

CHAPTER IX.

NAVAL GUN MOUNTS.

Section I.—General.

901. The mount is the entire system interposed between the structure of the ship and the gun.

The principal functions that a mount must perform are: (1) support the gun in such a position that it can readily be used, (2) provide for elevation and train, (3) provide for recoil and counter-recoil.

The principal requirements of a modern gun mount are: (1) Safety under all conditions, which necessitates proper design and requisite strength of materials, so that the mount will perform its functions with the least danger to the personnel operating it; (2) rapidity, ease, and smoothness of operation; (3) facility of adjustment; (4) simplicity and reliability; (5) gradual absorption of the shock of recoil and its distribution over a sufficient area of the ship to prevent injury to the ship's structure; (6) accurate and reliable control of power, either hand or motor.

902. Shipboard installations include many types of mounts, some of which are: (1) turret mounts, in which the guns are housed in an armored structure capable of rotation, the guns elevating independently of the structure.

(2) Pedestal mounts, in which a *carriage* rotates on a stationary *pedestal* or stand bolted to the ship's structure. Broadside and anti-aircraft mounts are usually of this type, as well as most other 3", 4", 5" and 6" mounts.

(3) Rail sockets, for use in mounting light guns at the ship's rail.

(4) Military top mounts, for use in mounting light guns in the tops.

Mounts sometimes used by the Navy elsewhere than on board ship are:

(1) Boat mounts, for use of one-pounder or other guns in the ships' boats.

(2) Field mounts, for use of field guns ashore with a landing force.

(3) Railway mounts, for use of large guns on railway cars ashore.

903. For purposes of introduction, a brief idea is here given as to the relation which the component parts of a representative shipboard mount bear to one another:

(1) The *slide* is a cylindrical casting within which the gun slides axially in recoil and counter-recoil. In elevation, the slide with its contained gun, operates independently of the rest of the mount. From either side of the slide, in a horizontal plane, project the trunnions, which rest in suitable bearings in

(2) The *carriage*. This is the part which rotates in train, carrying with it the slide and gun. In a turret mount the *deck lugs* and *gun girders* are together analogous to the carriage. The carriage rests upon and rotates on a roller path on a stationary member called

(3) The *stand*. This is bolted to the ship's structure. In a turret it is a heavy assemblage of girders built into the ship's structure.

904. Modern naval gun mountings are designed to have arcs of elevation approximately as follows: 8-inch mounts on heavy cruisers 40° , turret mounts on battleships of the *California* and *Maryland* classes 30° ; turrets on earlier classes of battleships were designed for 15° elevation, but on the *Oklahoma*, *Pennsylvania*, and *New Mexico* classes, this elevation was, on modernization, increased to 30° ; broadside guns, 20° elevation, and anti-aircraft guns 90° elevation. Turret guns have 5° depression and broadside and anti-aircraft guns have 10° depression. The train is usually limited only by the ship's structure and the location of the mount in the ship.

905. The metals used in naval gun mounts are cast steel, forged steel, and special bronzes. Cast iron is not used. Cast steel is used for the principal strength members, such as the carriage, slide, and stand, and also for the larger castings of the elevating and training gear. Bronze is used for all plain bearings and bushings where moving parts are of steel. Bronze is also used for the smaller castings, where the use of cast steel is impracticable, on account of the difficulties of casting, and for all metal parts coming in contact with the powder.

906. Stresses in deck structure and mount due to firing.—The bolts securing the mount to the deck and the deck structure itself must be capable of withstanding the weight of the gun and mount and the turning moment produced by the reaction of the slide trunnions in the trunnion seats of the carriage.

The forces acting on the deck structure and mount when the gun is fired are shown in Fig. 901.

R_r is the force of resistance to recoil exerted by the recoil cylinder. R_1 is the force tending to push the breech side of the stand down into the deck. R_2 is the force tending to tear the bolts at the muzzle side of the stand out of the deck. H is the shearing force, tending to shear off the bolts in a horizontal plane. W is the weight of the entire

mount, including the gun. These forces, R_1 , R_2 , and H_s , may be determined as follows:

For equilibrium, the summation of all horizontal forces is equal to zero, or

$$R_r - H_s = 0. \quad (1)$$

Taking moments about R_1 we get

$$R_r h - W m - R_2 l = 0, \quad (2)$$

or

$$R_2 = \frac{R_r h - W m}{l}. \quad (3)$$

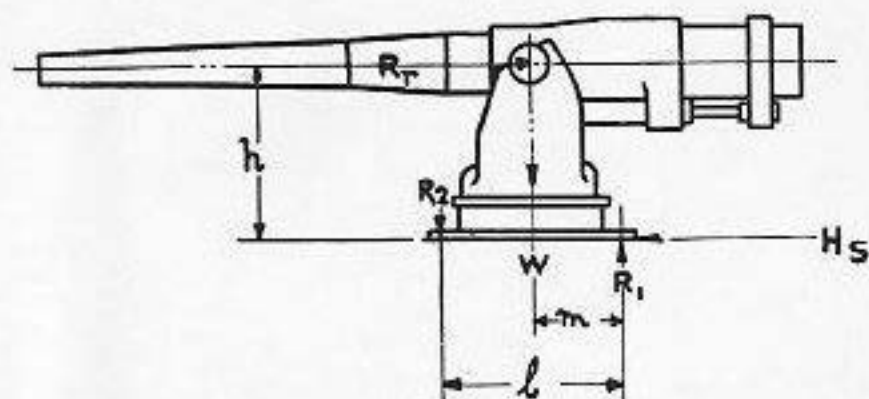


FIG. 901.

Taking moments about R_2 , we get

$$R_r h + W(l - m) - R_1 l = 0 \quad (4)$$

or

$$R_1 = \frac{R_r h + W(l - m)}{l} \quad (5)$$

R_1 and R_2 are expressed in terms of R_r , the other quantities being known. R_r can be found by methods outlined in Art. 1004.

Equations (3) and (5) give the value of the reactions at the beginning of recoil. The value of the reactions with the gun at extreme recoil may be determined by making the proper allowance for the movement of the weight of the recoiling parts through the distance of recoil.

When the gun is elevated the force R_r can be resolved into a vertical component acting downward with the weight of the gun and a horizontal component acting similarly to R_r above, but of less magnitude.

The computations above can be used in designing the strength of the mount, and the strength of the deck structure on which the mount is placed.

By taking the resultant of (1) R_r , acting parallel to the axis of the gun and (2) the weight of the parts supported by the trunnions, acting

vertically downward, the pressure on the trunnions during firing may be computed and the necessary strength of those parts then determined.

907. In the following pages descriptions of typical broadside, anti-aircraft, and turret gun mounts are given. These mounts are the ones most often encountered aboard ship. Further information as to special types of mounts is given in the chapters on naval landing guns and machine guns. The subjects of *sights*, and of *recoil and counter-recoil mechanisms* are not treated in detail in this chapter, being sufficiently covered in the chapters specially devoted to those subjects.

Section II.—A Broadside Gun Mount.

908. The following description of a typical broadside gun mount is to be studied with frequent reference to Plates I, II, III, and IV. The plates being in great detail, the description is intended to supplement a study of the plates, rather than the reverse.

The slide (Plate IV) is a cylindrical steel casting fitted with bronze front and rear liners in which the gun slides in recoil and counter-recoil. In the slide liners is cut a keyway into which the gun is keyed to prevent rotation. Cast solidly with the slide are two trunnions, with projecting bosses. The trunnions rest in bearings in the carriage arms and thereby support the slide and gun in the carriage. At the lower forward end of the slide is cast a pad to which is attached the adjustable elevating arc. The slide may be moved in elevation in a vertical plane about the trunnion axis, the gun moving with it in elevation. Beneath the slide and cast integrally with it are circular brackets that support the two recoil and counter-recoil cylinders. In the type of mount illustrated the recoil and counter-recoil elements are both contained in each of the two cylinders. Recoil is checked by the combined action of the recoil piston and liquid and of the counter-recoil springs, the gun being returned to battery by the energy stored in the compressed springs. Lugs are provided on the slide for the sights and other accessory apparatus. Pressure grease fittings on the slide force grease into grooves cut in the inner surfaces of the slide liners. In train the slide (and gun) move with the carriage.

909. The carriage (Plate III) consists essentially of a hollow cylindrical base with two upward-projecting arms cast integrally with it. These terminate in seats for the trunnion bearings and frictionless bearings. The trunnions are retained in their bearings by means of the cap squares. Elevation of the gun is accomplished through a two-hand drive mounted on the left-hand side of the carriage and functioning through bevel gears and a worm to the elevating pinion, which meshes

with the elevating arc attached to the slide. Brackets are bolted to the side of the carriage to support this mechanism. The arc of elevation is from 10° below horizontal to 20° above. The gun carriage is trained by means of a two-hand mechanism carried on brackets on the right-hand carriage arm, operating through bevel gears to a worm meshing with the training circle, which is a worm rack secured to the stand. Platforms for the pointer and trainer are secured to the base of the carriage. A bracket for supporting the battery box may be secured to the carriage base. The arms of the carriage are now made with extending shoulders to which may be bolted shields for the protection of the gun pointers.

910. The stand (Plate II) projects into the hollow base of the carriage, where it is guided by upper and lower bushings bearing against the bearings within the carriage base. The weight of the carriage is borne by rollers or balls which turn on hardened steel roller paths, housed in the carriage base and stand. A flange projecting upward from the base of the stand supports the training circle and the azimuth indicator arc. Water-tight handholes on opposite sides of the carriage base make the bearings readily accessible for inspection and give access to the holding-down clips. Holding-down clips are heavy metal lugs bolted to the stand and projecting over a flange of the carriage or, vice versa, for the purpose of holding the carriage on the stand when firing.

911. Frictionless bearings.—The upper surfaces of the carriage cheeks are machined to provide slots into which fit *cap squares* secured with cap-square bolts (see Fig. 902). Lost motion resulting from wearing of the trunnion bushings or seats is eliminated by tapered cap-square shoes or adjusting wedges fitting into slots in the cap squares and bearing against the trunnion bushing. These wedge-shaped shoes are forced into the slots by means of cap-square adjusting nuts or knobs turning on cap-square studs and bearing against shoulders on the outer ends of the cap-square shoes.

The knife-edges, upon which the oscillating parts rock when the gun is elevated or depressed, are housed within pockets cut in the extending lugs on the outer ends of the trunnion bosses. Each knife-edge slides in the lower end of the recess of the trunnion boss and is adjusted and secured in position by an adjusting screw which threads through the extending lug and is maintained in the desired position by a locking clamp secured by a locking-clamp bolt. The dead weight of the oscillating parts is transferred from the knife-edge to a knife-edge bearing held by a drive fit in a slot in the upper surface of the spring bar. The spring bar is supported on two alloy-steel rollers. Curved recesses at each end of the spring bar serve as upper roller

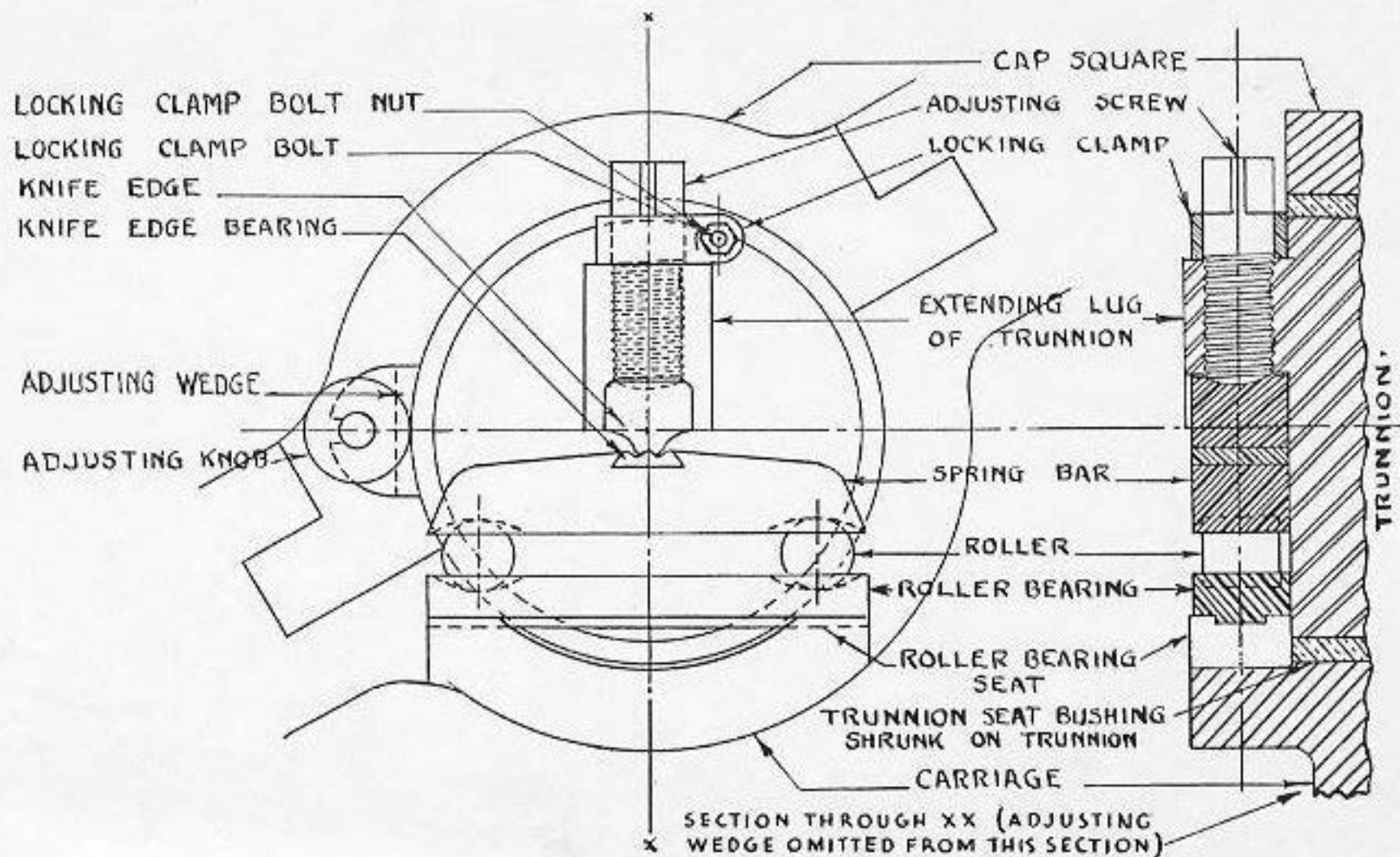


FIG. 902.—DETAILS OF FRICTIONLESS TRUNNION BEARING.

paths; similar recesses in the roller bearing function as lower roller paths. The roller bearing rests upon a projecting shoulder cast on the carriage arm below the trunnion seat. When the gun is at rest, the weight of the oscillating parts is carried by these frictionless bearings which transfer the weight directly to the carriage arms; but when the pressure on these bearings is increased by firing, the spring bars deflect and allow the trunnions to bear against the trunnion seats, providing ample support for the gun and slide. The frictionless bearings are protected by trunnion bearing covers bolted to the carriage arms.

912. **Adjustment of frictionless bearings.**—If the gun and slide are not properly and accurately balanced on the trunnions, the elevating gear will operate with difficulty, especially in one direction. If the elevating gear for a properly balanced gun does not operate properly, the cause will normally be found due to the improper adjustment of the frictionless bearings. If the adjusting screws are not adjusted so as to transfer the weight of the gun and slide to the spring bars, or if they are so adjusted that the trunnions are forced against the upper surfaces of their bearings, then the frictionless bearings will not function properly and elevation and depression will be difficult. These discrepancies may occur in either one or both bearings. Accurate adjustment of these bearings is easily accomplished by turning the adjusting screws until thin feelers may be inserted between the trunnions and their bearing surfaces, after which the adjusting nuts may be locked securely with the locking clamps provided.

Section III.—Anti-aircraft Mounts.

913. **General.**—In addition to small-caliber machine guns, our Navy now has the 3-inch 50-caliber, the 5-inch 25-caliber, and the 5-inch 38-caliber semi-automatic guns mounted on board ship for anti-aircraft batteries.

Anti-aircraft guns must be mounted on weather decks where they can fire at maximum elevation, have minimum interference from the ship's structure, and be reasonably clear of the blast of other guns.

The following are desirable features for anti-aircraft gun mounts:

- (1) High elevation.
- (2) Low trunnion height.
- (3) Ease and rapidity of elevation and training.
- (4) Rapidity of loading and firing.

Obviously some of these features can be obtained only at the expense of others.

To utilize economically on board ship the available gun positions, the tonnage, and the personnel, it is necessary that all anti-aircraft

guns also be efficient guns for firing at surface targets. The 5-inch 38-caliber guns for recent construction are two-purpose guns, *i.e.*, for use against surface and aircraft targets.

914. Plates V and VI show the 3-inch, 50-caliber anti-aircraft gun and mount.—As will be noted, the trunnion height is considerable—about 66 inches—and the mount is cut away at the rear to allow for 90° extreme elevation. Located on the upper deck, the gun is capable of training through 360° and, except over small arcs where the masts and stacks may interfere, it can be fired at all angles of train.

The details of the mount are shown in Plates V and VI. It will be seen that the carriage, which forms the greater part of the mount, rests over a low cylindrical stand that is bolted to a foundation plate in the deck. The carriage is supported on the stand by two ball bearings, an inner and an outer ball bearing. These two bearings are designed to

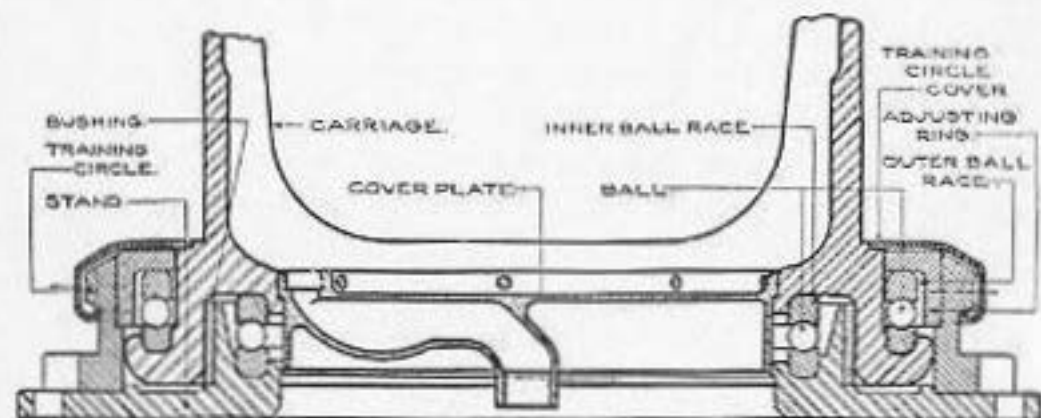
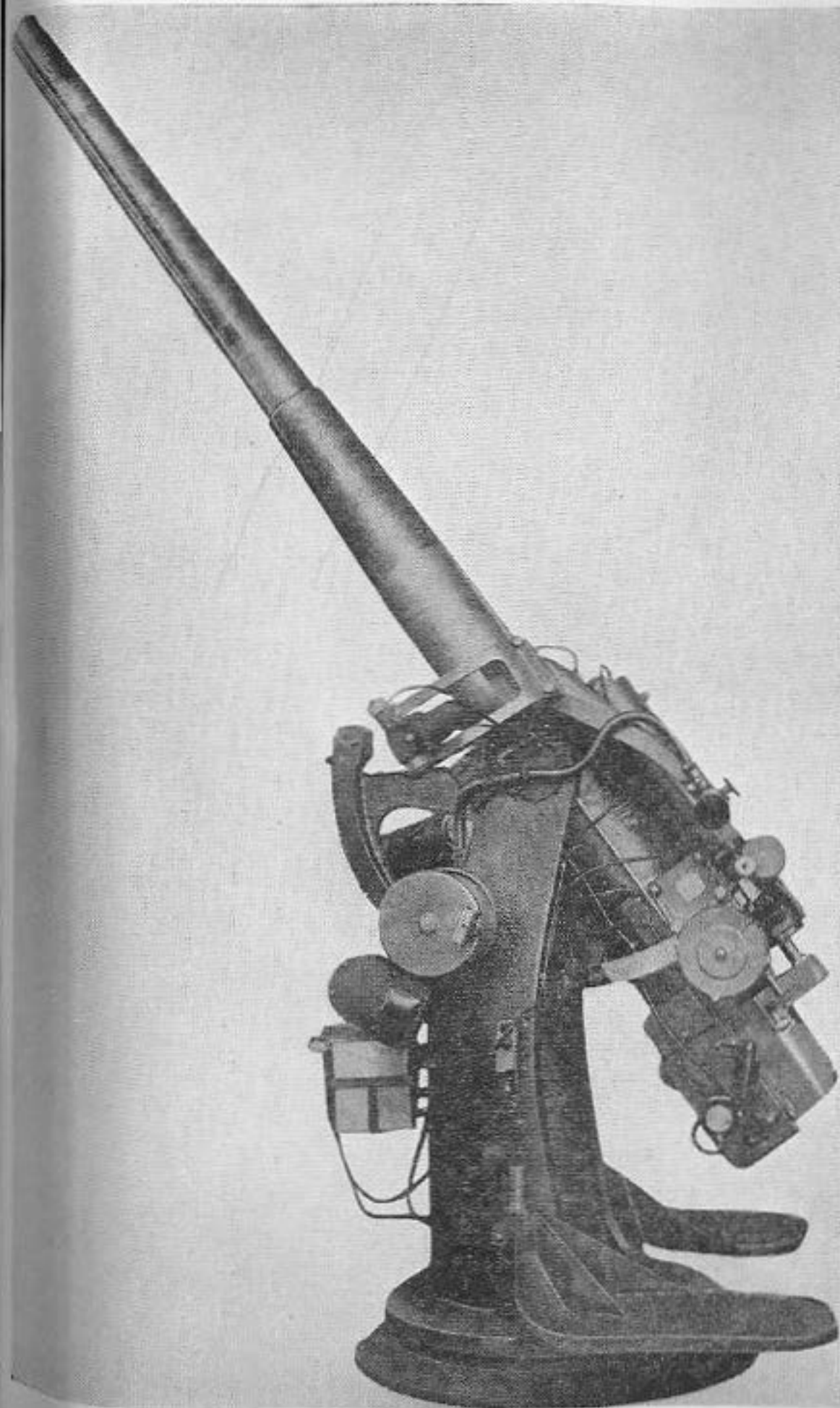


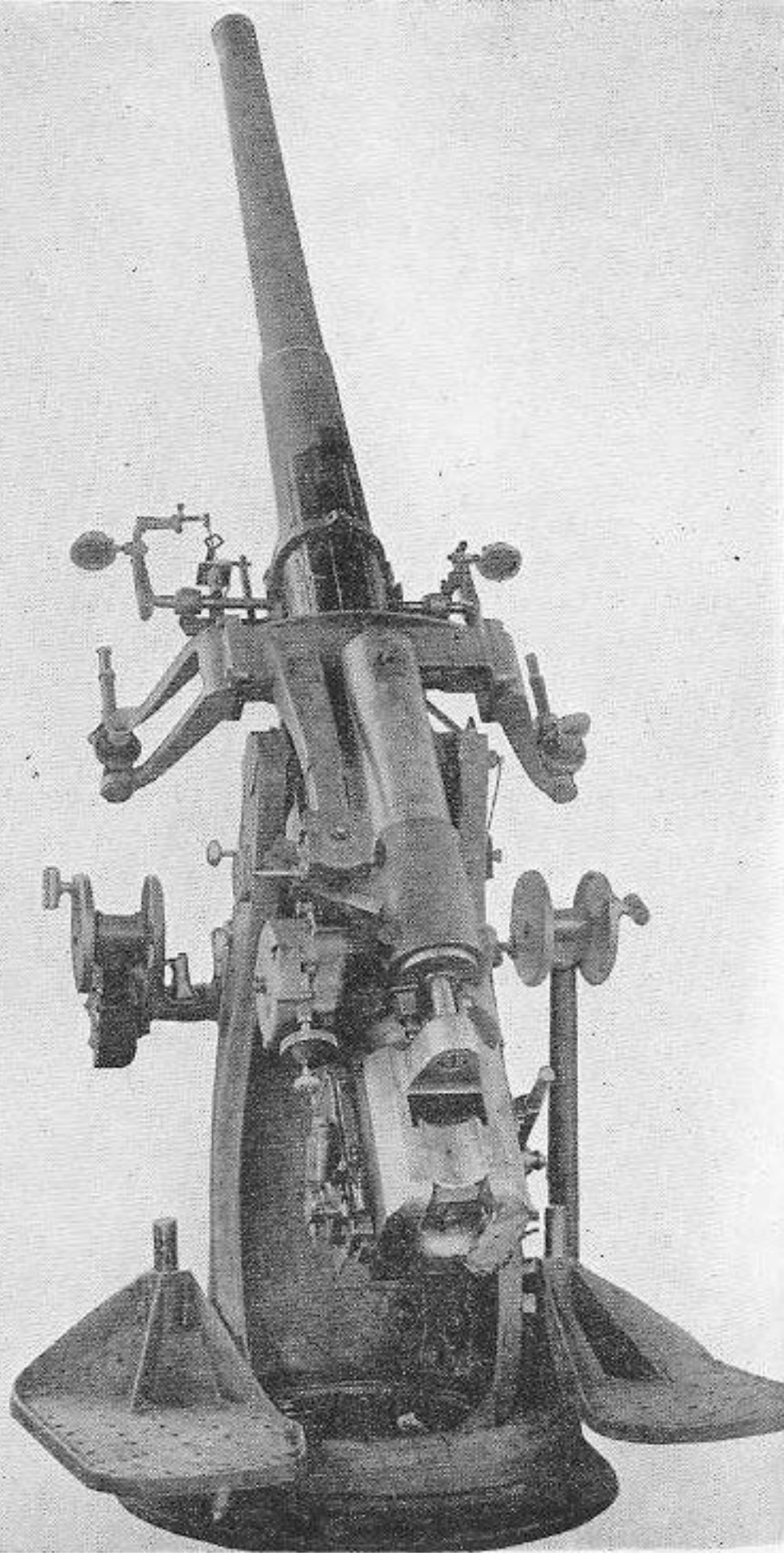
FIG. 903.—THE 3-INCH CARRIAGE, MARK XI, IS SUPPORTED ON TWO BALL BEARINGS AND IS HELD TO THE STAND BY AN ADJUSTING RING.

reduce friction to a minimum. The inner bearing takes the compression load, weight, and vertical downward thrust of recoil when the gun is fired. The outer bearing holds the carriage on the stand and thus takes the tension load due to roll of the ship and to upward thrust of recoil when the gun is fired at low angles of elevation. This is the function of the holding-down clips in the conventional broadside mount. Figure 903 shows the stand and a portion of the carriage, in section, and clearly indicates the details of assembly and the means by which the carriage is retained upon the stand. The bolts for securing the flange of the training circle to the flange of the stand have been omitted in the figure for the sake of clearness.

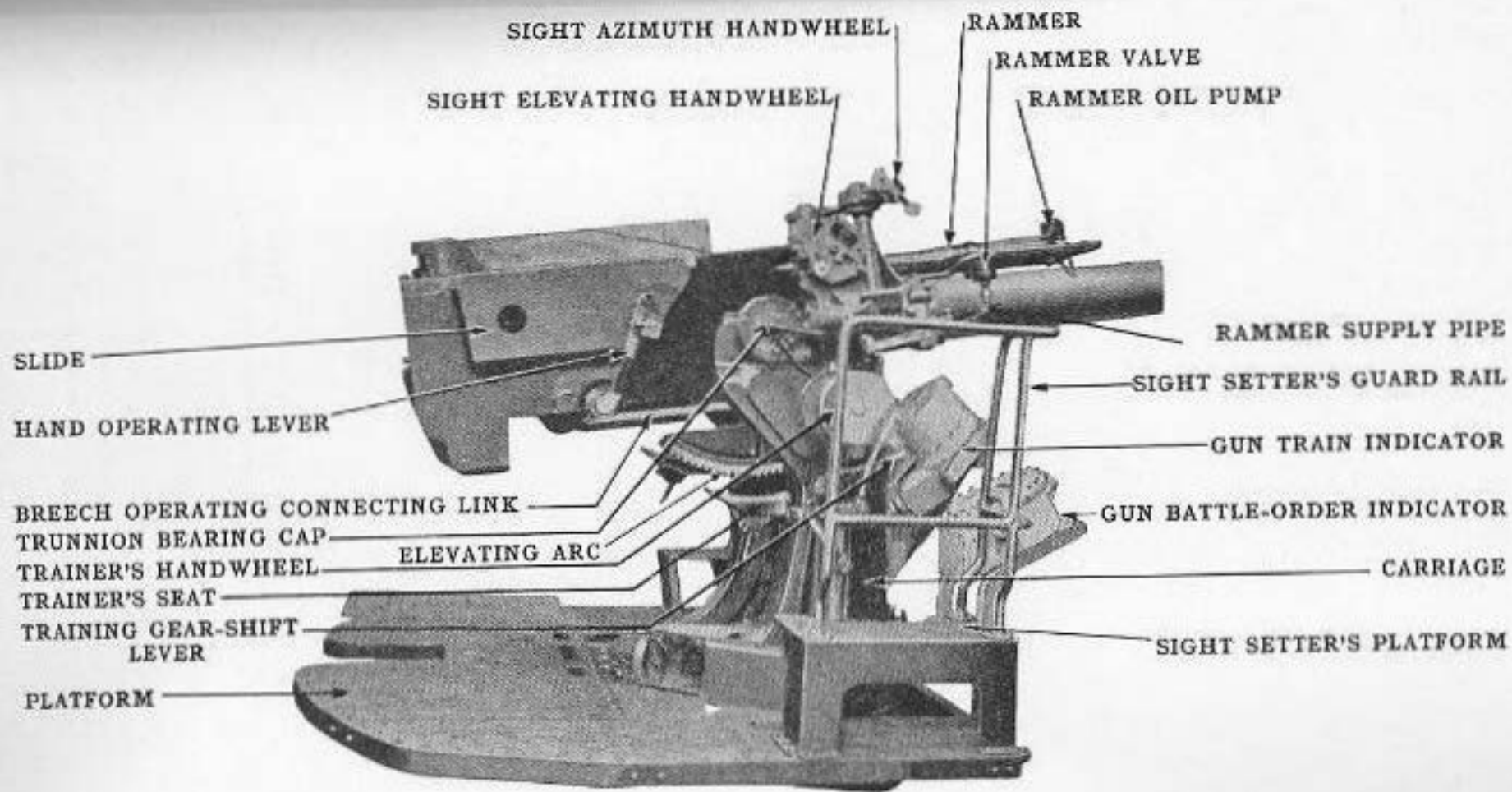
A training worm, meshing with the training circle, is connected by a suitable shaft and gearing with the trainer's two-hand drive shown at the right of the gun.



3-INCH 50-CALIBER ANTI-AIRCRAFT GUN AND MOUNT.

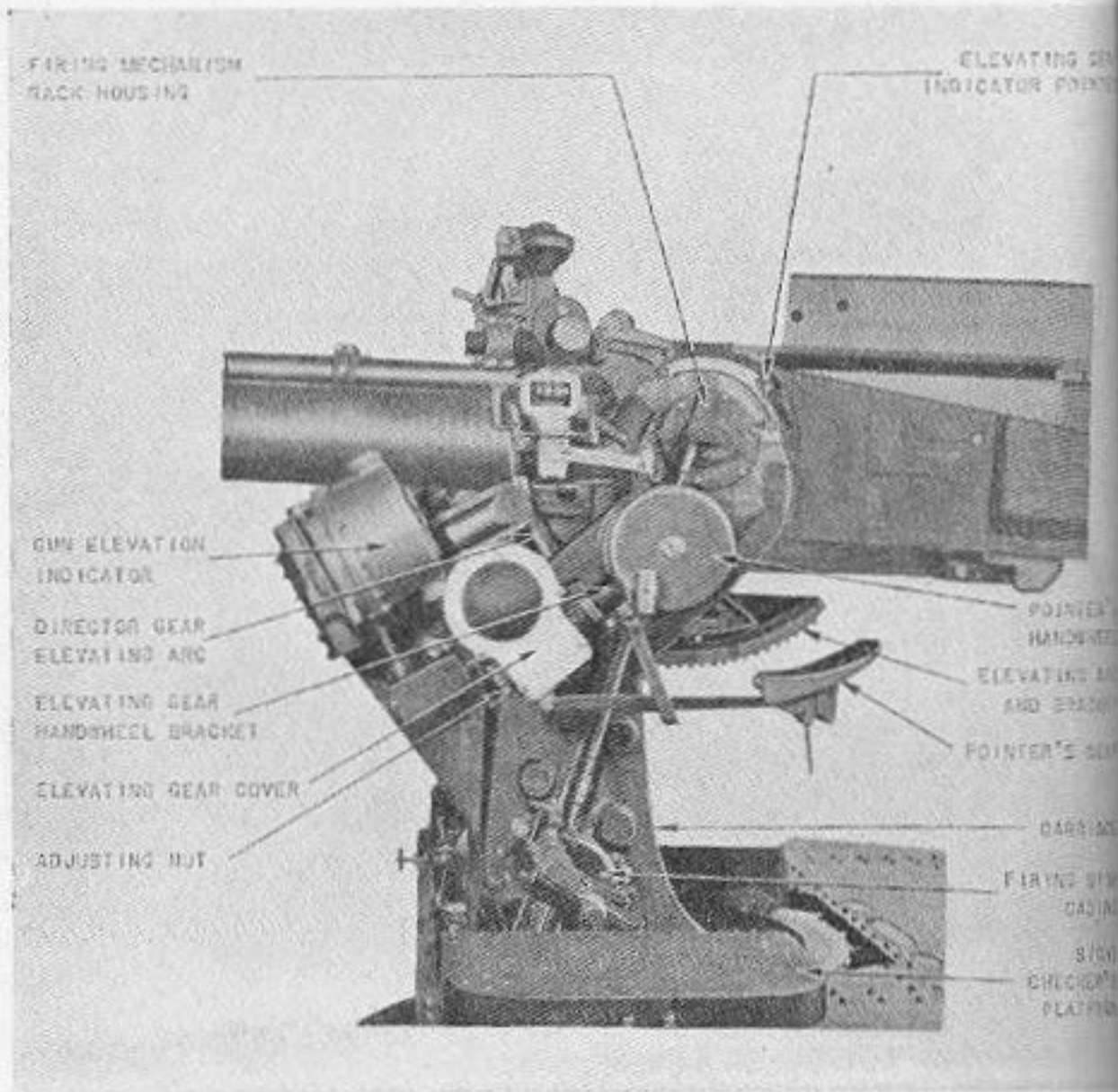


3-INCH 50-CALIBER ANTI-AIRCRAFT GUN AND MOUNT.



5-INCH ANTI-AIRCRAFT MOUNT, MARK XIX AND MARK XIX, MOD. 1, ASSEMBLY—RIGHT SIDE.

CHAPTER IX, PLATE VIII.



5-INCH ANTI-AIRCRAFT MOUNT, MARK XIX AND MARK XIX, MOD. 1,
POINTER'S SIDE. FUZE SETTER NOT SHOWN.

On the left side of the carriage is the pointer's two-hand drive, which actuates a pinion meshing with the elevating arc shown in Plate V.

The training and elevating gears are of the standard broadside mount type.

At the top of the carriage are the trunnion seats in which the trunnions rest. The latter form part of the slide through which the gun slides on recoil and counter-recoil.

915. The 5-inch, 25-caliber anti-aircraft gun was designed and developed by the Navy to fill the need for an anti-aircraft gun of larger caliber with high rate of fire. This gun is semi-automatic and is invariably used as such when firing at aircraft targets. While designed primarily as an anti-aircraft gun, it may also be used for firing at surface targets. The following brief description is intended to supplement a study of Plates VII and VIII.

The slide is a large box-shaped steel housing with a rear plate bolted on its after end.

(a) The slide houses the breech of the gun and guides the gun during recoil and counter-recoil.

(b) The forward ends of the two recoil piston rods are secured to the forward end of the slide. The recoil system is of the hydraulic type.

(c) The after end of the counter-recoil plunger is secured to the after end of the slide (rear plate). The counter-recoil system is of the hydraulic-pneumatic type.

(d) The trunnions are on the outboard sides of the slide, and, through them, the weight of the gun and the force of recoil are delivered to the carriage.

(e) The elevating arc is secured to the slide directly under the forward part.

(f) The breech mechanism hand-operating lever is mounted on the right side of the slide.

(g) The power rammer is mounted on the right side of the slide and above it.

The carriage is supported on the stand by two ball bearings, an inner and an outer ball bearing. The outer bearing takes the compression load, weight, and vertical downward thrust of recoil when gun is fired. The inner bearing holds the carriage on the stand and thus takes the tension load due to roll of the ship and to upward thrust of recoil when firing gun at low angles of elevation. It is thus seen that the functions performed by the inner and outer bearings of this mount are respectively performed by the outer and inner bearings of the 3-inch, 50-caliber mount illustrated in Fig. 903. The training and elevating gears are of the standard broadside-mount type.

The stand is a low heavy steel casting having a square base. The stand contains the lower ball race for the outer ball bearing and the upper ball race for the inner ball bearing.

The fuze setter is mounted to the left and aft of the breech of the gun on a platform which is attached to the gun carriage.

This gun can be moved rapidly in both elevation and train. The trunnions are equipped with roller bearings which serve both as main trunnion and frictionless trunnion bearings. These bearings are similar to those shown in Plate XIII.

Section IV.—Turret Mounts.

916. General considerations.—The turret installation on each class of ship varies, being a gradual development from type to type. In general, the developments in turret design have progressed from the use of a single gun in a turret, to a maximum of four guns in a turret. It may be accepted that this development is based upon sound principles and follows a corresponding increase in the size of the navies of the principal powers.

From the constructor's point of view, it has been practically demonstrated that the weight of installation per gun is the least for a three-gun turret, and increases in both directions from this number, due to the fact that the space occupied by that portion of the three guns contained inside the turret pan is bounded very nearly by a square, which is the largest rectangle which can be inscribed in a circle of a given size. It is also true that the least weight is required for designs where all guns are carried in one slide, but flexibility is thereby lost.

The primary objects to be accomplished in the design of a turret are accuracy and rapidity of gunfire, and efficiency and reliability of all mechanical features of the turret, combined with the maximum possible protection against damage by the enemy's gunfire. The details of gun and mount should be worked out to eliminate excessive dispersion in the fall of shot, and to avoid any increase in dispersion, caused by any progressive permanent deflection in metal which is strained by the forces resulting from the discharge of the guns. The various machines installed for use in the service of the guns should be designed with a liberal factor of safety to insure continuous operation over an extended period of time, and should be simple in design to facilitate upkeep, and to avoid the necessity of too much mechanical skill and experience on the part of the personnel. Protection is similar to insure against accident and should be the maximum which can be obtained without undue sacrifice of accuracy of gunfire and mechanical reliability.

917. **Historical.**—The earlier turret designs in the U. S. Navy were two-gun turrets with what is known as a *single-stage hoist*. That is, the powder and shell were taken from the magazines and shell rooms and placed in an open car for each gun, which was hoisted to the breech of the gun, traveling up and down in an open well. The guns were loaded, using rammers fixed in the rear of the turret so that the guns had to be brought to the horizontal position to be loaded.

When modern target practice was introduced in the Navy, about 1903, there occurred several very serious turret accidents, due to this open type of construction; and all turrets were modified by fitting them with automatic shutters, to seal the handling room from the turret chamber, except at the instant the car was passing the shutter. This was not entirely satisfactory, and new designs were made on the two-stage hoist principle; that is, the powder and shell were brought up from the handling room to an intermediate compartment in one set of hoists, and there transferred to another set which carried them to the guns. This permitted the introduction of a more positive flame seal between the turret chamber and the magazines as this intermediate compartment was fitted with interlocks which did not permit doors to be open at the same time to both turret and handling room. Variable loading positions were also provided by putting the rammer on an arm from the gun slide, thus permitting the gun to be loaded at any angle of elevation.

In an effort to secure an increased rate of fire and increased reliability of turret gear, many turrets were converted to "hand loading." The ammunition cars were removed and tube hoists, power-whip operated, were installed for hoisting shell. The powder was passed up by hand by men standing on fixed platforms at different levels. The telescopic rammers then in use were taken out and hand rammers used. Hand loading required larger turret crews and required a larger amount of strenuous work by these crews.

918. **Modern types.**—Modern target practice created the demand for, and the Bureau of Ordnance designed, manufactured, and installed much faster and more reliable turret machinery that displaced hand loading for turret guns. All powder cars now in use are of the flame-proof type. The pusher type of shell hoist has practically displaced the whip type. The chain type of rammer has displaced the telescopic type. Turret machinery is, in general, both fast and rugged. In the development of turret powder hoists, the maximum number of flame-proof compartments, fitted with interlocking flame seals, compatible with an adequate ammunition supply have been installed between the magazines and the guns.

A 14-INCH, 3-GUN TURRET.

The description which follows applies generally to all modern turrets, 8-inch to 16-inch inclusive.

919. Major structural subdivisions (See Plates IX and X).

(a) **The barbette.**—This is a cylinder of heavy armor surrounding the turret structure from the lowest protective deck up to the armored turret proper. The barbette is stationary and is not joined to the rest of the turret.

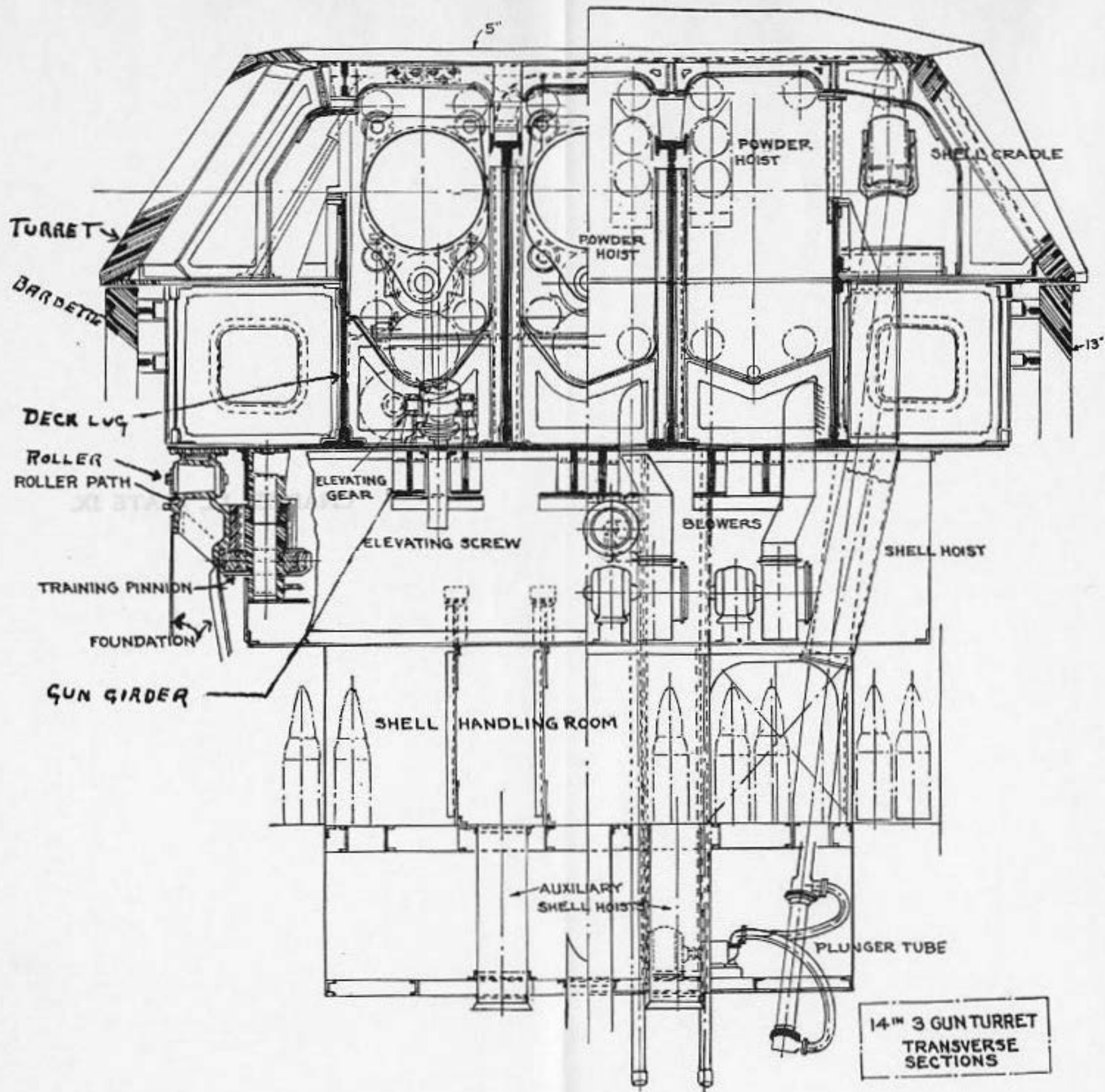
(b) **The turret foundation.**—This is a heavy structure of girders and beams built into the structure of the ship. It is cylindrical in shape and extends upward close to the inner surface of the barbette, to a point near the top of the barbette. At its top it supports the circular roller path, carrying the rollers on which the entire revolving portion of the turret rotates.

(c) **The turret proper.**—This is the heavily armored box-like structure from which the guns protrude, and which may be seen to rotate from the outside. The circular barbette armor extends from a point just below the armor secured to the revolving portion of the turret, down to the lowest protective deck of the ship, so that the turret roof, front, and side plates, together with the barbette and protective deck armor afford protection to the guns and machinery within the turret and to the magazines beneath the turret.

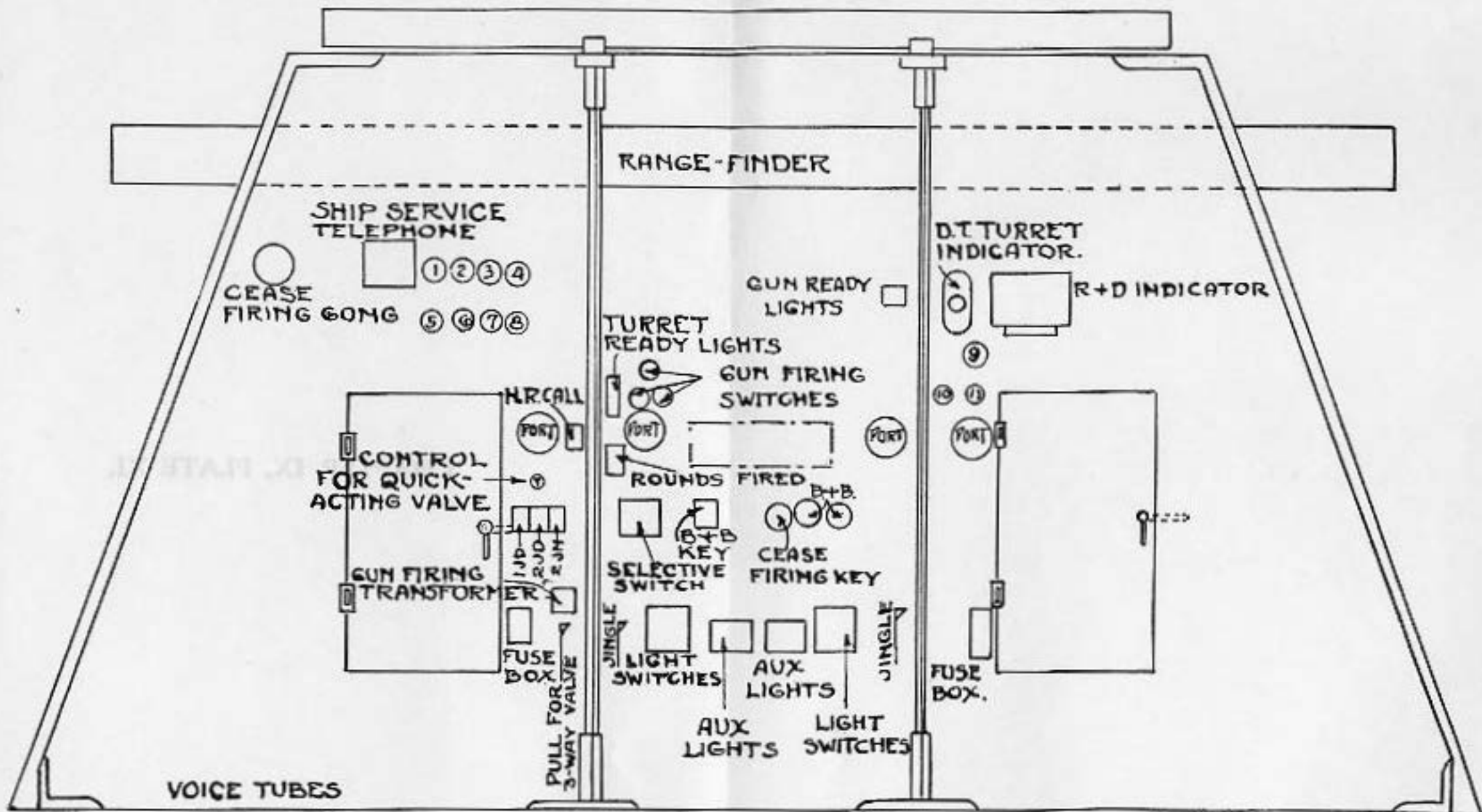
(d) **The revolving turret structure.**—This is all of the inner structure forming one assemblage with the turret proper, and extending downward within the turret foundation to the deck of the lower powder handling room. The weight of this structure and the turret proper rest and rotate on the rollers on the roller path. All the operating compartments, machinery, and other gear are in the turret revolving structure and turret proper.

920. Interior subdivisions.—(a) **The turret chamber** is that part of the turret surrounding the gun positions. It includes the gun chambers and the gun pits. The gun breeches are in the gun chambers, as well as the delivery ends of the shell hoists and powder supply. It is here that the guns are loaded.

(b) **The turret booth**, at the rear of the turret proper, is separated from the turret chamber by flame-proof bulkheads, and is so designed as to give the turret officer a direct view of the guns through suitable dead lights. (Plate XI.) Access to the turret chamber is obtained through doors. Each turret booth has a quick-acting lever or other device for operating the sprinkling system in the turret chamber and also in upper and lower powder-handling rooms and to drench powder in the train between lower and upper handling rooms. The turret booth



14" 3 GUN TURRET
 TRANSVERSE
 SECTIONS



- 1 WORK SHOP
- 2 OVERHANG TURRET
- 3 BREECH OF EACH GUN
- 4 SHELL HANDLING ROOM
- 5 POWDER HANDLING ROOM
- 6 LOWER HANDLING ROOM
- 7 TRAINERS + POINTERS
- 8 SHELL HANDLING ROOM

- 9 TO OTHER TURRETS OF SAME GROUP
- 10 TO PLOTTING ROOM FROM RANGE FINDER.
- 11 TO SUB

NOTE:-ALL VOICE TUBES TURNED
THRU ANGLE OF 90° INBOARD

14" 3 GUN TURRET
TURRET OFFICERS'
STATION

is also fitted with a lever or other device for operating an emergency alarm. The turret booth is habitually occupied by the turret officer when the turret is in operation.

(c) **Handling rooms.**—The handling rooms are spaces which are habitually utilized in the ammunition supply train for transferring powder or shell from the stowage to the supply hoists, from one hoist to another, or from one means of supply to another means of supply. These may be further distinguished as powder-handling rooms and shell-handling rooms. Shell stowage is the term used to designate open spaces where shells are stowed within the turret barbette on the circle decks at various heights and throughout the turret structure.

The magazines and lower powder handling room are adjacent to the bottom of the turret revolving structure. They are not in the turret proper but form an essential part of the ammunition supply facilities.

(d) **Other spaces** are the storage battery room, training gear room, hand passing platforms (for powder), tank compartment for the sprinkler water tanks, blower rooms, etc.

921. Special apparatus.—The general requirements regarding turret construction require that nothing shall be attached to the turret armor except fittings required by the structure, or fittings which by their nature and use cannot otherwise be placed for the efficient operation of the turret. Means are provided to prevent bolts, nuts, rivet heads, etc., flying in the turret as the result of shell impact. In all turrets, except single-slide turrets, flame-proof bulkheads separate the several guns.

A gun spray is installed near the breech of each gun and fitted with a quick-acting valve controlled from the turret booth, turret overhang, and gun chamber. Another water spray is fitted on the end of a flexible hose capable of being used in the gun breech or any other part of the turret gun chamber.

Each gun in the turret is fitted with a gas expelling device. Blowers are installed in the turret for ventilating purposes, and during gun firing the turret is maintained under a slight air pressure.

The intakes of the turret ventilating system are so located as to minimize the possibility of drawing into the system gases from fires in action. Care is taken, so far as practicable, to keep water and spray from entering the turrets through the gun ports, and sighting slits, while the turrets are being operated.

A sprinkling system is installed to drench powder in the gun chambers, upper handling room, lower handling room, and the powder train between upper and lower handling rooms where exposed in case of fire.

Voice tubes, bells, buzzers, telephone, and fire-control instruments are installed.

922. The turret mount.—The principal parts of a turret mount are (1) the gun, with breech mechanism and yoke, (2) slide, including recoil and counter-recoil mechanisms, (3) deck lugs and gun girders, (4) elevating and training gear, including rollers and roller paths, (5) shell and powder hoists, (6) rammer and spanning trays, (7) sights. (See Plates IX and X.)

The gun, yoke, breech mechanism, and sights are described in other chapters and will not be dealt with here.

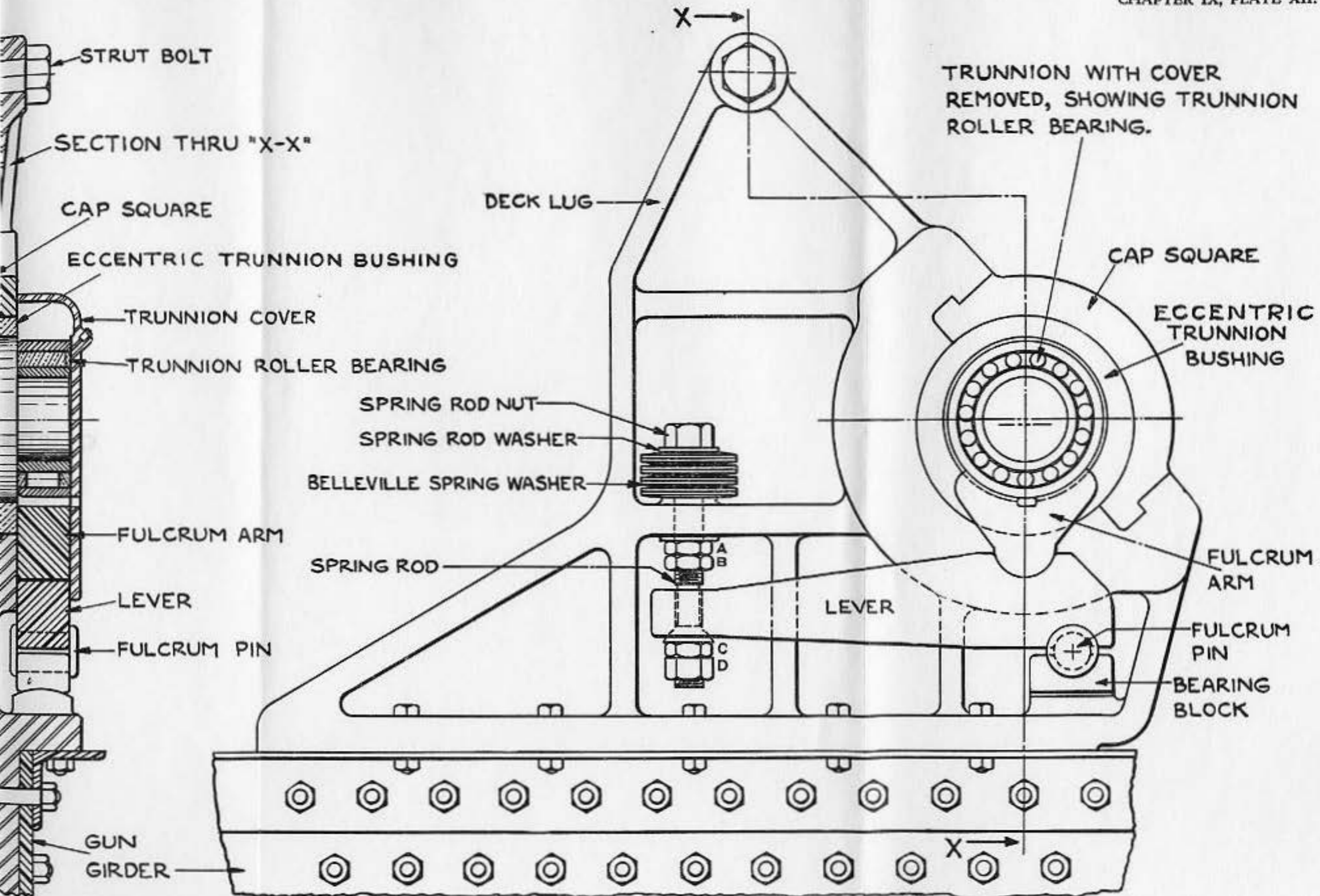
923. The gun slide, of which the trunnions are parts, supports the gun and the recoil and counter-recoil mechanisms. The slide, essentially a hollow cylinder, is of cast steel and is lined with bronze. The trunnions, about which the guns are moved in elevation, are located approximately at the center of gravity of the oscillating weights which they support and as close as practicable to the turret face plate in order that the port openings may be reduced to a minimum. On the gun slides of the *California* and *Maryland* classes, the trunnions are semicylindrical bosses, the upper forward sectors being cut away to permit installation closer to the turret face plate. Trunnion and deck lug of a modernized 14-inch battleship mount are illustrated in Plate XII; those of an 8-inch gun mount for a heavy cruiser in Plate XIII.

It will be noted that the 14-inch mount, having 30° elevation, adheres to the earlier method of a small frictionless bearing about which the gun is moved in elevation and a separate larger main bearing through which the forces of firing are transmitted to the ship's structure through the deck lugs and gun girders. The end thrust is taken up by the key and keyway of the trunnion bushing and deck lug. This trunnion bushing is eccentric. Rotation of this eccentric bushing permits adjustment for parallelism of the guns,

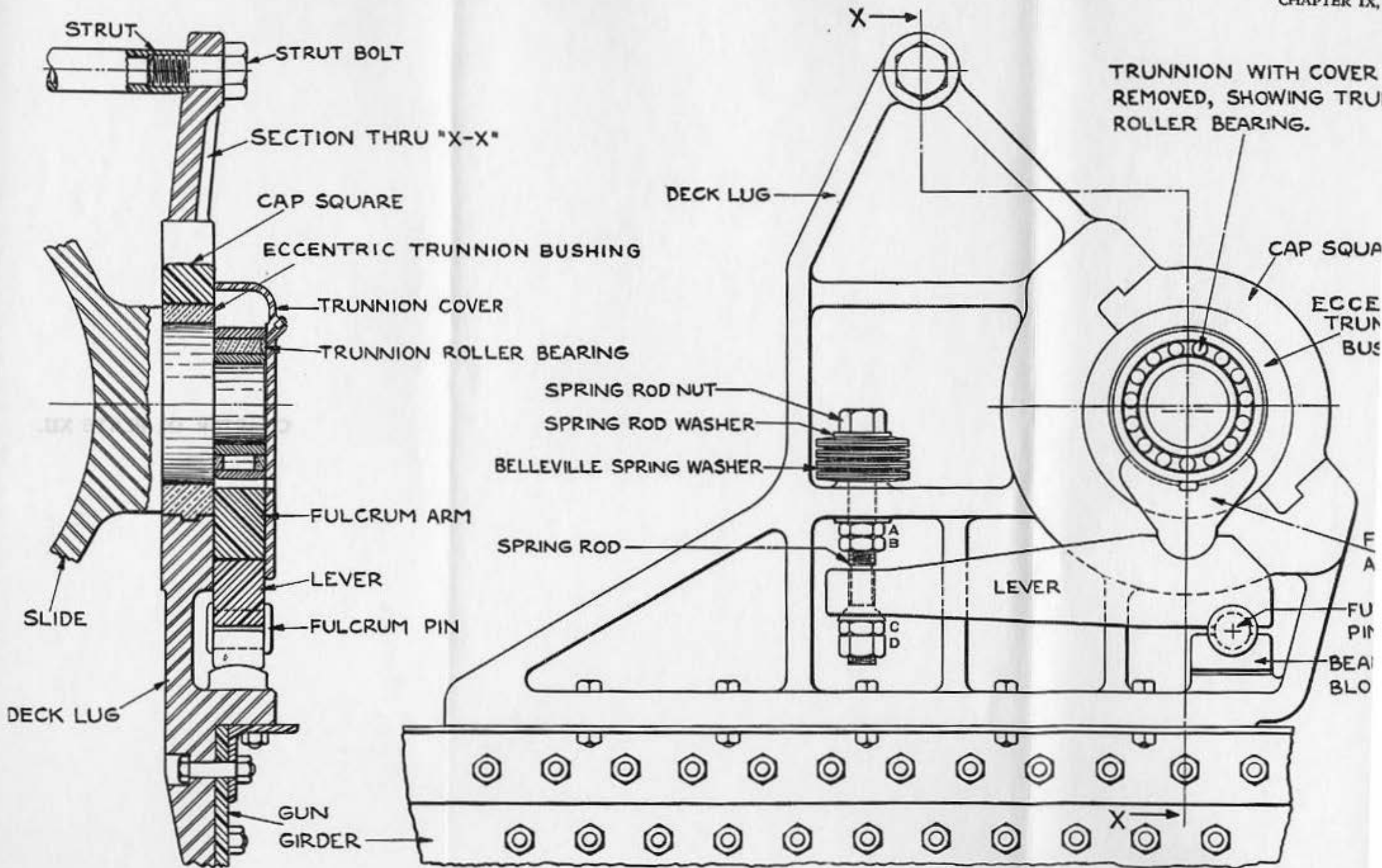
In the 8-inch mount, having 40° elevation, the main bearing is rendered as nearly frictionless as possible by the rollers. These roller bearings serve both as frictionless trunnion bearings and as the main trunnion bearings which take the entire load and shock when the guns are fired. These roller bearings have no adjustment of any sort. Note that the axial length of the rollers is divided into two to reduce the possibility of cracking the rollers due to their length or due to their being slightly canted. Due to greater roll and pitch of the heavy cruisers, this mount is fitted with thrust rings to transmit the end thrust.

To adjust the clearance of the trunnion bearing of the 14-inch mount (Plate XII): With all parts in place and nuts *A* and *B* slacked off,

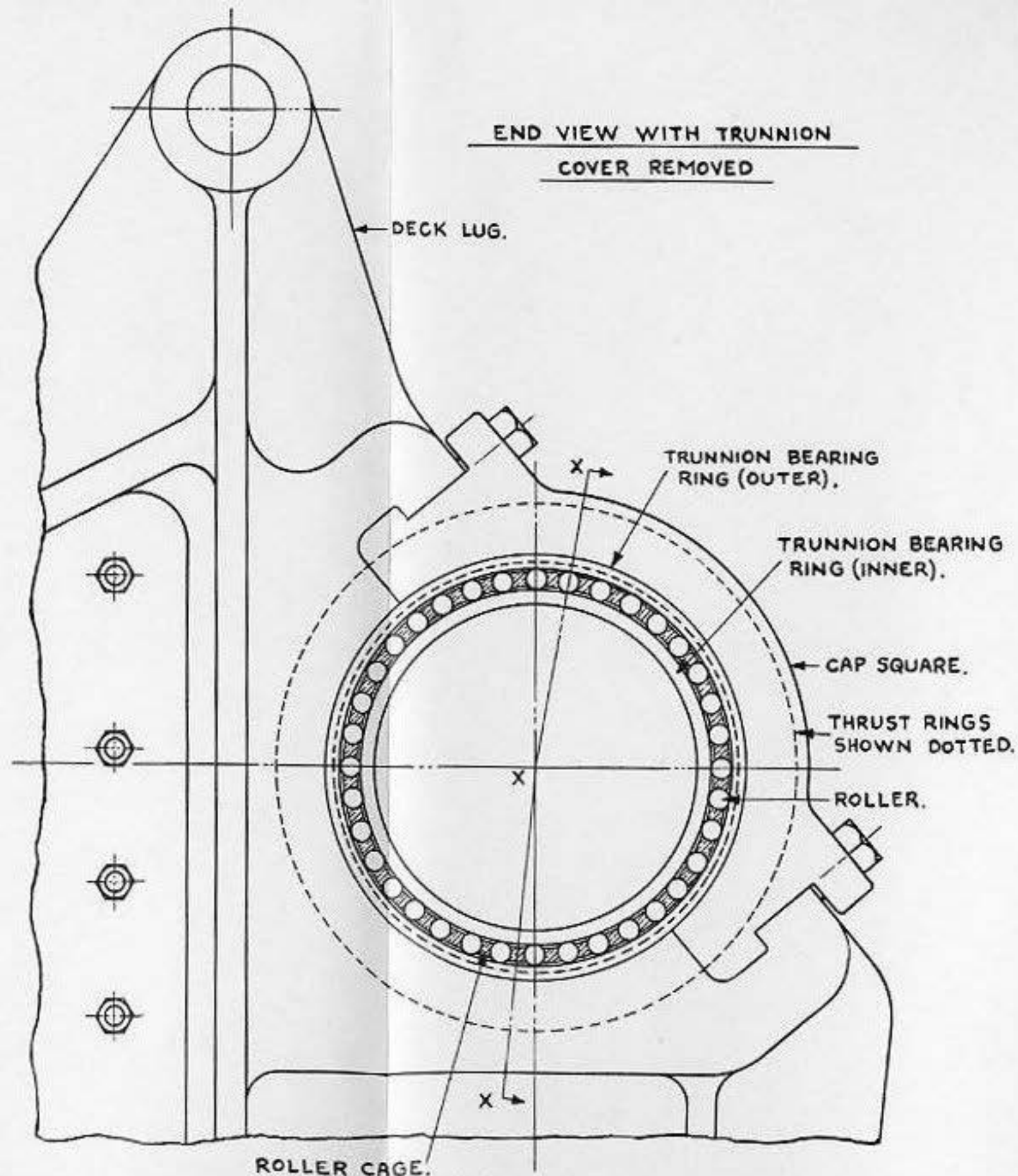
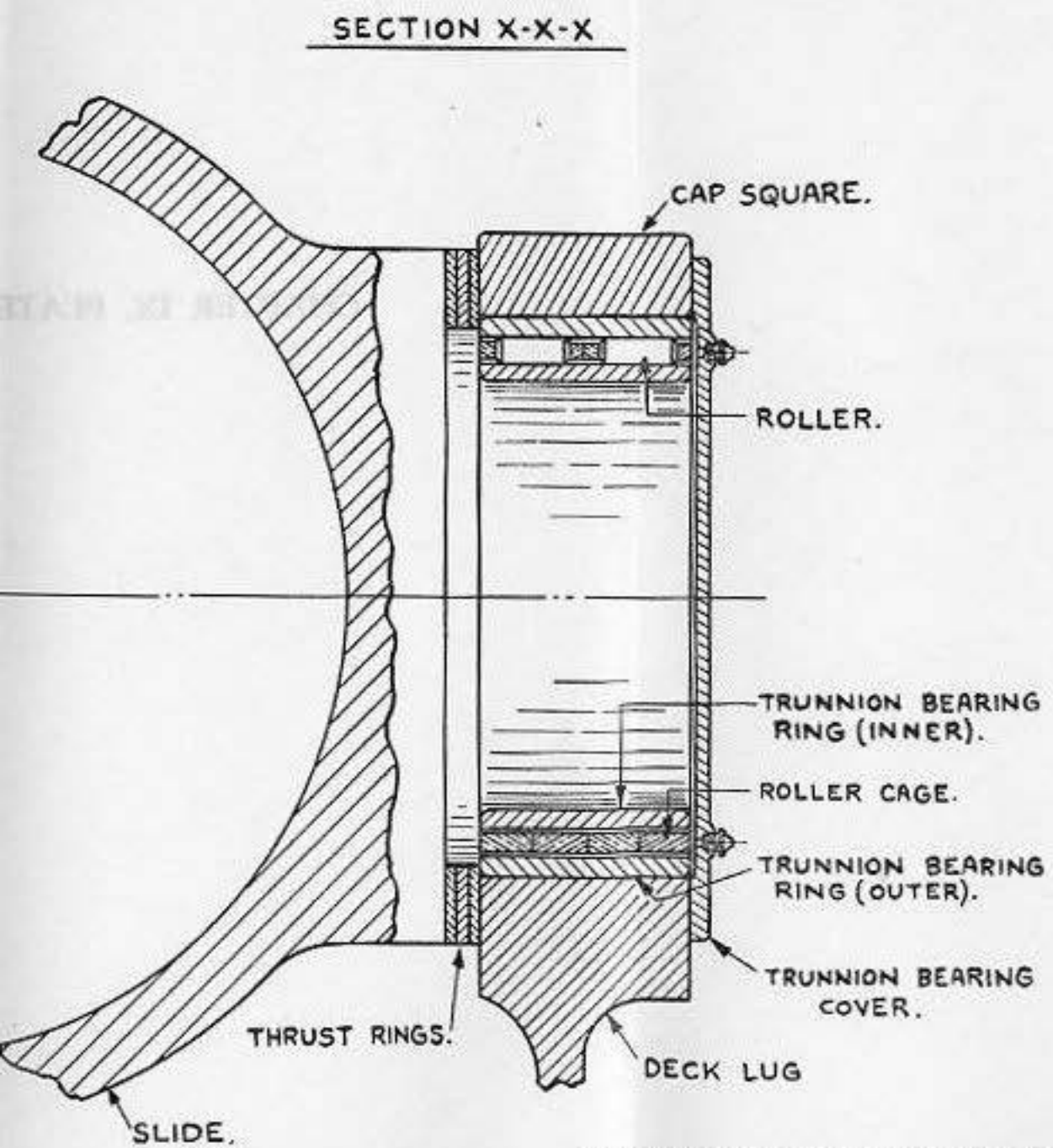
(1) Screw up nuts *C* and *D* until trunnion is lifted from its bearing



TRUNNION, TRUNNION BEARING AND OUTBOARD DECK LUG FOR 14-INCH MOUNT OF MODERNIZED BATTLESHIPS OF THE OKLAHOMA CLASS.



TRUNNION, TRUNNION BEARING AND OUTBOARD DECK LUG FOR 14-INCH MOUNT OF MODERNIZED BATTLESHIPS OF THE OKLAHOMA CLASS.



TRUNNION, TRUNNION BEARING AND LUG FOR 8-INCH TRIPLE MOUNT FOR HEAVY CRUISERS.

sufficiently to permit insertion of trunnion feeler gauge on under side of trunnion.

(2) Screw up nut *A* until firmly in contact with boss of deck lug, then screw up one-fourth of a turn additional. Set locknut *B* until in contact with *A*.

(3) Readjust nuts *C* and *D* by screwing up *C* until trunnion feeler gauge can again be inserted on under side of trunnion, set locknut *D* until in contact with *C*.

With the bearing adjusted as above, the entire weight and friction of moving the oscillating weights in elevation are borne upon the frictionless roller bearings and transmitted to the deck lug through the following parts: fulcrum arm, fulcrum pin, lever, spring rod, Belleville spring washers, spring rod washer, and spring rod nut. The Belleville spring washers are heavy saucer-shaped washers, alternate washers being inverted as shown. When the guns are fired the shock transmitted through the fulcrum arm, lever, spring rod, etc., causes the pairs of Belleville spring washers to dish or flatten, thus permitting the spring rod, spring rod washer, and spring rod nut to be lowered sufficiently to permit the lever and fulcrum arm to deposit the main trunnion in its bearing and so utilize its greater area to transmit the shock of firing to the deck lugs and to the ships structure.

924. The recoil mechanism, consisting of the recoil cylinder and throttling rods, is attached to the slide. The piston rod is attached to the gun yoke and recoils with the gun. During recoil, the liquid in the cylinder is forced through the orifices formed between the throttling rods and the apertures in the piston. The method of computing the proper dimensions of throttling rods is discussed in Chapter X.

The energy absorbed by the hydraulic brake results in a considerable heating of the recoil cylinder liquid. The expansion of the liquid is compensated for by means of an *expansion chamber* which has been provided for all turrets. This chamber is connected to the forward end of the recoil cylinder. It functions automatically, and requires no attention except the exercise of ordinary precaution, during the process of filling the recoil cylinders, to see that the expansion chamber remains empty.

The recoil mechanism performs its primary function during recoil, but it has a limited effect also on counter-recoil.

925. The counter-recoil mechanism, which is also attached to the slide, is provided for the primary purpose of returning the guns to the battery position at all angles of elevation. However, it does have a limited effect during the recoil.

Until recently, the force for returning the guns to battery was de-

rived entirely from the compression of the helical springs, but on account of the large increase of the recoiling weights and the angles to which guns are now elevated, springs are impracticable. In battleships of the *California* and *Maryland* classes the return of the guns to battery during counter-recoil is accomplished by a combination of springs and compressed air. In these mounts there are four counter-recoil spring tubes per gun. (Six in the case of 16-inch guns.) These spring tubes, two on top and two on the underneath side of the slide, are secured by means of straps bolted in place.

Secured to the yoke and running through each spring tube is a piston rod which has its piston at the end farthest removed from the yoke. Between this piston and the head of its tube nearest the yoke are six sets of double spiral springs, each two sets being separated by a disk that is supported on the rod.

The function of these springs is to return the gun to battery after recoil, and in order to do this at maximum elevation the springs are assembled with initial compression of approximately fifty inches. Air is also injected into the tubes from the gas-ejecting system at an initial pressure of 50 pounds per square inch, which is further compressed along with the springs when the gun recoils.

Upon counter-recoil the force of impact caused by the expansion of the counter-recoil springs and air is resisted by the necessity of returning the liquid in the recoil cylinder to the after side of the piston. There is also a counter-recoil check plunger which, as the gun returns to battery, enters a small cylinder provided at the forward end of the recoil cylinder. The fit of the plunger is such that a relatively good cushioning effect is realized. Counter-recoil systems of the modernized battleships are described in Art. 1021 *et seq.*

926. The deck lugs, which contain the trunnion seats and cap squares, are heavy steel castings bolted to the gun girders. Their function is the same as that of the carriage of a broadside mount. The gun girders form the supports for the deck lugs and elevating gear; and through them the firing forces, at the trunnions, are transmitted to the roller path. (See Plates XII and XIII.)

927. The elevating gear¹ (Plates IX and X).—In the latest turrets the guns are arranged to elevate independently. Under normal conditions, however, all three elevating gears are locked together by clutches so that all guns elevate together. The elevating gear provided

¹ All machinery of a modern turret is electrically operated. Speed control of elevation, train, some rammers, and pusher-type ammunition hoists is obtained through the use of universal speed gears. Other motors have straight electrical control. For a description of the universal speed gear, see Art. 932 *et seq.*

for all guns is similar. Sufficient power is provided in each set so that all three guns may be operated by any single set of electric and hydraulic motors. In case of a casualty which would increase the resistance imposed upon the elevating gear, the guns may be elevated with all three electric motors and speed gears operating simultaneously. The elevating gear for each gun consists of an electric motor driving a universal speed gear. The B-end of the speed gear connects to the elevating nut which drives the elevating screw attached to the slide. The elevating nut is supported by the oscillating bearing which in turn is supported by the transom casting attached to the turret structure. Rotation of the elevating nut imparts an upward or downward motion to the elevating screw depending on the direction of rotation of the nut.

The rate and amount of elevation of the guns are controlled through a two-hand drive connecting to the control shaft of the A-end of the hydraulic speed gear. This two-hand drive is located in a convenient position with reference to the sight telescope and gun-pointer's seat, so that the gun pointer may keep his eye on the telescope for all positions of the gun in elevation.

The follow-up type of control is used; one turn of the handwheel produces a definite angle of elevation of the gun; and the direction of rotation of the gun about the trunnion axis corresponds to the direction of rotation of the handwheel. A definite ratio also exists between the rate of rotation of the handwheel and the rate of elevation of the guns, and when the handwheels come to rest the gun is brought to rest. With the type of control described the guns can be operated with the same facility as a hand-operated mount.

928. The training gear.—The turret-revolving structure is rotated by the training-gear machinery driven by an electric motor and universal speed gear. (See Art. 932.) The driving end of the speed gear connects directly to the worm shaft which drives the worm wheel attached to the training pinion shaft. The *training pinion* (see Plate X), which is secured directly to the training-pinion shaft, meshes with the training rack secured to the turret foundation.

In the latest ships, one worm wheel and one pinion are used. The gear is driven by one main electric motor through a universal speed gear with a follow-up arrangement as for the elevating gear. The torque is transmitted from the motor to the training pinion direct without the use of friction discs, such as were used in the older turrets. In this case the gear is designed with sufficient strength to withstand the forces resulting from the firing of the guns, and the inertia of the turret due to starting and stopping.

Auxiliary training gear is provided for use in case the main electric motor or speed gear becomes disabled. This gear consists of a low-powered electric motor receiving current from storage batteries stowed in the revolving structure of the turret. The speed of train, as in the case of the main gear, is controlled through a small universal speed gear. Hand training is also provided for emergencies when power is not on the turret. This gear is not efficient, and is inadequate for training the turret at any satisfactory speed, being provided as a last resort.

As has been mentioned, the turret revolving structure rests on rollers which rest on a roller path supported on the turret foundation. The rollers, which are frustums of cones, are spaced by a separator ring floating on the roller axles. The weight and vertical forces resulting from firing are supported by the conical surface of the roller, and the horizontal thrust due to firing is transmitted from the revolving structure to the turret foundation through the roller flanges. The turret is also provided with holding-down clips attached to the revolving turret structure and projecting under the stationary turret roller path or vice versa, to prevent it from being thrown from its foundation by force from any outside source.

929. Powder supply (Plates IX and X).—The powder is stowed in the powder magazines in air-tight powder tanks. In supplying powder to the guns the powder is taken from the tanks and passed through flame-proof scuttles in the magazine doors to the lower powder-handling room. From this point the powder is carried by hand to the lower end of the powder conveyor where the powder bags are fed into the receiving end of an endless-chain conveyor hoist. Two hoists of this type are used. These hoists deliver the powder bags to the trays located in the upper powder-handling room beneath the pan separating the turret gun chamber from this room. One charge for each gun is assembled in this room for transmittal to the guns as required.

In the upper powder-handling room, the powder bags are loaded into the powder cars which convey the powder from the upper powder-handling room to the breech of the guns. One powder car is provided for each gun, and each car is arranged to carry a complete charge per trip. The charge is hoisted while the shell is being rammed into the gun. The powder car is flame proof so that the charge is completely protected from flarebacks until the bags are dumped out into spanning trays prior to being rammed into the gun. The upper powder hoist is of a reciprocating type, hydraulically operated. An A-end of a speed gear serves as a pump and delivers liquid under pressure. The motion of the car is controlled by the movement of the control screw of the speed gear. Flame-proof doors fitted with interlocks form a seal between the

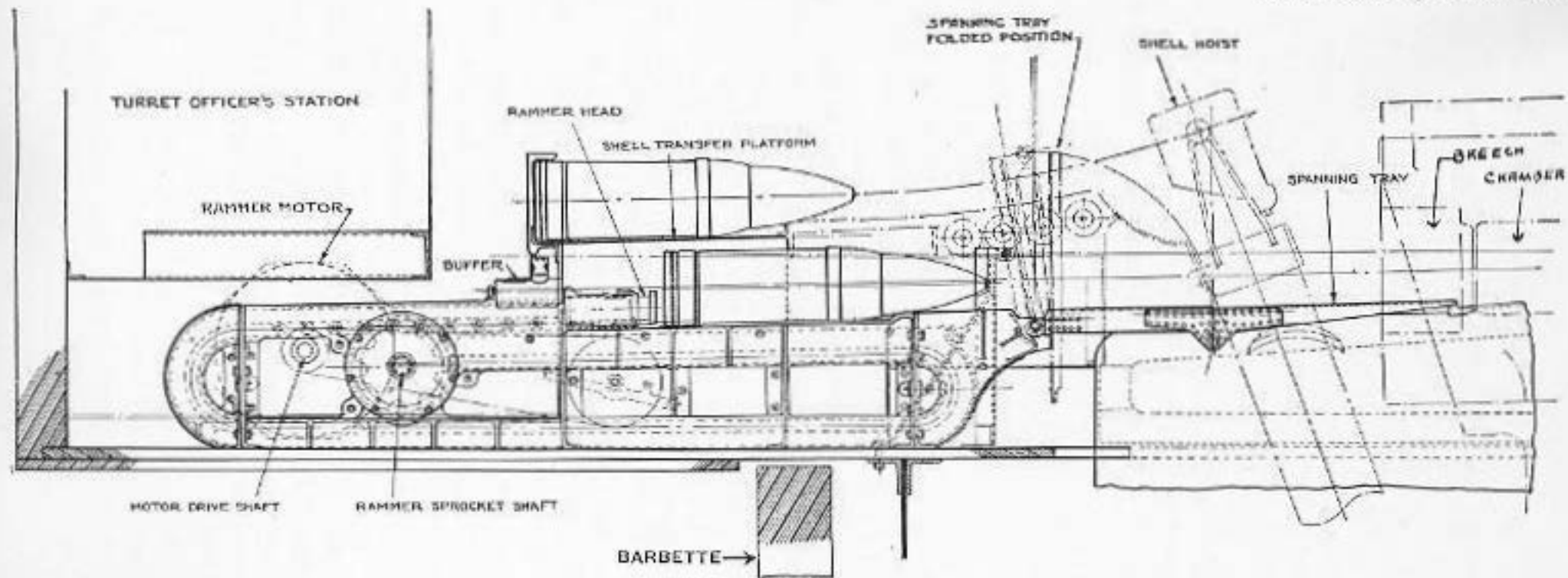
upper powder-handling room and the gun chamber of the turret, so that there can be no direct communication at any time between the gun chamber and the lower powder-handling room.

In case power is not available for hoisting powder, the powder bags may be hoisted from the lower handling room to the upper powder-handling room by means of a whip hoist provided. Upon arrival in the upper powder-handling room the powder bags are passed through hatches in the upper powder-hoist trunk to the breech of the gun by hand. Platforms are provided for the use of the powder-passing crew.

930. Shell hoists (Plates IX and X).—The shell hoist, which is a standard navy type, extends from the shell-handling room, located directly below the upper powder-handling room, to the gun chamber, at a point opposite the breech of each outboard gun. Two hoists are used. Shells are stowed on platforms in the turret foundation space and in the shell-handling room. The shells are stowed on their bases in such a way that one shell can be removed from its fastenings without disturbing the adjacent shells. The shell is parbuckled from its stowed position to the hoist by means of a manila rope running over a winch driven by the shell-hoist motor.

From its position in the lower end of the shell hoist, the shell is raised by a series of short strokes to the gun chamber above. After the hoist has once been filled, a shell arrives at the gun at the termination of each upward stroke. Another shell is then loaded into the lower end of the tube. The hoist is hydraulically operated by means of an A-end of a hydraulic speed gear. The speed gear, which acts as a pump, delivers liquid under pressure to a ram which actuates a rack bar and pawls which raise the column of shells in the hoist through a distance of one shell height on each upward stroke. During the return stroke of the ram the shells are supported by a series of pawls fixed to the shell tube. The motion of the hoist is controlled through the control screw of the hydraulic speed gear. The shells are dumped out of the upper end of the hoist by means of a cradle. From this point the shells are rolled to the guns. It is impossible to strike the shells below by means of this hoist. When power is not available in the turret for running the shell hoist, shells may be hoisted to the turret chamber by means of a chain purchase using an auxiliary tube.

931. Rammer and spanning tray (Plate XIV).—The shell and powder charge are rammed into position in the gun by means of a chain rammer. The guns are loaded at a fixed loading angle. After opening the breech, the spanning tray is carried forward from its folded position, at the forward end of the rammer, so as to extend into the chamber of the gun. The shell is then rammed from its position in the rammer tray



to its position in the gun by means of a chain. After loading the gun the tray is folded back clear of the recoil position of the gun. The rammer head is attached to the end of the chain that comes in contact with the shell, and is provided with hydraulic buffers to relieve the rammer mechanism of shock. The chain is contained in a rammer casing and is driven by a sprocket which in turn is driven by a hydraulic speed gear or some form of clutch. Direction of motion is controlled through the control shaft of the speed gear or by means of a clutch.

Section V.—The Waterbury Hydraulic Speed Gear.

932. The Waterbury hydraulic speed gear (Plates XV and XVI) is a machine for transmitting rotary power at variable speeds and in either direction without steps or abrupt gradations, while the source of power rotates continuously in one direction without any necessary change of speed. This source may be an engine of any kind, an electric motor, a shaft, or any rotating mechanism from which it is desired to transmit power. The medium of transmission is oil. This being practically incompressible, the driving is very positive, except to the extent of the very slight leakage necessary for lubrication.

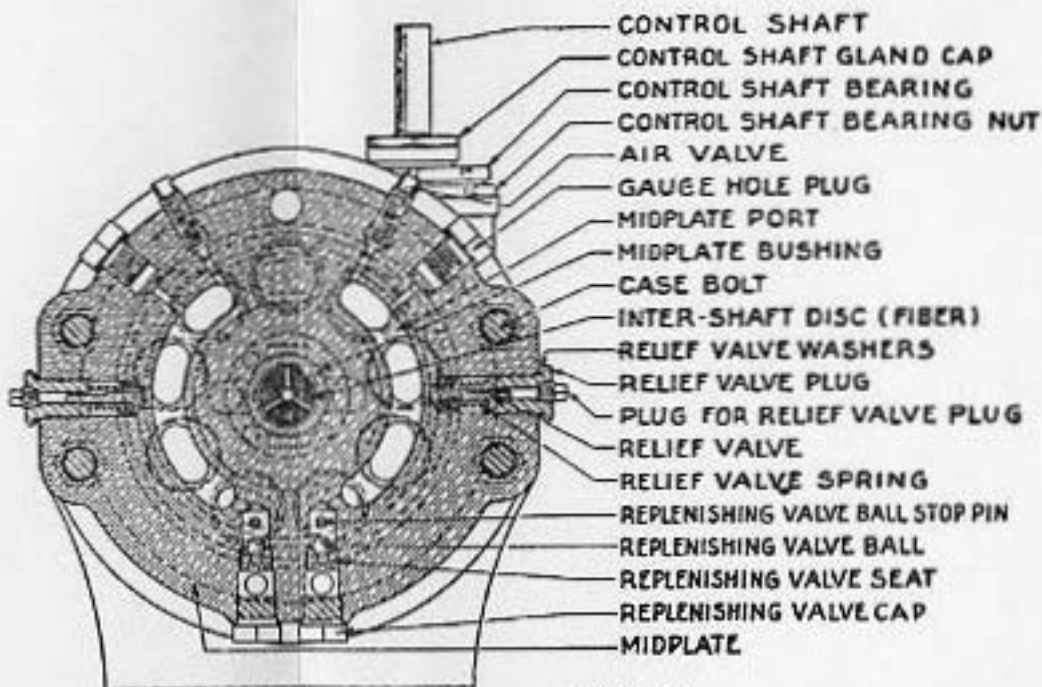
933. **A-end and B-end.**—Functionally the machine consists of two separate mechanisms designated, respectively, the A-end and the B-end.

The A-end is an oil pump operated by the driving power, whatever that may be. Its function is to deliver oil to the B-end at any required rate and pressure and receive it back again, thus keeping up an oil circulation. The A-end contains a controlling device by which the quantity of oil delivered to the B-end is regulated exactly to meet the speed requirements of the B-end. The shaft of the A-end is supposed to rotate in one direction only, at a constant speed.

The B-end is a hydraulic engine. Its rotating parts are almost exactly like those of the A-end. In its capacity as an engine its shaft rotates at any speed and in either direction in exact obedience to the quantity and direction of delivery of the oil it receives from the A-end.

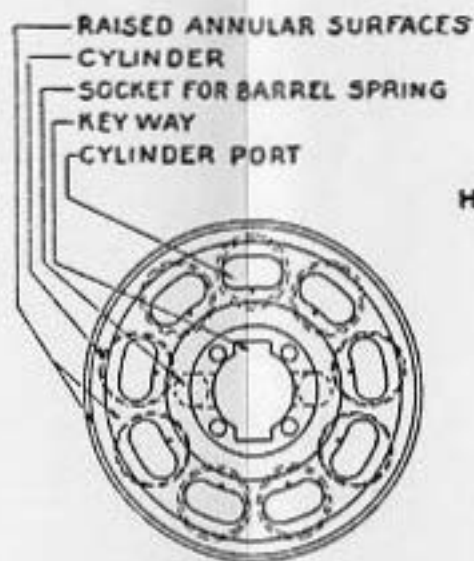
934. **Arrangement of the ends.**—When conditions permit, the two ends are united into one machine, a middle partition, called a *valveplate* or *midplate*, separating the two parts. If the two shafts are to stand in a straight line, the valveplate is a flat disc with parallel faces. If, however, the shafts are to stand in any other position than a straight line, the shape of the valveplate may be varied to meet the requirements.

The conditions of installation may be such as to require the locating of the A- and B-ends some distance apart. Each end will then have its



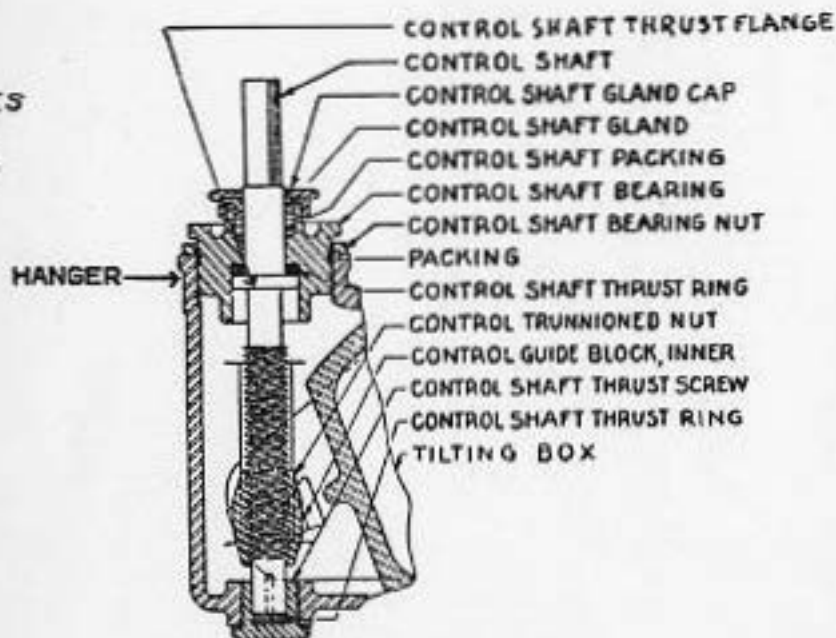
TRANSVERSE SECTION OF MIDPLATE.

FIG. 3



'A' CYLINDER BARREL AS SEEN FROM MIDPLATE.

FIG. 4



SCREW AND NUT TYPE OF CONTROL SHAFT

FIG. 5

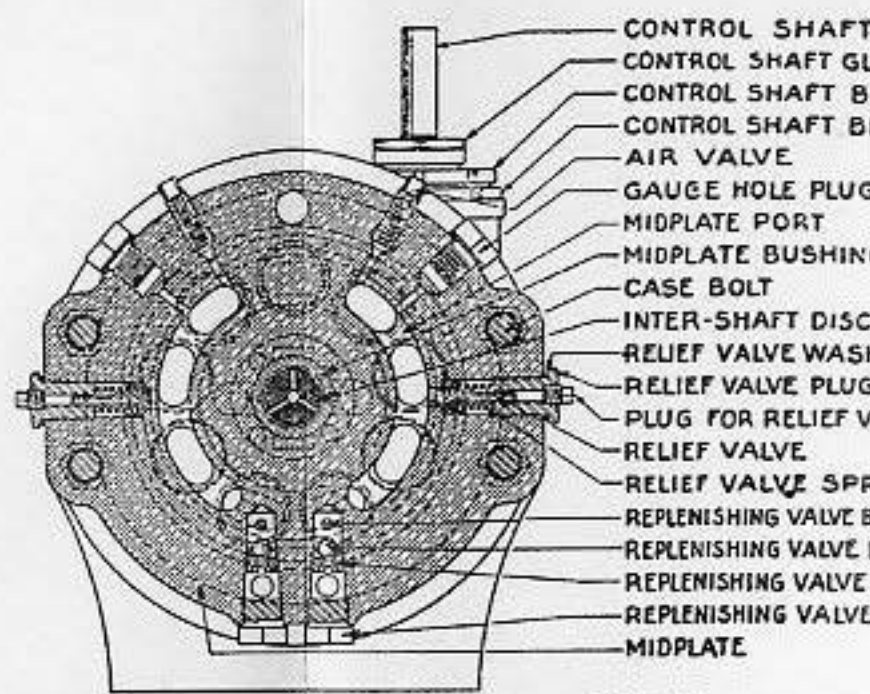
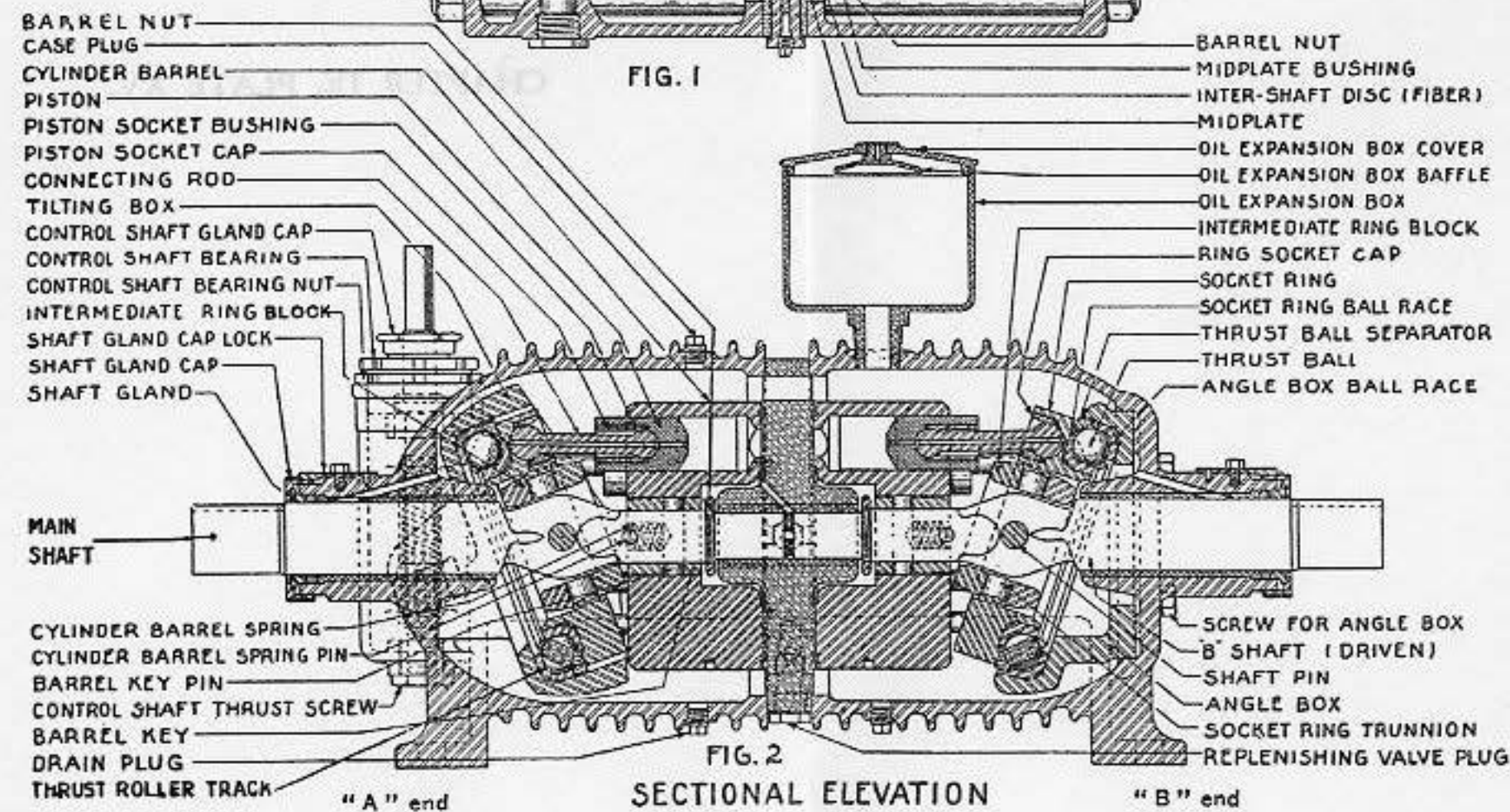
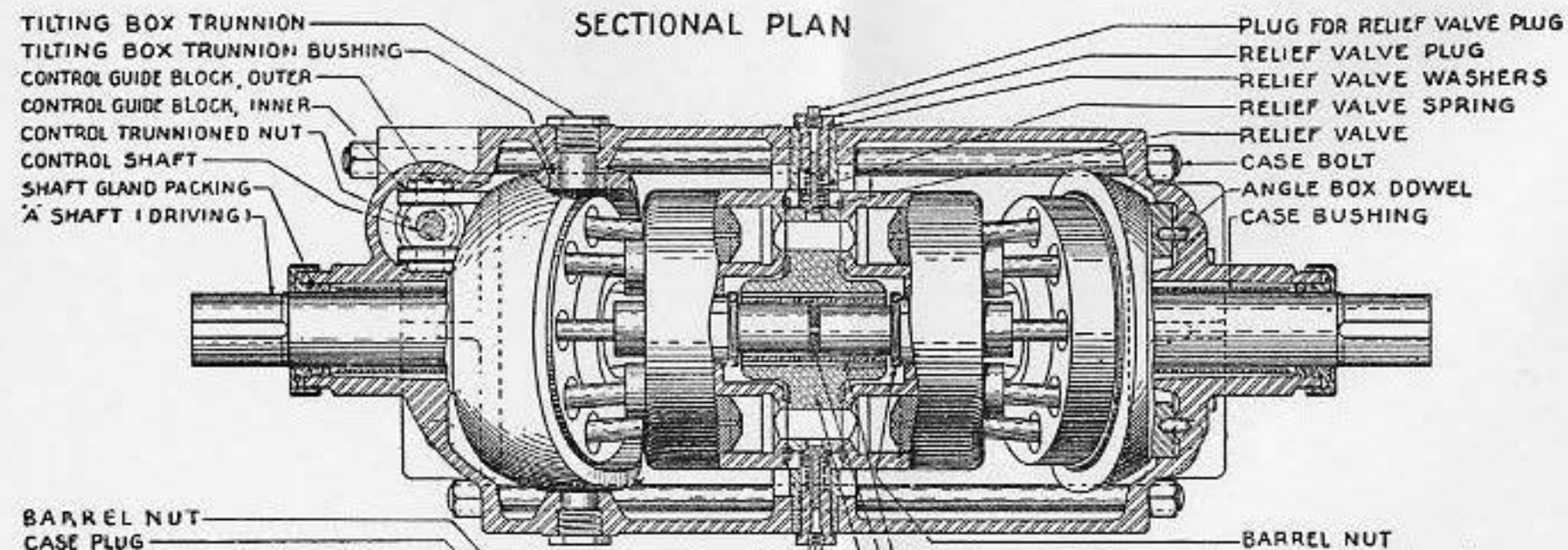


FIG. 3
TRANSVERSE SECTION
OF MIDPLATE.

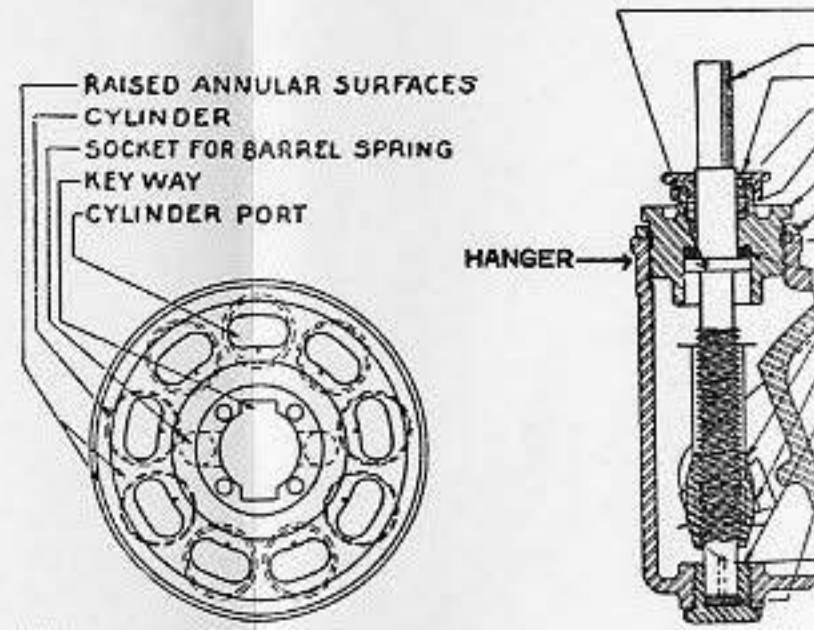


FIG. 4
'A' CYLINDER BARREL
AS SEEN FROM MIDPLATE,
SCREW OF CO

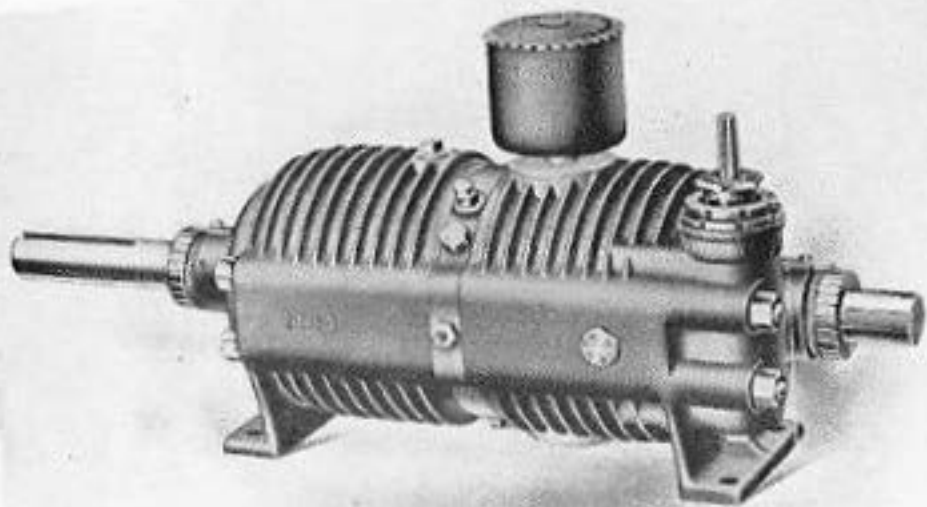


FIG. 1.—Exterior View.

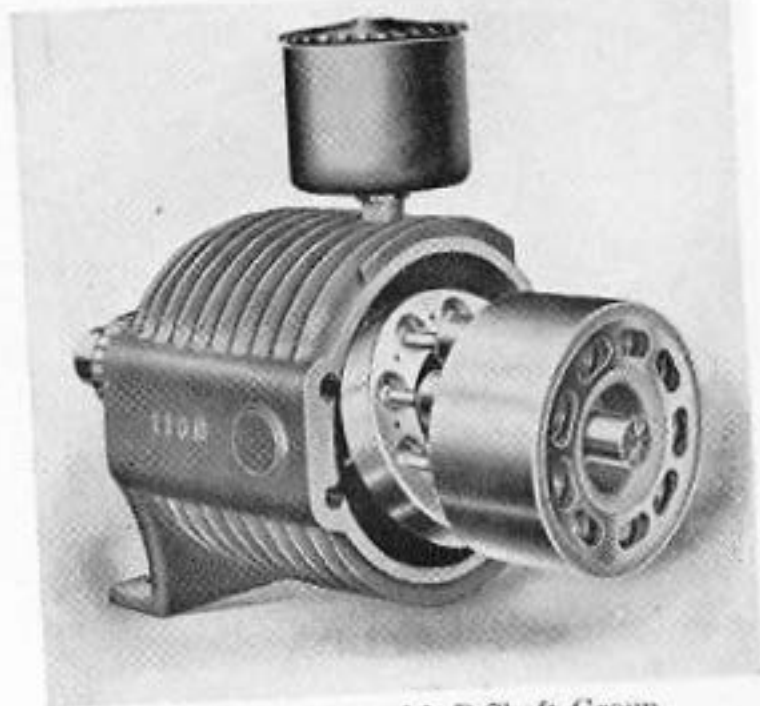


FIG. 3.—B-End, with B-Shaft Group.

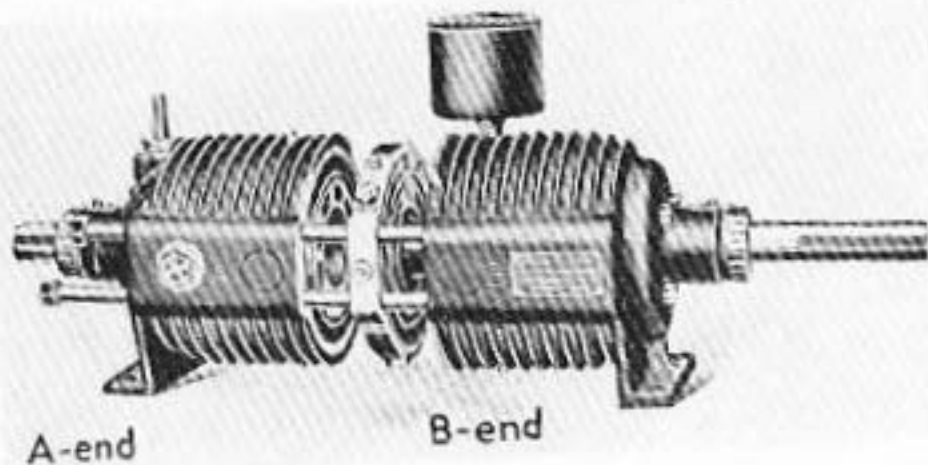


FIG. 2.—The Two Ends Partly Separated.

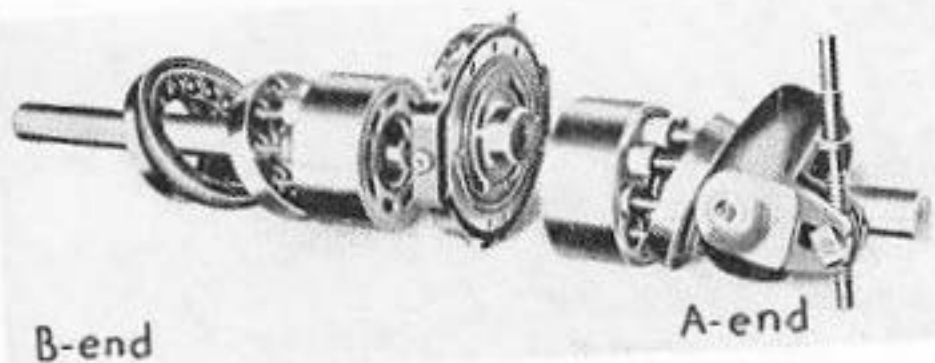


FIG. 4.—Internal Parts.

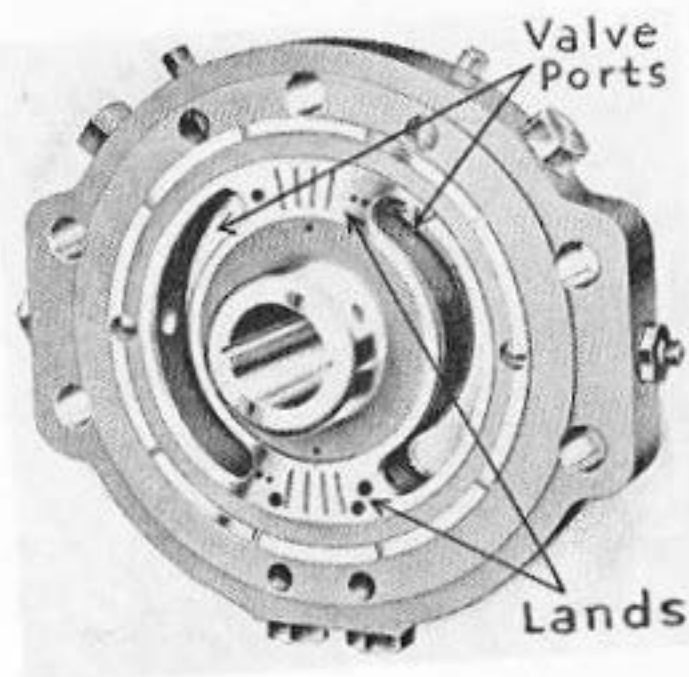


FIG. 5.—Midplate of Valveplate. (Showing the A-Face).

THE UNIVERSAL SPEED GEAR, TYPE C.

own valveplate, which may be appropriately termed an *endplate*. The two endplates will have their two main oil passages connected by two pipes. Since the chief function of the valveplate or endplates is to furnish passages for the circulation of oil between the two ends of the gear, it is evident that the connecting pipes may be so bent as to make possible an unlimited variety of arrangements.

935. Description.—To simplify the description let us consider only the unitized or C-type of machine wherein the shafts are in line with each other.

The fixed parts, which *do not* rotate with the shafts in the transmission of power, are the cases, the valveplate, the tilting box, the angle box, and the control shaft. It is important to remember these non-rotating parts.

All the working parts of the machine are enclosed within cylindrical shells, called *cases*, one for each end of the machine. The open, or large, ends of the cases are securely bolted against the opposite faces of the valveplate by long bolts passing through the cases and the valveplate. The other ends of the cases are closed in to form hubs through which the shafts extend. Legs cast on the cases provide means for securing the machine to its support.

Thus combined the cases form an oil reservoir within which the active parts rotate. The greater portion of the oil is not under pressure, but is in communication with the air through the *oil expansion box* on top of the case. The only active oil, which is directly used in transmitting the power, is enclosed within the *port passages* of the valveplate and within the cylinders ahead of the pistons.

936. Valveplate or midplate is a very important element of the machine. On each of its faces is carefully prepared a contact surface against which the face of a cylinder barrel rotates. Passing through the valveplate are two semi-annular passages, called *valveplate ports*, one in each half of the plate, extending from the A-face to the B-face, through which the oil circulates when transmitting power. Between the ports, both at the top and the bottom, are flat faces called *lands*, into which are cut short reduced extensions from the ports. As the cylinder barrel rotates, the cylinder ports pass in succession across these lands and the contents of each cylinder is for the moment imprisoned within the cylinder while being carried across from one port to the other. At the center of the valveplate are bearings for the inner ends of the shafts. Several valves are also located in the valveplate, which will be described further on under the heading *minor parts*.

937. Tilting box and angle box.—The purpose of the *tilting box* in the A-end is to carry a *thrust roller track* against which the *socket ring* may

rotate in a plane at any desired angle to its shaft. In the earlier designs there were two tilting boxes, one in each end of the machine, but later the B-tilting box was displaced by a wedge-shaped casting, called the *angle box*, carrying its roller track at an angle of about 20 degrees from perpendicular, and screwed securely to the end of the inside of the B-case. This substitute for the tilting box is possible for the B-end, since the angle is not changed after once being set. But in the A-end the tilting box must be retained for the reason that the speed and direction of rotation of the B-end are controlled by *changing the angle of the tilting box*. The tilting box is suspended, and may be oscillated, on two trunnions, which are screwed through from the outside of the case and enter bronze bushed holes in the tilting box. An elongated hole is cut through the bottom of the box so as to give a free passage for the main shaft even when the box is tilted to its maximum angle.

Projecting from the bottom of the box are four fingers or prongs forming guides or slideways for the guide blocks connected with the control shaft.

938. Control shaft.—The purpose of the *control shaft* is to tilt the tilting box on its trunnions either way from the neutral or perpendicular position according to the direction and speed required of the B-shaft. It is a threaded shaft provided with a *thrust flange*, or collar, made integral with the shaft. This flange bears against a fiber thrust ring adjusted against the flange of the control-shaft bearing, which is screwed into the hanger which forms a part of the case. The control-shaft bearing is locked in the hanger by the bearing nut. The lower end of the control shaft bears very freely in a socket in the control-shaft thrust screw, which is screwed into the bottom or lower end of the housing.

The threaded portion of the control shaft carries a trunnioned nut, whose trunnions carry four guide blocks, two on each trunnion. The outer two of these blocks slide in guideways planed in the sides of the housing. The inner blocks slide between the fingers on the bottom of the tilting box.

The turning of the control shaft causes the trunnioned nut to move up or down, carrying with it the fingers of the box. The angular positions of the tilting box are therefore determined by the rotation of the control shaft.

The rotating parts of the A- and B-ends are alike except the location of the sockets in the socket rings and of the cylinders and ports in the cylinder barrels. We may, therefore, confine our attention to one end only. These parts are so assembled upon the shaft as to form what may be called a shaft group, comprising the shaft, the cylinder barrel with the keys that connect it with the shaft, the socket ring with the uni-

versal joint that connects it with the shaft, and the pistons and connecting rods.

939. Shafts.—The A- and B-shafts are alike. Bushings in the hubs of the cases form the main bearings, while the inner ends of the shafts are provided with roller bearings in the valveplate. The ends of the two shafts are separated in the valve plate by a fiber disc called the *inter-shaft disc*. At the intersection of the plane of the socket ring the shaft is formed into a closed yoke around the universal-joint parts described under *universal joint*.

Where the shaft passes through the *barrel* it is flattened on two sides and perforated to receive the *barrel keys* and is threaded to receive the *barrel nut*.

The barrel nut performs no other function than to prevent the barrel from sliding off the shaft when the assembled group of shaft, barrel, and socket ring are being handled. When the gear is fully assembled and in operation the barrel does not touch the nut.

940. Cylinder barrel.—The cylinder barrel contains nine cylinders. It is loosely attached to the shaft by two keys provided with pivots fitting loosely in a hole through the shaft. The loose fit of the barrel on the shaft together with the pivoted keys gives it a slight freedom of motion so that its face can rest squarely against the face of the valveplate. Moreover, it can slide freely endwise along the shaft. This endwise motion is aided by a *barrel spring* backing against a pin in the shaft. The purpose of the spring is to hold the barrel against the valveplate when not in operation. When the oil is under pressure, the barrel is held against the valveplate automatically by reason of the fact that the cylinder ports are smaller than the pistons, giving an excess internal pressure, forcing the barrel towards the valveplate.

The cylinder barrel and keys do not transmit any of the working torque.

941. Pistons.—There are nine pistons in each barrel, the pistons and cylinders being ground and lapped to a smooth working fit without any packing. Narrow shallow annular grooves are cut around the pistons, which serve to interrupt the leakage stream lines and to trap dirt.

Connecting rods.—Each piston is connected to the socket ring by a *connecting rod*. The rods have perfectly spherical ball ends of unequal diameters. The smaller end is secured into a socket formed in the piston, which it fits perfectly, by a bronze split piston-socket bushing which is secured in place by a finely threaded piston-socket cap.

The main purpose for having one ball end smaller than the other is to make it possible to string the ring-socket cap and the piston-socket

cap over the smaller end; the smaller ball is prevented from being drawn back through the piston-socket cap by the split bushing.

The large ball end is secured in a socket in the socket ring by the ring-socket cap.

Through the end of the piston and through the whole length of the connecting rod is a small hole which feeds oil under pressure from the active oil system to lubricate the balls and sockets.

942. Socket ring.—The socket ring has cut into it nine sockets fitted with bronze ring socket caps against which rest the large ball ends of the connecting rods. These sockets are unequally spaced to correct certain irregularities of the universal joint.

The back of the socket ring is provided with a chrome-vanadium roller track which has two roller faces, one for the main conical thrust rolls and the other for the diagonal thrust, or cylindrical, rolls. (Plates XV and XVI and models in the Model Room illustrate the use of spherical rolls instead of cones and cylinders.)

On the inner body of the socket ring are formed the socket ring trunnions at right angles to the main shaft and shaft pin.

943. Universal joint connects the shaft and socket ring in much the same manner as a compass is mounted in its gimbal rings. This joint consists of a shaft-trunnioned intermediate ring block oscillating with the main shaft pin in the yoke of the main shaft, and oscillating about the socket ring trunnions at right angles to the shaft pin.

The entire working torque of the gear is transmitted through the socket ring, the universal joint trunnions, and the main shaft pin.

944. Minor parts. (a) Replenishing valves.—There is necessarily a small amount of leakage of oil from the high pressure active portion into the inactive body of oil enclosed in the cases. Provision must be made to replace this leakage as fast as it occurs, otherwise there would be a vacuum in the cylinders and port passages. For this reason there are two check valves in the lower part of the valveplate called *replenishing valves*. One of these is connected with each port passage and permits the oil to flow freely from the case space into the port passage, but prevents its flowing in the opposite direction.

The valve itself is a steel ball. The seat is a steel piece screwed in from the outside. The hole in the valveplate through which the seat is inserted is closed by a plug called the replenishing-valve cap.

(b) Relief valves.—In the transmitting of power at very low speed in the B-end it is possible that the oil pressure may rise to thousands of pounds per square inch should the resistance to be overcome be correspondingly great. It is therefore necessary to provide safety valves to be set at any desired maximum pressure, say 1,000 or 1,200 pounds

per square inch. Should the pressure exceed this amount the oil will escape from the high pressure port passage through a *relief valve* into the case space and flow back again through a replenishing valve into the low pressure port passage.

The relief-valve group consists of a valve, a spring, a plug, and adjusting washers. The plug forms the backing for the spring, compression of which is adjusted by the use of more or fewer copper washers under the head of the plug.

(c) **Air valves.**—At the highest points in the two port passages are needle valves. The purpose of these is to allow any air that may be imprisoned in the passages to escape into the case space whence it can rise through the oil expansion box. It is only necessary to open these valves one or two turns during the filling process, after which they are to be closed tight; they perform no other function.

Thimble caps are screwed over the ends of these valve screws to prevent oil from leaking out or air from being sucked in.

(d) **Oil expansion box.**—As the proper functioning of the machine requires that the medium of power transmission be practically incompressible, it is important that no air be allowed to mix with the oil. The case must therefore be entirely full of oil. To meet this requirement fully it is necessary to have the oil in the machine connected with an external supply that will always be in communication with the interior and yet not permit the entrance of air. The oil expansion box serves this purpose. In the illustrations the box is represented as connected directly with the top of the case. In practice, however, the box may be located in any convenient place near by and connected with the case by a pipe. The connections should always be such as to allow the easy escape of air from the case.

In the lid of the box will be noticed a baffle. Immediately above this are holes in communication with the outside air. The baffle prevents the splashing of the oil in the box from stopping the air holes, should there be a sudden rush of oil from the case into the box. This is an interesting and important phenomenon. Should the machine become overloaded, the flow of oil through the relief valve is more rapid than the supply through the replenishing valve for the reason that the relief valve is acting under high pressure while the replenishing valve is acting only under atmospheric pressure. A momentary vacuum is produced in the active body of oil, which is the same in effect as if the whole volume of oil had suddenly increased.

(e) **Stuffing boxes and packing.**—Where the shafts pass through the cases there are stuffing boxes. These are of the ordinary type and need no special comment further than to call attention to the kind and shape

of material used in packing. Leather cups of U-section are used, the U-channel being filled with pure asbestos yarn containing no paraffin, tallow, or wax filling. Two of these U-rings are used in each stuffing box. If they alone do not fill the box a sufficient quantity of asbestos yarn may be placed between the leather rings.

In the threaded surface of the control-shaft bearing is a groove which is to be filled with a leather strip called the control bearing thread packing. When the bearing piece is screwed into the hanger and the control-shaft bearing nut is screwed down tight, this leather strip is compressed into the channel between the top of the hanger, the nut, and the bearing so as to prevent any leakage of oil or air.

Where the end of the case fits against the valveplate, only a paper gasket is used. This is cut to fit that part of the face of the valveplate that comes in contact with the case. It is cemented to the valveplate with a solution of shellac in alcohol.

(f) **Plugs.**—The various plugs need only to be mentioned. In the valveplate are two gauge plugs. These close holes connected with each port passage for the attachment of pressure gauges when desired. In the cases are plugs for drainage, escape of air, equalizing pipes, etc.

945. The pressure of the oil in the valveplate passage depends upon the resistance offered to the turning of the B-shaft and not upon the speed. The pressure rises instantly to meet any resistance up to the capacity of the driving motor. If the A-socket ring stands almost perpendicular to the shaft, only a very small quantity of oil is transferred per rotation, which has the effect of giving a very great leverage, and even a small motor may produce a pressure of several hundred pounds, and, of course, a corresponding torque or turning effort on the B-shaft. The actually permissible pressure in any particular machine depends upon the strength of the parts, but is limited by the setting of the relief valves.

946. Operation of the gear.—In order that the functioning of the various parts of the machine may be understood, let us assume that the gear is assembled and filled with oil ready for running.

The entire space within the cases and valveplate not actually occupied by metal is filled with oil. No air pockets exist, and in order that no air may enter the case, the oil is made to fill the expansion box about half full. A definite portion of the oil is enclosed within the cylinders ahead of the pistons and within the port passages of the valveplate. This is the really active portion of the oil, and if there were no leakage this is all the oil that would be used in transmitting energy. The inactive oil which fills the space within the cases is never under pressure. It is simply a supply for lubrication, into which leakage from the active

oil may flow and from which this leakage is replenished through the replenishing valves, the total quantity remaining constant.

With our attention directed to the A-end of the sectional views, let us first assume that the A-tilting box with its socket ring is set at the neutral position, that is, perpendicular to the shaft. Under these conditions the shaft in rotating will carry around with it the socket ring and the cylinder barrel together with the pistons and connecting rods, but the pistons will have no tendency to reciprocate in the cylinders. There will, therefore, be no drawing of the oil in nor forcing it out through the valveplate. The only work done will be the stirring of the oil in the case by the revolving parts and the light friction of the shaft bearings and the sliding of the face of the cylinder barrel against the face of the valveplate. The B-end will not be disturbed.

If the control shaft be turned a little so as to move the top of the tilting box away from the valveplate and if the A-shaft be rotating over towards the observer, then the shaft will rotate the socket ring, which is attached to it by the universal joint, and will also rotate the cylinder barrel, which is keyed to it. The pistons and piston rods will rotate with these two parts, since they are contained in them. The tilting box remains stationary and the socket ring rotates within it, but is constrained by the roller bearings to maintain constantly the angle at which the tilting box may be tilted. All the pistons, as they move up on the far side of the machine, will draw in oil through the port in the far side of the valveplate; all the pistons as they move down on the near side will slide in towards the valveplate and force the oil through the port in the near side of the valveplate. The near port will thus be under pressure while the far port is in suction.

It should be noticed that when a piston reaches the top or higher position, in its revolution, it for an instant makes no end movement and the oil in that particular cylinder is carried across the land, or space between the two valveplate ports, from the suction side to the pressure side. The same condition exists when a cylinder is passing its lowest position, except that the piston is then at the inner end of its stroke and is passing from the pressure side to the suction side.

The quantity of oil forced through the valveplate port depends upon the angle at which the tilting box stands and consequently the length of the piston stroke.

We have spoken of forcing the oil through the valveplate port, but this cannot take place unless there is some means acting to receive the oil and carry it across to the port that is under suction. This is the function of the B-end. The B-socket ring always stands at an angle of about 70° to the B-shaft, and when the B-shaft rotates the B-pistons

will make their full stroke as they pass between the bottom and the top positions. Now, when the A-cylinders are moving down on the near side, as described above, oil is forced through the valveplate port of this side into the B-cylinders of the near side. But they cannot receive the oil unless their pistons move back to give space. *This movement of the pistons communicated to the inclined socket ring through the connecting rods causes the socket ring to rotate on its roller thrust bearing, and to carry the shaft around with it. The shaft in turn rotates the cylinder barrel keyed to it, and the whole group rotates in the opposite direction to the rotation of the A-shaft. (See Fig. 904.)*

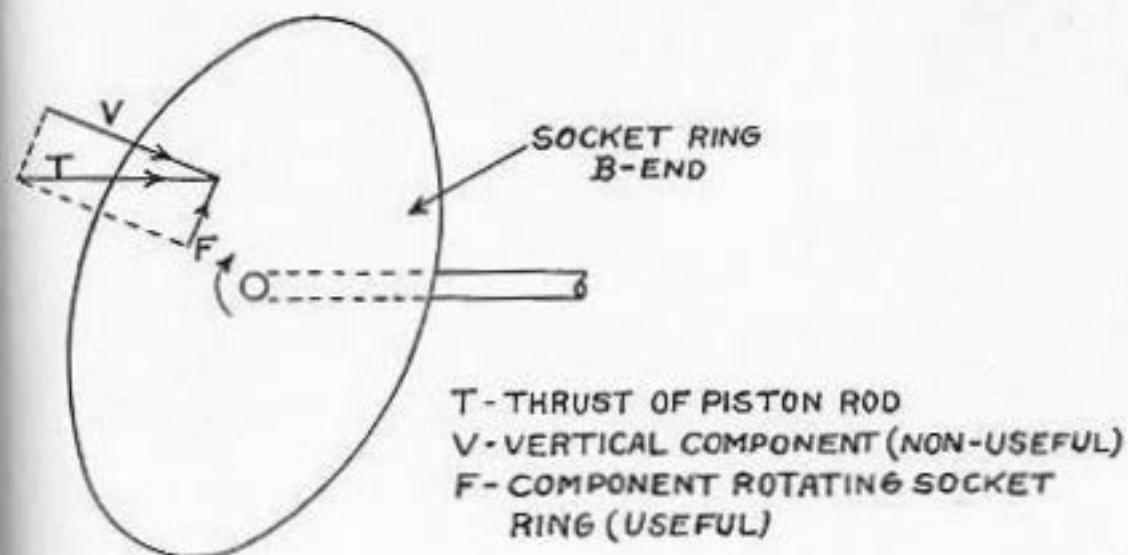
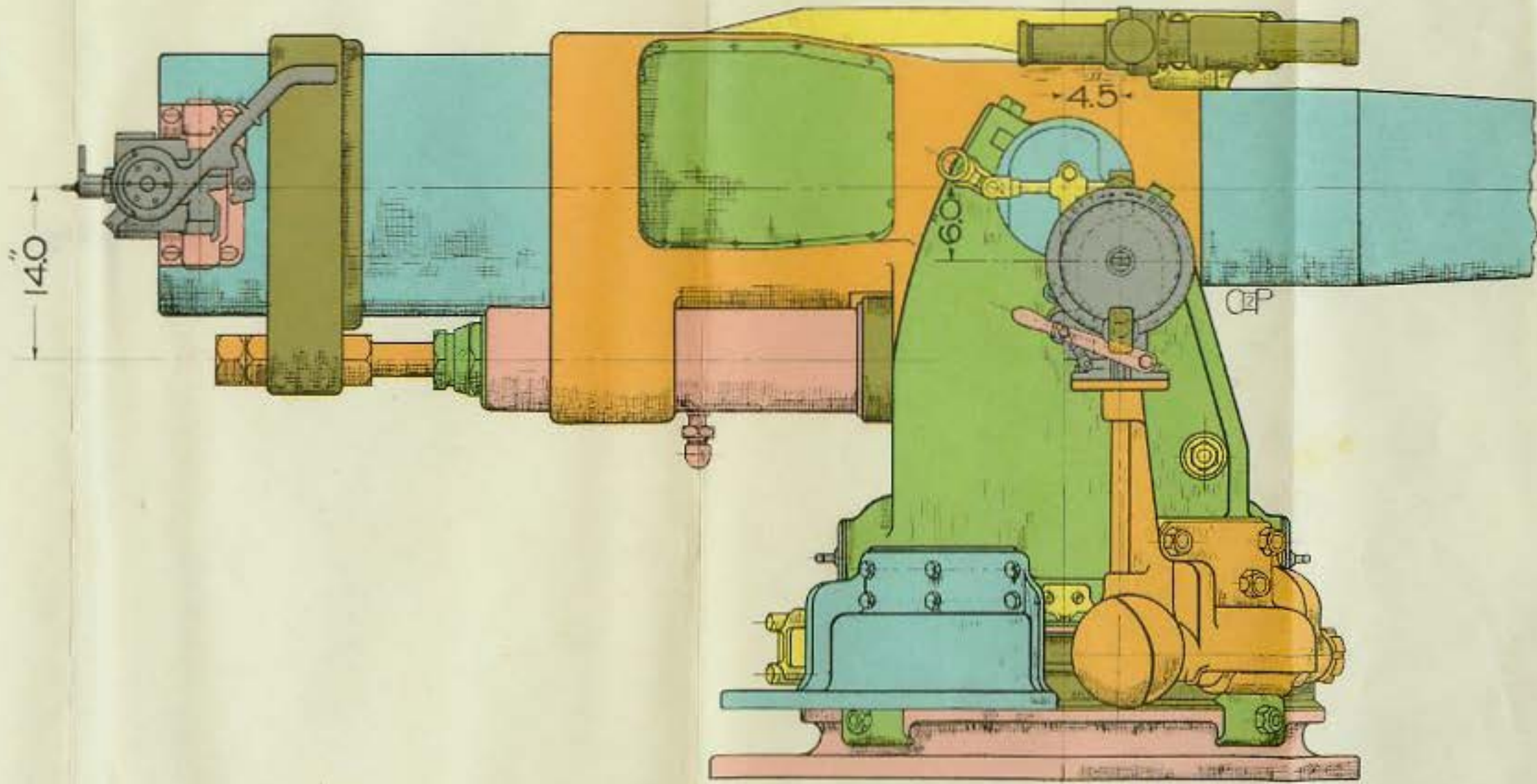
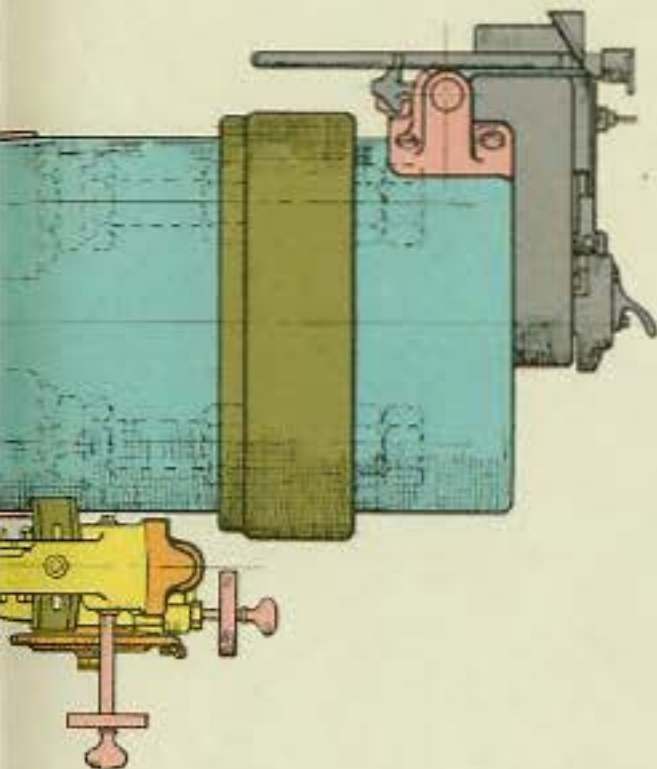


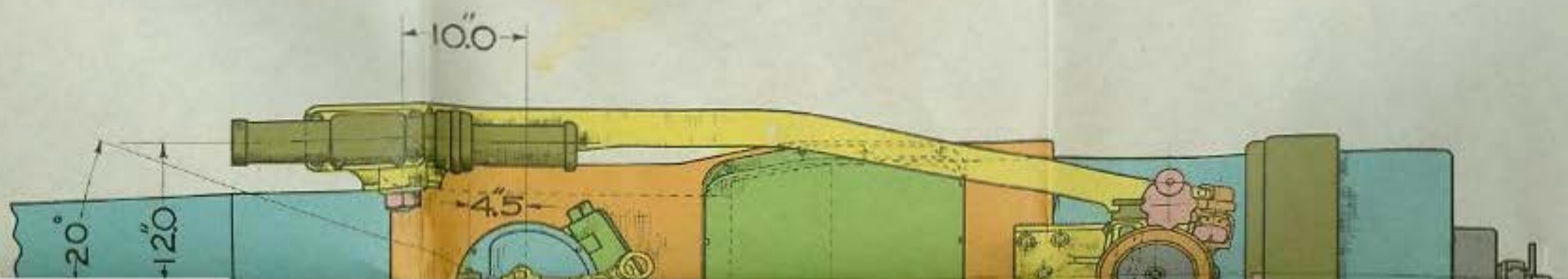
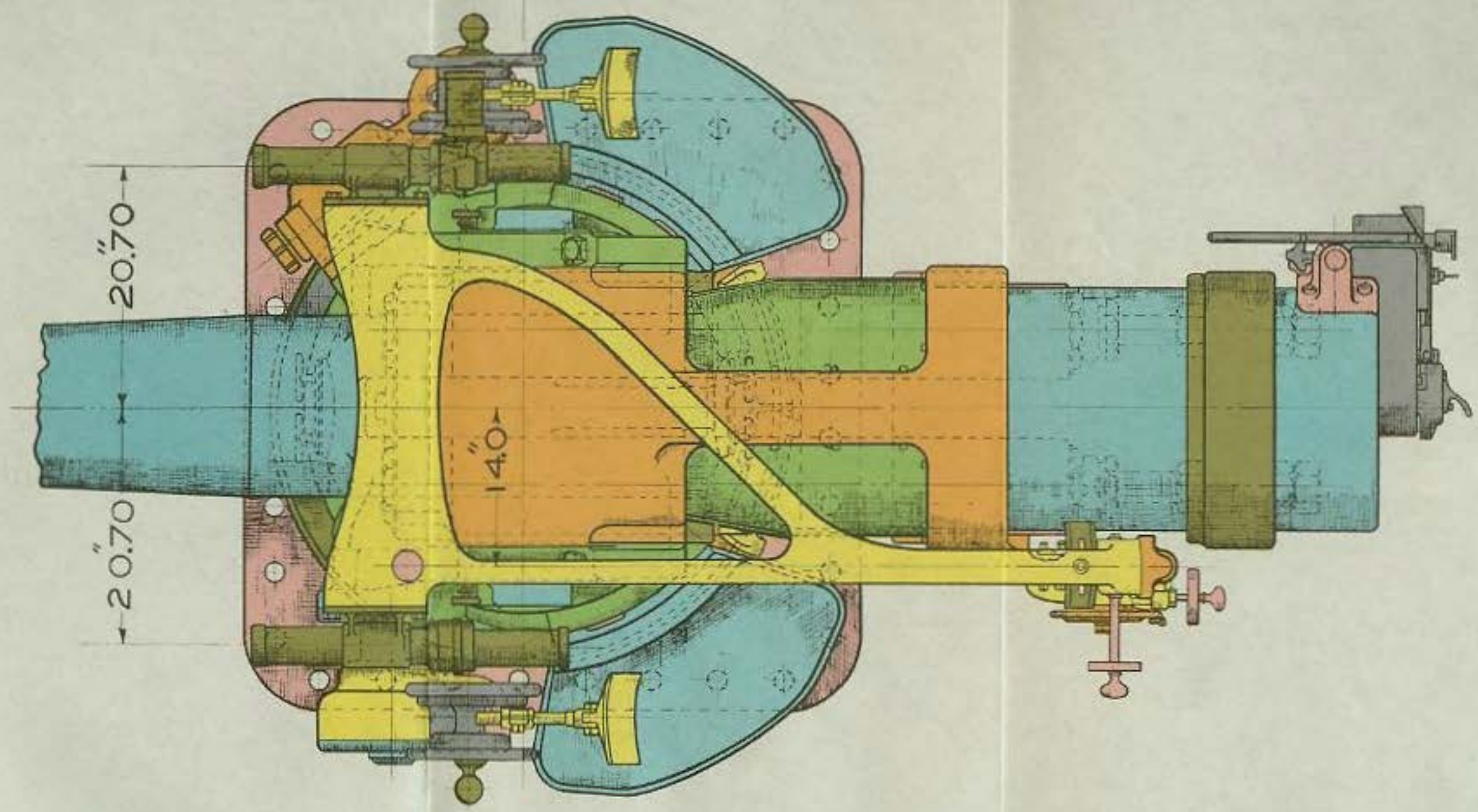
FIG. 904.

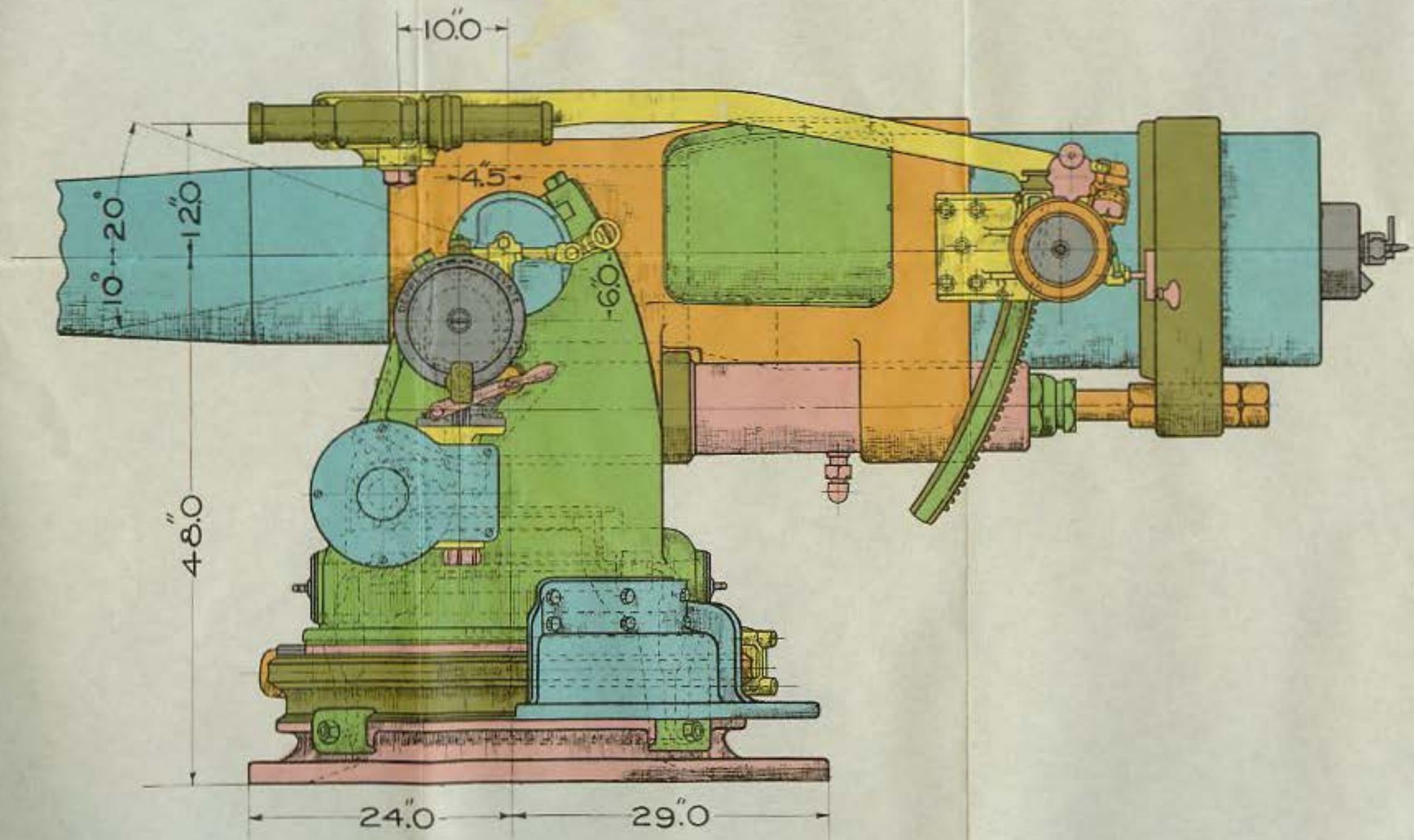
The speed of rotation of the B-shaft depends upon the quantity of oil it must take care of. The B-socket ring being always set at its maximum angle gives the pistons their full stroke. If each cylinder has a capacity of say 3 cubic inches, the revolving of all nine of the B-cylinders would transfer 27 cubic inches of oil from the near side to the far side. If now the control shaft of the A-end be turned so as to tilt the A-socket ring only a little, say enough to reciprocate each piston to the extent of displacing 1-100 of a cubic inch, all nine of the A-cylinders will together transfer 9-100 cubic inches of oil from the far side to the near side at each rotation of the shaft. Since the capacity of the B-cylinders per rotation of the B-shaft is 27 cubic inches, 300 rotations of the A-shaft will be necessary to rotate the B-shaft once. If the A-socket ring be tilted still farther, the B-shaft must rotate proportionately faster. The speed of the B-shaft is thus dependent upon the angle through which the tilting box has been turned.

We have thus far spoken of the A-socket ring as tilted in one direc-

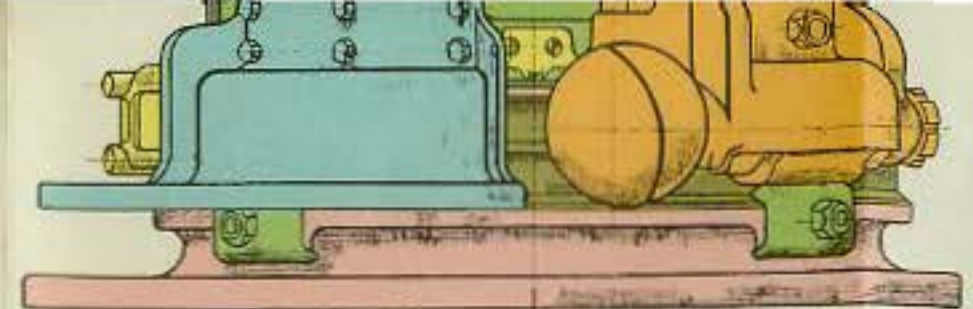
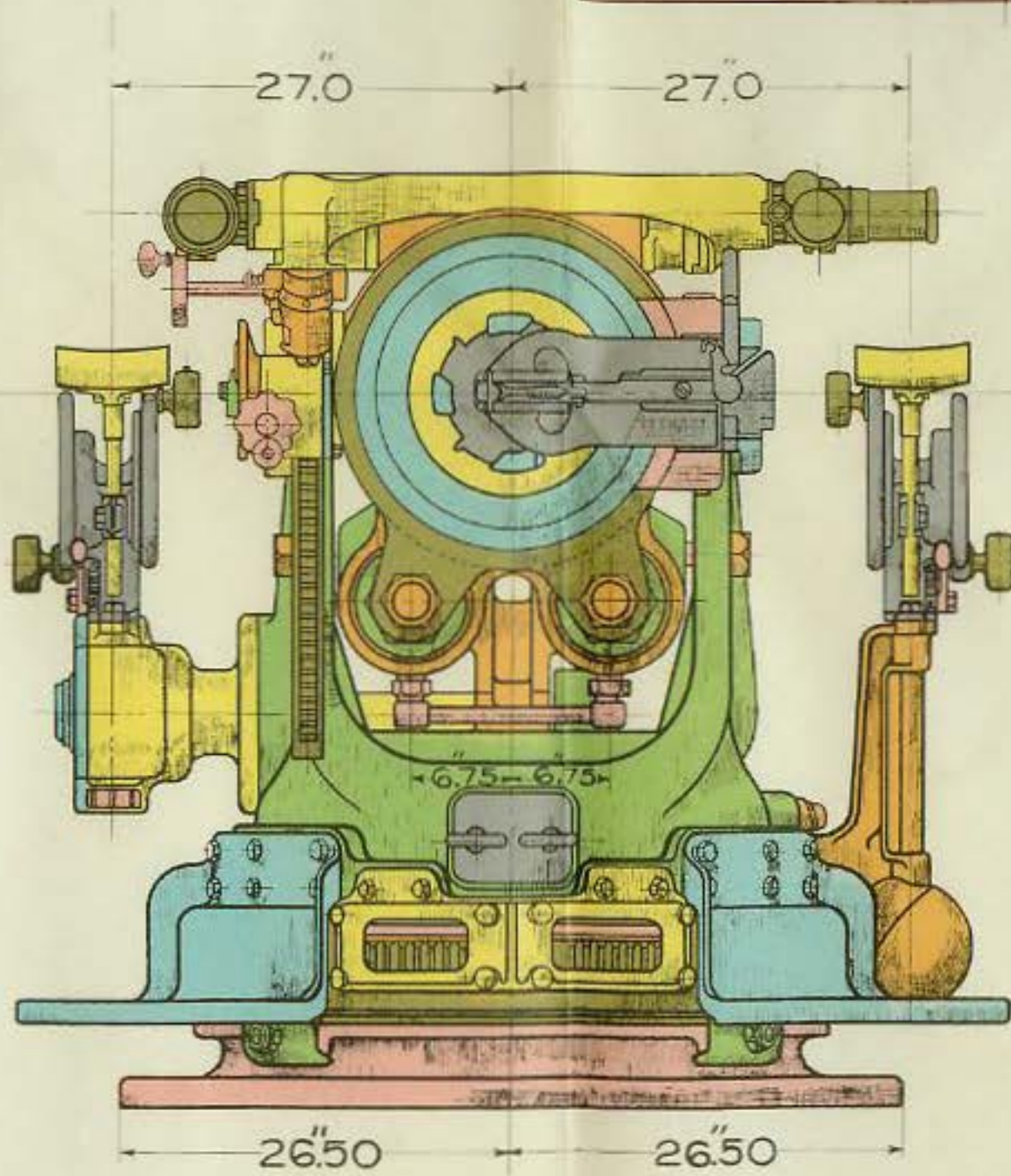
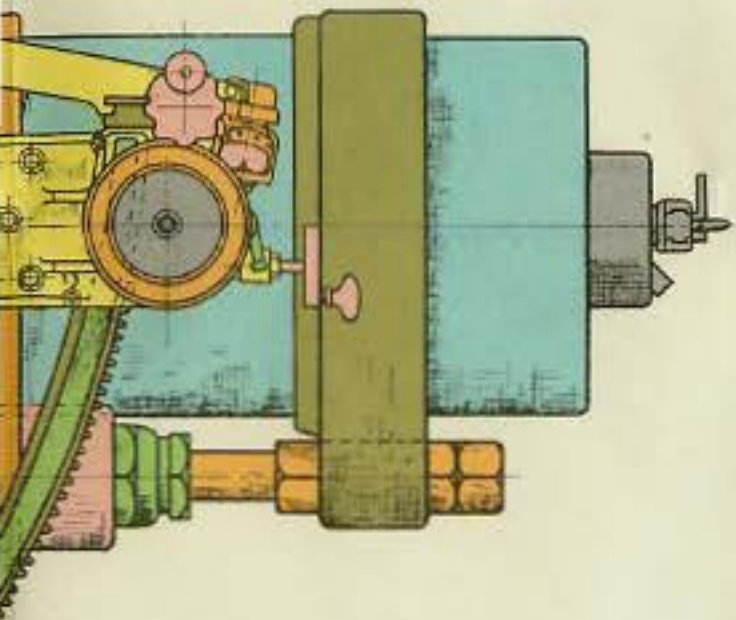
tion only. If it be tilted in the opposite direction, that is, with the top towards the valveplate, and the A-shaft still rotates in the same direction as before, the oil will be sucked in from the near port of the valveplate and carried across the lower land to the far side. This will, of course, cause the B-shaft to rotate opposite to its former direction, that is, in the same direction as the A-shaft.



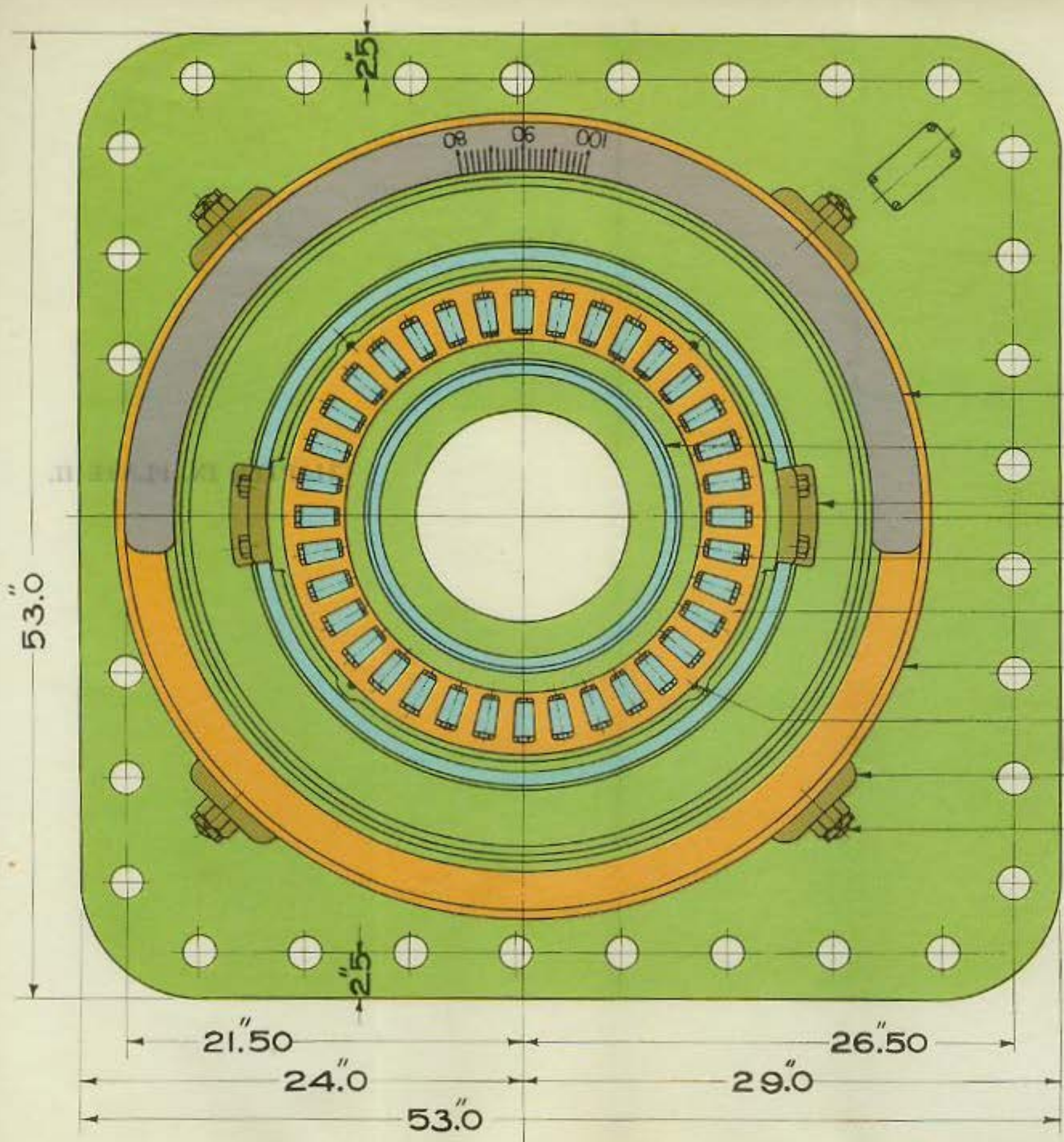




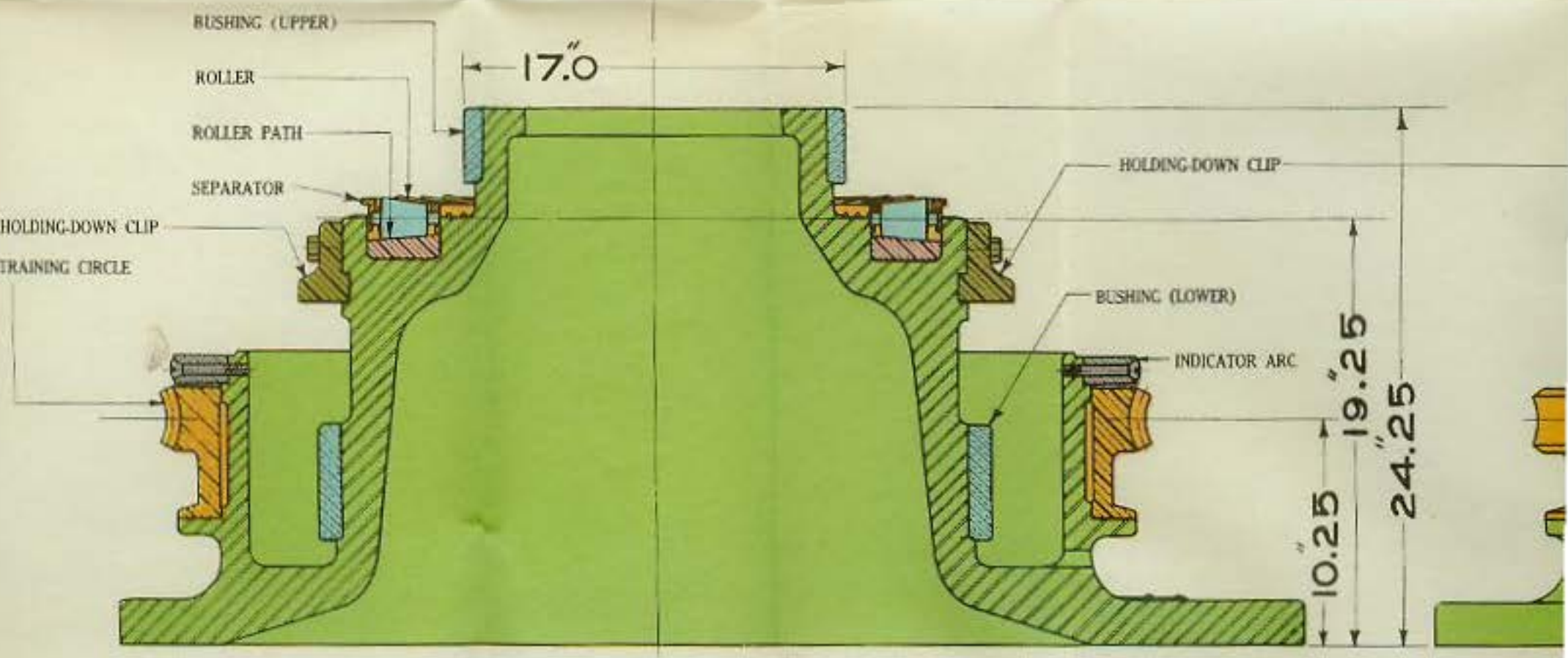
General Arrangement of the 5-inch Mount, Mark XIII, Modification 3



General Arrangement of the 5-inch Mount, Mark XIII, Modification 3

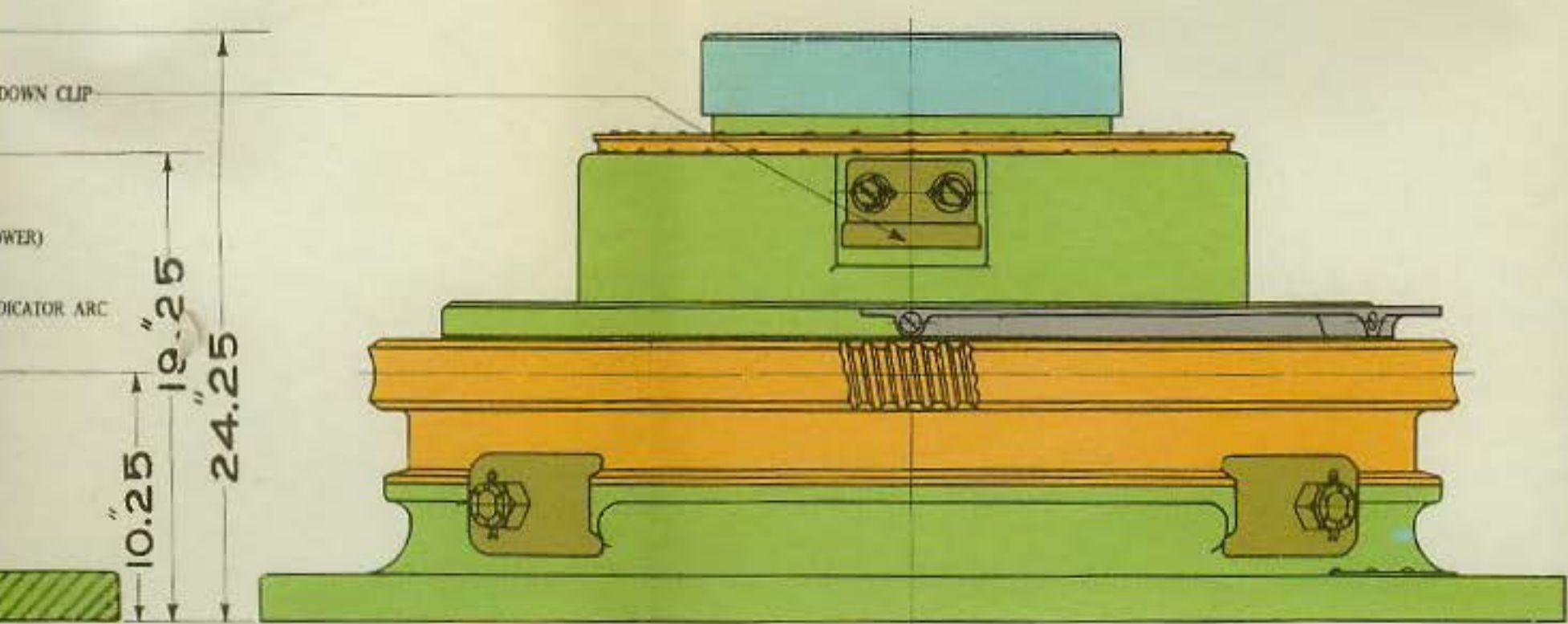
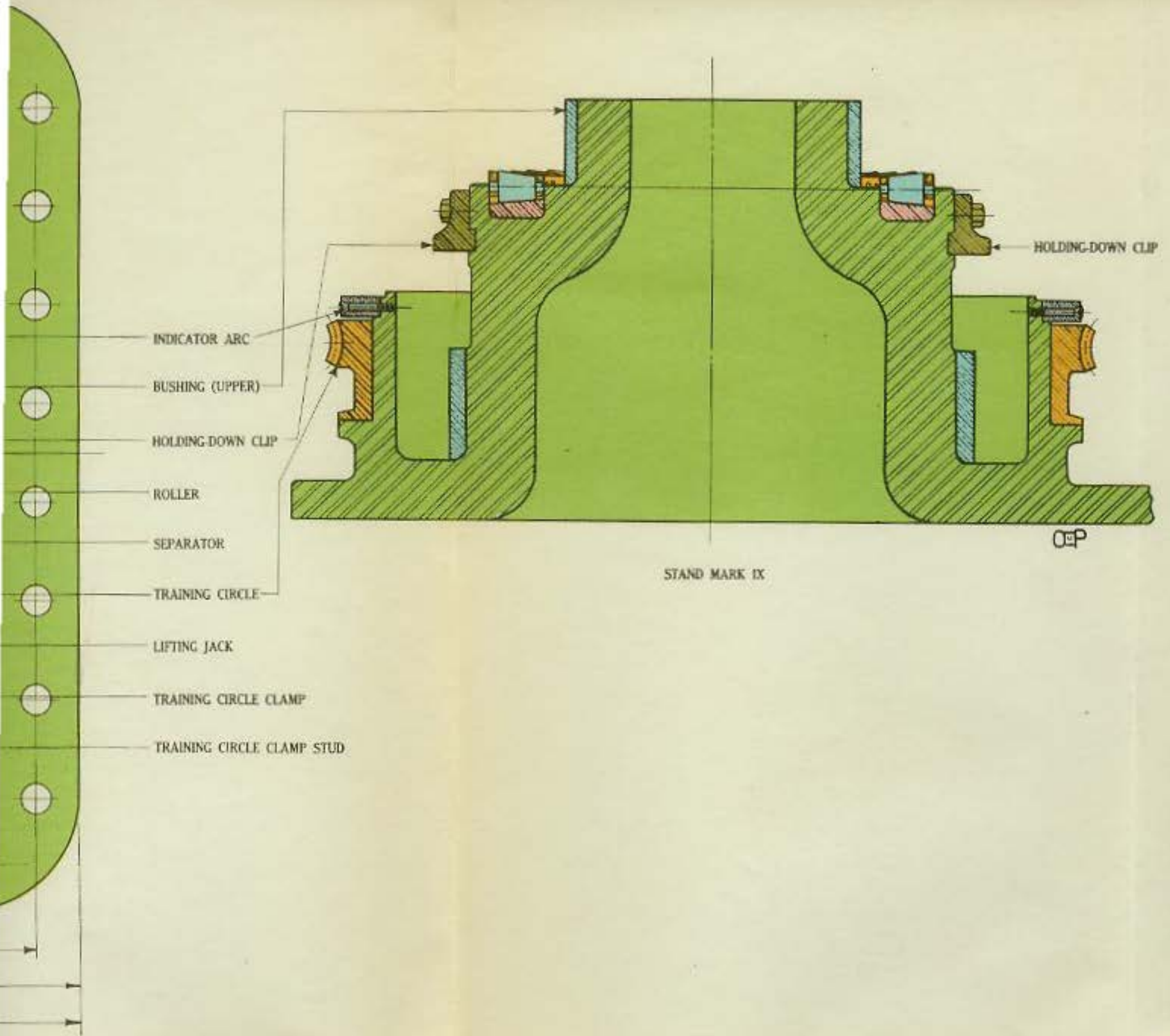


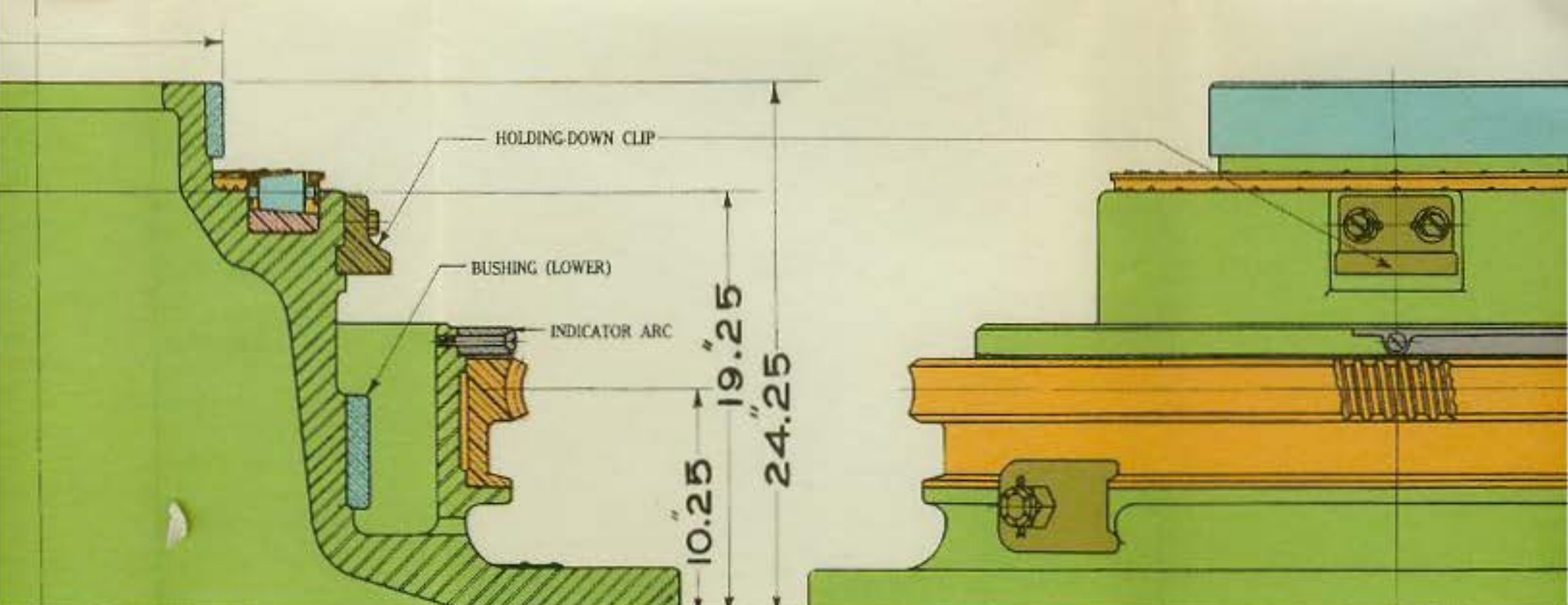
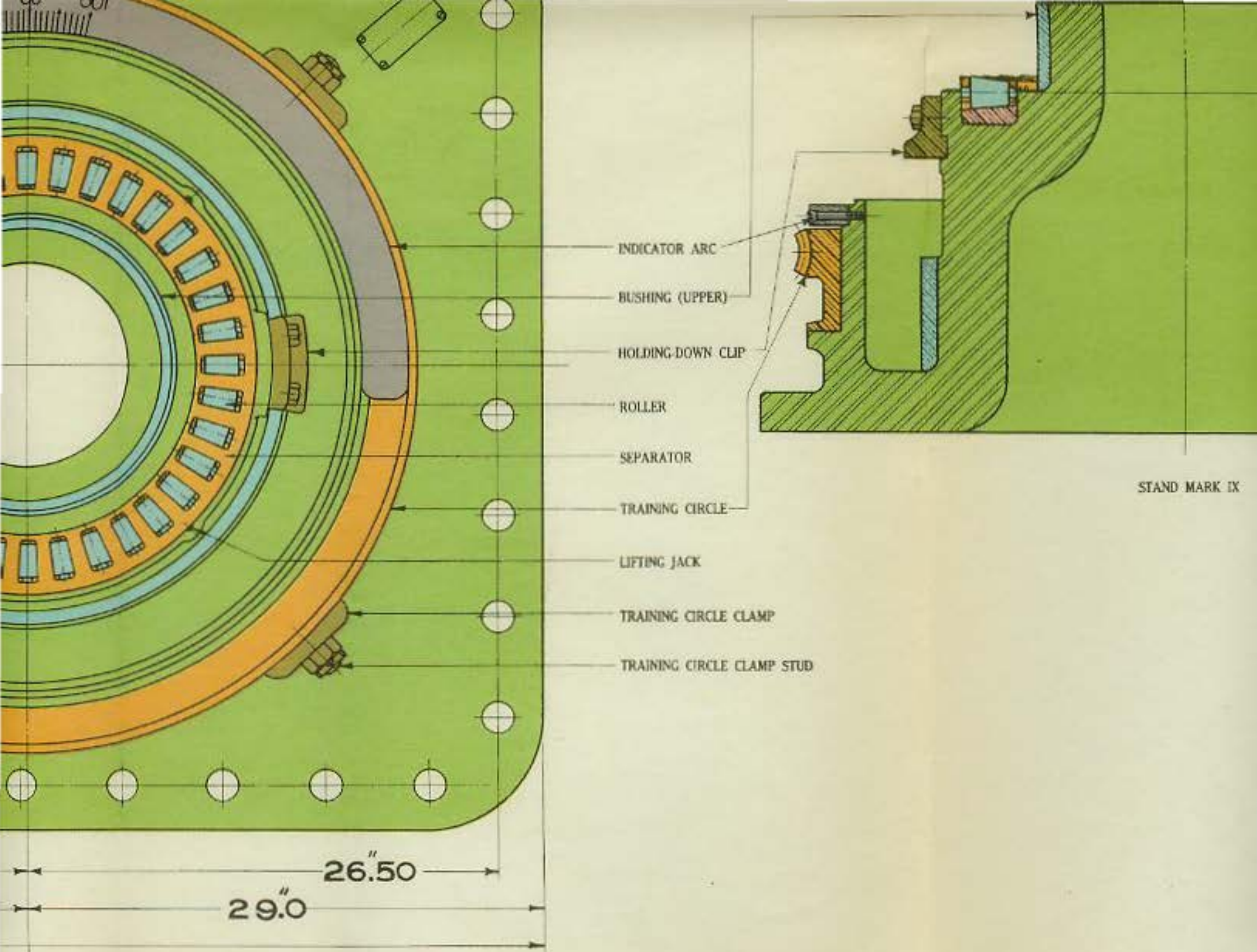
- INDICATOR ARC
- BUSHING (UPPER)
- HOLDING-DOWN CLIP
- ROLLER
- SEPARATOR
- TRAINING CIRCLE
- LIFTING JACK
- TRAINING CIRCLE CLAMP
- TRAINING CIRCLE CLAMP



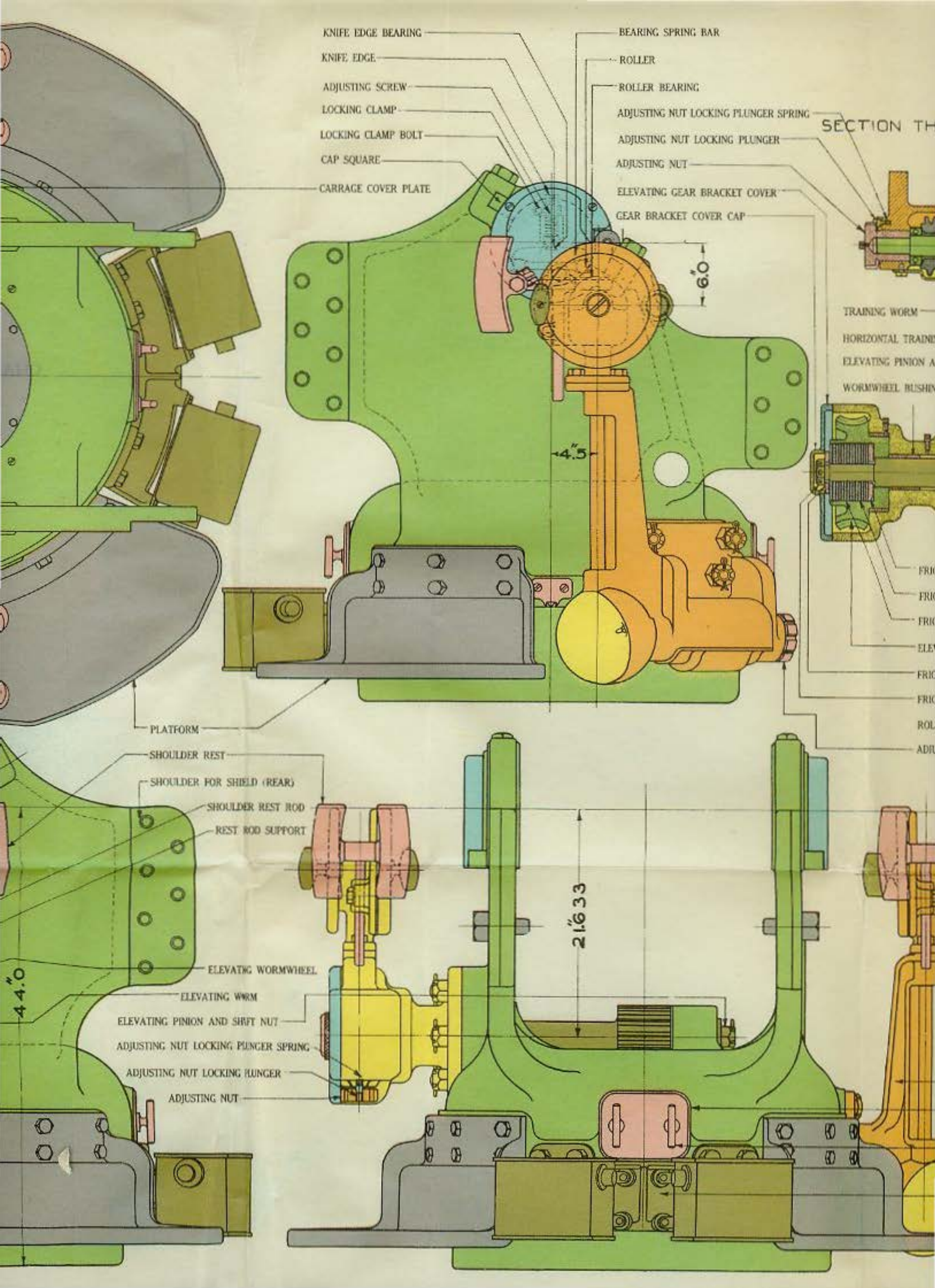
- BUSHING (UPPER)
- ROLLER
- ROLLER PATH
- SEPARATOR

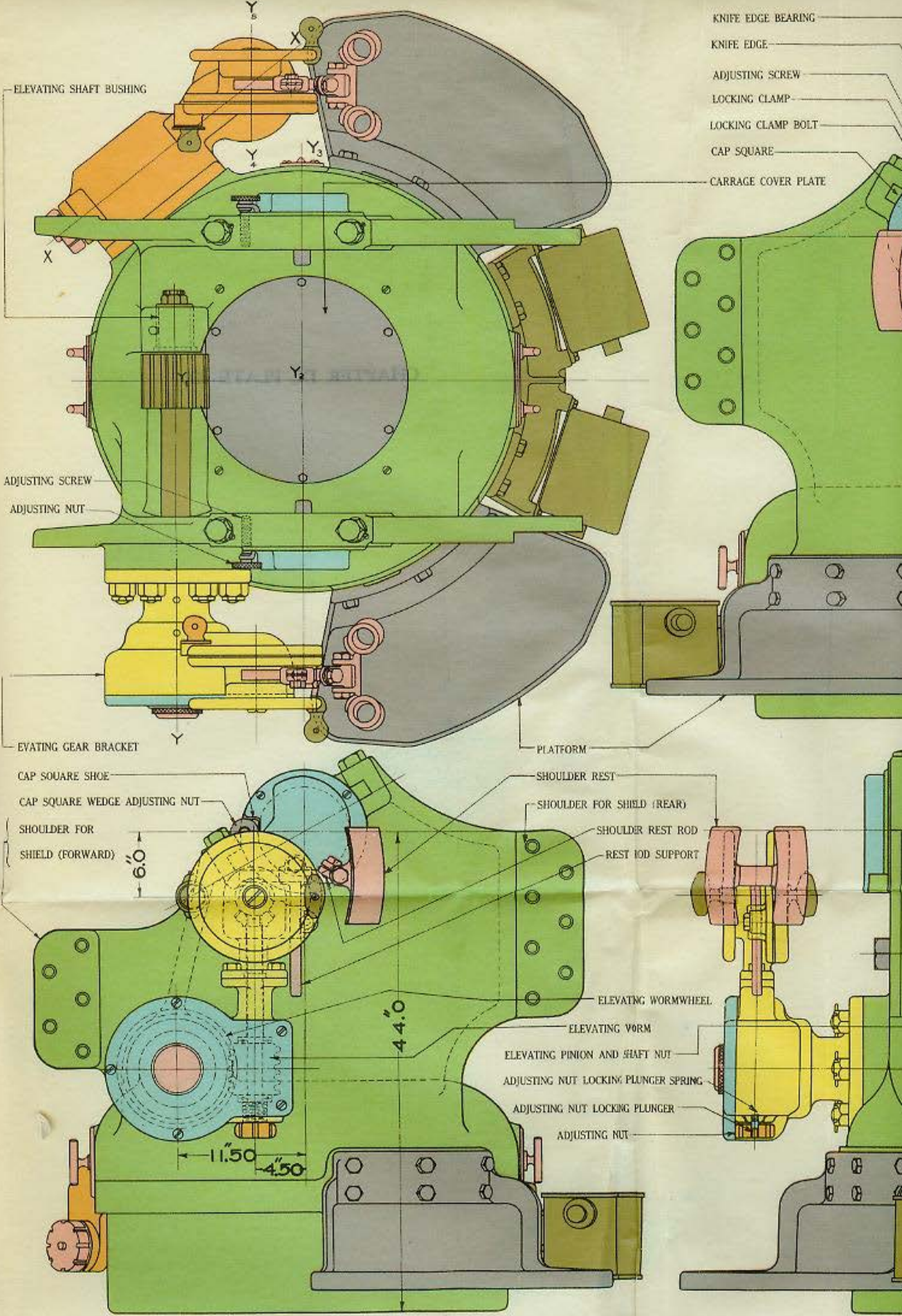
- HOLDING-DOWN CLIP
- BUSHING (LOWER)
- INDICATOR ARC





General Arrangement of the 5-inch Stand, Mark XI





ELEVATING SHAFT BUSHING

KNIFE EDGE BEARING

KNIFE EDGE

ADJUSTING SCREW

LOCKING CLAMP

LOCKING CLAMP BOLT

CAP SQUARE

CARRAGE COVER PLATE

ADJUSTING SCREW

ADJUSTING NUT

ELEVATING GEAR BRACKET

PLATFORM

CAP SQUARE SHOE

CAP SQUARE WEDGE ADJUSTING NUT

SHOULDER FOR SHIELD (FORWARD)

SHOULDER REST

SHOULDER FOR SHIELD (REAR)

SHOULDER REST ROD

REST ROD SUPPORT

6.0

4.4

ELEVATING WORMWHEEL

ELEVATING WORM

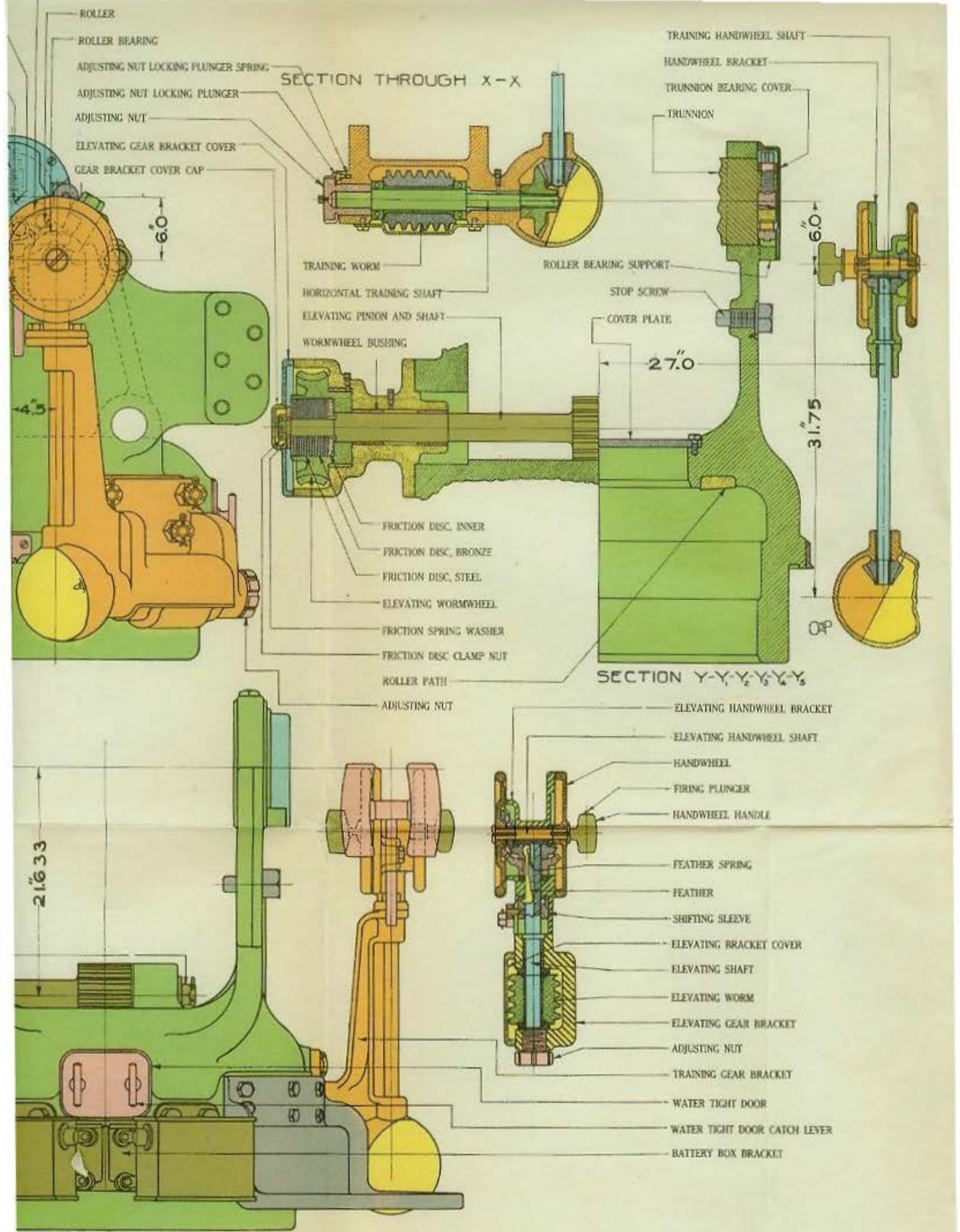
ELEVATING PINION AND SHAFT NUT

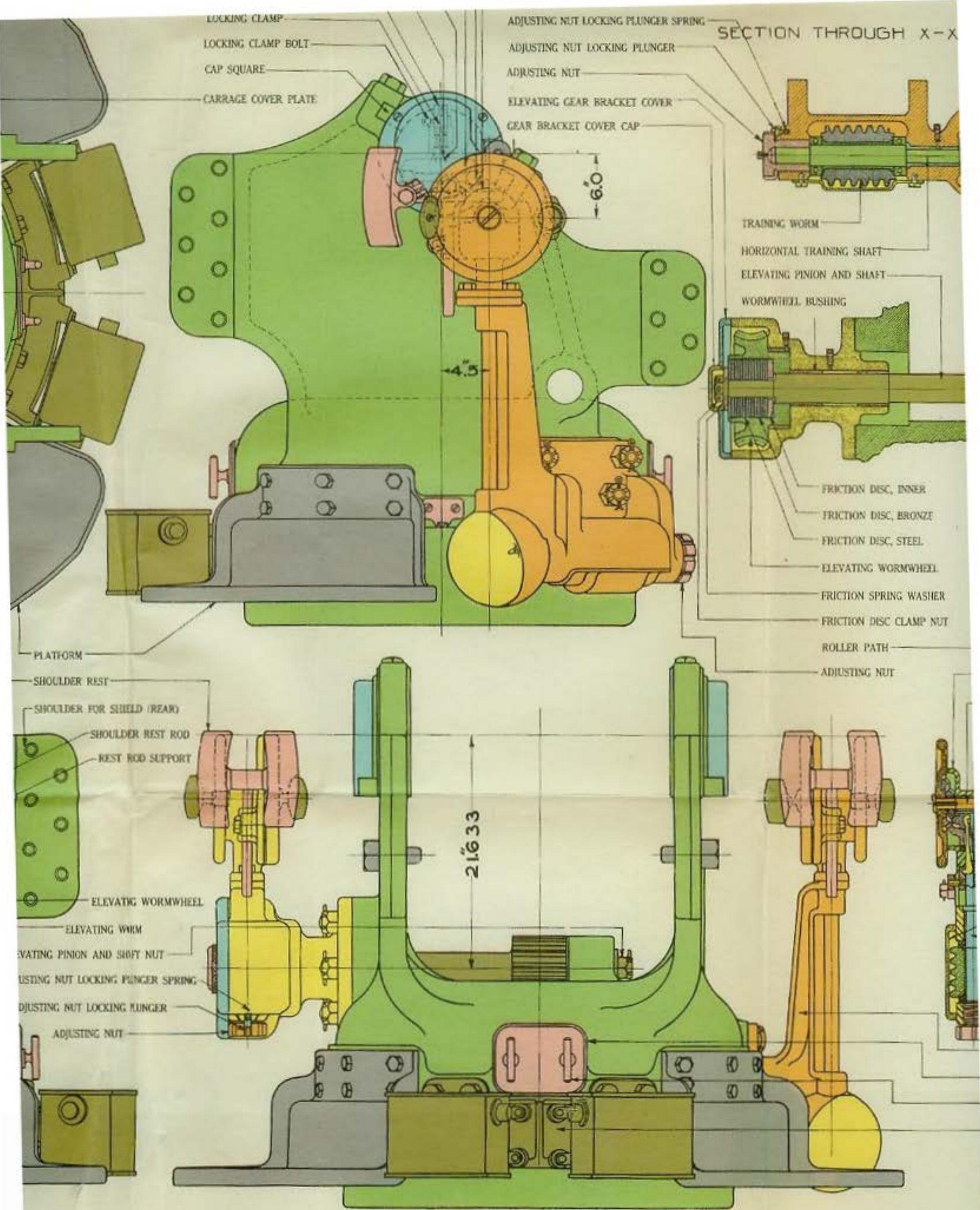
ADJUSTING NUT LOCKING PLUNGER SPRING

ADJUSTING NUT LOCKING PLUNGER

ADJUSTING NUT

11.50
4.50

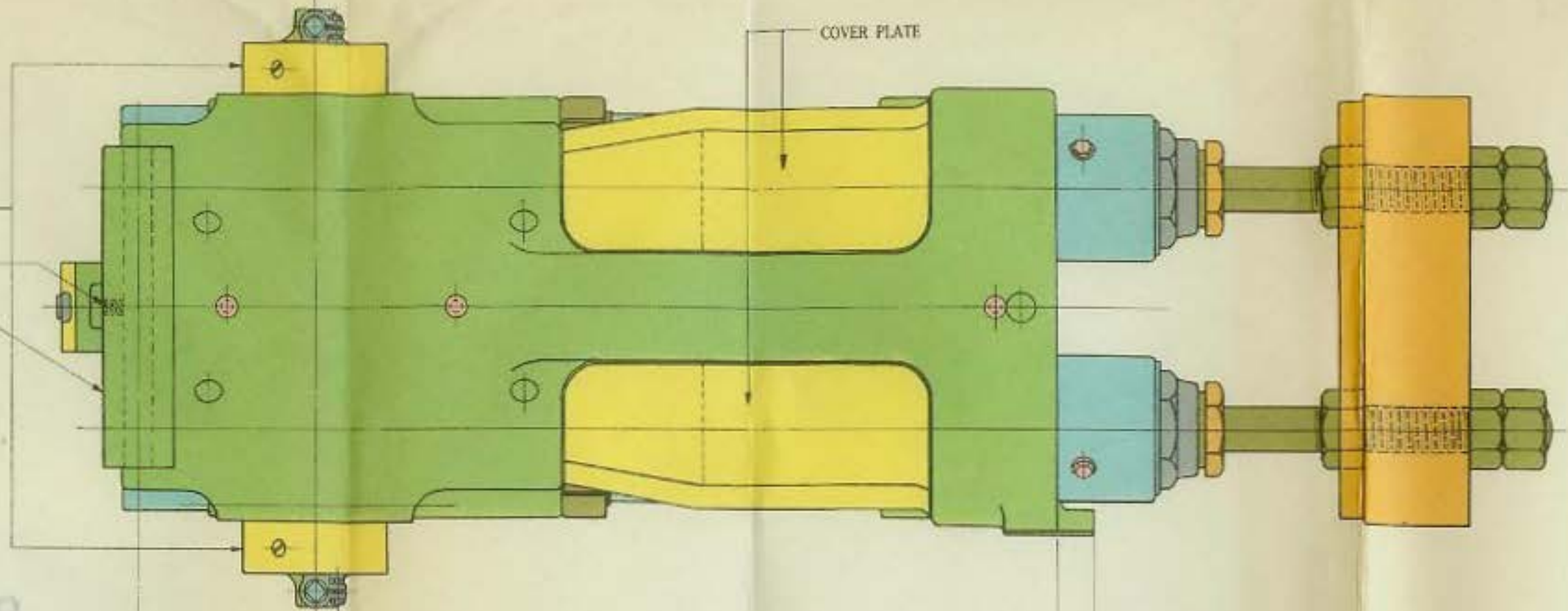




General Arrangement of the 5-inch Carriage, Mark XIII

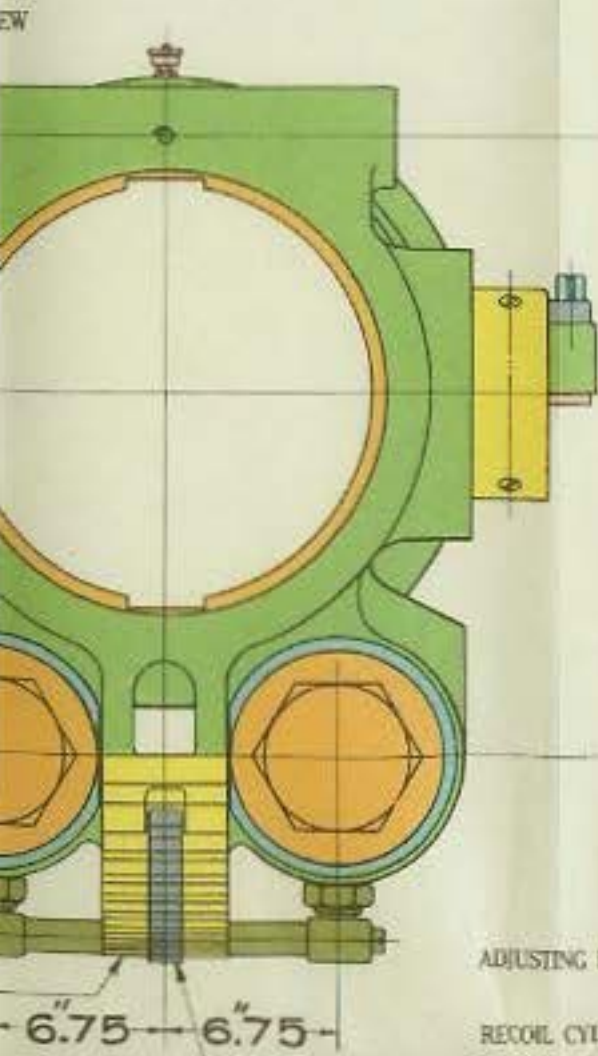
TRUNNION BUSHING
SIGHT SADDLE PIN LOCK SCREW
SIGHT YOKE LUG

COVER PLATE

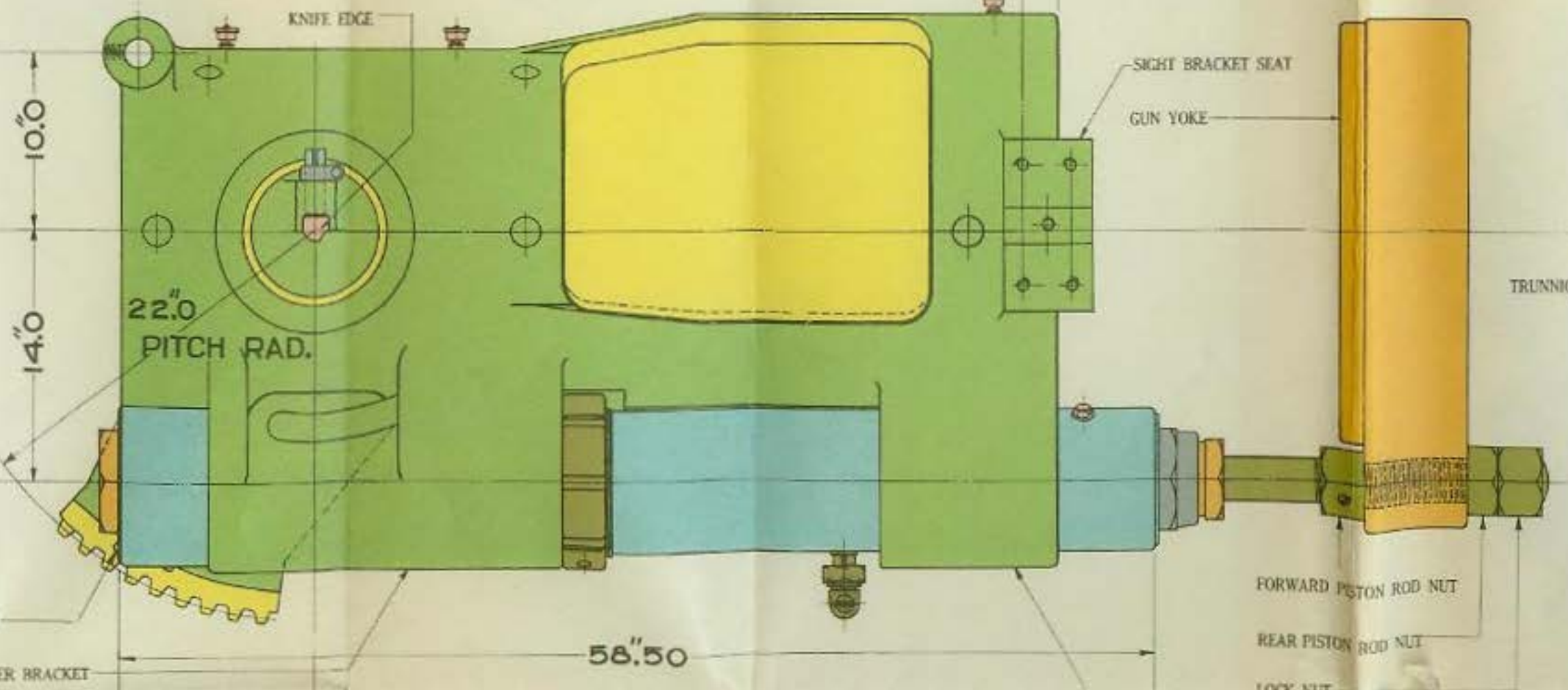


CHAPTER IX, PLATE IV.

10.0" 42.0" 2.0" 50.0"



ADJUSTING KEY
RECOIL CYLINDER BRACKET

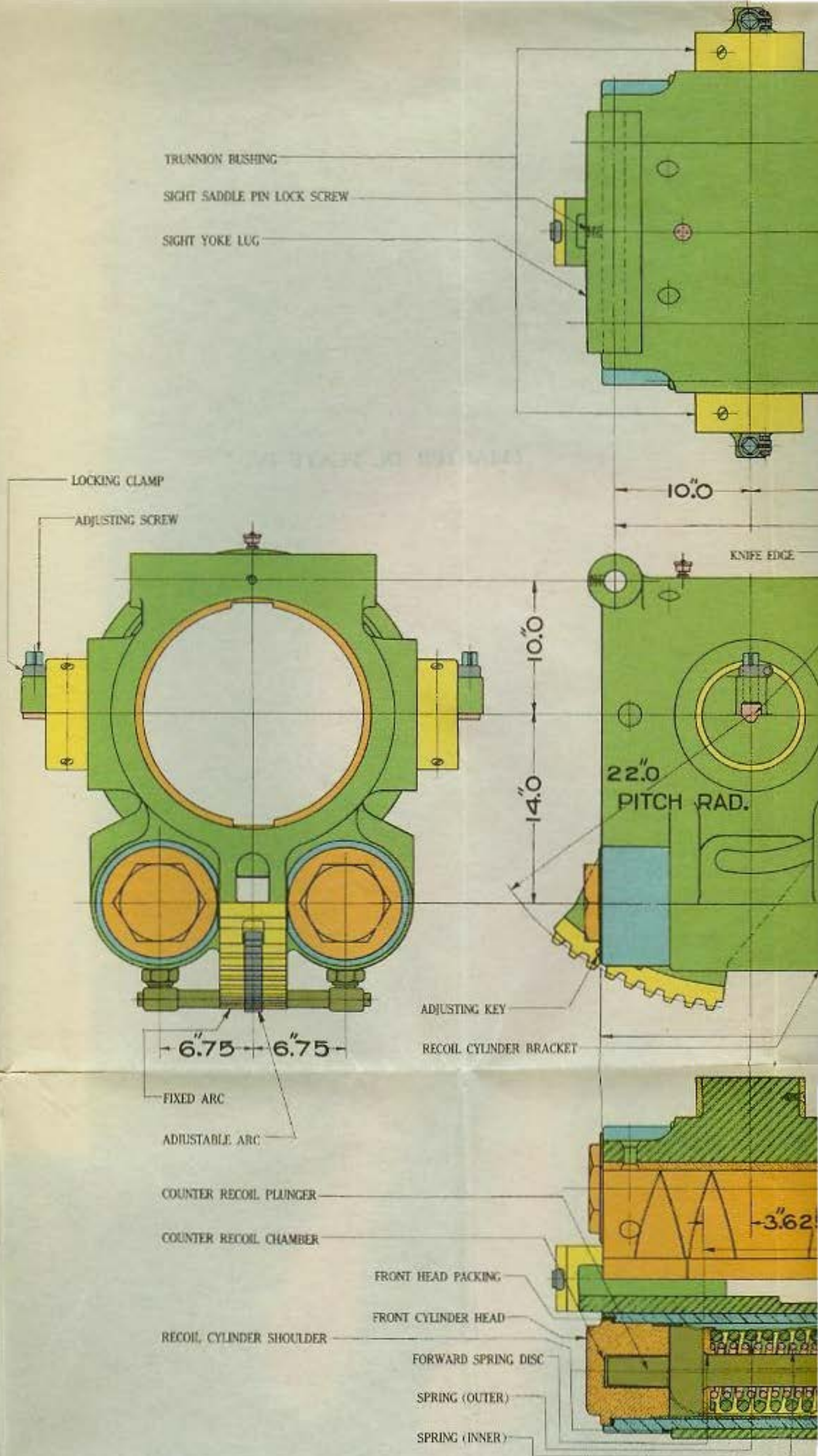


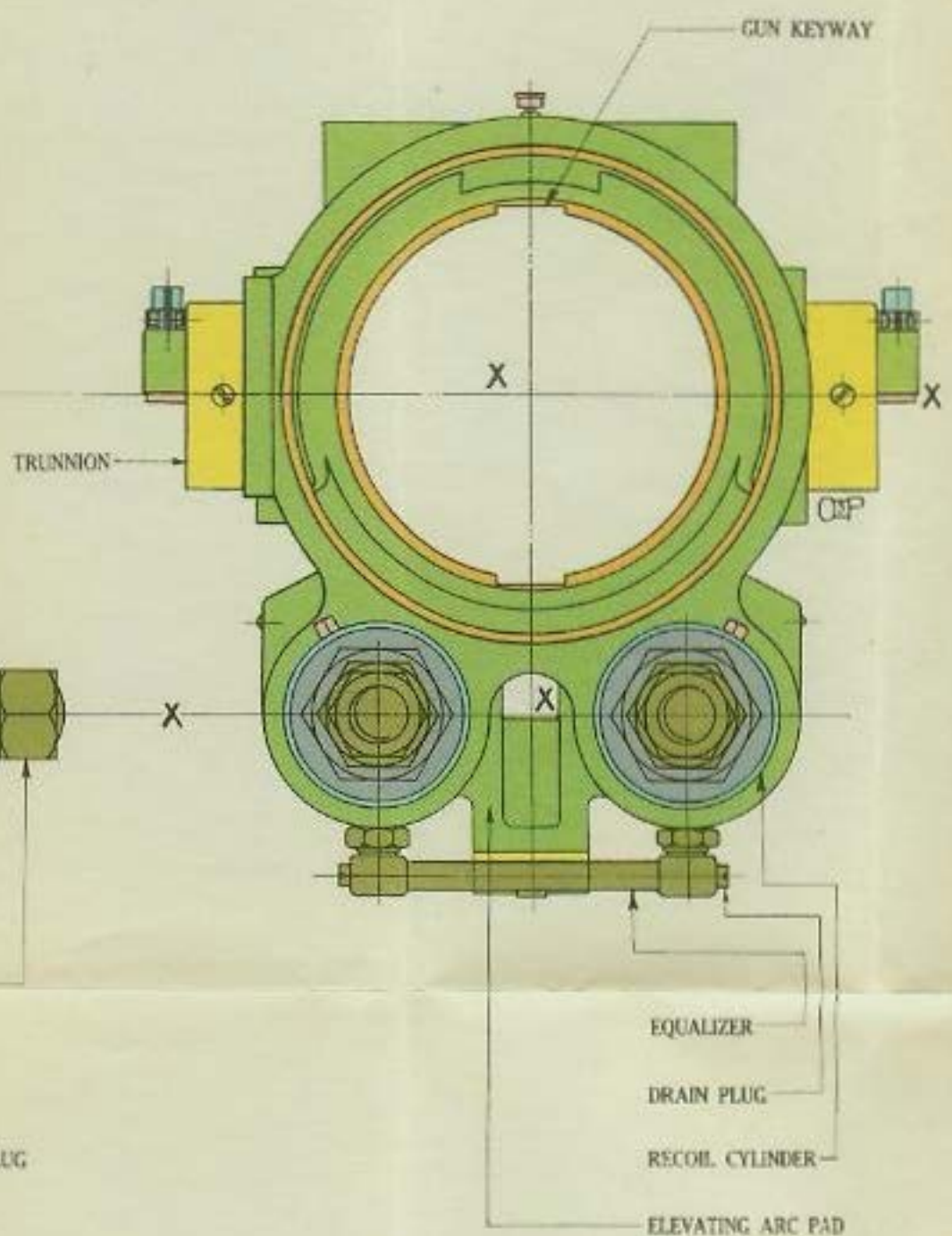
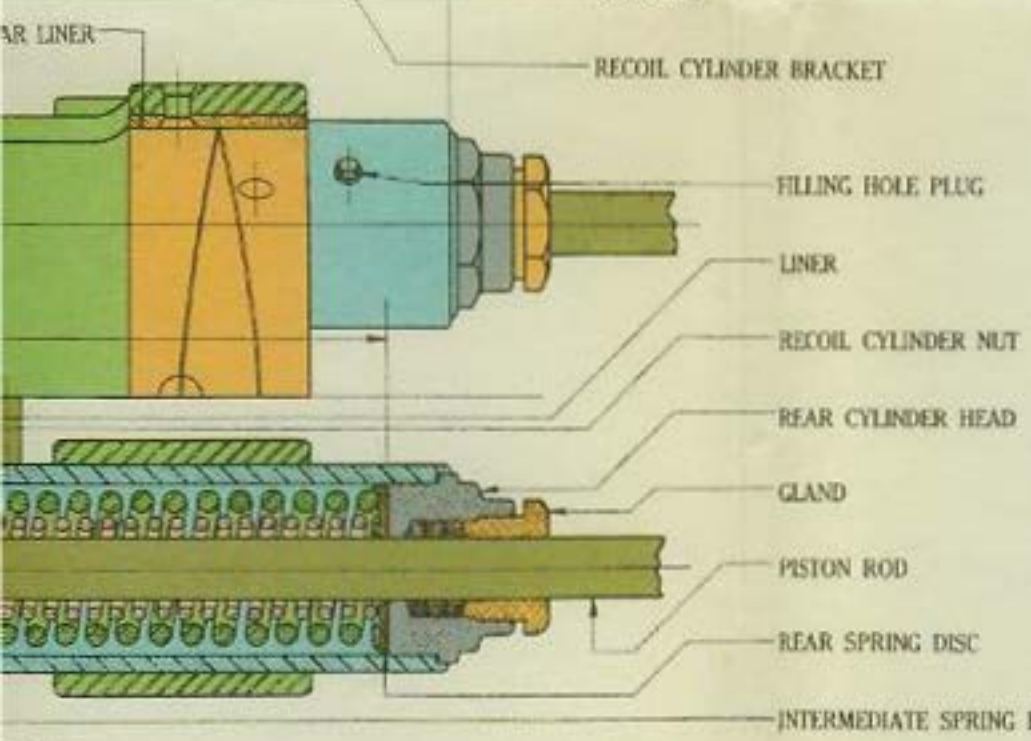
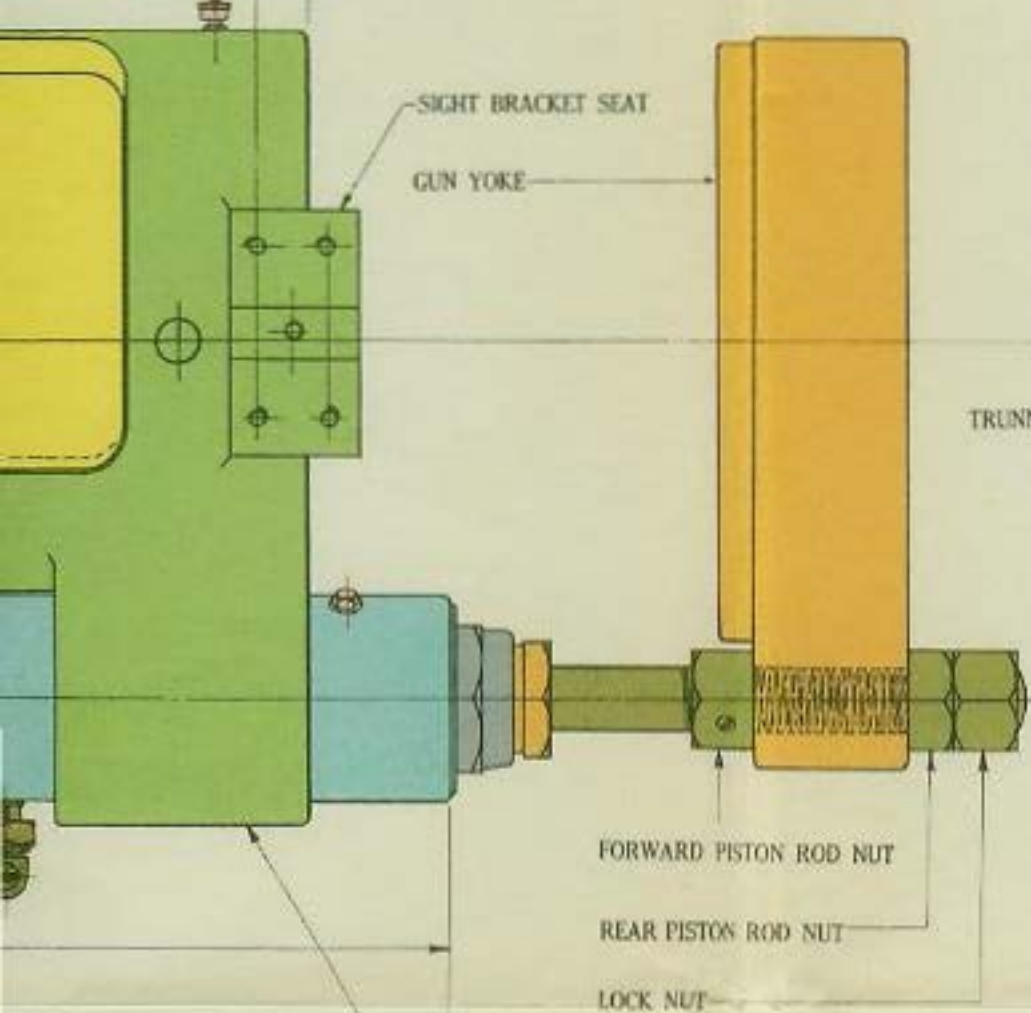
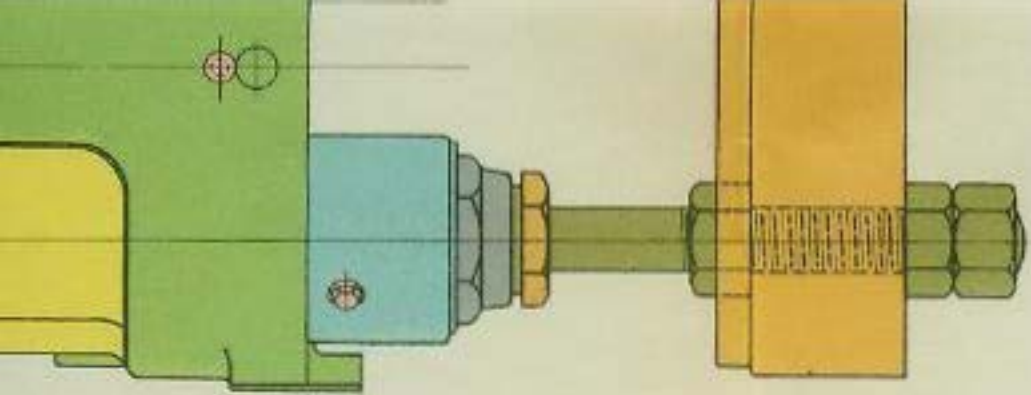
SIGHT BRACKET SEAT
GUN YOKE

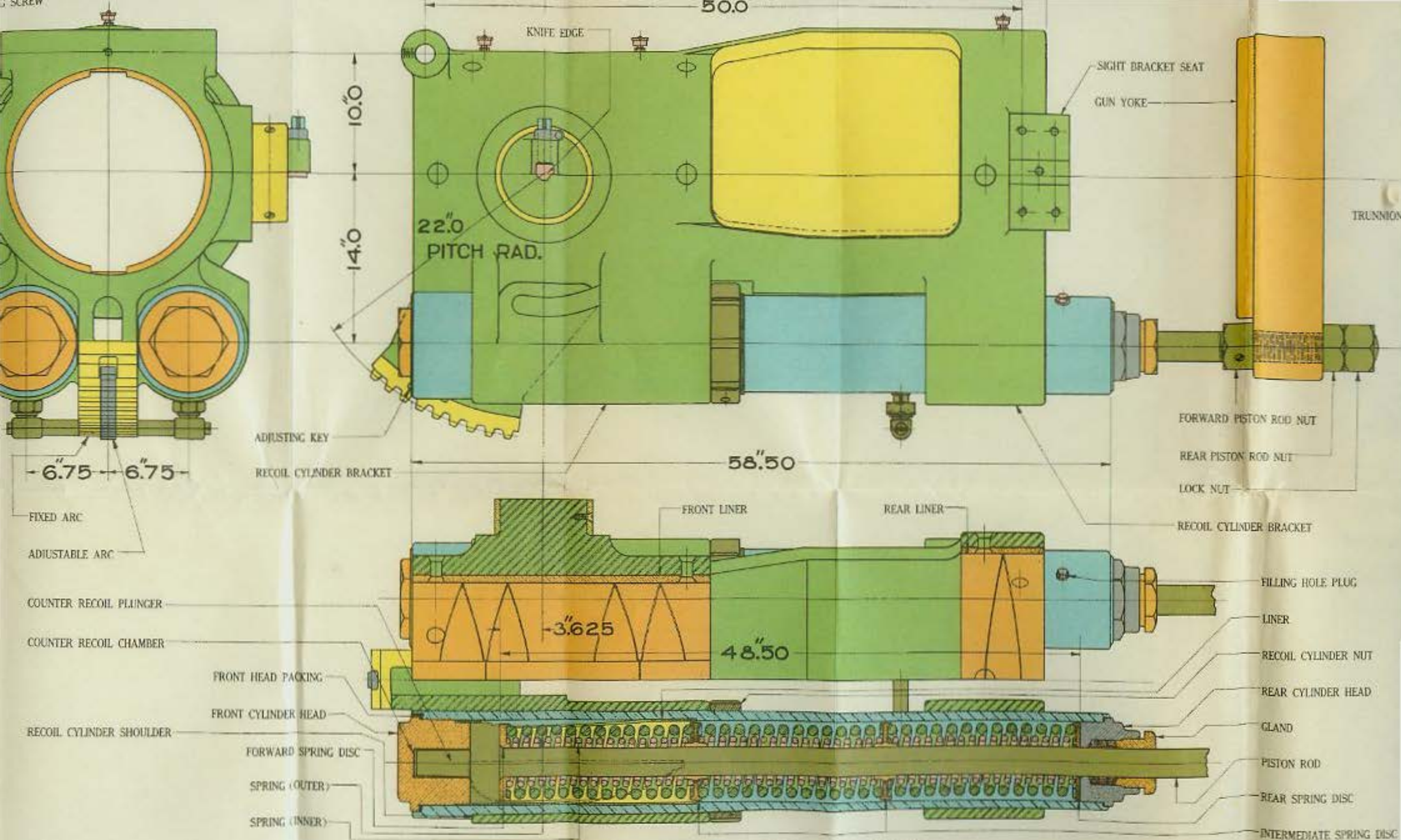
TRUNNION

FORWARD PISTON ROD NUT
REAR PISTON ROD NUT
LOCK NUT

58.50







SECTION THROUGH X-X-X-X

General Arrangement of the 5-inch Slide, Mark XIII