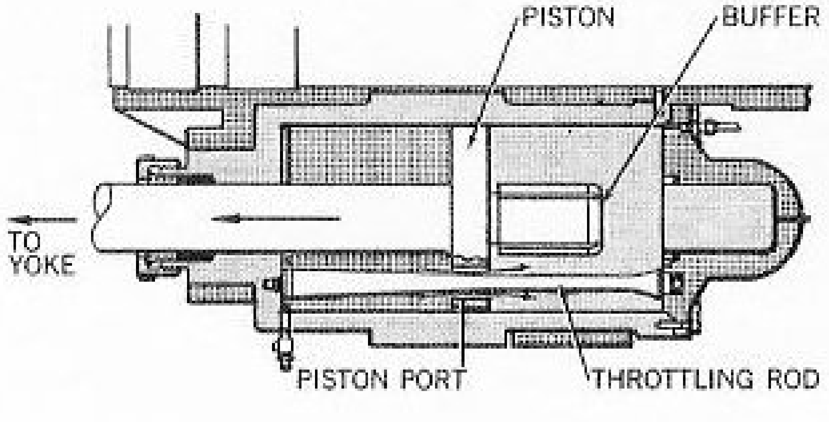


Figure 3-23B. 16-inch Gun Assemblies.
Gun Recoiling Action.

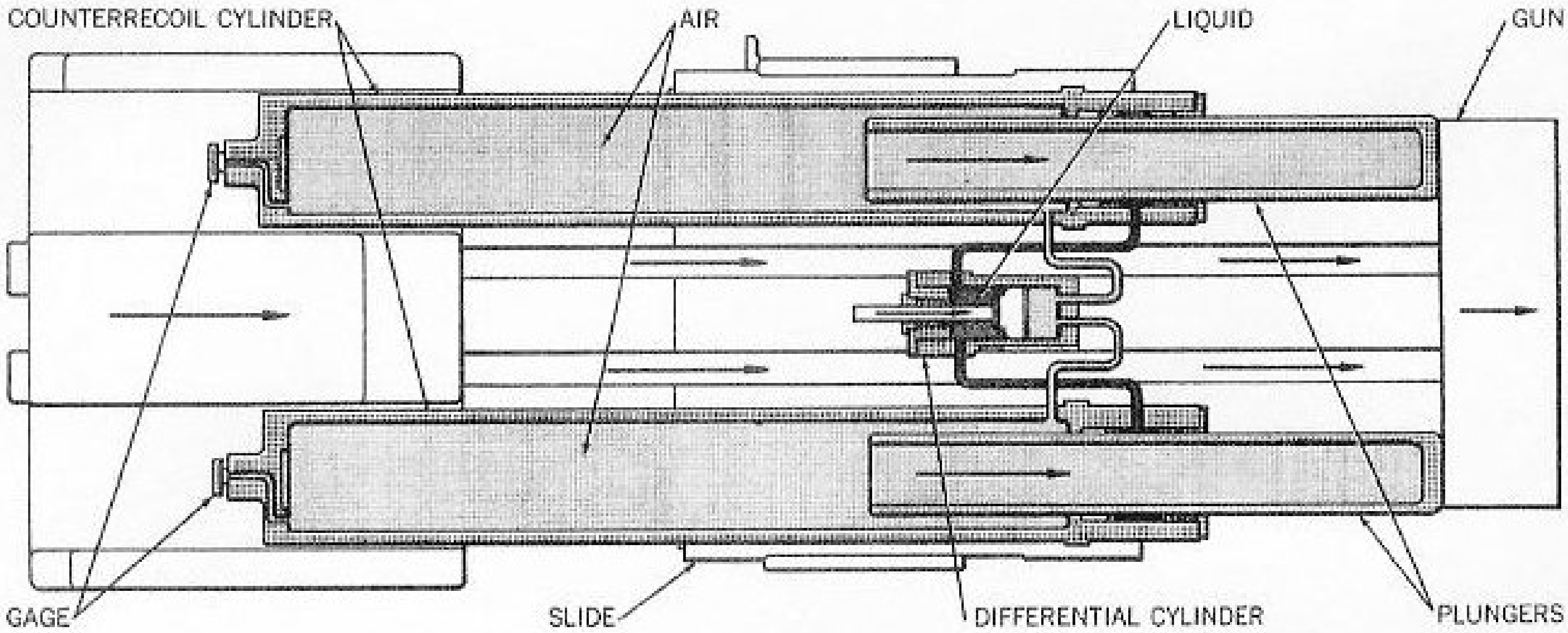


Figure 3-23C. 16-inch Gun Assemblies. Counterrecoil Action.

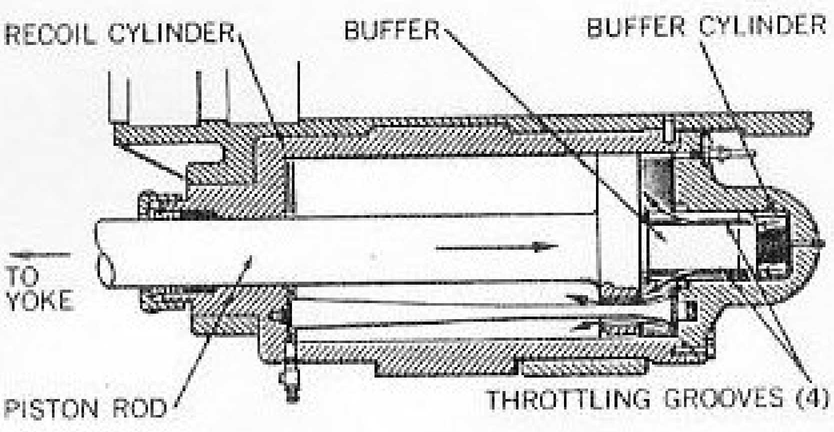


Figure 3-23D. 16-inch Gun Assemblies. Recoil Buffing Action During Counterrecoil.

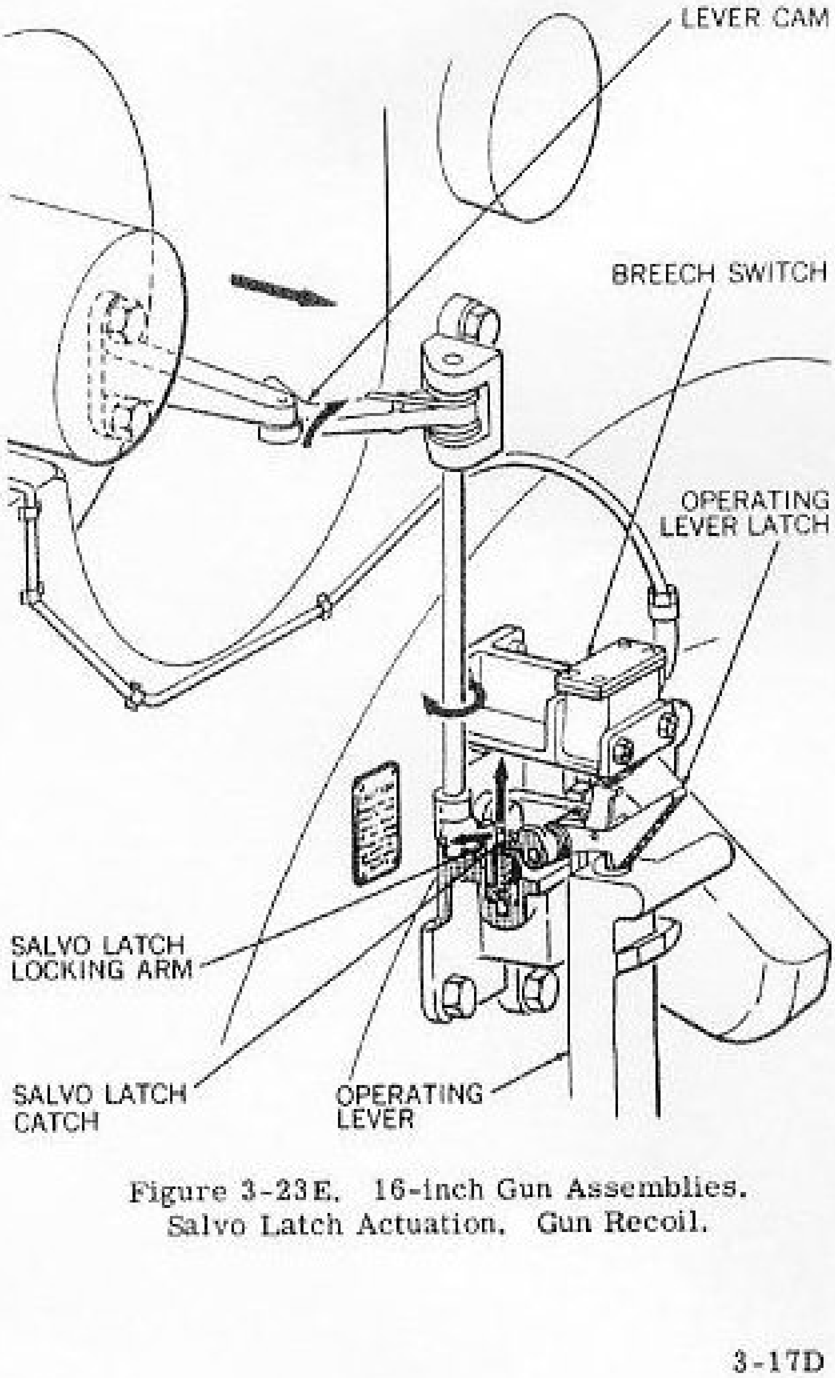


Figure 3-23E. 16-inch Gun Assemblies. Salvo Latch Actuation. Gun Recoil.

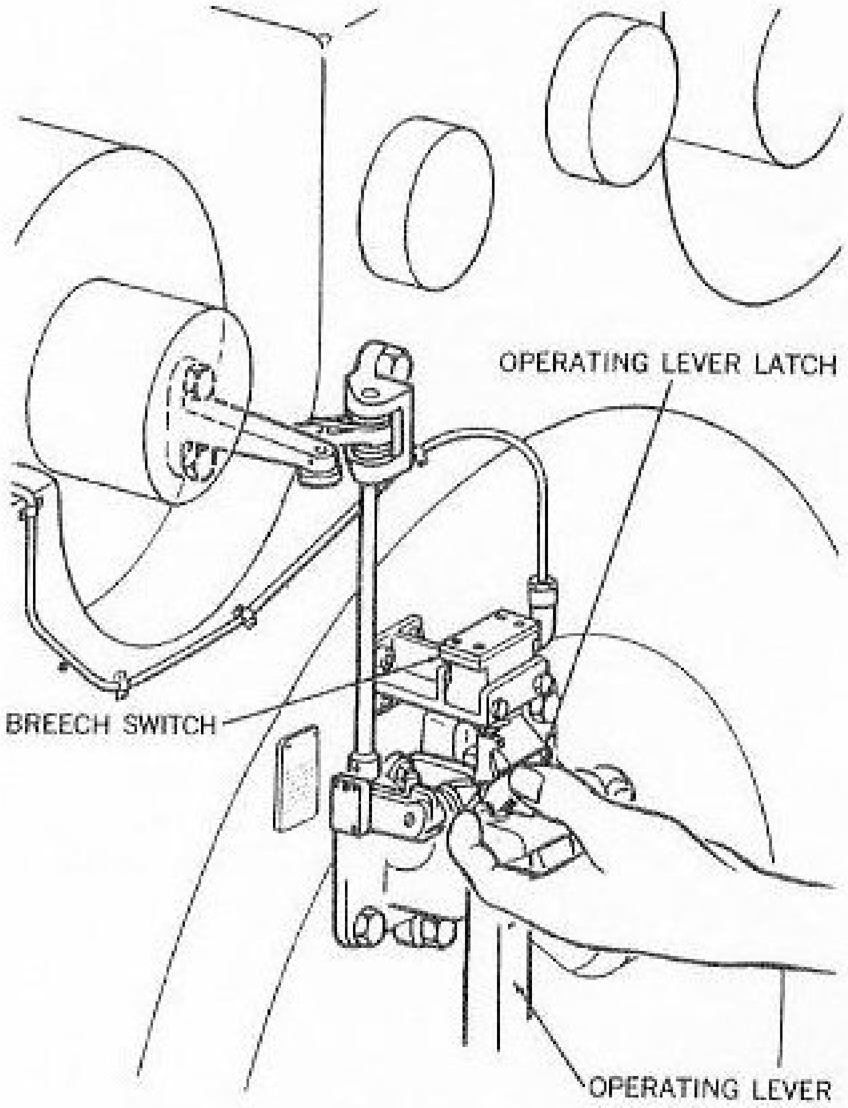


Figure 3-23F. 16-inch Gun Assemblies.
Breech Opening. Manual Operation.

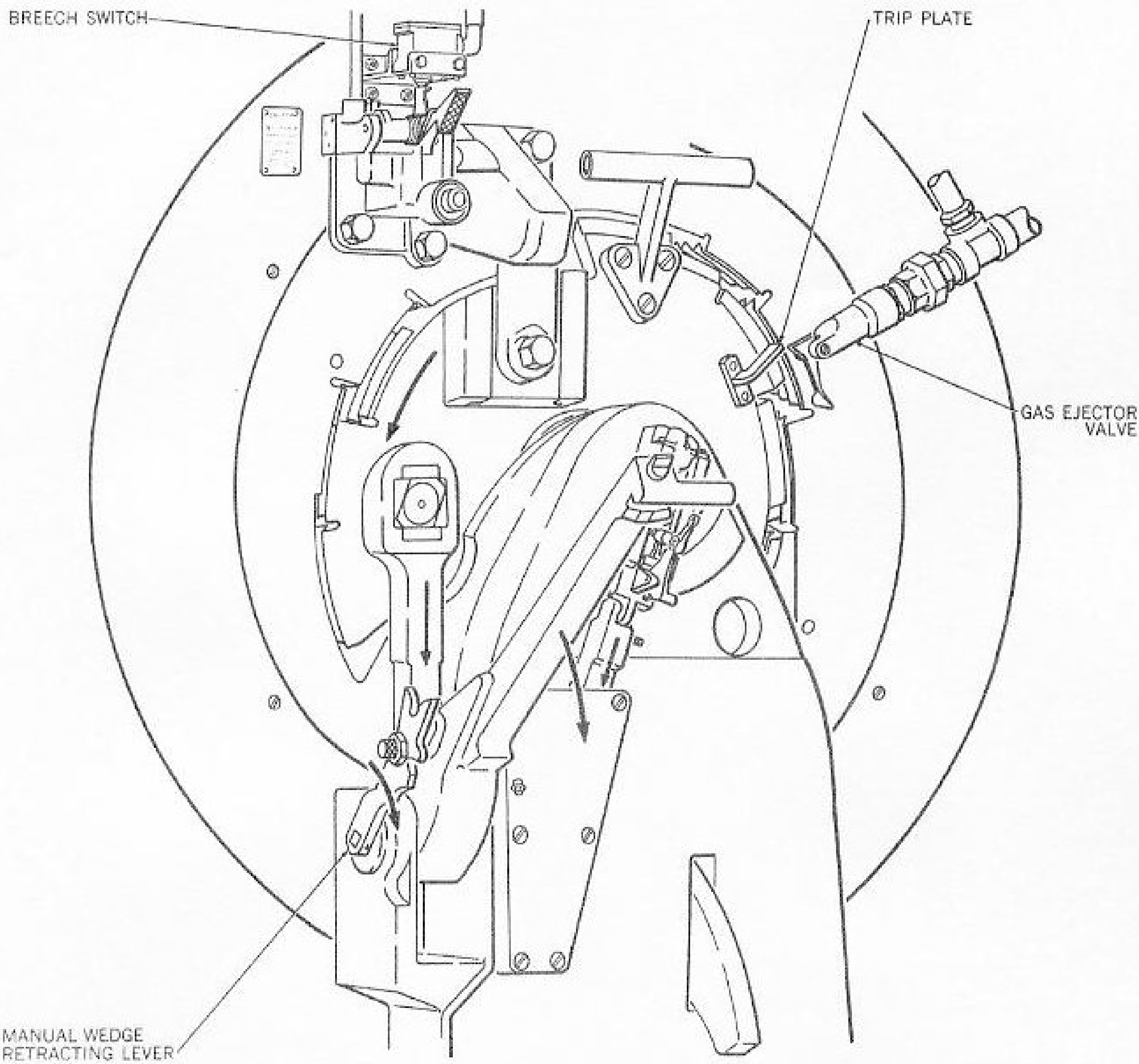


Figure 3-23G. 16-inch Gun Assemblies. Breech Opening. Plug Rotation. (Operating Lever Safety Ratchet Mechanism Assembly Not Shown; See Figure 3-3)

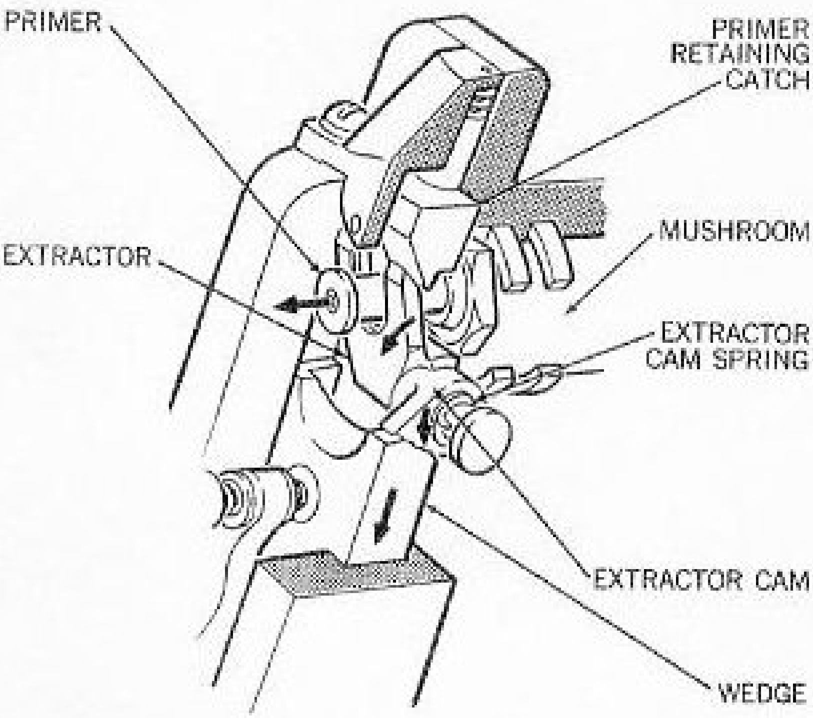


Figure 3-23H. 16-inch Gun Assemblies. Breech Opening Ejecting Primer.

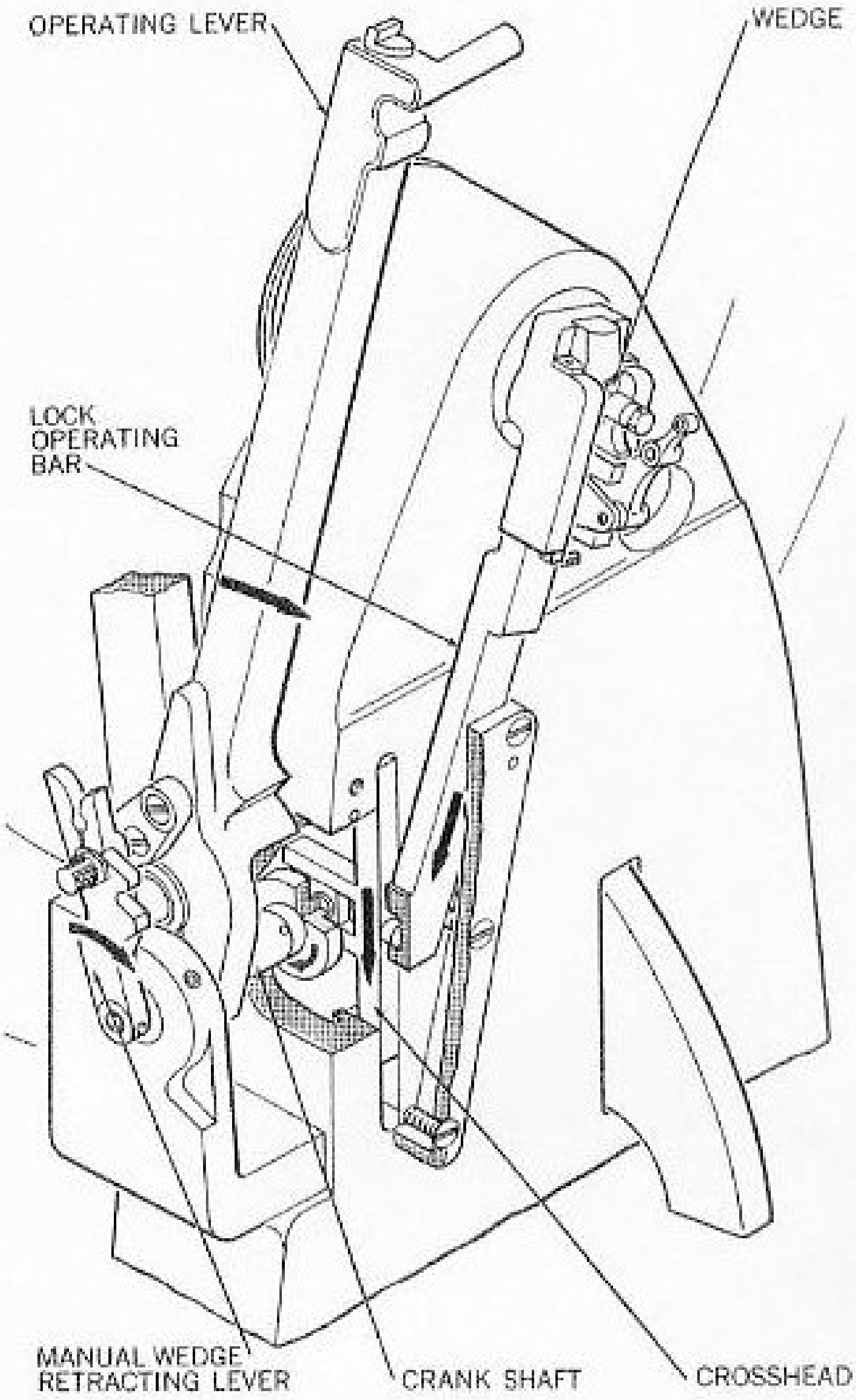


Figure 3-23I. 16-inch Gun Assemblies. Breech Opening. Extractor Cam Motion.

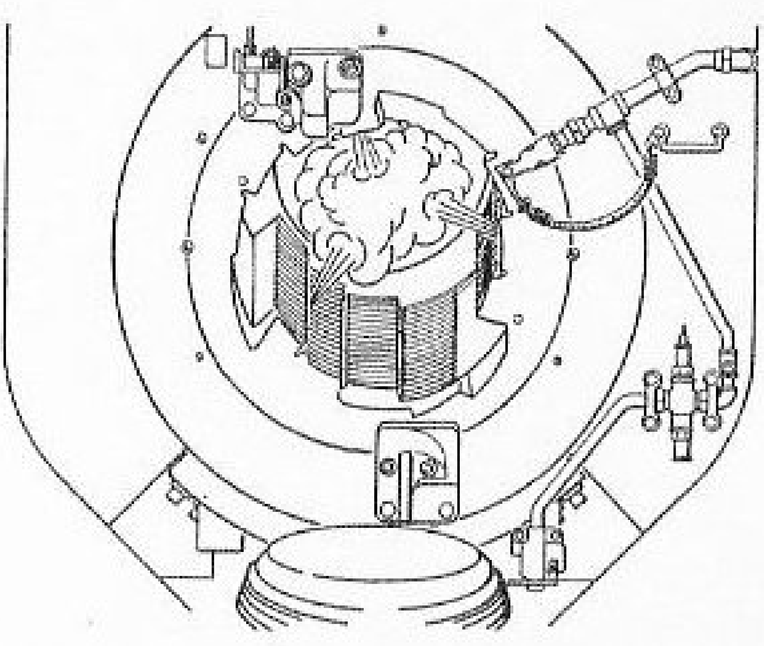


Figure 3-23J. 16-inch Gun Assemblies. Gas Ejector Action. Breech Open.

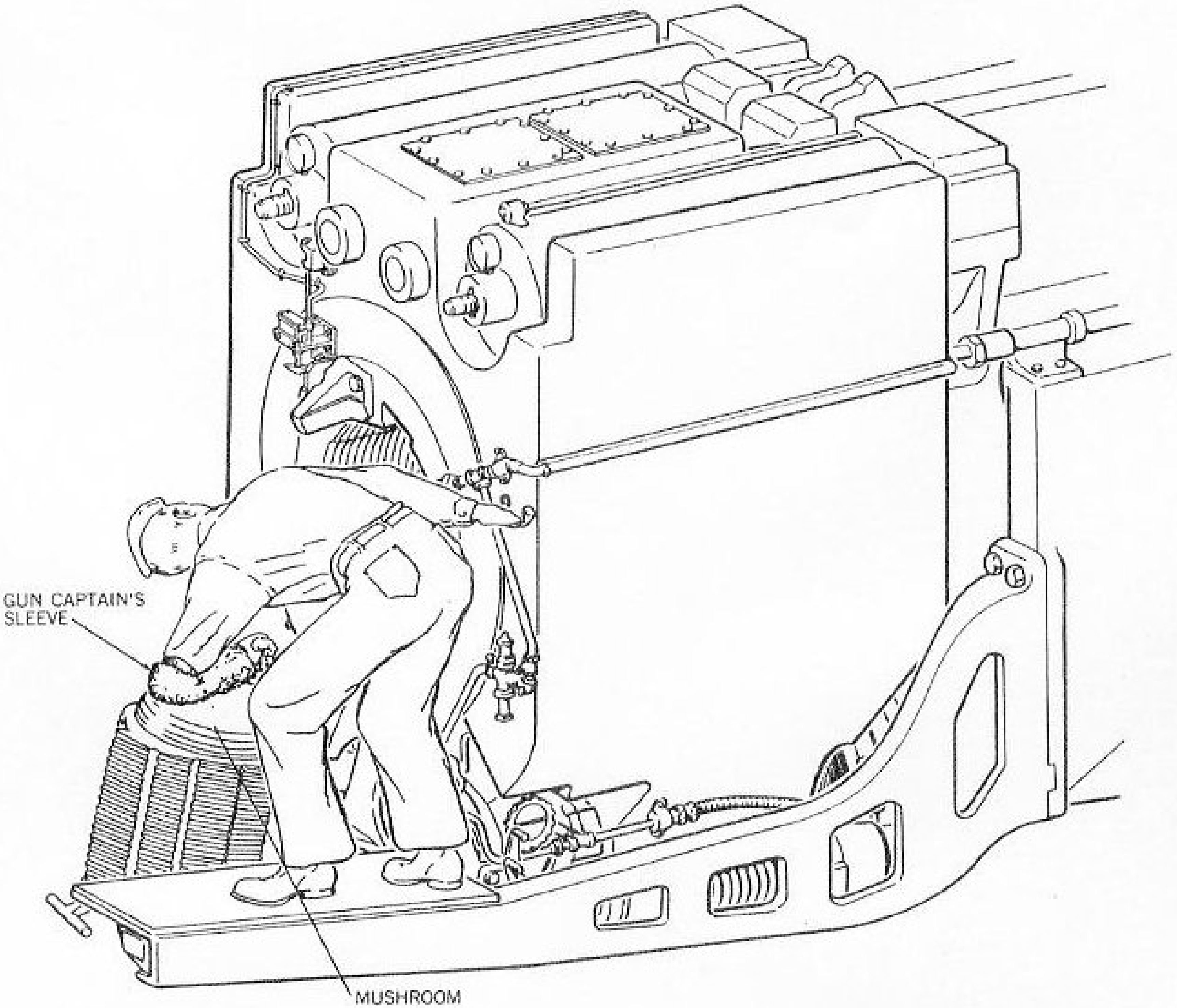


Figure 3-23K. 16-inch Gun Mk 6 Mod 1. Wiping Mushroom and Inspecting Gun Bore.

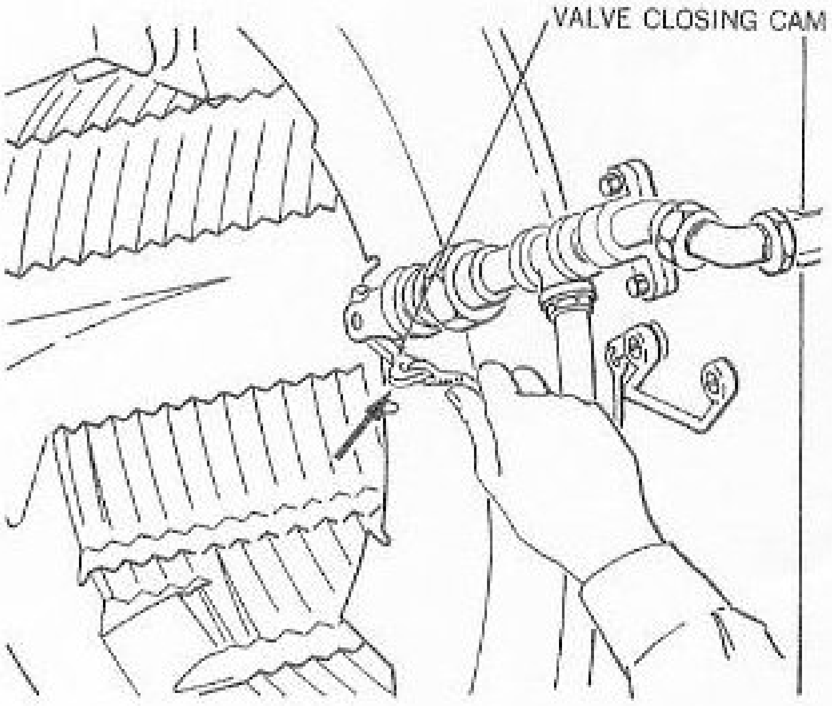


Figure 3-23L. 16-inch Gun Assemblies.
Closing Gas Ejector Valve Manually.

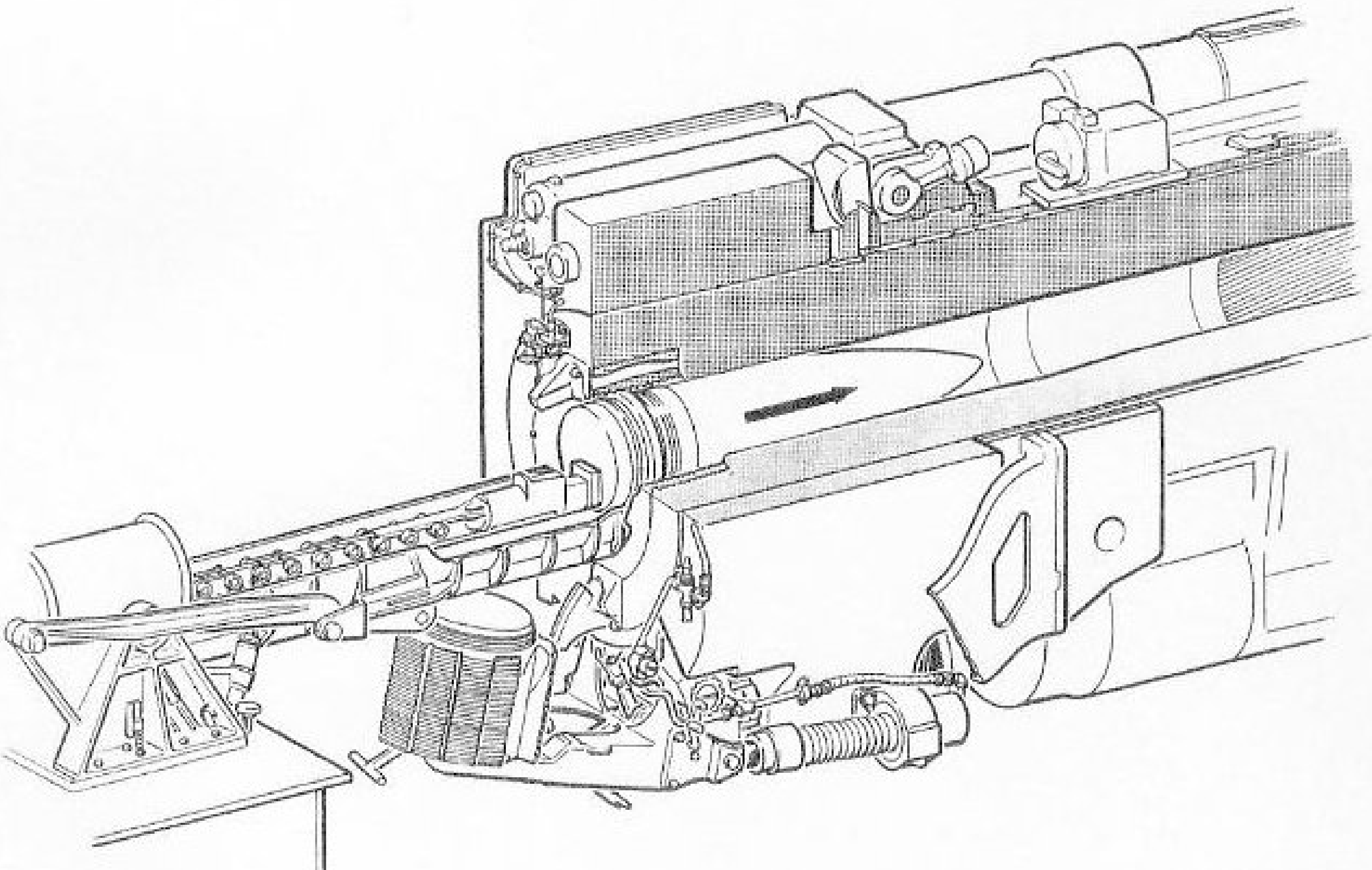


Figure 3-23M. 16-inch Gun Assemblies. Projectile Ramming Action.

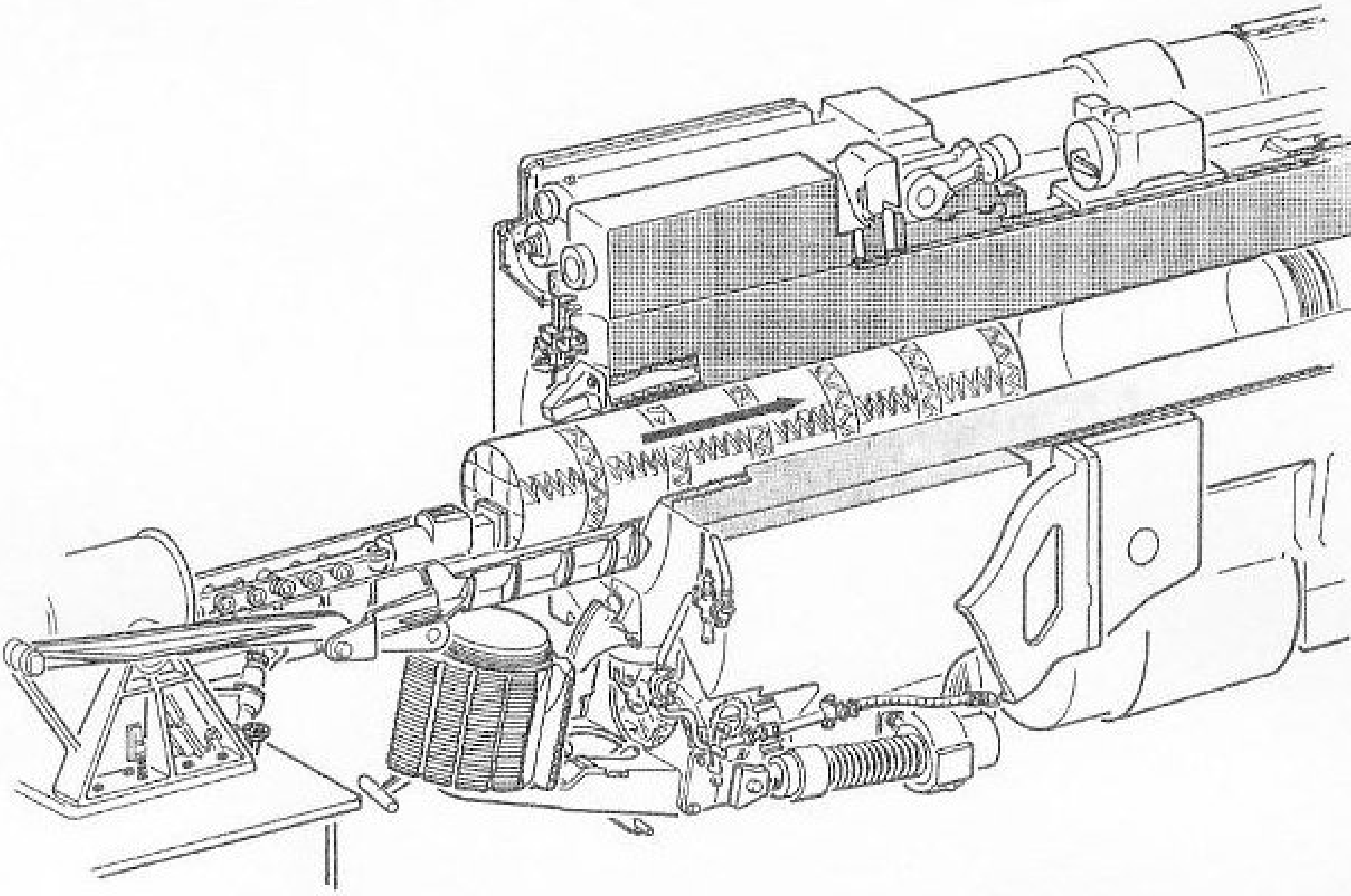


Figure 3-23N. 16-inch Gun Assemblies. Powder Ramming Action.

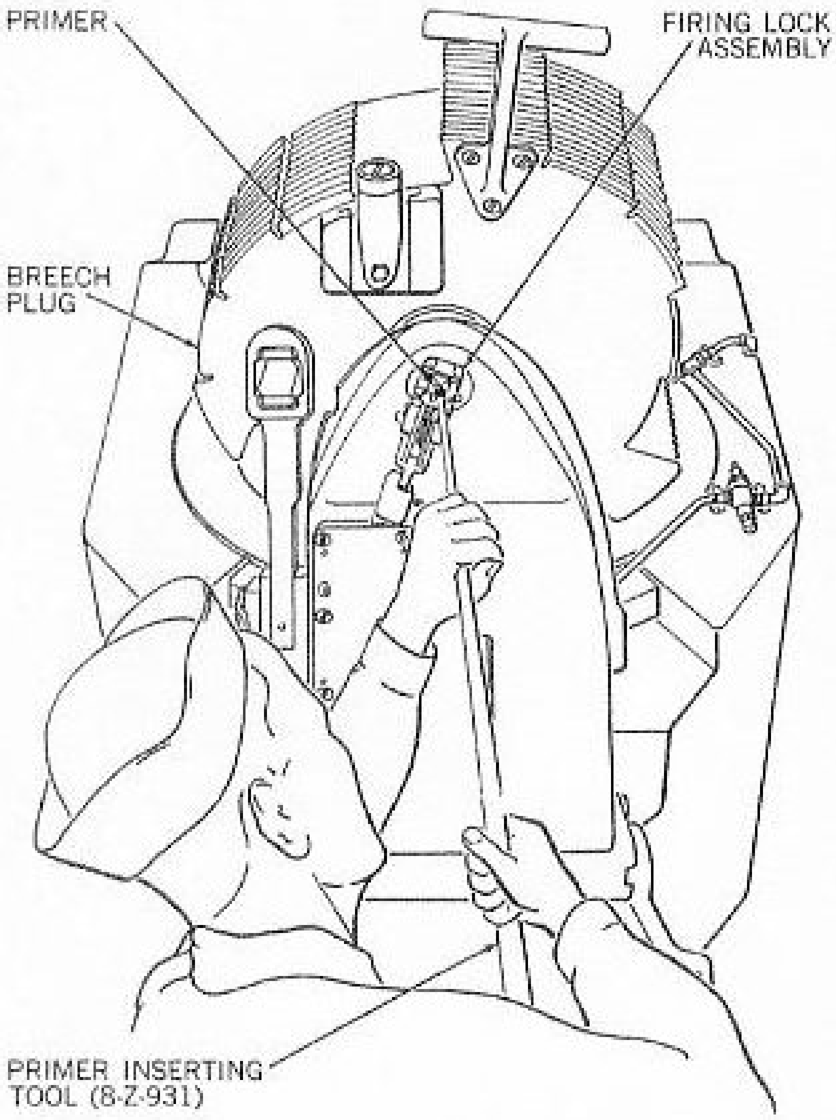


Figure 3-23O. 16-inch Gun Assemblies. Breech Open. Inserting Primer.

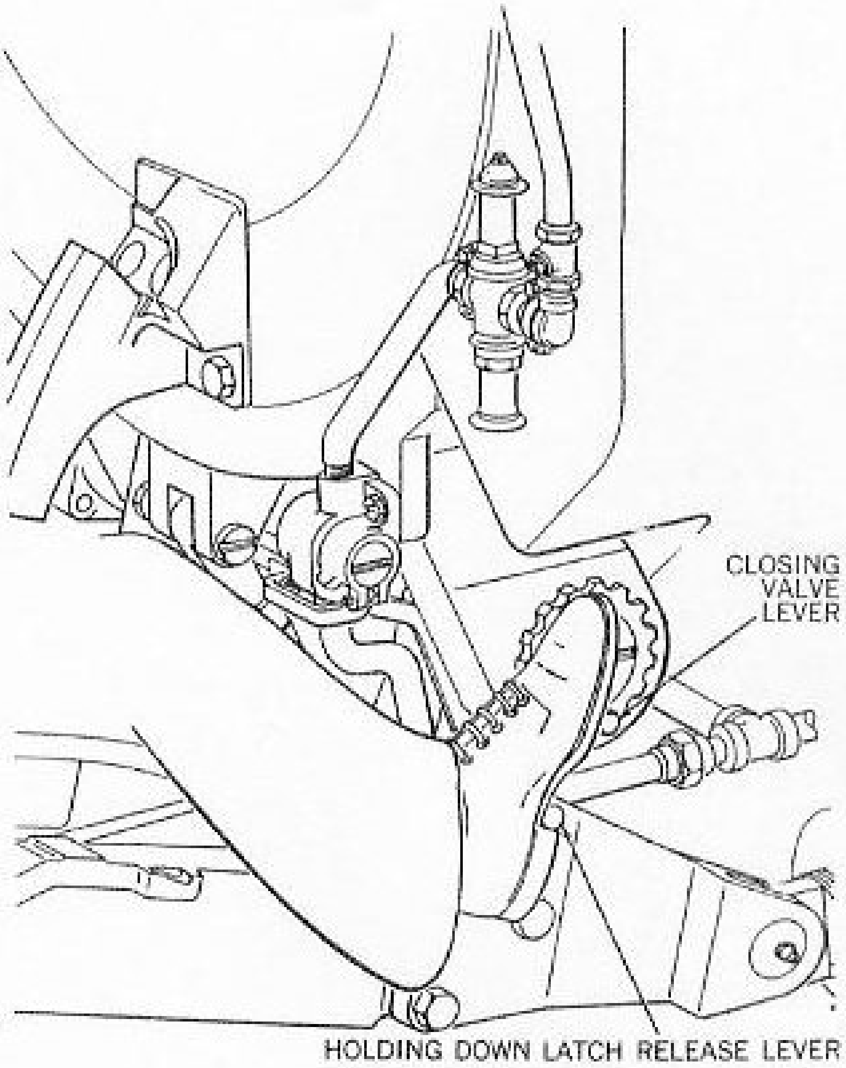


Figure 3-23P. 16-inch Gun Assemblies. Breech Closing Action.

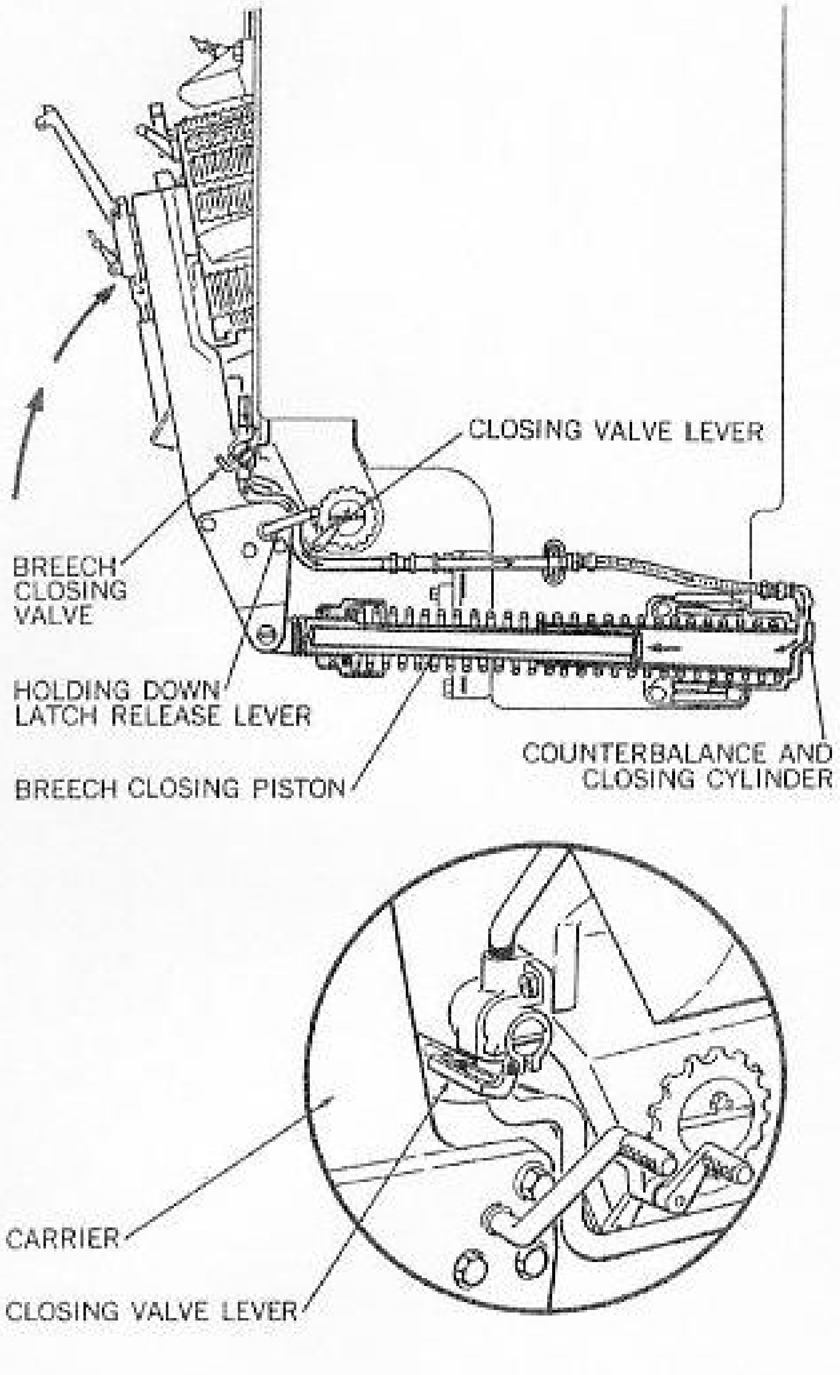


Figure 3-23Q. 16-inch Gun Assemblies. Breech Closing Cylinder Action.

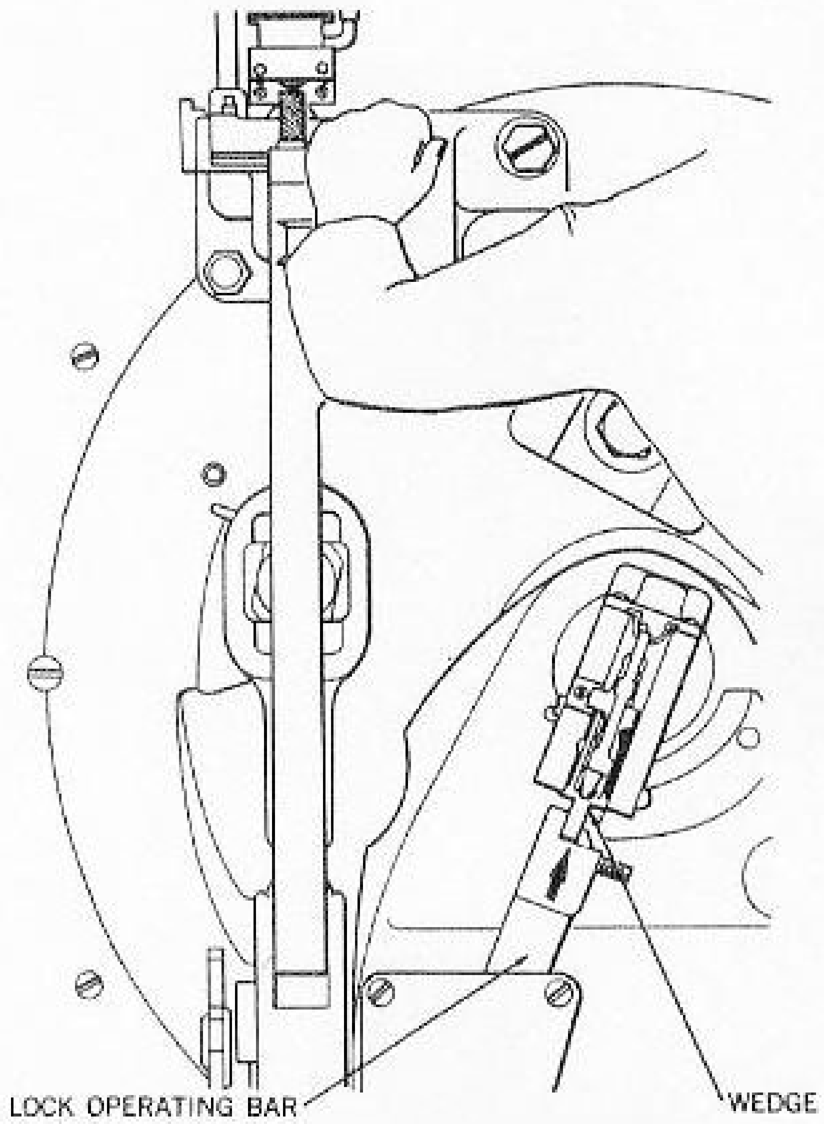


Figure 3-23R. 16-inch Gun Assemblies Final Breech Closing Action. Manual.

INSTRUCTIONS

General maintenance

The guns, breech mechanisms, firing locks, gas ejector systems, and yokes of each turret assembly are to be operated and maintained in accordance with the regulations of the Bureau of Ordnance Manual, the directions on the instruction plates of the assemblies, and the specific instructions in this chapter. Inspection, lubrication, and preservation are discussed in the following paragraphs.

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

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

Preservation and service care

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

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

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

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

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

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

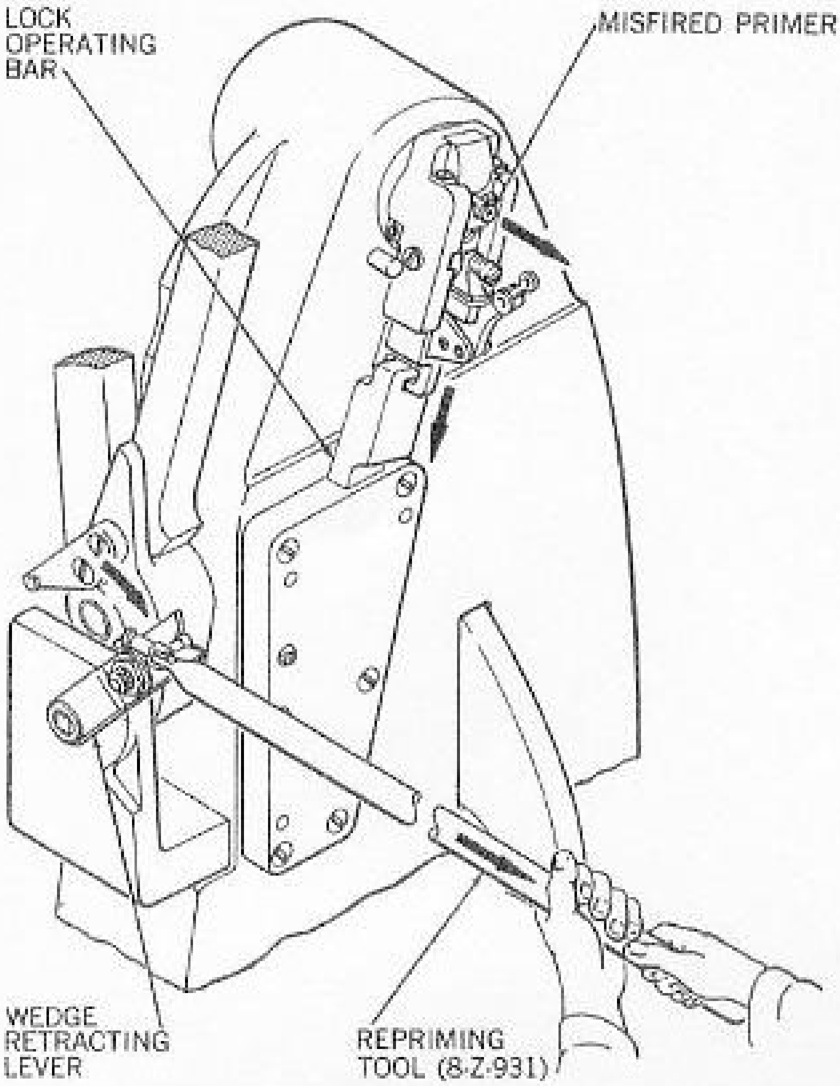


Figure 3-23S. 16-inch Gun Assemblies. Extracting Misfired Primer Without Opening Breech.

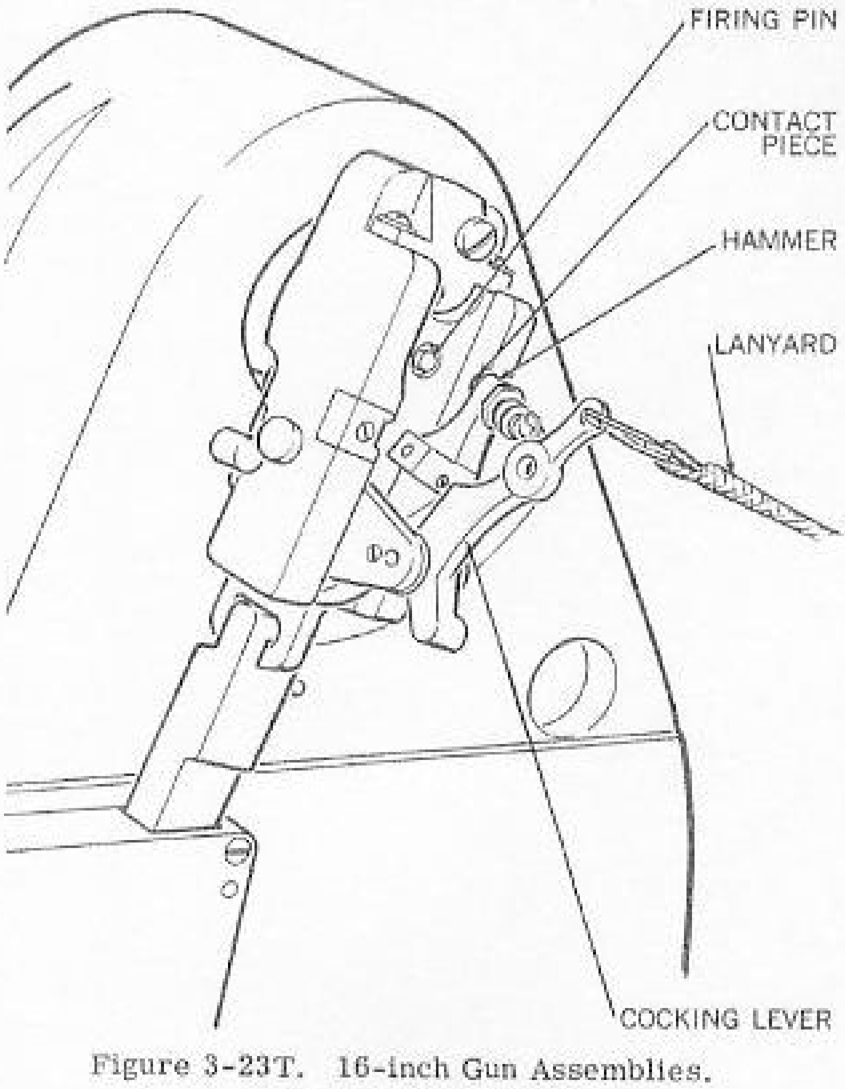


Figure 3-23T. 16-inch Gun Assemblies. Percussion Firing.

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

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

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

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

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

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

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

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

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

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

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

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

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

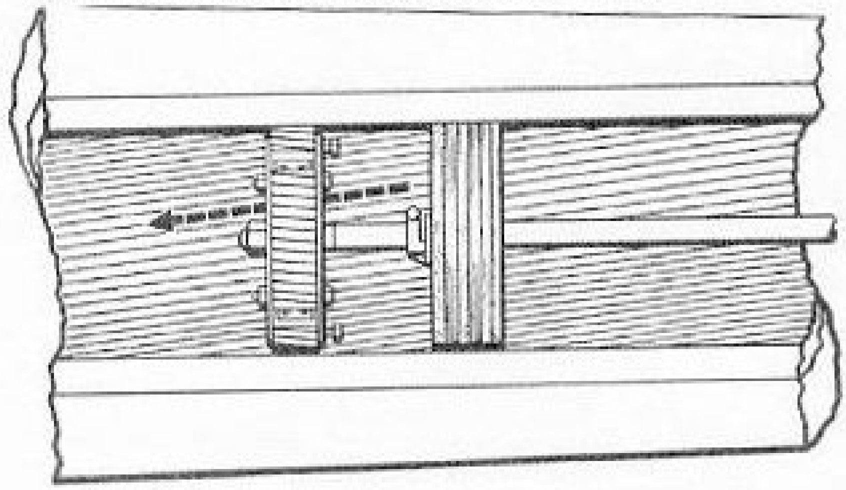


Figure 3-24. Use of Bore Lapping Head in the Care and Preservation of Gun Assemblies

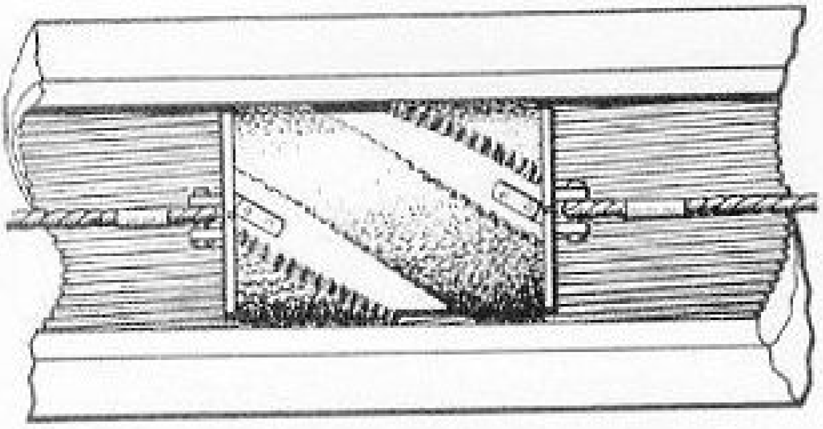


Figure 3-25. Use of Bristle Bore Sponge in the Care and Preservation of Gun Assemblies

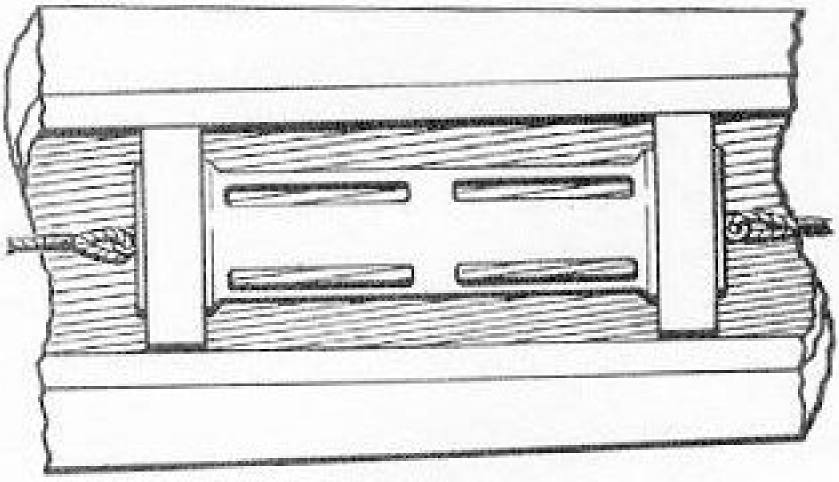


Figure 3-26. Use of Bore Gage in the Care and Preservation of Gun Assemblies

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

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

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

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

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

Operating and maintenance instructions

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

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

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

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

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

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

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

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

7. Wipe down all bright work.

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

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

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

11. Remove the tompion.

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

13. Inspect the obturator unit for scratches and misalignment.

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

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

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

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

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

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

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

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

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

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

7. Install the tompion or muzzle cover.

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

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

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

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

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

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

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

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

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

Backing out precautions

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

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

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

Adjustments

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

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

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

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

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

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

3. Replace the locking clamp on the carrier.

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

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

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

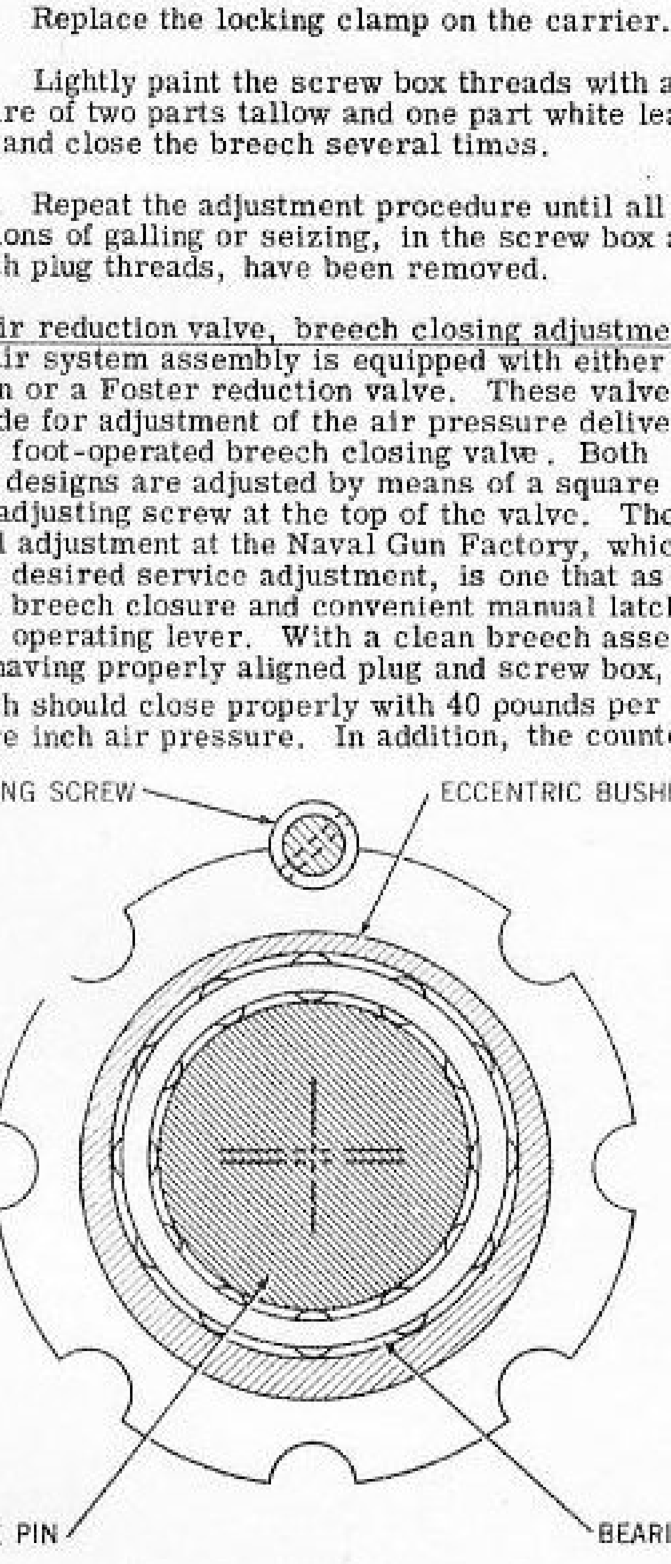


Figure 3-27. Breech Mechanism Carrier Hinge Adjustment

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

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

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

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

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

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

DISASSEMBLY AND ASSEMBLY

General instructions

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

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

Regunning procedure

General. The gun assembly and turret are designed to facilitate gun replacement by sliding the gun through the gun port to remove it. The following subparagraphs list in sequence the extent of turret preparations and the routine operations involved in sliding the gun out and sliding a new gun in. The yoke design and provisions made to free it from the gun shoulder should be studied as a necessary preliminary to these operations. Gun yokes are designed with bearing strips in the front and rear, and with white lead and tallow at assembly. This coating has been found inadequate to prevent corrosion after exposure to weather. Therefore, grease holes have been provided for the periodic injection of grease into the overbored area, to prevent such corrosion. These greasing holes should be used to inject penetrating oil at the time of regunning, if difficulty is encountered in removing the gun from the yoke.

Preparation for unyoking and sliding gun out of turret.

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

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

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

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

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

6. Remove the upper powder trunk door.

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

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

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

10. Bleed the counterrecoil air pressure.

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

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

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

Unyoking.

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

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

3. Rig the gun for pulling out.

4. Case loose the yoke locking ring.

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

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

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

8. Remove the yoke key.

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

10. Continue pulling the gun clear of the yoke.

Sliding gun out.

1. Place regunning rig on supporting timbers.

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

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

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

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

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

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

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

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

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

1. Rig the gun for pulling in.

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

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

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

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

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

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

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

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

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

10. Install the yoke ring and the key.

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

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

13. Rig for hauling the gun back to battery.

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

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

15. Remove the yoke supports.

Breech mechanism

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

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

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

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

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

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

4. Close the breech.

5. Remove and drain the breech opening buffer.

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

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

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

9. Remove the breech plug.

10. Remove the holding-down latch.

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

12. Remove the hinge lug from the gun shoulder.

13. Remove the lower rotating cam.

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

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

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

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

4. Assemble the holding-down latch.

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

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

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

8. Assemble the counterbalance and closing cylinder components.

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

10. Open the breech.

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

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

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

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

Firing lock

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

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

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

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

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

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

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

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

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

Mason valve

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

1. Remove the valve from the breech.

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

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

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

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

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

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

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

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

Assembly. The Mason valve is assembled as follows:

1. Insert the dashpot piston into the dashpot cylinder.

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

3. Assemble the main valve and spring.

4. Place the pilot valve in the seat.

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

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

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

Foster valve

Disassembly and assembly. For disassembly and assembly of the Foster valve, refer to drawing 179766. When disassembling this valve, it is important to relieve the tension on the adjusting spring and to remove the diaphragm before removing the main valve assembly.

Chapter 4

SLIDES

16-inch Slide Mark 6 Mod 0

16-inch Deck Lug Mark 7 Mod 0

GENERAL DESCRIPTION

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

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

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

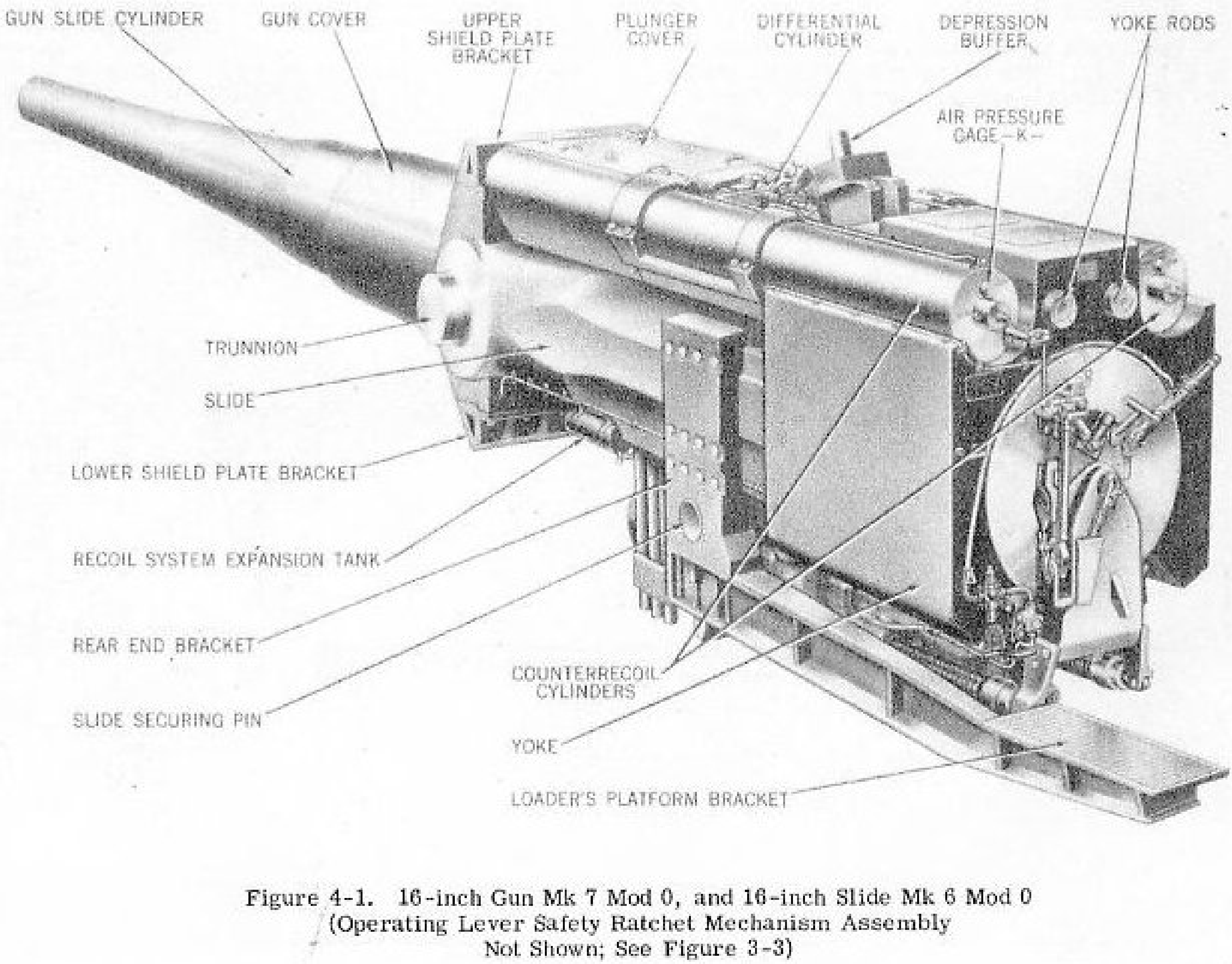


Figure 4-1. 16-inch Gun Mk 7 Mod 0, and 16-inch Slide Mk 6 Mod 0 (Operating Lever Safety Ratchet Mechanism Assembly Not Shown; See Figure 3-3)

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

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

Design features

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

Design differences

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

Access arrangements

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

DETAIL DESCRIPTION

Deck lug

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

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

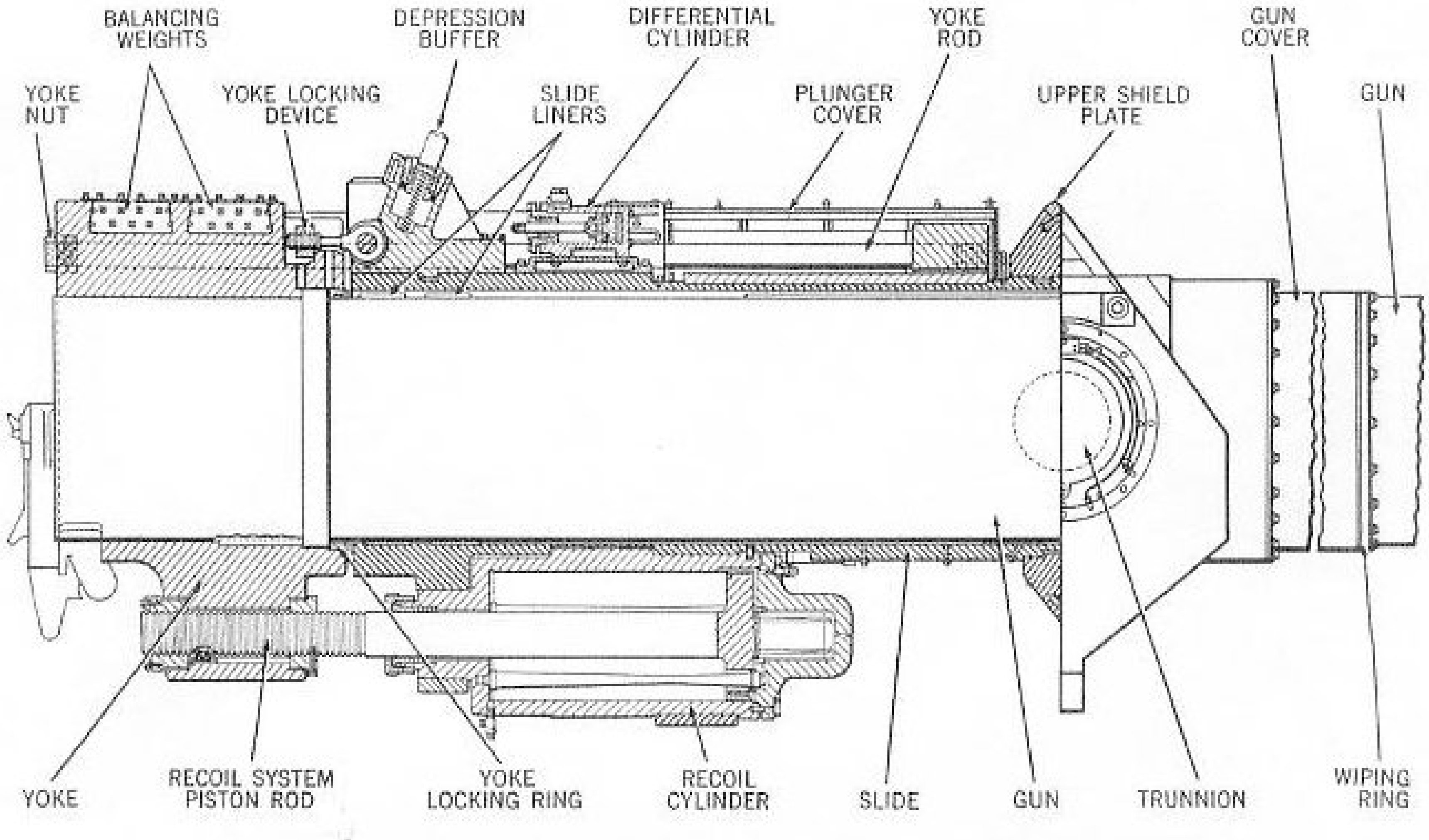


Figure 4-2. 16-inch Gun Mk 7 Mod 0 and Slide Mk 6 Mod 0, General Arrangement, Sectional View

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

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

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

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

Trunnion bearing assembly (fig. 4-4).

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

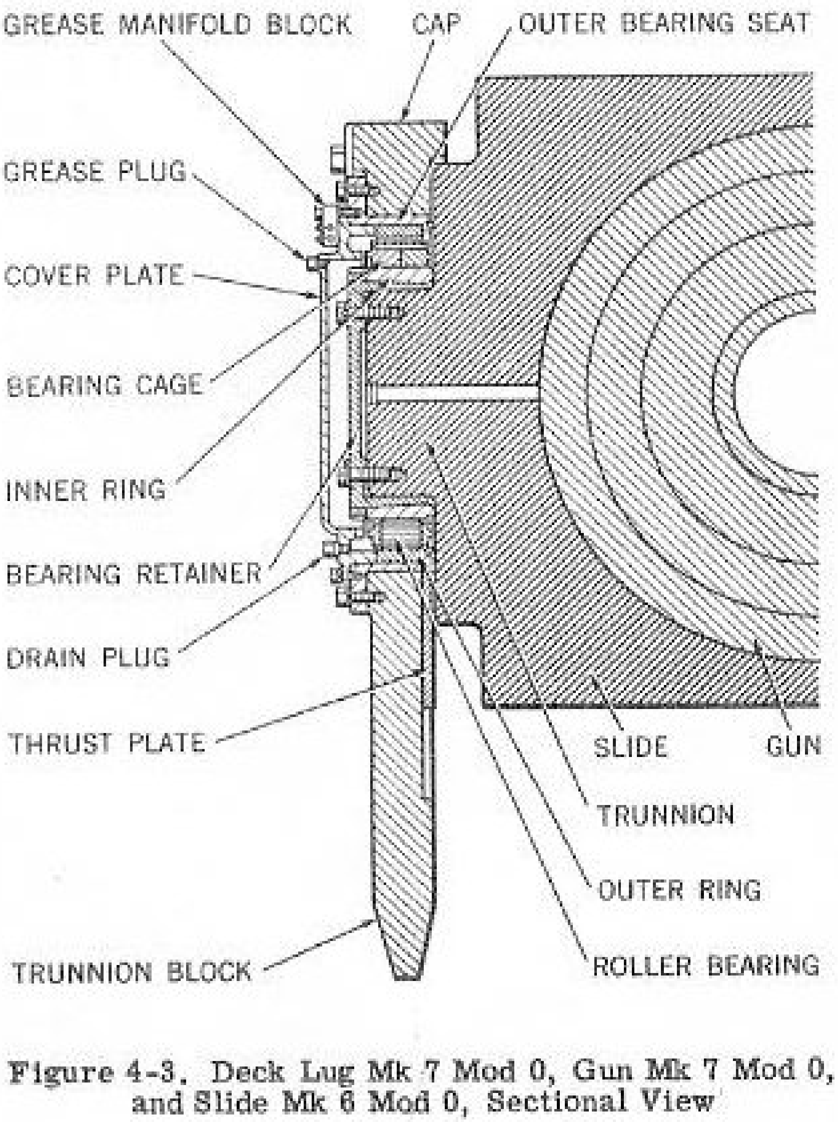


Figure 4-3. Deck Lug Mk 7 Mod 0, Gun Mk 7 Mod 0, and Slide Mk 6 Mod 0, Sectional View

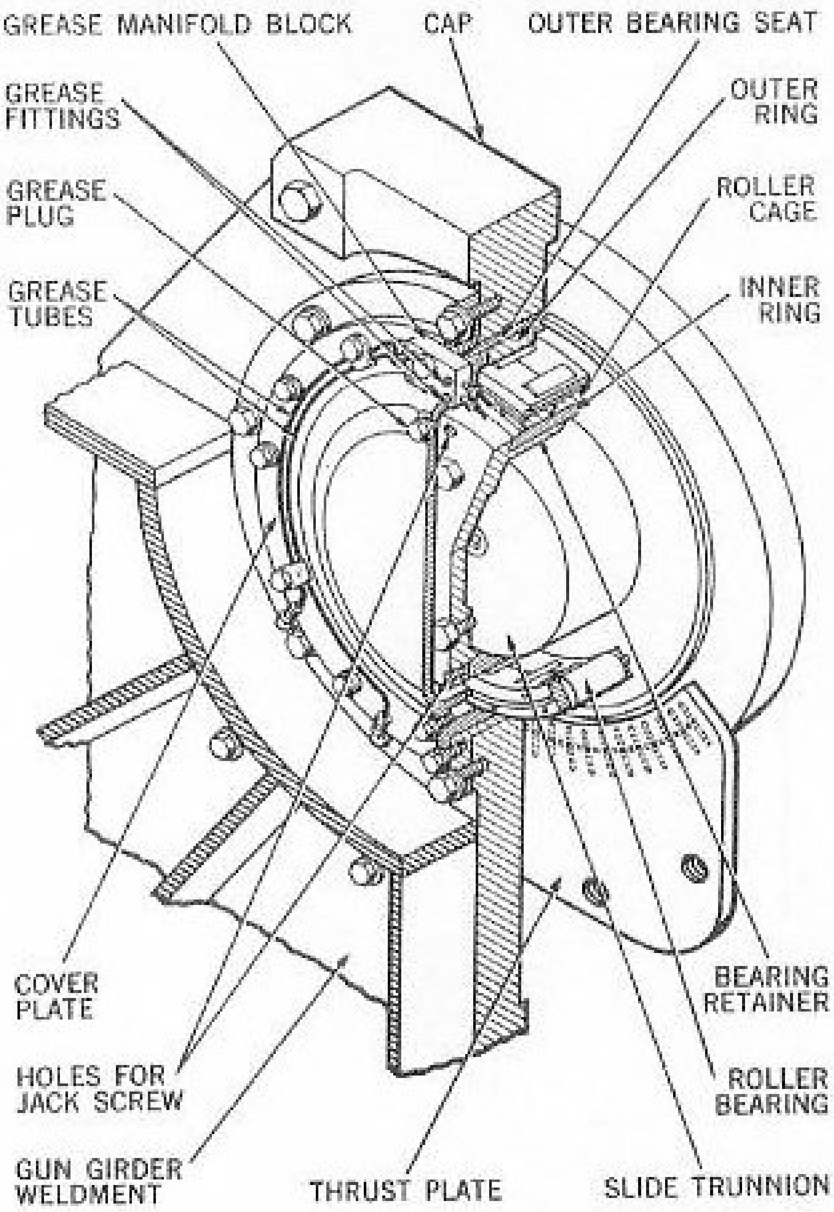


Figure 4-4. Deck Lug and Trunnion Bearing Assembly, General Arrangement

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

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

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

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

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

Slide (fig. 4-5)

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

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

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

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

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

Components. The gun slide consists of the following components:

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

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

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

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

Components. The recoil mechanism consists of the following components:

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

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

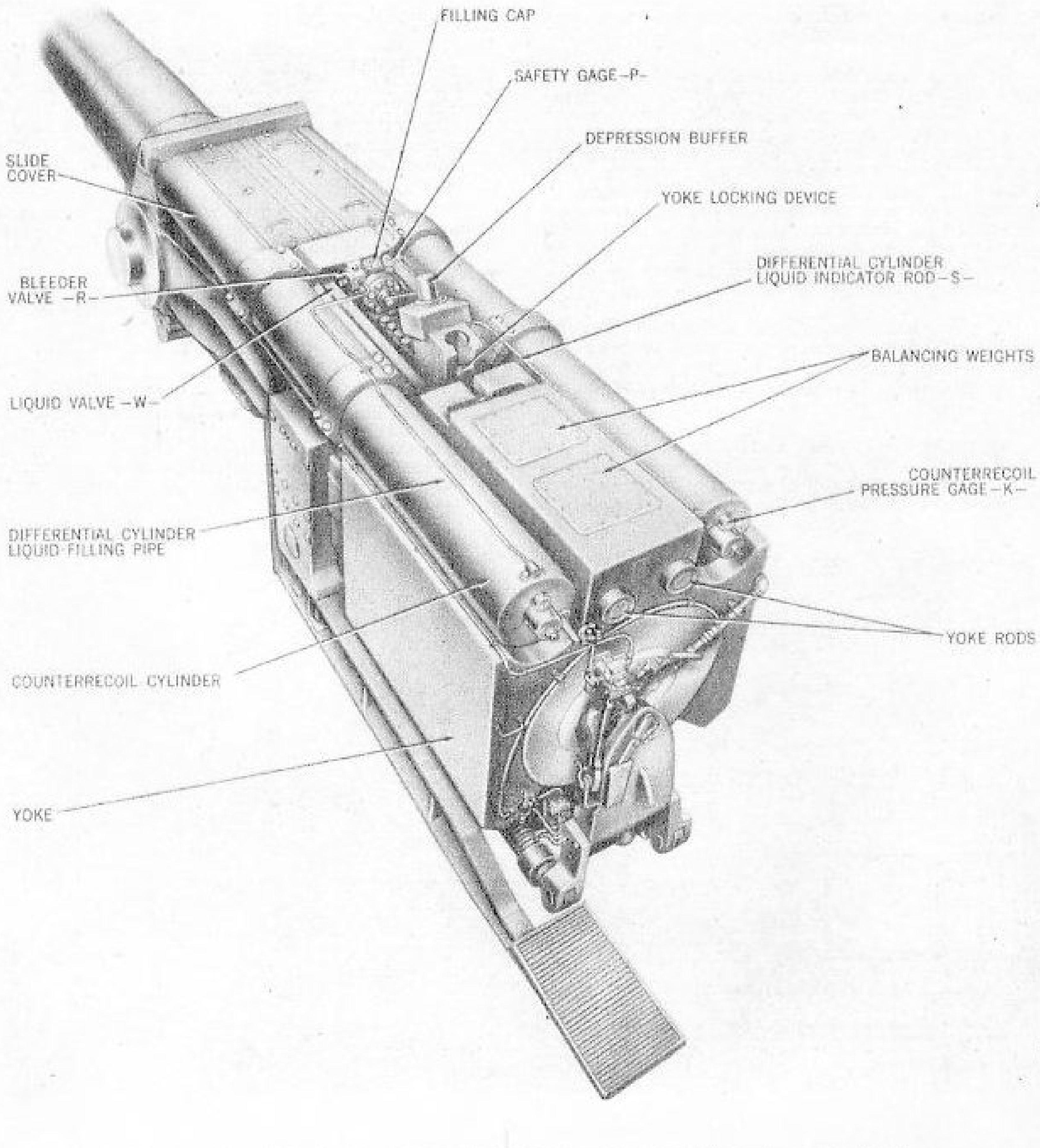


Figure 4-5. 16-inch Gun Mk 7 Mod 0 and 16-inch Slide Mk 6 Mod 0 Assembled (Operating Lever Safety Ratchet Mechanism Assembly Not Shown; See Figure 3-3)

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

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

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

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

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

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

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

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

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

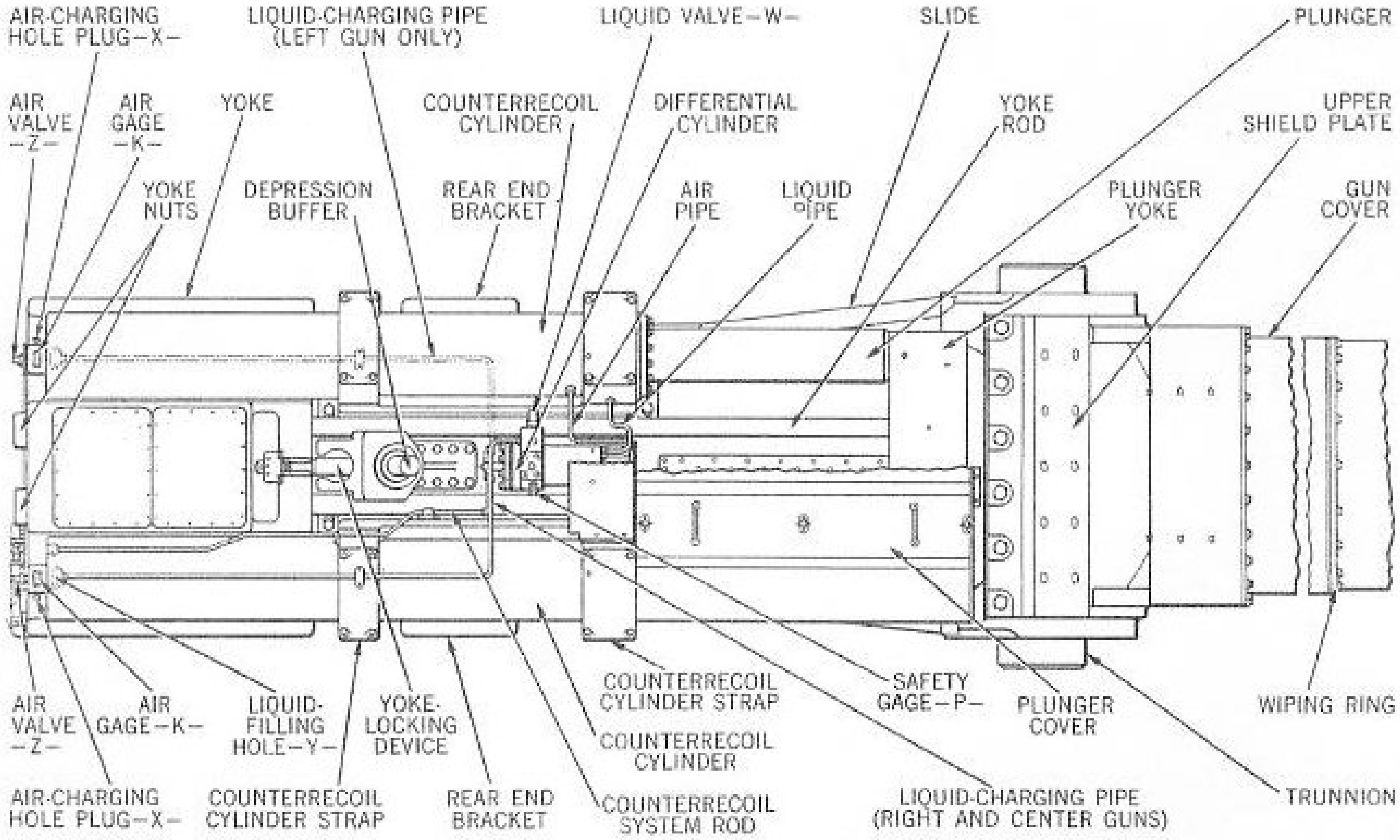


Figure 4-6. 16-inch Slide Mk 6 Mod 0, General Arrangement, Plan View

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

Components. The counterrecoil mechanism consists of the following components:

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

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

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

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

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

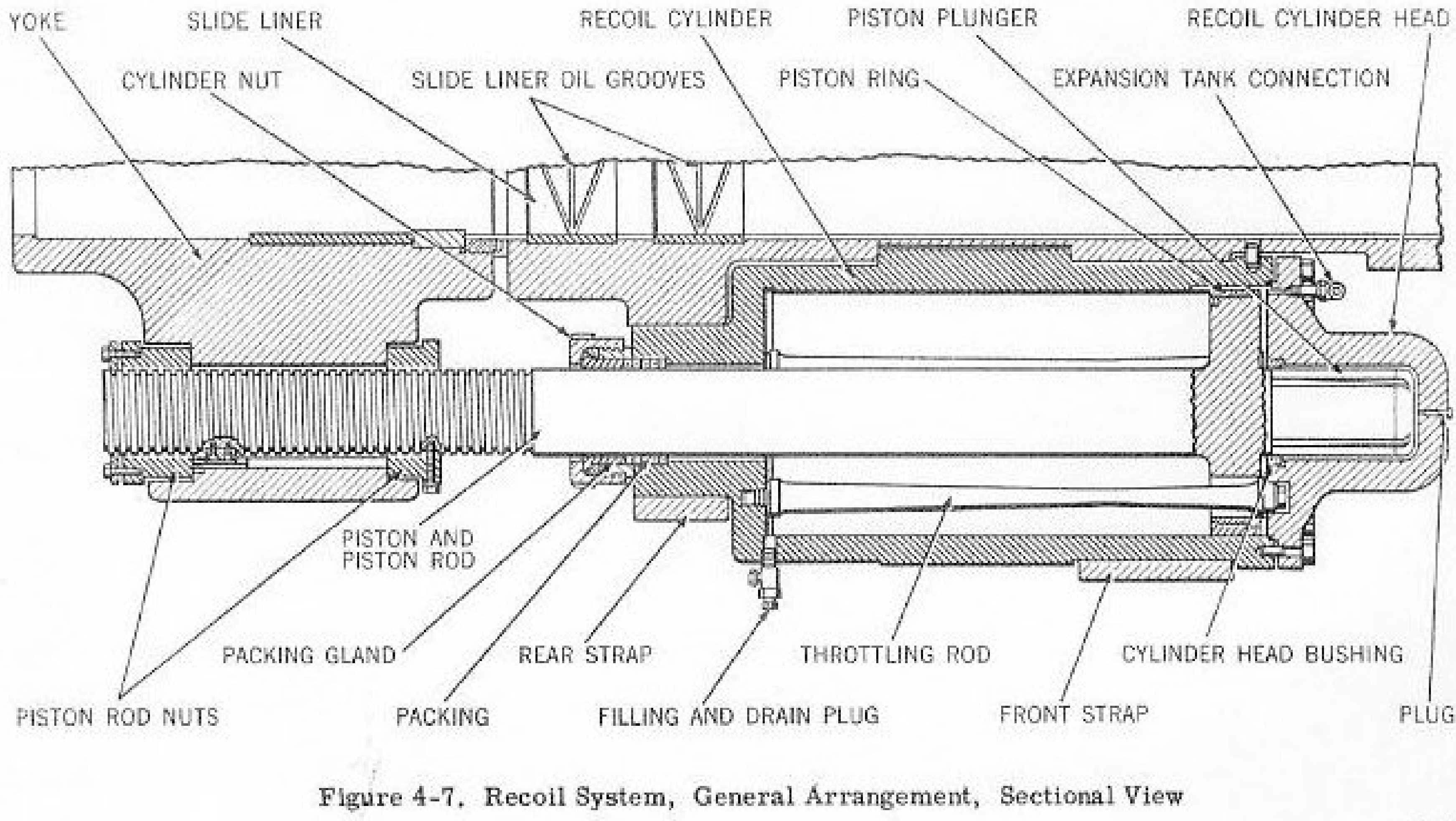


Figure 4-7. Recoil System, General Arrangement, Sectional View

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

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

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

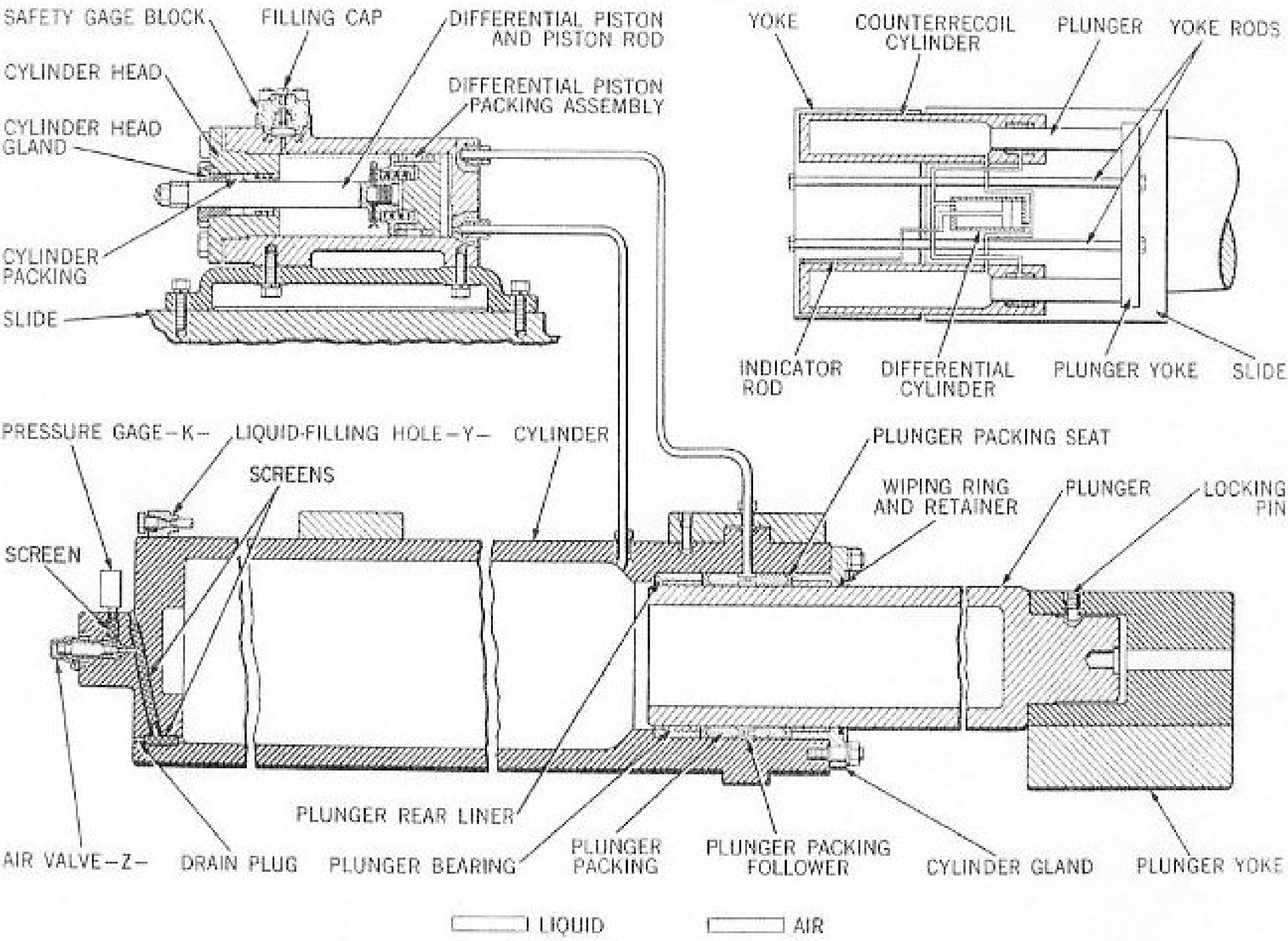


Figure 4-8. Counterrecoil System Schematic, Sectional View

*ORDALT 1324.

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

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

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

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

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

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

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

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

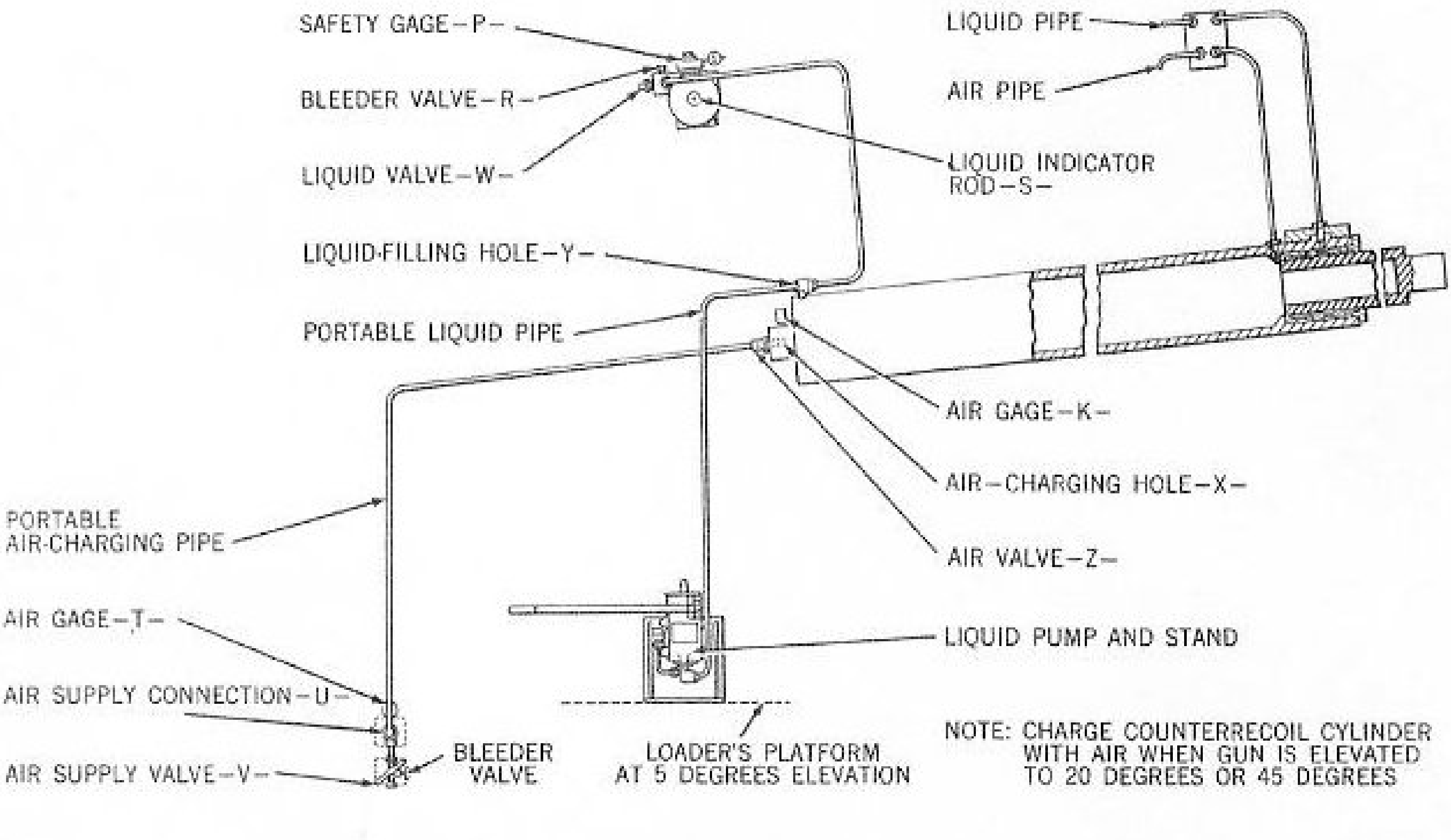


Figure 4-9. Counterrecoil System Air Charging and Liquid Devices

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

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

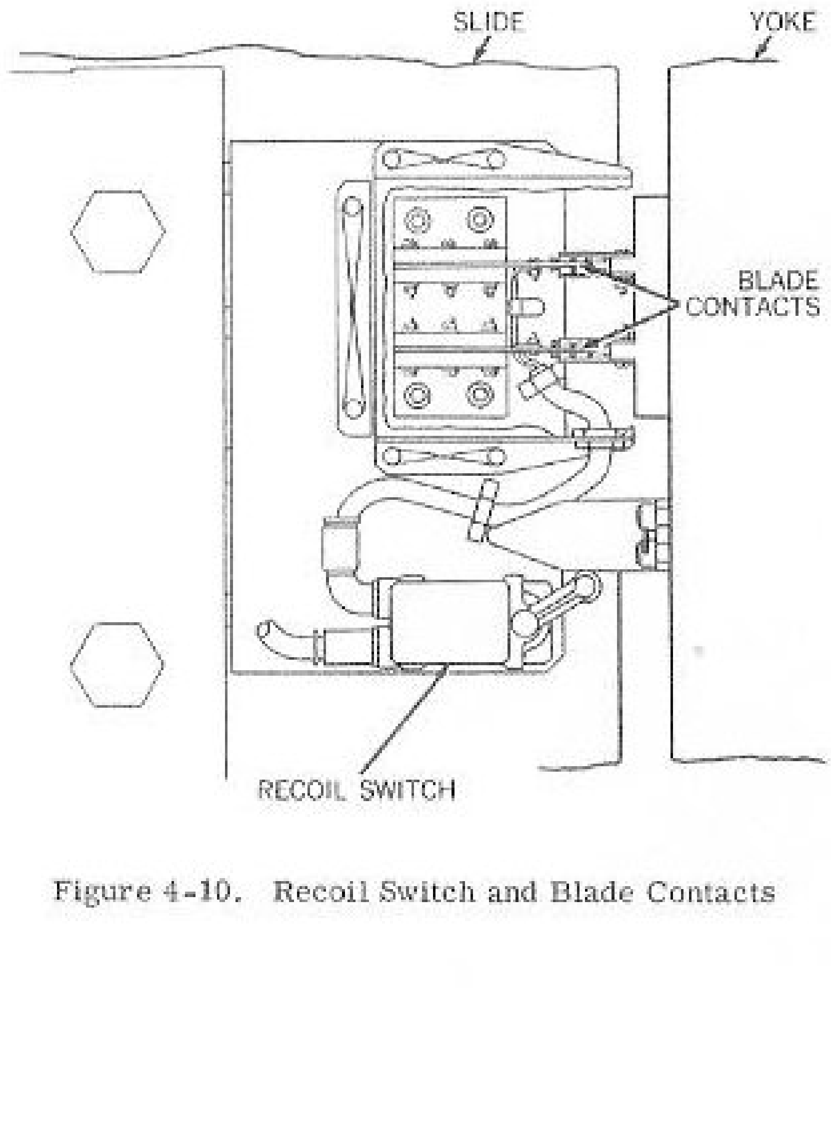


Figure 4-10. Recoil Switch and Blade Contacts

OPERATION

Slide operation when gun is fired.

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

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

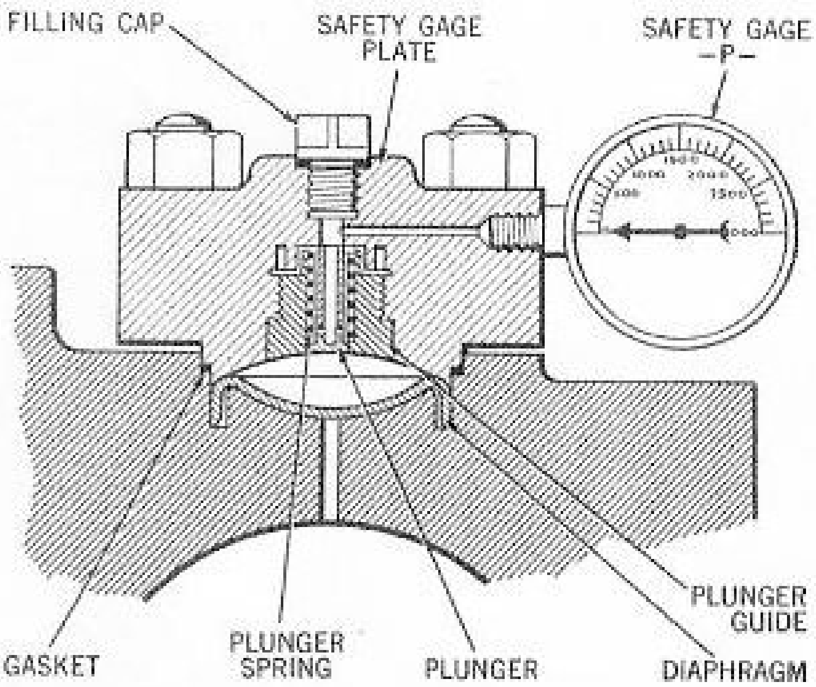


Figure 4-11. Counterrecoil System Differential Cylinder Safety Gage, Sectional View

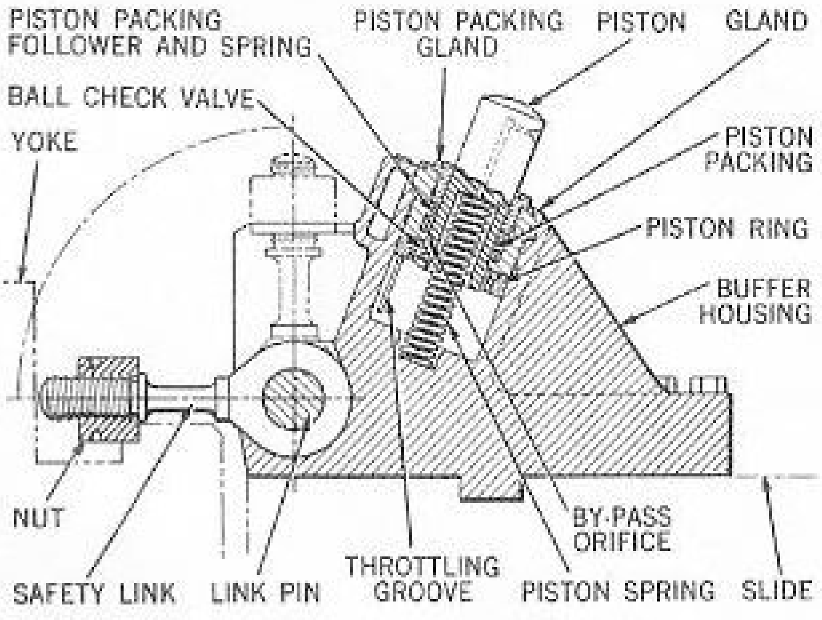


Figure 4-12. Depression Buffer and Yoke-Locking Device, Sectional View

INSTRUCTIONS

General instructions

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

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

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

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

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

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

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

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

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

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

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

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

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

6. Disconnect and stow the yoke locking device.

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

8. Make certain that the plunger covers are secure.

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

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

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

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

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

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

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

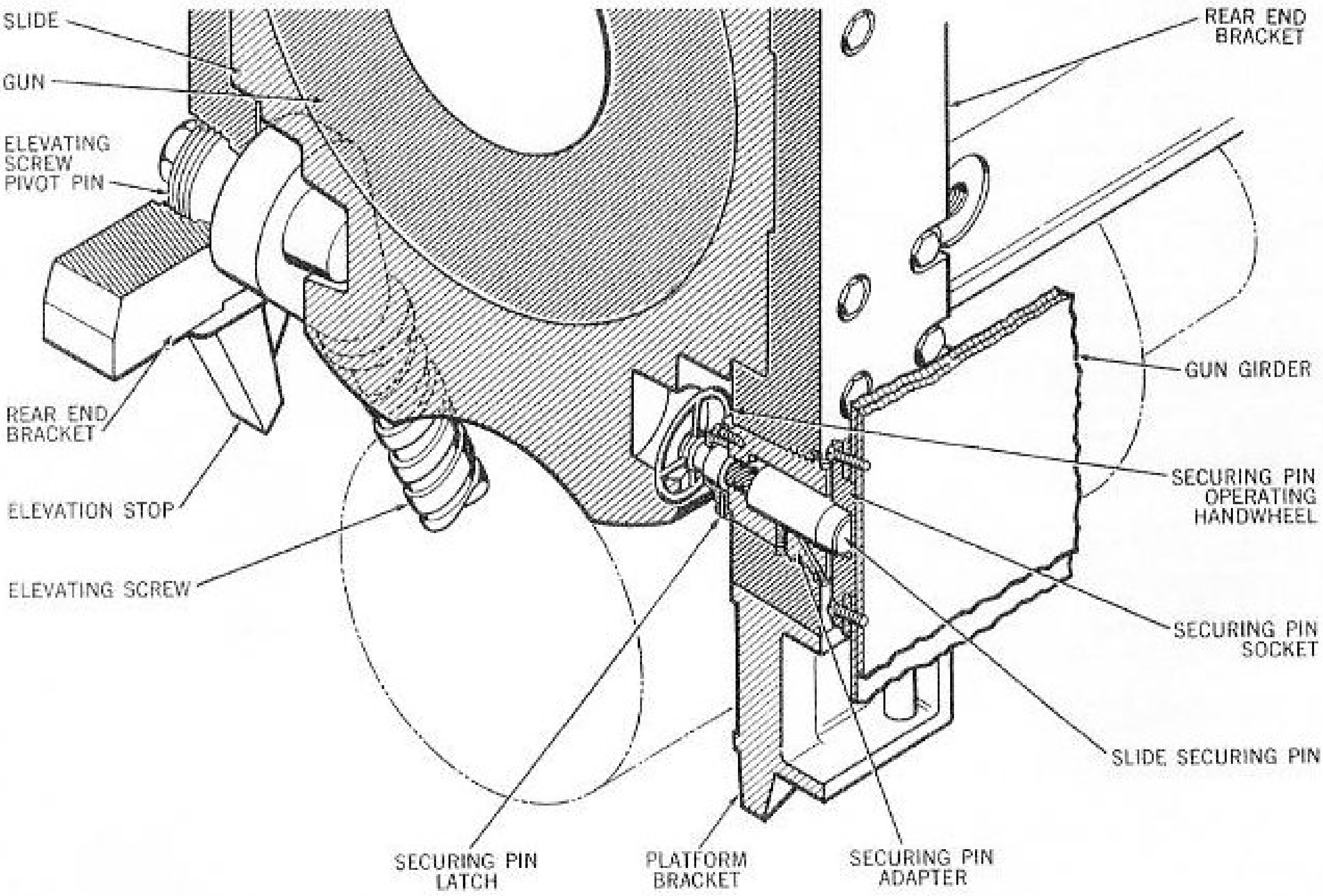


Figure 4-13. Slide Rear End Brackets, Slide Securing Device and Elevating Screw Pin, Sectional View

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

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

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

General slide servicing instructions

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

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

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

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

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

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

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

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

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

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

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

Servicing instructions for slide recoil and counterrecoil systems

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

Filling routine.

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

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

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

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

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

6. Open the filling and drain valve.

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

8. Close the filling and drain valve.

9. Remove hose and replace cap.

10. Replace the cap plug.

Draining routine.

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

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

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

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

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

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

1. Drain the recoil system as outlined above.

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

3. Uncouple the yoke locking device.

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

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

6. Back off the cylinder nut with spanner wrench.

7. Slide the packing gland out.

8. Remove the split rings of worn packings.

9. Carefully clean the packing seat.

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

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

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

13. Fill the recoil system as outlined above.

14. Retract the slide securing pin.

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

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

Part identity. The labeled parts and their symbols are:

1. On turret structure

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

2. On each mechanism

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

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

INSTRUCTION PLATE

AIR GAGE

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

INSTRUCTION PLATE

LIQUID INDICATOR

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

The servicing instructions and warnings quoted from drawing 232190 are:

WARNING

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

COUNTERRECOIL SYSTEM

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

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

LIQUID SYSTEM

TO FILL WHEN BOTH AIR AND LIQUID SYSTEMS ARE EMPTY:

1. SET GUNS TO FIVE DEGREES ELEVATION.

2. DISASSEMBLE SAFETY GAGE PLATE.

3. DISASSEMBLE SAFETY GAGE LEATHER DIAPHRAGM.

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

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

6. OPEN BLEEDER VALVE -R-.

7. SECURE LIQUID PUMP TO LOADER'S PLATFORM.

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

9. PUMP LIQUID INTO SYSTEM.

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

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

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

13. ASSEMBLE SAFETY GAGE PLATE.

14. REMOVE SAFETY GAGE FILLING CAP AND GASKET.

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

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

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

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

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

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

TO REPLENISH UNDER AIR PRESSURE

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

21. SET GUNS TO FIVE DEGREES ELEVATION.

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

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

SAFETY GAGE P

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

A. LOSS OF LIQUID FROM ABOVE THE LEATHER DIAPHRAGM.

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

C. INSUFFICIENT AIR PRESSURE ON THE SYSTEM.

D. DEFECTIVE SAFETY GAGE.

TO FILL OR REPLENISH

SAFETY GAGE P

24. BLEED AIR SYSTEM (OPERATIONS 27 AND 29).

25. PERFORM OPERATIONS 14, 15, AND 16.

AIR SYSTEM

TO CHARGE WHEN EMPTY

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

26. ELEVATE GUNS TO 20 DEGREES ELEVATION.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

C. REASSEMBLE AND PERFORM OPERATIONS 1 TO 20.

D. PERFORM OPERATIONS 26 TO 36.

TO REPLENISH

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

CAUTION: MAKE SURE YOKE LOCKING DEVICE IS CONNECTED.

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

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

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

TO OBTAIN READING OF AIR PRESSURE ON SYSTEM

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

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

41. OPEN AIR VALVE -Z- ONE TURN.

42. READ PRESSURE ON AIR GAGE -K-.

43. CLOSE AIR VALVE -Z-.

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

General note

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

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

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

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

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

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

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

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

Routine tests of the slide

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

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

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

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

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

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

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

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

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

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

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

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

1. Open the counterrecoil and differential cylinders.

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

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

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

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

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

Adjustments

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

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

DISASSEMBLY AND ASSEMBLY

General instructions

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

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

1. Secure the yoke locking device.

2. Seat the slide securing pin in its socket.

3. Remove the plunger cover.

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

5. Remove air valve cap Z and plug X.

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

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

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

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

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

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

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

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

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

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

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

16. Remove the eye nut and rail fixture.

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

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

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

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

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

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

Chapter 5

ELEVATING GEAR

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

16-inch Elevating Receiver Regulator Mark 10 Mod 0

GENERAL DESCRIPTION

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

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

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

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

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

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

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

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

Design differences

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

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

Elevating gear data.

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

Power drive

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

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

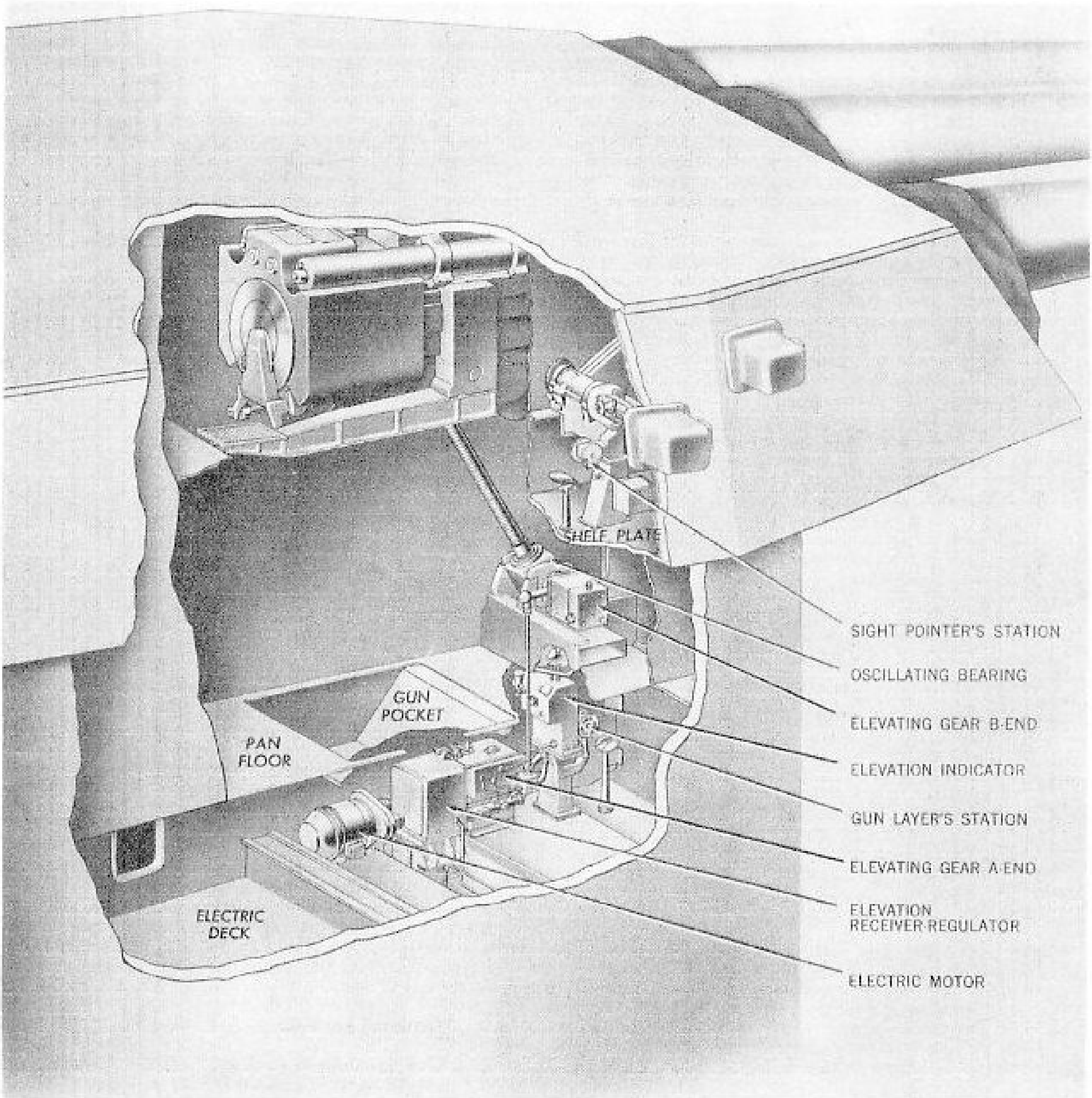


Figure 5-1. 16-inch Elevating Gear Mk 5 Mod 0, General Arrangement

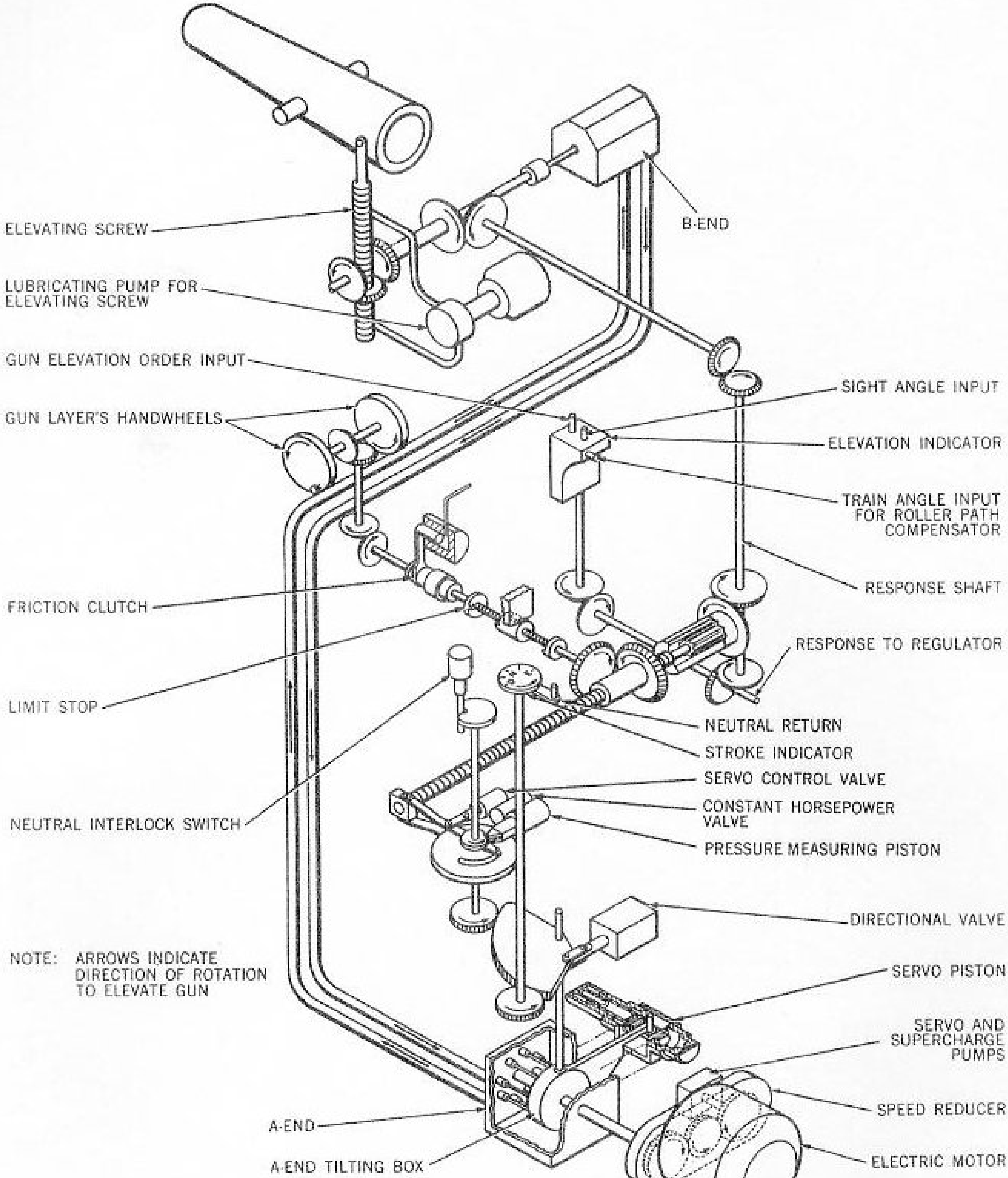


Figure 5-2. 16-inch Elevating Gear Mk 5 Mod 0, Schematic Arrangement

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

Motor data.

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

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

Controller data.

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

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

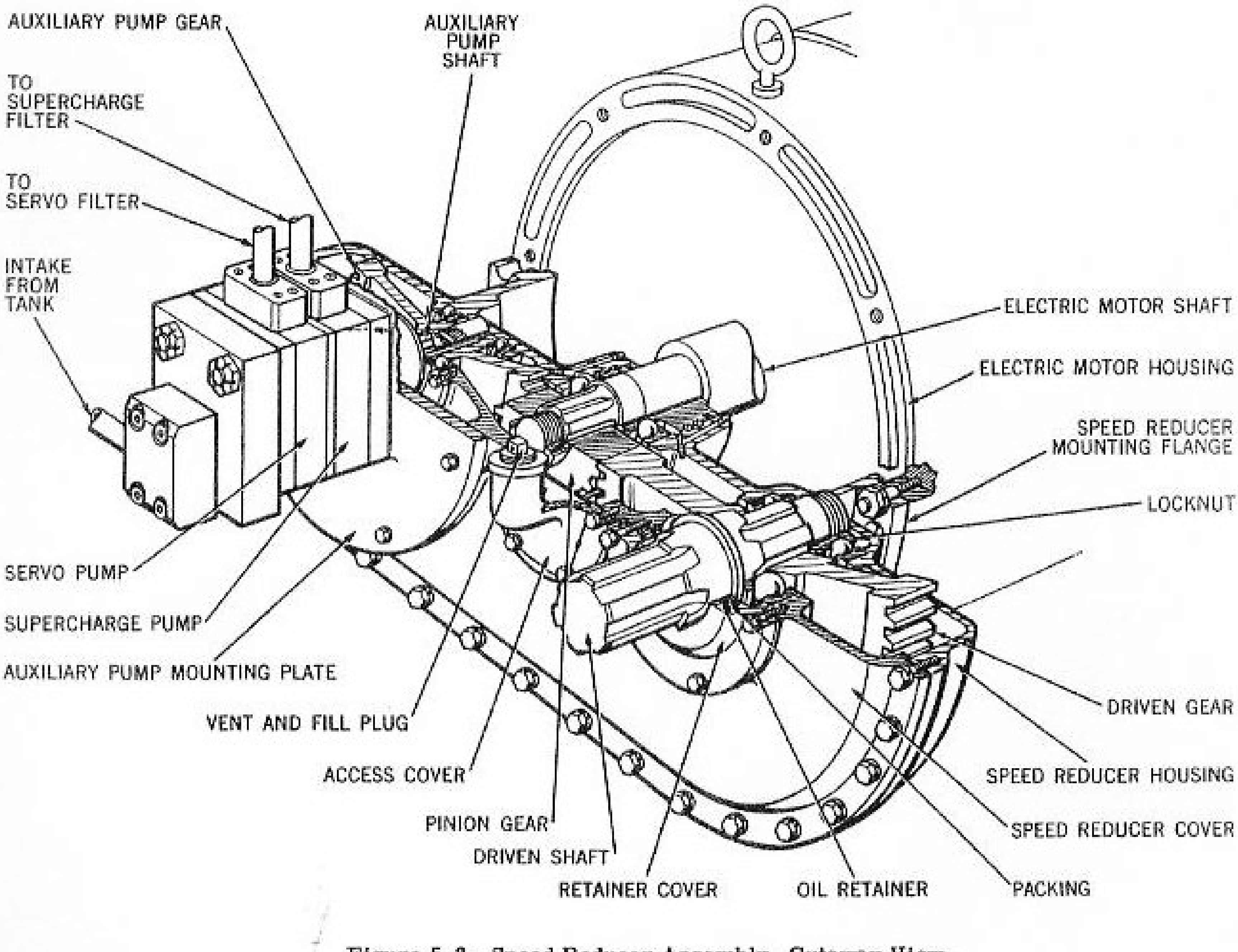


Figure 5-3. Speed Reducer Assembly, Cutaway View

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

Speed reducer data.

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

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

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

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

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

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

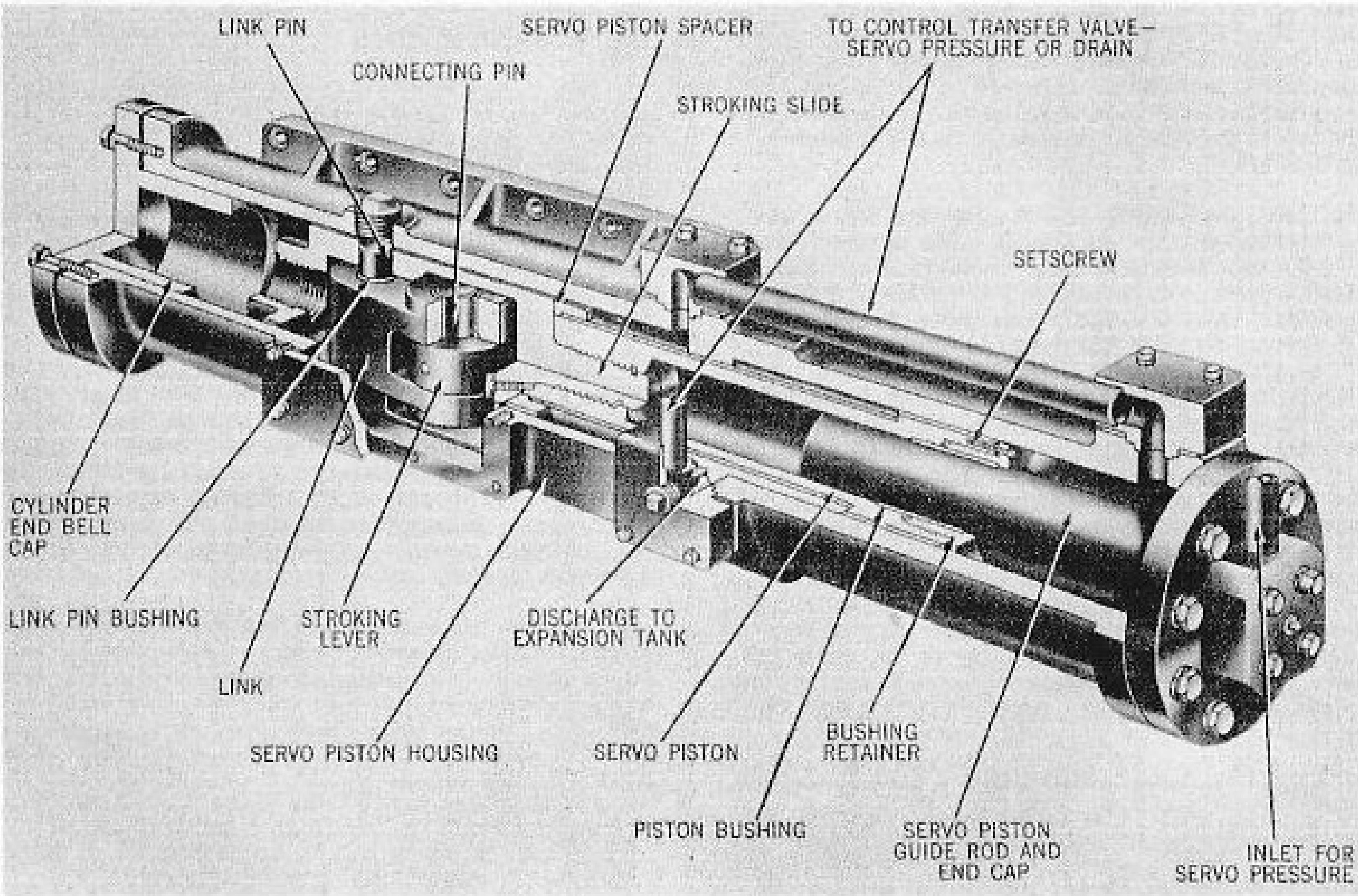


Figure 5-4. Servo Piston Assembly, Cutaway View

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2. As a relief by-pass valve.

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

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

A-end data.

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

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

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

Hydraulic motor (B-end).

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

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

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

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

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

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

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

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

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

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

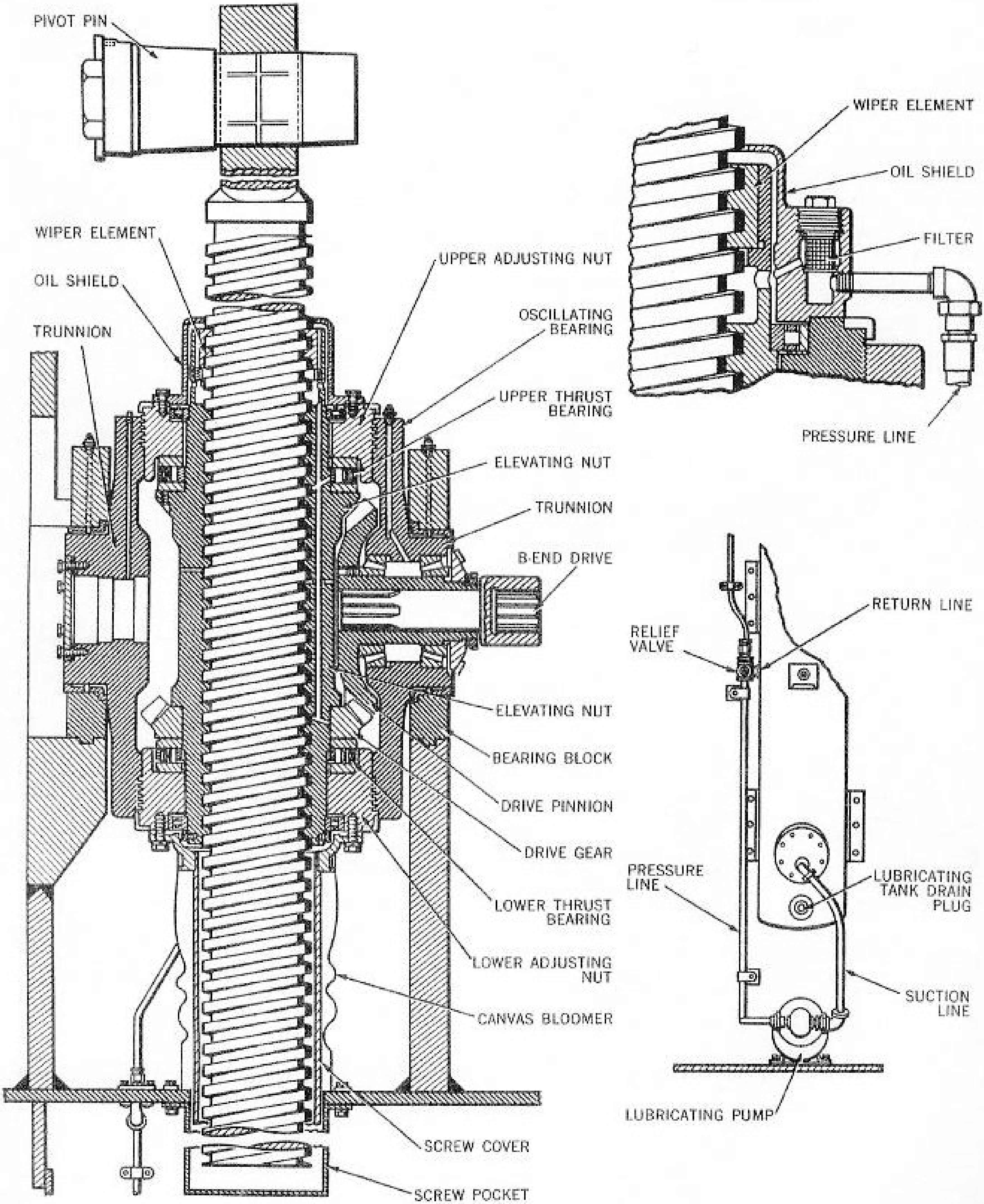


Figure 5-5. Elevating Gear Oscillating Bearing, Sectional Views

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

B-end data.

Speed (maximum), rpm.	500
Torque load	
Normal, rated, ft-lb	2000
Maximum, rated, ft-lb	2200
Oil temperatures	
Normal operating range, F	120 to 175
Maximum permitted, F	185
Displacement, cubic inches	134.82
Manufacturer	Northern Pump Company
Manufacturer's designation, size	frame 71 43
Drawing	268459

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

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

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

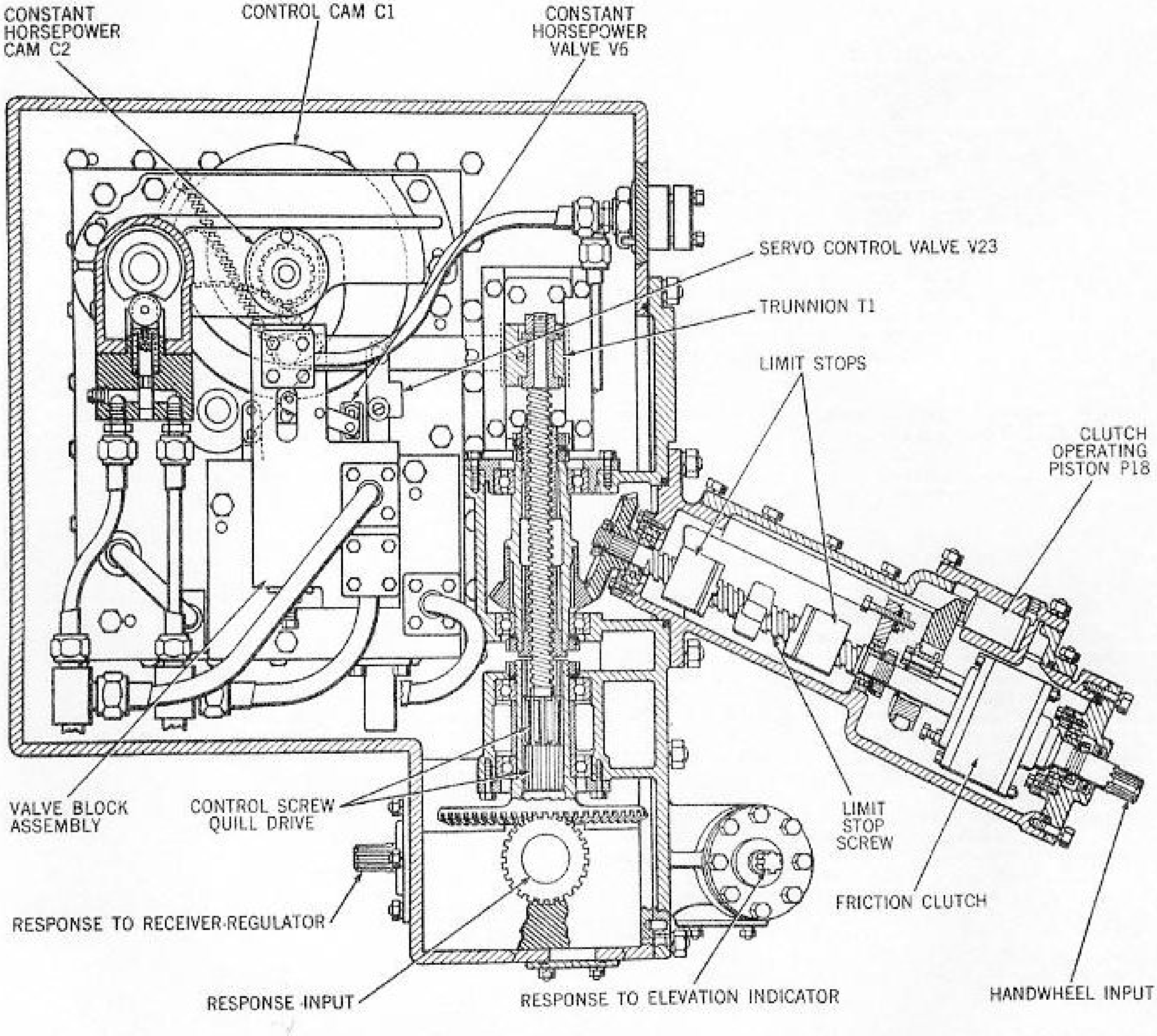


Figure 5-6. Control Box Mechanism, Sectional View

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

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

Oscillating bearing assembly

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

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

Components. The oscillating bearing assembly comprises the following:

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

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

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

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

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

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

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

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

Elevating gear controls

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. A servo control system relief valve.

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

5. Stroking piston control valve.

6. Hydraulic control valves.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Receiver-regulator

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

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

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

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

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

Receiver-regulator instrument.

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

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

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

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

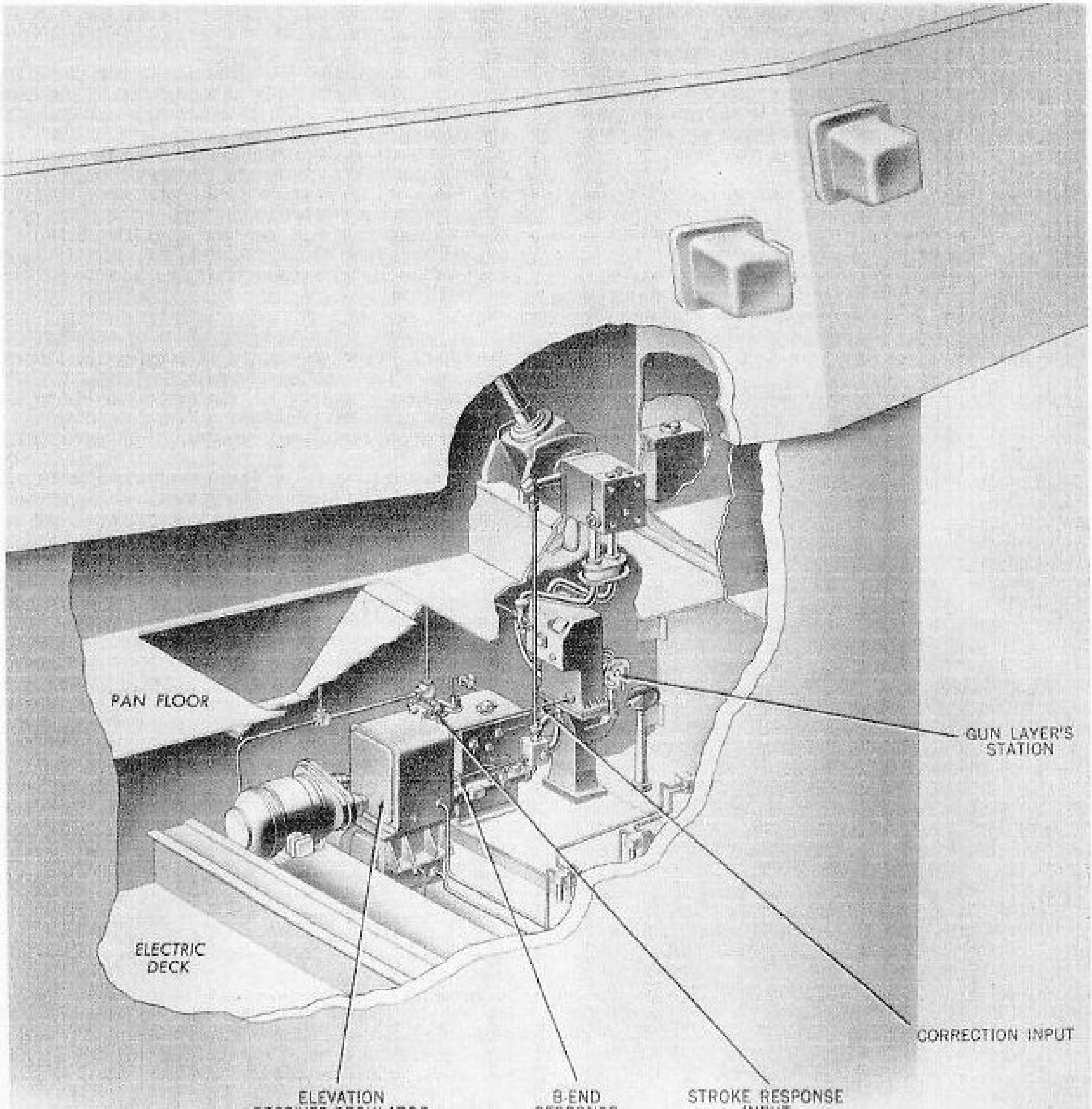


Figure 5-7. 16-inch Elevation Receiver-Regulator Mk 10 Mod 0, General Arrangement

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

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

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

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

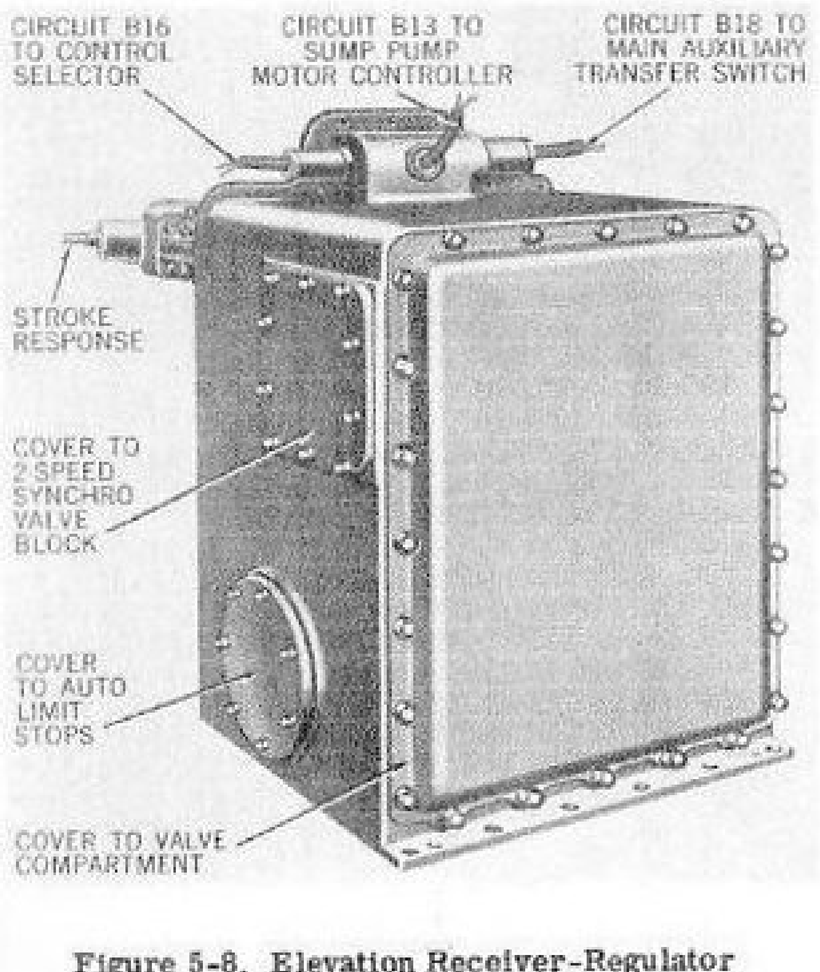


Figure 5-8. Elevation Receiver-Regulator Mk 10 Mod 0, Front View

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

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

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

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

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

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

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

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

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

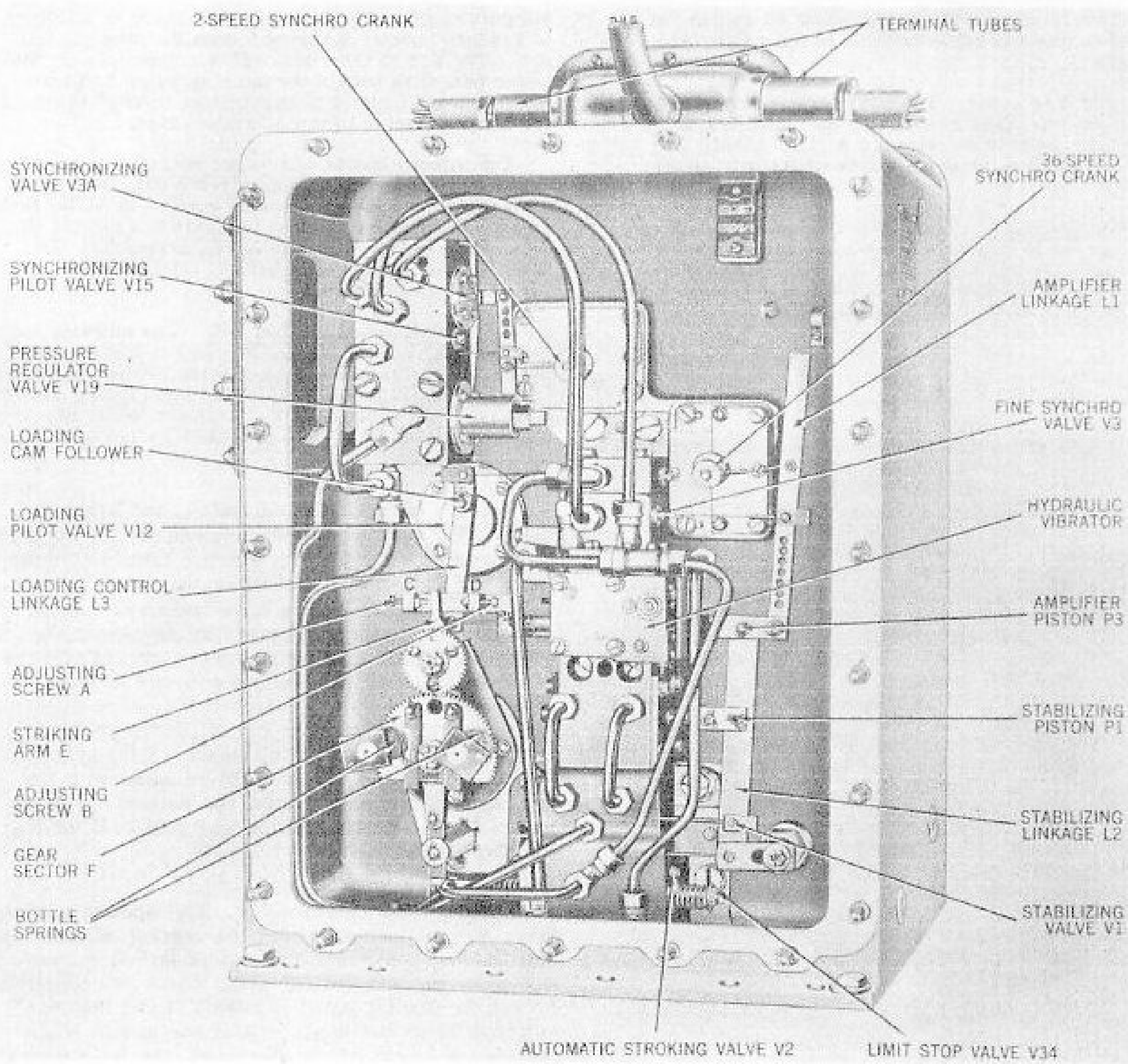


Figure 5-9. Elevation Receiver-Regulator Mk 10 Mod 0, Valve Compartment

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

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

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

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

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

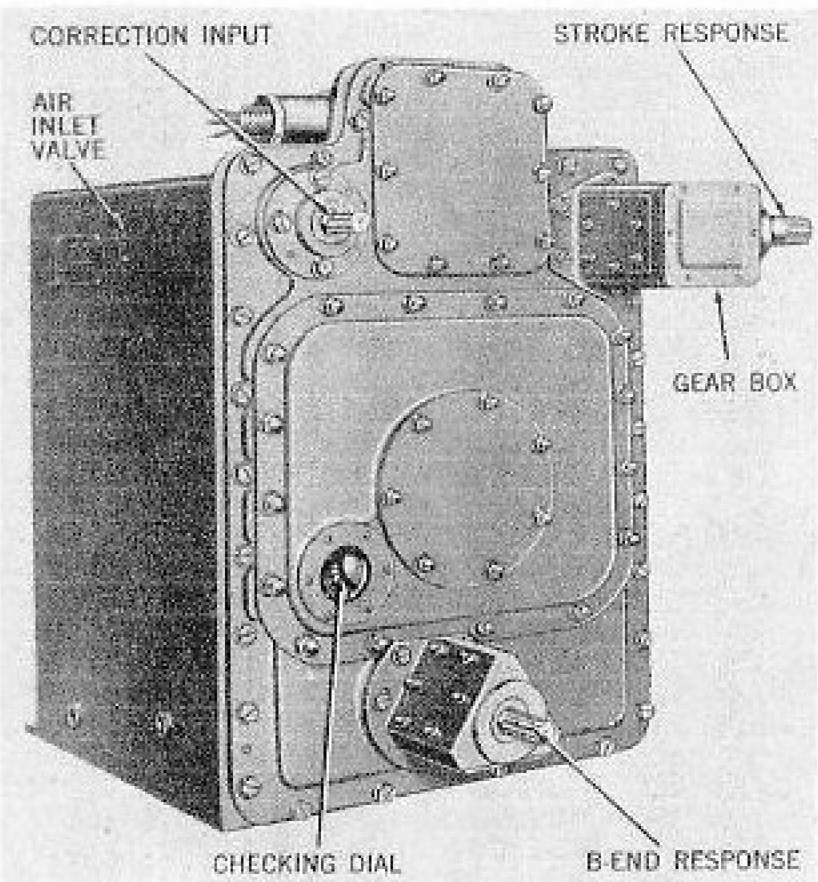


Figure 5-10. Elevation Receiver-Regulator Mk 10 Mod 0, Rear View

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

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

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

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

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

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

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

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

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

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

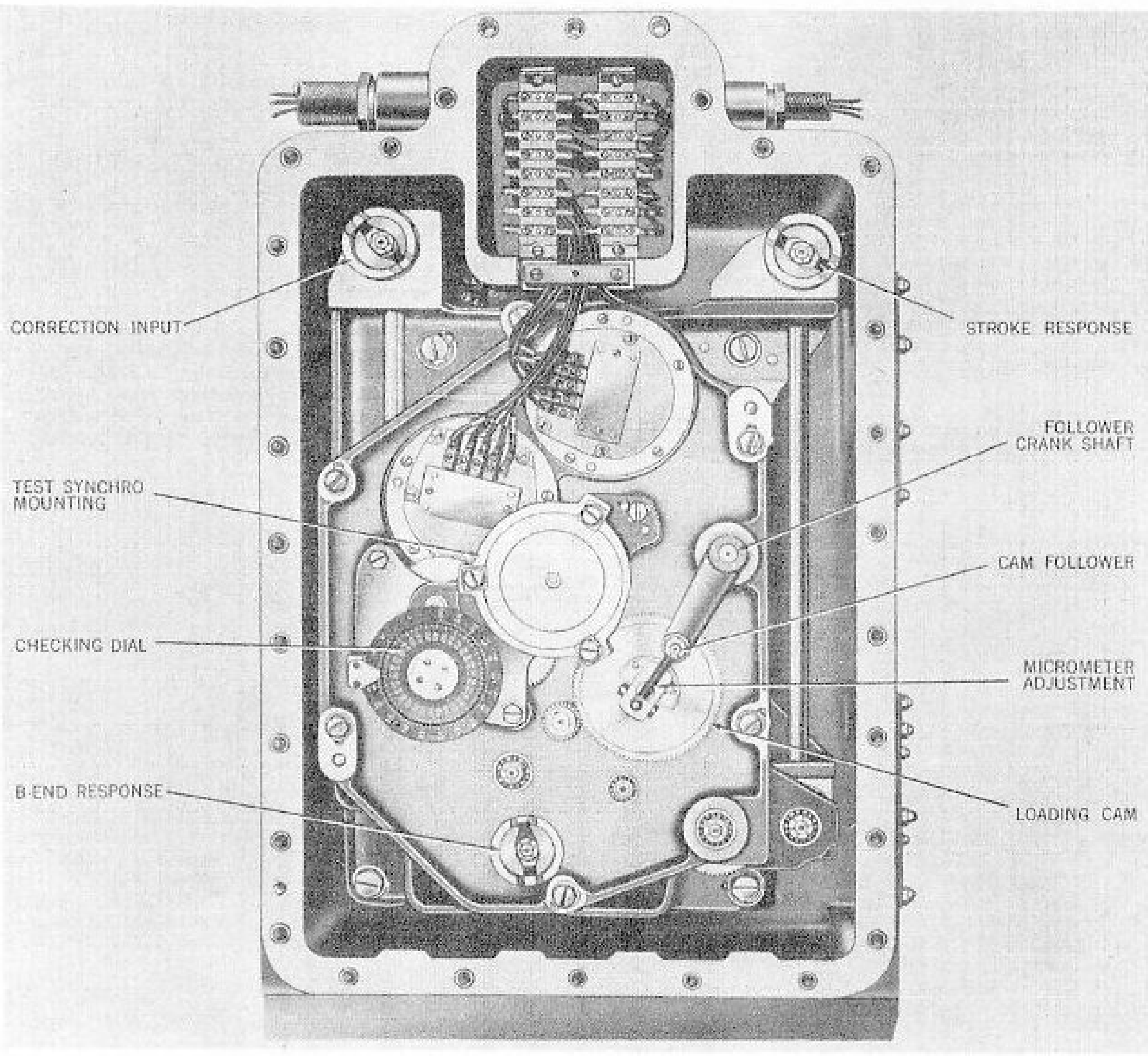


Figure 5-11. Elevation Receiver -Regulator Mk 10 Mod 0, Rear View - Back Plate Removed

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

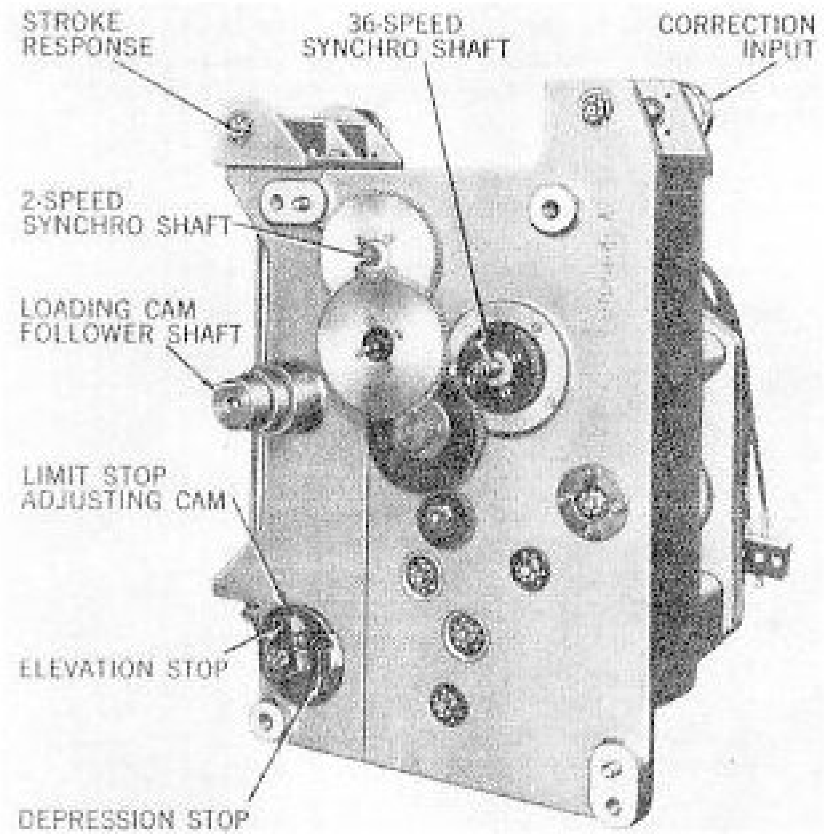


Figure 5-12. Elevation Receiver-Regulator Mk 10 Mod 0, Gear Train Assembly, Front View

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

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

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

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

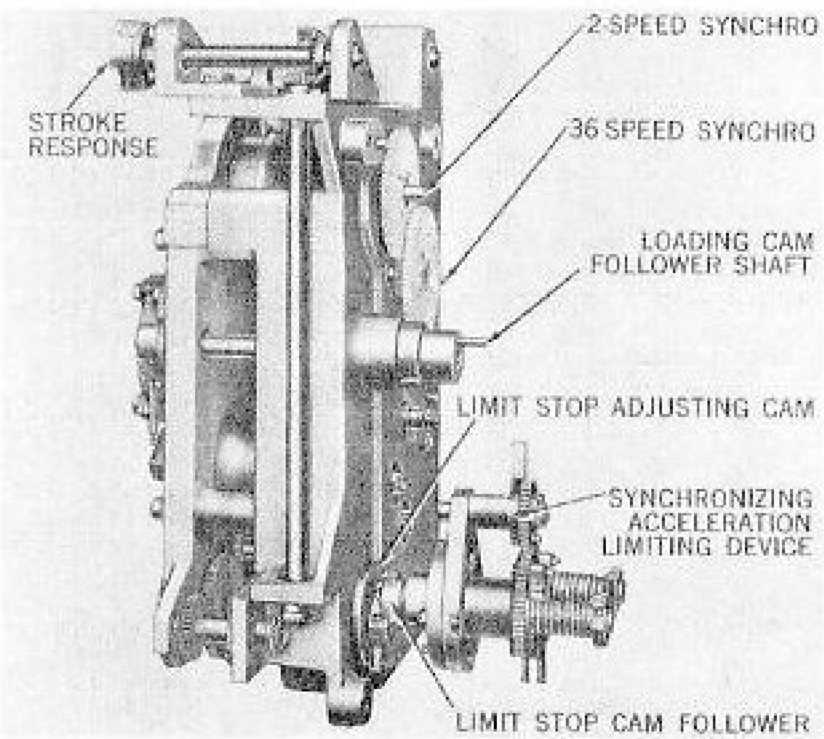


Figure 5-13. Elevation Receiver-Regulator Mk 10 Mod 0 Gear Train Assembly, Side View

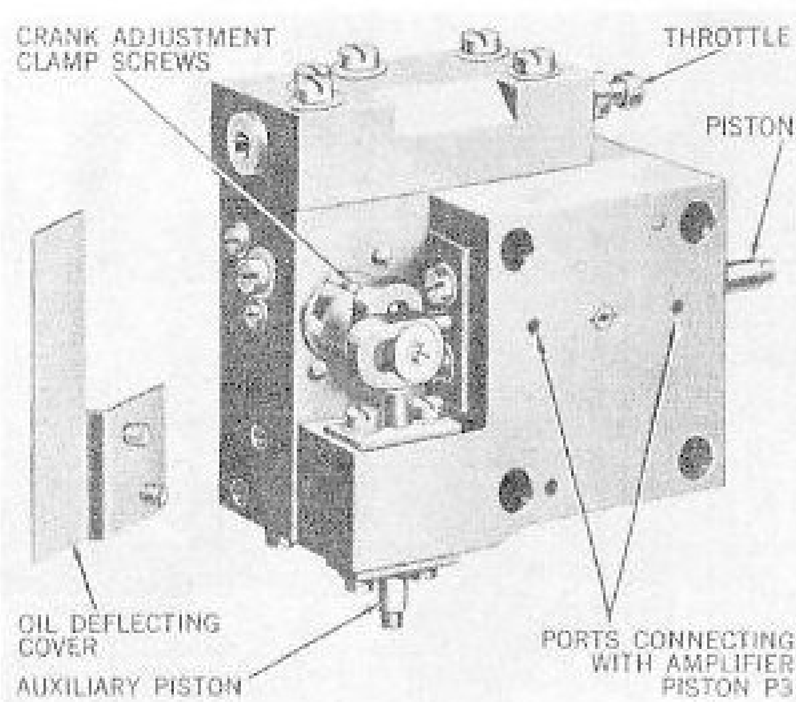


Figure 5-14. Elevation Receiver-Regulator Mk 10 Mod 0 Hydraulic Vibrator

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

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

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

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

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

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

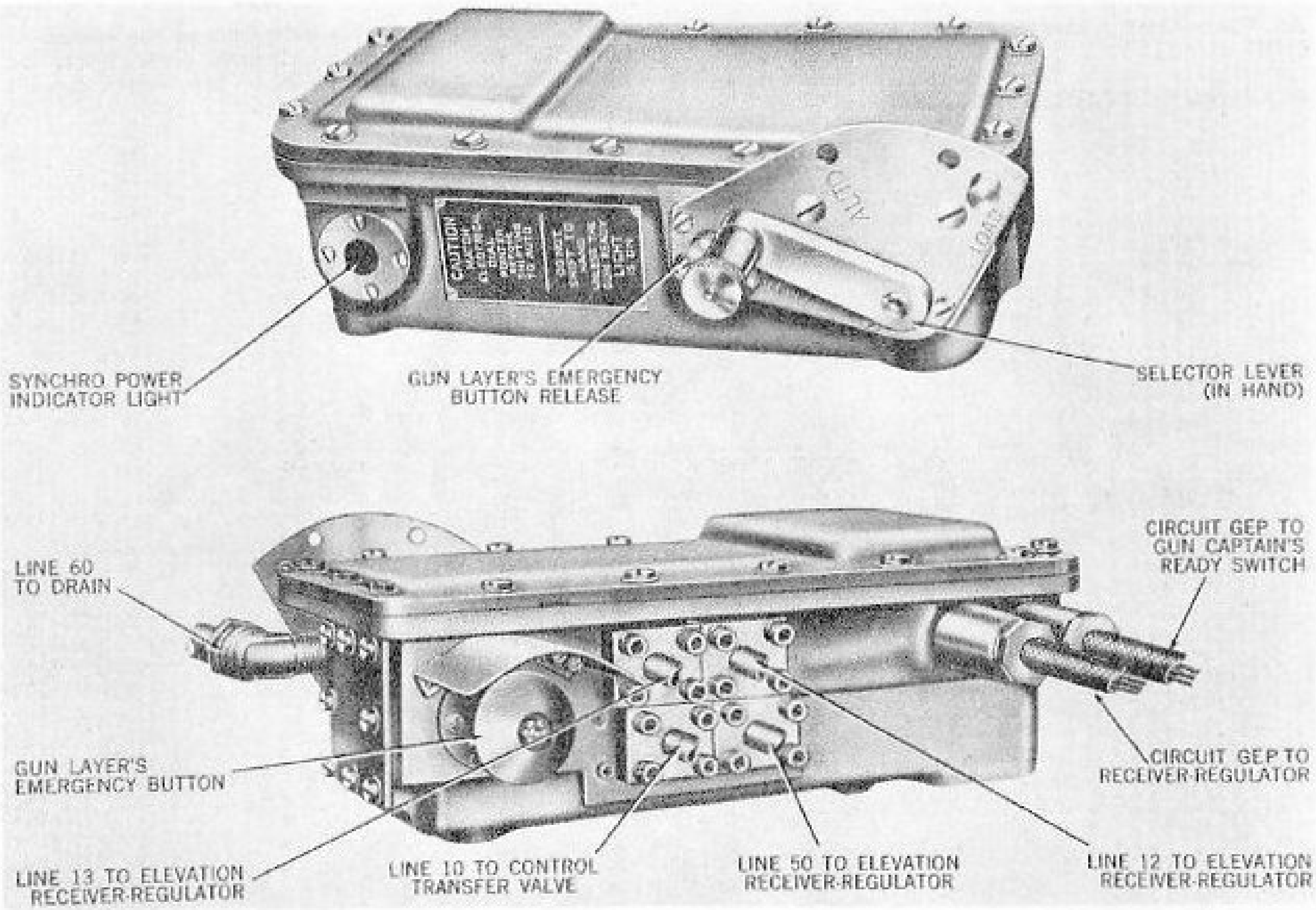


Figure 5-15. Elevation Receiver-Regulator Mk 10 Mod 0 Selector and Synchro Failure Valve

OPERATION

General - hand and automatic control

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

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

Starting

Perform the following operations when starting the electric motor:

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

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

3. Press the START-EMERG button.

Stopping

When stopping the elevating gear, perform the following operations:

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

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

3. Press the STOP button.

Hand control, servo operation

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

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

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

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

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

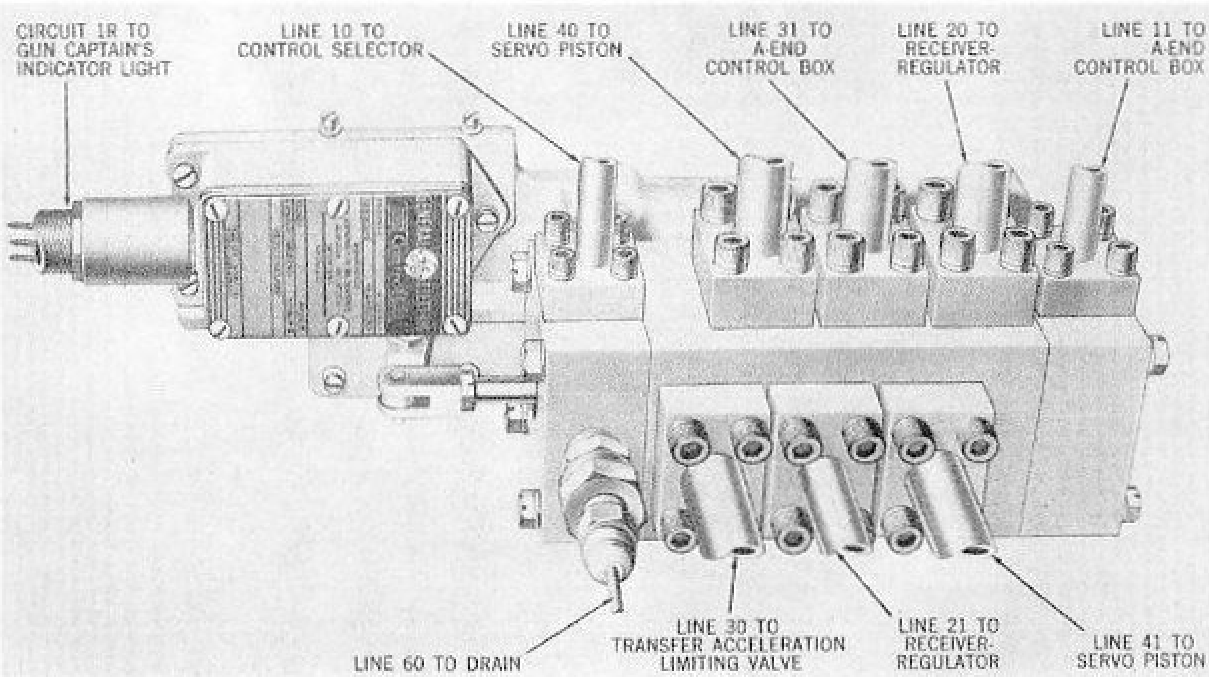


Figure 5-16. Elevation Receiver-Regulator Mk 10 Mod 0 Control Transfer Valve

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

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

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

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

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

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

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

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

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

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

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

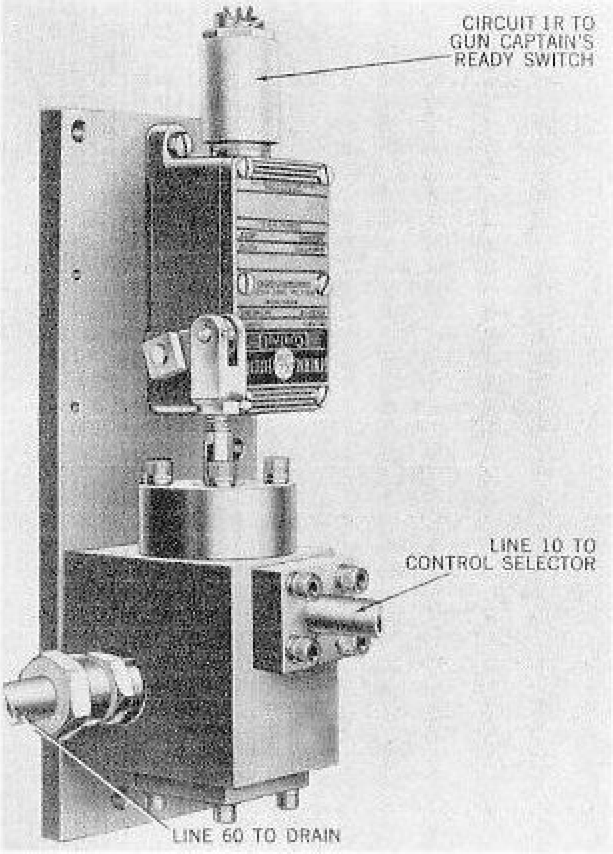


Figure 5-17. Elevation Receiver-Regulator Mk 10 Mod 0 Pressure-operated Indicator Switch

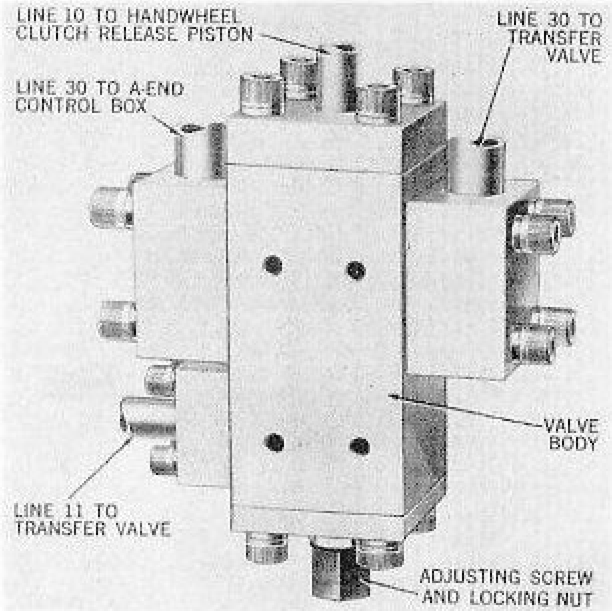


Figure 5-18. Elevation Receiver-Regulator Mk 10 Mod 0 Transfer Acceleration Limiting Valve

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

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

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

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

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

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

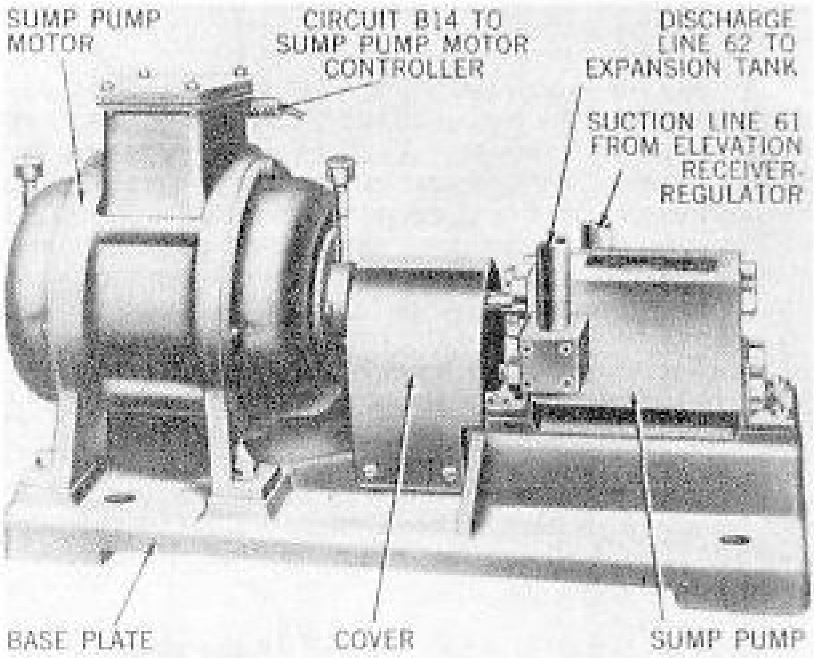


Figure 5-20. Elevation Receiver-Regulator Mk 10 Mod 0 Sump Pump

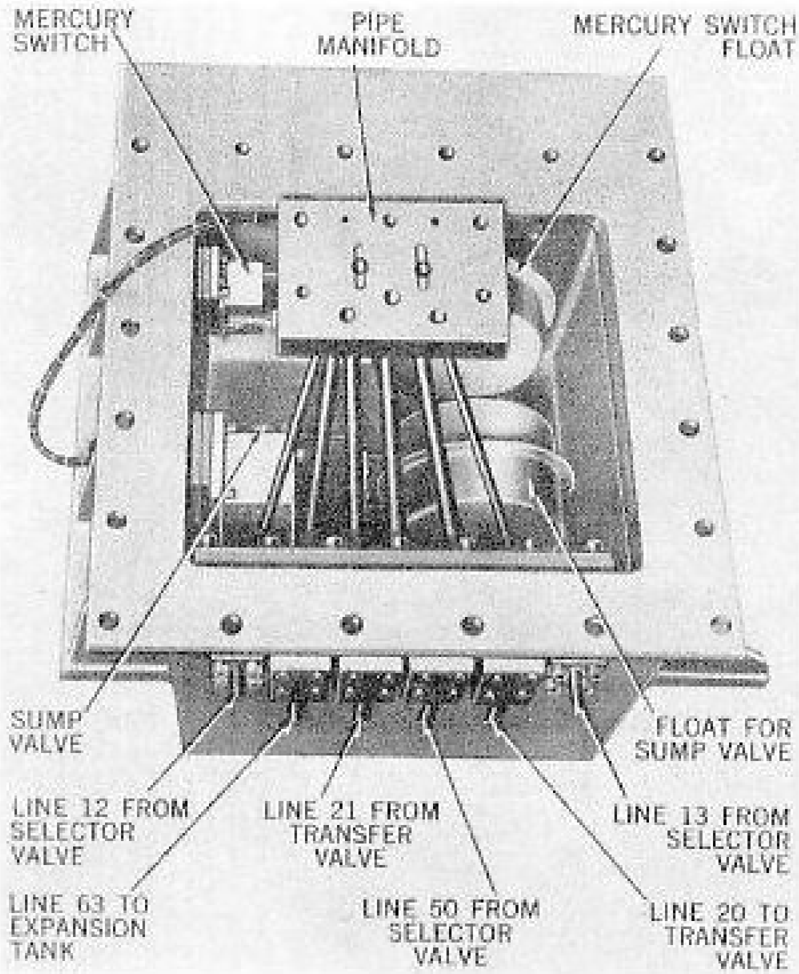


Figure 5-19. Elevation Receiver-Regulator Mk 10 Mod 0 Sump Tank, Top View

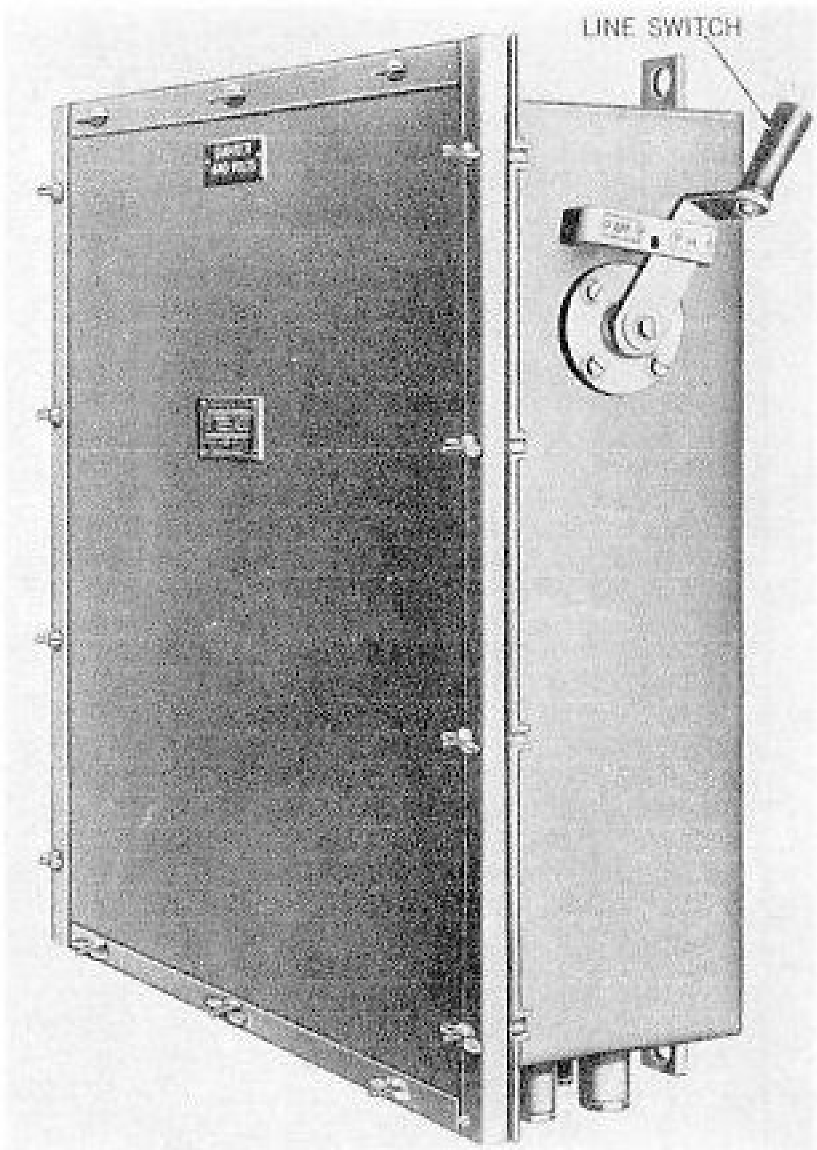


Figure 5-21. Elevation Receiver-Regulator Sump Pump Control Unit

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

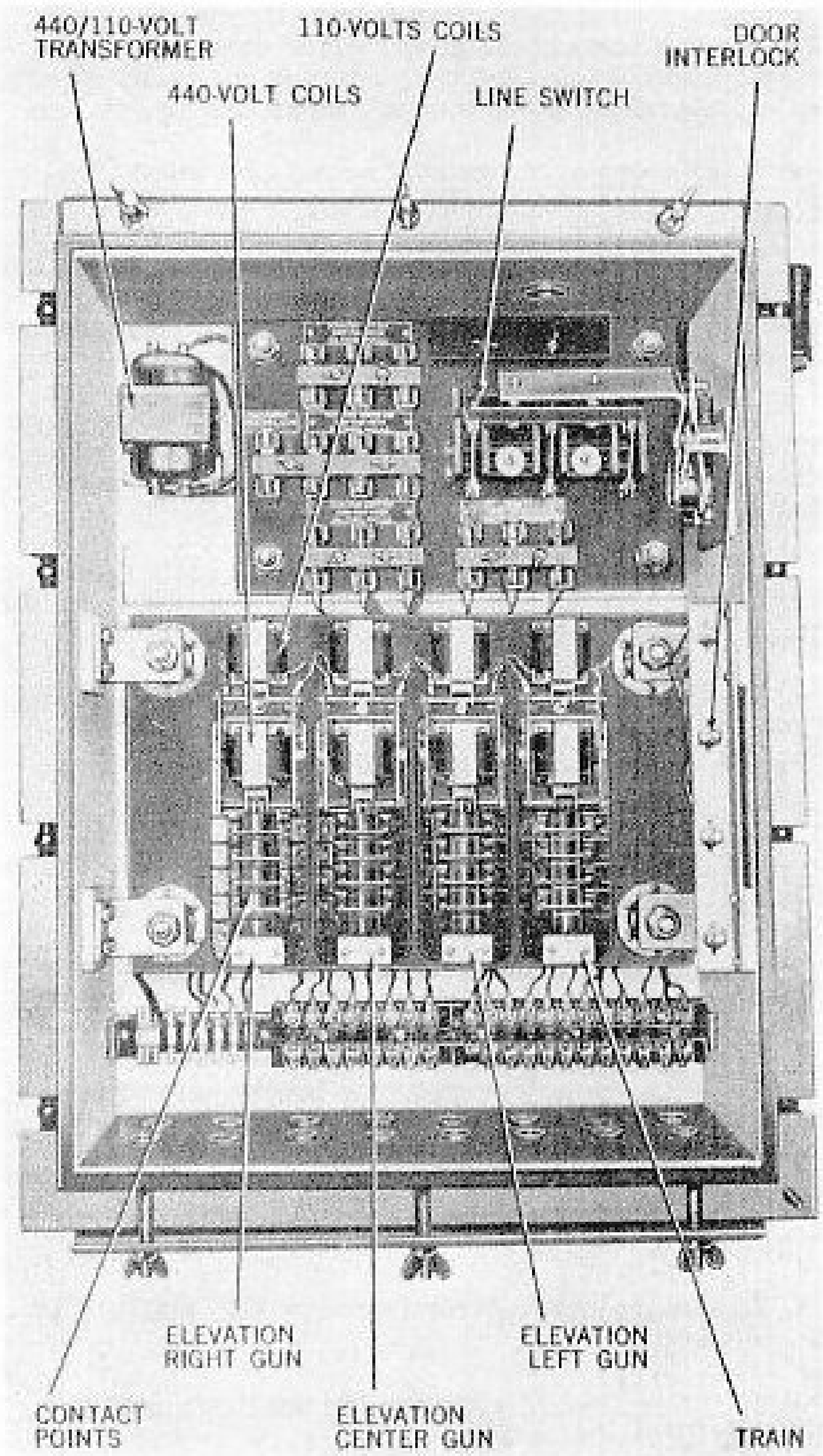


Figure 5-22. Elevation Receiver-Regulator, Sump Control Unit, Door Open

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

VALVE AND PISTON SYMBOLS

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

ELECTRICAL SYMBOL

S7 SERVO NEUTRAL INTERLOCK SWITCH

MECHANICAL SYMBOLS

C2 CONSTANT HP CAM
C3 NEUTRAL INTERLOCK SWITCH CAM

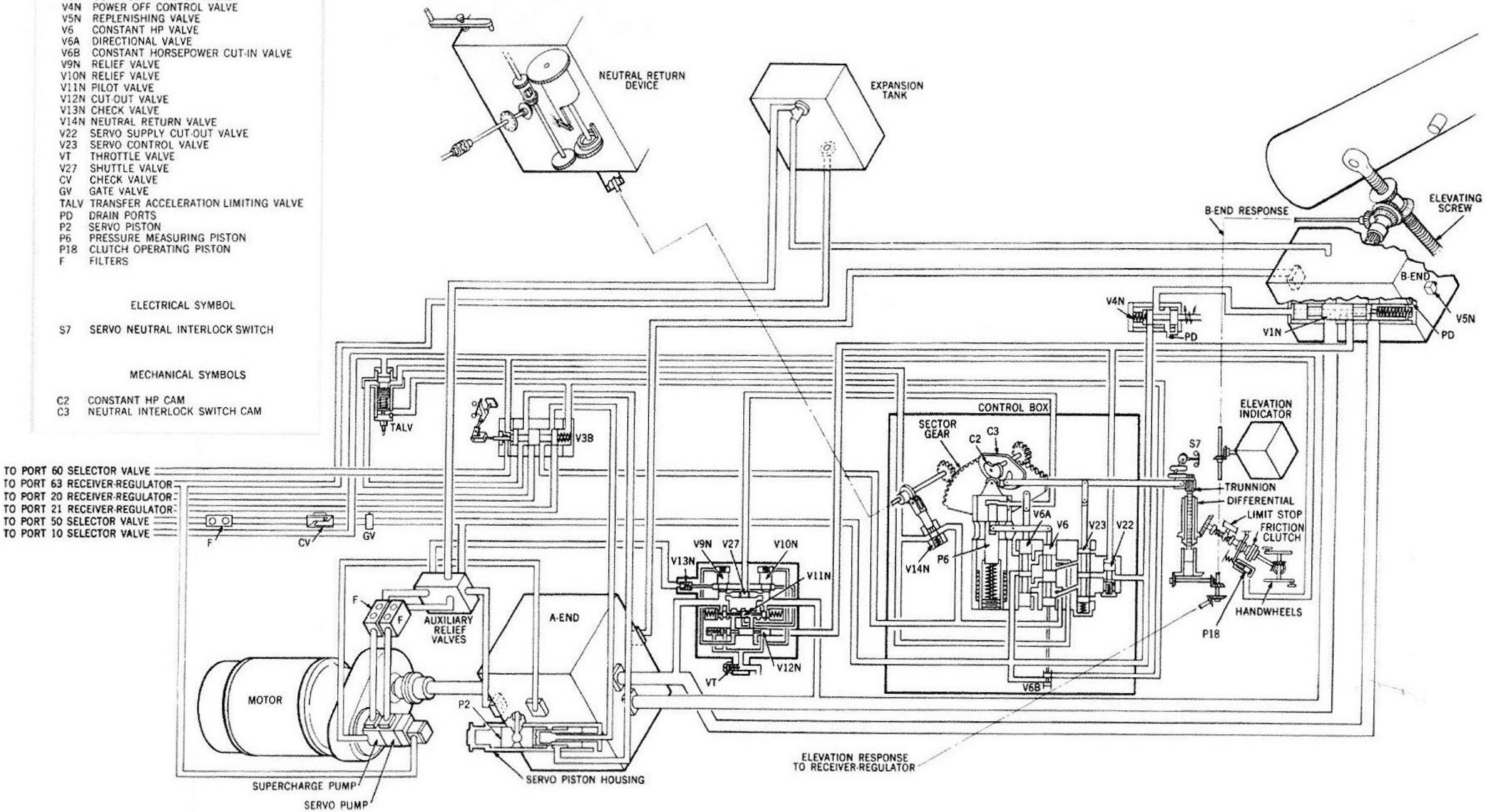


Figure 5-24. Elevating Gear Transmission Control Diagram, Power Off

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

ELECTRICAL SYMBOL
S7 SERVO NEUTRAL INTERLOCK SWITCH

MECHANICAL SYMBOLS
C2 CONSTANT HP CAM
C3 NEUTRAL INTERLOCK SWITCH CAM

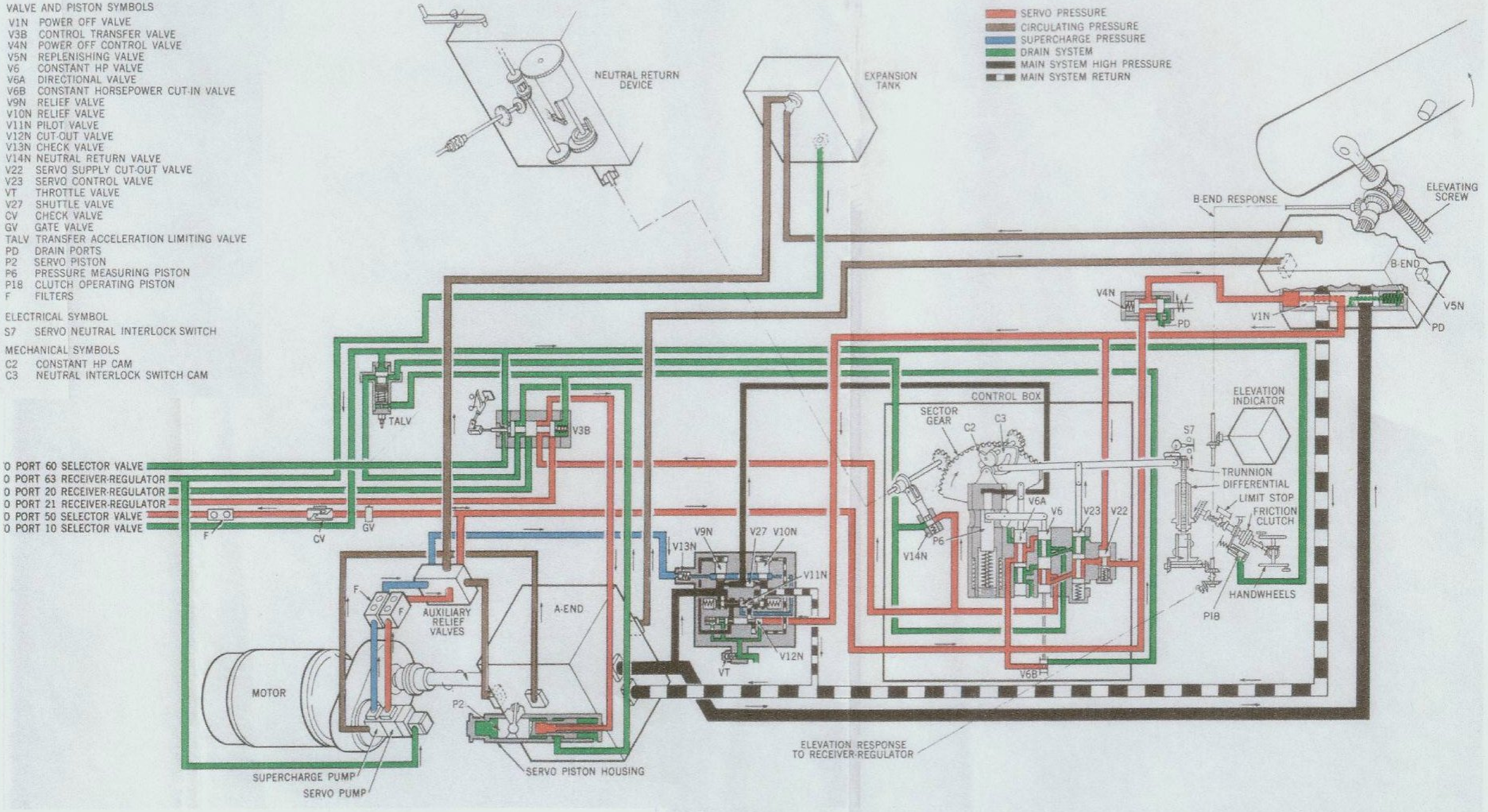


Figure 5-25. Elevating Gear Transmission Control Diagram. Gun Elevating, Selector at HAND

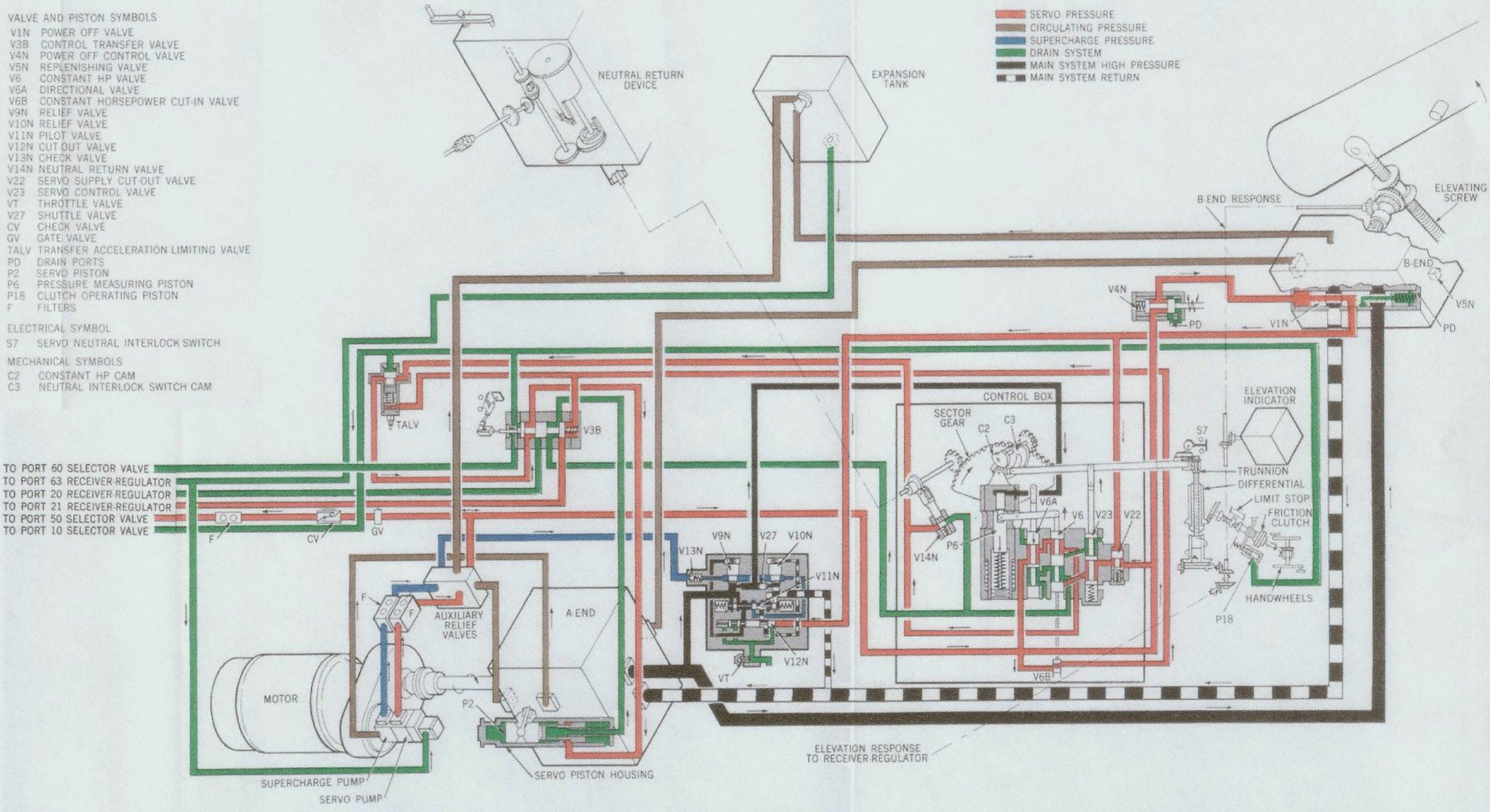


Figure 5-26. Elevating Gear Transmission Control Diagram. Gun Elevating, Selector at HAND, Constant Horsepower Control

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

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

ELECTRICAL SYMBOL
S7 SERVO NEUTRAL INTERLOCK SWITCH

MECHANICAL SYMBOLS
C2 CONSTANT HP CAM
C3 NEUTRAL INTERLOCK SWITCH CAM

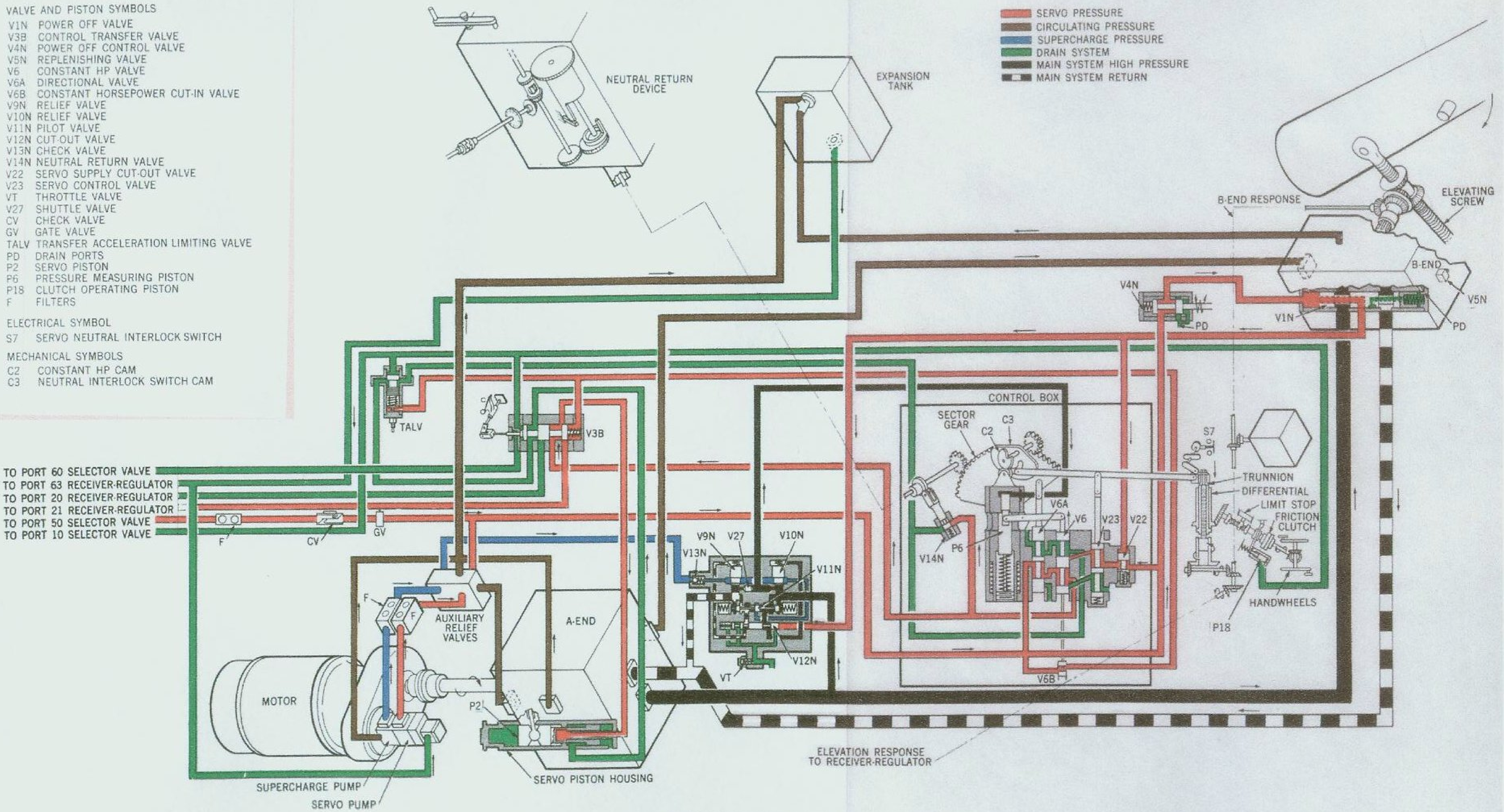


Figure 5-28. Elevating Gear Transmission Control Diagram. Gun Depressing, Constant Horsepower Control

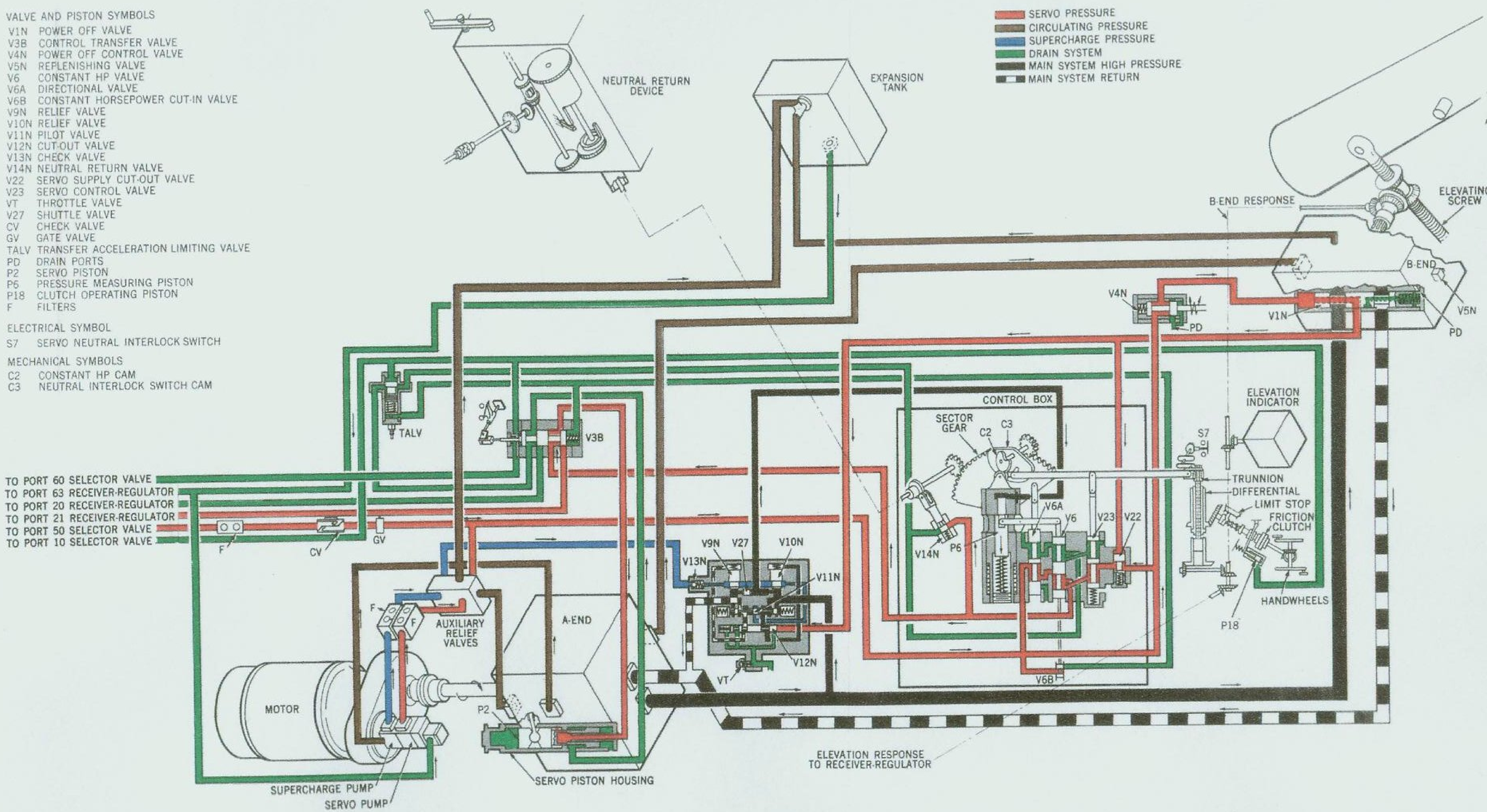


Figure 5-29. Elevating Gear Transmission Control Diagram. Gun Depressing, Limit Stop Control

VALVE AND PISTON SYMBOLS

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

ELECTRICAL SYMBOLS

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

MECHANICAL SYMBOLS

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

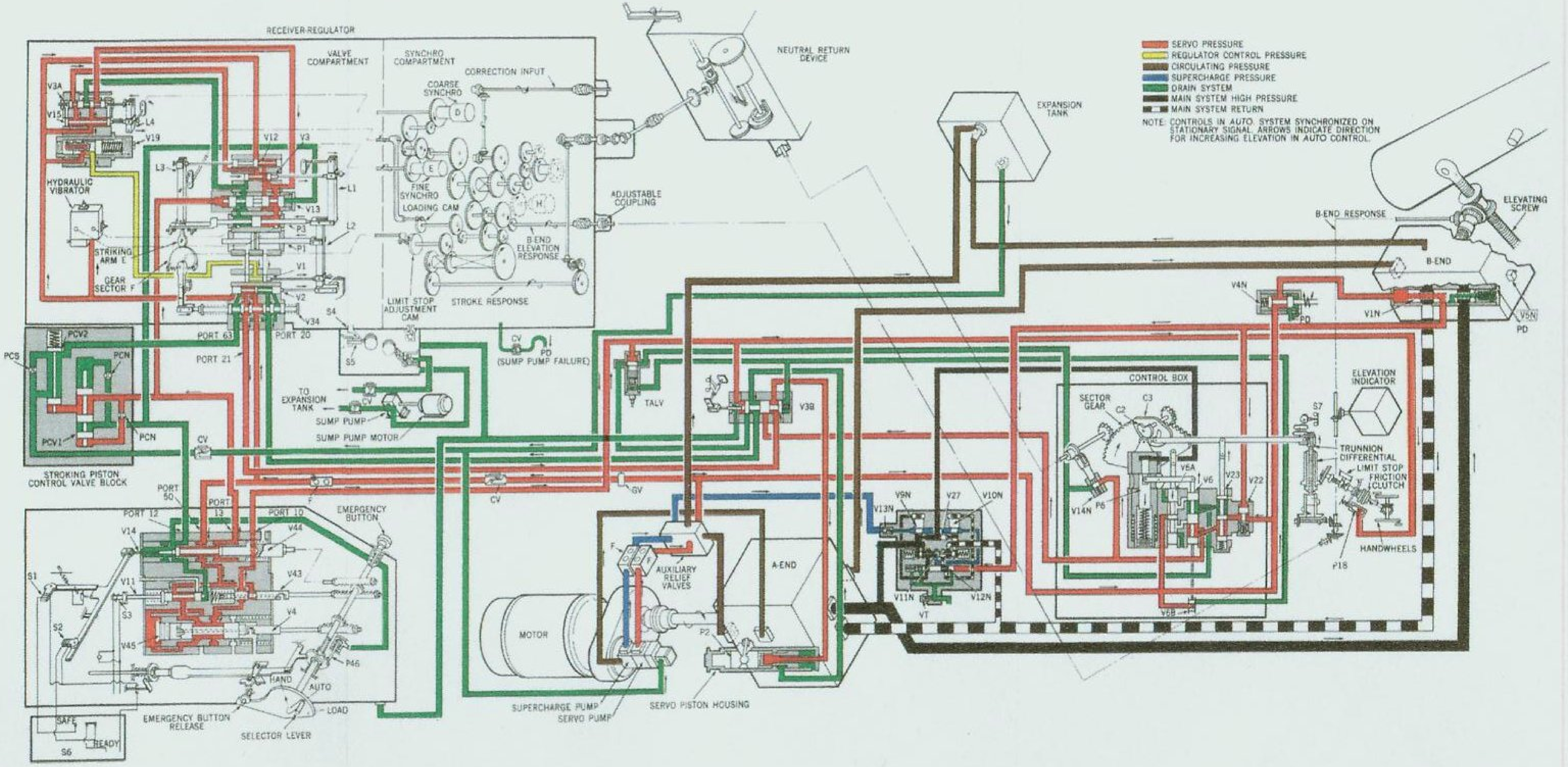


Figure 5-30. 16-inch Elevating Gear Hydraulic System, Schematic Diagram

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

If synchro power fails:

1. Solenoid S3 is de-energized.

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

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

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

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

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

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

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

INSTRUCTIONS

General instructions

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

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

1. Alignment of shafting
2. Electric and hydraulic connections
3. Fluid-level gages
4. Lubrication

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

Operating precautions

The following operating precautions must be observed:

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

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

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

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

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

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

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

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

2. Perform the "Before operating" lubrication.

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

4. Verify that the filters are clear.

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

6. Position the control selector lever at HAND.

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

Before operating under load:

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

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

3. Slowly turn the gun layer's handwheels.

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

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

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

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

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

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

4. Match pointers

5. Move the control selector lever to AUTO.

General servicing instructions

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

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

2. Check the condition of the plunger packings.

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

4. Verify the alignment of the plungers and stops.

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

Filling the hydraulic system. To fill the hydraulic system:

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

2. Close the control box drain valve.

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

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

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

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

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

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

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

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

3. Check and clean the oil filters.

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

Refer to chapter 17 for detailed instructions.

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

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

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

Operating trouble diagnosis

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. Check the valve block for sticky valves.

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

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

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

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

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

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

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

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

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

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

Control selector troubles.

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

1. Press the emergency button release. If there is still no response to the gun captain's switch, transfer to HAND control.

2. Check the control selector solenoids. To check the solenoids, the control selector cover must be removed. If the solenoids do not operate, short-circuit the switch in the selector valve. Next, check for loose connections or broken wires. Connect a lamp or voltmeter across each solenoid. If this check shows that there is voltage across a solenoid and it does not operate, replace the solenoid.

3. If the solenoids operate properly, remove the cover from the valve compartment of the receiver-regulator and loosen the tube fittings at the right and left ends of the loading transfer valve V13. If oil appears at the right fitting when the gun captain's switch is moved to SAFE but does not appear at the left fitting when the switch is moved to READY, the loading position valve V14 should be set farther into the selector valve block. If the oil flow conditions are reversed, adjust the loading position valve V14 farther out of the selector valve block. When the adjustment is correct, oil flow at the right fitting (when the gun captain's switch is on SAFE) should be about equal to oil flow at the left fitting (when the gun captain's switch is on READY).

Return of synchro power puts gun in AUTO. If a return of synchro power (after failure) automatically puts the gun in AUTO, check the following possible source of trouble:

The latching valve V45 fails to move all the way to the left when synchro power is lost. The most probable reason for this is dirt. The dirt may be cleared away by turning the synchro power off and repeatedly moving the control selector lever between HAND and AUTO. If this operation fails, check the adjustment of the selector valve V4. If the trouble persists after the selector valve V4 is properly adjusted, it will be necessary to disassemble the valve block to correct the trouble.

Gun does not respond to selector LOAD position. If the gun does not respond to the control selector, LOAD position, check the following possible source of trouble:

If the loading transfer valve V13 does not move to the right, the loading valve V43 is not correctly adjusted. If the transfer valve does go to automatic but the gun does not go to load position, then the loading interlock valve V44 is not properly adjusted.

Gun stays in LOAD when selector is moved to HAND or AUTO. If the gun stays in LOAD when the selector lever is moved to HAND or AUTO, the spring may not be moving the loading interlock valve V44 to the left. This binding may be due to dirt, or it may be due to mechanical interference or misalignment.

Adjustments

The equipment is adjusted and checked for satisfactory operation at the time of installation. Adjustments thereafter should be in accordance with the following instructions:

Adjustment of elevating screw. Lost motion at the juncture of the elevating screw and slide is not removable by adjustment. The elevating screw pivot pin and the pin bearing are not adjustable.

Adjustment of elevating unit. Lost motion between the elevating nut and the elevating screw threads may be removed by adjustment.

To adjust the elevating nut:

1. Disconnect the lubricating oil line from the oil shield.

2. Remove the ten securing bolts of the oil shield. Remove the oil shield.

3. Turn the upper adjusting nut in the necessary direction using spanner wrench number 8-Z-956-6.

The lower adjusting nut of the oscillating bearing assembly is adjusted in a similar manner.

Adjustment of limit stops. The limit stops must be adjusted to control the limits of gun elevation movement.

To adjust the elevating gear limit stops:

1. Remove the cover plate.

2. Loosen the lock cap set screws of both limit stops; disengage the lock caps.

3. Position the limit stops at the extreme ends of the screw to permit unrestricted movement of the traveling nut.

4. Position the control selector lever at HAND.

5. Start the power drive.

6. Depress the gun to the desired angle of maximum depression.

7. Stop the power drive.

8. Disconnect the coupling between the A-end response shaft and the B-end response shafting.

9. Disconnect the elevation response coupling to the receiver-regulator.

10. Disconnect the elevation response coupling to the elevation indicator.

11. Loosen the lock cap setscrew of the limit stop nearest the handwheels; disengage the lock cap from the limit stop.

12. Move the limit stop until it makes contact with the travelling nut; engage the lock cap.

13. Slowly turn the handwheels to back the traveling nut three threads away from the limit stop.

14. Disengage the lock cap and move the limit stop until it makes contact with the traveling nut. Engage the lock cap and secure in position.

15. Connect the response shaft couplings that were disconnected in steps 8, 9, and 10.

16. Slowly turn the handwheels to engage the traveling nut with the limit stop just set; turn the handwheels until the friction clutch slips.

17. Slowly turn the handwheels in the opposite direction 1.8 turns; this operation resets the servo control valve V23 in its approximate neutral position.

18. Start the power drive.

19. Elevate the gun to the desired angle of maximum elevation.

20. Stop the power drive. Adjust the elevation limit stop away from the handwheels). Repeat the adjustment procedure of operations 8 through 17, inclusive.

21. Replace the cover plate.

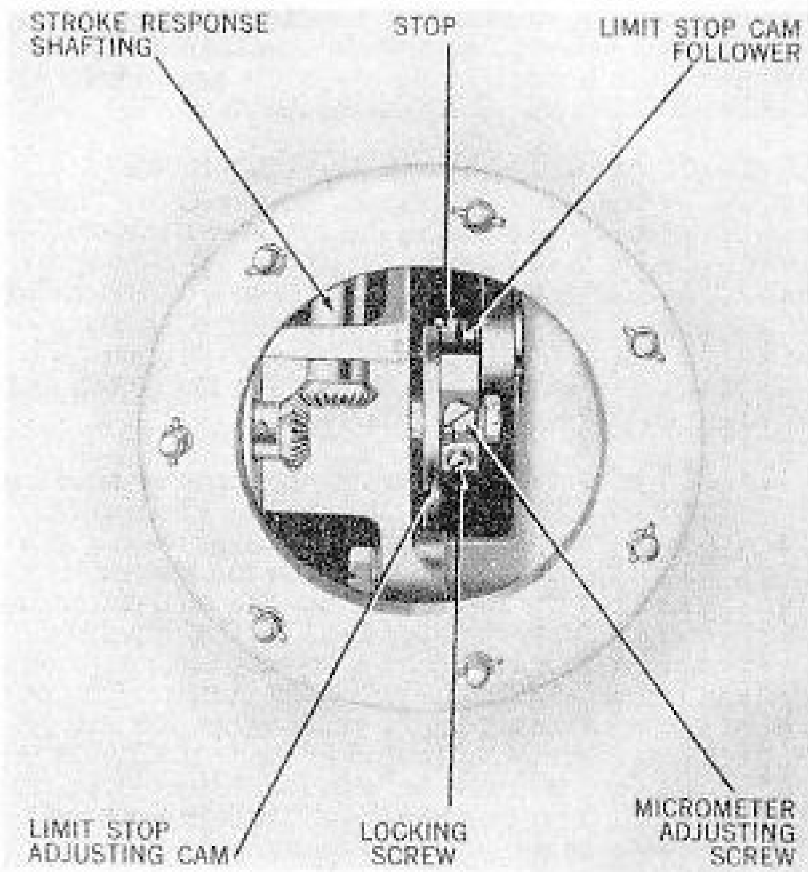


Figure 5-31. Elevation Receiver-Regulator Mk 10 Mod 0, Limit Stop Cover Removed

Adjustment of handwheel friction clutch. The spring-engaged friction clutch between the handwheels and the limit stop screw must be adjusted when it slips and does not transmit the desired torque for hand operation of the elevating gear.

To increase the friction of the clutch:

1. Remove the cover plate.

2. Tighten the three cap screws.

3. Replace the cover plate.

Adjustment of A-end pilot valve for system high-pressure relief. The pilot valve spring for each side (fig. 5-32) must be adjusted separately to control the two main valves.

To adjust the pilot valve springs:

1. Remove the valve cap.

2. Loosen the locknut.

3. Turn the valve spring adjusting screw in to raise the pressure setting; turn the valve spring adjusting screw out to lower the pressure setting. The pilot valve should unload each main valve at 1850 pounds per square inch pressure.

4. Tighten the locknut after the valve spring is adjusted.

5. Replace the valve cap.

Adjustment of constant horsepower device. The constant horsepower device must be adjusted to limit the maximum horsepower taken from the electric motor (fig. 5-33).

To adjust the constant horsepower device:

1. Remove the cover from the control box.

2. Turn the adjusting screw in to increase the horsepower taken from the electric motor; turn the adjusting screw out to decrease the horsepower taken from the electric motor.

3. Replace the cover on the control box.

The adjustment made by the manufacturer regulates the electric motor input to the A-end at approximately 108 horsepower.

Adjustment of B-end valve plate relief valve. The B-end valve plate relief valve V5N (fig. 5-34), a pressure-operated safety relief valve, must be adjusted to bypass fluid in the B-end should servo pressure failure close the power-off valve V1N.

To adjust the B-end valve plate relief valve:

1. Remove the relief valve cap.

2. Turn the valve spring adjusting nut in to raise the pressure setting; turn the valve spring adjusting nut out to lower the pressure setting.

3. Replace the valve cap.

The B-end relief valve should relieve at a slightly higher pressure than the A-end pilot valve.

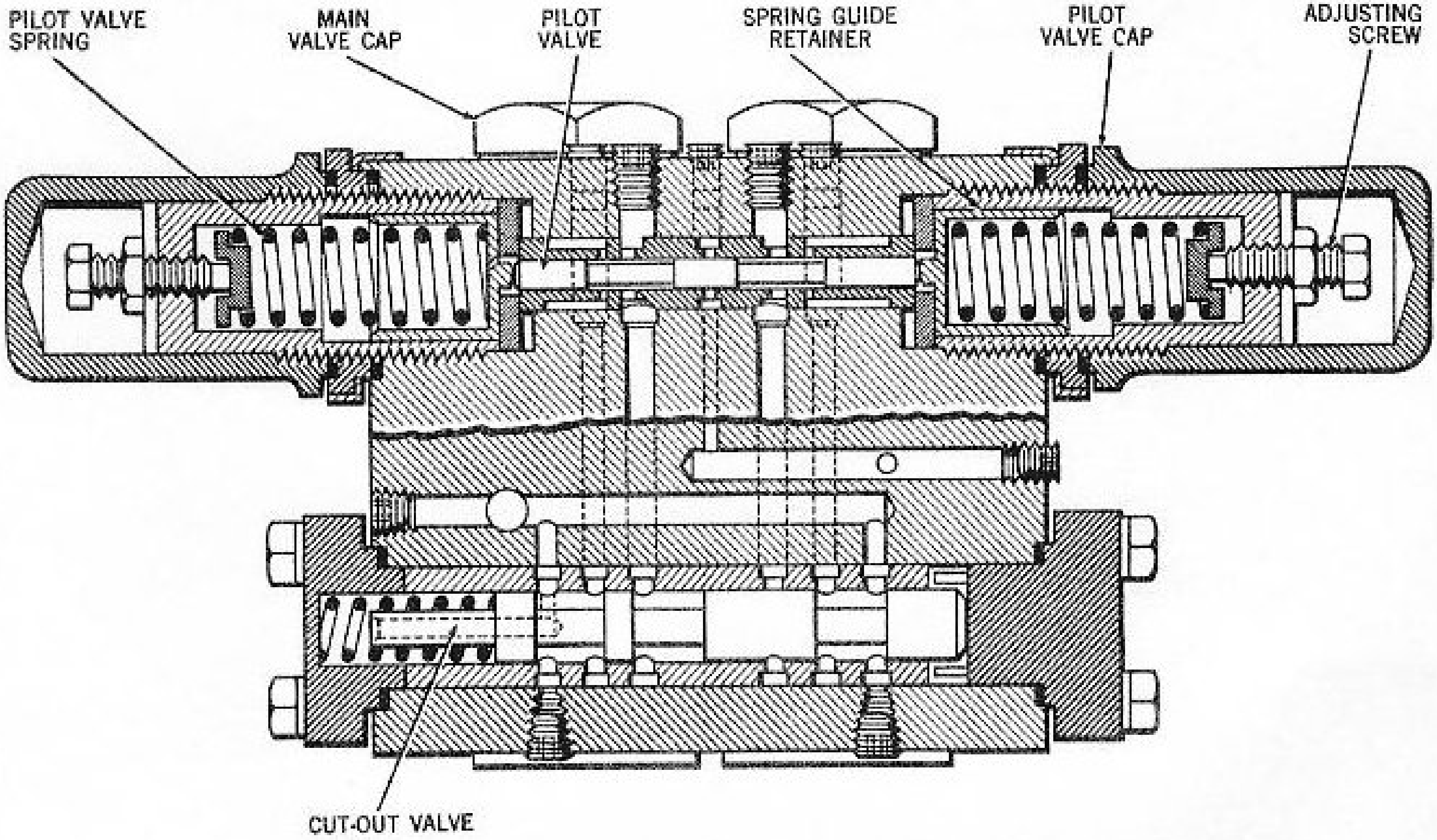


Figure 5-32. Elevating Gear Main System Relief Valve Adjustment, Sectional View

Adjustment of synchronizing acceleration control device. The synchronizing acceleration control is adjusted to remove rough gun operation caused by operation of the constant horsepower device while the gun is moving to the loading position or in coarse synchro control.

To adjust the synchronizing acceleration control device:

1. Start the power drive.

2. Position the control selector lever at AUTO.

3. Remove the cover from the receiver-regulator valve compartment (fig. 5-9).

4. Operate the gun into the elevation and depression limit stops. Measure the travel of the limit stop valve V34 while the gun is resting at each stop. Check the travel of the V34 for equal travel to each side, approximately 7/32 inch.

5. Loosen locknuts of adjusting screws A and B.

6. Back off adjusting screws A and B until they are flush with their supports C and D.

7. Place amplifier piston P3 in the center of its travel.

8. Engage striking arm E with gear sector F so that striking arm E is approximately halfway between C and D.

9. Set adjusting screws A and B so that V34 is moved approximately 5/32 inch when P3 is at its extreme travel.

This adjustment will produce a movement of V34 that is less than that required for limit stop operation. If adjusting screws A and B are set to produce travel equal to the limit stop travel, the gun will come to a halt.

10. Operate the gun to and from load position; observe the gun movement. If the movement of the gun is "jumpy" during acceleration; perform step 11.

11. Turn in the adjusting screws A and B until the "jump" is eliminated, or until the loading and synchronizing cycles are slowed down to an unobjectionable extent.

12. Tighten locknuts on A and B.

Adjustment of stroking piston control valve. The stroking piston control valve is adjusted to eliminate roughness in the automatic load cycle. Before proceeding as below check the selector valve for correct adjustment (described on page 5-40). Refer to drawing 387191.

To adjust the stroking piston control valve:

1. Start the power drive.

2. Move the gun to 4100 minutes.

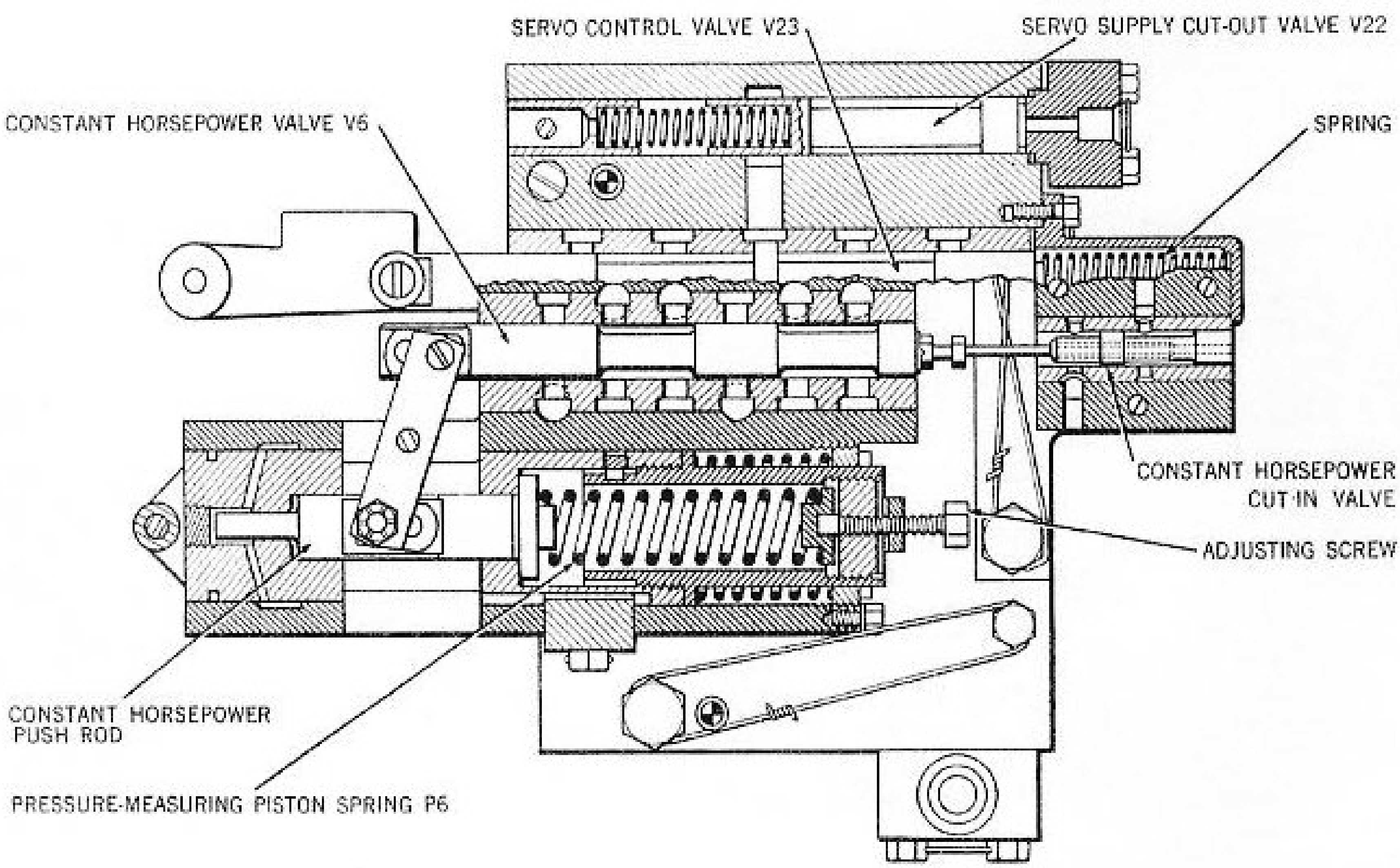


Figure 5-33. Elevating Gear Constant Horsepower Adjustment, Sectional View

3. Have a gun order signal of 4100 minutes transmitted to the receiver-regulator.

4. Move the control selector lever to AUTO.

5. Operate the gun through the automatic load cycle several times and check the number of times the constant horsepower valve or the relief valve operates.

6. Remove valve cap 387194-7 and loosen locknut 12-Z-38-59.

7. Screw in adjusting screw 387193-8 until the gun moves smoothly to its load position. If the adjusting screw is screwed in too far, the stroke response will move slowly part way and will jump before the end of stroke is reached.

8. Operate the gun through the automatic load cycle from various angles of elevation. If all operations are smooth, the adjustment is correct.

9. Tighten locknut 12-Z-38-59 and replace valve cap 387194-7.

The needle valves 387193-6 are factory adjusted to cause a time delay of 1.60 seconds in operation of valve 387193-2. This setting must be maintained.

Adjustment of gun elevation order indicating dial. The gun elevation order indicating dial must be adjusted to provide an elevation position reference.

To adjust the gun elevation order indicating dial:

1. Disconnect the elevation response shaft coupling at the receiver-regulator.

2. Disconnect the stroke response shaft coupling at the receiver-regulator.

3. Move the control selector lever to HAND.

4. Start the power drive.

5. Operate the gun to the desired angle of elevating limit stop. Stop the power drive.

6. Rotate the elevation response shaft counterclockwise until checking dial indicates desired limit stop angle of elevated gun.

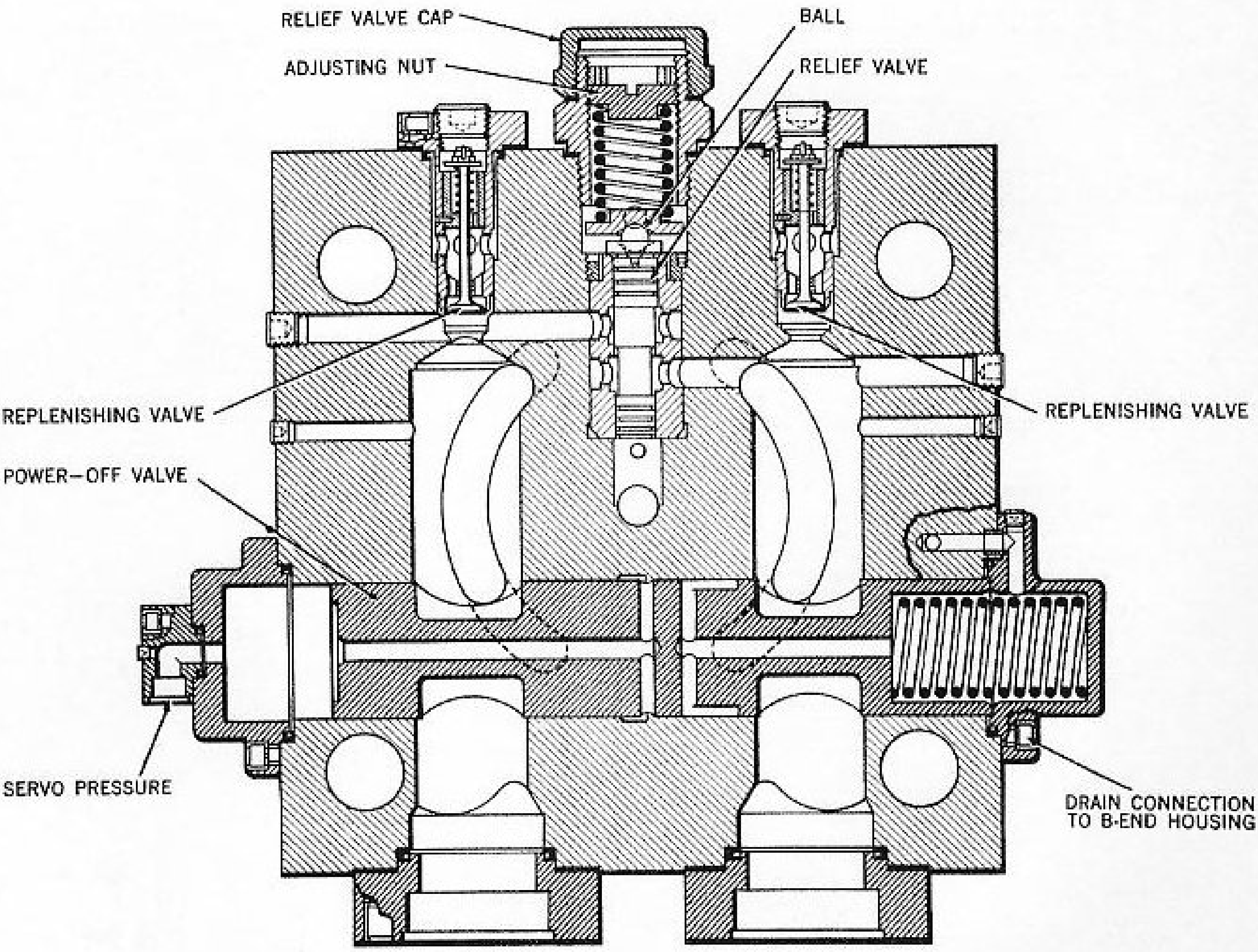


Figure 5-34. Elevating Gear B-end Relief Valve Adjustment, Sectional View

7. Rotate the stroke response shaft clockwise until the outer stop cam moves the cam follower to its limit. This operation should move the limit stop valve V34 approximately 9/32 inch to the right.

8. Connect the stroke response shaft coupling to the receiver-regulator. If it is necessary to move the receiver-regulator shaft in order to engage the coupling, the shaft must be moved clockwise so as not to change the adjustment of V34.

9. Rotate the elevation response shaft clockwise until the checking dial indicates the desired limit stop angle of depressed gun.

10. Move the inner stop cam by use of the micro adjustment (fig. 5-11) until the cam follower reaches its limit. This operation should move the limit stop valve V34 approximately 9/32 inch to the left.

11. Rotate the elevation response shaft counter-clockwise until checking dial reads 2300 minutes.

12. Turn the adjusting screw on the loading cam until the cam follower is in the cam detent and is in line with the center of the cam and the center of the cam follower crankshaft. Secure the loading cam.

13. Rotate the elevation response shaft until checking dial reading is the same as that of the elevation indicator.

14. Connect the elevation response shaft coupling at the receiver-regulator.

Adjustment of linkages L1, L2, and L3. The amplifier linkage L1, positioned by the fine (36-speed) synchro is attached to the fine synchro valve V3, to the amplifier piston P3, and to the top of the stabilizing linkage L2.

The stabilizing linkage L2 interconnects the stabilizing valve V1 and automatic stroking valve V2 with the stabilizing piston P1 and the amplifier piston P3.

The loading valve linkage L3, actuated by the loading cam, is attached to the loading pilot valve V12.

These linkages must be adjusted at a mechanical zero as follows:

1. Start the power drive.

2. Position the gun at 2300 minute elevation. Stop the drive.

3. Have a gun elevation order of 2300 minutes transmitted.

4. Position the amplifier piston P3 so that it is at the center of its travel.

5. Position the amplifier linkage L1 so that it is parallel with the valve block. Secure the fine synchro E crank arm wire to the top of the amplifier linkage L1.

6. Position the synchronizing valve V3A so that it is at the center of its travel.

7. Position the coarse synchro linkage parallel to the valve block of the synchronizing valve V3A and the synchronizing pilot valve V15. Secure the coarse synchro D crank arm wire to the bottom of the valve linkage.

8. Position the stabilizing linkage L2 so that it is parallel with the center valve block.

9. Adjust the connecting wire of the automatic stroking valve V2 so that the end of the automatic stroking valve V2 is flush with the end of its sleeve.

10. Position the loading valve linkage L3 parallel with the center valve block and secure the adjustment.

Adjustment of synchronizing pilot valve V15. The synchronizing pilot valve V15, actuated by the coarse synchro, must be adjusted to control the action of the amplifier piston P3.

To zero the valve blocks hydraulically and to adjust the synchronizing pilot valve V15:

1. With the control selector lever at HAND, start the power drive.

2. Position the gun captain's switch at READY; admit hydraulic fluid to the receiver-regulator.

3. Adjust the synchronizing pilot valve V15 so that the loading valve linkage L3 is parallel to the center valve block. The fine synchro valve V3 should now have control of the amplifier piston P3.

4. Adjust the fine synchro valve V3 so that the amplifier linkage L1 is parallel to the valve block and the amplifier piston P3 is centered.

5. Adjust the stabilizing valve V1 so that the stabilizing linkage L2 is parallel to the valve block.

6. Move the gun captain's switch to SAFE. Adjust the loading pilot valve V12 so that the amplifier piston P3 is centered. The amplifier piston should not move when the gun captain's switch is moved from SAFE to READY or from READY to SAFE.

7. Position the gun and the gun order signal to 3300 minutes.

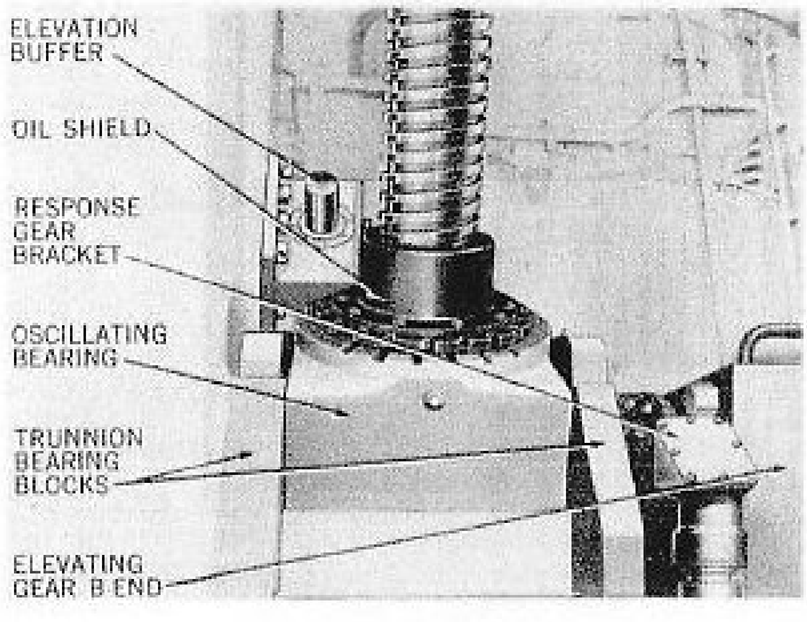


Figure 5-35. Elevation Buffer and Oscillating Bearing

8. Operate the handwheels slowly so that the gun moves from 3000 minutes to 3600 minutes.

9. Observe the position of the fine (36-speed) synchro crank arm when the coarse (2-speed) synchro relinquishes control to the fine synchro valve V3. (The amplifier piston P3 will move from its extreme position at this point.)

10. Adjust V15 toward its clevis if the larger angle of the fine (36-speed) synchro crank arm occurs during the outstroke of V15. Adjust V15 away from its clevis if the larger angle occurs during the instroke of V15.

11. Repeat operation 10 until the crank arm angles are equal.

Adjustment of automatic stroking valve V2 and stabilizing valve V1. The automatic stroking valve V2 and the stabilizing valve V1, both positioned by the stabilizing linkage L2, must be adjusted to prevent gun oscillation.

The automatic stroking valve V2 and stabilizing valve V1 are adjusted as follows:

1. Move the control selector lever to HAND.

2. Start the power drive.

3. Position the gun and the gun order signal at 3 300 minutes; move the gun captain's switch to READY. Move the selector lever to AUTO. Because the adjustment of the automatic stroking valve V2 has been only approximate, the gun will probably move off the signal as much as 15 minutes.

4. Loosen the connecting wire of the automatic stroking valve V2 so that the valve may be repositioned in its sleeve.

5. Adjust the automatic stroking valve V2 until the gun is within three minutes of the gun order signal. If V2 is not equipped with an adjusting clevis, make the necessary adjustment with the stabilizing valve V1.

Adjustment for synchro electrical zero. The synchros must be set to the input gun order signal by setting the synchro cranks at the proper positions on the rotor shaft.

To adjust for synchro electrical zero, proceed as follows:

1. Disconnect the elevation response shaft coupling at the receiver-regulator.

2. Move the control selector lever to HAND.

3. Start the power drive.

4. Position the gun at 200 minutes (zero elevation).

5. Stop the power drive.

6. Have a gun elevation order signal of 2000 minutes transmitted to the receiver-regulator.

7. Have a gun order signal for increasing gun elevation transmitted; observe direction of synchro rotation. The fine (36-speed) synchro should rotate clockwise; the coarse (2-speed) synchro should rotate counterclockwise.

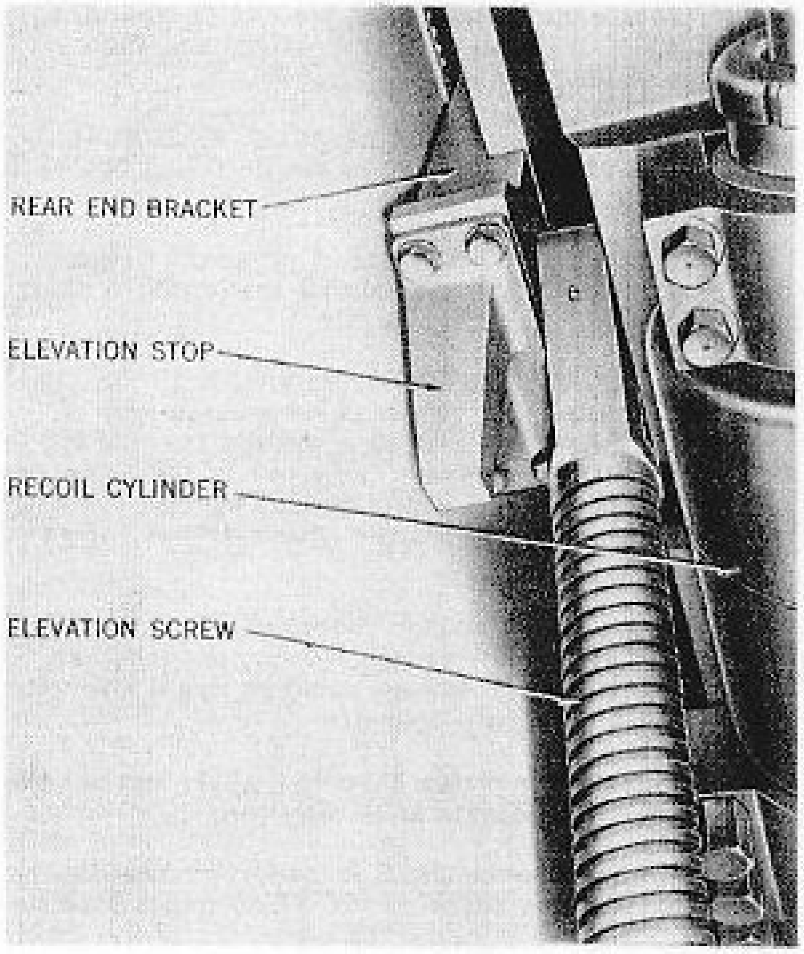


Figure 5-36. Elevating Screw

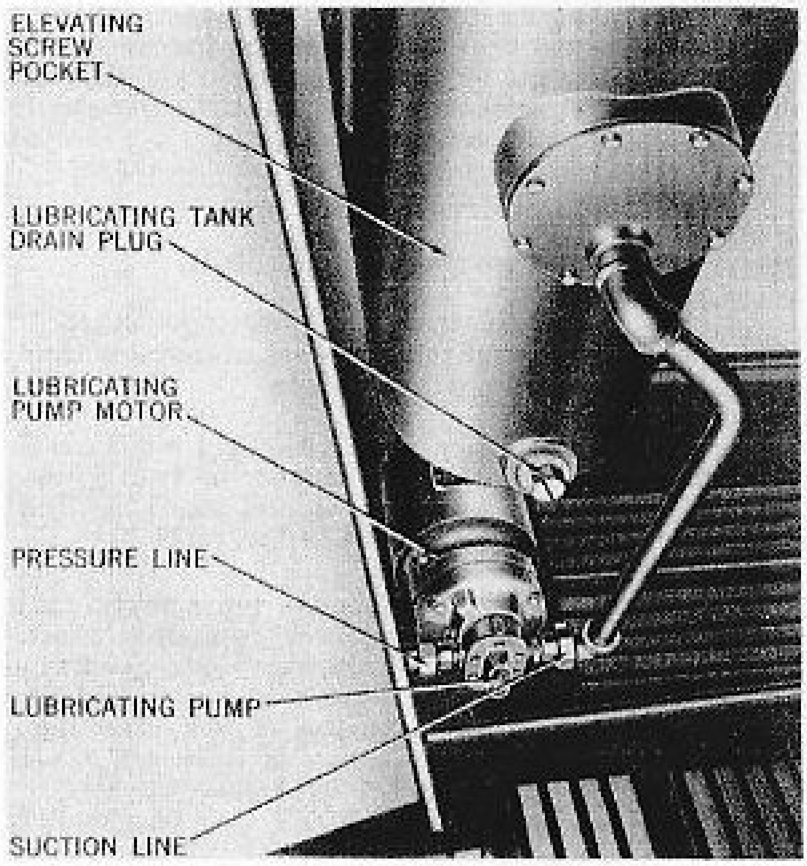


Figure 5-37. Elevating Screw Lubrication Pump and Cover

8. Have the gun order signal returned to 2000 minutes.

9. Install the crank of the coarse (2-speed) synchro with the crank arm near vertical and the crank below the synchro shaft.

10. Rotate the elevation response shaft until the crank of the coarse synchro is vertical and below the synchro shaft.

11. Install the fine (36-speed) synchro crank assembly with the crank arm above the synchro shaft and as near vertical as possible.

12. Engage the flexible-drive ring with the synchro shaft drive pins; this may be done at any of three positions, 120 degrees apart (by turning the drive pin plate 180 degrees, any one of the three positions may be used). Later-model receiver-regulators are equipped with geared crank drives for greater selectivity.

13. Rotate the elevation response shaft until the fine (36-speed) synchro crank is exactly vertical. Permit the coarse (2-speed) synchro crank to move off vertical during this operation.

14. Hold the elevation response shaft and set the checking dial to indicate 2000 minutes.

Replacement installation of receiver-regulator; initial settings and adjustments. The procedure for synchronizing and aligning the elements of the receiver-regulator, when installing the instrument, is described below. The installation should be performed only by personnel familiar with the instrument design.

Check the hydraulic piping with the schematic piping diagram on drawing 319585. Note particularly the direction of all check valves.

Check the wiring by having a gun order signal transmitted to the receiver-regulator for increasing elevation. The fine (36-speed) synchro should rotate clockwise, and the coarse (2-speed) synchro should rotate counterclockwise.

Proceed as follows:

1. Couple the correction input shaft.

2. Rotate the elevation response input shaft counterclockwise until the checking dial reads the desired stop angle for elevated gun.

3. Rotate the stroke response input shaft clockwise until the outer stop cam moves the cam follower to its extreme position. This should move the limit stop valve V34 about 9/32 inch to the right.

4. Couple the stroke response input shaft. If it is necessary to move the receiver-regulator shaft to engage the coupling, rotate the shaft clockwise so that the travel of the limit stop valve V34 is not reduced. Note that position of the adjusting screw in the stroke gear box. If it is not readily accessible, rotate the receiver-regulator shaft clockwise until the adjusting screw may be reached.

5. Rotate the elevation response input shaft clockwise until the checking dial indicates the desired limit stop angle for a depressed gun.

6. Move the inner stop cam by use of the inside micrometer adjustment (fig. 5-11) until the cam follower reaches its extreme position. The limit stop valve V34 should move to the left about 9/32 inch.

7. Rotate the elevation response shaft counterclockwise until the checking dial reading is 2300 minutes.

8. Adjust the loading cam until the cam follower is in the cam detent and is in line with the center of the follower crank shaft. Secure the adjustment.

9. Rotate the elevation response input shaft until the checking dial reading is the same as the mechanical angle reader in the elevation indicator.

10. Couple the elevation response input shaft.

11. Adjust the elevation response input shaft so that the checking dial and the elevation indicator readings correspond.

After coupleting the foregoing sequence of adjustments, make the following selector valve check:

1. Move the control selector lever to HAND.

2. Start the power drive.

3. Move the gun to 2300 minutes.

4. Have a gun order signal of 2500 minutes transmitted to the receiver-regulator.

5. Admit hydraulic fluid to the receiver-regulator.

6. Move the gun captain's switch to SAFE; the stabilizing linkage L2 should be parallel to the valve block.

7. Move the gun captain's switch to READY; the top of the stabilizing linkage L2 should move to the left. The link should respond at once when the gun captain's switch is moved.

All of the preliminary adjustments have now been completed. Place the gun in AUTO control as follows:

1. Move the gun order signal to 3300 minutes.

2. Move the gun to 3300 minutes in HAND control.

3. Position the gun captain's switch on READY.

4. Check the position of the synchro crank arms. The fine (36-speed) synchro crank arm should be vertical and up. The coarse (2-speed) synchro crank arm should be vertical and down. The amplifier linkage L1 should be vertical.

5. Move the selector lever to AUTO; the gun should not move any appreciable amount. If the gun moves off the signal and does not come to rest at once, return the selector lever to HAND immediately.

Assuming that conditions are normal, the gun is now under control of the synchro signal.

For the final limit-stop adjustments (fig. 5-31), proceed as follows:

1. Move the gun order signal slowly to the desir- elevation limit-stop angle. The gun should come to rest before the desired angle is reached.

2. "Walk" the gun slowly to the desired position by means of the micrometer adjustment on the stroke response input. Secure the locking screw. One complete turn of the adjusting screw changes the limit-stop adjustment by approximately 35 minutes. Clockwise rotation of the adjusting screw moves the limit stop position up.

3. Move the gun order signal to the desired depression limit-stop angle. The gun should come to rest before this angle is reached.

4. "Walk" the gun slowly to the desired position by means of the micrometer adjustment on the limit-stop cam. It may be necessary to turn the electric motor off in order to reach the limit stop. In such cases several trials may be required. One complete turn of the adjusting screw changes the limit-stop setting by approximately 160 minutes. Clockwise rotation of the adjusting screw moves the limit-stop position down. For example, if the limit stop has brought the gun to rest at 2060 minutes, one complete turn clockwise of the adjusting screw would move the stop position to approximately 1900 minutes.

For the final load position adjustments, proceed as follows:

1. Move the gun order signal to 2300 minutes with the gun in AUTO control.

2. Position the gun captain's switch on SAFE. The gun will probably move a few minutes. If the movement is excessive, return the selector lever to HAND and check the loading valve and linkage.

3. "Walk" the gun slowly to the desired loading position by means of the micrometer adjustment on the loading cam. One turn of the adjusting screw changes the loading position approximately 100 minutes. Clockwise rotation of the adjusting screw lowers the adjusting screw.

DISASSEMBLY AND ASSEMBLY

Disassembly and assembly of the elevating gear equipment should be performed by personnel familiar with the equipment and procedure and equipped with the standard and special tools required for the job. Instructions applying to major components presume removal from installed positions to a convenient location for disassembly. Instructions applying to hydraulic mechanisms presume draining of the system and removal of external pipe lines. Assembly procedures are omitted if they are the exact reversal of disassembly operations. The equipment drawings and illustrations should be studied carefully before starting operations.

Disassembly of the speed reducer

Before disassembling the electric-motor speed reducer, study drawing 268473.

Proceed as follows:

1. Remove the securing bolts from the servo and supercharge pump assembly. Remove the pump assembly from its mounting flange on the speed-reducer gear case cover.

2. Remove the retainer cover carefully; do not damage the oil seal.

3. Remove the gear case cover from the speed reducer housing.

4. Remove the main driven gear, the auxiliary pump gear, and the pinion gear, together with their attached shafts.

Disassembly of the A-end pump

The instructions in this paragraph give the sequence of disassembly of a complete A-end. In many cases, complete disassembly of an A-end is not necessary. It is advisable to analyze the trouble and study drawings 268458 and 268461 of the assembly carefully before starting to disassemble the unit.

Proceed as follows:

1. Disconnect all the piping to the relief valve assembly.

2. Remove the relief valve assembly after first removing the six Allen screws in the back of the relief valve assembly.

3. Remove the packing gland and the packing cover.

4. Turn the A-end over so that it rests on its front end plate with the drive shaft down. Wooden supports should be placed under the front end plate. Care must be taken to prevent the weight of the A-end from resting on the control housing or servo cylinder housing. It is not essential to turn the A-end over, as outlined above, in the disassembly of the unit; however, it does facilitate the operation.

5. Remove the cap nuts from the A-end housing studs and lift out the studs.

6. Remove the valve plate, locknut, and lock washer.

7. Remove the bearing from the drive shaft.

8. Remove the cylinder barrel from the drive shaft and pistons. When removing the cylinder barrel, care must be taken to hold the connecting rods so that the pistons will not bump into each other or into other parts of the pump unit. This must be done in order to prevent damage when the pistons are freed by the removal of the cylinder barrel.

9. Remove the cylinder barrel keys and spring. The inner assembly of all parts that are attached to the drive shaft, including the bearings, may now be lifted out of the A-end case as one assembly.

10. The tilting box cannot be removed from the housing until the control box and servo piston assembly have been removed. It is not necessary to remove the tilting box from the housing to remove the thrust bearing race. The tilting box has three 1/2-inch 13 NC thread holes, tapped in the underside. These holes are threaded for jackscrews, used for removing the thrust bearing.

Removal and disassembly of the servo piston

Before removing the servo piston, study drawings 268466 and 268545.

Proceed as follows:

1. Remove the access cover, the machine bolt, and the two pipe plugs from the servo cylinder.

2. Center the servo piston and remove the connecting pin by driving it down.

3. Remove the bolts that secure the servo cylinder to the A-end case, and remove the servo cylinder as a complete assembly.

4. Remove the cylinder end cap and the cylinder end cap and guide rod.

5. Remove the servo piston by first unscrewing it from the stroking slide.

Disassembly and assembly of the control mechanism

Before disassembling the control mechanism, study drawing 268468 carefully.

The valves, valve plungers, valve sleeves, control screws, gears, and related parts must be handled with utmost care in disassembly or assembly.

Proceed as follows:

1. Remove control case cover plate.

2. Uncouple the handwheel input.

3. Remove from the control case, as a unit, the housing containing the limit stops and friction clutch. Disassembly of this unit is apparent from the drawing.

4. Remove the differential control screw and connecting linkage.

5. Disconnect and remove the valve block assembly. Disassembly of this unit is apparent from drawing 268470.

When the control mechanism is assembled, keep all looseness in the linkages and backlash in the gears at a minimum to avoid lost motion. When oil seals are assembled on shafts, extreme care must be taken not to crack or stretch the oil seals. Use a sheet of thin brass as a thimble to start the seal over the end of the shaft.

Disassembly and assembly of supercharge and servo pumps

Disassembly of the two pumps is similar. Both pumps can be removed from the speed reducer housing as a unit, if desired. Study drawing 268463 carefully before disassembling.

To disassemble:

1. Remove the four nuts on one end of the pump and tap out the four stud bolts.

2. Remove the bearing plate, the liner plate, and the servo pump cylinder.

3. Turn the pump over and remove the mounting plate, the liner plate, and the supercharge pump cylinder.

4. Push the driven shaft down and out of the driven gear from the same end of the pump.

5. Push the drive shaft down about 1/16 inch until the key in the drive shaft touches the bearing plate. Care must be taken so that the key does not hit the bearing plate and damage it. Raise the shaft and put a shim under the gear equal to the amount that the shaft was pushed down. Repeat the procedure until the gear has been removed.

To assemble the pump:

Assembly of the servo and supercharge pumps is made in the reverse order of disassembly. When assembling, coat the mating plates with a very thin shellac. The drive shaft should be turned slowly as the nuts are tightened in order to assure clearance and alignment of the gears. The pumps must not be run unless they can be turned freely by hand.

Disassembly and assembly of the B-end

Before disassembling the B-end, study drawings 268459 and 268462 carefully.

To disassemble the B-end:

1. Remove the mounting flange and the oil seal.

2. Tip the pump on end, with the drive shaft pointing down.

3. Remove the cap nuts from the studs and remove the B-end case studs.

4. Remove the valve plate assembly from the B-end case.

5. Remove the drive shaft from the bearing.

6. Remove the cylinder barrel. Care must be taken to hold the connecting rods so that the pistons will not bump into each other or into other parts of the pump unit.

7. Remove the cylinder barrel keys and spring. The inner assembly of all parts that are attached to the drive shaft, including the bearing, may now be removed from the B-end case in one assembly.

The B-end is assembled in the reverse procedure and sequence of the disassembly. Make certain that all parts fit freely and are well lubricated.

Removal and replacement of synchros

The synchros can be removed and replaced without disassembling the gear train or removing them from the case. To remove and replace the fine (36-speed) synchro, proceed as follows:

1. Disconnect the synchro crank connecting wire from the amplifier linkage L1.

2. Remove the synchro crank assembly. It may be necessary to move the sleeve of the loading pilot valve V12 to the left in order to clear the assembly.

3. Remove the coupling piece from the synchro shaft.

4. Remove the screws that hold the drive gear to the stator. Hold the gear so that it does not drop down into the receiver-regulator.

5. Remove the back cover plate.

6. Remove the checking dial and test synchro mounting.

7. Remove the synchro brush holder.

8. Remove the synchro retainer.

9. Remove the synchro.

10. Insert the new synchro. A 6-inch piece of tubing placed over the synchro shaft will aid in guiding the synchro into place. The synchro should fit very snugly in its bearing. As a result, some difficulty may be experienced in inserting the synchro if it does not enter the bearing squarely. If the synchro resists inserting, take it out and start over. Do not force the synchro.

11. Replace the synchro retainer.

12. Replace the synchro brush holder.

13. Replace the checking dial and test synchro mounting.

14. Replace the back cover.

15. Replace the stator drive gear and tighten the holding screws.

16. Replace the coupling piece on the synchro shaft.

17. Replace the synchro crank assembly.

18. Connect the crank to the amplifier linkage.

19. Check all the adjustments of linkages and valves of the receiver-regulator.

The same procedure is followed to remove and replace the coarse (2-speed) synchro, except first break input shaft couplings and remove large gear-compartment cover.

Removal and replacement of valves in the receiver-regulator

All the valves are matched with respective sleeves; therefore, whenever replacements are made, both the valve stem and the sleeve must be replaced. The pieces are marked with serial numbers, and the stem must be assembled so that its number is on the same end of the assembly as the sleeve number. The numbers must correspond. When the sleeve is placed in the block, the number must be toward the link to which the valve stem attaches.

Removal and replacement of the hydraulic vibrator

The hydraulic vibrator may be removed as a unit by disconnecting its supply pipe and removing the four mounting screws. Except in the case of emergency, repairs to the vibrator should be made at the factory. Constant-flow valves may be interchanged where necessary. When a new hydraulic vibrator is installed, it should be adjusted in accordance with the instructions in the "Trouble analysis" section of this chapter.

Replacement limits of parts reassembled

The A-end and B-end pistons should be fitted 0.003 inch under the bore diameter in the cylinder barrel.

All replacement valve plungers in the controls should be ground 0.001 inch under the diameter of the bore in the valve sleeves. The edges should be sharp, but without burrs.

All replacement sleeves for the valves in the control should have the hole ground and lapped with the port openings sharp, but without burrs.