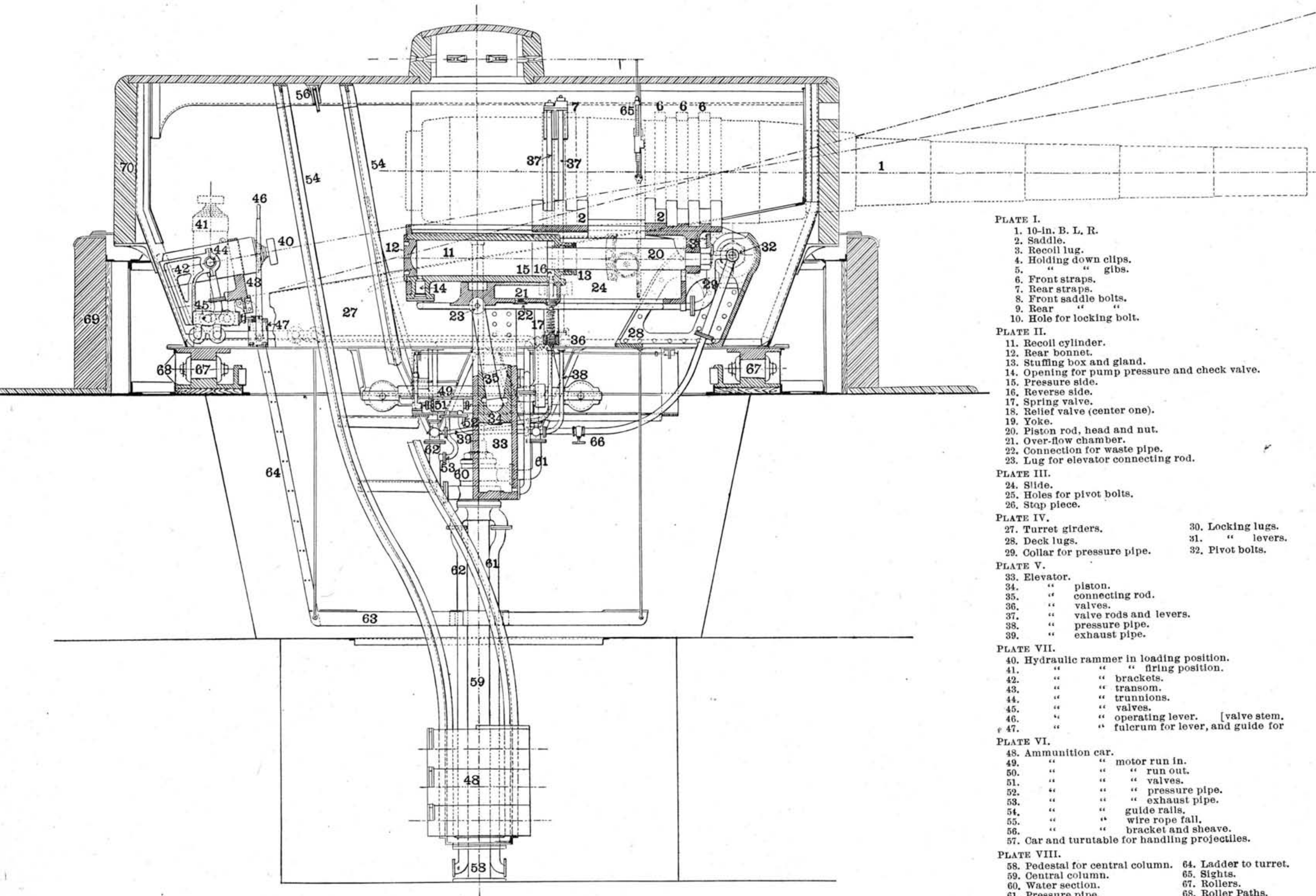


GENERAL PLAN, SLIDE ELEVATION, 10-INCH TURRET MOUNT, MARK II.

PLATE I.
1. 10-in. B. L. R.
2. Saddle.
3. Recoil lug.
4. Holding down clips.
5. " " gibs.
6. Front straps.
7. Rear straps.
8. Front saddle bolts.
9. Rear " "
10. Hole for locking bolt.

PLATE II.
11. Recoil cylinder.
12. Rear bonnet.
13. Stuffing box and gland.
14. Opening for pump pressure and check valve.
15. Pressure side.
16. Reverse side.
17. Spring valve.
18. Relief valve (center one).
19. Yoke.
20. Piston rod, head and nut.
21. Over-flow chamber.
22. Connection for waste pipe.
23. Lug for elevator connecting rod.

PLATE III.
24. Slide.
25. Holes for pivot bolts.
26. Stqp piece.

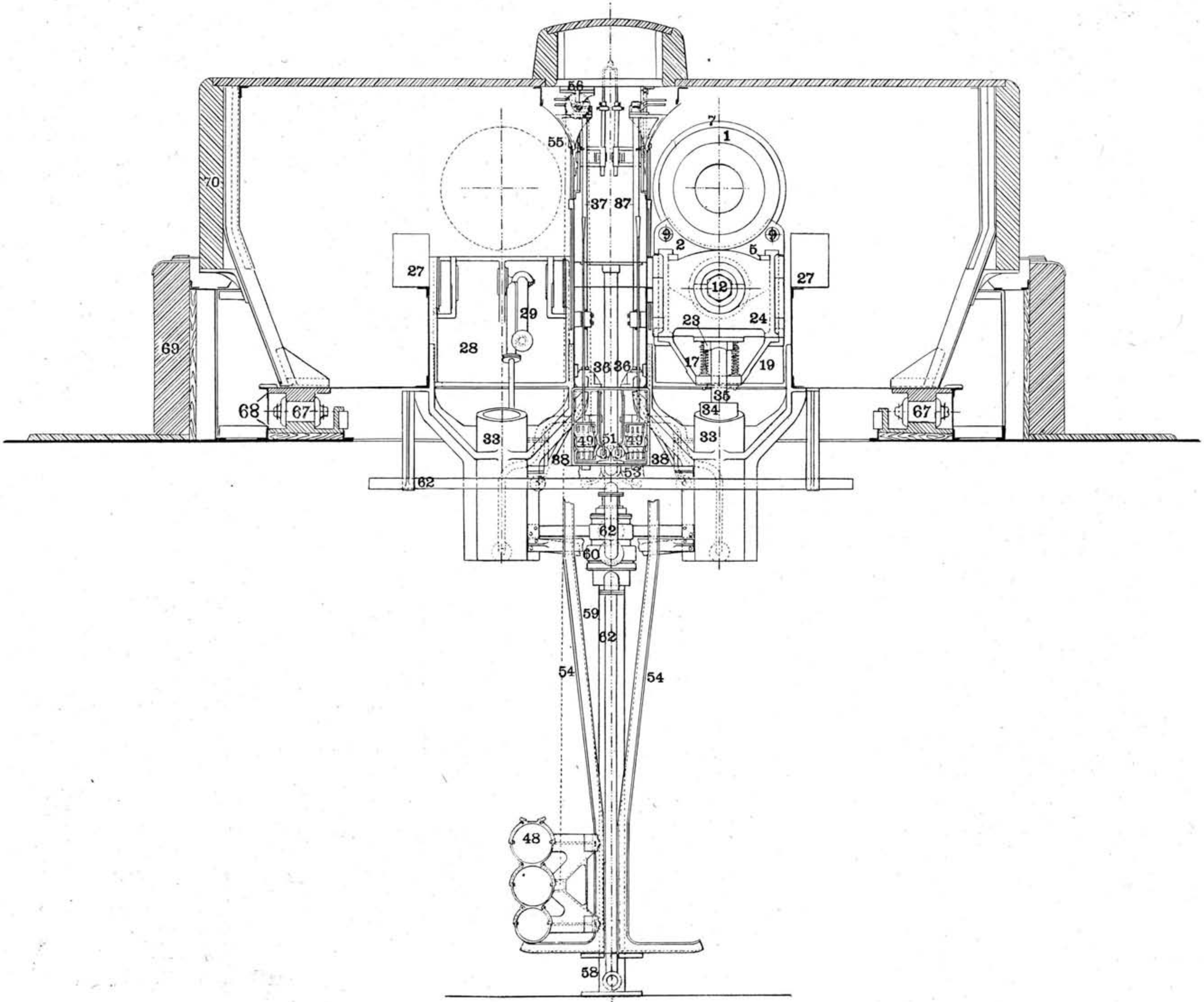
PLATE IV.
27. Turret girders.
28. Deck lugs.
29. Collar for pressure pipe.
30. Locking lugs.
31. " levers.
32. Pivot bolts.

PLATE V.
33. Elevator.
34. " piston.
35. " connecting rod.
36. " valves.
37. " valve rods and levers.
38. " pressure pipe.
39. " exhaust pipe.

PLATE VII.
40. Hydraulic rammer in loading position.
41. " " " firing position.
42. " " brackets.
43. " " transom.
44. " " trunnions.
45. " " valves.
46. " " operating lever.
47. " " fulcrum for lever, and guide for valve stem.

PLATE VI.
48. Ammunition car.
49. " " motor run in.
50. " " " run out.
51. " " " valves.
52. " " " pressure pipe.
53. " " " exhaust pipe.
54. " " guide rails.
55. " " wire rope fall.
56. " " bracket and sheave.
57. Car and turntable for handling projectiles.

PLATE VIII.
58. Pedestal for central column.
59. Central column.
60. Water section.
61. Pressure pipe.
62. Exhaust pipe.
63. Platform.
64. Ladder to turret.
65. Sights.
67. Rollers.
68. Roller Paths.
69. Barbette.
70. Turret.



GENERAL PLAN, REAR VIEW, 10-INCH TURRET MOUNT, MARK II.

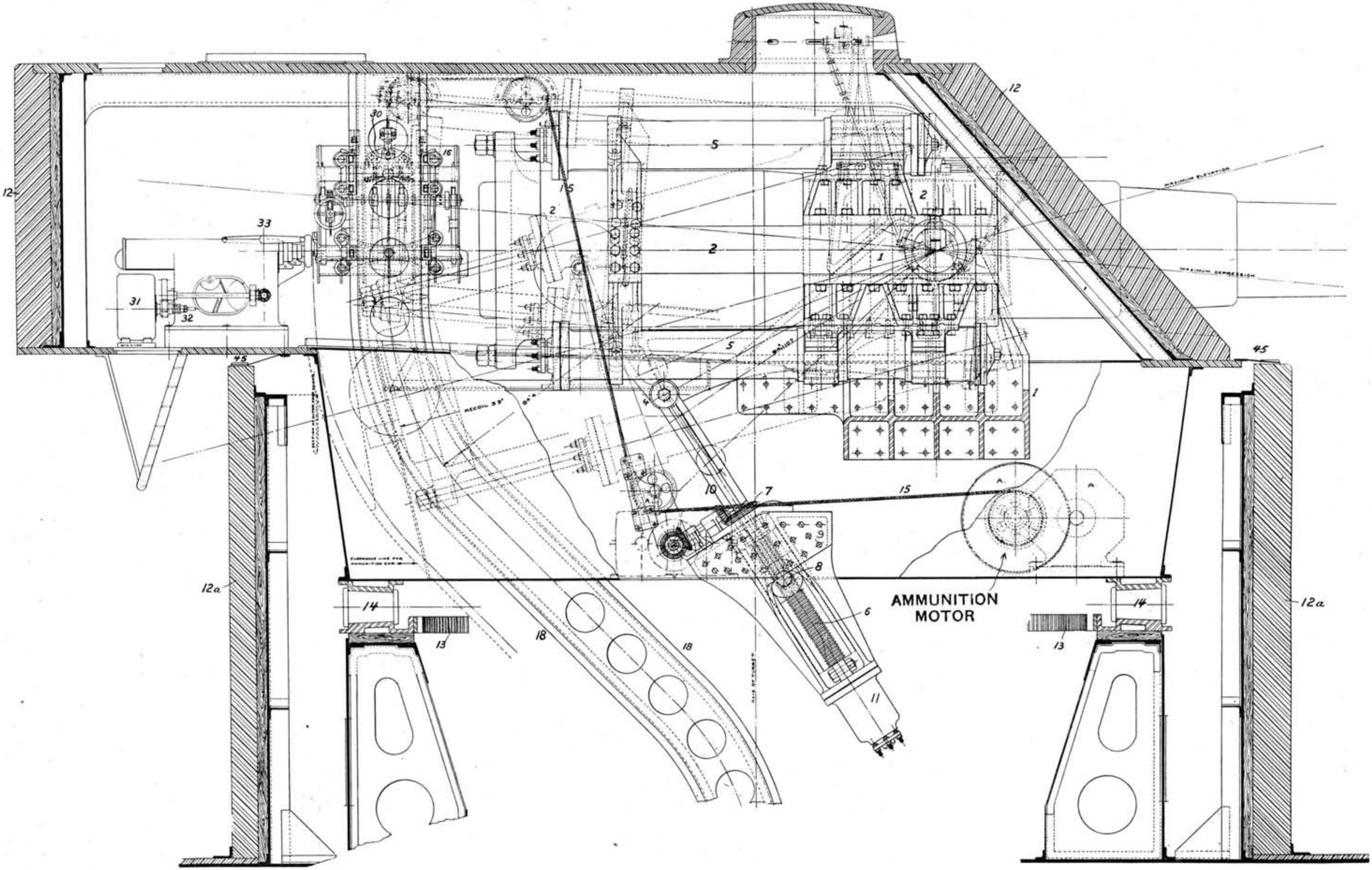
CHAPTER XV.

12-INCH TURRET MOUNT MARK IV.

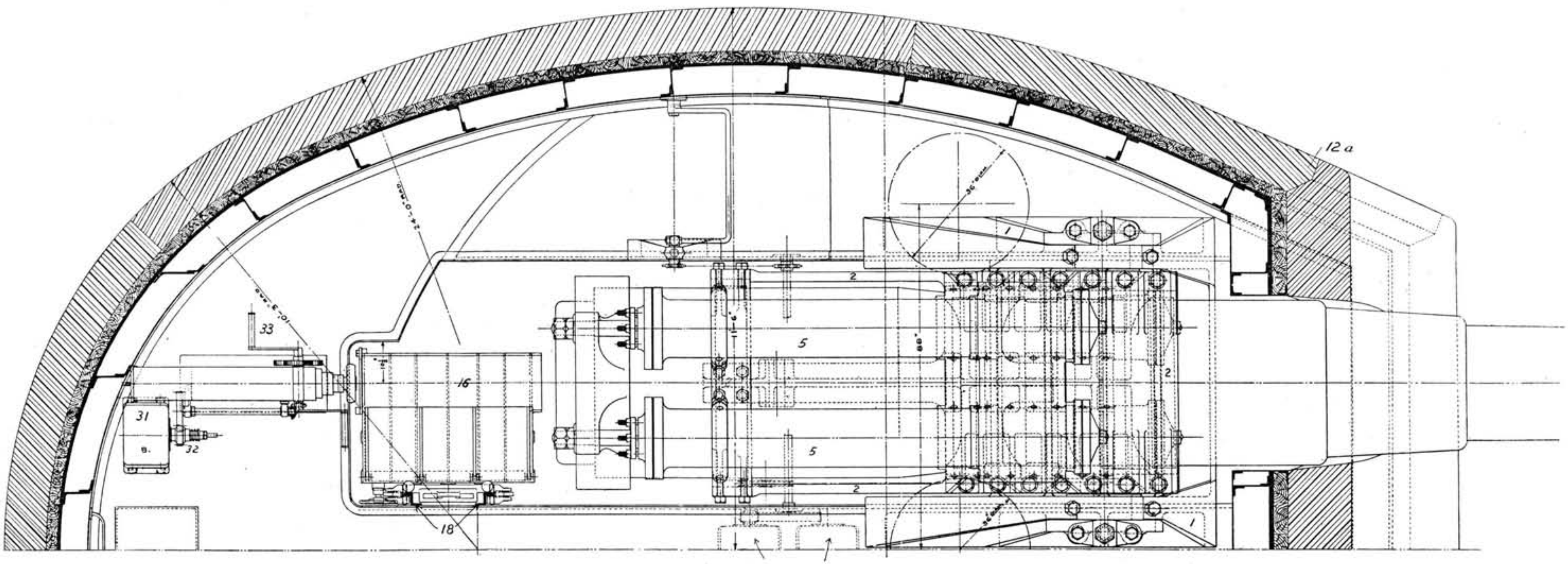
1. The Mark IV Turret Mount, on which are installed the 12-inch guns of the battleships "Maine," "Missouri" and "Ohio," and the monitors "Arkansas," "Wyoming," "Nevada" and "Florida," is a hydraulic-recoil spring-return mount in which all machinery is electrically operated and controlled. Two 32 kilowatt dynamos furnish the electric power required for running all the motors of the turret; one, which is for this purpose run as a separately excited shunt machine, feeds the two 35 H. P. training motors; the other, which is excited as for other purposes, feeds the two 20 H. P. ammunition-hoist motors, the two 5 H. P. rammer motors and the two 5 H. P. elevating motors. The training and ammunition-hoist motors are shunt wound, those for rammer and elevator are series wound, and all are controlled by the ordinary electric car controllers. In lieu of main fuzes, mechanical circuit breakers are placed in all but the rammer motor circuits; the motors, when starting, have to overcome the inertia of the heavy moving parts, thus throwing large currents through the armatures which would frequently blow out fuzes—particularly when the motors are handled by inexperienced men. Since the circuit breakers can easily be thrown "in" again, much time that would otherwise be wasted in replacing fuzes is saved; if the controller levers are put over one division at a time when starting, the circuit breakers will not act, as long as everything is in good order; but if the levers be thrown around quickly, the heavy current will nearly always break the circuit before the armature can start.

Plate I is a vertical longitudinal section between the guns showing the left mounting in profile. Plate II is a plan of the left half of the turret (section taken at the level of the trunnions). Plate III is a cross section of the left half of the turret showing the recoil cylinders and gun slide in profile and in section. (The description is written for the turret of the "Arkansas.")

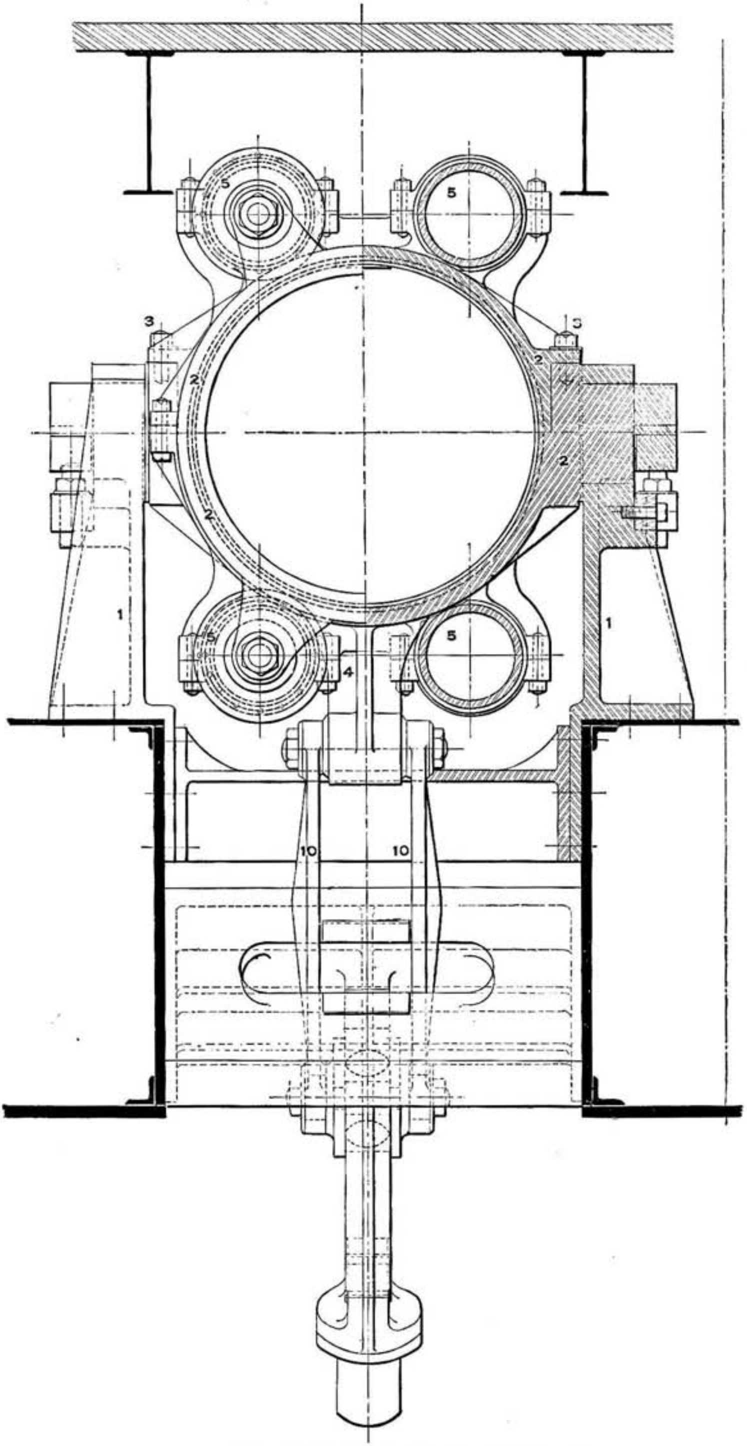
The *turntable,* to which the turret armor and all revolving parts of the mounting are secured, is built up of steel plates and angle irons and rotates on live rollers (14), which travel on a roller path built up inside the barbette framing. The cone-shaped rollers are spaced by two floating rings which are secured to their axles; the weight of the revolving parts of the installation rests upon the rollers and the horizontal thrust of the guns in recoiling is transmitted to the ship by their flanges. The circular barbette (12a), 8 inches to 12 inches in thickness, extends from the armored deck well above the turntable, while the guns and upper parts of their mountings are protected by the turret (12), 11 inches to 12 inches in thickness, which rests upon the turntable and connects with the barbette armor. The turntable is revolved by two 35 H. P. training motors which are placed beneath the armored deck outside the barbette structure and operate vertical training shafts placed diametrically opposite each other, with respect to the axis of rotation of the turntable. These shafts are stationary and bear, on their upper ends, pinions which gear in the circular training rack (13) of the turntable. There is a friction collar on each shaft which yields to the twist given the turntable on firing one of the guns and prevents the training gear from being deranged by it. The training shafts are cross connected by shafting and bevel gearing, which insures that the two motors shall turn at the same rate, and enables one motor to turn both shafts, should it become necessary. Suitable hand gear, which may be thrown in by a clutch, (at the same time disconnecting the motor), is installed at each motor. The turret is secured for sea by: (1) the *locking bolt,* operated inside the turret, the principal use of which is to fix the securing position of the turret; it passes through the turntable to a socket near the top of the barbette and will go in place only when the turret is accurately placed in the securing position; (2) *wedges,* setting up between the upper inside edge of barbette armor and the lower outside edge of turret armor; these wedges, four in number, prevent any severe strain on the roller flanges, as the ship is listed; (3) outside *turn buckles,* which secure the turret to the barbette armor. (None of the securing gear is shown on



12-INCH TURRET MOUNT, MARK IV.

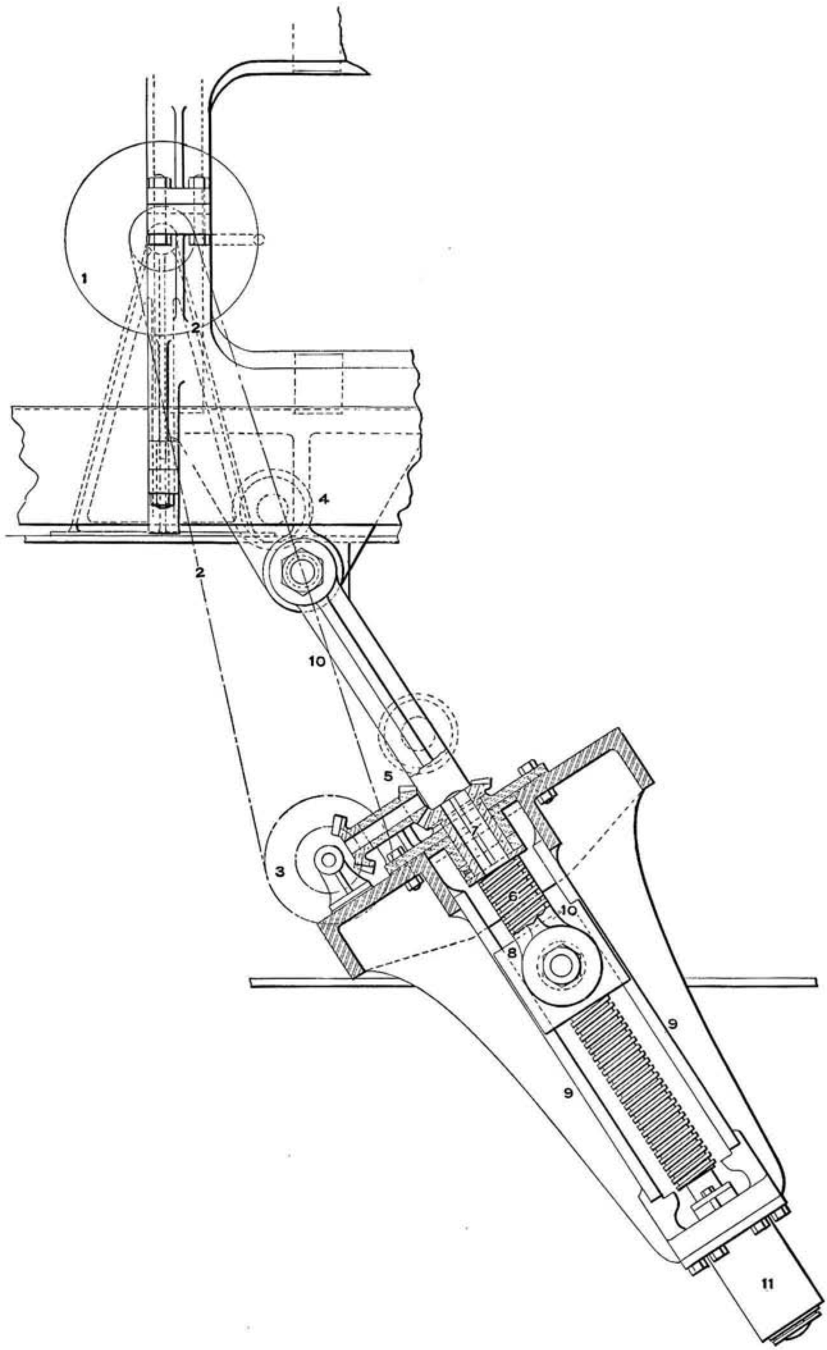


12-INCH TURRET MOUNT, MARK IV.



12-INCH TURRET MOUNT, MARK IV.

CHAPTER XV. PLATE IV. Par. 4.



ELEVATING GEAR, 12-INCH MOUNT, MARK IV.

the plates.] The apron (45) rotates with the turret and, when lowered, bears on a gasket on the barbette and makes a watertight joint; it must be raised before turning the turret. The principal parts of the mounting are:

The Gun and Gun Slide.
The Recoil Cylinders.
The Deck Lugs.
The Elevating Gear.
The Ammunition Hoist; and
The Rammer.

2. **The Gun Slide** [Plates I, II and III (2)], in which the gun rests is a sleeve built up of several steel castings bolted together; it is bushed with bronze giving the gun a five feet bearing at the trunnions and a shorter one near the breech; the trunnions are parts of the slide and are placed at the center of gravity of gun and slide combined; knife-edged trunnions are shown but are not fitted in all 12-inch mounts of this type. The four cast-steel recoil cylinders are secured to the slide by collars bolted over each end. The connecting rods (10) of the elevating gear, are bolted to the lug (4) which is cast on the slide.

3. **The Recoil Cylinders** [Plates I, II and III (5)], four in number, are secured to the slide while their piston rods, projecting through stuffing boxes at the rear ends, are secured to a yoke around the breech of the gun: because of the inclined turret front the upper cylinders are made two feet shorter than the lower ones. The two upper and the two lower cylinders are connected by an equalizing pipe and all are rifled with tapering grooves in the usual manner. The counter-recoil springs surround the piston rods and are divided, by separating disks, into seven and nine sections respectively in each of the upper and lower cylinders; the springs are made in three sizes and in three diameters, the outside spring being made of the largest wire. The recoil with full charge of powder is about 33 inches.

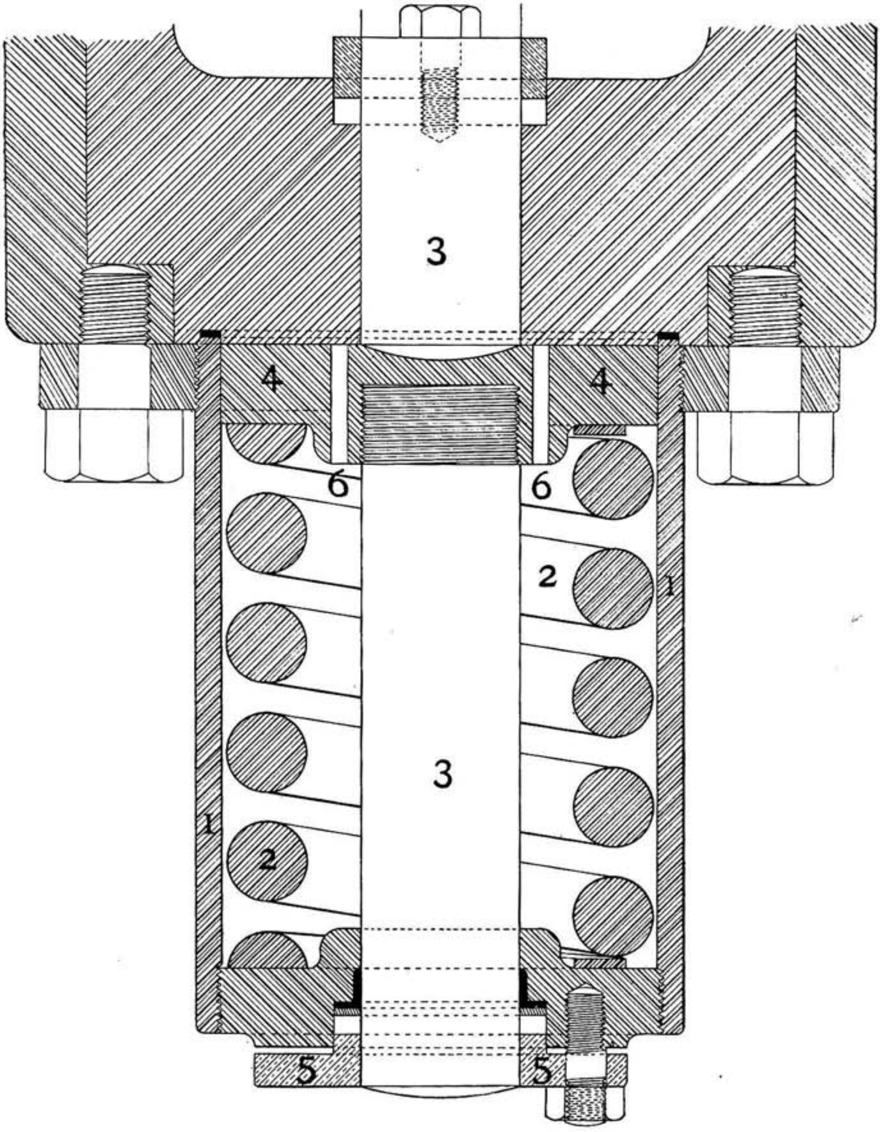
The *deck lugs* (1), which bear the trunnion seats and cap squares, are heavy steel castings bolted to the turntable.

4. **The Elevating Gear** (Plates I, III and IV) is actuated by a 5 H. P. motor, placed between the guns under the turret floor, whose armature shaft gears with the shaft (2). The motor is

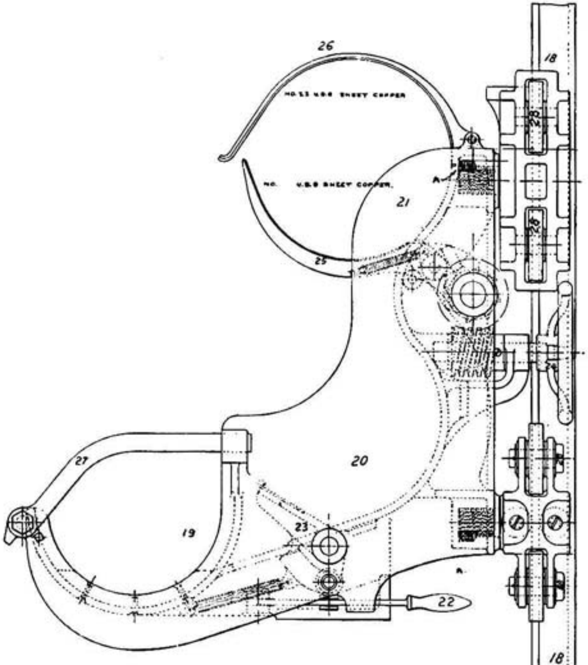
thus directly connected by shafting to the bevel wheel (7), held by a feather to the elevator shaft (6) in such a manner that the elevator may have a slight downward motion through, but must turn with, (7); this mechanism is carried on a heavy bracket (9) bolted to the turntable. By turning the elevating motor in either direction, the elevator shaft is revolved and, it being practically restrained from a motion of translation, the travelling nut (8), to which the lower ends of the connecting rods (10) are secured, is moved along its guides and the breech is raised or lowered. In Plate IV (1) is the hand elevating wheel, connected by the chain (2) and the sprocket wheel (3) to the shaft to which the motor is geared; it is not necessary to disconnect the motor when using the hand gear.

The *dash pot* (11) is bolted to the elevator bracket and contains the mechanism for controlling the jump; it is shown in detail by Plate V. The lower end of the elevator shaft rests on the dash pot piston (4); the spring (2), under considerable initial tension, keeps the shaft pressed upward against a collar at its upper end and, in the ordinary working of the gun, does not yield but holds the shaft up in place. When the gun is fired, however, the elevator shaft is driven down forcibly, by the jump, and the piston (4) is pressed downward against the spring; when the jump has been thus absorbed, the spring brings the gun back to its former position. The dash pot is filled with recoil liquid which, escaping through the holes (6), cushions the movement of the piston in each direction.

5. **The Ammunition Hoist**—one for each gun—is worked by a 20 H. P. motor secured to the turntable, beneath the turret floor, directly below the gun port; the motor is controlled from the turret in rear of the gun. The armature shaft is geared to a drum on which is wound a three inch wire cable (15) which passes over leading blocks at the top of the turret and is secured to the ammunition car (16). The car travels on the guide rails (18)—leading upward from the handling room—which are a part of and rotate with the turntable. Each gun has its own magazine and shell room, opening into a common handling room, and the turret and handling rooms are, with their crews, under the charge of the turret officer. The projectiles are lifted by differential purchases,



HYDRAULIC ELEVATOR BUFFER, 12-INCH MOUNT, MARK IV.



AMMUNITION CAR, 12-INCH TURRET MOUNT, MARK IV.

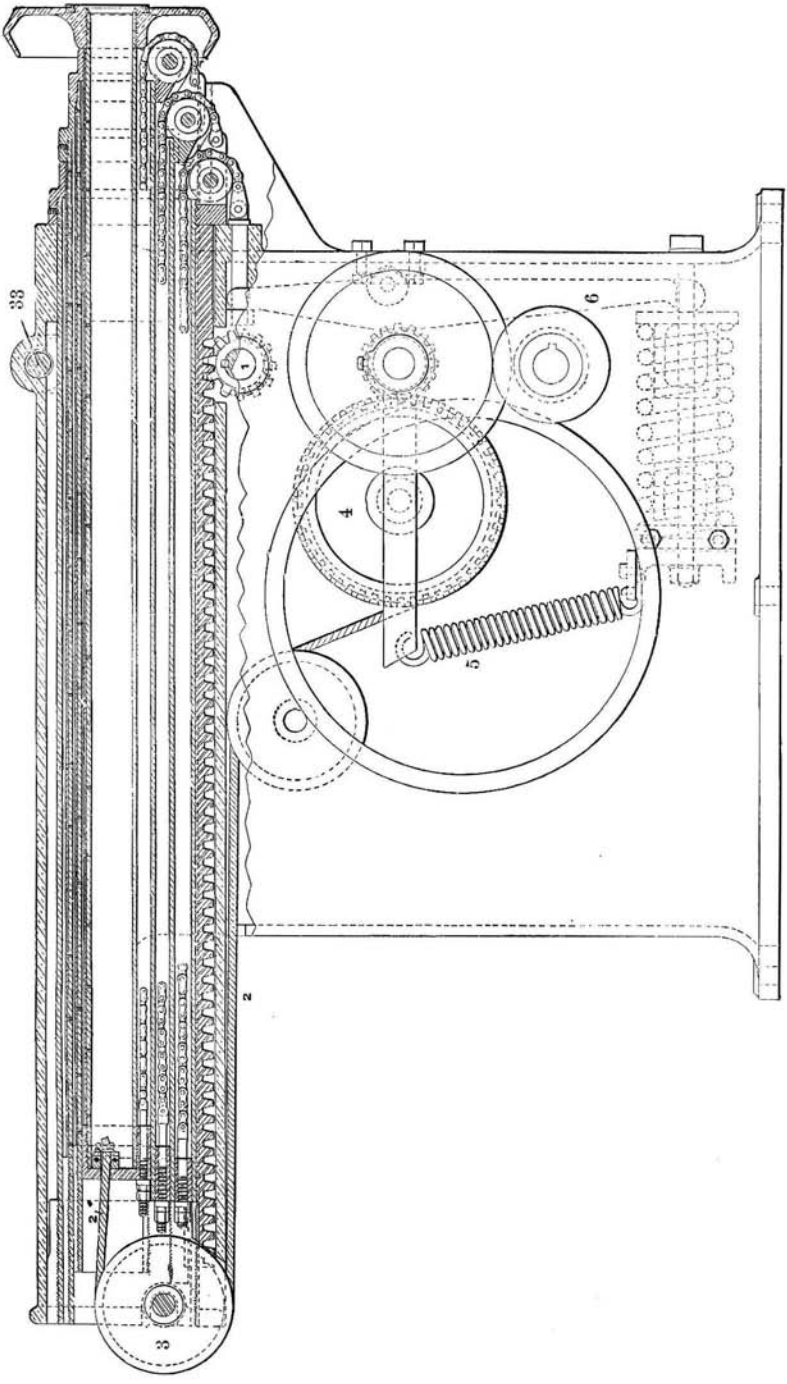
rolled to the handling room on overhead trolleys and landed on the handling room car from which they are pushed by hand into the ammunition car. The powder charge is made up in four sections and is transferred from magazine to car by hand.

The *ammunition car* (Plate VI) travels by its rollers (28) on the guide rails (18) and has but two positions of rest, the loading position, opposite the rammer, and the charging position in the handling room; but the car will remain in any position on the rails when the power is cut off the motor,—an electrically actuated brake holding the motor's armature shaft rigidly, whenever power is *off* the motor. The upward motion is limited by stops and the loading position just below is fixed by the loading hook (not shown). The projectile is brought up in the lowest compartment (19) which is the only one that comes opposite the rammer head; the shell latch (27) keeps the projectile in place while it is being hoisted. The first powder section rests in (20) on the powder tray (23); the hand lever (22) trips this tray, whereupon the powder rolls down opposite the rammer. The last section of powder is brought up in (21), the powder tray (25) being tripped by the powder wheel (24). The hinged copper cover (26) protects the powder from injury while it is in the car. The hoisting cable is secured to the upper ends of two pawls [(30) Plate I] which are held clear of their rests by the weight of the car as long as everything is in good order; if the cable should carry away, however, these pawls will be forced by springs into their rests on the guide rails and the car will not fall.

6. **The Rammer** (Plates I, II and VII) is a telescopic chain rammer actuated by a 5 H. P. electric motor; the rammer is secured to the turret floor in a position such that it will deliver its stroke along the axis of the bore when the gun is in its level or loading position. The motor (31), which is connected by geared shafting to the pinion (1) (Plate VII), actuates the motor in extension and in retraction; the friction disk (32) is designed to yield when the rammer is brought up suddenly (as when the projectile stops on reaching its seat), and to thus prevent the mechanism from being strained by the momentum of the armature. The rammer may also be worked by the crank (33) which, when connected, gears with the pinion (1).

The rammer consists of five sections of hard drawn brass tubing, fitting one within the other, the outer section being stationary, mounted on suitable framing about 2½ feet above the turret floor; the rear end of each section, except the outer one, is connected by a chain passing over a roller at the front end of the next larger section to the front end of the second outside section; for instance, the inner section is connected to the third. On the lower side of the outside section is a rack, extending nearly its whole length, and a pinion (1) gearing into it; the section can be made to move forward by the motion given to the pinion by either hand or electric power applied by suitable gearing to the shaft on which the pinion is mounted. The forward motion of the outer section opens out each of the other sections by the same amount and when the outer section has traveled forward the length of the rack the rammer head on the innermost section has reached the limit of its travel. A ⅜-inch wire rope is secured to the inner section, passes over the leader (3) and around the drum (4) to which it is secured. The drum is so connected to (1) that the cable will be paid out at the proper rate while the rammer is being extended; and, when the motor is reversed, the drum winds in the cable, drawing back all the sections but the outer one, which is withdrawn by the pinion (1) which extends it. The spring (5) relieves the shock when the sections are drawn back too forcibly; the spring buffer (6) assists the friction disk in cushioning shocks in the extension of the rammer. In the future, rammers are to be built on the above principle, but the chains will be on top of the sections, thus helping support the weight when the rammer is extended and preventing the sections from binding.

7. **Miscellaneous Fittings.**—Placed in the turret roof, well forward, are the three armored sighting hoods. The trainer's hood, between the guns, contains the trainer's sight, an indicator showing the position of the turret in train, and the controller for the training motors, with the circuit breaker and two ammeters which measure the strength and direction of the current through the motors. The pointer's hoods are placed outside the guns, and each contains the telescopic and the night sight, the firing key and the elevating motor controller and circuit breaker; there are no rest lugs to this mounting and the pointer lays the gun to its



TELESCOPE RAMMER 12-INCH MOUNT, MARK IV.

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Chapter XV.

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loading position by an indicator in the hood, which shows the position of the gun in elevation. A powerful smoke fan and loading platforms are installed. The communications are: speaking tube and bell pull from the handling room, telephone connection to the hand-turning gear, dynamo room and conning tower, and electric range and battle-order indicators which transmit from the conning tower. (Some of the "Notes on Turret Mounts" in "Gun and Torpedo Drill Book, 1900," refer to the above type of turret.)

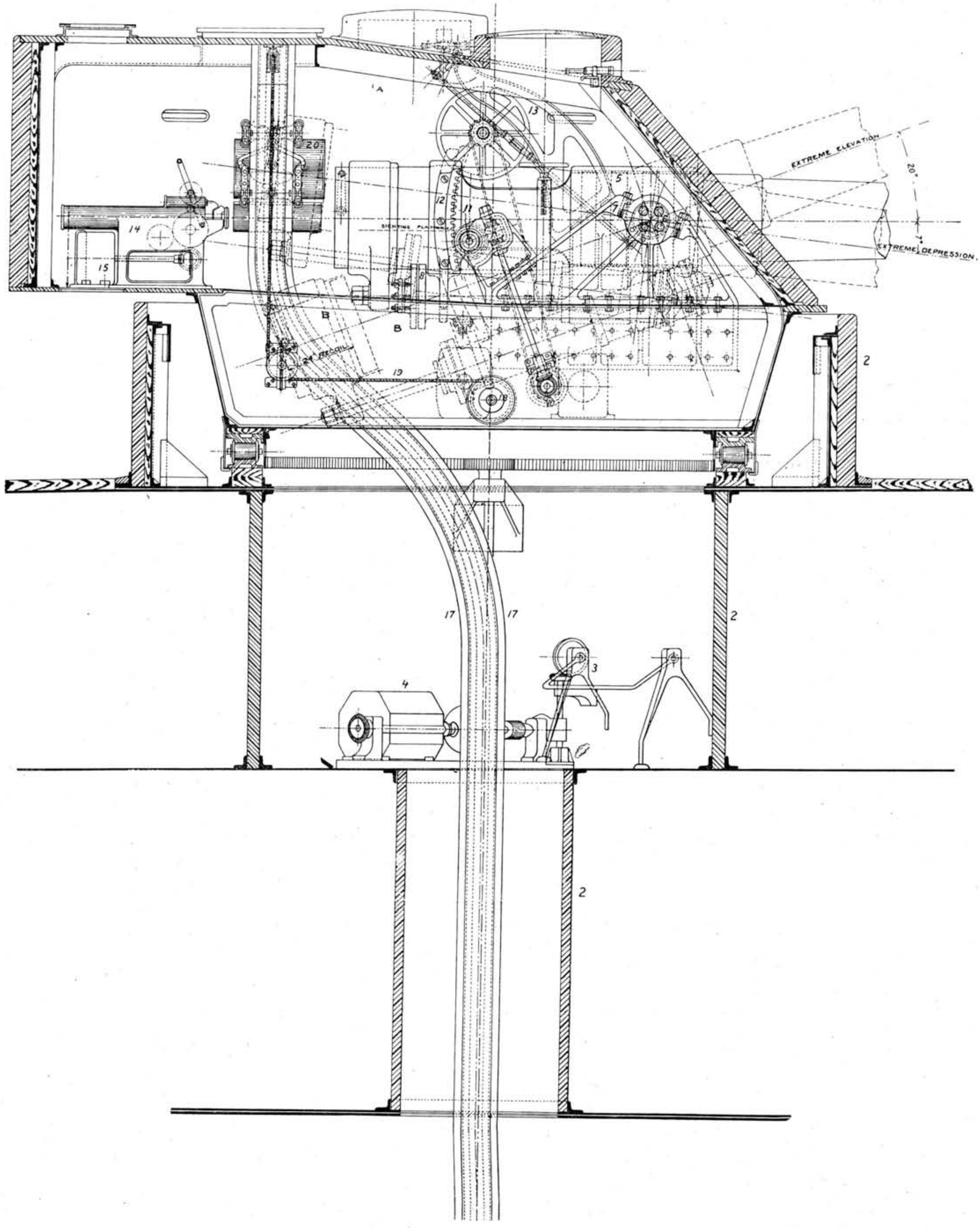
CHAPTER XVI.

8-INCH TURRET MOUNT MARK XII.

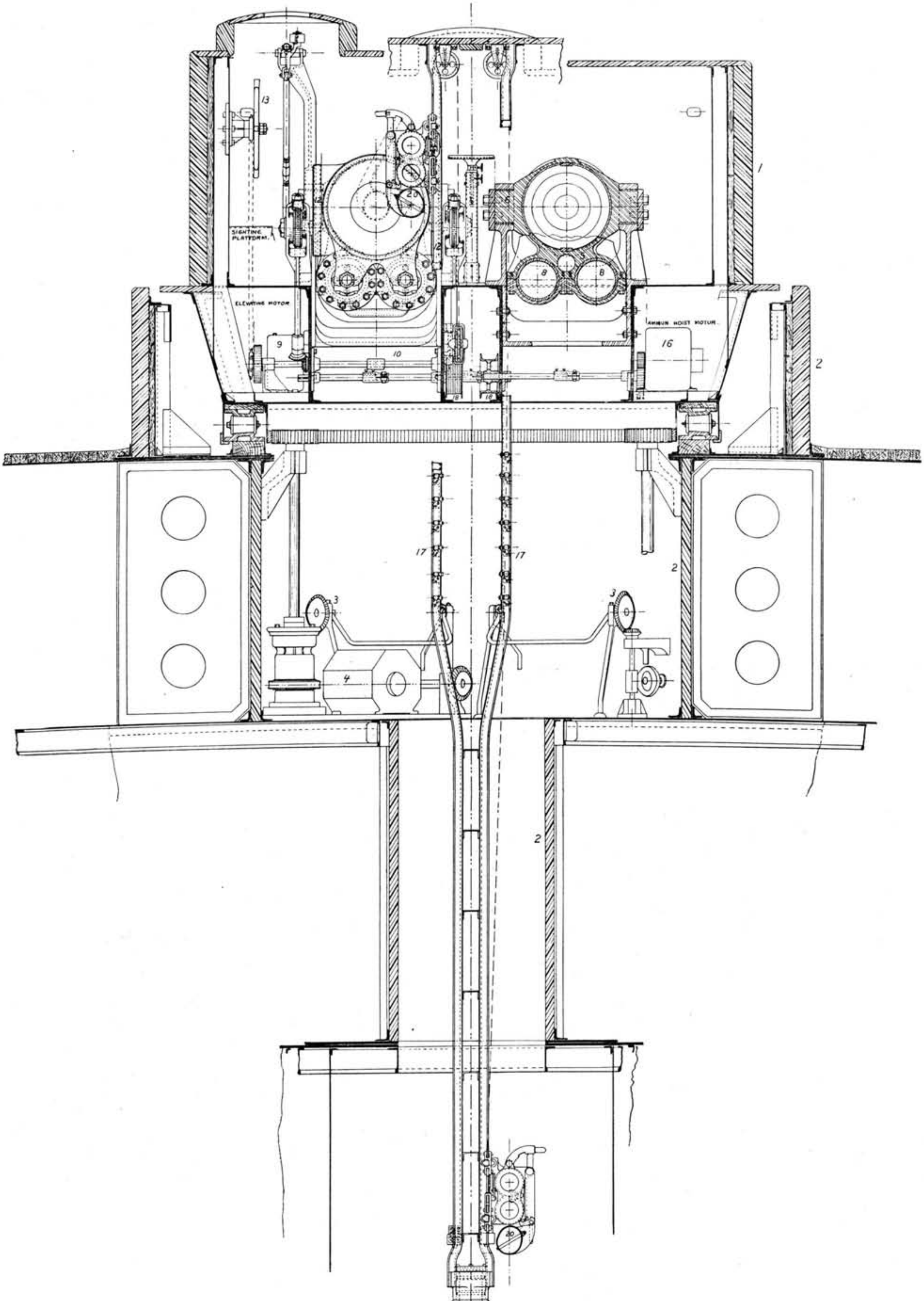
1. The Mark XII mount is a hydraulic-recoil, spring-return, electrically operated and controlled mount, and, as installed on ships of the "Pennsylvania" class, is in most respects similar to the 12-inch Mark IV mount described in the preceding chapter. Plate I is a vertical longitudinal section; Plate II, a vertical cross section with right half showing the slide in section and left half giving the interior of the turret in profile; Plate III is a plan in which one recoil cylinder is shown in section. (The following description is complete only as concerns those parts that materially differ from the corresponding ones of the 12-inch Mark IV turret.)

The *turret* (1), six inches in thickness, has three sighting hoods as in the turrets of the "Arkansas" class, and the forward half of the roof is sloped downward at a slight angle. The *barbette* (2), extending down to the protective deck, is from three to six inches thick, and, to economize in weight, the diameter is reduced, between the lower decks, so that the barbette is divided into three parts of different sizes; the lowest part is of so small a diameter that it is merely an ammunition tube. The bases of the turret mounts of most armored cruisers, and of some battleships, are usually protected in this way. The hand (3) and the electric (4) training gears are installed inside the barbette at the level of the berth deck. The cast steel slide (5) is in the common form of a sleeve about the gun body and its trunnions (6) rest in seats on the tops of the deck lugs (7). The two recoil cylinders (8), each containing counter-recoil springs in three sizes, are both bolted to the *under* side of the slide and their piston rods are secured to a yoke about the breech of the gun.

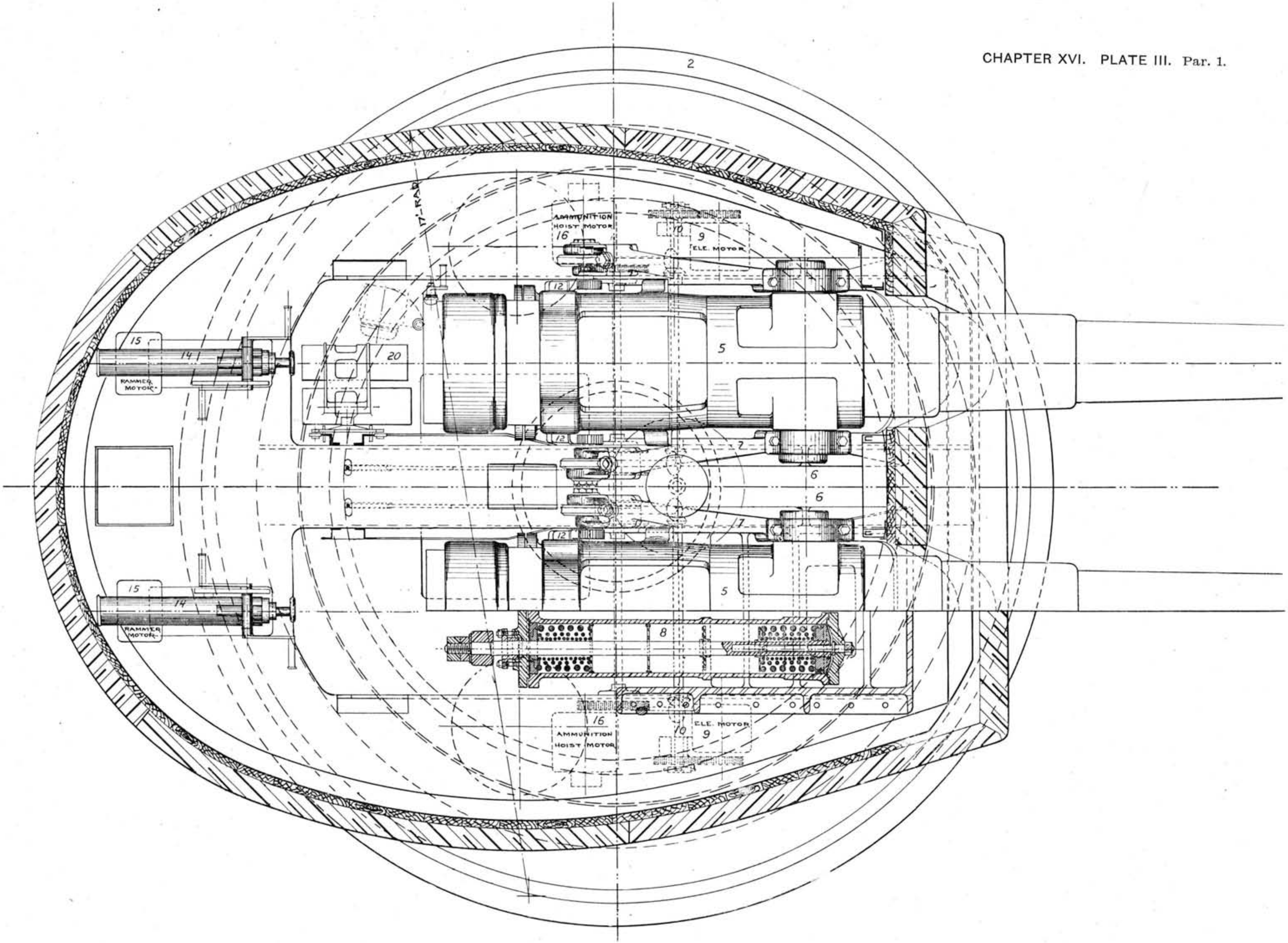
2. **The Elevating Gear** of each gun is actuated by an electric motor (9) placed under the turret floor outside of the gun. The armature shaft is geared to a cross shaft (10) which is in turn



8-INCH TURRET MOUNT, MARK XII.



8-INCH TURRET MOUNT, MARK XII.



8-INCH TURRET MOUNT, MARK XII.

Page 196b

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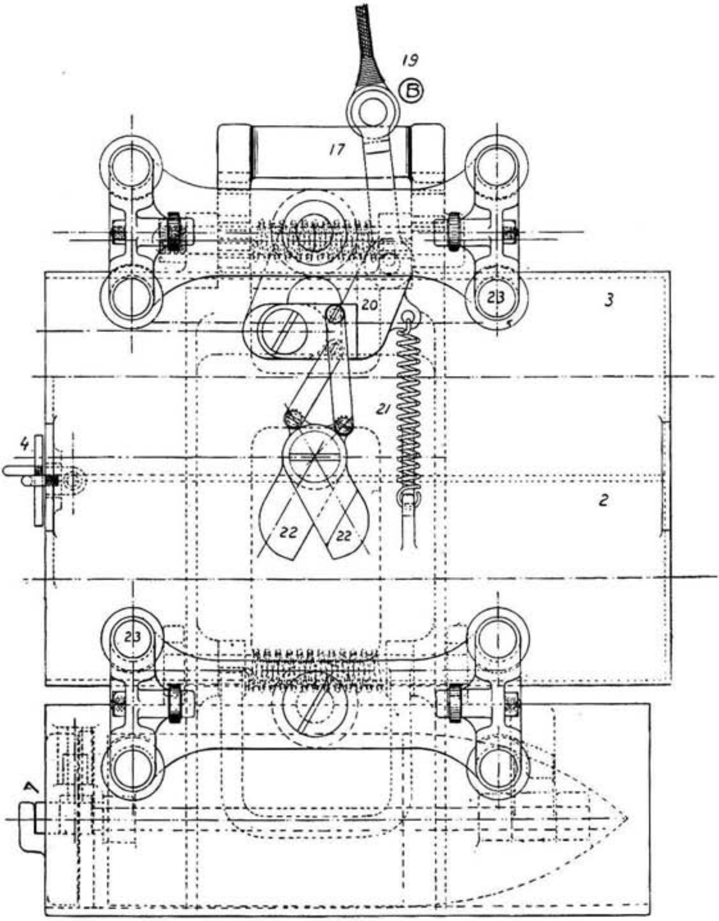
connected by shafting and bevel gearing to elevating pinions (11) at each side of the gun; elevating arcs (12), in which these pinions gear, are bolted to each side of the gun slide. A hand elevating wheel (13), to be operated by the gun pointer from his station, is connected by a chain and sprocket wheels to the same shaft that the motor is geared to. One of the pinions of the elevating shaft is held between two friction disks which cushion the jump of the gun by permitting the pinion to slip around between them. The disks are set up by a heavy nut, accessible from one side, and, when properly adjusted, they will slip at each fire enough to change the position of the gun in elevation a small amount.

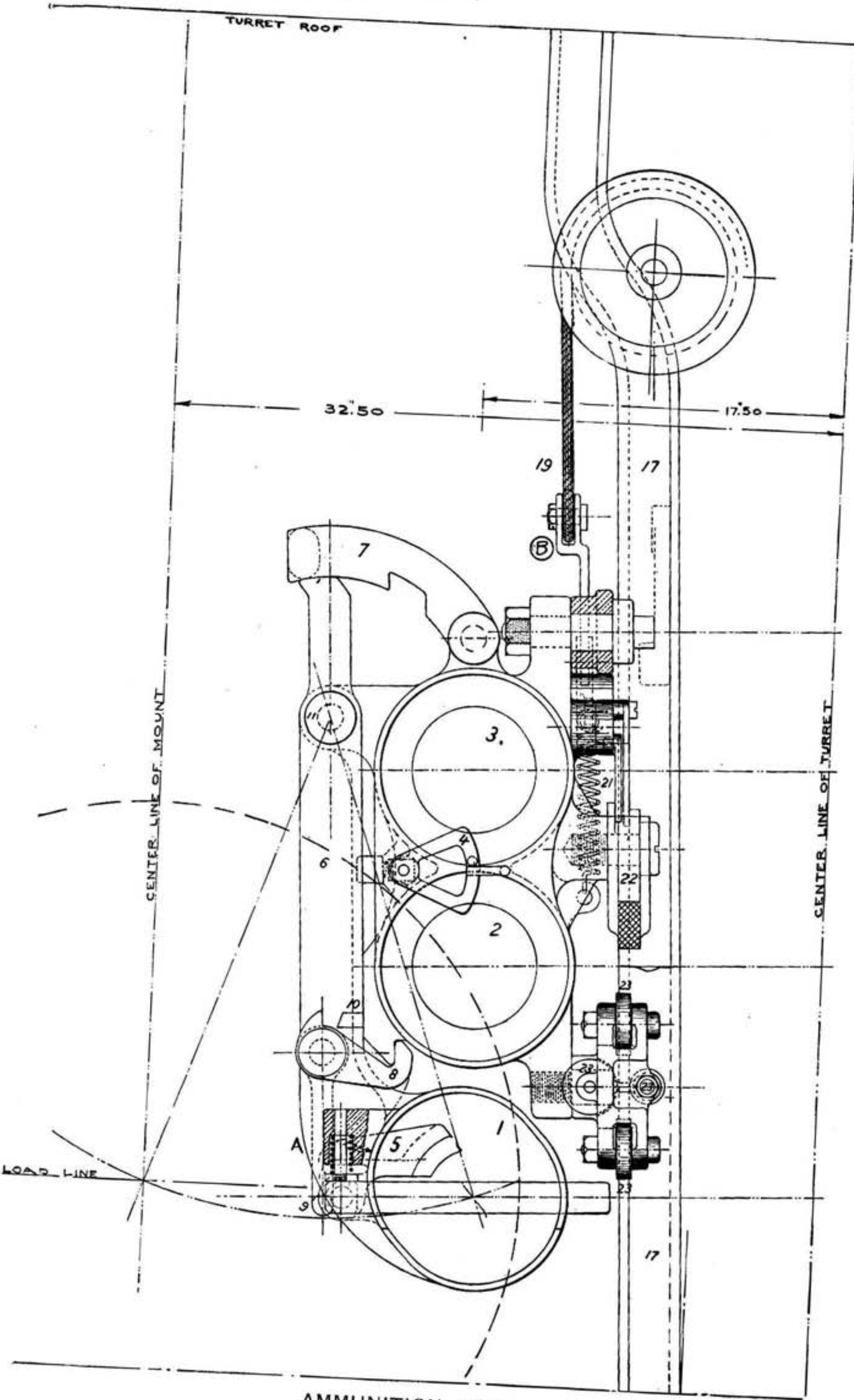
3. **The Rammers** (14) are of the chain telescopic type, driven by motors (15) placed beneath the rammer casing. The rammers work in about the same manner as do those of the Mark IV 12-inch installation; the different sections, however, are not concentric and the driving chains are placed on their tops. The spring buffers are also arranged differently; that for shocks in running out is on top of the casing as shown; the other, for shocks of withdrawal, is inside the innermost section. The loading position is at level.

4. **The Ammunition Hoists** are worked by 8 H. P. motors (16) installed beneath the turret floor near the elevating motors; the motors gear with shafts, each of which bears on its inner end the drum (18) on which the hoisting cable (19) is wound. This cable, after passing over leaders, leads down and is secured to the ammunition car (20). The magazines and shell rooms open into a common handling room and the ammunition crews, with the entire turret installation, are under the immediate command of the turret officer. Because of the restricted size of the lower part of the barbette or ammunition tube—the diameter is fifty inches—it was not practicable to design a car that would hoist the projectile directly to the loading position. As at present designed, the car is hoisted to a fixed position, after which the projectile compartment is swung over by hand into the loading position.

The *ammunition car*, (as shown on Plates IV and V, it is slightly different from that of Plate II), is held to the guide rails (19) by double rollers that embrace the rails on three sides. The hoisting cable is secured to a short bell-crank lever (20), which



AMMUNITION CAR.
Back.

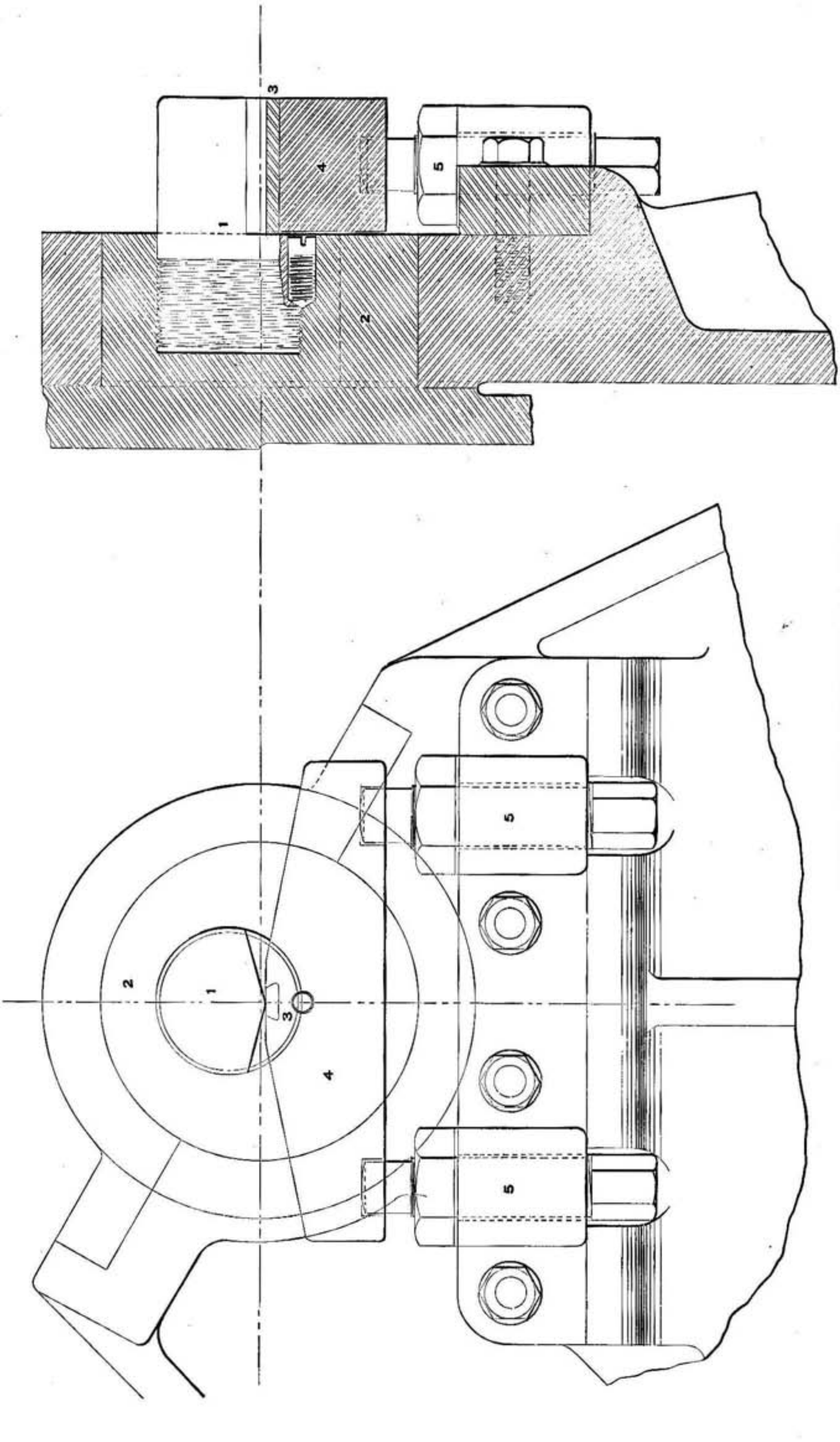


AMMUNITION CAR.
Rear view.

is held up as long as the weight of the car is on the cable; should the latter break, the spring (21) will draw the end of the bell crank downward and, by the connecting rods, force the lower ends of the pawls (22) outward and the car will be caught and held on the lugs on the inner edges of the guide rails. The two sections of the powder charge, both retained in place by one powder catch (4), are hoisted in the upper compartments (2) and (3); it is intended to transfer the powder from the car to the gun by hand. The projectile compartment (1), not of the same casting with the upper compartment, is pivoted to the upper part of the car by the long lever (6) and during loading is handled as follows: The car having been hoisted up to the stops, one of the gun servants grasps the handle (9) and draws it toward him. This handle first swings outward on its pivot, disengaging the hook (8), until brought up by the lug (10), whereupon the shell carrier (1) swings outward on the pivot (11) until the pawl (7) engages the upper end of the lever and the projectile is held in line with the bore. The shell latch (5) having been raised, the chain rammer sends the projectile home, is withdrawn, and the pawl (7) is raised, permitting the shell carrier to swing back into place.

5. **Knife Edge Trunnion Bearings** (Plate VI) are fitted to many guns of 8-inch calibre and upwards to relieve the friction of the trunnions, caused by the great weight of the gun bearing on the trunnion seats, and thus require less powerful elevating machinery. The small trunnions (1) are screwed into the faces of the ordinary slide trunnions (2) and their lower sides are faced away, forming knife edges nearly in prolongation of the center line of the slide trunnions. The supporting bar (4), into which it dovetailed a very hard steel face (3), is so adjusted by the bolts (5) that the knife edge is given a firm bearing, taking the weight of the gun. When not in use the supporting bar should be lowered until the gun rests entirely in its ordinary trunnion seats. To prepare for firing, or for exercise, the bar is leveled and raised until a thin piece of paper can be inserted beneath (2); the elasticity of the bar (4) permits the greater part of the shock of discharge to act on the trunnion seats.

6. **Counter-recoil Checks for Turret Mounts.**—Because of the necessity of mounting turret guns with their trunnions close



KNIFE EDGE TRUNNION BEARING.

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to the gun port and thus keeping down the area of the port openings for required arcs of elevation, it is not practicable to have front cylinder bonnets of sufficient length to accommodate the "dash-pot" checks employed in the intermediate mounts. The device for the 8-inch mount, Mark XII (Plate III) is the same as the "dash-pot" in principle, but arrives at the result without lengthening the cylinder bonnet. In the front end of the piston rod is a counterbore that receives a grooved rod which is firmly screwed into the front bonnet. During recoil, the piston rod is drawn to the rear and the counterbore fills with the recoil liquid; then, as the gun returns to battery, this liquid is forced out again by the grooved rod, as it enters the counterbore, and the counter recoil is cushioned.

The Balancing of Turrets, Forms of Armor, Loading Positions, Etc.

7. **Hydraulic Turret Mounts,** of U. S., and the earlier foreign ships, are installed in round turrets; the diameter must be great enough to give room in rear of the guns for performing the loading operations, for the recoil, etc., but so great a *transverse* dimension is not necessary and much waste space is left at the sides, in addition to the disadvantage of presenting a broad target. The barbette must be of even greater diameter, to permit the turret to rest inside of it, affording more waste space and adding to the uneconomically disposed weight of armor. The guns and their mountings must be installed close to the gun port and an "unbalanced" turret, whose center of gravity does not coincide with the center of rotation, is the result; the center of gravity of all the revolving parts of the "Indiana's" 13-inch turrets is about four feet from the center of rotation. When both of these turrets are trained abeam on the same side, the effect is that of moving several hundred tons four feet from the center line and giving the ship a list that immerses the side armor on the engaged side and places her in an unfavorable position for receiving fire. Also, in an unbalanced turret of this kind, greater power is required in training, particularly if the ship is listed and the turret moving "up hill," and more powerful motors must be installed; the control of train-

ing machinery is difficult, since the turret will run "down hill" with ease and be made to revolve in the other direction only with great effort.

In later ships, the barbettes are round but of smaller diameter and the turrets are placed on top, instead of resting below the upper edge. The turrets are oval-shaped instead of being round, and overhang the barbette in rear of the guns enough to bring the center of gravity of the moving parts in coincidence with the center of rotation. Weight is saved by these balanced turrets, the size of target is reduced, the ship will not list when turrets are trained abeam and the motors, having the same effort to make under all conditions, run easily and smoothly and are readily controlled.

The fronts of the earlier turrets are all vertical cylindrical surfaces, make large targets, and have large port openings; in more recently constructed turrets, the port plates are plane, inclined from 40° to 45° to the vertical and have smaller gun ports for the same arc of elevation. The turret roof is sometimes sloped downward from the rear, at a small angle, making part of the target too oblique for projectiles to bite. The sides and rear of the turret are made slightly thinner than the barbette and turret front, which are about the same in thickness. Most turret and barbette armor is backed with wood. In all turrets, automatic cut-offs stop the turning motors as the limit of train in either direction is approached.

In all turret mounts of U. S. ships, the guns are loaded in any position in train and in but one position in elevation—except in the pneumatic turrets of the "Terror," which load in any position, and a few 8-inch turrets using only hand rammers, which load in any position *near* the level point. Formerly, many turret guns, particularly those of foreign navies, could be loaded in but one, or at best two, positions in train and the turrets were laid in those positions before the rammer could act or the ammunition be hoisted; a great waste of time is involved in such systems of loading. It is possible, as has been done abroad, to install the rammer on an arm extending rearward from the gun slide, lock the ammunition car to the slide as well, and thus load in any position,—since car and rammer will follow the breech of the gun and keep in line with the bore, irrespective of any change in elevation; as can readily be seen by an inspection of the longitudinal section of a turret, either the height of the turret or the diameter of the barbette must be greatly increased to make the installation of this system possible. If the loading position is fixed at level, as in our later turrets for instance, the gun may be pointed as soon as the rammer is withdrawn after loading the last powder sections and, during the few seconds occupied in completing the loading and sending the car down, the target should be picked up and the pointer ready to fire as soon as he receives the "ready" signal. Thus, little if any decrease in the rate of fire should be occasioned by the restriction of one loading position in elevation, and the weight of armor is kept down by adhering to it.

The Respective Advantages and Disadvantages of Steam, Pneumatic, Hydraulic and Electric Motive Power for Turret Mounts.

8. The rapidity and accuracy of the aimed fire of a turret gun are controlled to a large extent by machinery—the elevating and training gear, the ammunition hoist, the rammer, etc. The motive power, by which this machinery is operated, materially influences the general efficiency of the mounting and on this point there is much difference of opinion. Summing up the views of ordnance engineers of this and of foreign countries, the advantages and disadvantages of the four kinds of power are put forth as follows:

Steam.—Steam engines with their pipe leads, valves, etc., which radiate much heat, will, even when carefully designed, greatly overheat the lower decks and compartments which are difficult to ventilate; in addition to this, they are next to impossible inside a turret, owing to the danger of scalding the crews in the likely contingency of joints being damaged and pipes broken in action. The only practicable utilization of this power is for training, as is done in U. S. hydraulic and the earlier 8-inch turret mounts. But, because of the difficulty in getting control,—through a long system of levers that invariably has much lost motion,—that will give slow movements and quick starting and stopping powers, steam engines are not suitable as turning machinery. Besides, in consequence of the intermittent nature of the work done, there is likelihood of complete failure, due to the condensation of steam in the cylinders and long pipe leads. This may be overcome by a properly designed system of draining, but it would add complications. The sole advantage of steam actuated machinery lies in the lightness of the installation.

Compressed air has one great advantage compared with steam: —no return pipe is required, as all motors may exhaust into the atmosphere, materially assisting ventilation, but the noise of the free exhaust is objectionable. Unless all the motors are made very large and cumbersome, compressed air must, to obtain the power necessary, be worked at a very high pressure, and a damaged pipe might therefore cause a serious explosion. The air compressing machinery must be large and heavy or be run at a high speed; thus, if the air be compressed only to a reasonably safe pressure, weight and power must be uneconomically used. The control system is necessarily similar to that required by steam and is nearly as inaccurate; both steam and air are inherently defective because of their compressible elasticity.

Hydraulic power, the favorite in the British navy, is used in U. S. hydraulic turrets as previously described and in a few turrets for training purposes as well; it is the only power that approaches the suitability of electricity as a motive power. The pipes, giving out no heat, may be laid anywhere, the system is economical and not of great weight, no explosion is possible, if damage occurs, the exact place can be readily discovered, and it may be utilized to return the guns to battery. Its disadvantages, when compared with electric power, are that any damage is difficult of repair and hand power gear is not easily substituted for hydraulic motors; the enormous pressures make joints difficult to pack tightly and they are all likely to leak badly after a few shocks and cause much inconvenience, to say the least, in the handling room; with these high pressures, bad water hammers will occur when a motor is suddenly stopped and, even when handled by experienced men, they frequently give out. Either the motors must be installed near the control stations or mechanical connections, involving lost motion, be employed; in either case little success has been met in obtaining the fine and immediate

TURRET MOUNTS, U. S. NAVY.

	MOUNTS.							GUNS.			
No.	Vessel.	Mark of mount.	Type of mount.	Loading point.	Depression.	Elevation.	Train.	Number of Gun.	Caliber.	Recoil.	Breech mech. mark.
1	Illinois	13″ Mark IV	Spring Ret. H. Bal.	2° Elevation	5°	15°	270°	29 to 32	35	39″	II
2	Wisconsin	13 Mark IV	Spring Ret. H. Bal.	2 Elevation	5	15	270	25 to 28	35	39	II
3	Alabama	13 Mark IV	Spring Ret. H. Bal.	2 Elevation	5	15	270	21 to 24	35	39	II
4	Kentucky	13 Mark III	Spring Ret. H. Bal.	2 Elevation	5	15	270	17 to 20	35	39	II
5	Kearsage	13 Mark III	Spring Ret. H. Bal.	2 Elevation	5	15	270	14, 15, 16, 33	35	39	II
6	Oregon	13 Mark II	Hydraulic	10 Elevation	5	15	270	5 to 8	35	52	I
7	Massachusetts ..	13 Mark II	Hydraulic	10 Elevation	5	15	270	9 to 12	35	52	I
8	Indiana	13 Mark II	Hydraulic	10 Elevation	5	15	270	....	35	52	I
9	Georgia	12″ Mark V	Spring Ret. H. Bal.	....	..	..	..	....	40	..	..
10	Nebraska	12 Mark V	Spring Ret. H. Bal.	....	..	..	..	....	40	..	..
11	New Jersey	12 Mark V	Spring Ret. H. Bal.	....	..	..	..	....	40	..	..
12	Rhode Island ...	12 Mark V	Spring Ret. H. Bal.	....	..	..	..	....	40	..	..
13	Virginia	12 Mark V	Spring Ret. H. Bal.	....	..	..	..	....	40	..	..
14	Ohio	12 Mark IV	Spring Ret. H. Bal.	Level	5	15	270	....	40	33	VI
15	Missouri	12 Mark IV	Spring Ret. H. Bal.	Level	5	15	270	....	40	33	VI
16	Maine	12 Mark IV	Spring Ret. H. Bal.	Level	5	15	270	23 to 26	40	33	VI
17	Nevada	12 Mark IV	Spring Ret. H. Bal.	Level	3	15	300	19 and 20	40	33	VI
18	Florida	12 Mark IV	Spring Ret. H. Bal.	Level	3	15	300	21 and 22	40	33	VI
19	Arkansas	12 Mark IV	Spring Ret. H. Bal.	Level	3	15	300	17 and 18	40	33	VI
20	Wyoming	12 Mark IV	Spring Ret. H. Bal.	Level	3	15	300	15 and 16	40	33	VI
21	Iowa	12 Mark III	Spring Ret. H. Bal.	3 Elevation	5	14	270	9 to 12	35	38	V
22	Texas	12 Mark II	Hydraulic	Level	4	15	..	3 and 4	35	48	III
23	Puritan	12 Mark I	Hydraulic	9½ Elevation	3	15	270	5 to 8	35	48	IV
24	Monterey	12 Mark I	Hydraulic	9½ Elevation	3	15	270	1 and 2	35	48	II
25	Terror	10″ Mark IV	Pneumatic	Any	3	13	270	17 to 20	30	40	IV
26	Monadnock	10 Mark II	Hydraulic	10 Elevation	3	15	270	13, 14, 21, 22	30	40	V
27	Amphitrite	10 Mark II	Hydraulic	10 Elevation	3	15	270	7, 8, 11, 12	30	40	V
28	Monterey	10 Mark II	Hydraulic	10 Elevation	3	15	270	5 and 6	30	40	II
29	Miantonomoh ...	10 Mark I	Hydraulic	13½ Elevation	3	13½	270	1 to 4	30–34	40	I
30	Georgia	8″ Mark	Superposed	....	..	..	..	....	45	..	..
31	Georgia	8 Mark	Spring Ret. H. Bal.	....	..	..	..	....	45	..	..
32	Nebraska	8 Mark	Superposed	....	..	..	..	....	45	..	..
33	Nebraska	8 Mark	Spring Ret. H. Bal.	....	..	..	..	....	45	..	..
34	New Jersey	8 Mark	Superposed	....	..	..	..	....	45	..	..
35	New Jersey	8 Mark	Spring Ret. H. Bal.	....	..	..	..	....	45	..	..
36	Rhode Island	8 Mark	Superposed	....	..	..	..	....	45	..	..
37	Rhode Island	8 Mark	Spring Ret. H. Bal.	....	..	..	..	....	45	..	..
38	Virginia	8 Mark	Superposed	....	..	..	..	....	45	..	..
39	Virginia	8 Mark	Spring Ret. H. Bal.	....	..	..	..	....	45	..	..
40	California	8 Mark XII	Spring Ret. H. Bal.	Level	7	20	270	....	45	24	V
41	South Dakota ...	8 Mark XII	Spring Ret. H. Bal.	Level	7	20	270	....	45	24	V
42	West Virginia ...	8 Mark XII	Spring Ret. H. Bal.	Level	7	20	270	....	45	24	V
43	Maryland	8 Mark XII	Spring Ret. H. Bal.	Level	7	20	270	....	45	24	V
44	Colorado	8 Mark XII	Spring Ret. H. Bal.	Level	7	20	270	....	45	24	V
45	Pennsylvania ...	8 Mark XII	Spring Ret. H. Bal.	Level	7	20	270	....	45	24	V
46	Kentuck	8 Mark IX	Superposed	Level	7	14	270	77 to 80	35	24	III
47	Kearsarge	8 Mark IX	Superposed	Level	7	14	270	73 to 76	35	24	III
48	Iowa	8 Mark VIII	Spring Return	Level	7	13	..	61 to 68	35	24	III
49	Brooklyn	8 Mark VIII	Spring Return	Level	7	13	..	53 to 60	35	24	III
50	Oregon	8 Mark VII	Spring Return	Level	7	13	120	30, 31, 32, 38, 39, 40, 43, 47	35	24	III
51	Massachusetts ..	8 Mark VII	Spring Return	Level	7	13	120	41, 42, 44, 45, 46, 48, 49, 50	35	24	III
52	Indiana	8 Mark VII	Spring Return	Level	7	13	120	22 to 29	35	24	III
53	Olympia	8 Mark VI	Gravity Return	Level	4	13	..	34 to 37	35	28	III
54	New York	8 Mark V	Gravity Return	Level	4	13	..	16 to 21	35	28″	I

		RECOIL SYSTEM.								
					Cylinders.					
							Springs number of		Liquid. Gallons.	
No.	Vessel.	Recoil, how checked.	Method of returning Gun to battery.	Counter recoil check.	No.	Test. Steel.	Upper.	Lower.	Upper.	Lower.
1	Illinois	Springs & Liquid	Springs	Plunger on Head	4	1000	8	12	40	49
2	Wisconsin	Springs & Liquid	Springs	Plunger on Head	4	1000	8	12	40	49
3	Alabama	Springs & Liquid	Springs	Plunger on Head	4	1000	8	12	40	49
4	Kentucky	Springs & Liquid	Springs	Plunger on Head	4	1000	11	11	44	44
5	Kearsage	Springs & Liquid	Springs	Plunger on Head	4	1000	11	11	44	44
6	Oregon	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
7	Massachusetts	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
8	Indiana	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
9	Georgia	Springs & Liquid	Springs	....	2	....	..	..	..	..
10	Nebraska	Springs & Liquid	Springs	....	2	....	..	..	..	..
11	New Jersey	Springs & Liquid	Springs	....	2	....	..	..	..	..
12	Rhode Island	Springs & Liquid	Springs	....	2	....	..	..	..	..
13	Virginia	Springs & Liquid	Springs	....	2	....	..	..	..	..
14	Ohio	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5
15	Missouri	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5
16	Maine	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5
17	Nevada	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5
18	Florida	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5
19	Arkansas	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5
20	Wyoming	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5
21	Iowa	Springs & Liquid	Springs	Plunger on Head	5	3500	12	12	35.7	35.7
22	Texas	Hydraulic	Gun Motor	Buffer Springs	1	3500	None	None	..	..
23	Puritan	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
24	Monterey	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
25	Terror	Pneumatic	Pneumatic	Buffer Springs	2	3500	..	..	..	..
26	Monadnock	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
27	Amphitrite	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
28	Monterey	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..
29	Miantonomoh	Hydraulic	Hydraulic	Buffer Springs	1	6000	..	..	..	..
30	Georgia	....	....	....	.	....	..	..	..	..
31	Georgia	....	....	....	.	....	..	..	..	..
32	Nebraska	....	....	....	.	....	..	..	..	..
33	Nebraska	....	....	....	.	....	..	..	..	..
34	New Jersey	....	....	....	.	....	..	..	..	..
35	New Jersey	....	....	....	.	....	..	..	..	..
36	Rhode Island	....	....	....	.	....	..	..	..	..
37	Rhode Island	....	....	....	.	....	..	..	..	..
38	Virginia	....	....	....	.	....	..	..	..	..
39	Virginia	....	....	....	.	....	..	..	..	..
40	California	Springs & Liquid	Springs	Plunger on Head	2	1000	..	5	..	..
41	South Dakota	Springs & Liquid	Springs	Plunger on Head	2	1000	..	5	..	..
42	West Virginia	Springs & Liquid	Springs	Plunger on Head	2	1000	..	5	..	..
43	Maryland	Springs & Liquid	Springs	Plunger on Head	2	1000	..	5	..	..
44	Colorado	Springs & Liquid	Springs	Plunger on Head	2	1000	..	5	..	..
45	Pennsylvania	Springs & Liquid	Springs	Plunger on Head	2	1000	..	5	..	..
46	Kentuck	Springs & Liquid	Springs	Plunger on Head	2	2000	..	6	..	14.5
47	Kearsarge	Springs & Liquid	Springs	Plunger on Head	2	2000	..	6	..	14.5
48	Iowa	Springs & Liquid	Springs	Dash-Pot	3	2000	..	6	..	10.2
49	Brooklyn	Springs & Liquid	Springs	Dash-Pot	3	2000	..	6	..	10.2
50	Oregon	Springs & Liquid	Springs	Dash-Pot	3	3500	..	6	..	10.2
51	Massachusetts	Springs & Liquid	Springs	Dash-Pot	3	3500	..	6	..	10.2
52	Indiana	Springs & Liquid	Springs	Dash-Pot	3	3500	..	6	..	10.2
53	Olympia	Liquid	Gravity	Buffer Springs	1	2100	..	..	..	9.7
54	New York	Liquid	Gravity	Buffer Springs	1	2100	..	..	..	9.7

		OPERATING MECHANISM.												
		Training Gear.		Elevating Gear.			Ammunition Hoist.			Rammer.				
No.	Vessel.	H. P.	Power.	H. P.	Power.	Method of relieving shock.	H. P.	Power.	Type of Car.	H. P.	Power.	Type.	REMARKS.	No.
1	Illinois	50	Electric	3½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Mark III and IV Motors are 80 Volts.	1
2	Wisconsin	50	Electric	3½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	....	2
3	Alabama	50	Electric	3½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Triple Recoil Springs in 13″ Mounts Mark III and IV.	3
4	Kentucky	50	Electric	2½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Mark III Hoist Motors are 160 Volts.	4
5	Kearsage	50	Electric	2½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	First Mount having "wave," or "Kearsarge," Car.	5
6	Oregon	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	Mark II—Turret secured by chocks when at sea.	6
7	Massachusetts	..	Steam	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	13″ Mounts:—Right-hand are even numbers.	7
8	Indiana	..	Steam	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	....	8
9	Georgia	..	Electric	..	....	....	..	Electric	....	..	....	....	....	9
10	Nebraska	..	Electric	..	....	....	..	Electric	....	..	....	....	....	10
11	New Jersey	..	Electric	..	....	....	..	Electric	....	..	....	....	....	11
12	Rhode Island	..	Electric	..	....	....	..	Electric	....	..	....	....	....	12
13	Virginia	..	Electric	..	....	....	..	Electric	....	..	....	....	....	13
14	Ohio	35	Electric	3½	Motor & Hand	None	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	....	14
15	Missouri	35	Electric	3½	Motor & Hand	None	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	....	15
16	Maine	35	Electric	3½	Motor & Hand	None	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Mark III and IV Motors are 80 Volts.	16
17	Nevada	35	Electric	3½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Last Mount having Elevating Dash-Pots.	17
18	Florida	35	Electric	3½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	....	18
19	Arkansas	35	Electric	3½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Triple Recoil Springs in 12″ Mounts Mark III and IV.	19
20	Wyoming	35	Electric	3½	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Last Mount having Heart shaped Trunnions.	20
21	Iowa	..	Hydraulic	..	Hand	Dash-Pots	..	Hydraulic	3 Cylinder	5	Motor & Hand	Rotary	....	21
22	Texas	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	"Kearsarge"	..	Hydraulic	Hydro-Pneumatic	1000 lbs. Working Pressure.	22
23	Puritan	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	12″ Guns:—Right-hand even numbers.	23
24	Monterey	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	....	24
25	Terror	..	Pneumatic	..	Hydro-Pneumatic	None	..	Pneumatic	"Kearsarge"	..	Pneumatic	Telescopic	40 Atmospheres for Recoil Cylinders, 11 for Elevating &c.	25
26	Monadnock	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	All Hydraulic Pressures are 600 lbs. sqr. in.	26
27	Amphitrite	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	Mounts in Forward Turrets Lowest number.	27
28	Monterey	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	10″ Mounts:—Right-hand are even numbers.	28
29	Miantonomoh	..	Steam.	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydraulic	No rifling in Recoil Cylinders—12 Relief Valves.	29
30	Georgia	..	....	..	....	....	..	....	....	..	....	....	....	30
31	Georgia	..	....	..	....	....	..	....	....	..	....	....	....	31
32	Nebraska	..	....	..	....	....	..	....	....	..	....	....	....	32
33	Nebraska	..	....	..	....	....	..	....	....	..	....	....	....	33
34	New Jersey	..	....	..	....	....	..	....	....	..	....	....	....	34
35	New Jersey	..	....	..	....	....	..	....	....	..	....	....	....	35
36	Rhode Island	..	....	..	....	....	..	....	....	..	....	....	....	36
37	Rhode Island	..	....	..	....	....	..	....	....	..	....	....	....	37
38	Virginia	..	....	..	....	....	..	....	....	..	....	....	....	38
39	Virginia	..	....	..	....	....	..	....	....	..	....	....	....	39
40	California	..	Electric	..	Hand	Friction Disks	..	Electric	3 Cylinder	..	Electric	Chain	....	40
41	South Dakota	..	Electric	..	Hand	Friction Disks	..	Electric	3 Cylinder	..	Electric	Chain	....	41
42	West Virginia	..	Electric	..	Hand	Friction Disks	..	Electric	3 Cylinder	..	Electric	Chain	....	42
43	Maryland	..	Electric	..	Hand	Friction Disks	..	Electric	3 Cylinder	..	Electric	Chain	....	43
44	Colorado	..	Electric	..	Hand	Friction Disks	..	Electric	3 Cylinder	..	Electric	Chain	Mark VIII, IX and XII Motors are 80 Volts.	44
45	Pennsylvania	..	Electric	..	Hand	Friction Disks	8	Electric	3 Cylinder	..	Electric	Chain	Recoil Springs interchangeable with 12″ and 13″.	45
46	Kentuck	..	Electric	..	Hand	Thrust Spring	6	Electric	3 Cylinder	..	None	None	Mark IX Hoist Motors are 160 Volts.	46
47	Kearsarge	..	Electric	..	Hand	Thrust Spring	6	Electric	3 Cylinder	..	....	....	Mark V, VI and VII Motors are 80 Volts.	47
48	Iowa	..	Steam	..	Hand	Dash-Pots	7	Electric	3 Cylinder	..	....	....	Fitted with Hand Gear also, for training.	48
49	Brooklyn	52	Steam & Elec.	..	Hand	Dash-Pots	7	Electric	3 Cylinder	..	....	....	....	49
50	Oregon	..	Steam	..	Hand	Spring rear of worm	7	Electric	3 Cylinder	..	....	....	Liquid mixture contains 4 parts Glycerine—1 part Water.	50
51	Massachusetts	..	Steam	..	Hand	Spring rear of worm	7	Electric	3 Cylinder	..	....	....	8″ Marks V, VI, VII and VIII:—Double Hoist.	51
52	Indiana	..	Steam	..	Hand	Spring rear of worm	7	Electric	3 Cylinder	..	....	....	Double Springs in 8″ Mounts Mark VII, VIII and IX.	52
53	Olympia	20	Electric	..	Hand	Friction Disks	6	Electric	3 Cylinder	..	....	....	Cylinders made of Bronze in (53) and (54).	53
54	New York	..	Steam	..	Hand	Friction Disks	8	Electric	3 Cylinder	..	....	....	Hoist extends to Turret Floor only.	54

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Back of large foldout table

control that is essential in the motive machinery of the pointing gear; it is interesting to know that in British naval turrets, where hydraulic training gear is extensively employed, electric motors are employed to run the supply pumps of the hydraulic system.

Electric power is used in the turret mounts of late U. S. ships to the exclusion of all others. The ship's generators, which are necessarily installed for other purposes anyhow, are utilized and the weight of pumping machinery and piping is saved. The wires may be led anywhere, an explosion is impossible and a broken connection can be readily repaired; the control station may be at any distance from the motor which may be tucked away in any safe secure place, utilizing waste space and giving more room in the turret; safety devices, which make damage by improper handling nearly impossible, may be easily fitted; hand gear is easily substituted for any damaged motor and the turret is never flooded by leaky pipes and joints; the great advantage lies in the extreme sensitiveness to control of the gun-pointing machinery, by which a turret or gun may be started and stopped in a small fraction of a degree; any motor may be reversed when running at full speed,—a proceeding that would sadly strain a hydraulic motor. The only disadvantages are that the installation is rather heavy, gear trains are required for most of the motors, which must have a high speed of rotation, and that difficulty is often experienced in discovering the cause of a failure. Electric machinery for operating turret mounts, as for most other purposes, is, in the United States, considered greatly superior to any other.

9. Plate VII gives statistics for U. S. turret ships. The table was compiled in 1902 and at that time contained statistics of all turrets then designed—in so far as the details had been decided upon.

CHAPTER XVII.

FIRING ATTACHMENTS.

1. In United States naval guns, the term "*firing mechanism*" is used to designate that part of the breech mechanism which directly explodes the primer and thus fires the gun. The "*firing attachments*" comprise those appliances, fitted to the gun and mount, which put the firing mechanism in operation. The lock lanyard, electric firing battery, wires, terminals, firing key, etc., are "*attachments*." The two terms, firing *mechanism* and firing attachments, must not be confused.

In addition to friction primers, now considered obsolete except for torpedo discharge, two methods are employed in firing guns,—by electric and by percussion primers. The latter method is most suitable, and is used exclusively, for the small guns of the secondary battery, while the first method is mainly used for the larger guns, it being more satisfactory for the following reasons:

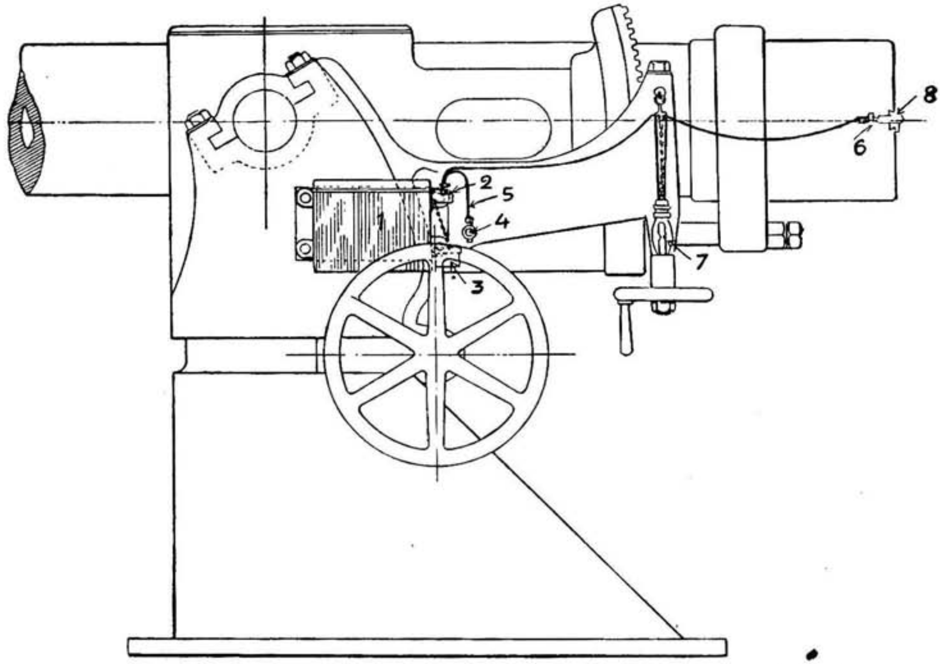
(a) Electric primers are less liable to cause accidents than are percussion or friction primers containing fulminate of mercury; the electric firing circuit may have as many "breaks" as are considered necessary, which are automatically closed only when the gun is in all respects ready for firing, thus making premature discharge impossible; the primers contain no explosive of the sensitiveness of the fulminates and consequently permit rougher handling; several serious explosions have been caused abroad by the blow of the breech block, while being closed in the ordinary manner, against the base of the percussion-primed cartridge case.

(b) Electric primers shorten the "firing interval," or the time that elapses between the instant the gun pointer wills to fire and the instant the projectile leaves the muzzle. This interval, which on the average is about $\frac{3}{10}$ of a second, has two factors: (a) the personal factor (which is much the greater), depending on the pointer's quickness and nerve, and (b) the time consumed by the travel of the projectile along the bore and by the mechanical action of the firing devices. With electric primers, the pointer's muscles act through a less distance and the passage of the current is more nearly instantaneous than is the action of the lock lanyard, sear, hammer, etc., and this part, at least, of the firing interval is reduced. Besides that advantage, the effort required to operate the firing key is very slight, the pointer may keep his hand upon it with safety and need never take his eye from the sight; if, while using percussion primers, the pointer's station is far from the breech of the gun it may be necessary for another man to pull the lanyard, at his command.

2. **Percussion firing** for the main battery guns is now retained only as an alternative when the electric current fails. Formerly (until 1899), separate primers were employed for the two kinds of firing and changing primers also necessitated changing from percussion to electric firing mechanisms and attachments, or vice versa; the 4-inch R. F. gun with Fletcher breech mechanism, shown on Plate I, is of this variety and the ammunition for it is either percussion or electric primed—both kinds being carried. At present, "combination" primers, which will explode either by electricity or by percussion, are used with all main battery guns, and the same firing mechanism may be used in either manner. If, because of the electrical failure of the primer or other reason, it be desired to fire by percussion, it may be done by the simple expedient of attaching a lanyard and pulling back the hammer or firing pin to the cocked position. This constitutes a desirable advantage, but, on the other hand, the combination primers also contain fulminate of mercury and are as sensitive and consequently as dangerous as are ordinary percussion primers. In the attachment shown on Plate I, to change to percussion primers, remove the firing wire and attachment lug (8) and replace the latter by a similarly shaped lug containing a trigger to which the lanyard is hooked.

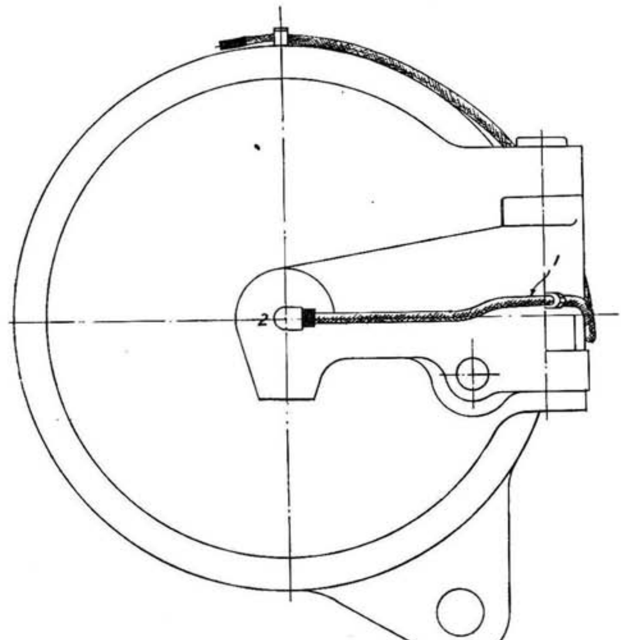
3. **The Electric Firing Attachments** shown in Plates II and III are for a 6-inch Q. F. gun—Vickers mechanism and automatic lock—and in Plates IV and V, the attachments for a 12-inch turret gun with Mark VIII lock. The attachment consists of the insulated firing wire (1) connected to the lug (2), the firing key (3),

CHAPTER XVII. PLATE I. Par. 2.

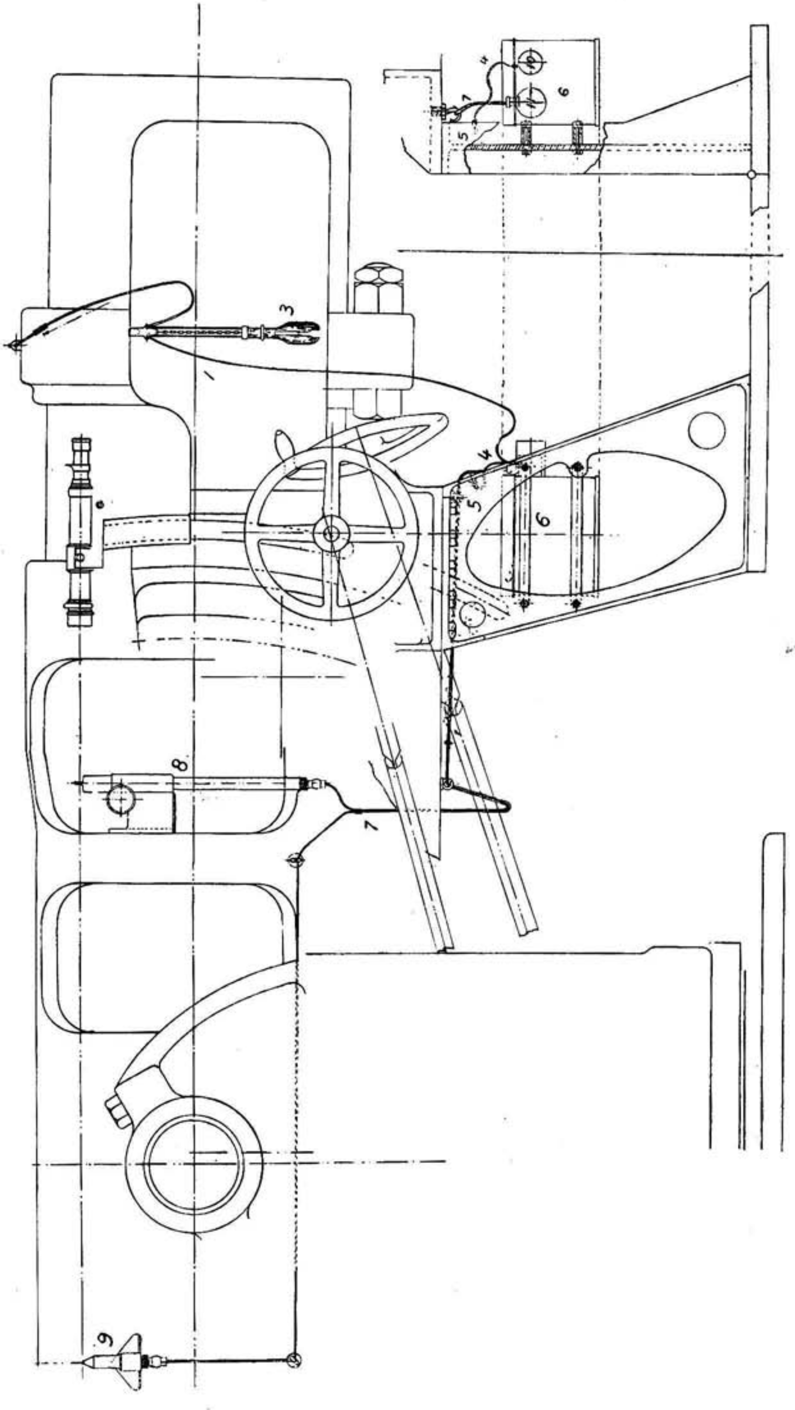


1. Battery box.
2. Battery terminals.
3. Cover.
4. Earth terminal.
5. Earth connection.
6. Gun terminal.
7. Firing key.
8. Attachment lug.

CHAPTER XVII. PLATE II. Par. 3.



ELECTRIC FIRING ATTACHMENTS OF 6-INCH Q. F.



ELECTRIC FIRING ATTACHMENTS OF 6-INCH Q. F.

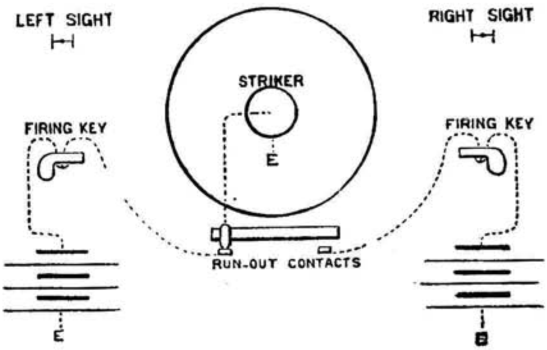
the battery (6), the earth connection (4), the earth terminal (5) and the battery terminals (10).

The *battery* consists of a number of Mesco dry cells connected in series—each cell sealed with pitch; the battery, having an average E. M. F. of 4 or 5 volts, resistance 1 ohm, is put up in a tightly covered "battery box" which is secured to a training part of the mount or turret. The poles are connected to the battery terminals, which are protected when the circuit is not in use by a screwed cover. The poles are also connected to the terminals (11), from which are led the connecting wires (7) to the night sights (8) and (9), as will be explained in a subsequent chapter.

One pole of the battery is connected to the gun carriage, or to the turret framing, by a short wire, with brass cones at each end. This wire is called the *earth connection* (4), and its ends go respectively to one of the battery terminals (10), and to a socket on the carriage or turret framing called the *earth terminal* (5).

From the other battery terminal is led the firing wire (1), in which is inserted the firing key (3), to the lock (2). The current thus passes from battery through firing wire and firing key to the lock and insulated firing pin which rests against the primer; after passing through and heating up the bridge of the primer, it goes to the grounded part of the primer, thence to gun, mount, earth terminal and earth connection, to the battery again.

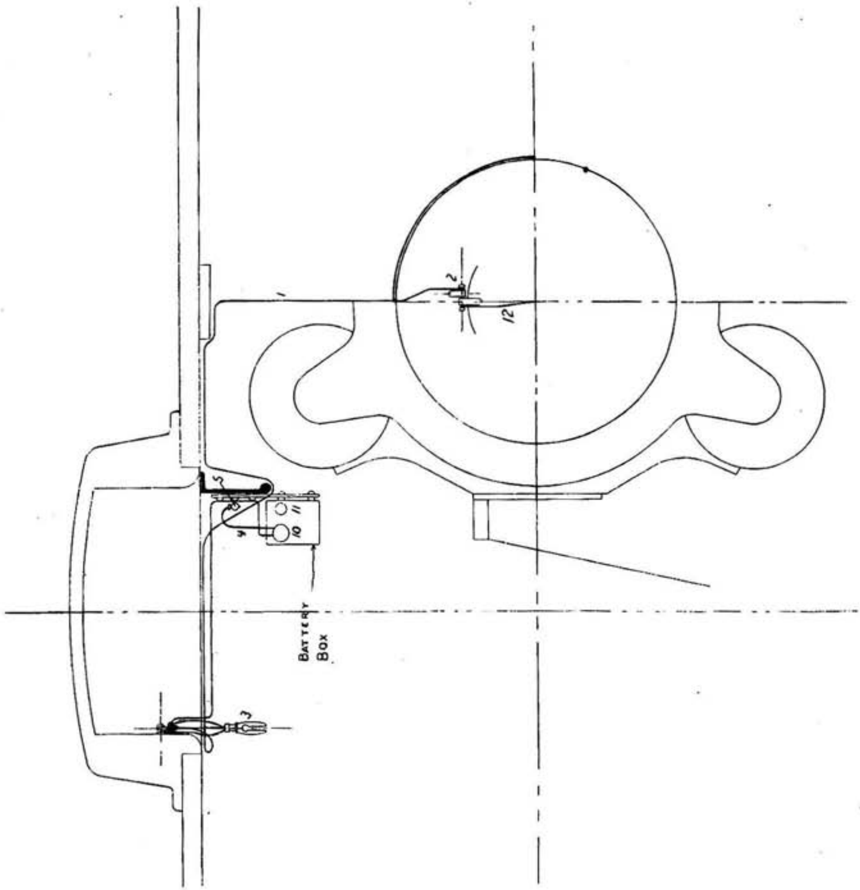
4. The Firing Key (3) consists of two pieces of wood, shaped to fit the hand and joined together at the smaller end. Each piece is fitted with a brass contact stud projecting from its inner face, the natural spring of the wood keeping the two parts separated and so maintaining, normally, a break between the studs. The adjacent ends of the two sections of the firing wire enter longitudinal holes, bored one in each part, and are secured by screws to the contact studs. Consequently the break in the firing wire is closed when a squeeze of the hand brings the contact pieces together. The other break is in the firing mechanism, both in guns of latest and of less recent type. In the rapid firing guns, the firing point does not connect with the primer, nor the contact point of the firing case with that of the attachment lug, until the breech is entirely closed. In the quick firing guns, also, the firing point is automatically pushed against the primer and the connection made only on completion of the fermeture. In turret guns, as is shown in Plate V, a short wire (12) leads from the contact lug (2) to the lock, at which the connection is made by closing the wedge of the lock. The contact points at (2) must touch before the circuit is completed, and this occurs only when the breech is entirely closed. These two "breaks" are considered a sufficient precaution against premature firing, and no accident, of that kind, has occurred with the electric attachment of U. S. naval guns.



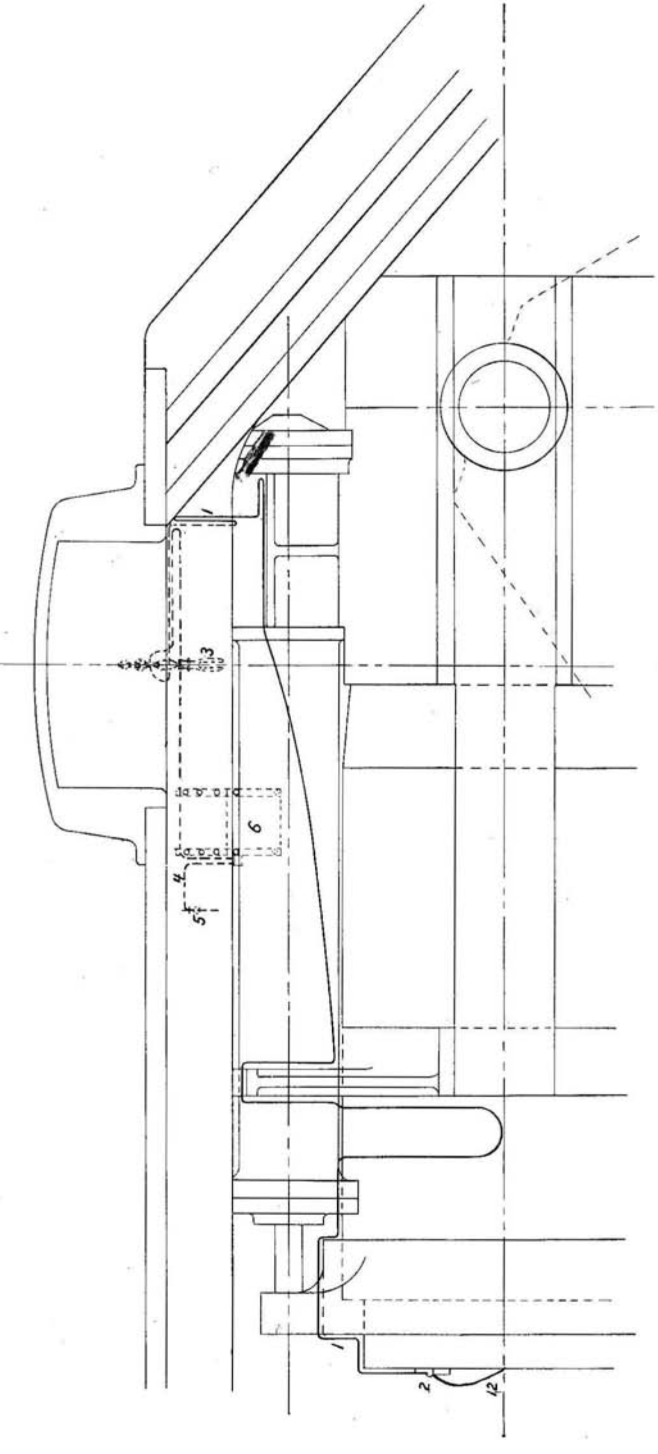
6-INCH RAPID-FIRE GUN CIRCUITS.

In the British navy an additional break, called the "run-out contact," is made in the circuit; the system is shown by the diagram. Two batteries are used, the run-out contact is made only when the gun is in battery and a trigger firing key instead of bulb is used. The trigger key with pistol grip has recently been adopted for the Q. F. and R. F. guns of the U. S. navy.

5. **Care of Electric Firing Attachments.**—While the firing batteries should remain unimpaired for several years, it frequently happens that some of the cells deteriorate from internal action, and consequently it is very necessary to keep a close watch on each battery in order to replace defective cells. For this purpose "battery testers" are supplied, consisting of a fuse bridge in circuit with a resistance coil such that, if the firing battery is in proper condition, it will illuminate the bridge without burning it out. Firing batteries should be tested daily by applying the points of the testers to the battery terminals, and if the current fails to



ELECTRIC FIRING ATTACHMENTS FOR TURRETS.



ELECTRIC FIRING ATTACHMENTS FOR TURRETS.

illuminate the bridge, the battery box should be opened, the trouble located, and the defective cell or cells replaced by new ones. Of course, if a battery be allowed to short circuit in any way, such as by connecting the terminals, it will run down, but beyond this no trouble with the batteries is to be anticipated save the occasional deterioration of single cells by local action. Above all it must be remembered that a battery which is in good condition will never give out suddenly—there is no possibility of a battery which tests properly in the morning failing in the afternoon. A battery will fire thousands of primers before it is exhausted and will fire hundreds more rapidly than any gun can be fired, without showing any material loss in strength. Consequently, if reasonable care is taken to watch the batteries, it need never be feared that they are at fault when a missfire occurs—the fault will most certainly be found to be somewhere in the circuit. Moreover, there is a practical certainty that the primer itself will not fail. Every primer is tested with a current after manufacture, and such an occurrence as an electrical primer, which will not explode with the ordinary current, is unknown at the naval proving ground where electric firing has been exclusively used for several years. Besides watching the batteries, then, the most important thing is to see that there is no break in the electric connections and no excessive resistance due to imperfect or dirty contacts. On guns other than those in turrets, the firing key and wire and the earth connections should be removed after exercise so as to allow putting the cover over the battery terminals, thus preventing short circuiting the battery by water or other means. The terminals of the wires and the contact studs of the firing key should be kept clean and free from grease, and they should be kept in a dry place. The electric firing pins and the attachment lugs may also be habitually kept off the rapid-fire guns, if thought desirable, except that attachment lugs which are secured by screws should be kept in place,—to prevent constant wear making the screws too loose. When the lug is kept on the gun its spring socket can be protected by keeping a soft wood plug in it.

In the case of turret guns, the connections at the battery terminals should be broken after exercise and the cover put on, but other portions of the attachments should be kept in place.

The daily test having shown that the firing battery is in good condition—the connections between the cells good and no cell run down—and examination having shown that all contact surfaces are clean and free from grease, it is only necessary, in order to prepare for firing, to seat the terminals of the firing wire and of the earth connection firmly in their respective sockets. If, after this, a missfire occurs, it may be considered as almost certainly due to one of the following things:

(1) *The shock of firing,* or some other cause, may have loosened one of the connections. This is the most frequent cause, and after a missfire no time should be lost in hunting elsewhere for the trouble until it has been determined that the connections are in order. With the attachments in use at present, the first discharge of a heavy gun will often jar the connections loose, no matter how carefully and firmly they be made. A few seconds should suffice to determine this and to remedy it.

(2) *A leaky primer* may have fouled the primer seat, or may have coated the point of the firing pin with an insulating residue. If there has been any escape of gas from the vent of a Q. F. or B. L. R. gun, the primer seat must be well cleaned before entering the next primer, and in case of a leaky primer in a R. F. cartridge case, the point of the firing pin should be wiped clean before the next fire.

(3) *Grease or dirt* may have coated some of the contact points, or even the primer itself. If other cause be not discovered, wipe all the contacts clean with a dry rag.

(4) *In rapid-fire guns the inner point of the firing pin* may have been struck by something and bent over so as to short circuit with the breech plug. If this has happened, it will be seen on opening the breech and can be remedied at once by bending the point back.

In guns of Q. F. and B. L. R. type the greatest pains should be taken to prevent any wear or erosion of the primer seat, as a very slight enlargement will result in gas leaks to the rear with possible disablement of the firing lock and injury to the gun servants. This will probably make it necessary to keep primer seats well coated with oil, and consequently one of the important things to do in preparing for firing exercises is to carefully wipe dry and clean the primer seats. A small pine stick and dry cotton waste will serve for this purpose.

In rapid-fire guns the surface of the cartridge case is so great that it is improbable that any amount of oil in the chamber will insulate the case from the gun. It will be a useful precaution, however, to wipe the face of the breech plug dry before commencing firing.

CHAPTER XVIII.

SIGHTS.

Definitions and General Principles.

1. In designing a gun with its mounting, there must be kept in view the requirements necessary to attain its two main objects: (a) After loading as rapidly as possible, to propel the projectiles successively along paths of the same curvature and to absorb the recoil without unduly straining any part; (b) to rapidly point the gun so as to impart an initial direction to the flight of the projectiles which will cause them to strike the target. The gun, including the breech mechanism and the recoil mechanism, have to do mainly with the requirements in (a); the sights and the training and elevating gears with those in (b).

There are two methods of laying guns—directing them so as to strike the target:—*direct* and *indirect* pointing.

Direct pointing is employed in firing with high powered guns when the target is in view from the gun emplacement; it is obviously the method generally used with guns afloat, and the only one in which naval men are seriously interested.

Indirect pointing is resorted to when the target cannot be seen from the gun; as in mortar firing from deep emplacements (the usual condition), and in field operations when the fire of a gun is to be directed at an enemy concealed by an eminence not in his immediate front. In one system, the elevation is obtained by laying the gun at an angle above the horizontal which will give the required range. This angle is measured by a "gunner's quadrant," an instrument adjusted to a machined surface on the gun which is parallel to the bore. The quadrant has a graduated arc of 90 degrees, along which one end of the limb travels and is clamped at the angle of elevation required; the limb, bearing a spirit level, is pivoted at the center of the quadrant. In pointing, the quadrant is set at the proper angle (measured or estimated), laid on the gun and the latter is elevated until the limb of the quadrant is level; the instrument is removed before firing.

For guns of position giving indirect fire, such as coast defense mortars, the mount is accurately leveled and the elevations may be read from a scale, on the elevating arc, graduated in degrees. Associated with such defenses, is a system of position finding, designed to measure the angular distance of the target from a fixed vertical reference plane; the guns are pointed laterally by training them through the same arc, measured on the graduated training circle, the zero point of which is, with the center of the mounting, in the reference plane. This method is only applicable to fixed guns on shore.

When the target is visible from some point sufficiently near to communicate with the gun, an auxiliary mark, which is visible from the gun, is set up and the sights, set at an estimated elevation, are directed at it. An observer notes the fall of the projectile and alters the position of the mark and the setting of the sights until the target is hit. The latter method is the practical one for naval forces operating on shore; with any system of indirect pointing, an observer, who can see the fall of the shot and thus correct errors in the pointing, is essential.

2. **The Trajectory** is the curve described by the projectile in passing from the muzzle of the gun to the point of impact; its vertical curvature is due to the force of gravity. In most cases, there is also a slight lateral curvature caused by the rapid rotation of the projectile on its axis, imparted by the rifling; this deviation from the vertical plane of fire, called the *drift*, is to the right for right-handed rifling, and is corrected by a permanent shop adjustment of the sight.

The *axis* of the *bore* is its geometrical axis; the axis of the trunnions, which, in firing, is supposed to be horizontal, is their common geometrical axis; it is at right angles to the axis of the bore.

The *line of sight* is a straight line through the two sight points which, in the act of firing, also includes the target.

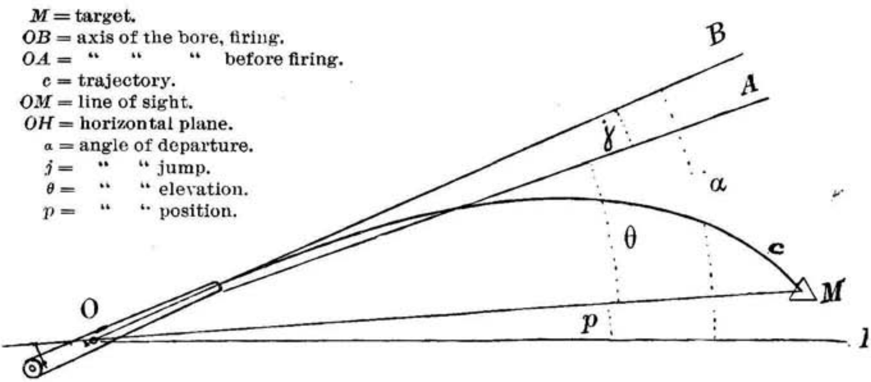
The *line of departure* is the line in which the projectile is moving as it leaves the gun, or is a tangent to the trajectory at that point.

The *jump* is the small vertical angle, usually upward, which the axis of the bore describes in the act of firing; it is due to the straining of the mount. It is determined experimentally and is applied as an index correction in marking the sights.

The *angle of position* is the angle included between a line passing through the gun and target and the horizontal plane; for all practical purposes, this angle disappears when gun and target are afloat.

The *angle of elevation* is the vertical angle between the line of sight and the axis of the bore.

The *angle of departure* is that included between the line of departure and the horizontal plane; it is the algebraical sum of the angles of elevation, jump and position.



The *range* is the linear distance from the gun to the intersection of the trajectory with the line of sight.

3. **In Pointing** a gun, two distinct steps must be taken:—(a) Adjusting the line of sight to make such vertical and horizontal angles with the axis of the bore that the trajectory will intersect it at a distance from the gun equal to the distance of the target, i. e., setting the sight; (b) directing the line of sight at the target and retaining it there until the moment of firing. The first step is the duty of the officer in control of the fire, through his subordinates, and requires experience, keen observation and a high order of intelligence and knowledge of the theory of gunnery. The second step is in the province of the gun pointer and requires no thought

or knowledge of the principles of ordnance or gunnery, being merely a matter of eyesight, nerve and manual dexterity.

The "*point-blank*" range of a gun is the distance through which its trajectory may—without appreciable error—be assumed to be a straight line; in firing at targets inside such range, the gun is not elevated and the line of sight (disregarding the jump) coincides with the axis of the bore; this distance is necessarily short, but increases as the trajectory is flattened, which is a direct result and one of the great advantages of increasing the velocity. However, if the target is beyond the limit of point-blank range, which is the general case, some or all of the following adjustments must be made to give the line of sight the necessary horizontal and vertical angles with the axis of the bore: *Jump, drift, range, wind, motion of gun and motion of target.* The first two are permanent adjustments and their values are determined in ranging the gun and the correction made while fitting the sights. (In this consideration, the errors of the gun itself, variation in the powder, etc., and errors in measuring the range of the target are not touched upon.)

When a gun is "ranged" at the proving ground, a curve of the range under standard conditions for all angles of elevation up to 15 degrees is obtained; the deviations due to drift are also recorded and plotted, but the curve so obtained is assumed a straight line without much error. During the ranging, the gun is directed at a mark on a paper screen, at a known distance from the gun, by means of bore sights; the projectile makes a round hole in the screen, the center of which gives the offset, due to jump, from the point aimed at. The jump depends somewhat on the rigidity of the gun platform and is variable, but its value is only a few minutes of arc. This data obtained, the gun is returned to the gun factory to have its sights fitted. By means of T-squares secured to breech and muzzle tompions and a trunnion square, a line parallel to the axis of the bore is obtained which passes through the front sight point—if open sights are being fitted. The distance between the sights,—the *sight radius*—being known, the right triangle is solved to fix the height of the rear sight point above this line for the different angles of elevation; after applying the jump, the ranges corresponding to these angles