

TEXT-BOOK

OF

ORDNANCE AND GUNNERY

REVISED AND ARRANGED FOR THE USE OF MIDSHIPMEN AT THE
U. S. NAVAL ACADEMY

BY

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PREFACE

The last edition of Ingersoll's Text-Book of Ordnance and Gunnery (which has been the standard in the Navy for many years) having been exhausted, and the author not being in a position to revise the work, this volume has been prepared to meet the demands of the Naval Academy as well as the service at large.

In preparing this work, Ingersoll's Text-Book and various official and standard publications have been consulted, and, with a view to bringing the book as nearly up to date as possible, only modern service materials and methods have been described in full.

Chapter I, on "Metals, Gun Forgings and Manufacture of Armor Plate," was prepared with the assistance of Lieutenant Henry F. Bryan, U. S. Navy, Inspector of Ordnance. The plates and some of the data for this chapter were obtained through the courtesy of Edward M. McIlvain, Esq., President of the Bethlehem Steel Company.

Chapters XXIV, on "Gunpowder," and XXXI, on "The Proving Ground," were prepared by Lieutenant Joseph Strauss, U. S. Navy.

Chapters XXIX and XXX, on "Armor Protection for Ships and Guns," and "Penetration of Projectiles," respectively, were prepared by Lieutenant Cleland Davis, U. S. Navy.

Chapter XXXIV, on "Practical Naval Gunnery," was prepared by Lieutenant-Commander William S. Sims, U. S. Navy, and Lieutenant Ridley McLean, U. S. Navy.

The official publications and pamphlets issued by the Bureau of Ordnance and edited by Lieutenant F. K. Hill, U. S. Navy, and Lieutenant William C. Watts, U. S. Navy, have been freely consulted with the permission of the Bureau, and the editors are indebted to Lieutenants V. O. Chase and F. K. Hill, of the Bureau of Ordnance for much valuable information and assistance.

The following named officers, on duty at the Washington Navy

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Lieutenant Victor S. Houston, U. S. Navy.

The Naval Institute Proceedings, the Publications of the Office of Naval Intelligence, and the articles on Ordnance, by Professor P. R. Alger, U. S. Navy, have also been consulted.

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NAVAL ACADEMY,
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CHAPTER I.

METALS, GUN FORGINGS AND MANUFACTURE OF ARMOR PLATE.*

The Qualities of Gun Metals.

1. **Definitions:**—a. *Stress.*—The term stress is used to denote the system of forces which act to produce alterations of figure and volume of a solid and of its parts.

b. *Strain.*—In technical literature, the term strain is sometimes used to denote stress, and sometimes the change of shape caused by the stress. Here it will always be used in the latter sense; that is, to denote the change of shape caused by the stress.

c. *Fracture* of a solid occurs when, under the action of a stress, a strain is carried so far as to cause actual division of the solid into parts.

d. *Kinds of Strain.*—To each kind of stress there corresponds a kind of strain, as follows: For longitudinal stress we have a strain either of extension or compression; and, if the strain is carried far enough, a fracture will occur by tearing, in the former case, and by crushing or cleaving in the latter case. For transverse stress we have the strains of distortion, torsion, and bending, which, if carried far enough, produce fractures by shearing, wrenching, and breaking across respectively.

2. **Physical Properties of Metals.**—Metals have the following properties, to a greater or less degree, with which we are more particularly concerned in the case of metals used in gun construction. These principal properties are *malleability, ductility, hardness, toughness, tensile strength, and elasticity.*

*In revising this chapter the editors were greatly indebted to Lieutenant Henry F. Bryan, U. S. Navy, Inspector of Ordnance, for assistance and information. Acknowledgment is also due to President E. M. McIlvain and the officials of the Bethlehem Steel Company for details and sketches.

a. *Malleability*.—A metal is said to be malleable when it may be permanently extended in all directions without rupture, by pressure (as in rolling) or by impact (as in hammering).

b. *Ductility*.—A metal is ductile when it may be extended permanently by traction, as in wire drawing. Only malleable metals are ductile, but their ductility is not necessarily in the same ratio as their malleability.

c. *Hardness*.—A metal is said to be *soft* when it yields readily to compression without fracture, and does not return to its original form on the removal of the compressive stress; and on the other hand, a metal is said to be *hard* when it does not yield readily to compression; that is, when the ratio of the compressive stress to the permanent strain produced is very great. The terms *hardness* and *softness*, however, are only comparative when used in describing metals; thus we have hard and soft leads, while any sort of lead is soft as compared with wrought iron, which latter is called soft when compared with cast iron.

d. **Toughness* in a metal is a relative term to express the power of resisting fracture by bending or torsion; and is measured by the number of times to which a definite section of the metal can be bent through a certain angle on either side of the perpendicular without any fracture.

e. *Tensile Strength*.—The tensile strength, or ultimate strength, of a metal is the unit-stress required to produce fracture. Thus if a bar whose cross section is A breaks under a tensile stress P , the tensile strength of the material is $\frac{P}{A}$.

3. **Elasticity, Elastic Strength, Modulus of Elasticity, Set.**—The *elasticity* of a metal is the property it possesses of resisting permanent deformation when subjected to a stress.

“† All experiment and experience agree in establishing the five following laws for cases of simple tension and compression, which may be regarded as the fundamental principles of the science of the strength of materials:

“1. When a small stress is caused in a body, a small deforma-

*Steel and Iron, W. H. Greenwood.

†Text-book on the Mechanics of Materials, Merriman.

tion is produced; and on the removal of the stress, the body springs back to its original form. For small stresses, then, materials may be regarded as perfectly elastic.

"2. Under small stresses the deformations are approximately proportional to the forces, or stresses, which produce them, and also approximately proportional to the length of the bar or body (Hooke's law).

"3. When the stress is great enough, a deformation is produced which is partly permanent, that is, the body does not spring back entirely to its original form on removal of the stress. This permanent part is termed a *set*. In such cases, the deformations are not proportional to the stresses.

"4. When the stress is greater still, the deformation rapidly increases, and the body finally ruptures.

"5. A sudden stress, or shock, is more injurious than a steady stress, or than a stress gradually applied.

"The words small and great, used in stating these laws, have very different values and limits for different kinds of materials and stresses."

"*The Elastic Strength* is that unit-stress at which the permanent set is first visible, and within which the stress is directly proportional to the deformation. For stresses less than the elastic strength, bodies are perfectly elastic, resuming their original form on removal of the stress. The limit of *strain*, or deformation, within which the law holds good, is called the *elastic limit*. Beyond the elastic limit a permanent alteration of shape occurs, or, in other words, the elasticity of the metal has been impaired and a *permanent set* is produced. It is a fundamental rule for all engineering construction that materials can not safely be strained beyond their elastic limit.

"*The Coefficient of Elasticity* of a bar for tension, compression, or shearing, is the ratio of the unit-stress to the unit deformation (strain), provided the elastic limit of the material be not exceeded. Let 'S' be the unit-stress, 'e' the unit deformation, and 'E' the coefficient of elasticity. Then, by the definition $E = \frac{S}{e}$ and $S = Ee$. By law (2) 'E' is a constant for each material, until 'S' reaches the elastic limit. Beyond this limit 'e' increases more

rapidly than 'S,' and the ratio is no longer constant. Since 'E' varies inversely with 'e,' the coefficient of elasticity may be regarded as a measure of the stiffness of the material. The stiffer the material the less is the change in length under a given stress, and the greater is 'E.' The values of 'E' for materials have been determined by experiments with testing machines. 'E' is necessarily expressed in the same unit as the unit-stress. 'E' is also called the *Modulus of Elasticity*."

4. The Most Necessary Physical Qualities of Metals used in steel gun-making are great tensile strength combined with high elastic limit, toughness, and the required hardness to endure the wear in the bore due to the erosive action of the powder gases, and the friction or balloting of the projectile.

Guns have been made of various metals, principally bronze, cast iron, wrought iron, steel, and nickel steel. At the present time (March, 1903), all the high power guns in use in the Navy are made of steel. Forgings for 12-inch, 10-inch and 7-inch guns are now being made of nickel steel; and it is probable that nickel steel will replace steel in gun-making. Nickel steel gun barrels have been used for the past seven or eight years for sporting fire arms, and for Army and Navy magazine rifles.

As we are especially interested in the metals now used in gun-making (steel, and nickel steel), only a brief mention will be made of the others:

5. Bronze, an alloy of copper and tin, is expensive, too soft for the bores of large rifled guns, is injured by the heat of high charges, and is liable to flaws due to the segregation of its constituents. It is very ductile, is tough, but is low in elastic limit and tensile strength. It is now used for minor parts subject to no great strain, as sight brackets, hand wheels, liners to avoid the wear of steel against steel, etc. Bureau of Ordnance requirements: Tensile strength 30,000, elastic strength 13,000, elongation 25 per cent, contraction 25 per cent.

6. Cast Iron is cheap, easily worked, but of low elastic limit and tensile strength. It can be fused and cast without difficulty, and is comparatively hard. It is not malleable, and cannot be welded, and is brittle. Castings are very uncertain in character, due to the method of manufacture. Many, apparently perfect on

surface inspection, develop serious flaws in machining, and have to be rejected. Cast iron is not now used for either guns or mounts.

7. **Wrought Iron** is almost infusible, but is readily welded. Its tensile strength and elastic limit are low; but on account of its ductility, requires a large amount of work to extend it from its elastic limit to fracture, which makes it a comparatively safe material to use for guns, as a gun will give evidence of giving away before actual fracture takes place. The bores of wrought iron guns have been permanently indented or bruised by moderate firing, the metal not being hard enough. This is a serious defect under the high pressures modern guns must stand. Wrought iron is no longer used in either guns or mounts.

8. **Cast Steel** has a higher tensile strength and elastic limit than, but not so great a ductility as, wrought iron. As stated in the case of cast iron, all castings are uncertain, hidden defects often being developed only in machining.

9. **Forged Steel** combines more good qualities for use in modern guns than bronze, cast iron, wrought iron, or cast steel. It is easily fused, is malleable, and is a more or less weldable, according as it is soft or hard. It is tough and elastic, with a much higher elastic limit and tensile strength than wrought iron or cast steel. Its elastic limit, or elongation within that limit, is much higher than for the other metals above noted; and this quality makes it especially suitable for gun-making, in view of the strains which are set up in guns by heavy charges. The method of manufacture, given later in detail, increases to a great degree its elastic limit and tensile strength. The manufacture of steel has been so perfected that a very uniform product is now obtainable.

10. **Temper.**—When steel is heated to a red heat and then suddenly cooled, for example by plunging it into cold water, we say that we *temper* it, and this operation, of frequent use in industry, considerably modifies the physical properties of steel. The hardness of the metal is sensibly increased, and becomes greater as the decrease of the temperature has been greater and more sudden, or, as is said, the temper has been *stronger*. The tensile strength also varies very much, but is greater or less according to whether the temper is weak or strong. With a weak temper, the tensile

strength reaches its maximum; by afterwards increasing the strength of the temper it diminishes more and more, and finally the metal becomes as fragile as glass. The metal acquires a new property by temper—*elasticity of flexion*. This consists of the quality possessed by a finely tempered steel blade, for example a sabre blade, of returning to its original form when, after having been bent under a certain force, it is left to itself.

The properties of wrought iron are not sensibly modified by temper, which is ordinarily expressed by saying that wrought iron does not temper.

The properties of certain cast irons are considerably modified when, after having been liquefied, they are cooled suddenly; therefore we may say, from this point of view, that cast iron takes temper like steel.

To state in a few words the physical characteristics which may serve to distinguish wrought iron, steel, and cast iron, we may say wrought iron is forgeable, weldable, practically infusible, and does not temper; steel is forgeable, weldable, fusible, and takes temper; cast iron is neither forgeable nor weldable, it is relatively very fusible, and is susceptible of being tempered.

11. Distinctive Characteristics of Steel.—That which particularly distinguishes wrought iron from steel is the property possessed by the latter of receiving temper; that is, of being considerably modified by the action of temper. With a metallurgist, all metal with an iron base which is forgeable and capable of being tempered is steel; if it cannot be tempered it is simply iron.

12. Definition of Steel.—Reasoning from the foregoing, steel is a *fusible, malleable alloy of iron produced in any way whatever, and containing a smaller proportion of carbon or other hardening element than is contained in cast iron, and is capable of receiving temper*.

13. Processes for Obtaining Cast Steel.—There are a variety of processes for removing a portion of the carbon from cast iron and producing steel, that is, by removing the carbon under such conditions as to obtain a melted product; among which may be mentioned that of melting in crucibles, giving *crucible steel*; the open hearth plan, giving *Siemens or Siemens-Martin steel*; the plan of blowing air through molten cast iron, producing *Bessemer*

steel. In whatever way made, the material is essentially the same, depending upon its chemical composition and physical structure for its properties. The open hearth process is described later on.

14. High and Low Steel.—In consequence of the extension given to the word *steel*, we understand to-day under this name metals which present considerable differences both in regard to composition and physical properties. Hence, practitioners have been obliged to distinguish the varieties of steel according to their proportion of carbon—sometimes by numbers, and sometimes by more or less characteristic names. When the metal contains a large proportion of carbon, it ordinarily is called *high* or *hard steel*. If the proportion of carbon is small, it is called *low* or *soft steel*, and a still smaller proportion will be *extra low steel*. In some maufactories, for example, the name of low steel is given to a metal containing 0.20 to 0.25 per cent of carbon, and a metal in which the proportion of carbon is inferior to 0.20 per cent is designated *extra low steel*.

15. Nickel Steel.—The use of nickel in steel for gun forgings, while only of recent development, has been found to impart very desirable qualities; and this alloy, containing definite proportions of nickel, can be successfully and uniformly produced by the open hearth process. The physical qualities of nickel steel vary greatly, according to the amount of nickel contained. A steel containing about $3\frac{1}{4}$ per cent of nickel, has, up to the present time, been generally used for gun forgings; and much information as to its qualities has been obtained. In general, the presence of this amount of nickel ($3\frac{1}{4}$ per cent) increases the tensile strength and elastic limit without causing a corresponding reduction in elongation and contraction of area; and the elastic limit is also increased relatively to the tensile strength. This condition indicates toughness. Crystallization after forging is also avoided; and a fine granular or amorphous condition results. This steel is more sensitive to temper, and it is in tempered steel that the improved qualities are most apparent. As shown by the ballistic tests of armor plate, the presence of nickel materially increases the resistance in shock. In short, the nickel improves the physical qualities of mild steel in all respects. It is thought probable that tubes of nickel steel may offer an increased resistance to the erosion of the

bore of the gun as compared with simple steel. The use of nickel also permits a reduction of carbon.

Gun Forgings.

16. The Open Hearth Process.—As all gun forgings are made of open hearth steel, only that process will be considered.

Iron is obtained from its ores by melting them in large blast furnaces with coke or coal, various fluxes being added, according to the nature of the ores, to carry off the earthy matters. The metal so obtained is run into sand or metal moulds in the shape of the well known bars called "pig iron." The metal in this state is termed "cast iron," and contains various foreign elements, carbon and silicon principally. Cast iron contains by weight from 2 per cent to 5 per cent of carbon, which exists in two states, either chemically combined with the iron or mechanically mixed with it. If we remove the carbon from the cast iron so that the amount is less than 2 per cent, we have either wrought iron or steel, according to the amount of carbon removed, the subsequent treatment of the metal, or both combined. Theoretically, wrought iron approaches to pure iron, and contains from .1 to .3 per cent of carbon. Extra soft or *low steels*, however, contain no greater proportion of carbon than this. Melted cast iron is reduced to wrought iron by puddling, or boiling, by the mere oxidation, or burning out, of the excess of carbon and silicon from the cast iron.

17. * The Regenerative Gas Furnace was invented by William Siemens, afterwards Sir William. A Frenchman named Martin used this furnace, developing what was known for some years as Siemens-Martin steel, or open hearth steel; but now known only as open hearth steel.

"At first, open hearth steel was made upon a specially prepared sand bottom, by first melting a bath of cast iron and then adding wrought iron to the bath until, by the additions of wrought iron and the action of the flame, the carbon and silicon of the cast iron were reduced until the whole became a mass of molten steel. Sometimes iron ore is used instead of wrought iron as the reduc-

* Steel, William Metcalf.

ing agent; this is called the pig and ore process. Now in general practice, wrought iron, steel scrap, and iron ore are used, sometimes alone and sometimes together, as economy and special requirements make it convenient. This is known as the open hearth process.

“The fact that the phosphorus of the iron remained in the steel notwithstanding the active combustion and high temperature, led to the dictum that at high temperatures phosphorus could not be eliminated from iron. This conclusion was credited because, in some of the so-called direct processes of making iron when the temperature was never high enough to melt steel, all, or nearly all, of the phosphorus was removed from the iron. For many years steel makers the world over worked upon this basis, and devoted themselves to procuring for their work iron containing not more than ten points (.10 per cent) phosphorus. Two young English chemists, Sidney Gilchrist Thomas and Percy C. Gilchrist, concluded that the question was one of chemistry, and not one of temperature; and set to work to obtain a basic lining, and to produce a basic slag which should retain in it the phosphorus of the iron. They succeeded, and produced a steel practically free from phosphorus. For the practical working of their process, it was found better, or necessary to use iron low in silicon and high in phosphorus, using the phosphorus as a fuel to produce the high temperature necessary, instead of the silicon of the acid process. In the acid process, it is found necessary to have high silicon—2 per cent or more—to produce the temperature necessary to keep steel liquid; in the Thomas-Gilchrist process phosphorus takes the place of silicon for this purpose. This discovery, first applied in working out the basic Bessemer process, was tried in the open hearth; a basic bottom of dolomite, or of magnesite, was substituted for the acid sand bottom, and care was taken to secure a basic slag in the bath. Success was greater than in the Bessemer process; phosphorus was eliminated and a product better in every way obtained. This, the basic open hearth process, is now used extensively over the whole civilized world.

“Neither the basic nor the acid process removes sulphur, so that this element must still be kept low in the original charge, until some way be found for its sure and economical elimination.

If too much sulphur be present, the steel can not be worked conveniently under the hammer."

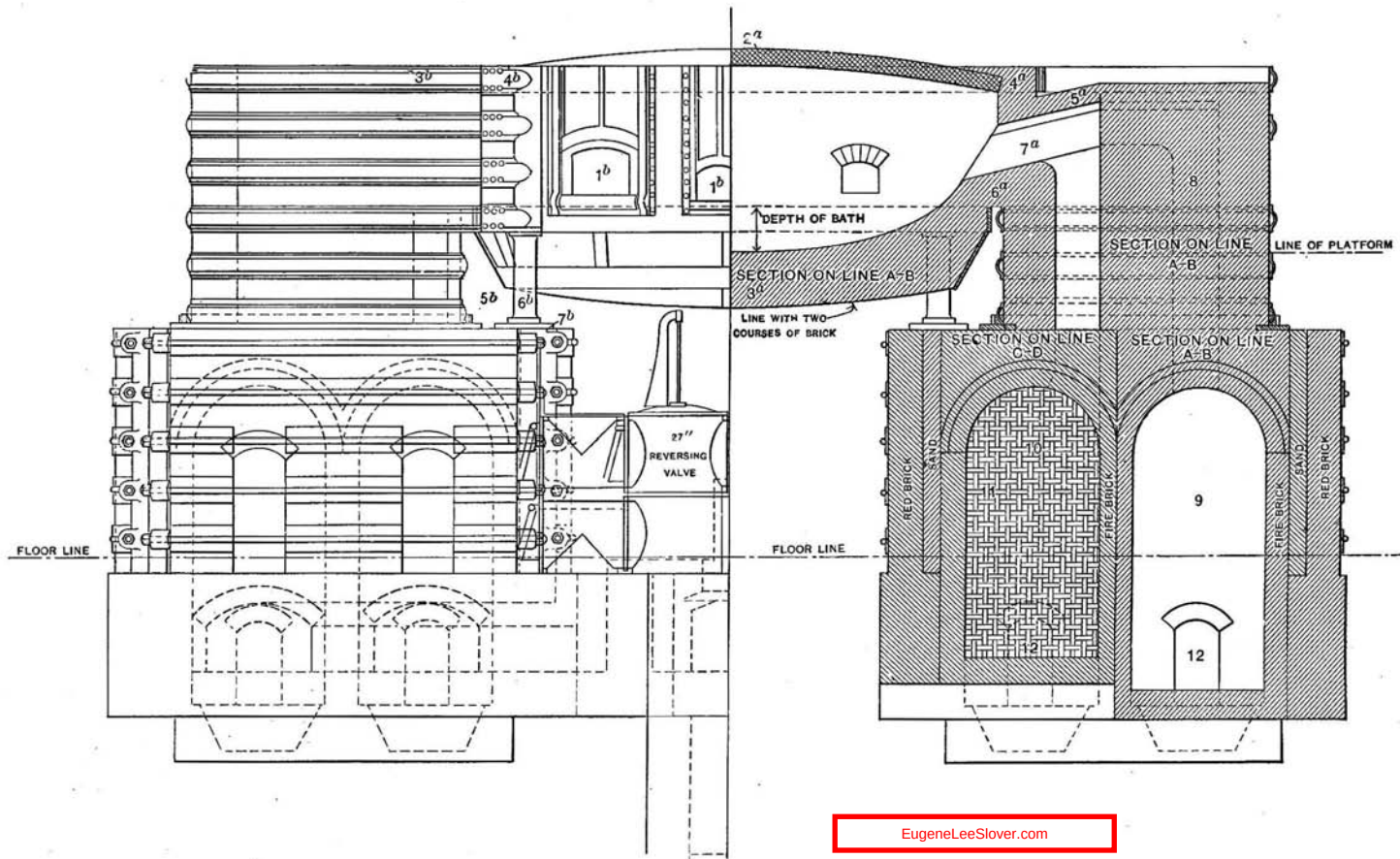
18. "**Carbon.**—In the acid open hearth process, it is usual to burn the carbon out almost entirely, and then add the desired amount with the spiegel-eisen or ferro-manganese. Higher carbon may be obtained by the addition of pure pig iron. In good practice, the melt is stopped at the carbon desired with great success, thus saving time and expense. In the basic open hearth the melter, by care and good judgment, stops his melt at the required carbon; and so avoids any additional operations, unless his charge is excessively high in phosphorus, and his steel is to be very low in the same; in that case, he may have to melt clear down and recarbonize. Steel of 1.30 per cent carbon with phosphorus less than .05 per cent may be made on the basic hearth from a charge containing .10 per cent to .12 per cent phosphorus without melting below 1.30 carbon."

19. "*** The Siemens Regenerative Gas Furnace** consists of three parts; viz., (1) the producers or apparatus for the generation of the crude gas; (2) the regenerators or chambers filled with a checker work of fire-bricks, which alternately absorb and store up the waste heat of the flame and gases as they escape from the furnace hearth, and then subsequently give up this heat to the gases from the producers, and to the air for supporting their combustion, as each of them passes through the separate regenerators before meeting for combustion upon the bed or hearth of the furnace; and (3) the furnace structure proper."

Plate I shows the details of a 40-ton open hearth furnace of the Bethlehem Steel Works.

On an elevated platform are located a number of these furnaces to which the charge of raw material must be raised. During the process of melting, a small dipperful of the molten metal is, from time to time, taken out of the furnace and rapidly tested, to find out how the refining is taking place; and when the charge is ready, the metal is poured from the furnace into ladles, which in turn empty into moulds located in the casting pit underneath. Plate II shows a ladle and an end view of the pit.

* Steel and Iron, Greenwood.



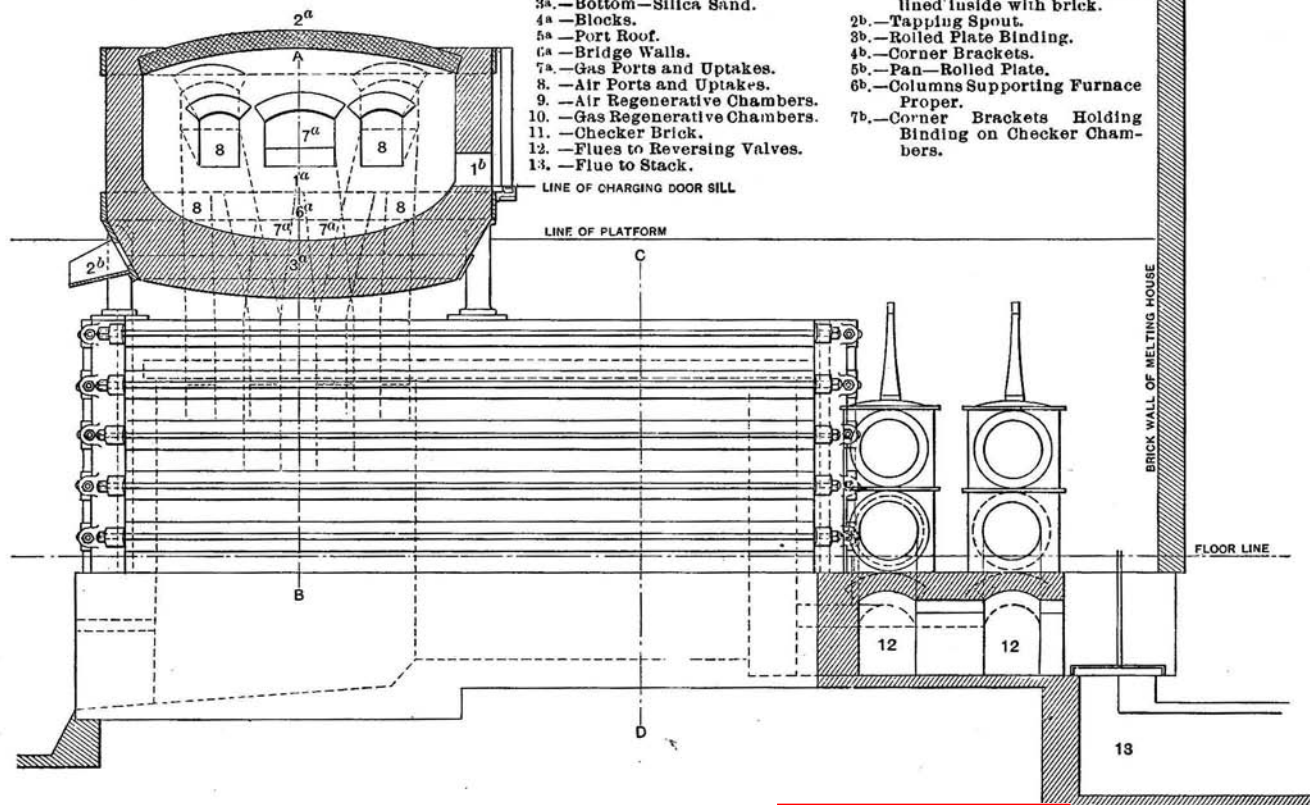
BETHLEHEM STEEL COMPANY'S 40-TON OPEN HEARTH FURNACE.

SECTION A B.

- 1a.—Body of Furnace.
- 2a.—Roof—9" Silica Brick.
- 3a.—Bottom—Silica Sand.
- 4a.—Blocks.
- 5a.—Port Roof.
- 6a.—Bridge Walls.
- 7a.—Gas Ports and Uptakes.
- 8.—Air Ports and Uptakes.
- 9.—Air Regenerative Chambers.
- 10.—Gas Regenerative Chambers.
- 11.—Checker Brick.
- 12.—Flues to Reversing Valves.
- 13.—Flue to Stack.

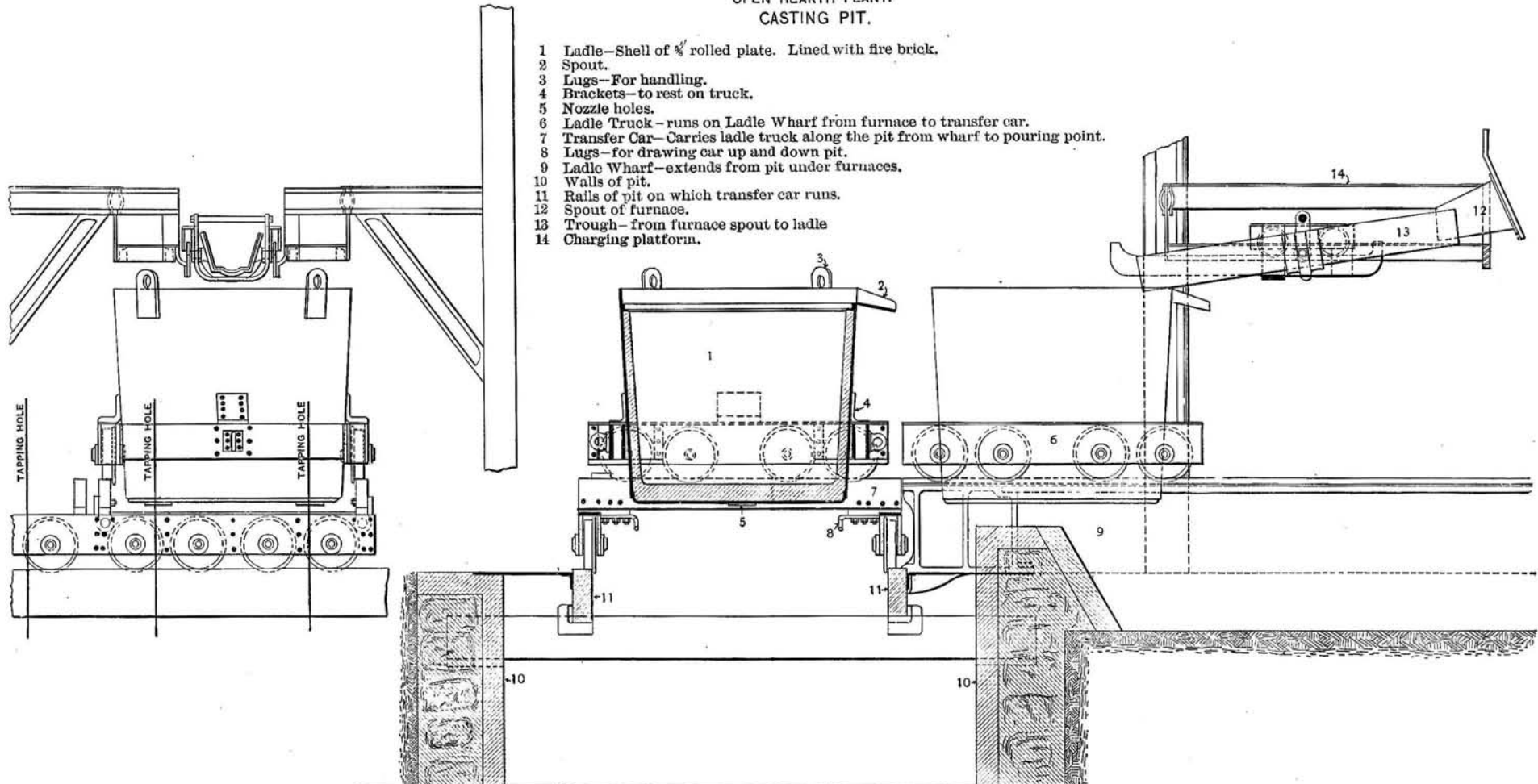
OUTER BINDING, DOORS, ETC.

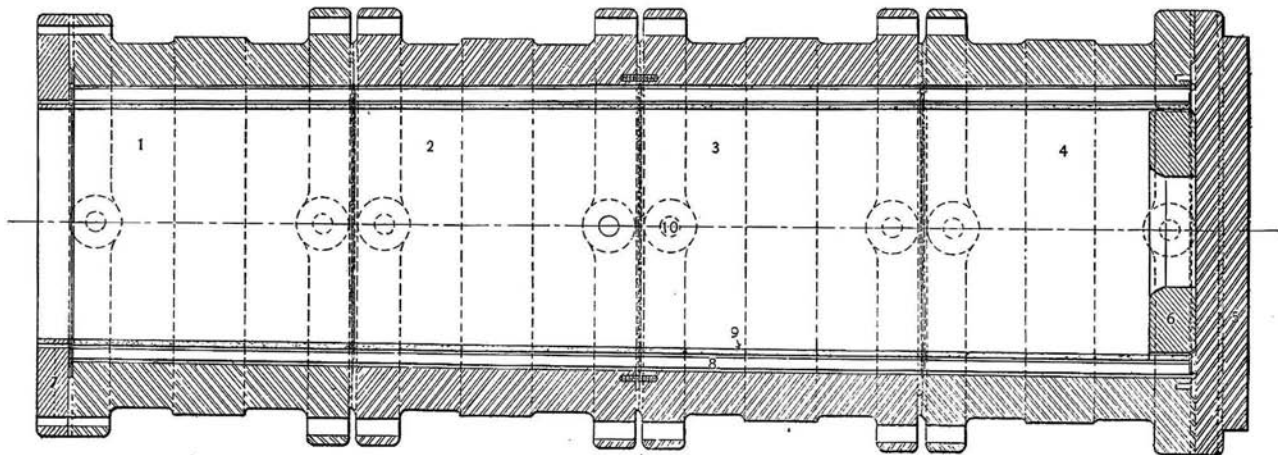
- 1b.—Charging Doors.—Cast Iron water cooled frames; Doors lined inside with brick.
- 2b.—Tapping Spout.
- 3b.—Rolled Plate Binding.
- 4b.—Corner Brackets.
- 5b.—Pan—Rolled Plate.
- 6b.—Columns Supporting Furnace Proper.
- 7b.—Corner Brackets Holding Binding on Checker Chambers.



THE BETHLEHEM IRON CO.
OPEN HEARTH PLANT.
CASTING PIT.

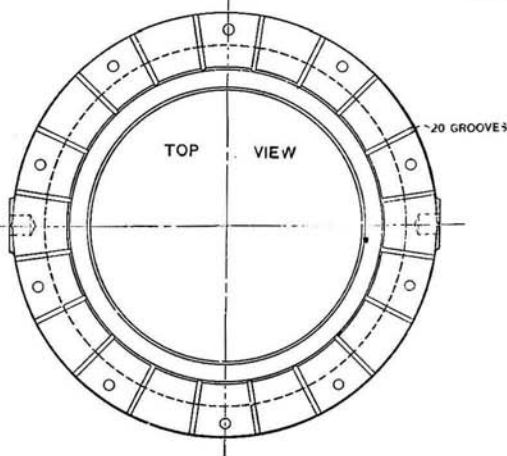
- 1 Ladle—Shell of $\frac{3}{4}$ rolled plate. Lined with fire brick.
- 2 Spout.
- 3 Lugs—For handling.
- 4 Brackets—to rest on truck.
- 5 Nozzle holes.
- 6 Ladle Truck—runs on Ladle Wharf from furnace to transfer car.
- 7 Transfer Car—Carries ladle truck along the pit from wharf to pouring point.
- 8 Lugs—for drawing car up and down pit.
- 9 Ladle Wharf—extends from pit under furnaces.
- 10 Walls of pit.
- 11 Rails of pit on which transfer car runs.
- 12 Spout of furnace.
- 13 Trough—from furnace spout to ladle
- 14 Charging platform.



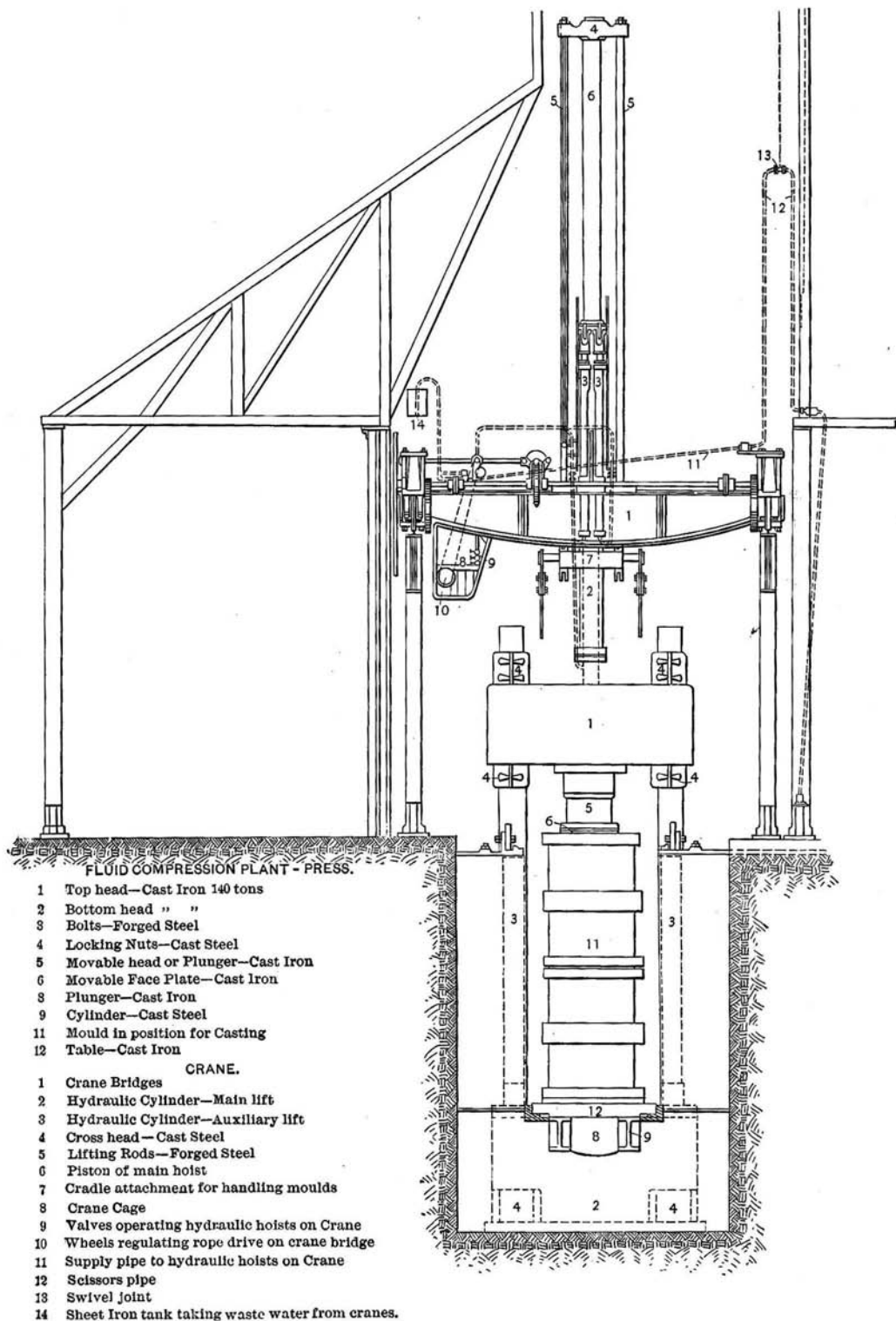


42"RD. MOULD FOR POURING FLUID COMPRESSED INGOTS.

- | | | | |
|----|------------------------------|-------|--------------------------------|
| 1 | 2 | 3 & 4 | Sections of mould, Cast Steel. |
| 5 | Bottom | | Cast Iron |
| 6 | Well Plate | " " | |
| 7 | Top Ring | " " | |
| 8 | Staves | " " | |
| 9 | Lining | Sand | |
| 10 | Holes for pins for Handling. | | |
- Bottom is clamped on. Sections are bolted together.
Grooves in joints for gas vents.



THE BETHLEHEM IRON CO.
42-INCH INGOT MOULD.
FLUID COMPRESSION PLANT.



THE BETHLEHEM IRON CO.
GENERAL ARRANGEMENT OF CASTING PRESS AND CRANES

20. The Casting of the Ingot.—Steel ingots for guns are cast solid by the Whitworth process, and are known as fluid compressed steel. The object of compressing the liquid metal in the mould immediately after casting is to get rid of the blow holes, and to obtain a metal of high density. Blow holes are cavities caused by air imprisoned when pouring the metal into the mould; at certain stages in cooling, gas is generated, also causing blow holes.

21. The Flask.—The flask into which the molten metal is poured from the ladle is made of steel, and is built up of sections united by broad flanges bolted together in such numbers as to accommodate the length of the ingot to be cast. The interior of the flask is lined with long rods square in section, longitudinally arranged, which form when in place a complete cylindrical interior surface. Where the square edges of these rods meet they are cut away, both on the inside and on the outside, and, at intervals of two inches, small holes are drilled through between the rods, forming a channel way from the interior to the exterior for the passage of gas and flame. The interior is then lined with moulding composition. The flange at the bottom of the flask, as well as that at the top, is perforated with small holes which act as a continuation to the perforations between the segments of the lining for the escape of gas. The details of the mould for pouring fluid compressed ingots are shown in Plate III.

22. Fluid Compression.—The metal is poured directly into the mould from the top. The mould is then moved (by means of a railway at the bottom of the casting pit, which is a deep trench running parallel to the position of the furnaces) to a position under the movable head of the press which is allowed to descend until the piston is in contact with the metal in the mould, and in this position it is locked; a shower of metal is caused, which ceases almost immediately, by the complete closing of the mould. The first impress felt by the metal is due to the weight of the press alone. This pressure is gradually increased from below by hydraulic action, applied by four rams upon the table on which the flask rests, until the pressure exerted amounts to 6 tons per square inch. During the period of compression, the flow of gas and flame from the apertures in the flanges of the flask, at top and at bottom,

is continuous and violent, exhibiting the practical effect of the compression. This pressure is applied by the direct action of steam and pumping engines, and is indicated by a dial. After the maximum pressure is reached, the pump is taken off, and a uniform pressure of about 1500 pounds per square inch is established by attaching an accumulator to the press, and allowed to remain until the metal is sufficiently cool to insure no farther contraction in the mould.

The contraction in length in the mould during the action of the pump, while the maximum pressure is being reached and sustained, amounts to one-eighth the length of the ingot. After this effect has been produced, there is no farther advantage derived from the pressure in the way of eliminating impurities, but the contraction in cooling still goes on, and the pressure by the accumulator is considered necessary in order to follow up the metal as it contracts, to prevent cracks being started at the end and on the exterior of the ingot by the adhesion of particles of the metal to the sides of the mould. The details of the fluid press, mould, and cranes are shown in Plate IV.

23. Defects of Ingots.—Besides blow holes, ingots often show "piping" and "segregation." The metal, when it is poured into a mould, cools and solidifies first at the surface of the mould; and, as the solid metal keeps cooling toward the center, it shrinks and draws away from it. This shrinkage draws principally from the center and top, these being the parts that solidify last. It is, therefore, to take care of this shrinkage that more metal is added to the length of the ingot than would otherwise be required. The hydraulic pressure applied at the top forces the fluid metal from this added part down through the center, and keeps the latter filled where otherwise there would be a cavity or "pipe." Segregation occurs principally in large ingots. This is a separation of the various ingredients of steel (sulphur, phosphorus, manganese, silicon, &c.), each of which has its own temperature of cooling. As the mass cools, the tendency of these ingredients is toward the central and upper portions where it cools, thus forming a central core of impurities. Even the fluid compression does not entirely prevent this. A solid ingot is, however, obtained, which is absolutely necessary, as steel will not readily weld; so that original defects in the ingot cannot be later remedied by hammering.

24. The Discard.—The extra length, having served its purpose of supplying metal to fill "blow holes" and "pipes," and of collecting segregation, is cut off and returned to scrap.

With fluid compressed ingots, the required discard is 10 per cent of the weight of the ingot from the upper end, and three linear inches from the lower end.

25. The Mandrel.—The ingot, after being cored, is forged on a mandrel. A mandrel is merely a cylindrical steel shaft (sometimes hollow, and sometimes solid), with a long tail piece, or handle (either forming part of the mandrel, or screwed into it at each end). The ingot is forged down over the body of the mandrel, thereby decreasing in exterior diameter, but increasing in length. By a skilled man, the ingot can be prevented from sticking to the mandrel; occasionally, however, it is necessary to withdraw the mandrel by means of a hydraulic tool.

Forgings are to be annealed, then oil tempered under such conditions as will assure their resistance, and again annealed. The last process must be an annealing one.

26. Forging.—The re-heating of the ingot before forging is a delicate operation, as great care must be taken to make the heat penetrate the metal slowly and uniformly. As already explained, the metal in the ingot, during the process of cooling, is being drawn out in all directions to fill the mould. When it is cold therefore, it is in a condition of strain throughout its interior. If it were put cold into a hot furnace to be re-heated, the surface metal would immediately expand, and draw further away from the center, causing an additional strain on the inside metal. In very large ingots, cracks are thus apt to form in the center, and the forgings are liable to break later in service, from the fact that they have not been properly re-heated.

Then comes the forging process proper. The pressure applied should be such as to penetrate the ingot to the center, causing a flow of metal throughout the mass. This flow of the metal requires a certain amount of time, during which the pressure must be maintained. Under the slow motion of the forging press, time is allowed for the molecules of the metal to move easily, and the pressure is felt throughout the forging. During the period of forging, a great deal of work is put into the metal.

In the manufacture of hollow forgings, the conditions of shaping are in all respects favorable to the production of sound work of the highest quality. The axial hole into which the mandrel fits removes the portions made defective by segregation and piping; and renders visible any interior defects which have not been removed by boring. The bored ingot forms a hollow cylinder with walls much thinner than the cross section of the solid ingot; this greatly facilitates heating and practically removes the danger of internal cracking during heating. The forging of the comparatively thin walls of the cylinder over a solid mandrel makes it possible to turn the forging out at a low and uniform heat, thus fixing a uniformly fine or amorphous grain. A solid forging, on the other hand, of the same outside diameter, would be much hotter toward the central axis than on the outside; and the gradual loss of this high internal heat will tend to coarse the grain by crystallization, and set up interior strains. In the hollow forgings, any internal defects are visible, while their presence in solid forgings are hidden and can only be disclosed by boring.

27. Reduction of Cross Section by Forging.—For tubes, plugs, and mushrooms, each ingot will be reduced in diameter, by forging, at least 50 per cent at the largest diameter of the piece, and at no point less than this. For jackets, each ingot will be reduced in diameter, by forging, at least 40 per cent at the largest diameter of the jacket, and at no point less than this.

In case tubes are forged on a mandrel from bored ingots, the walls of the ingots at all points must be reduced in thickness by forging, at least 50 per cent. In case jackets and hoops are forged in the same way, the walls of the ingots at all points must be reduced in thickness, by forging, at least 40 per cent.

In case hoops are forged from solid ingots by upsetting and punching and subsequent elongation or enlarging on a mandrel, the walls at all points must be reduced in thickness, by forging on the mandrel, at least 33 per cent.

28. Annealing.—The next process is that of annealing. The primary object of annealing is to relieve the internal strains set up by forging, and by the rapid and irregular cooling during and after forging. Further, annealing alters the molecular condition of the steel, and when applied under proper conditions, has a ten-

dency to break up crystallization and fix a finer or more nearly amorphous grain, whereby the toughness of the material is increased.

To anneal steel, the ingot is heated to a red heat, and then left to cool slowly. The particles thus readjust themselves to a normal condition. This may be done in a furnace by drawing the fires after heating, or by packing the ingot with cast iron borings or ashes so that it is protected from the air; the process sometimes takes several days for a large ingot. The general effect of annealing, as indicated by the tensile tests of specimens, is to lower the tensile strength and elastic limit and to increase the elongation and contraction of area.

29. Tempering, or Hardening, of steel forgings consists in cooling them rapidly, usually by immersion in oil, from a red heat varying in degree according to conditions, and hence it is generally spoken of as *oil tempering*. The object of this treatment is, first, to break up the irregular and more or less laminated and coarse crystalline structure produced by forging, and to fix a fine or amorphous condition of grain; and second, to modify the physical properties of the metal, with a view of obtaining the most desirable combination practicable.

The sudden cooling in oil, or otherwise, naturally produces strains which, unless properly guarded against and relieved, are hurtful, and, under certain conditions, may be so great as to cause actual rupture. To avoid this latter danger, precautions as to shape as well as to composition and heating are necessary, but of first importance is the removal, when possible, of the metal along axial lines before tempering, so as to effect internal as well as external cooling. This must often be done by machining, but it is evident that forging hollow furnishes a product especially adapted to tempering.

30. The Process of Tempering.—A tube of steel is lifted by a powerful crane and placed in a perpendicular position in an upright furnace which has been previously heated with wood or gas fuel to a red heat. It rests on an iron shoe placed on the grate bars to prevent the cold air from coming in contact with its extreme end. Great care is taken to heat the mass uniformly.

The amount of heat received by the steel is judged by eye—the

color of the heat being the guide—and by long practice and attention. The more uniform the temperature, the straighter the tube will keep, and the more even its temper. After the steel has acquired the proper uniform temperature throughout, the traveling crane is brought over the furnace, its top removed, and the large iron tongs, pendent from the crane, fasten themselves to the steel tube; a small collar being upon its end to prevent the tongs slipping.

31. The Oil Bath.—The tube of steel is now drawn out of the furnace and sunk into a large iron tank of suitable depth containing several thousand gallons of oil. The heated steel, in passing into the oil will sometimes cause the surface oil to take fire, which is extinguished by closing the top of the tank.

A covering of coal is also formed round the steel by the burned oil, which greatly retards transmission of heat.

The tank has a water space surrounding it, and as the steel parts with its heat, raising the temperature of the oil, the temperature of the water is also raised. The water, as it is heated, is drawn off by an escape pipe, and a supply of cold water is continually running in, so that the heat is gradually taken from the mass. Exceeding toughness is the result of the operation; the tensile strength of the steel is made higher, and it is harder and more elastic.

32. Re-annealing.—*Annealing is again resorted to after tempering*; first, to relieve strains, and secondly, to soften the metal to a degree required to obtain the physical qualities aimed at. The effect of this double treatment—tempering and annealing—as indicated by tensile tests, is, in general, to increase the elastic limit relatively to the tensile strength, and, when the hardness is “drawn” by annealing, to increase materially the elongation and especially the contraction of area.

33. Specimens are now cut from the forging, before delivery to the gun-maker, to determine if it meets the requirements of the specifications.

34. Recapitulation of Processes.—The various processes through which the steel passes may be stated in their order as follows: casting, forging, annealing to get rid of stains induced by forging, tempering, and re-annealing. The last process, by whatever method followed, must be an annealing one.

35. The Effect on the Physical Properties of Steel of Oil Tempering and Annealing.—The effects of temper vary with the nature of the steel, and are much more pronounced as the steel is more carbonized and homogeneous.

The following table, from tests made by the Navy Department, will give an idea of the effect of oil temper on the physical properties of mild or medium hard steel, for example :

ELASTIC STRENGTH.		TENSILE STRENGTH.		ELONGATION.	
Before tempering. Tons.	After tempering. Tons.	Before tempering. Tons.	After tempering. Tons.	Before tempering. Inches.	After tempering. Inches.
13	29.2	26.8	45.2	.737	.433
13	27.8	27.8	46.0	.707	.345
12	26.0	27.6	39.6	.713	.420
12	25.8	28.0	41.0	.633	.480
13.77	34.15	28.11	49.8	.596	.260
12.18	34.8	26.9	49.4	.564	.202

Thus it will be seen that the elastic strength is more than doubled, the tensile strength raised more than 60 per cent, while the elongation is reduced over 40 per cent.

The re-annealing process reduces the tensile and elastic strength from 10 to 15 per cent, and restores the ductility, as measured by the elongation, from 25 to 40 per cent.

36. Determination of the Physical Properties of Metals.—This is accomplished by subjecting specimens of the metal to the action of different stresses in testing machines, and observing the effect on the specimens in alteration of volume and figure by means of accurate measuring instruments.

37. Testing Machines.—The testing machines are generally a combination of levers for recording the stress, and a system of gearing or hydraulic machinery by which the stress is produced.

Specimens are usually prepared to an adopted shape. In the case of gun metals they are cylindrical, and are turned to the same diameter for a certain length, usually not less than two inches and not more than ten inches for tensile tests; and in addition, ends are allowed for the purpose of attaching the specimen to the machine. For compressive tests the specimen is also cylindrical,

the height being twice the diameter. The capacity of the machine limits the diameter of these specimens.

In making a tensile test the specimen is marked at two points as far apart as the finished length between grips will allow, and the length is carefully measured between these points. The diameter is also measured by micrometer calipers. It is then placed in the machine and subjected to successive tensile stresses, the elongation being noted for each stress, both when the load is on and after it has been removed. When a permanent set equal to the smallest division the measuring instrument is capable of recording is shown, the elastic limit has just been reached within the limits of accuracy of the instruments, and the corresponding stress is the elastic strength of the metal. It is usual to increase the load by small increments when near the elastic strength. If the elongation is not noted, the elastic strength may approximately be determined by watching the weighing lever as the increments of the load are put on, and if the lever remains steady, the limit has not been reached; but when a load is put on and the lever falls after it has recorded the stress, it shows that the metal has permanently stretched. The corresponding strength is then the elastic strength approximately. The elastic elongation should, however, be recorded whenever possible. After the determination of the elastic strength, the specimen is subjected to further stress until rupture takes place. The highest record made by the weighing bar is the *tensile strength*. After rupture, the pieces are joined, and the distance between points measured. The percentage of total elongation is thus determined. Similarly, the percentage of reduction of area is found by measuring the diameter at the point of fracture.

To obtain the elastic strength for compression, a compressive stress is put on the specimen, and the height of the cylinder carefully measured: the stress which produces the smallest permanent set observable is the elastic strength for compression within the limits of the accuracy of the instruments.

Finally, the results are reduced to a standard for area and length. Tensile and elastic strengths are expressed in pounds or tons per square inch; elongation, as elongation per inch, or per cent of elongation per total length.

38. Comparative Strength of Forgings.—It will be seen from an inspection of the tables in par. 57, showing the requirements of the Navy Department regarding the elastic and tensile strengths of tubes, jackets and hoops, that the hoops are stronger than the jackets, and the jackets stronger than the tubes. Manifestly it would be desirable that the opposite rule should obtain—that the tube should be the strongest part of the structure. The explanation is to be found in the fact that it is impossible to make a *large* mass of steel as nearly perfect as a *small* piece. The smaller the forging the more uniform its texture and the more readily and the more perfectly will it yield to the processes of annealing, tempering, etc.,—the processes that affect its tensile and elastic strength. The Navy Department is forced to recognize these facts in its specifications. This matter will be referred to later on in discussing the principles of gun construction.

39. Inspection of Forgings.—To ensure compliance with all specifications the Bureau shall have the right to keep agents or inspectors at the works where the guns and mounts are built, who shall have free access to all parts thereof, and who shall be permitted to witness all the processes of manufacture, and to examine all the contractor's records with reference to such matters.

40. Forgings are to be made of open-hearth steel, of domestic manufacture, from the best quality of raw material, uniform in quality throughout the mass of each forging and throughout the whole order for forgings of the same calibre, and free from slag, seams, cracks, cavities, flaws, blowholes, unsoundness, foreign substances, and all other defects affecting their resistance and value.

41. Forgings are to be annealed, oil tempered under such conditions as will assure their resistance, and again annealed. No piece will be accepted, nor will its test specimens be broken or considered, unless the last process has been an annealing one. The forging must be left with a uniform fine grain.

42. All pieces forged solid must be annealed and otherwise treated after being rough bored and turned to the above dimensions. Pieces forged on a mandrel may be annealed before being rough bored and turned. Hoops whose forged thickness is less than 4 inches may be treated and tested before being rough bored and turned.

43. The contractor must deliver each forging and casting in such condition as to allow of its being finished true and to the dimensions that were standard at the time said piece was rough bored and turned, ordinary care being exercised in machine work.

44. If the inspector finds that any part of a forging has received less hammering or other beneficial treatment than it should properly have received, as compared with the parts from which test bars are to be taken, the piece will be rejected.

45. After the final forging, all heating must be uniform or uniformly graded throughout the entire piece, and all heating for tempering and all immersing shall be executed with the forging in a vertical position. The whole of the piece must be subjected to the treatment at the same time.

46. The contractor shall state for each piece, in writing, the exact treatment it has received.

47. The inspector shall examine all fractures of the metal, in the course of manufacture, for the purpose of determining whether it is of uniform and homogeneous structure.

48. **Tests and Acceptance.**—Forgings presented for provisional tests and acceptance will be critically inspected for defects of soundness and workmanship (as aforementioned). The records and facts as to their composition and treatment, and all other matters affecting them, will be considered, and they will be subjected to physical tests. They must conform to the requirements in all particulars, and must meet all inquiry and tests successfully in order to be provisionally accepted.

49. Physical tests will be directed toward the exhibition of all the principal physical qualities of the metal. Those to which particular attention will be devoted are tensile strength, elasticity, and extensibility.

50. These tests are to be made on cylindrical specimens 2 inches long between measuring points, $\frac{1}{2}$ inch in diameter, and of the general shape shown on the appended drawings. The specimens are to be taken from the forgings after final treatment *transversely to the axis of the bore of the finished gun*, and within the finished section prolonged. They are to be taken as near the finished piece as practicable, leaving sufficient metal for submitting additional test bars in case of re-treatment.

51. Test specimens shall not be cut off until from examination the forging is known to be sufficiently straight to machine finish to the required dimensions. If any doubt as to this exists the forging must be heated and straightened and then re-annealed before testing.

52. Test bars shall be cut and tests made under the supervision of an agent or inspector of the Department, who may make the tests personally if he should so desire. He will stamp and have the custody of each test bar.

53. If the contractor provides a testing machine of a pattern approved by the Department, the tests may be made at his works; otherwise the test bars will be suitably packed and delivered by the contractor, for transportation to such place as the Department may direct. The expense of *testing* in this latter case will be borne by the Department. The contractor has the right to be present at tests outside his works. Under any circumstances the Department may, if it so elects, have the tests made at any place.

54. The contractor shall first present three specimens from each end of a tube or jacket, from the end nearest the upper end of the ingot or casting of each hoop or plug, and from one face of a trunnion band; and from mushrooms, two transverse specimens from the head and one longitudinal specimen from the stem. The central axis of these longitudinal specimens from the mushroom stem need not be nearer the central axis of the forging than one-half of the radius of the latter.

55. In case the length of any hoop forging exceeds two and a half times its interior diameter, two specimens shall be presented from each end of such forging, instead of three specimens from the upper end.

56. The specimens taken from either end of forgings shall be considered independently of those taken from the other end of the same piece.

57. If all the specimens from any forging show physical qualities in each particular equal to or exceeding the figures in the following table, the forging shall be provisionally accepted, but if more than one specimen from either end of the forging fail to do so, the forging shall be rejected:

FOR GUNS OF 8-INCH CALIBRE AND BELOW.

	Tubes.	Jackets.	Hoops.	* Plugs.	* Mush-rooms.
Tensile strength.....	85,000	90,000	95,000	90,000	90,000
Elastic limit.....	45,000	50,000	55,000	60,000	60,000
Elongation after fracture.....	+18	+18	+18	+18	+18
Contraction of area.....	+30	+30	+30	+30	+30

* Nickel steel.

† Per cent.

FOR GUNS ABOVE 8-INCH CALIBRE

	Tubes.	Jackets.	Hoops.	* Plugs.	* Mush-rooms.
Tensile strength.....	85,000	88,000	95,000	90,000	90,000
Elastic limit.....	45,000	50,000	55,000	55,000	55,000
Elongation after fracture.....	+18	+18	+18	+17	+17
Contraction of area.....	+30	+30	+30	+30	+30

* Nickel steel.

† Per cent.

When forgings are required to be of nickel steel the physical requirements for guns of all calibres shall be, with about $3\frac{1}{2}$ per cent of nickel in all forgings, as follows :

	Tubes.	Jackets.	Hoops.	Plugs.	Mush-rooms.
Tensile strength.....	90,000	90,000	95,000	As prescribed for the different calibres in the above tables.	
Elastic limit.....	55,000	60,000	65,000		
Elongation after fracture. . .	*18	*18	*18		
Contraction of area.....	*30	*30	*30		

* Per cent.

Manufacture of Armor Plates.

58. **Modern Armor** is made of steel, the face of the plates being hardened by the process of supercarbonization.

The ideal plate would be composed of a metal homogeneously hardened throughout so as to make it as hard, if not harder, than an armor piercing projectile, and at the same time so tough as not to be shattered upon impact of the projectile. But this is metallurgically impossible of attainment. The most that can be done at present is to harden the face of the plate for a certain depth, leaving the back of the plate of tough steel to support the hard face. The principle is therefore very similar to that of compound armor which was composed of a hard steel face cast and supported upon a wrought iron back.

A short history of the development of armor, and a description of the methods of applying armor to a ship, together with a discussion of ballistics, will be found in chapter XXIX.

59. Face-hardened Armor.—Two kinds of face-hardened armor are used in the United States Navy—the “Harvey” and the “Krupp.”

The Harvey process is used for plates having a thickness of five inches and less; the Krupp, for those having a thickness greater than five inches.

Thin plates and hollow forgings, such as turret tops, doors, communication and ammunition hoist tubes, are made of homogeneous nickel steel oil or water tempered and annealed, but not face-hardened.

The bolts are of the best quality of nickel steel, oil or water tempered and then annealed, and contain about $3\frac{1}{4}$ per cent of nickel.

60. Harvey Armor contains carbon, manganese, silicon, phosphorus, sulphur, generally a small amount of copper and nickel. The per cent of phosphorus, sulphur and copper is kept as low as possible, while the carbon and the nickel, silicon and manganese are present in predetermined quantities.

61. Krupp Armor contains carbon, manganese, silicon, phosphorus, sulphur, nickel and chrome, the nickel, carbon, and chrome appearing in predetermined proportions, while the silicon, phosphorus and sulphur are kept at a minimum.

The addition of nickel (about $3\frac{1}{4}$ per cent), aided somewhat by the small per cent of manganese in the case of Krupp armor, gives great strength and toughness. The further addition of the chrome makes the metal more sensitive to temper, thereby permitting a greater depth of chill below the surface. It increases the affinity of the metal for carbon, which results in supercarbonization to a greater depth, and with careful treatment, gives the plate a tough fibrous back which resists cracking. It is this quality which marks the superiority of Krupp armor.

62. Manufacture of Armor Plate.—The manufacture of modern face-hardened armor comprises a series of operations which require the greatest care and attention to details to produce the best results, and these operations are so elaborate that a period

of nine months is allowed in the manufacture of service armor from the time of the receipt of the original drawings until the completion and delivery of the plates. The ingot is cast from steel made by the open-hearth process. The composition is predetermined.

63. Casting the Ingot.—The ingot mould is made up of cast iron sections, the parts of which are bolted together, the horizontal sections being held together by clamps. Each section contains on the interior numerous vertical webs, between which the back sand is pressed. A wooden pattern, in sections, is used, around which the facing sand (that next the ingot) is tightly pressed by rammers. The pattern is finally withdrawn, and long nails driven into the sand at close intervals to hold together the facing and the back sand, thus making the mould stronger, permitting the ingot to strip better. Outside of, and at each end of the mould, is a vertical tube or gate, each connecting with the interior of the mould at the bottom, near the middle of its length.

64. The molten metal is run from the open hearth furnace into a large ladle, which in turn is moved over a gate of the mould and then tapped. It is to get rid of the part containing segregation that the discard is made. When the mould has been filled, it is allowed to cool. The shape of the ingot is shown in the accompanying sketch. The projection on one end is for the purpose of handling the ingot.

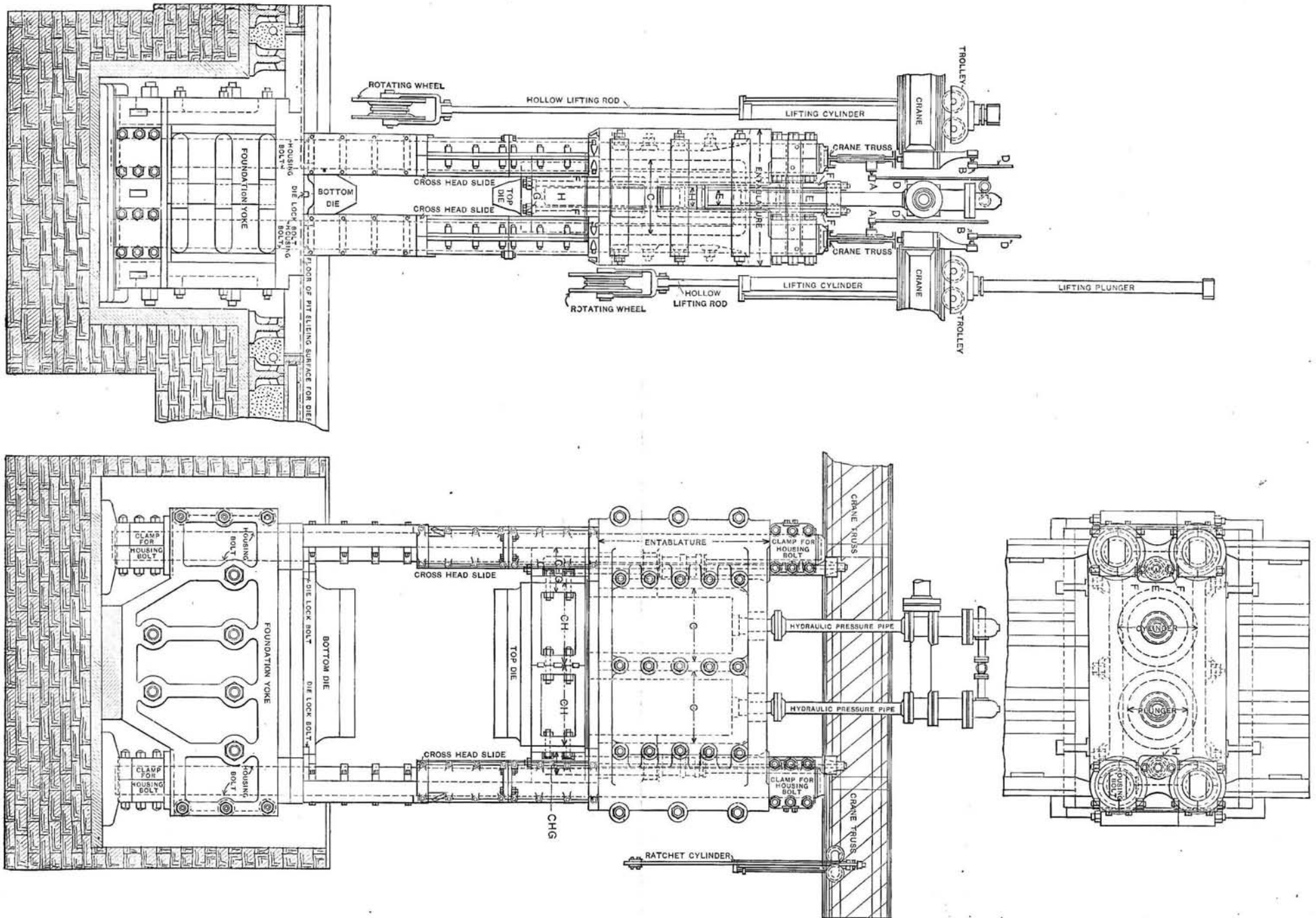
65. Forging.—When the ingot is cool enough, the mould is stripped away, and the ingot lifted out and cleaned. It is then sent to the forge where it is reheated in a furnace, and then forged by the forging press to a thickness somewhat greater than the finished plate.

66. Forging Press.—A general view of the Bethlehem Steel Company's Double Forging Press is shown in Plate V.

The construction of the press embodies a number of principal parts which are named or lettered on the plate mentioned.

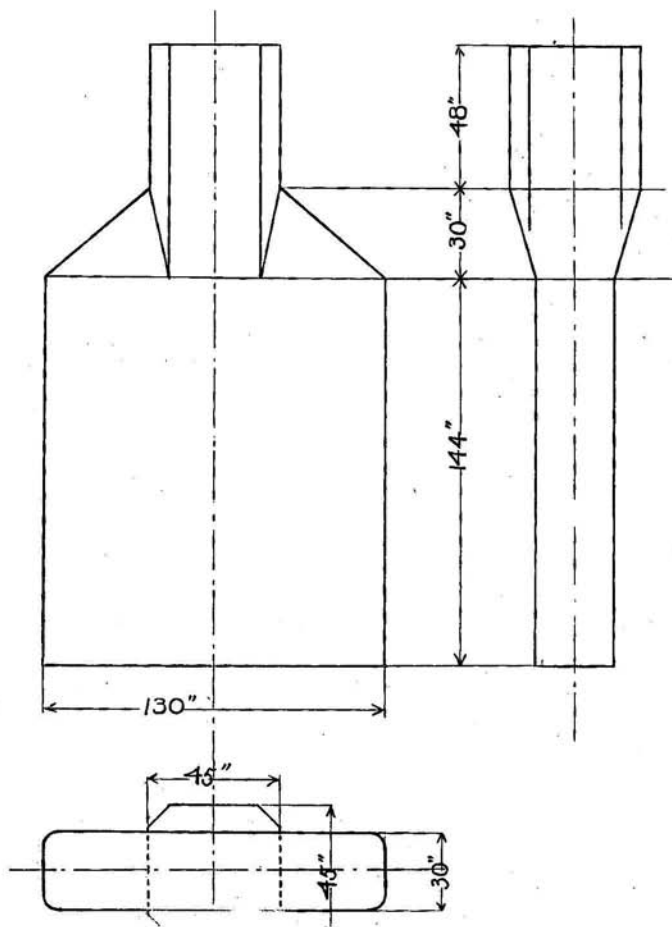
The *foundation yoke* is made of heavy sections bolted together by powerful bolts.

Four vertical *housing bolts* pass through the "foundation yoke" and through the *entablature*, which is made in two parts clamped together by heavy bolts.



THE BETHLEHEM IRON CO.
501½-INCH DOUBLE FORGING PRESS.

A number of parallel grooves, somewhat similar to threads, are cut at each end of each housing bolt and *split clamps* are bolted over these threaded parts, thus transmitting all strain due to forg-



Armor Ingot. Par. 64.

ing, through the housing bolts, and making of the entablature, the foundation yoke and the four housing bolts, a self-contained apparatus requiring no bracing from without.

The entablature is bored out to receive two steel cylinders (marked "C" "C") of 50½ inches internal diameter.

Within these two cylinders, two *plungers* operate with vertical motion.

Cast on the bottom end of each of these plungers and in one piece, with each plunger, are the two halves of the *cross-head* (marked "C. H.").

Bolted to each end of the cross-head are the *cross-head guides* (marked "CHG") which serve to transmit lateral strain to the *cross-head slides*, which are bolted to each of the four vertical housing bolts.

A removable *bottom die* is arranged to slide on the steel floor of the pit. This die is made either straight or tapered along its top edge according to the shape of the armor plate desired.

This die is pushed along the floor of the pit in either direction by an apparatus operated by two powerful hydraulic cylinders, which are not shown on the drawing.

The removable *top die* may be bolted to the under surface of the cross-head, and this die also, may be made of the proper shape to forge any shape desired in the armor plate. Hydraulic pressure is introduced to the interior of the cylinders by *hydraulic pressure pipes* passing through the top of the entablature and fitted into the tops of the cylinders in such a manner that the greater the pressure, the tighter the joint becomes. The engine for producing this pressure is not shown in the drawing, but is capable of producing a pressure of seven thousand pounds per square inch.

The total maximum pressure which the press is able to exert, is in the neighborhood of fourteen thousand (14,000) tons.

The seven thousand (7000) pounds hydraulic pressure is used only for driving the plungers downward, as the forging is done on the down stroke. The plungers are lifted on the stroke after each blow, by two *lifting cylinders*, one on each side of the press (marked "H").

A plunger (marked "E") operates in each cylinder ("H") which is connected to the cross-head through two lifting rods (marked "F" "F"), which pass through the cross-head guide on each side and are secured by nuts shown at "G."

In order to remove dies from the pit, to place new dies in the pit, and to handle armor-plate ingots which are being forged, two heavy traveling cranes are used with a capacity of about 250 tons each. These cranes are also used to charge ingots into the heating furnaces and to draw them from the furnaces when they are ready to be forged.

The ingots are carried in a very heavy flat link chain, similar to a bicycle chain on a very large scale.

This chain passes over a *rotating wheel*, to which rotary motion can be imparted by means of a combination of worm and spur gearing not shown on the drawing.

The worm is situated at the bottom end of a vertical shaft which passes through the *hollow lifting rod*. On the top end of the vertical shaft are arranged bevel gears which are connected through a series of shafting to a pneumatic engine situated at one end of the crane.

The hollow lifting rod is fastened at its top end to a small cross-head extending across the tops of two *lifting plungers*.

These lifting plungers operate up and down in a pair of lifting cylinders which are carried along the bridge of the crane by a heavy *trolley*.

The motion of the trolley along the bridge of the crane is obtained by means of a pair of pneumatic engines situated at one end of the crane.

The bridge of the crane is also moved along the rails on the top of the crane trusses by a pair of pneumatic engines.

All the pneumatic engines on the crane are controlled by an operator in a cage at one end of the crane.

All lifting on the crane is done by hydraulic power under a pressure of twenty-six hundred (2600 lbs.) pounds to the square inch.

The hydraulic power, as well as the pneumatic power, is transmitted from stationary connections (marked "A" "A") through hinged *scissors pipes* (marked "DD") to the moving connections (marked "B" "B") on the plate. Separate pipes are used for the water and air, although only one set of pipe connection is shown.

The lifting rods on the crane are controlled by a lever situated on the floor of the building.

67. Process of Forging.—The armor ingot being heated to a red heat is removed from the furnace by the crane, the chain being secured at the projection on the ingot, and the weight of the ingot being counterbalanced by a long, heavy beam on the opposite side of the lifting chain.

The ingot is swung easily into position and its end is pointed fair and landed on the lower die of the forging press (see Plate V). The upper die is then forced down upon the ingot, the throw being so regulated as to diminish the thickness of the ingot about 3 inches at each stroke. The metal flows evenly in all directions under the irresistible and steady pressure of the press, and after each stroke the ingot is moved along on the lower die until its thickness has been reduced by the same amount throughout its length. Its thickness is thus gradually diminished, while its length and breadth are increased until the desired dimensions are reached. This ends the operation of forging, and the plate is now ready for the process of carbonization, or face-hardening.

68. Carbonizing—Harvey Process.—After forging, the plate is face-hardened. The Harvey process of cementation, or face-hardening, is accomplished in a dry carbon furnace, the result being an integral plate supercarbonized to a considerable depth, giving an extremely hard, elastic face, bound together and supported by a tough back, having a minimum tendency to crack.

69. The Dry Carbon Furnace is built with a row of longitudinal flues under its floor. The flame from the coal comes from two fires placed at the smoke-stack end of the furnace, passes over the charge, then down vertical flues in the opposite end and then returning to stack through the longitudinal flues underneath the floor.

In this furnace two plates are generally carbonized together, the bottom plate resting on a bed of sand. The dry carbonizing material is placed on top of this plate and the other plate placed face down on the carbonizing material. The whole charge is then covered with sand to prevent contact with the flame or with air.

Two gas pipes are run through the carbonizing material into which iron rods are introduced and periodically drawn to examine the temperature of the furnace; the temperature being judged by the color to which these rods are heated.

The carbonizing material is a mixture of wood and animal charcoal. The time necessary for carbonization varies as with the gas furnace, according to the thickness of the plate. It takes generally from four to ten days to bring a furnace up to heat, after which it is maintained from four to ten days at the heat of carbonization. The charge is then cooled slowly and the plates removed after they have cooled down below a red heat.

70. The Krupp Process.—Many of the details of both the Harvey and Krupp processes are secret. The peculiarities and advantages of Krupp armor are secured as much by its chemical composition—especially as regards chrome, nickel and manganese—as by the method of carbonization employed. Even when cementation is accomplished in the same manner, carbon will be absorbed to a greater depth in Krupp than in Harvey armor, giving a greater depth of chill or hard face, and an increased resistance to penetration of about 25 per cent.

The ingot being cast in a mould, cooled and stripped, is reheated and forged. The plate is then charged in a furnace, which is brought to a temperature of approximately 2000° F., and coal gas is passed along the face of the plate which is to be carbonized. The heat breaks up the gas and deposits carbon on the face of the plate, and this carbon is gradually absorbed until the desired degree of carbonization is obtained. From the time of charging until the operation is completed requires a little over three weeks.

71. Gas Carbon Furnace.—Carbonizing furnaces are of two kinds, *dry carbon* and *gas*. The former has been described in par. 69. In the latter the gas flame is supplied to the furnace through a row of ports on each side, only one side being used at a time, that is, one side is used for a short time, when the flame is shut off from that side and the ports on the other side opened, the flame in each case being deflected from the ceiling of the furnace. During carbonization, temperatures are taken with a Siemens pyrometer, the temperature balls being placed on top of the upper plate. The time necessary for carbonization varies with the thickness of the plate; it takes about two days to bring the furnace up to heat, after which five to thirteen days are needed.

72. Depth of Carbonization.—In both Krupp and Harvey processes it is impossible to regulate the depth to which carbon is

introduced or to increase that depth beyond a certain point. The reason of this is that the carbon is absorbed decrementally—that is, it begins to shade away from the surface, the carbon in each successive layer being absorbed from that immediately preceding it, so that the limit in the surface layer being fixed to retain the characteristics of steel, the depth to which carbon is introduced is determined by that limit.

73. Treatment after Carbonization.—The plate is then taken from the furnace, scaled, then heated and reformed to the thickness required for the finished plate.

74. The Oil Tempering consists in plunging the heated plate into a large, deep tank of oil.

75. In Annealing, the plate is slowly heated, being gradually moved into the heated furnace; and is also allowed to cool slowly.

76. Machine Work.—Whatever machine work can best be done on the plate before bending is now done.

77. Bending.—Krupp plates are bent to the required shape under the bending press and again annealed.

Much greater care is needed with a Krupp than with a Harvey plate.

Bethlehem Steel Co's. 7000-ton Hydraulic Bending Press.

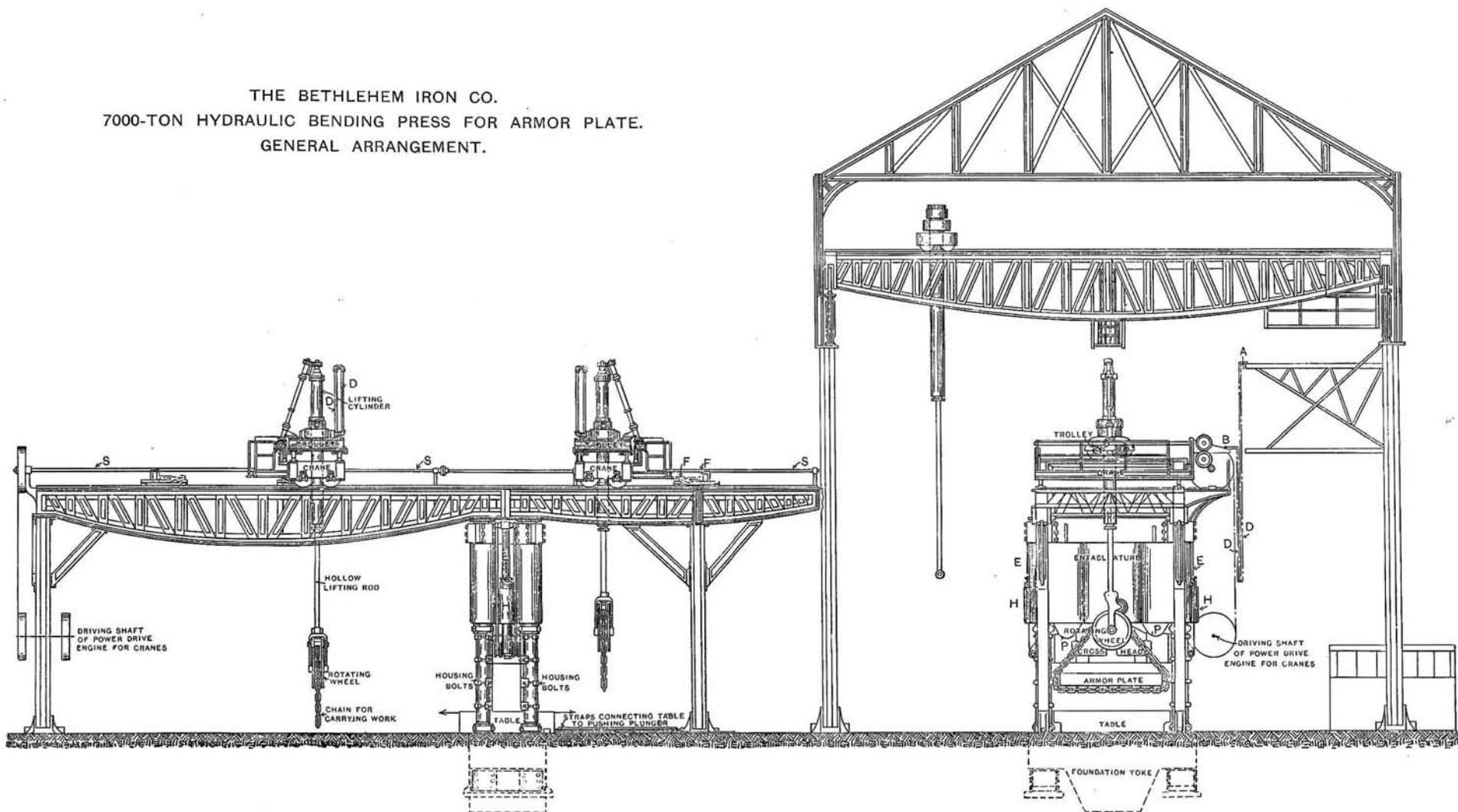
78. The Bending Press, shown in Plate VI, is, in general, similar to the forging press, having a *foundation yoke* and *entablature* connected by four housing bolts and having two plungers operating a cross-head and sliding in two vertical cylinders contained in the entablature.

A *sliding table* is, however, arranged on the floor of the press in place of removable dies, as in the forging press.

The two plungers P. P. have rounded ends on the bottom, forming with the rounded cavities on the cross-head a pair of ball and socket joints which allow the cross-head to be inclined to a horizontal when necessary, to produce a twist or warp in the armor plate.

The cranes are operated by a steam engine bolted to one of the columns supporting the crane trusses. This engine is connected to a long shaft (marked "S") by means of a belt fastened over two belt pulleys.

THE BETHLEHEM IRON CO.
7000-TON HYDRAULIC BENDING PRESS FOR ARMOR PLATE.
GENERAL ARRANGEMENT.



The cranes are similar to those at the forging press and the *scissors pipe* hydraulic connections are shown at "D" "D" being connected with the stationary pipe at "A" and with the moving pipe at "B."

The long shaft ("S") is supported at the extreme ends and at its center by stationary bearings; intermediate between these bearings are arranged special *tumbler bearings* (shown at "F" "F") so arranged that when the crane is about to occupy the space where one side of the bearing supports the shaft, this side of the bearing is made to fall out of the way, and by falling to elevate the other side of the bearing into position to support the shaft.

79. Bending Process.—The armor plate is brought by the crane to the bending press and landed on the table, where it is gradually bent to the required curvature by men who, by long experience, are specially skilled in conducting this operation.

80. Spraying.—After bending, plates are sometimes heated and hardened by spraying with water. This operation usually causes the plate to warp, so that it must be rectified under a heavy press. It is then finish-machined and erected. The result is a plate extremely hard on the face to a depth of about $\frac{1}{2}$ inch, this hardness shading away into chilled metal to a depth of about 2 inches from the surface, and this, in turn, shading away into a tough fibrous backing.

81. Armor Specifications and Tests.—The Inspector of Ordnance where armor is being manufactured for the Navy shall be permitted to examine freely the raw material, and to witness the processes of manufacture, in order that the finished product may conform to the specifications.

82. Manufacture and Chemical Analysis.—All the plates of each class of armor should be of the same quality, and, therefore, the steel used for their manufacture must be prepared from the same materials and by the same process. The plates must be cast, pressed, bent, cemented, tempered, and face-hardened according to the best methods, under similar conditions, and the whole method of manufacture must be practically identical for all the plates of the same class.

The chemical composition of all armor shall be such as will produce plates of the most resisting quality, and shall contain about $3\frac{1}{4}$ per cent nickel.

All raw material shall be chemically analyzed in the most approved manner by the contractor before use, and proper records thereof and proper melting records shall be kept by him. The product shall be uniform, and shall be manufactured by the open-hearth process.

83. Processes.—The ingot to be used in the manufacture of armor plates shall be so proportioned that it will produce the best result, and its weight shall be not less than twice that of the trimmed and finished plate, or, if more than one plate is made from an ingot, its weight shall be at least twice the combined weight of all the trimmed and finished plates made therefrom, except where plates to be manufactured from the ingot are to have a finished thickness greater than 6 inches, in which case the ingot shall be so proportioned that the amount of discard will be such as will produce the proper result, but in no case less than one and two-thirds times the combined weight of all the trimmed and finished plates made therefrom, and a discard of not less than 25 per cent shall be made from the upper end. In estimating for the observance of this rule, the calculated weights of the finished plates shall be used. In manufacture, a discard of not less than 30 per cent of the weight of the ingot shall be made from the upper end.

The ingot shall be forged or rolled as much as the best practice requires, but the ratio between the mean cross section of the ingot and that of the trimmed and finished plates shall not be less than three, except in special cases of very large plates, when less reduction may be allowed, except where plates to be manufactured from the ingot are of a finished thickness greater than 6 inches, in which case the ingot shall be forged or rolled as much as the best practice requires, but the ratio between the mean cross section of the ingot and that of the trimmed and finished plate shall be what good practice dictates but shall not be less than two and one-half, except in special cases of very large plates, when less reduction may be allowed.

During the process of reduction no metal shall be cut off, except such as will clearly have no further beneficial effect on the working of the metal which is to compose the finished plate.

Whatever method may be adopted for producing the ingot the part used must be equal in quality and in all other respects to an

ingot cast in the usual way, from which at least 30 per cent by weight has been discarded from the upper end. In the manufacture of hollow armor forgings, if fluid-compressed ingots are used, a discard of not less than 25 per cent of the weight of the ingot shall be made from the upper end.

Ingots must be free from imperfections that would injuriously affect the finished plate.

At least one chemical analysis shall be made, by and at the expense of the contractor, from each plate or forging. This analysis may be made from trimmings taken from physical test specimens to be cut from the plate before hardening.

If more than one plate is made from an ingot, an analysis shall be made from a specimen cut from the upper end of the uppermost plate, with reference to its position in the ingot, and the second analysis shall be made from a specimen cut from the lower end of the lowermost plate. An additional analysis may also be taken from time to time from the central region of such plates.

In face-hardened plates, an additional analysis for carbon shall be made from drillings taken from the treated surface at each end of each plate in such manner as to determine the amount of the carbonization, at depths of $1/16$ inch, $1/2$ inch, and 1 inch.

84. Tests for Uniformity.—After the plates have been subjected to all the treatment they are to receive, tests will be made from them for the purpose of exhibiting relative quality. For this purpose the character of the metal in the plates at ends will be compared and two specimens may be taken from points indicated by the inspector where results representative of the comparative quality of the plates will be obtained. In the case of face-hardened plates these tests shall be taken after hardening, unless the thickness or hardness of the plates renders it impracticable.

In all cases where test specimens are cut from face-hardened plates after carbonization or after water-hardening, they shall be located well in from the surface in order that the elongation and strength may not be affected by an accidental carbonization or decarbonization of the surface metal.

The hardened surface of all face-hardened plates shall be carefully examined after tempering, to detect any lack of uniformity in the hardness. For this purpose center punches, files, or ham-

mer and chisel, or similar means, shall be employed, and any marked departure from the desired uniformity shall be remedied by additional treatment.

Cracks in the hardened face of plates that are characteristic of the process by which they are manufactured will not necessarily be considered defects if not of such a character as to affect the ballistic quality of the plates.

The most important point to which attention will, at this time, be directed is uniformity of quality in the plates.

85. Rectifying Curvature.—When it is necessary to correct the curvature or rectify plates by bending after final treatment and testing, they may be heated to a temperature which will enable rectification, but not higher than 100° F. less than that of the last annealing. The hardness of the face must not, however, be impaired.

86. Ballistic tests are described in chapter XXIX, after which the plates which belong to the same class as the one which passes the test are ready for delivery.

CHAPTER II.

NAVAL RIFLED GUNS.

General Discussion.—Definitions.

1. **Rifled Gun.**—A *rifled* gun is so called on account of the spiral grooves which are cut in the surface of the bore, and into which the projections or soft metal bands on the projectile are forced, thus imparting rotation to the projectile about its longitudinal axis when it is driven out of the bore. When the charge and projectile are placed in the gun from the breech end it is termed a *breech-loading gun*, and is generally designated by the calibre in inches, and by the initials B. L. R.; or by R. F. if a *rapid-fire gun*.

2. **Lands.**—The spaces between grooves are called lands.

3. **Rib Rifling.**—When the grooves are very wide and the lands very narrow the gun is said to be *rib rifled*, and the lands are called *ribs*.

4. **Calibre.**—The calibre of a rifled gun is the diameter of a cylinder which touches the *highest* points of all the *lands*. In the case of rib rifling it is the diameter of a cylinder which touches the *lowest* points of all the grooves.

5. **The Term "Mark."**—For the sake of convenience or brevity, each gun of whatsoever calibre that differs considerably from those preceding is given a "mark," numbered serially, thus, 6-inch Mark I, 6-inch Mark VI, etc. There may be one or a large number of guns in each mark.

The differences creating marks may lie either in the construction of the gun, type of breech mechanism, manner of mounting (if a change on the gun is involved), or a difference in some important part or dimension.

This system of marks is carried on throughout ordnance, not only for guns, but for gun mounts, breech mechanisms, sights, powder tanks, firing mechanisms; in fact, all articles made according to standard drawings.

6. **The Bore of a Gun** is the cylindrical hole cut, or left, in the direction of the length and in the axis, to form a path for the projectile. It serves also to contain the powder charge before firing, as well as to confine the powder gases after firing.

In all modern breech-loading guns, the bore extends from the rear face of the gun tube to the muzzle face. This is called the *length of the bore*.

7. **Length in Calibres.**—It has become customary to designate guns by their length in calibres; for example, a “30-calibre 6-inch B. L. R.” This term defines the *total length* of the gun, and gives an approximate idea as to its power. But a more accurate method of comparing the power of guns of the same calibre is to give the *travel of the projectile in the bore* in calibres, since the velocity, and therefore the power of the gun is a function of the *travel*.

8. **Powder Chamber.**—The powder chamber is that part of the bore in which the powder charge is placed, and the *capacity* of the powder chamber is the cubical contents of all the space between the base of the projectile and the face of the breech-plug, whatever the shape of that space may be. Powder chambers in high-powered B. L. guns are larger in diameter than the remainder of the bore. The cylindrical part of the chamber is joined to the “compression slope” by an easy slope called the *slope of the powder chamber*. The “compression slope” is the short and comparatively steep slope against which the rotation band seats when the projectile is rammed home.

9. **Increase in Diameter of Powder Chamber.**—The development of great velocity and power has been accomplished by the use of relatively heavy charges of powder in guns of great length. And in order to keep the maximum pressure within reasonable limits (and thus avoid making guns too heavy and unwieldy) “slow burning” or “progressive powders” are used. If the powder chamber were maintained the same size as the rifled part of the bore, the cartridge would be too long and thus cause wave pressures, which might endanger the safety of the gun. Wave pressures are believed to occur only when very long cartridges are used; therefore the chamber must be greater in diameter than the rest of the bore in order to *reduce the length* of the cartridge for the same weight of charge.

10. Parts of a Gun as viewed from the outside: All guns have these parts, viz., the breech, muzzle, body or cylinder, and chase; and some guns the base, reenforce, trunnions, rimbases, and elevating band.

The *breech* is the rear end of the gun, while the *muzzle* is the front end. In the case of the old muzzle-loading guns "breech" used to be defined as the mass of solid metal to the rear of the bottom of the bore called "base," while the muzzle was that part terminating the chase where there was increased thickness of metal.

The *body* or cylinder, at the breech end of a gun, is that part over the chamber (and in high-power guns over part of the rifled bore) where the metal is the thickest. The outside diameter being about the same for the above distance gives rise to the name *cylinder*.

The *chase* of a gun may be defined as the sloping portion forward of the cylinder extending to the muzzle, whether in one taper or in stepped tapers caused by hoops.

The *reenforce*, found on cast guns, is the curved portion connecting the cylindrical "body" with the "chase," or sloping portion.

In long high-powered guns, the end of the chase forms a curve at the muzzle of increased diameter, which is known as the "bell muzzle." The metal is increased at that point to give greater strength and thus prevent enlargement of the bore due to high muzzle pressures from smokeless powder. It is easily seen that the metal at the end of a tube has not the same support as a section further to the rear.

Trunnions are two cylindrical arms on the sides of a gun at right angles to the axis, at or near the center of gravity, to support the gun on the carriage. In cast guns the trunnions are in one with the gun, while in "built-up" guns they are carried on a separate band. No gun, in our service, over 8 inches in calibre has trunnions.

The *rimbases* are the larger parts of the trunnions next to the gun which take against the sides of the carriage.

All guns are now made *trunnionless*, being supported by sleeves within which the gun recoils, the recoil being checked by hy-

draulic cylinders attached to the sleeves, the pistons of which are connected by their rods to a yoke on the gun. These sleeves have trunnions that rest in seats on the gun carriage. The first heavy guns built, exceeding 8 inches in calibre, rest in saddles, and are held thereto by suitable straps passing over the gun body. The saddle slides on the mount which carries the gun, and the recoil is checked by the hydraulic cylinders fixed to the mounting, the piston rods being secured to the saddle.

11. The Object in Rifling a Gun, primarily, is to give rotation to the projectile about its longer axis. Hence, of necessity, elongated projectiles are used in rifles.

Rotation is necessary to prevent the shell from "tumbling"; to cause the shell to fly steadily point first.

The principle of the rifle may be illustrated by a rapidly spinning top which stands upright. The projectile on leaving the muzzle of the gun has imparted to it a velocity of translation, or onward velocity; and a velocity of rotation about the longer axis.

12. Manner in which Rotation is Given.—In breech-loading rifles, rotation is accomplished by a copper rotation or driving band which is pressed into an annular score in the body of the projectile near the base and is kept from turning by roughening the score; the band moulds itself into the grooves of the rifling as the projectile moves along the bore.

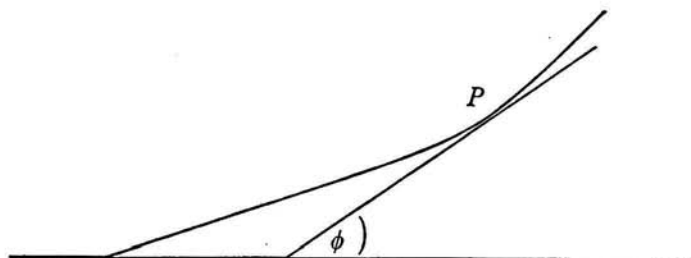
13. Definition of Twist as applied to rifling: *Twist* is the term generally used to define the angle of inclination of the groove, at any point, to the axis of the gun's bore; or the pitch of the rifling; or the distance in which the spiral makes one complete turn. Hence rifling may be treated like a screw thread.

The latter term is the usual one used to describe rifling, and it is customary to use as a unit of measurement the calibre of the gun itself. Thus, one turn in 25 calibres for a 6-inch gun means that the rifling would cause the shell to revolve once around its axis while traversing a distance of $25 \times 6 = 150$ inches, in the direction of the axis.

14. Kinds of Twist.—There are, (1) "uniform twist," or where the angle of inclination is the same throughout the bore; (2) "increasing twist," or where the angle of inclination con-

stantly increases toward the muzzle. This twist may start from 0, or a small inclination, and increase to the full amount at the muzzle. Uniformly *increasing* twist is the one adopted for all modern United States Navy guns, and it usually increases from 0 at the origin to one turn in 25 calibres at the muzzle. (3) Combined uniform and increasing twist (not used in our service).

15. Measure of Twist.—If the rifling of a gun be developed, each land will show as a curve as shown in the sketch. The angle ϕ which the tangent to the curve at any point P makes with the axial line is a measure of the twist of the rifling at that point. The twist is usually expressed as the tangent of the angle ϕ .



Curve of Rifling. Par. 15.

16. The Forms of Rifling Grooves (see Plate I).—There are various forms, but only two are found in the United States Navy. They are called (1) “poly-groove plain section” and (2) “poly-groove hooked section.” The term “poly-groove” simply means a *large number* of wide shallow grooves of equal width suitable for soft rotation bands.

Plain-section grooves (Fig. 1) are those in which the bottom of each is concentric with the bore, the sides terminating in quadrants of a small circle, both alike. This form is used for all guns below 6 inches in calibre (except the 5-inch Mark V), and is used on the Marks I and II 6-inch and 8-inch guns.

Hooked-section groove (Fig. 2) is a shallow groove consisting of a driving side, the curve of which is a part of small circle (radius about 0.09 inch), then a small portion (about one-quarter) of the groove is concentric with the bore, while the remaining side is sloped off into the bore by radii and a straight taper,

FIG. 1. PLAIN SECTION GROOVES.



FIG. 2 HOOKED SECTION GROOVES



FORMS OF RIFLING.

forming the *lands* between the grooves. This is the more modern groove and is used for all guns of and above 6 inches in calibre and for the 5-inch Mark V gun. The depth of a groove is usually 0.05 inch (for large guns); the width usually decreases from the breech toward the muzzle, in order that the rotation band may completely fill the groove and thus prevent the escape of the powder gas around the projectile. If the grooves were not narrowed, the cutting away of the metal on the rotation band would leave a gradually increasing space for the gases to flow through and thus produce erosion of the bore.

17. Driving Side of a Groove (see Figs. 1 and 2).—Facing the muzzle of the gun, if the twist be right-handed (always right-handed in United States Navy guns), the driving edge is on the right hand.

By "driving edge" is meant that edge which forces the band, and with it the shell, to rotate about the longitudinal axis.

18. Uniform compared with Increasing Twist.—Uniform twist is simpler; the *mean* pressure between driving surfaces is less, but the *maximum* pressure is greater than with "increasing twist." The maximum pressure between driving surfaces in uniform twist is greatest at the *start* and the band is more or less apt to strip for this reason.

With "increasing twist" the *least* pressure is at the beginning of the projectile's movement, as the rotation band is not forced to take the whole twist of the rifling at once, while the *greatest* pressure is at the muzzle. The rifling has a better grip on the band at the start. Thus it will be seen that "increasing twist" is more suitable for heavy guns, especially when large powder charges are used, giving high velocities.

It should be noted, (1) that *powder erosion* is less with increasing twist, due probably to the fact that new metal of the band is constantly moulded into the grooves, thus preventing the escape of gas around the projectile; (2) a narrower band must be used with increasing twist than with uniform, on account of the constantly changing angle of the rifling.

19. Windage means the space left between the outer surface of a projectile and the surface of the bore of a smoothbore gun. The projectile in this case must be a trifle smaller in diameter than the calibre of the gun, in order to

In the case of smoothbore guns, as there is no rotation band on the shell, there must be some escape of powder gas on firing. It is not usual to say that a breech-loading rifle has windage, because the rotation band fills the space.

20. Guns Classed Aboard Ship.—The following is the usual, or general, shipboard classification: (1) Main-battery guns; (2) secondary-battery guns; (3) field guns; (4) small arms.

21. Main-battery Guns.—All guns of and above 4 inches in calibre constitute the "main battery."

Some small vessels, such as torpedo boats and destroyers, may not carry a gun as large as a 4-inch; in this case such as are carried constitute the "battery."

22. Classes and Calibres of United States Navy Main-battery Guns.—The main-battery guns are divided into: (1) Heavy-calibre and turret guns. These are the 13-inch, 12-inch, 10-inch, and 8-inch guns. (2) Intermediate-calibre guns. These are the ordinary rapid-fire and quick-fire types, represented by the 6-inch, 5-inch, and 4-inch guns (and the new 7-inch).

23. Secondary-battery or Light-calibre Guns.—All guns, of whatever type, of a calibre less than 4 inches, and guns of small-arm calibre (not fired from the shoulder or held in the hand), such as machine guns, constitute the "secondary battery." Some small vessels carry nothing but "secondary-battery" guns.

24. Types and Calibres of United States Navy Secondary Guns.—(1) Rapid-firing guns. These are the 3-inch 50-calibre (or 14-pounder guns); the 6-pounder, calibre 2.244 inches; the 3-pounder, calibre 1.85 inches; and the 1-pounder, calibre 1.457 inches. (2) Semi-automatic rapid-fire guns: The 6-pounder, calibre 2.244 inches; 3-pounder, calibre 1.85 inches. (3) Automatic rapid-fire guns: The Maxim 1-pounder, calibre 1.457 inches. (4) Machine guns; the Gatlings of 30 and 6 millimeter (or 0.236 inch) calibres; the automatic guns, calibre 30 and 6 millimeters (or 0.236 inch); the revolving cannon, 53-millimeter, 47-millimeter, and 37-millimeter calibres, firing shell weighing 3.9 pounds, 2.4 pounds, and 1 pound, respectively. There are only a few revolving cannon now in the service.

25. Field Guns.—These are light guns, usually of, or less than, 3 inches in calibre, mounted on "field carriages" for operations

on shore. When of a single-shot or rapid-fire type, specially designated as "field," they are usually lighter in weight and shorter than the Navy gun of the same calibre.

The secondary guns of a ship's battery, especially the 1-pounder revolving cannon, machine, or automatic guns, are, however, often mounted on "field carriages" and used as "field guns."

There are two types of "field guns," (1) ordinary and (2) rapid-firing. The ordinary type is represented by the old 3-inch breech-loading rifled howitzer, of which a number are still in the service. The rapid-fire type is represented by the Fletcher 3-inch field gun, firing a shrapnel (weight, 12 pounds), and a 6-pounder Driggs-Schroeder field gun.

26. Small Arms are those fired from the shoulder or held in the hand. They are usually of a calibre less than .50 inch. The types are the rifle (musket) and revolver.

The rifles are the Hotchkiss magazine, of .45 calibre; the Lee bolt magazine, .45 calibre; the Lee straight pull, calibre 6 millimeters; and the United States magazine rifle, .30 calibre (Krag-Jorgensen). The two former are used only for subcalibre practice. The revolvers used are the Colt's and the Smith and Wesson double-action Navy, calibre .38, six shots.

27. Boat Guns.—These are the "field" or lighter guns of the secondary battery, mounted on special boat mounts in a ship's larger boats, such as launches and cutters.

28. Top Guns are a part of a ship's secondary battery mounted in the "military tops" on special "top mounts." The smaller-calibre guns, such as the 1-pounder rapid-fire, 1-pounder automatic rapid-fire, Colt automatic, and Gatling guns are those generally used as "top guns."

29. Minor-calibre Guns.—The term "minor-calibre" is sometimes applied to guns of a calibre less than 4 inches, and hence means a "secondary-battery" gun.

30. Great Guns is an old term used for the guns of the main battery, arising probably from their weight or size, to distinguish from howitzers, small arms, etc. The term is still often used as an adjective, thus: "Great-gun practice."

31. Definition of Rapid-fire Guns.—A rapid-fire gun is a

single-shot (single barrel) gun of a greater calibre than small arms, using "fixed ammunition," or a cartridge case, and having a quick-acting breech mechanism operated by a single movement of the hand, or automatically opened by the gun's discharge.

The short definition used by some is: A gun that uses a metallic cartridge case, on the supposition that it is known that the breech mechanism is quick-acting.

Strictly speaking, the gun mount should be included in the definition. A mount permitting quick and easy elevation and train, having practically a "run-out position" of the gun is a *sine qua non*.

32. Definition of Automatic Gun.—This is one in which, the first shot having been fired by hand, the explosion of each cartridge successively and continuously operates the mechanism to eject the empty case and to load and fire another cartridge, so long as ammunition is properly fed.

33. Definition of Semi-automatic Rapid-fire Gun.—This is a single-shot gun in which one operation of the hand is required for each fire, the other operations being performed automatically by the explosion of the cartridge.

34. Definition of Automatic Rapid-fire Gun.—It is an automatic gun, the calibre of which is of a size to permit the use of an explosive shell (calibre greater than 1 inch, weight of shell not less than 1 pound).

NOTE.—It will thus be seen that the only distinction between an automatic gun and an automatic rapid-fire gun is that of the calibre. The simple term "automatic gun" is used to denote a gun of *small arm calibre*.

35. Definition of Machine Gun.—This is one of small-arm calibre only (in a broad sense a machine gun may be of any calibre, and in that sense is so used later on for the purpose of classification), from which a continuous rapid fire can be maintained by the operation of its mechanism either by hand or by motor power, causing successively the loading, firing, and the extraction of the empty case, the ammunition being suitably supplied.

36. Definition of Revolving Cannon.—It is a gun of minor

calibre, firing explosive shells, in which by the simple turning of a crank, a number of barrels intermittently revolve in front of a hollowed-out breechlock containing the mechanism. This mechanism performs for each barrel, during its revolution, the successive operations of loading, firing, and extracting.

The rapidity of fire, therefore, depends upon the speed of the revolution of the crank, the ammunition being properly supplied. The ammunition is usually fed by hand into a hopper or trough.

37. Definition of Quick-fire Gun.—This is a single-shot gun, usually of a calibre not less than 4 inches nor greater than 8 inches, having a quick-acting breech mechanism operated by a single movement of the hand, or in some automatic manner; not using a metallic cartridge case, but loaded in the ordinary manner and provided with a suitable "gas check."

NOTE.—It will thus be seen that the essential differences between a rapid-fire gun and a quick-fire gun are in the ammunition, manner of loading, and the provision of a "gas-check."

38. Names of Standard Main-battery Rapid-fire and Quick-fire Guns:

Four-inch rapid-fire, Dashiell, Fletcher, and Driggs-Schroeder.

Five-inch rapid-fire, Dashiell and Fletcher.

Five-inch quick-fire, Vickers.

Six-inch rapid-fire, Fletcher and one Dashiell.

Six-inch quick-fire, Vickers (and one experimental Fletcher).

Also six-inch rapid-fire, with Bethlehem breech closure for the U. S. S. Baltimore.

39. Names of Standard Secondary Guns:

First, rapid-fire guns—Hotchkiss and Driggs-Schroeder 6-pounders, 3-pounders, and 1-pounders.

Second, semi-automatic rapid-fire guns—Maxim (Nordenfelt) 6-pounder and 3-pounder.

Third, automatic rapid-fire guns—Maxim (Nordenfelt) 37-millimeter or 1-pounder.

Fourth, machine guns—Gatlings, .45 calibre and .30 calibre; Colt automatic guns, calibre .30 and 6 millimeters (0.236 inch); revolving cannon, Hotchkiss 47-

millimeter and 37-millimeter (also a few 53-millimeter).

40. Names, Types, and Calibres of Foreign-built Guns used in the Service:

Armstrong 6-inch rapid-fire (on *New Orleans* and *Albany*).

Vickers 6-inch quick-fire (only one).

Armstrong 4.7-inch rapid fire (on *New Orleans* and *Albany*).

Maxim-Nordenfelt 4.7-inch rapid-fire (only two), Melstrom breech mechanism. Made by Vickers & Co.
Welin 4.7-inch rapid-fire (only one). Made by Vickers & Co.

Hotchkiss 14-pounder and 9-pounder rapid-fire guns.

Maxim-Nordenfelt 3-inch, or 12½-pounder, rapid-fire gun, Melstrom breech mechanism (only one).

Nordenfelt 6-pounder rapid-fire guns, Mark II.

Maxim (Nordenfelt) 6-pounder and 3-pounder semi-automatic rapid-fire guns.

Maxim (Nordenfelt) 3-pounder rapid-fire guns; Maxim 1-pounder automatic, and a number of English and French built Hotchkiss 6-pounder and 3-pounder rapid-fire guns; French 1-pounder Hotchkiss guns; a few French-built Hotchkiss revolving cannon of 53-millimeter and 47-millimeter calibres.

41. A Pneumatic Gun is one in which highly compressed air instead of powder gas is used to propel the projectile. The construction is quite different from that of powder guns, the form being cylindrical, as the air pressure is not great. The only guns in our service of this type are the so-called dynamite guns formerly used on board the *Vesuvius*.

42. Designation of Guns.—Guns are usually named or designated either by (1) calibre in inches; (2) weight of projectile expressed in pounds (if not less than one pound); (3) the name of the breech mechanism or its character; (4) combination of (1) and (3) or (2) and (3). Sometimes these are followed by the length of bore in calibres, and an abbreviation for the "distinguishing terms," breech-loading, or muzzle-loading, rifle; or the

special terms, rapid-fire gun (R. F. G.), quick-fire gun (Q. F. G.), or the character of the ammunition.

Thus, for modern guns of or above 3-inch calibre, 6-inch 40-calibre B. L. R. means a 6-inch breech-loading rifle 40 calibres length of bore; 5-inch R. F. G., a 5-inch rapid-fire gun; 6-inch 50-calibre Q. F. G., a 6-inch quick-firing gun 50 calibres long; and 8-inch M. L. R., an 8-inch muzzle-loading rifle.

For old smoothbore guns, the number indicating the inches of calibre is written in the Roman style and no distinguishing term is used, thus, XV-inch gun.

For modern guns below 3 inches in calibre, 6-pounder H., means a 6-pounder Hotchkiss gun; a 6-pounder 50-calibre D. S. R. F. G., a 6-pounder Driggs-Schroeder rapid-fire gun 50 calibres length of bore; Maxim (Nordenfelt) heavy 1-pounder, a gun firing a one-pound shell fitted with a Maxim (Nordenfelt) breech action and using a heavy charge to distinguish from the same calibre gun using a lighter charge; Colt automatic gun, a gun with the automatic breech action of the Colt patent (see definition of automatic guns).

For small arms, the designation in our service has not followed any rule; .45-calibre Lee means a rifle of .45-inch calibre with a Lee breech mechanism; 6-mm. rifle, a rifle of 6-millimeter calibre with a Lee straight-pull breech mechanism; U. S. magazine rifle, a rifle of .30-inch calibre with Krag breech mechanism.

In addition to the above, where there are different marks (see definition of term) of the same calibre, the following form or designation is sometimes used: 5-inch 40-calibre R. F. G., Mark III, or 6-pounder Maxim (Nordenfelt), Mark III. Some guns retain their foreign designation; 37-mm. Hotchkiss R. C., meaning a Hotchkiss revolving cannon, calibre 37 millimeters (1.456 inches).

The usual *service method* is to write the calibre and the mark only, thus, 8-inch Mark III; 6-pounder Mark II, Hotchkiss.

43. High-Powered Guns.—Previous to the year 1879 a muzzle velocity of 1350 to 1450 f. s. was considered good with a rifled gun, and the power of the projectile to penetrate armor, and the other ballistic properties of the gun were limited by those velocities.

The introduction of slow burning *brown powder*, and a con-

siderable increase in the length of naval guns had the effect to increase the muzzle velocity to about 2000 f. s., which was the rule for several years.

The comparatively recent perfection of smokeless powders, marks the next increase in muzzle velocity. The absence of solid residue, after the combustion of smokeless powder, leaves more space for gases in the chamber. With the same, or even a smaller maximum pressure, about double the initial volume of gas is evolved, which, expanding to the muzzle (and being constantly augmented by the evolution of more gas from the slow or progressive burning powder), increases the pressure along the bore and gives to the projectile increased acceleration and a much greater initial or muzzle velocity.

The new types of naval guns are designed for a muzzle velocity of about 3000 f. s.

Still greater velocities have been attained in experimental guns.

44. Increase in Power since 1879.—The power, or energy, of the projectile at any range increases as the square of the velocity; it is, therefore, evident that by increasing the muzzle velocity from 1450 f. s. to 3000 f. s. the muzzle energy is more than quadrupled with the same weight of projectile. Hence the term *high-powered guns* is applied to guns having an attainable muzzle velocity of about 2500 f. s. and upward, and the term is applied to guns of all calibres.

The only low-powered guns at present in service are the field guns.

45. Practical Questions in Gun Construction.—A *high-powered breech-loading gun* being a necessity, the question arises, how shall the gun be constructed?

A gun may be considered as a tube destined to withstand a given pressure from within, throwing a projectile which shall produce certain effects at given distances. In constructing such a tube, we must first consider what pressures it will have to withstand at the various points of its length, and then make it strong enough to insure perfect safety. The bore also should be of such material as to stand the wear and tear of firing a large number of rounds without being so damaged by expansion or abrasion as to interfere with the shooting.

Not only must the gun be sufficiently strong, but it must not be too heavy; so it is important that the material shall be arranged in such a manner that there may be no waste of its strength—in fact, so arranged that every part shall perform its own share in withstanding the pressure from within. Shortly after the shot begins to move, the pressure inside the gun decreases, and continues to decrease as the projectile approaches the muzzle; for this reason the gun is made stronger at the powder chamber than toward the muzzle end.

Looking simply to the construction of a gun cylinder, we find that the two principal stresses to which such a cylinder is subjected upon the explosion of the charge are, first, a circumferential or *tangential stress* or tension tending to split the gun open longitudinally, usually called *hoop tension*; second, a *longitudinal stress* tending to pull the gun apart in the direction of its length.

Now, the least complicated method of making a gun would seem to be that of casting it as a homogeneous hollow cylinder; but if we take such a tube, made of one material throughout, we find that its tangential strength to resist a pressure from within does not increase uniformly with its thickness.

We find, practically, that with a given material we soon reach a limit beyond which any additional thickness of wall aids but little in enabling the cylinder to withstand such a pressure. Supposing the metal to be incompressible, this limit is taken at about half a calibre, so that—for example in the cylinder of an hydraulic press—if the thickness of the walls be equal to one-half the diameter of the piston which works inside, then the cylinder will be nearly as strong as if it were ten times as thick.

It is generally conceded that no possible thickness can enable a simple cylinder to bear a continual pressure from within *greater on each square inch* than the tenacity of a square inch bar of the same material; that is to say, if the tensile strength of cast iron be 12 tons per square inch, no cast iron gun, however thick, could bear a charge which would strain it beyond that point; for, on the first round the interior layer would be ruptured before the outer portion could come into play, and every succeeding round would tend to make matters worse.

From the above it is clear that guns made by casting iron,

bronze, or steel into homogeneous cylinders cannot be made strong enough to bear more than a certain pressure from within. Now, the working pressure which we require a high-powered gun to withstand is not less than 18 tons per square inch, and we require, further, that this pressure shall not strain the gun beyond the elastic limit of the metal, in order that the bore of the gun shall not be permanently enlarged. Now, the elastic limit of cast steel is from 15 to 20 tons per square inch, and we have seen that steel has a higher elastic limit than either iron or bronze, so that, allowing a margin of safety, it will not do to make a high-powered gun of cast homogeneous metal even when we use cast steel. We must resort, then, to what is termed the built-up system, and it can be shown mathematically that a built-up gun, properly constructed, of the same dimensions and material as a homogeneous gun, is stronger than the latter. A *built-up* gun is one in which the principal parts are separately constructed and then united in a peculiar manner; and guns so constructed may be composed of different kinds of metal, or of the same kind of metal throughout. We now come to the two principles of construction for strong and heavy guns. They are:

46. First—The Principle of Varying Elasticities.—This consists in placing that metal which stretches most *within its elastic limit* around the surface of the bore, so that by its enlargement the explosive stress is transmitted to the other parts exterior to it. This method is exemplified in guns which have a steel tube surrounded by wrought iron coils, and in the Palliser system, in which a wrought iron or steel tube is surrounded by cast iron. With different grades of steel—high and low steel for example—the steel which shows the greater elongation within the elastic limit is the more suitable to be placed next to the bore. Carrying out this theory in practice is another matter, because in the case of very long tubes there is more difficulty and uncertainty of manufacture with the higher grades of steel than with the lower, and the difficulty increases with the size. *For this reason the principle of varying elasticities is only applicable where the different parts of a gun are made of different metals.*

47. Second—The Principle of Initial Tensions.—This consists in giving to the exterior portions of the gun a certain initial

tension, gradually decreasing toward the interior, and giving to the interior parts a certain normal state of compression by the grip of the outer cylinders and coils.

If by the system of initial tensions the interior can be put in a state of compression within the elastic limit of the metal, the amount of compression is so much additional strength to the interior tube, since the compression must be first overcome before the powder gases can exert a tension on the interior tube, as will be shown in the theory of gun construction. In order to exert compression, then, the outer coils or hoops must be in a state of normal tension, and in addition to that they must have a margin of strength within their elastic limits to withstand the additional tension transmitted by the explosion of the charge.

The exact amount of tension and compression for all parts of the gun when at rest, or when resisting the explosion of the charge, so that all parts shall be strained to a point not exceeding their elastic limits, is a matter for mathematical calculation, and is treated at length in works on the theory of gun construction.

The principle of initial tensions, carried to an extreme limit, would be exemplified in the case of a gun composed of an infinite number of infinitely thin hoops properly shrunk together. When so assembled, the tension in such a gun, when the powder pressure acts, would be uniform throughout the thickness. The greater the number of hoops the nearer this theory is approached in practice, but there are practical difficulties in manufacturing, such as the accurate machine work necessary and the greatly increased cost, so that it is not considered practicable to use more than four layers in the case of guns now designed. In the case of wire guns or ribbon-wound guns this theory is better exemplified, and when successful manufacture is possible in these cases, stronger guns of the same weight must be the result.

The principle of *initial tensions* is followed in all built up guns for the Navy. And as all parts of the gun are made of high grade steel it is practically impossible, in following the principle of initial tensions, to secure, also, the advantages of varying elasticities, because the tube being much larger than the jacket and the jacket much larger than the hoop, the elastic strengths of the several parts will vary inversely as the size, and thus the principle of varying elasticities will be violated.

48. Shrinkage.—Practically, the compression of the interior and tension of the exterior is effected in manufacture, after the amounts for each have been calculated, either (1) by *shrinkage*, (2) by forcing two cylinders of slightly coned surfaces upon one another by hydraulic pressure, or (3) by winding steel wire, or riband, over a steel tube.

If the method of *shrinkage* be employed, the hoops or tubes to be shrunk on must be accurately bored, and the outer coil expanded by heat until it is sufficiently large to fit easily over the inner coil or tube. The inner diameter of the outside coil when cold must be a little smaller than the outside diameter of the inner tube, and this difference of diameters is called the *shrinkage*. While the outer coil is cooling and contracting it compresses the inner one, making the diameter of the latter a little smaller than before. The amount by which the exterior diameter is decreased is called the *compression*.

Again, the outer coil itself is stretched on account of the resistance of the inner one, and its interior diameter is slightly increased. This increase is called the *extension*.

The *shrinkage* is always equal to the *compression* plus the *extension*, and the exact amount must be previously calculated by the known extension and compression of various metals under certain stresses and given circumstances.

49. The Thickness of Walls.—Having settled upon the built-up gun as the proper construction to follow, it only remains to describe in general terms how the thickness of the walls is determined.

Experiments with crusher gauges placed at different distances along the bore of a gun, and formulas for constructing pressure curves, have enabled gunmakers to form a good idea of the pressures at different distances from the bottom of the bore. Hence a curve of pressures can be constructed for a given powder that will approximate to the truth for practical purposes; a good margin of safety is always allowed, and the various thicknesses of metal to withstand the pressures at different points of length of bore follow at once, the calibre and length of gun having previously been fixed by the amount of work the gun is expected to perform.

After a drawing of the gun has been completed, the elastic strength to resist powder pressure is computed at all points, together with the shrinkages. The strength curve is then compared with the pressure curve, and if there is not a sufficient margin of safety, a re-adjustment of the dimensions of the parts of the gun is then made, and the elastic strength is re-computed.

50. Built-up Guns in the Service.—These comprise all guns of the main battery and the larger part of the secondary battery. The 6-pounder and 3-pounder Maxim semi-automatic rapid-fire; 1-pounder Maxim automatic rapid-fire; 53-millimeter, 47-millimeter, and 37-millimeter revolving cannon, are *single* forgings.

51. Building up Secondary Guns.—The principle of the system is the same as for main-battery guns. The number of the parts usually does not exceed three, viz., tube, jacket, and locking hoop. The latter is usually screwed on, and bears the front sight.

52. The Wire-Wound Gun.—As stated above, this is an example of the "initial tension" system. The wire is wound in layers around an inner tube of steel. Each layer is wound with a different tension of the wire, and each layer exerts a compression on the layers which are inside of it. The result is that when completed the outer layers are in extension, gradually diminishing to the inner layers, which are in compression; all within the elastic limit. As wire can be made of enormous strength (as much as 200,000 pounds per square inch tensile strength), this type of gun is the strongest for the same weight of any yet developed.

In the different types of wire-wound guns, the inner tube may be either one piece of steel, or a number of longitudinal bars of special shape like the staves of a barrel gripped together by the wire to form a tube. As narrow bars can be made stronger than one large forging, this "stave" or "*segmental*" *wire-wound gun* is *supposed* to represent the highest type of built-up gun and will stand enormous pressure (35 tons per square inch and more have been recorded).

The usual way, however, of building up wire-wound guns is to have a solid forging for the tube, stepped at the rear end, the

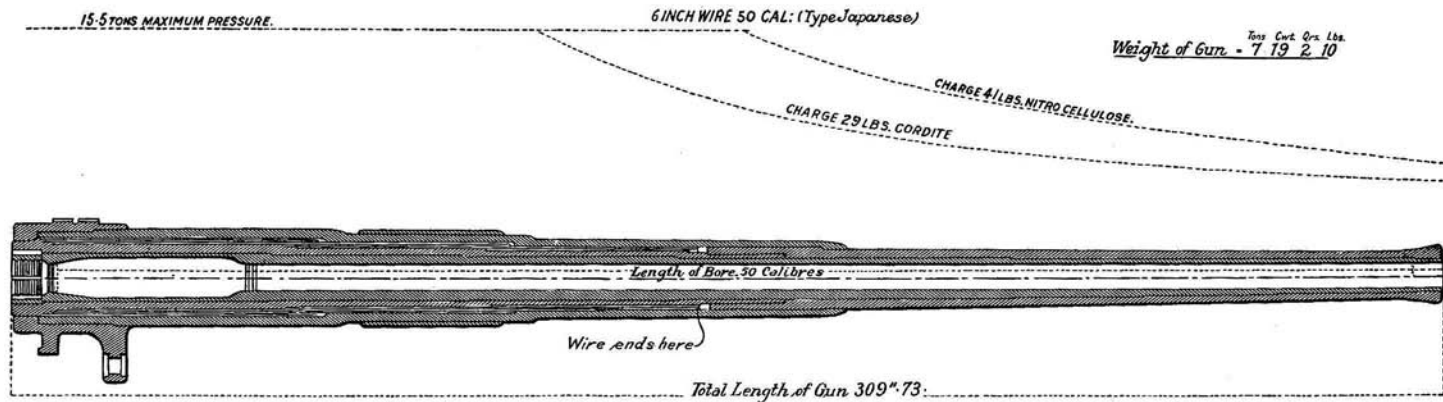
wire being wound only over the parts covering the chamber and the rear end of the rifled bore. The ordinary hoops are shrunk on over the chase, and an outer hoop or hoops, also shrunk on, cover the wire-wound part.

There are no wire-wound guns in our service. There are some difficulties incident to the manufacture, and other drawbacks as to protection of wire, defective *longitudinal* strength, etc., which make this type, on the whole, less satisfactory than the ordinary hooped gun. A good many wire-wound guns from 5 to 12 inches in calibre are found in the English service.

53. Foreign Wire-Wound Guns.—The 12-inch 40-calibre wire-wound gun of British type is constructed with two tubes, one inside the other, extending the whole length of the gun, thus admitting of rapid and efficient repair when the inner tube is worn out or injured. The radial strains on firing are overcome by the shrinkage of the outer tube over the inner, and by winding wire at varying tensions over the outer tube from the breech to a point near the muzzle. The jacket and a long chase hoop are then shrunk on over the wire to confine it, and are locked together. The longitudinal strain is taken by connecting the outer tube (in which the breechblock houses) to the jacket by a breech ring.

Plate II shows the 6-inch 50-calibre wire-wound gun now being constructed by Vickers Sons and Maxim for the Japanese government. It will be seen by reference to this diagram that the wire only extends for about one-half the length of the shot travel, the radial strains in the chase being taken by a solid steel hoop shrunk over the inner tube. In guns of 50 calibres length, the elimination of the wire over the chase enables the girder strength to be somewhat improved, so that there is no fear of the extra length causing the gun to droop. It will be seen that the breechblock houses in the jacket and that the latter is connected by a large breech ring to an outer jacket which is shrunk on over the wire and securely locked to the chase hoop. By this system of construction great longitudinal strength is secured.

54. Nickel Steel v. Wire Winding.—Messrs. Krupp, who have done so much for the improvement of ordnance generally, use



FOREIGN WIRE WOUND GUNS. Par. 53.

Ballistics.	Cordite.	Nitro-Cellulose.
Weight of Projectiles.....	100 Lbs.	100 Lbs.
Weight of Charge	29 "	41 "
Muzzle Velocity (Ft. Secs.)	3000 "	3000 "
Muzzle Energy (Ft. Tons).....	6240 "	6240 "

nickel steel for all the tubes except the inner. The use of nickel steel instead of ordinary steel has no doubt some advantages, notably greater strength of material; but this high quality of steel is not so necessary with wire-wound guns, owing to the extra strength given by the wire far exceeding that of any ordinary nickel steel. There is much in favor of using a steel giving a high elastic limit and good elongation for the smaller types of guns, for which the wire system is perhaps less suited. By using suitable steel and treating it by a special process the necessary strength can be obtained without the addition of nickel.

(General Information Series No. 21, July, 1902.)

CHAPTER III.

CONSTRUCTION OF NAVAL GUNS.

Details of Construction at the Gun Factory.*

1. **General Features of Main Battery Guns.**—The *heavy guns*, as before designated, have the same general features, speaking of the gun body alone, and are represented in section in Plates IV, V and VI.

The guns are composed of a *steel tube*, in one piece, extending the whole length of the bore; a *jacket* shrunk over the tube from its breech end, extending about two-fifths of the length of the tube; *jacket hoops* shrunk over the jacket; *locking hoops*; and *chase hoops*, extending to the muzzle, except in guns of over 35 calibres in length, in which cases the chase hoops end at a length of 35 calibres, approximately; the later marks of guns have longer jacket and chase hoops than the earlier models, reducing the number of parts materially.

2. **Recent and Future Changes in Gun Construction.**—The general use of smokeless powder in all naval guns, with the consequent increase in the powder pressure along the bore toward the muzzle, requires that the chase of new guns shall be strengthened. In recent designs, therefore, the chase hoops have been carried to the muzzle. In the 6-inch Mark VIII, 7-inch Mark II, and the 12-inch Mark V, there is one long chase hoop extending from the trunnions to the muzzle, and the muzzle has a "swell" to give additional strength at that point.

Future designs may provide for two continuous tubes, so that the inner tube or "liner," in case of injury to the bore from premature explosion of shells or other cause, may be replaced by a new tube, thus prolonging the life of the gun.

*The greater part of the information used in the revision of this chapter was obtained from the pamphlet edited by Lieut. F. K. Hill, U. S. Navy, Bureau of Ordnance.

3. Gun Forgings.—As has been stated, the forgings for tube, jackets, breech-plugs, and hoops are of open hearth steel, forged, oil-tempered, and annealed, and are furnished by the steel makers to the Naval Gun Factory, at Washington, D. C., rough-bored and turned to dimensions fixed by the Bureau of Ordnance, Navy Department.

The physical characteristics of each piece are determined at the steel works in the presence of the Government Inspector.

The trunnion bands, plug trays, and hinges for plug trays are open hearth steel castings; elevating bands are of wrought iron.

The material for face plates of breech-plugs, racks, pinions, and other parts of the breech mechanism is forged steel, specially ordered with regard to its physical properties for the purpose.

4. Receipt of Forgings.—(1) Forgings when received at the gun factory are weighed, carefully examined for the steel works' and inspector of ordnance marks for identification, and no work is to be done unless the latter are found. They are measured to ascertain if they are of proper size and shape to work out the finished drawings. A careful examination is made for gouges, etc., in rough machining, or for any defects not likely to disappear in finish machining; and an examination for any warping, especially of the tube, jacket, and the long chase hoop forward of the jacket, is made by placing the piece in a lathe and observing how much the outside "runs out of true." If there is any doubt about any of the above points the matter is referred to the Bureau of Ordnance. The forgings are entered on a rough forging book which shows the date of receipt, marks, weight, and dimensions, usually by a sketch, and the assignment for guns serially is at once made and placed on each forging. The above are the personal duties of the Assistant Inspector of Ordnance, responsible to the Superintendent of the gun factory.

5. The Assignment of Shrinkages is made by the Bureau of Ordnance, and is generally the same for guns made from a lot of forgings ordered when the characteristics of the metal are prescribed and strictly adhered to within certain tolerances. Hence, for each order, if the specifications differ, a new table of shrinkages is assigned. This matter being one theoretically worked out, will not be treated of in this book. The shrinkage of course differs with the characteristics of the metal of the parts.

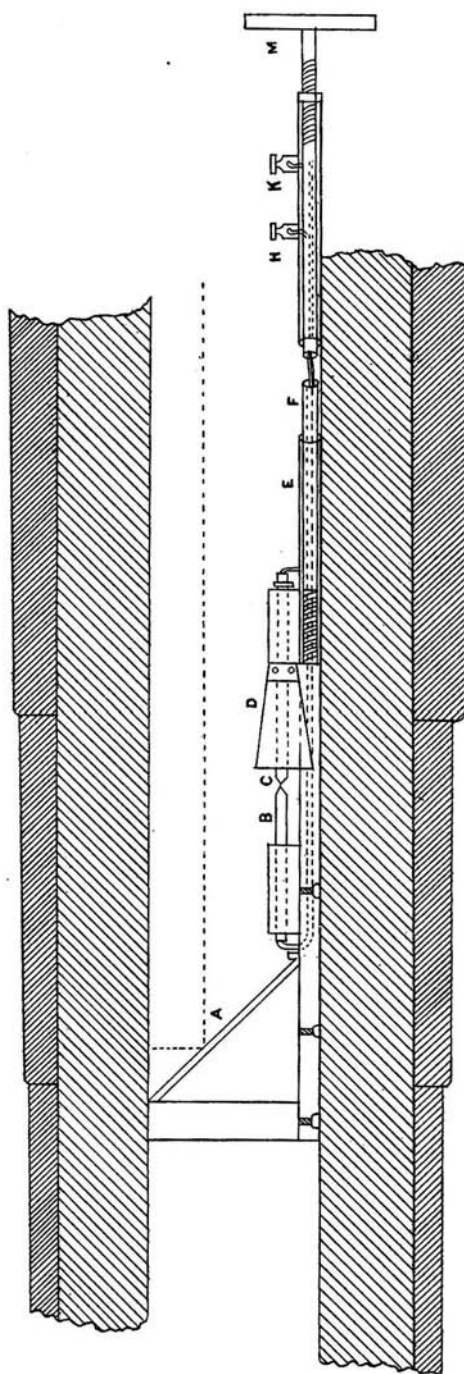
A thumb rule for shrinkages is as follows for metal as found to-day, or recently used: The jacket and first chase hoop have shrinkages in thousandths of an inch nearly equal to twice the calibre of the gun in inches, thus 4-inch jacket Marks II to VI, 0.008-inch; 4-inch Mark VII jacket, 0.009-inch; 4-inch B hoops Marks II to VI, 0.008-inch; 6-inch Mark IV jacket, 0.012-inch; 6-inch Mark IV D hoop 0.013-inch. Jacket hoops usually have a shrinkage in thousandths of an inch nearly equal to four times the calibre of the gun in inches; thus 6-inch Mark IV, A and B hoops, 0.024-inch; 6-inch Mark IV, C hoop, 0.022-inch. Chamber liners for converted guns have a shrinkage in thousandths of an inch nearly equal to one and one-half times the calibre of the gun in inches; thus 6-inch Marks II or III, chamber liners, 0.009-inch.

6. Rough Boring and Turning of Forgings.—The first step in the construction of guns is to rough bore all jackets, tubes and hoops, and rough turn the shrinkage surface of the tube, and the outer surface of the jackets. During these operations careful examinations are made to discover indications of defects, and discolorations of the metal which are examined under a magnifying glass. No discolorations, sand seams, or splits, specks, snakes, blowholes, etc., are overlooked however slight, and note is made of all. This inspection is the personal duty of the assistant inspector supervising the work. Experience is the guide in these cases, and great care is imperative to ensure nothing but sound metal in the gun. In machining, should marks be removed they are transferred elsewhere. If any piece is scant on one side, or warped, care is taken to place the centers in the lathe to favor the scant side in order that the piece may true up on finishing.

7. Machining the Jacket.—The jacket is placed in the lathe with forward end to the face plate and there clamped, and an adjustable center placed in the rear end, and so thrown as to bore to the best advantage. A rest bearing and a recess for a clamp (used to lift the jacket in assembling) are turned on the outside near the rear end. The steady rest is put in place and accurately adjusted, the rear center is removed and the screw box and step, if any, is accurately bored to within one-tenth of an inch of finished size. The position of the jacket is reversed, and a rest bearing is turned on the forward end. The jacket is now

bored to the finished diameter called for on the drawing. The boring requires three bits; 1st, a hog bit which brings the bore to within four-tenths of an inch of finished diameter; 2nd, a rough packed-bit bringing the diameter to within three-tenths inch finished size; and lastly a "finish" packed-bit to full size. An accurate entrance for the hog bit is first opened, using an ordinary turning tool. The bits are freely lubricated with oil, in fact the bore becomes a trough for oil, being stopped up at the rear end. The front end is faced off true to within one-tenth inch of the finished length of the jacket, and the inner edge is rounded to 0.2-inch diameter to give an easy entrance over the tube when shrunk on. (In case there is no shoulder on the tube as with some smaller guns, the jacket is faced off to neat length.) The jacket is then rough turned to within one-tenth inch of finished size, using two cuts, first a roughing cut with a round nose tool, second a smooth cut with a flat nose tool. The jacket is now removed from the lathe landed on skids, and examined carefully for defects such as scores, tool marks, cracks, sand splits, etc., by the assistant inspector using the "electric bore searcher." Plate I. This consists of two hollow rods, *E* and *F*, carrying a head which supports a mirror, *A*, inclined at 45° with the axis of the bore, and a pair of carbon points, *B*, *C*, the wires from which lead through the rod *F* to the binding posts *H*, *K*. A hood, *D*, is fitted in rear of the carbon point, *C*, to obscure the light from the observer. The points are adjusted by wheel, *M*, on the inner rod, which moves the carrier of the carbon, *C*. A photographic camera can also be used on the rod to obtain views of defects developed in the bore during manufacture. The rods are graduated to inches and tenths, so that the location of any injury or defect can be determined.

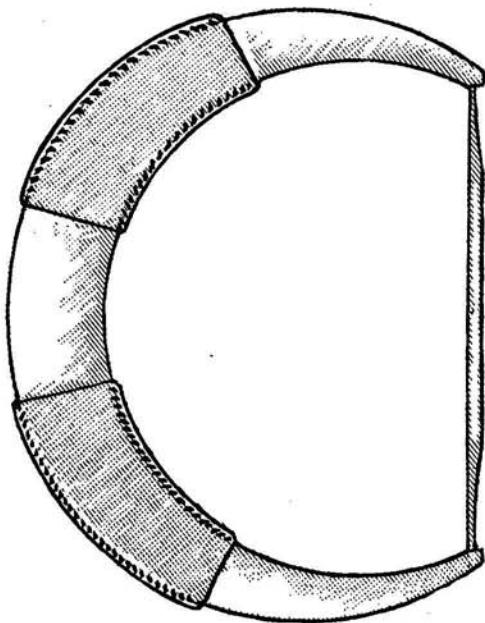
The bore is carefully stargauged for each inch of length, commencing at the front end, to the nearest one-thousandth of an inch, the points of the gauge being reversed when bottom of bore is reached, then stargauge withdrawn, and readings taken. A record is preserved in the rough manufacture book. All fillets are tested with fillet gauges. The neat length is measured and divided into four lengths which are marked with fine cuts or a punch, and the outside diameters taken. These points serve the



ELECTRIC BORE SEARCHER.

purpose of determining whether, after heating and assembling, the piece has recovered longitudinally, whether contraction has been uniform, or to determine the extension of the jacket, if any.

8. A **Shrinkage Sheet** for the jacket is now prepared by the assistant inspector for the use of the workman in turning the tube. A blue print with no dimensions, showing the tube and assembled parts, called the "shrinkage sheet," is provided for this



Snap Gauge. Par. 8.

purpose. Each gun has one such sheet on which is written, with soda or acid, the numbers of the different forgings making up the gun, the date when the shrinkage dimensions are written for each part, with the initials of the assistant inspector and superintendent of gun factory. To the diameters of the jacket's bore, as shown by the stargauge, is added the assigned shrinkage for the jacket, and these are marked off in lengths corresponding to those in the jacket. A steel point for each separate diameter is made and accurately tested in the measuring machine. By these the work-

men set their crescent-shaped *snap gauges*, for trying the diameters of the tube when turning for shrinkage. These points are all verified by the assistant inspector, and the length in inches and thousandths is stamped thereon. The same thing is done in the case of hoops. In this connection it might be said that all fillet gauges made by the gauge maker are of steel plate, and the radii are stamped on for that gun or part of gun. These gauges should also be verified.

9. Boring and Turning the Tube.—The tube is placed in the lathe, breech end to the face plate, adjustable center in muzzle end, having due regard for any minor defects or warping. Steady rest bearings are turned so that it may be bored true and at the same time leave enough metal above the finished drawing size to true up. The steady rests are then put in place and center removed. The tube is now bored, beginning at the muzzle end, using two and sometimes three bits, one hog bit and two packed bits. The first cut brings the diameter to within one-half inch of full size for any gun of and above the 8-inch, and three-tenths inch for smaller calibres; the second and last cuts, one-quarter and two-tenths inch respectively. The hog bit, about four calibres in length, must have a long and accurate bearing first bored with the ordinary tool. The muzzle is faced off true. While the boring is going on, etc., rough turning is also done, bringing the diameter to one-tenth inch of shrinkage size. The first bit (hog or packed, either can be used), having passed through half the length of the tube, the latter is reversed in the lathe and the other end is bored. This reduces the chance of the bit running out. (In calibres below 8-inch, for relatively short guns, the bit is run all the way through, but should the bit start to run "out" the position in the lathe is reversed.) It is usual to draw out the roughing bit twice for each half length of the tube for guns above 8-inch. The packed bit, or bits, are then passed *all the way* through the bore from one end. It is found that in boring it is best to revolve the tube as rapidly as the metal of the bit will allow, and use a moderate feed (5 or 6 inches an hour). After each cut the bore is examined with a light for defects. The other end of the tube is faced to neat length. After boring, the tube is electric lighted and inspected in the same manner as for the

jacket, and stargauged from the muzzle end. The tube is then transferred to the "shrinkage turning lathe," muzzle end to the face plate, on centers, and also steady rests; top braces being used in the case of long tubes for small guns where springing may occur. (This lathe is only for smaller guns, being one which is in good order and allows no spring.) The shrinkage surface for the jacket is now turned, the last cut being taken with a broad, flat nose tool (1 inch to 2 inches wide), to insure a smooth, accurate surface. This turning requires a very good mechanic, as the tolerances are only one-thousandth of an inch. The shrinkage sheet above mentioned is used. When the shrinkage surface is completed, the lengths for different diameters are laid off, and the assistant inspector of ordnance carefully calipers the diameters, checks the lengths, inspects fillets and shoulders, and looks out for defects. The tube and jacket are now ready for assembling.

10. Balance Rod for Testing the Bore of Guns, or Long Tubes.—This machine is used to ascertain whether or not a bit is running true, or so that the inside will be true with the outside and hence the thickness of the walls the same on all sides. It is inserted in the bore at intervals of about one-third of the tube's length. If the rod, when in place and properly adjusted, shows no movement at its rear end while the tube is revolving, it can be assumed that the bore is concentric with the bearing surfaces on which the tube is turning; but if there is any movement to the rear end of the rod, the amount of such movement will indicate the eccentricity of the bore, at the point where the front end of the rod is in contact with the bore; in this case the centers are thrown, and the bore trued up with a bit of slightly larger diameter.

11. Preparations to Assemble the Jacket.—The tube being ready, clamps are placed on it at the center of gravity and it is lifted by the overhead crane and placed in the "shrinking pit," muzzle end down (some of the later guns, as 5-inch, Mark V, have the jacket shrunk on from the muzzle end, hence the tube would be placed breech down in the pit), accurately plumbed so as to stand vertical, and held within the holes in the two heavy movable tables by four large screws, the muzzle resting on the lower plat-

form. A water pipe is run up through the tube to within a few inches of the top, to carry off the waste water used in cooling the tube. The water is admitted into the bore of the tube from the lower platform.

12. Expanding the Jacket is accomplished by heating it in a hot-air furnace. The clamps are placed in the recess on the rear end of the jacket, the latter is lifted by the overhead crane and lowered into the furnace, forward end down (except for jackets assembled in the reverse manner, as the 5-inch, Mark V), where it rests on a platform or pedestal, and the furnace top is placed on. The expansion should be gradual and uniform, and never exceeds five one-thousandths ($5/1000$) of an inch for each inch of diameter of the heated piece (this rule applies to all parts). For the 13-inch jacket, then, the expansion will amount to 0.06-inch; others in proportion. From time to time, near the end of the heating, the expansion of the bore is tried by means of cross points placed on a long steel rod entered through a door in the furnace top. The cross points are set for a diameter very slightly in excess of the required diameter. The jacket must not be heated beyond a black heat, or about 600 degrees, nor should it be subjected to any heavy blows while so heated (this rule applies to all parts). Time, then, is the factor to get the desired expansion without overheating. The 12-inch, Mark III, jacket (13-inch about the same) remains in the furnace about 30 hours, about 14 of which are required for raising the temperature up to 575 degrees Fah., which is maintained for sixteen hours. For smaller guns, the furnace being hot, less time is necessary.

13. The Hot-Air Furnace for Jackets (6-inch and above) is a vertical cylinder built in sections, to suit the particular lengths of jackets, and made of fire brick and asbestos. Heated air flows through a large pipe from the air heating furnace to the bottom of the hot air (jacket) furnace, passes through openings, up and around the jacket, and out through a large pipe in the top section, the overflow being regulated by a damper. The temperature of the furnace is shown by a pyrometer let in the furnace cover.

The air-heating furnace is a rectangular brick structure containing a system of pipes through which air is forced by a blower and thence to the hot air furnace. The air is heated by means

of a number of *aerating burners* at the base of the furnace; crude petroleum is used, being delivered as a spray by means of compressed air. The jacket being in place, the burners are lighted, and when the pyrometer registers 575 degrees Fah., all but three burners are cut off, so that an even temperature can be maintained.

14. Shrinking on the Jacket.—The jacket having been expanded, the hot air is shut off, furnace cover removed, and the jacket is lifted out of the furnace by means of the overhead traveling crane. The bore is again tried with cross points and then wiped clean, using a wet muslin sponge on the end of a rod, after which the jacket is swung vertically over the tube and accurately centered over the latter. The jacket is then slowly and carefully lowered over the tube, being guided by men having asbestos gloves and wet cloths on their hands, until it brings up at the proper point on the tube. During the lowering, the jacket is turned first one way and then the other about its axis, to prevent galling or abrasion should there be an imperfect centering. If any difficulty arises in lowering, and the jacket does not go on smoothly and easily, it should be immediately lifted off, the operation suspended and the jacket allowed to cool, an examination being made for galls, abrasions, or other causes likely to interfere with the process. It is well to test the bore of the jacket with the cross points, to see whether the fault is due to cooling and consequent contraction; and should this be the case, and no galling is observed on the tube, the jacket is put in the furnace again and heated until the proper expansion is again obtained. The cross points should be verified. Water is turned on and allowed to circulate through the bore of the tube, to hasten cooling. The weight of the jacket renders it unnecessary to use a spray of water over the point where the junction is made on the shoulder of the tube. It is usual to try the heat of the jacket's exterior at the top, middle and bottom, before assembling, by rubbing on it strips of alloys which melt at different temperatures, the temperature for lead being considered 600 degrees.

15. To Starguage the Tube for Jacket Compression.—After the jacket is quite cold (and it is usual to wait not less than 16 hours for guns over 8-inch in calibre, and from 2 to 8 hours for others), the assembled tube and jacket are lifted from the shrink-

ing pit and landed on skids. The bore of the tube is then carefully stargauged at each inch of length from the rear end to a point under the front end of the jacket, and the measurements recorded in the manufacture book. The diameters being compared with those taken before assembling, the amount of compression due to the grip of the jacket is ascertained, and should the results be abnormal the matter is referred to the Bureau. The lengths of the jacket between the marked points, and also the outside diameters, are then recorded, to note the condition as to recovery from longitudinal expansion and to ascertain the extension of the jacket. In the case of small guns, it is usual to strike the jacket (when cold) several heavy blows with a sledge-hammer, to relieve any tensions (the existence of which is shown by audible reports).

16. Boring the Hoops.—The hoops are bored as nearly as possible to the drawing dimensions, while the jacket is being bored, or at any convenient time. As a rule the *short* hoops of guns of and under 6-inch in calibre use a special, cylindrical chuck made of cast iron nearly the length of the tube, which is bolted to the face plate of the lathe, the hoops being centered thereon by means of radial set screws. In this case the hoop is bored, rear end faced off and fillet turned, using two packed bits, except for very short hoops, which use an ordinary bar tool in the lathe tool head. Longer hoops, such as the D hoop of the 6-inch, Mark IV, gun, are bored just like the jackets. For guns of 8-inch calibre and above, the hoops are fixed by clamp screws within cylindrical rests which form a part of the lathe, and instead of using packed bits, or ordinary bar tool, in the lathe tool head, there is a boring bar provided having one or more cutters fitted with what might be called a "star feed," that is, during each revolution the tool is set along a predetermined amount. In this case the hoop remains fixed; the cutting tool revolves. The metal of the bore of hoops (except the long chase hoop forward of the jacket in the case of more modern guns) is inspected before removing from the machine, as it would be difficult to rechuck should any defect be found requiring another small cut. The *front* ends of chase hoops and the rear ends of jacket hoops are not faced to neat length until after assembling. All fillets and shoulders are tried

with what are called "profile gauges," made of sheet steel (this also applies to shoulders on any exterior parts of the gun). Hoops are stargauged from the rear end (chase hoops) for each one inch of length; electric lighted, etc., as for jackets.

17. Assembling Hoops.—The assembled tube and jacket is now placed in the lathe, upon centers in the ends of the tube, muzzle end to the face plate, a rest bearing turned at the rear end of the jacket, a steady rest then placed, and the rear center removed. The screw box is trued up for a center, jacket faced off to within 0.1 to 0.15-inch finished length, and then center placed in the rear end of the tube. It is usual in the larger guns to face the screw box for a length 0.2-inch greater than the drawing. The gun is reversed in the lathe and a rest bearing turned in the forward end of the jacket. The chase (of the tube) is now turned to shrinkage diameters for the chase (or tube) hoops, in accordance with the *bored* diameters of the hoops plus the shrinkage, using the "shrinkage sheet" already mentioned, and exacting inspections as for the shrinkage for the jacket.

The first chase hoop for all guns of and below 8-inch in calibre is assembled with the gun in the pit (breech end down, secured as for assembling the jacket) in the same manner as for the jacket, except that a spray of cold water is turned on at the joint to hasten cooling at that point, so as to obtain a close joint. The spray is given by means of a perforated copper ring (generally two rings) surrounding the gun and connected to the water system. In the case of long hoops, such as the D hoop of the 6-inch Mark IV gun, or E hoop of the 6-inch Mark VI gun, where the contraction of course is considerable, the contraction is followed up by means of a heavy iron yoke placed over the hoop and constantly forced down against the upper end of the hoop by means of long tie rods and nuts. The pressure is kept up for about twelve minutes, when the lower end of the hoop has taken a firm hold of the tube. All other chase hoops are shrunk on with the gun horizontal, lying on skids. The heated hoop, after being wiped out and tested with cross points, is brought to the gun by an overhead crane hooked into a clamp ring, or in the case of very small hoops, brought by men in a bearer and slipped over the muzzle, held in position by means of wood braces pass-

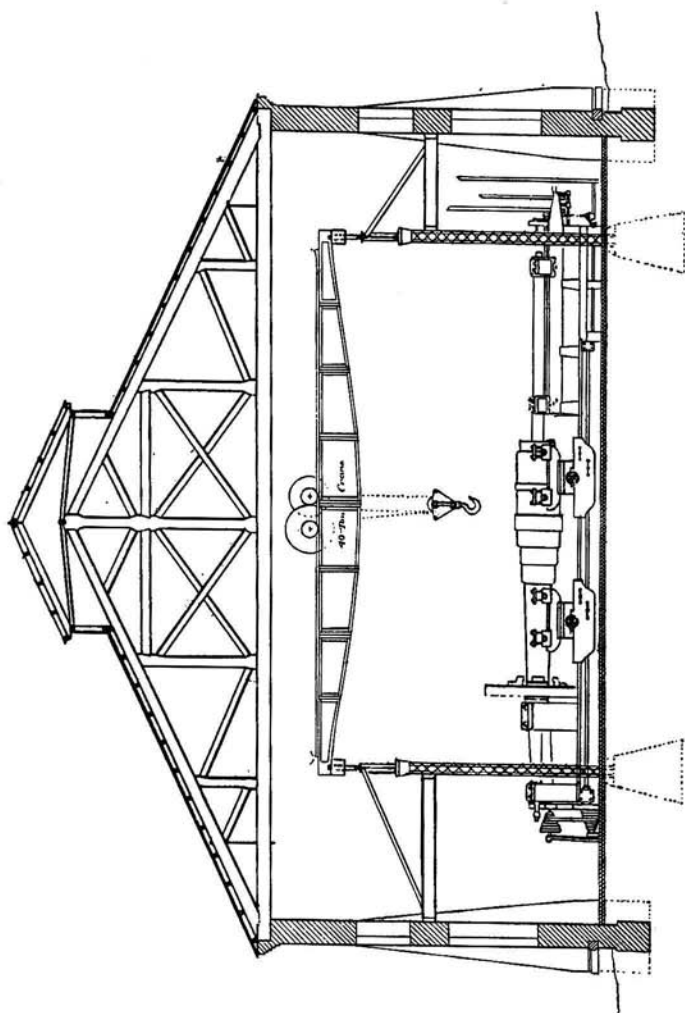
ing from the face of the hoop to a cross head carried by a rod through the gun, and set up by nuts at the breech of the gun. The gun must be properly supported by a screw jack at the muzzle during the cooling. Cold water spray is used at the joint.

Chase hoops for all guns above 8 inches in calibre and those forward of the first chase hoop of the latter, are put on with the gun horizontal. A second hoop is never shrunk on until the gun is quite cold.

All chase hoops for 10-inch, 12-inch and 13-inch guns are put on while the gun is in the lathe. The hoop has a clamp band placed at its center of gravity for lifting, and when hot is lifted by the crane, inspected with the cross points, wiped out with a wet muslin sponge, then carried by the crane to the gun on the lathe, and slipped over the muzzle to its seating, the gun being supported by steady rests. To follow up the contraction, and hold the hoop in place, a wood brace is placed on each side between the hoop and back head of the lathe and kept screwed up, while the usual spray of cold water is turned on at the joint. Chase hoops other than tube hoops, if any, as for heavy guns, are next assembled. The center in the muzzle end of the tube is replaced and the shrinkage surface and hoop are turned on the front end of the jacket and rear end of the first chase (tube) hoop. The tube locking (or chase locking) hoop is then assembled as before. The shrinkage surface and hoop are next turned over the shoulder on the jacket and rear end of the previous hoop, and the jacket locking hoop is assembled. In the case of the 13-inch guns the screw thread for the chase "guard hoop" forward of the last tube hoop is cut, and the thread having been cut in said hoop, the latter is screwed on. While the shrinkage surfaces for the chase hoops are being turned, the body of the jacket is worked down close to shrinkage dimensions for the jacket hoops, provided the lathe has a second tool carriage, which is the case for the lathes used for heavy guns.

The tube is now stargauged for compression from the muzzle end, under the chase hoops, record noted as in the case of stargauging after assembling the jacket.

18. The Jacket Hoops are next assembled. The gun is reversed in the lathe (with its muzzle to face plate), a rest bearing



TRANSVERSE SECTION OF 8-INCH GUN SHOP,
Showing Gun in Lathe.

is turned on the jacket locking hoop, and a steady rest put in place in the case of heavy guns. The shrinkage diameters for the jacket hoops are next turned on the jacket. During this operation the chase hoops are worked closer to the finished dimensions. For 6-inch R. F. guns having no jacket locking hoop, the shrinkage diameters for the chase locking hoop and all jacket hoops are turned at once, so that all hoops other than the first chase hoop are successively assembled, first the chase locking hoop with the gun horizontal on skids, afterwards the jacket hoops with the gun in the pit muzzle down. This may also hold true for the 8-inch guns. In the case of the 6-inch, Mark VI gun, the final hoop put on is the locking hoop, which is screwed over the rear end of the chase locking hoop and the front end of the B (or forward jacket) hoop, after complete shrinkage. The jacket hoops for all guns above the 8-inch are then assembled in a similar manner to the chase hoops, beginning with the forward one, the gun being horizontal in the lathe.

The 12-inch, Mark III gun, having an outer jacket called D hoop, forming a fourth layer over the chamber, is next turned for said hoop, and the latter shrunk on.

The final hoop assembled for 13-inch and 12-inch guns is the outer locking hoop, which screws over the juncture of the front jacket hoop and the chase locking hoop. This may be deferred to the next operation, when the gun is finished.

The rear end of the tube is now stargauged for the total compression of the bore under the jacket hoops, and record made as before. The gun is now completely assembled, and the next operation is to "finish the gun," which includes finish-boring, chambering, finish-turning the outside, rifling, chasing and slotting screw box, lapping the bore, and fitting the breech mechanism.

19. Finish-boring.—The gun is now placed in the boring lathe with breech end to face plate on centers, and two rest bearings are turned, rests put in position, and muzzle center removed. The gun is now finish-bored, using two packed bits, the last cut being about 0.03-inch on the diameter. Great care must now be exercised to insure boring the tube straight, and the "balance rod" previously described is used to test the accuracy at 10, 15, 20 and 25 feet from the muzzle in the case of 12-inch (and 13-inch) guns.

20. Finishing the Outside.—In the case of heavy guns, the outside is finish-turned while being finished-bored. Smaller guns (6-inch and below) are not finished on the outside until after finish-boring, for the reason that should the bit fail to follow exactly the hole already in the tube, and "run out of line," the outside would not be symmetrical with the inside; and another reason is, that the fast speed found best for boring is not the best for fine turning. In fact, the outside may be finished any time after finish-boring. Should the gun have trunnions, the gun is placed in lathe, breech end to face plate, and screw thread cut for trunnion band, which is then screwed on. For guns screwing into a sleeve, the left hand thread is chased. Care is necessary so that when the sleeve is screwed on it will bring up firmly against the shoulder provided for it. Special gauges are made to show the starting point of the thread, and when finished is tested by screwing on a bronze sleeve gauge, in length and diameter the same as the service sleeve. When home, the register line should agree with the top line on the gun. In turning to finish dimensions the mechanic is furnished with a drawing of the finished gun, with "points" for setting snap gauges, graduated rods for lengths, and profile and fillet gauges. The gun should be inspected in the lathe before removing.

For 12-inch and 13-inch guns the outside is finished while finish-boring; the thread for the outer locking hoop is chased, and after finish-boring is completed the locking hoop is screwed on, having removed the muzzle center. The muzzle is faced to its proper length and all lengths determined. The gun is now reversed in the lathe (muzzle to face plate), suspended between centers in each end of the tube, and the surface for a rear steady rest trued up if necessary. The steady rest is then adjusted and rear center removed. The breech is faced to exact length, and rear end of gun sloped off to the rear in guns requiring it. The screw box may now be bored to finished size and length. A steel rod of the exact length of the screw box, and a steel point of proper diameter, are furnished the mechanic to work by.

21. Chambering.—The gun is now chambered. For 6-inch to 13-inch guns having the ordinary chambers, the latter is bored, using, first, a hog bit; second, a (rough) packed bit; third, a

roughing slope bit; fourth, by a finish packed bit; fifth, by a finish slope bit; and lastly, by a taper-reamer for the gas-check slope. The finishing bits are long, of the exact diameter of the chamber (that is, ground so as to bore to the exact diameter). For guns having the enlarged chamber, as the 6-inch, Mark VI, and 12-inch, Mark III, a different method is pursued. The chamber is first roughed out with a hog bit, then two packed bits are used and two slope bits. The powder chamber being larger than the mouth (or entrance) must be bored with a special boring bar and tool. This bar is hollowed, and is provided with a cutter that can be set out any desired amount by means of internal gearing worked from the outside clear of the breech. Finally the gas-check slope is finished with a taper-reamer.

The chambers for R. F. guns are tapered to receive fixed ammunition. Usually they are roughed out to desired taper, using a boring bar carrying a cutter fed in by hand, the rear end of bar being thrown out of line with gun's axis. Chambers having a straight part, and the compression slope, are roughed out with a packed bit. The finishing cut is now taken with a long packed bit, or reamer, ground so as to bore the chamber to exact dimensions. This bit must be very accurately made and carefully inspected by the officer supervising the work. The bit is entered a certain distance, which must be accurately looked out for, and if practicable the assistant inspector should see to it personally. The chamber is now measured at the rear end, and if correct it may be assumed that the gun is properly chambered.

22. Threading the Screw Box.—The gun is in proper position for this operation. The lathe is geared to pitch of thread desired, and the proper tool fixed to tool post. The lathe revolves while the carriage for tool moves along laterally at the proper speed, and the cutter being properly adjusted, the thread is cut in the screw box. The point for beginning the thread is clearly shown on the working drawing. Some are chased left handed (as for most R. F. guns), others right handed, as per directions on the drawing. The threads are inspected by means of sheet-steel thread gauges, the diameters by points. The length of the threaded part is verified and particular care is paid to the point of commencing the thread, a special gauge being provided for this. Before the gun

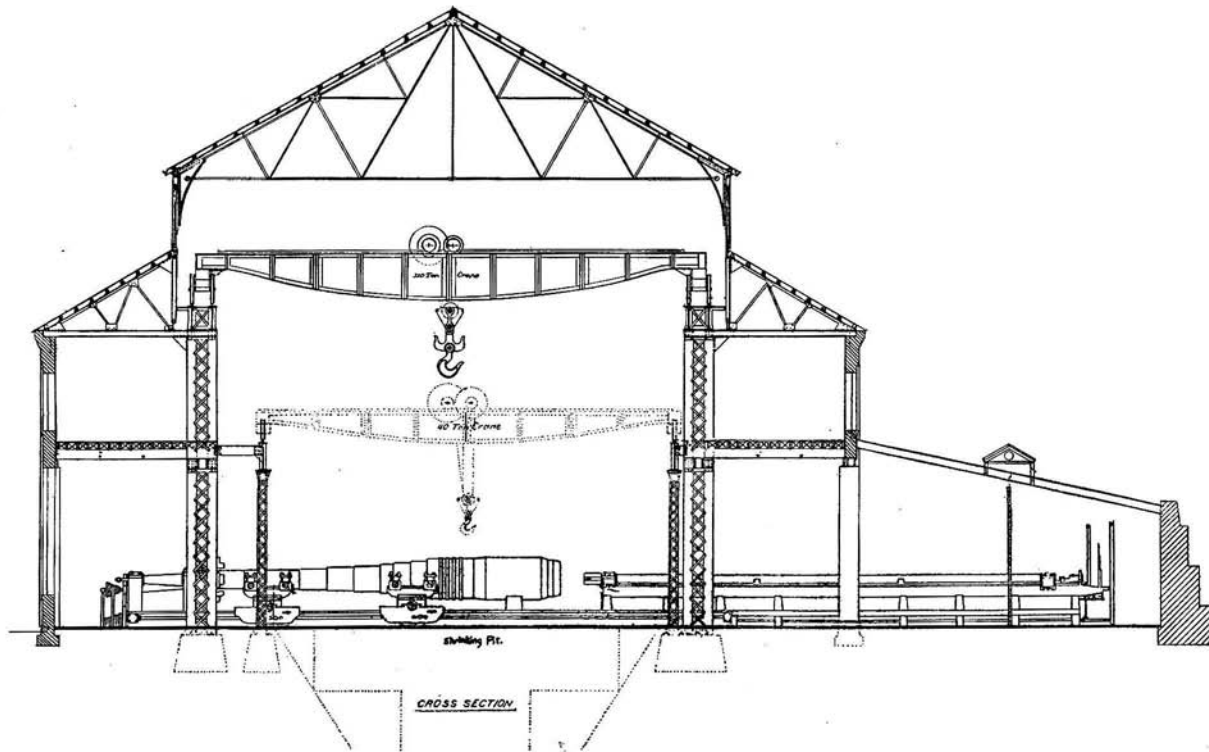
is removed from the lathe the screw box should be inspected by the officer, and a brass plug representing the service breech plug as to threads, lengths, and any flanges, is screwed in to try the screw box or threads for screw box collar. Any defect can easily be remedied while the gun is in the lathe. In the case of certain new guns (models 1898 up) of or below 6-inch in calibre, the screw box threads are cut within a ring or screw box collar, which in turn is screwed into the gun. The method for chasing the outside thread is the same as before. For chasing the Welin, or stepped thread screw box, see par. 35.

23. Stargauging Gun after Finish-Boring and Chambering.

—The gun is now removed from the lathe and landed on skids or blocks. The bore and chamber are carefully stargauged, the former for each inch of length, the latter for each half inch, and the record noted on the manufacture sheets. The gun is lighted with the electric bore searcher, and a careful examination is made for all defects in the metal, tool marks and rough places, the latter especially about the front end of the chamber for R. F. guns where the mouth of the cartridge case seats on the compression slope; and for ordinary chambers, the gas-check slope. Any roughness is, if possible, removed, using emery paper on revolving cylinders. The gun may now be rifled, or the screw box slotted, which ever is more convenient.

24. Slotting the Screw Box.—The first operation is to “lay off” the screw box. This is done by screwing a plug into the screw box and attaching to it a *division wheel* graduated into degrees and provided with a lever, or working arm, with a set screw. The line for commencing the screw thread is then found and lightly traced on the breech face of the gun, the marking arm being used for a guide for the scratcher (a bradawl). The drawing for the screw box is then consulted and the number of degrees to the first division is found, also the number of sections to the screw box. The marker is then successively placed on these divisions, and lines traced on the breech face. The top and bottom lines—the vertical line and the horizontal line of the gun—are then traced on the breech face. The vertical line is transferred to the top of the gun in the fore and aft direction.

If the vertical and horizontal lines on the muzzle face have not



TRANSVERSE SECTION OF 13-INCH GUN SHOP,
Showing 110-ton and 40-ton Cranes with Gun in Rifling Machine.

been placed while the gun is in the lathe, they are now transferred there from the breech. This may be done as follows: The gun is leveled, bringing the horizontal line on the breech level by using spirit levels on the marking arm of the division wheel; a plug is put in the muzzle bearing two cross-arms; these are brought horizontal and vertical, respectively, and the lines traced on the muzzle.

The gun is now taken to the slotting machine. In the case of 10-inch, 12-inch and 13-inch guns the slotter is in rear of the rests that support the gun for rifling, so that the gun does not require moving until it is rifled and the screw box slotted. For 4-inch, 5-inch, 6-inch and 8-inch guns the rifling and slotting machines are separate. The gun lies horizontally on rests with the axis of the bore in exact coincidence with the head of the slotter. The latter is provided with a head which is given a reciprocal movement by suitable machinery. The head has a circular feed and is provided with one, two, three or four cutters, according to the divisions of the screw box and convenience of the work. For small guns having four blanks, for instance, all four will be cut at the same time. The cutter is set exactly on one of the divisions, length of stroke adjusted, etc., and machinery started. Light cuts are taken, and hence several passages with increased depth of cut are necessary. As a rule, blanks are cut about 0.06-inch wider than the threaded sections to give clearance in entering and withdrawing the plug. Gauges of the exact width and radius of the blanks, and points for the diameters are supplied to the workman. Careful inspection is made for the width and diameter of blanks.

For special mechanisms of those other than the slotted screw type, the manner of shaping the breech box or mortise differs with the type.

25. Rifling a Gun consists in cutting spiral grooves in the surface of the bore from the compression slope to the muzzle end by means of the rifling machine. All guns at the gun factory are rifled from the muzzle end. The rifling embodies the rifling machine guide plate, rifling bar, rifling head, and cutters, and suitable gauges and points for the guidance of the workman.

26. The Rifling Machine consists of a cast iron bed and shears,

stationary rests or supports to hold the gun, one stationary and two movable rests to support the rifling bar, and the machinery to move the rifling bar, consisting principally of a screw and clogged gearing driven by ordinary pulley belts and wheels. The rifling head is attached to the rifling bar by a taper socket and key. The bar is supported by three rests, one stationary at the front end (next to the muzzle of the gun), having on top a stud which fits into the rifling groove on the bar by which the latter is turned while it passes back and forth through the gun; a moveable rest near the center of the bar to support the weight of the latter, which is actuated by the screw of the machine, and the third or rear rest, to which the rifling bar is held, and which is driven by the screw giving the fore and aft movement. For the heavy guns a bronze semi-circular trough is provided, in which slides the bar, to facilitate lubrication and to act as a guide.

27. The Rifling Bar is made of steel, slightly less in diameter than the bore of the gun and of a length somewhat greater, and upon its outer surface the rifling groove is cut. This groove is the exact counterpart of those to be cut in the gun, and is in fact the template, guide or cam. One rifling bar generally serves for two or more marks of guns of the same calibre (sometimes of two calibres), the different grooves being cut thereon clear of each other and suitably marked for identification. For guns having the same width of groove throughout the bore, such as all "plain section" grooves, but one groove is necessary on the bar. Other guns having the "hooked section" require two grooves, one to cut the groove of equal width throughout, the other to increase the width at the rear end, tapering to original width at the muzzle. These grooves are cut on the rifling bar, using a guide plate, the general principle of which is as follows:

28. The Guide Plate represents the developed spiral of the rifling on a plane surface and is a cast iron plate having one edge cut accurately to said curve, forming a *cam*, while the other is parallel to the axis (of the rifling or gun). The rifling bar is placed in position on the rifling machine and the guide plate is bolted on one side of the machine with its straight edge parallel to the axis of the bar. By means of a special mechanism the curve of the rifling is transferred from the guide plate to the

outer surface of the rifling bar and the groove is cut upon the latter. Each new mark of rifling requires a separate guide plate and separate groove on the bar. The latter is used indefinitely. The guide plate must be very accurately made, and the guide grooves on the rifling bar very accurately cut, working to the nearest one-half thousandth (0.0005-inch), if possible. Drawings are supplied giving full data for the rifling of each mark and calibre of gun, showing in general the developed rifling for the guide plate, and with directions for making the latter, etc.

29. The Rifling Head consists of a cylinder very nearly equal to the diameter of the bore, on which are placed three or four cutter boxes carrying the cutting tools. The cutters are made of the exact form of the groove in the gun, and are set out simultaneously the desired amount by an independent screw with a cone bearing in the center of the head. It is usual to set each cutter equally from the center; then by using the cone, the depth of the cut is regulated.

30. The Method of Rifling.—The gun is placed in the machine on the stationary rests, muzzle end to the rifling head, with its bore exactly in prolongation of the axis of the rifling bar. The cutters of the rifling head are set out by the cone to cut the desired depth. As an aid for regulating the cut, there is a graduated circle on the front face of the rifling head, and an indicator arm on the screw regulating the cone bearing, which shows the extent of raising or lowering the cutter. The full depth of the groove is not taken in one cut, but several passages of the rifling head are necessary. The rifling bar is advanced by the screw of the machine, the head enters the bore of the gun and travels the distances regulated, while the stud on the forward rest, entering the groove on the bar, causes the latter to turn as it advances, thus cutting the desired spiral. The first lot of grooves having been cut, either the rifling head, or the gun itself, is revolved the necessary amount for cutting the next group, and so on. Guns of and above 8-inch in calibre remain fixed, while the cutter head is revolved on the bar by means of a worm wheel and worm, the former having an index to show amount of turn. Smaller guns are revolved while the cutter head remains fixed. The muzzle end of the gun is secured in a revolving rest, which is turned by a worm wheel.

As the rifling head moves through the bore it is lubricated liberally with oil. After each passage, the cuttings are scraped out of the bore from the breech end.

31. Lapping the Bore.—To remove the burrs caused by the cutters of the rifling head, the bore of the gun is "lapped out," first the grooves, then the tops of the lands, the gun being placed in the "lapping machine" for this purpose. Small guns, or those under 4-inch in calibre, are lapped by having the gun rested on skids. The lapping may be postponed until after the breech mechanism is fitted, according to the convenience of the shop.

There are two sets of tools. The lapping tool for the grooves consists of a head or spider having four arms, each bearing a copper lap fitting in the grooves, which are held out to their work by flat coach springs. The lapping tool for the tops of the lands, usually called "bore lap," is a half cylinder of lead of nearly the radius of the bore.

The operation is as follows: The groove lapping tool is entered in the muzzle of the gun, drawn through the bore to the origin of rifling, and then back again to the muzzle, the motion being reversed by suitable gearing. The gun is well slushed with emery powder and oil, and the lap is drawn backward and forward until the surface and edges of the grooves are smooth. This requires two or more passages, when the tool is shifted to lap four more grooves, etc. The bore is lapped in a similar manner, using the half lead cylinder, the gun itself being turned now and then, so as to cover the whole surface. The stargauge record after final boring is consulted, and should the bore be a little small it can be lapped to the proper size, trying the diameter from time to time with the stargauge, cleaning out the bore first, however. Care is taken not to injure the compression slope nor to lap out unevenly. Experience is the guide. In some cases emery cloth may be put on the lapping tool, for instance, to remove burrs after the gun has been fired, for then the surface of the bore becomes very hard.

32. Tolerances; General Notes.—The following tolerances are usually allowed in machining: (1) Shrinkage surface, a variation of $5/1000$ of an inch from assigned diameters, but a variation of not more than $1/1000$ of an inch from the assigned *shrinkage* at any point. (2) Diameter of bore and compression slope,

3/1000 inch above; chamber of guns of an above 6-inch in calibre 5/1000 inch; and 2/1000 of an inch for smaller guns (not small arms). (3) Exterior diameters, 1/100 inch, more or less, from drawing size. Drawing lengths of hoops, screw box, chamber, compression slope, finished bore 1/100 inch, more or less, from drawing size. (5) Diameter of screw box, 3/1000 inch above assigned diameter; diameter of breech plug, 3/1000 inch, more or less.

33. Stargauging and Calipering for Shrinkage Surfaces are done at every inch. All measurements for length are made from the rear end of the tube. Figured dimensions on drawings are used. The method of construction shown on drawings is never deviated from without authority from the Bureau of Ordnance. All measurements originate from the standard scale in the gun shop (for guns made at gun factory). All screw holes for sights placed on gun, holes for fitting breech mechanism, and all parts of breech mechanism are drilled to templates or fitted to templates to insure interchangeability. All gauges used for calipering must be subjected to the same conditions of temperature, so that gun and gauge will be of as nearly the same temperature as possible; hence when using snap gauges especially, holding them unduly in the hand, or allowing them to rest on steam heaters, lie in the sun, etc., should be avoided.

34. Fitting the Breech Mechanism varies according to the gun and type of mechanism, a detailed description of which would be out of place here. The general character of the various mechanisms is described and illustrated in succeeding chapters. The following general remarks will apply to all.

A cast iron working template or dummy of the breech of each type and calibre of gun below the ten-inch, is provided, made as accurately as possible. After the experimental gun and mechanism has been completed and proved and the detailed drawings altered to meet all changes, such parts as would unduly wear are faced or bushed with steel. Each mechanism, after completion, is fitted to this template, and hence they will be interchangeable. All parts of the breech mechanism where possible are provided with suitable jigs, templates, formers, and the necessary tools if special are manufactured. In some cases, as for the Vicker's mechanism,

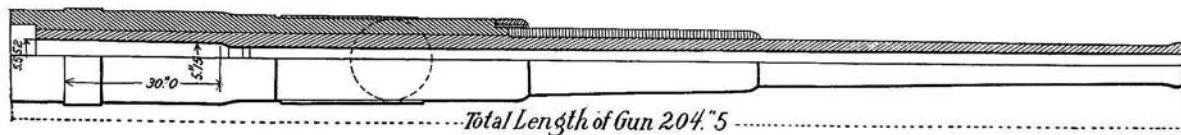
special inspection jigs, templates, etc., are provided, and each part must be a true fit. The above are usually made of steel. Certain portions liable to wear are made of hardened steel, or hardened bushings and pieces are let in, according to standard drawings, and rigidly inspected by the assistant inspector of ordnance having supervision of the work. It is now usual to use milling machines and tools for all parts of modern R. F. and Q. F. breech mechanisms, thus reducing the cost of work and the time consumed, and insuring greater accuracy and absolute uniformity. When the breech of a gun requires certain holes to be bored, it is usual to have a cast iron jig placed over the breech, and clamped to a certain line; then the holes are drilled, so that all guns are alike. In fact, every precaution is taken to insure uniformity. The screw box and all parts of the mechanism are smoothed and slightly polished with fine emery paper.

35. The Method of Chasing the Welin Thread differs somewhat from that of the ordinary interrupted screw, and hence the following outline description is given. The Welin plug, instead of being threaded on one diameter, has a number of steps of different diameters, and therefore the number of blanks cut is less than usual; thus an ordinary breech plug, having twelve sections, would have six blanks, while the Welin has but three, or it might be four. An ordinary six section plug would have three blanks, while the Welin has but two. It will thus be seen that there is about fifty per cent more holding or threaded surface on the Welin plug, should the maximum length of an ordinary plug be retained. Therefore, for the same holding strength, the length of the Welin plug may be considerably reduced, and hence the weight is less.

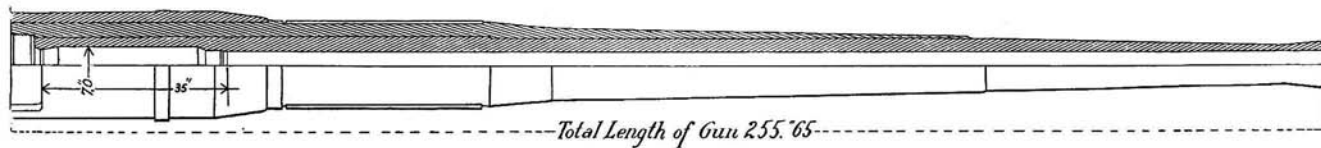
The chasing is done in the ordinary engine lathe. The plug is first bored to the finished size, then turned to the finished outer diameter and the ends squared up. The steps are then laid off according to drawing, using a copper or sheet steel gauge made for that purpose. The plug is then placed in the slotter, and the steps and blanks cut, leaving the radii of the steps slightly greater than the finished size, a small longitudinal clearance groove cut between the threaded sections (usually about 0.15-inch) for convenience in chasing, and placed on a mandrel secured in the lathe centers in the usual way. In order to chase the thread on two or



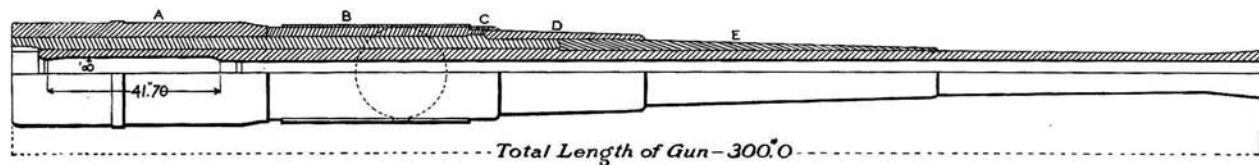
3-INCH RAPID FIRE GUN, MARK III.



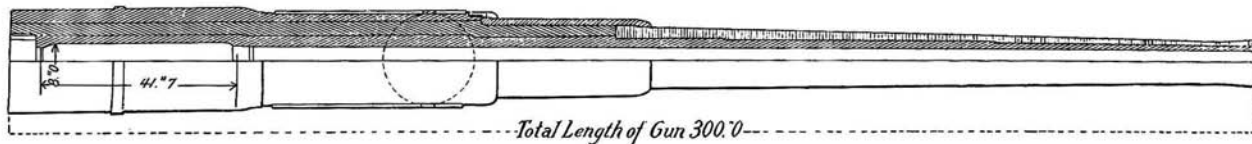
4-INCH BREECH-LOADING RIFLE, MARK VII.



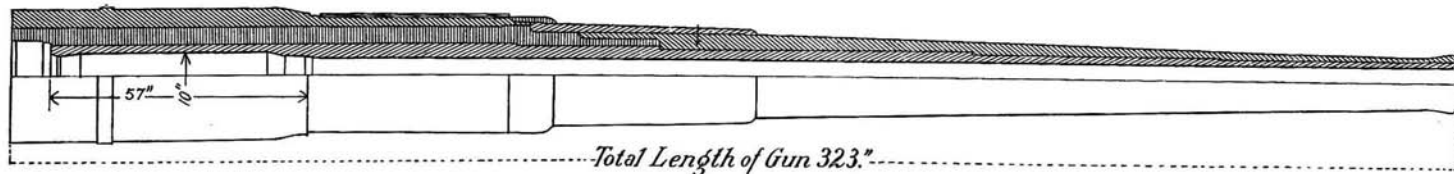
5-INCH BREECH-LOADING RIFLE, MARK V.



Total Length of Gun—300.0
6-INCH BREECH-LOADING RIFLE, MARK VI.



Total Length of Gun 300.0
6-INCH BREECH-LOADING RIFLE, MARK VIII.



Total Length of Gun 323.
7-INCH BREECH-LOADING RIFLE, MARK II.

more different radii with the plug revolving constantly in the same direction, a special device is attached to the lathe which holds the tool on the step, and automatically releases it as soon as the clearance groove is reached ready for the step of the next radius.

36. The Elevating-Band, When Used.—This is lightly shrunk on, and keyed to prevent its turning.

A key is screwed into the gun through the bottom of the trunnion band for the same purpose.

37. Center of Gravity.—The position of the center of gravity of the gun is now determined by balancing it on a knife-edge—if the gun is a light gun—otherwise it is computed. The breech mechanism and also the sights, if possible, should be in place when the center of gravity is obtained.

38. Weight.—The weight of the gun, marked on the breech, includes the weight of the breech mechanism and sights, but not that of the elevator arcs and bolts. The preponderance at the center of the elevating band is also determined. The gun is then finally inspected; all outside dimensions being verified, breech mechanism set up and worked, and all hand-work thoroughly examined.

After final inspection, the gun is marked, and then goes to the Naval Ordnance Proving Ground for proof firing. (See chapter on Proving Ground.)

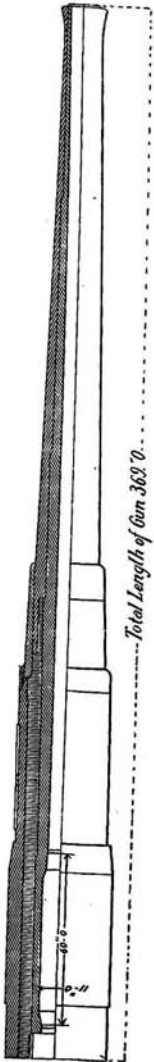
39. Recent Designs.—The Mark VI 50-calibre 6-inch Guns (Plate V), comprise Nos. 204 to 253, inclusive, and are for the battleships Maine, Ohio, and Missouri. These guns will all be quick-firing, loaded in the ordinary manner, and fitted with Vickers quick-firing breech mechanism known as Mark VI. They will be mounted on the Mark X or XI pedestal mounts.

The gun is composed of a tube, jacket, chase hoop *E*, chase-locking hoop *D*, jacket hoops *B* and *A*, and a short jacket-locking hoop *C*, merely screwed on. The tube 293.74 inches long has shrunk over its rear end for a length of 124.74 inches the jacket (total length 131 inches). The screw box in assembling being of smaller diameter than the tube brings up on the rear face of the latter. The screw box is afterwards bored out to a larger diameter than the tube to receive the breech collar box. A locking shoulder 3 inches long is left on the jacket near the front end,

forward of which to the end (18 inches) the jacket is turned down to a diameter of $15\frac{1}{2}$ inches, leaving a large front shoulder and jog. The *E* (chase) hoop, $90\frac{1}{2}$ inches long, is shrunk over the tube forward of and abutting the jacket, and also abutting a small radius at the same point on the tube, which is turned cylindrical under *E*. The *D* or chase-locking hoop 39 inches long is shrunk on over the rear-end of *E*, the turned-down end of the jacket abutting the shoulder on *E*; also a hook 2 inches long brings up on a shoulder left on the *E* hoop, thus locking the chase hoop to the jacket. The jacket hoop *B* abuts and covers the shoulder on jacket, and abuts the rear face of *D*. The *A* hoop covers the jacket to the breech face. That part of the *B* hoop's outer surface over the jacket shoulder for a length of 3 inches has turned on it a right-hand thread, and a short locking-hoop *C* (7 inches long) is then screwed on. A hook brings up on a shoulder left on *D*, thus locking together the whole system. Over the gun's center of gravity for a length of 44 inches the gun is cylindrical on a diameter of 22.30 inches. It is planed off to a diameter of 21.75 inches, leaving a longitudinal key 3 inches wide at the top and bottom to prevent the gun turning within the sleeve cylinder of the recoil slide. The maximum diameter of the gun body is 24 inches, extending from 7 inches to 47.5 inches forward of the breech except for the yoke shoulder ($2\frac{1}{2}$ inches wide, diameter $24\frac{1}{2}$ inches) which is 24 inches forward of the breech face. The muzzle of the gun is bell-shaped, diameter of bell $10\frac{1}{2}$ inches, diameter of neck 9 inches. The gun is otherwise shaped as shown. Total weight of gun including breech mechanism is about 18,900 pounds.

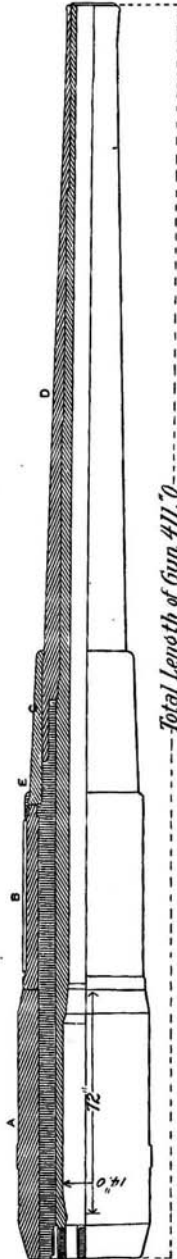
A hinge plate to carry the breech mechanism is bolted to the right side of the breech in a slot cut in the circumference of the *A* hoop and is held by four radial screws, such that the center of the hinge-pin hole lies without the gun.

The screw box is formed in the collar. The collar, 6.258 inches long and 12.8 inches diameter, is screwed into the recess in the jacket to the rear of chamber. The screw box is of the Welin or stepped-screw type, being planed out to form nine sections, a blank and two steps in three groups. The diameters of the blanks are 10.75 inches and threaded sections 10 inches and 9.25 inches. The threaded sections are separated by a space of $\frac{1}{8}$ inch to facilitate



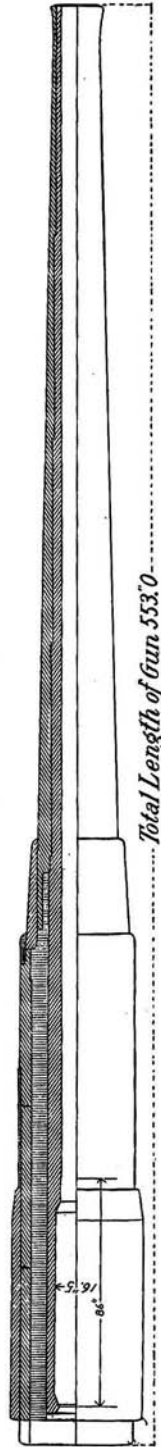
Total Length of Gun 362'0

8-INCH GUN, MARK VI.



Total Length of Gun 411'0

10-INCH GUN, MARK III.



Total Length of Gun 553'0

12-INCH GUN, MARK V.

manufacture. The threads are right-handed abutment thread, pitch 0.5 inch, depth 0.25 inch.

The chamber has a total length of 48.416 inches from the rear face of the tube to the rifling at front end of compression slope. It is of the enlarged type, with restricted mouth and a double loaded slope. The mouth consists of the gas-check seat 1.35 inches long, tapering from a diameter of $7\frac{7}{8}$ inches at the rear face of the tube to $7\frac{1}{4}$ inches, and thence cylindrical for $\frac{1}{2}$ inch. This is joined by a straight taper 4 inches long to the powder chamber, which has a diameter of 8 inches, the end of the taper being curved with an inside radius of 4 inches. The powder chamber is cylindrical for 34.7 inches to the first loading slope, which is a straight taper 4 inches long to a diameter of $6\frac{1}{2}$ inches, the ends being rounded by inside and outside radii of 4 inches and 1 inch, respectively. Then comes the second loading slope (3.83 inches long) a straight taper to 6.14 inches diameter ending at the compression slope. This slope is composed of a taper (0.28 inches long) to a diameter of 6.10 inches; thence cylindrical for 0.556 inch to the second slope; then tapers (0.20 inch long) to 6 inches diameter formed by inside and outside radii of 0.21 inch to the rifling. The total length for powder charge is about $40\frac{1}{2}$ inches.

The rifling consists of 24 equal grooves, hooped section, 0.4847 inch wide at the rear end and decreasing to 0.4147 inch wide at the muzzle and 0.05 inch deep. It is a right-hand twist increasing from 0 at the origin to one turn in 25 calibres at the muzzle. The length of rifled bore is 245.526 inches.

40. Latest 6-inch Gun.—The 6-inch 50-calibre mark VIII gun is shown in Plate V. A comparison of this gun with the Mark VI, described in the previous paragraph, illustrates the tendency to strengthen the chase of new guns. It will be noted that the chase hoop in the Mark VIII gun extends from the forward end of the jacket to the muzzle; that the exterior diameter at a distance of one foot from the muzzle is increased from 9 inches to 10 inches; that the swell of the muzzle is longer, and that the diameter at the top of the swell is increased from $10\frac{1}{2}$ inches to 11 inches. In other respects the differences in these two marks are immaterial.

41. New 7-inch Gun.—The 7-inch 45-calibre Mark II gun is

shown in Plate V. It will be noted that, in the general features of its design this gun is similar to the 6-inch Mark VIII. The parts and principal dimensions are shown in the figure.

42. The Latest 8-inch, 10-inch and 12-inch Guns are shown in Plate VI. In all these guns we find a long chase hoop carried to the muzzle, with the same general method of construction and arrangement of locking hoops as for the 6- and 7-inch guns. In reducing the number of hoops in comparison with guns designed a few years ago, and in carrying the chase hoop from the jacket to the muzzle the girder strength is greatly increased to resist drooping in long guns. There is also more metal, and greater strength from the shrinkage of the chase hoop to resist the increased or sustained pressure along the bore, due to smokeless powder. The locking system, and the stiffness of the construction, gives great longitudinal strength, and foreshadows the next change in gun construction which will doubtless be the adoption of two tubes continuous from breech to muzzle.

In the 12-inch gun a D hoop is shrunk on over the rear jacket hoop, giving four thicknesses over the powder chamber.

43. Table of Elements.—A table of elements of U. S. Naval guns of all calibres which was correct to April 1, 1903, will be found at the end of this chapter.

BALLISTIC ELEMENTS OF U. S. NAVAL GUNS.

(18)

Guns.	Cal.	Mark.	Length in in.	Capacity of powder chamber in cu. in.	Travel of projectile. In.	Weight of projectile in lbs.		Initial velocity F. S.	Maximum pressure, Tons.	Maximum wt. charge S. P. Lbs.	Weight desired. Lbs.	Weight ballistic sample. Lbs.	Remarks.
						Com-mon.	A. P.						
1-Pdr. (H. Light, Short).....	20	I	33.15	4.69	25.90	1	1	1450	8	40 gms.	35 gms.	10	Guns No. 1 to 26.
1-Pdr. (" Long).....	35	I mod.	....	4.69	....	1	1	1450	8	40 "	35 "	10	27 to 30.
1-Pdr. (D. S. Light).....	..	II expl.	....	....	....	1	1	....	....	....	....	....	14, 15.
1-Pdr. (" Heavy).....	40	II	61.08	7.43	53.36	1	1	2100	11	70 "	65 "	10	1 to 13, 19, 33, 34.
1-Pdr. (").....	40	II mod.	....	7.43	....	1	1	2100	11	70 "	65 "	10	20 to 26, 31, 32.
1-Pdr. (H. Heavy).....	40	III	62.00	7.43	53.00	1	1	2100	11	70 "	65 "	10	1 to 25, 27 to 53, 55 to 58.
1-Pdr. (D. S. Heavy).....	50	IV	75.98	7.43	67.93	1	1	2100	11	70 "	65 "	10	27 to 30.
1-Pdr. (H. ").....	40	V	62.37	7.43	53.07	1	1	2100	11	70 "	65 "	10	26, 54, 59 to 274, 376 to 425, 476 to 575.
1-Pdr. (M. N. Heavy Aut.)...	40	VI	89.50	7.43	57.07	1	1	2100	11	70 "	65 "	10	275 to 375.
1-Pdr. (" Lt. Long Aut.)...	30	VII	69.35	4.69	40.42	1	1	1450	8	40 "	35 "	10	1 to 51.
1-Pdr. (H. Semi-Aut.).....	40	VIII	62.37	7.43	53.07	1	1	2100	11	70 "	65 "	10	426 to 475.
1-Pdr. (M. N. Light Short)...	..	IX	....	....	....	1	1	1450	8	40 "	35 "	10	1 to 13.
3-Pdr. (H.).....	40	I	80.63	46.42	60.30	3	3	2200	15	400 "	360 "	20	1 to 39.
3-Pdr. (H. French).....	..	I mod.	....	46.42	....	3	3	2200	15	400 "	360 "	20	70 to 83.
3-Pdr. (D. S.).....	45	II	87.95	46.42	69.49	3	3	2200	15	400 "	360 "	20	1 to 10.
3-Pdr. (M. N.).....	..	III	....	46.42	....	3	3	2200	15	400 "	360 "	20	114 to 116.
3-Pdr. (H. Semi-Aut.).....	50	IV	99.05	46.42	78.74	3	3	2200	15	400 "	360 "	20	172 to 221.
3-Pdr. (D. S.).....	..	V	....	46.42	....	3	3	2200	15	400 "	360 "	20	11 to 20.
3-Pdr. (M. N. Semi-Aut.).....	..	VI	....	46.42	....	3	3	2200	15	400 "	360 "	20	117 to 171.
3-Pdr. (H. Armstrong).....	..	VII	....	46.42	....	3	3	2200	15	400 "	360 "	20	40 to 69, 84 to 113.
6-Pdr. (H.).....	40	I & II	97.63	50.52	79.17	6	6	2240	15	600 "	550 "	20	.....
6-Pdr. (").....	45	III	108.86	50.52	90.39	6	6	2240	15	600 "	550 "	20	54 to 153.
6-Pdr. (D. S. Field).....	30	IV	72.00	32.99	59.87	6	6	....	....	....	....	....	2, 4, 5.
6-Pdr. (").....	30	IV mod.	72.00	32.99	59.87	6	6	....	....	....	....	....	6 to
6-Pdr. (Field, Lynch Mech.)...	30	V	72.00	32.99	59.87	6	6	....	....	....	....	....	1, 3.
6-Pdr. (D. S.).....	45	VI	107.33	50.52	90.39	6	6	2240	15	600 "	550 "	20	1 to 110, 65 & 68 have Mark VIII B. M.
6-Pdr. (H.).....	45	VII	108.86	50.52	90.39	6	6	2240	15	600 "	550 "	20	154 to 443.
6-Pdr. (D. S.).....	50	VIII	118.55	50.52	101.60	6	6	2240	15	600 "	550 "	20	111 to 208.
6-Pdr. (M. N. Semi-Aut.)...	45	IX	103.25	50.52	84.25	6	6	2240	15	600 "	550 "	20	446 to 561.
6-Pdr. (Nord.).....	..	X	....	....	....	....	....	....	....	....	....	....	.....
6-Pdr. (D. Sea by S-A.).....	50	XI	120.00	50.52	101.46	6	6	2240	15	600 "	550 "	20	562.
6-Pdr. (H. Armstrong).....	..	XII	....	....	....	....	....	....	....	....	....	....	.....

BALLISTIC ELEMENTS OF U. S. NAVAL GUNS.—Continued.

Guns.	Cal.	Mark.	Length in in.	Capacity of powder chamber in cu. in.	Travel of projectile. In.	Weight of projectile in lbs.		Initial velocity F. S.	Maximum pressure. Tons.	Maximum wt. charge S. P. Lbs.	Weight desired. Lbs.	Weight ballistic sample. Lbs.	Remarks.
						Common.	A. P.						
3-inch Gun	25	I & I mod.	69.60	32.51	59.60	13.2	Shrapnel.	1150	11	250 gms.	230 gms.	20	Guns No. 1 to 100.
3-inch Gun	50	II	153.80	219.61	128.32	13	13	2800	15	5.5 lbs.	5 lbs.	100	102 to 201.
3-inch Gun	50	III	154.30	219.61	127.92	13	13	2800	15	5.5 "	5 "	100	1 to 101.
4-inch Gun	40	I con.	163.75	331.22	131.61	33	32	2300	14	7.70	7	100	1, 3, 6.
4-inch Gun	40	I con.	159.75	331.22	128.00	33	32	2300	14	7.70	7	100	2.
4-inch Gun	40	II	164.00	331.22	132.00	33	32	2300	14	7.70	7	100	4, 5.
4-inch Gun	40	III	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	7 to 69, 71, 73, 74, 82, 84, 87.
4-inch Gun	40	IV	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	108 to 117, 180 to 209.
4-inch Gun	40	V	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	70, 72, 75 to 81, 83, 85, 86, 88 to 98.
4-inch Gun	40	VI	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	99 to 107, 118 to 179, 256, 282 to 291.
4-inch Gun	50	VII	204.50	652.25	168.27	33	32	2900	15.5	15.75	15	100	213 to 254, 257 to 281.
4.7-inch Gun	45	I	....	....	....	45	....	....	....	13.75	13.0	100	.....
4.7-inch Gun	45	II	....	....	....	45	....	....	....	13.75	13.0	100	.....
4.7-inch Gun	50	III	236.20	480.61	205.30	45	....	2600	14.9	13.75	13.0	100	.....
4.7-inch Gun	..	IV	....	....	....	....	....	....	....	....	....	....	.....
5-inch Gun	30	I con.	159.97	656.07	121.73	50	50	2200	14	16	15	200	1, 2.
5-inch Gun	40	II	206.00	656.07	167.76	50	50	2550	14	16	15	200	3 to 70.
5-inch Gun	40	III	205.83	656.07	167.76	50	50	2550	14	16	15	200	87 to 199.
5-inch Gun	40	IV	206.00	656.07	167.76	50	50	2550	14	16	15	200	71 to 86.
5-inch Gun	50	V	255.65	1200.00	215.67	60	60	2900	15.5 to 16	26	24.5	...	.....
6-inch Gun	30	I	189.70	1420.52	139.05	100	103.9	2150	14	26	24.5	300	1.
6-inch Gun	30	II con. A.	193.53	1317.89	142.93	100	103.9	2150	14	26	24.5	300	2 to 21.
6-inch Gun	30	III	196.00	1311.04	149.66	100	103.9	2150	14	26	24.5	300	22, 25, 26, 28, 30, 38, 39, 40, 41, 43 to 48, 81 to 86, 89 to 98, 104, 105, 107, 109, 112.
6-inch Gun	30	III con. A.	196.00	1317.89	145.40	100	103.9	2150	14	26	24.5	300	16 Guns from this drawing no No.
6-inch Gun	30	III con. B.	196.00	1317.89	145.40	100	103.9	2150	14	26	24.5	300	23, 24, 27, 29, 32 to 37, 42, 49 to 80, 87, 99 to 103, 106, 108, 110, 111, 113 to 119, 122 to 124.
6-inch Gun	35	III mod. I	226.00	1311.04	179.66	100	103.9	2300	14	26	24.5	300	126, 129 to 132, 88.

BALLISTIC ELEMENTS OF U. S. NAVAL GUNS.—Concluded.

Guns.	Cal.	Mark.	Length in in.	Capacity of powder chamber in cu. in.	Travel of projectile, in.	Weight of projectile in lbs.		Initial velocity F. S.	Maximum pressure, tons.	Maximum wt. charge S. P. Lbs.	Weight desired, Lbs.	Weight ballistic sample, Lbs.	Remarks.
						Com-mon.	A. P.						
6-inch Gun	40	III mod. 2	256.00	1311.04	209.66	100	103.9	2400	14	26	24.5	300	Guns No. 120, 128.
6-inch Gun	40	III con. D.	256.00	1317.89	205.40	100	103.9	2400	14	26	21.5	300	121, 127.
6-inch Gun	40	IV mod.	256.41	1317.89	205.81	100	103.9	2400	14	26	24.5	300	135 to 153, 155 to 176, 260 to 263.
6-inch Gun	40	IV mod.	256.10	1317.89	205.50	100	103.9	2400	14	26	24.5	300	133, 134.
6-inch Gun	50	V	309.25	1091.47	267.30	100	103.9	2600	14.8	26	24.5	300	198 to 209.
6-inch Gun	46	VI exp'l.	276.258	2101.02	223.78	100	103.9	2900	15	44	40	300	197.
6-inch Gun	50	VI	300.00	2101.02	247.52	100	103.9	2900	15.5-16	44	40	300	210 to 259, 277 to 360.
6-inch Gun	40	VII	254.11	1317.89	205.81	160	103.9	2400	14	26	24.5	300	264 to 276, Bethlehem.
6 inch Gun	50	VIII	300.00	2101.02	247.52	100	103.9	2900	15.5-16	44	40	300	361.
7-inch Gun	45	I	315.00	3631.87	251.21	165	....	2800	15.5	70	65	600	.....
7-inch Gun	45	II	323.00	3631.87	259.21	165	....	2800	15.5	70	65	600	.....
8-inch Gun	30	I	257.99	3574.40	197.83	250	257	2200	14	63	59	600	2. At W. N. Y.
8-inch Gun	30	I	257.99	3661.01	196.83	250	257	2200	14	63	59	600	4. " "
8-inch Gun	30	I con. A.	254.61	3517.24	196.84	250	257	2200	14	63	59	600	1, 3. On the Atlanta.
8-inch Gun	30	II con. A.	255.60	3517.24	197.83	250	257	2200	14	63	59	600	5, 6 On Boston. 7, 8, W. N. Y.
8-inch Gun	30	III exp'l.	261.00	3185.31	201.93	250	257	2200	14	63	59	600	15 only.
8-inch Gun	35	III	304.50	3185.31	245.43	250	257	2300	14	63	59	600	9 to 14, 16 to 21.
8-inch Gun	35	III mod. 1	304.50	3185.31	245.43	250	257	2300	14	63	59	600	34 to 50, 53 to 68.
8-inch Gun	40	III mod. 3	344.50	3185.31	285.43	250	257	2300	14	63	59	600	33 & 51.
8-inch Gun	35	IV	304.50	3185.31	245.43	250	257	2300	14	63	59	600	22 to 26, 28 to 32.
8-inch Gun	35	IV mod.	303.84	3185.31	244.77	250	257	2300	14	63	59	600	27.
8-inch Gun	35	IV mod.	304.50	3185.31	245.43	250	257	2300	14	63	59	600	69 to 76.
8-inch Gun	35	IV mod.	304.50	3165.07	245.43	250	257	2300	14	63	59	600	77 to 82.
8-inch Gun	40	V	343.00	5250.22	272.65	250	257	2800	16.5	115	110	1000	.....
8 inch Gun	45	VI	369.00	5250.22	298.65	250	257	....	....	....	....	....	.....
10-inch Gun	30	I	329.10	6906.29	249.91	500	511.6	2200	14	135	125	1200	1, 2.
10-inch Gun	34	I mod.	365.00	6906.29	286.41	500	511.6	2200	14	135	125	1200	3, 4.
10-inch Gun	30	II	329.10	6860.09	249.91	500	511.6	2200	14	135	125	1200	5 to 8, 11 to 14, 17 to 26.
10-inch Gun	40	III	411.00	10221.93	325.84	500	511.6	2800	16.5	240	225	1500	.....
12-inch Gun	35	I	441.00	12145.33	344.80	850	868.4	2250	14	205	190	1500	1 to 8.
12-inch Gun	35	II	441.00	12145.33	344.12	850	868.4	2250	14	205	190	1500	9 to 14.
12-inch Gun	40	III	493.00	17623.60	388.80	850	868.4	2800	16.5	370	350	2500	15 to 40, 46, 47.
12-inch Gun	40	III mod.	493.00	17167.76	390.80	850	868.4	2800	16.5	370	350	2500	41 to 45, 48 to 56.
13-inch Gun	35	I	479.10	15289.85	373.19	1100	1116	2300	14	295	275	2000	1 to 25.
13-inch Gun	35	II	479.10	15241.72	373.19	1100	1116	2300	14	295	275	2000	26 to 34.

Correct to April 1, 1906.

CHAPTER IV.

BREECH MECHANISMS.

1. Definition of Breech Mechanism or Fermeture.—This is a mechanical device for closing the rear end of the chamber or bore of a breech-loading gun. The term includes the breech plug or block, the mechanism contained in or with it, and the necessary operating gear.

2. Requirements for a Breech Mechanism.—The following may be said to be the principal requirements of a breech mechanism :

(1) *Safety.*—Under this head will be included : (a) The stopping of all escape of gas to the rear ; (b) the gun must not be weakened by the attachment of the breech mechanism ; (c) the breech plug must be securely locked to avoid *decussment* on firing ; (d) there must be no danger from premature discharge ; (e) there must be strength to prevent any part being blown to the rear ; (f) the obturation or sealing to prevent the escape of gas to the rear must be automatic, greater pressure insuring better obturation.

(2) *Ease and Rapidity of Working.*—Otherwise, rapid and continuous fire can not be maintained. Hence this would include facility in loading and certainty of extraction for rapid-fire guns.

(3) *Not Easily Put Out of Order.*—In other words, it must be able to meet service conditions and hard usage. Parts should have a reserve of strength. All the mechanisms should be so designed as to be protected by the gun itself.

(4) *Ease of Repair.*—Parts most exposed to wear should be so designed as to permit of being replaced. This will also include accessibility to parts, so that breakage of a part will not disable a mechanism for a long time.

(5) *Interchangeability.*—Not only should individual parts be made interchangeable by accurate workmanship, but the whole mechanism should be capable of being mounted on similar guns. This is to meet service conditions.

3. **The Breechblock or Plug** is the movable piece closing the breech of a gun, withdrawn for loading, and closed before firing. It is carried in "built-up" guns by the jacket, within a screw box, mortise, or housing. The term applies to any shape of piece, or any system of closure.

In small arms and certain special guns the term breech "bolt" is often used instead of plug or block; and "breech action" is a better term in this case than "breech mechanism."

4. **Breech Piece** is a term sometimes used (as in the Krupp system) for a heavy piece of metal on the breech of a gun, which contains the breech plug or block.

5. **Systems of Breechblocks for United States Navy Guns.**—There are seven (Plate I) principal systems of breechblocks used in the United States Navy for both service and foreign built guns, viz.: (1) The interrupted screw (Fig. 1), (2) the sliding wedge (Fig. 2), (3) the rotary block (Fig. 3), (4) combined rotary and sliding system (Fig. 4), (5) the conical spiral thread (Fig. 5), (6) the sliding-bolt and turn-bolt systems (Figs. 6, 7 and 8), and (7) special fermetures.

The interrupted-screw and the conical spiral-thread systems are used for all guns of and above 3 inches in calibre. Secondary rapid-fire guns use systems (2), (3), and (4). Small-arm rifles, as well as certain automatic and machine guns, generally use the "sliding-bolt system." "Special fermetures" will be referred to as described.

Special guns, such as automatic, automatic rapid-fire, machine guns, etc., more properly use "breech actions," in which there are different methods of closing the breech and operating the mechanism. The systems in these cases are defined by the names of the guns.

In our service the interrupted-screw system is represented in nearly all of the main-battery guns; the sliding wedge by the Hotchkiss 6-pounder, 3-pounder, and 1-pounder rapid-fire guns, Maxim 6-pounder and 3-pounder semi-automatic rapid-fire guns; the rotary block in the Driggs-Schroeder 6-pounder, 3-pounder, 1-pounder, and two 4-inch rapid-fire guns; the combined rotary and sliding-wedge system by the Nordenfelt 6-pounder and 3-pounder rapid-fire guns; and the conical spiral thread, experi-

FIG. 1. INTERRUPTED SCREW.
ALL MAIN BATTERIES.
4" PLUG.

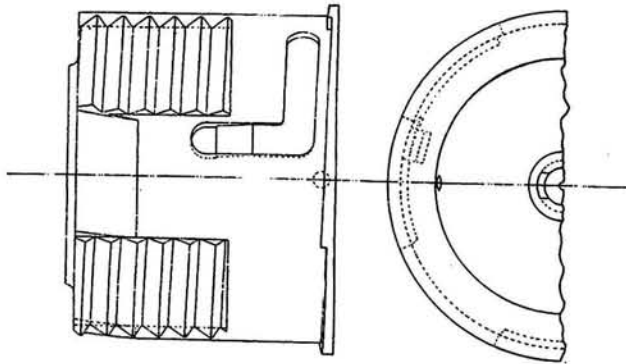


FIG. 2. SLIDING WEDGE.
HOTCHKISS 5-PDR.

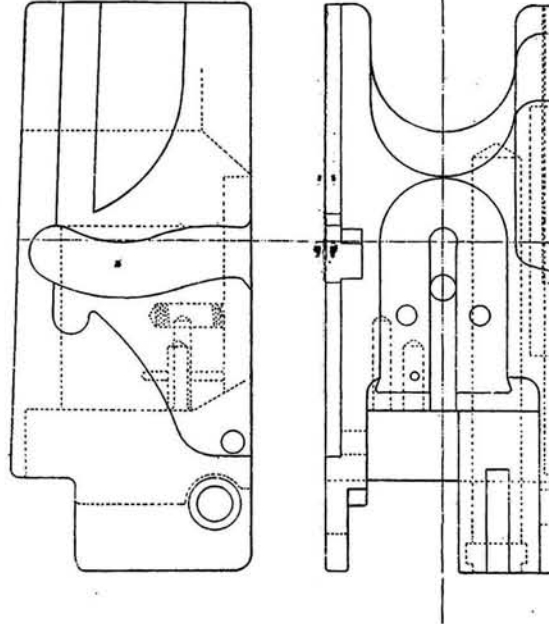


FIG. 3. ROTARY BLOCK.
BRIGGS-SCHROEDER 6-PDR.

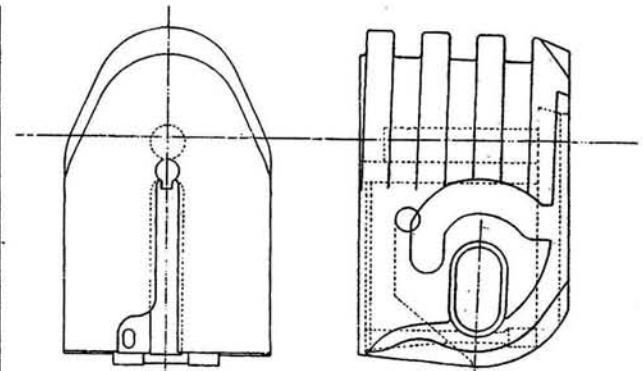


FIG. 4. COMBINED ROTARY AND SLIDING WEDGE
NORDENFELT 6-PDR.

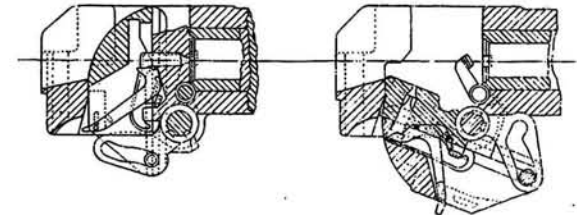


FIG. 6. SLIDING BOLT SYSTEM.
LEE STRAIGHT PULL.

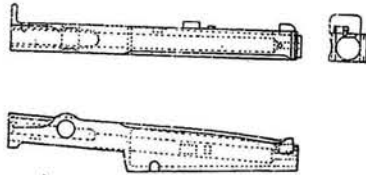


FIG. 5. CONICAL SPIRAL THREAD.
HAESELER 4" PLUG.

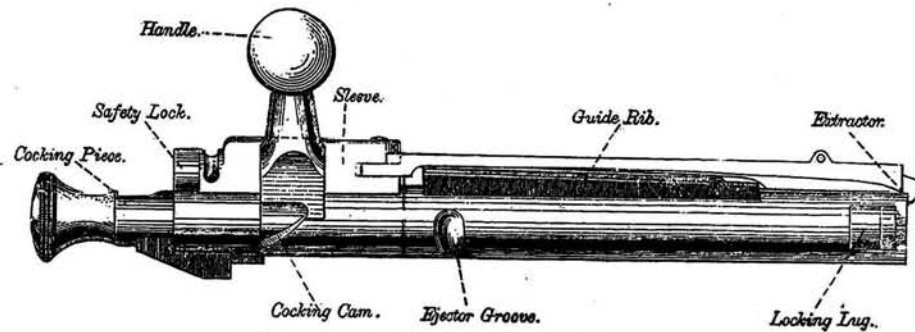
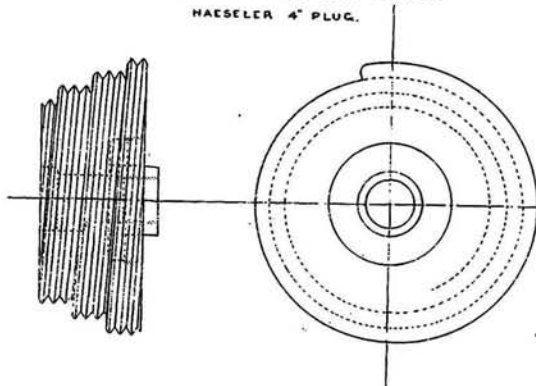


FIG. 7. TURN BOLT SYSTEM. U. S. MAGAZINE RIFLE.

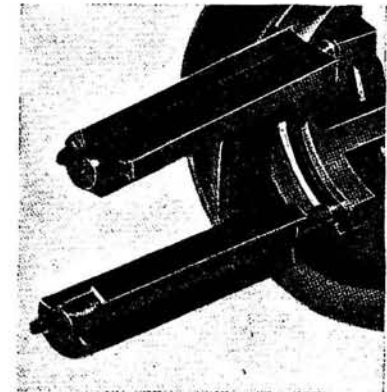


FIG. 8. SLIDING BOLT SYSTEM.
GATLING, MARK II, .30 CAL.

mentally in an 8-inch nickel-steel gun (one was made and tried previously in a 4-inch gun).

6. The Interrupted-screw System, also called "slotted-screw," is divided into four classes (Plate II): (1) French interrupted screw (Fig. 1), (2) Elswick interrupted screw (Fig. 2), (3) Welin interrupted screw (Fig. 3), and (4) Maxim-Nordenfelt Mark M, or the Melstrom, interrupted thread (Fig. 4).

In general, an interrupted-screw plug means that the plug, having been threaded, has two or more sections of the thread removed in the direction of the axis. Similar interruptions are made in the female thread of the screw box in the gun, in order that the plug may be entered or withdrawn in one motion, and only a portion of a turn given to lock or unlock the same in the screw box.

(1) *The French interrupted screw* (Fig. 1) is the ordinary system of fermeture and has been long in use. The breech plug, cylindrical in shape, has a male screw thread cut on its circumference the character of which varies according to particular designs. It is then divided into a number of equal sections in the longitudinal direction (always divisible by two, usually six, eight, or twelve) and the threads of alternate sections are then slotted out. The female thread in the screw box is similarly slotted. In closing the breech, the threaded sections of the plug are brought opposite to the blank sections of the screw box; the plug is pushed in either by hand or by some sort of mechanism to the proper distance, and a fraction of a turn to the right or left is given to interlock the threaded sections. The amount of turn necessary depends upon the number of divisions; six divisions would require sixty degrees, eight divisions forty-five degrees, etc. The system is independent of the methods of operating the mechanism.

(2) *The Elswick interrupted screw* (Fig. 2) differs from the French, or ordinary, in that the forward part of the plug is conical and the rear part cylindrical. The threaded sections of the coned portion correspond longitudinally with the blank or planed sections of the cylindrical part. The advantages claimed for this arrangement are: (1) The working of the mechanism is facilitated, as the translation and swinging out or in can be accomplished in one motion; (2) the arrangement of the threaded sections dis-

tributes the strain throughout the entire circumference of the plug ; (3) the cone shape distributes the engagement over a large transverse section of the gun.

(3) *The Welin interrupted screw* or "stepped-thread" system (Fig. 3) has the block divided circumferentially into six equal sections, each semicircle having a blank and two stepped-threaded sections. The blanks have the greatest diameters and the stepped-threaded sections are in two smaller diameters, the larger step being diametrically opposite the smaller step in the other semicircle. The blanks are cut concavely and convexly, with the hinge pin as a center, and the upper part of the teeth of the first step, with the adjoining edges, are also cut, both cuttings being to give clearance in swinging the plug.

(4) *The Maxim-Nordenfeldt interrupted screw* (Fig. 4) has the following peculiarities: The plug is slightly conical, larger end at the front, having a V thread of slight pitch, and interrupted, not by planing down to the root of the thread, but by cutting off the metal of the plug equally on opposite sides parallel to the axis, forming, more or less, a square cross section. The screw box is similarly shaped. The advantage claimed is that the plug is less likely to be blown out with excessive pressures. There is no doubt that the method of interruption considerably weakens the plug, and to make up in holding power the length of the plug is a trifle longer than it would be with other systems.

7. The Sliding-wedge System (Plate I, Fig. 2), exemplified in the Hotchkiss guns, has a rectangular wedge-shaped block (containing the firing mechanism) that slides up and down in a vertical mortise within the square-shaped breech of the gun, and is guided by vertical ribs. It is moved by means of a crank, journaled in the right cheek of the mortise; a stud on the other end of the crank moves in a cam groove in the side of the block. The wedge completely closes the mortise when up, and gives a sliding movement to the cartridge case in shoving it home.

Some field guns have the block working transversely to the axis of the gun, instead of vertically.

8. The Rotary-block System (Plate I, Fig. 3).—In this system, whatever the shape of the block, method of operation, or locking, the block rotates on an axis (generally transverse) to close or open

FIG. 1 FRENCH INTERRUPTED SCREW.

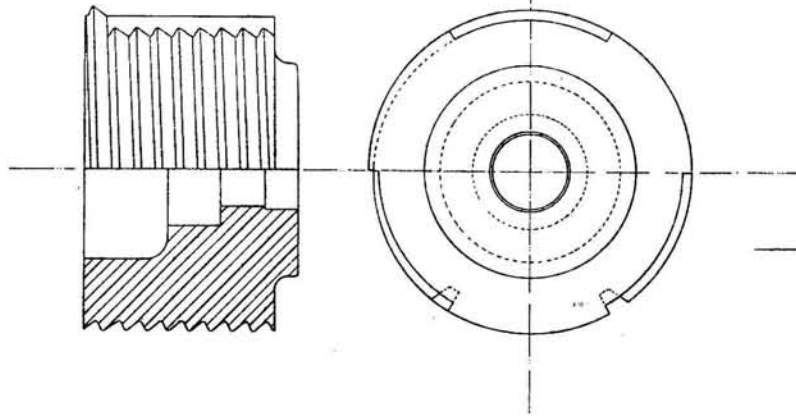


FIG. 3. WELIN INTERRUPTED SCREW.

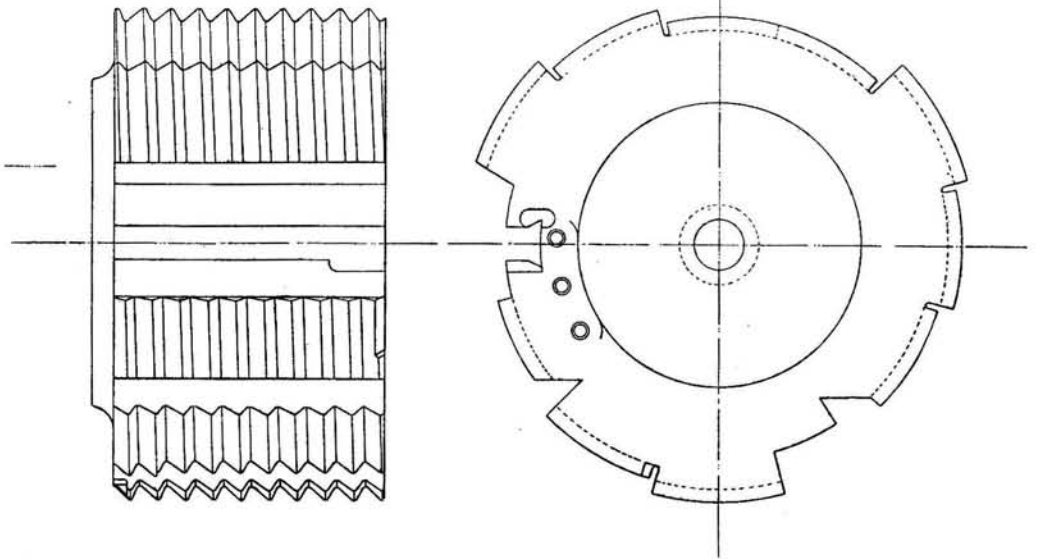


FIG. 2. ELSWICK INTERRUPTED SCREW.

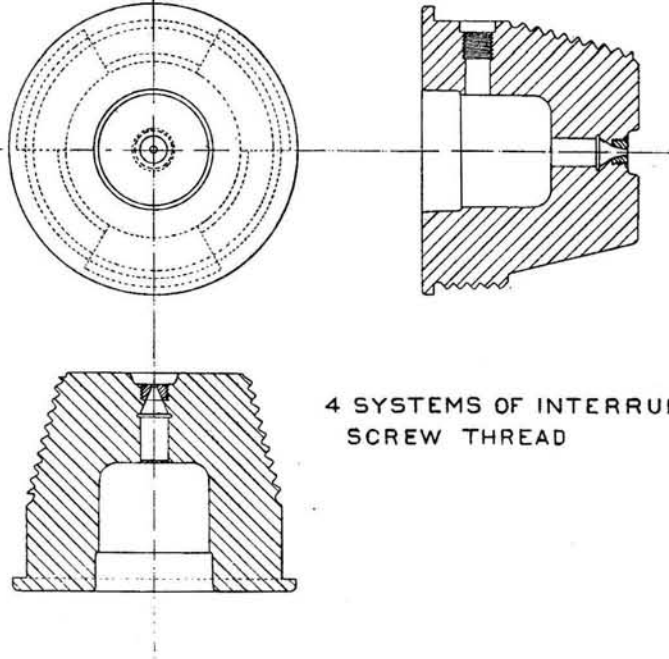
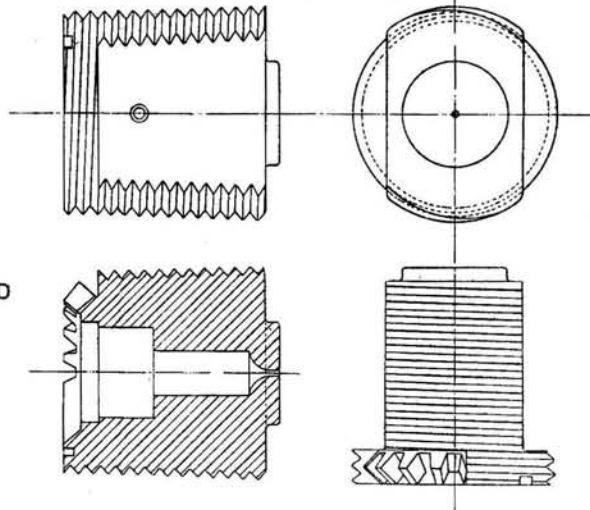


FIG. 4. M.-N. MARK M, OR THE MELSTROM INTERRUPTED SCREW.



4 SYSTEMS OF INTERRUPTED
SCREW THREAD

the breech, the upper part of the block falling to the rear in opening. There may be some vertical movement for the locking or unlocking.

This system is exemplified in our service by the Driggs-Schroeder guns. It has a rectangular block with rounded top, working entirely within the breech housing, and is locked by means of collars on the top of the block engaging in corresponding grooves in the housing. The grooves are inclined slightly to the front, so that the final movement in closing is upward and to the front, pushing the cartridge case home. The operation is through a cam within the block, moving against curved surfaces in the block's recess. The cam is moved by a transverse axis.

9. The Combined Rotary and Sliding-wedge System (Plate I, Fig. 4) is exemplified in our service in the Nordenfeldt 6-pounder and 3-pounder rapid-fire guns. The breechblock may be said to consist of two parts, the block and the wedge, the latter slides on the front face of the former in the locking or unlocking movement, while, to cover or uncover the breech, both rotate about a transverse axis, the top falling to the rear in opening.

10. The Conical Spiral-thread System of Breechblock (Plate I, Fig. 5) is represented by the Haeseler patent, and consists of a short cone, on which is chased a continuous multiple thread. The threads are parallel, of equal diameter and axial pitch. The advantages of this system may be said to be, (1) only a small height of tooth is necessary, requiring but a small revolution of the plug to disengage or engage; (2) only two motions are necessary to open the breech, viz., rotation and swing; (3) ease of manufacture; (4) lightness, and short length of block.

The advantages become more apparent as the size of the gun increases, especially as to (4).

11. The Sliding-bolt and Turn-bolt Systems (Plate I, Figs. 6, 7 and 8).—In these systems a more or less cylindrical piece, containing at least the firing pin and spring or hammer, moves longitudinally in a "receiver" attached to the gun barrel, and may be worked either by hand, as for small-arm rifles, or by certain mechanism, as in the Colt automatic gun. The bolt may have only a direct movement to the rear and front, giving the name "straight pull," or may have a part attached which is turned for locking or

unlocking, giving the name of "turn bolt." These systems are exemplified in the Lee straight-pull rifle, the Krag-Jorgensen rifle, in the lock for each barrel of the Gatling gun, and in the Colt automatic gun.

12. Special Fermetures.—Under this head will be grouped various methods of closing the breech for secondary guns used in our service, exemplified in the vertical sliding carrier of the lock in the Maxim automatic guns, and in the solid breechblocks of the revolving cannon. They will be specially described for those guns.

13. Systems of Operating Breech Mechanisms.—It may be said that there are two general systems, (1) ordinary, (2) quick-acting. Each of these is subdivided into certain types. These types often give the name of the gun, coupled, perhaps, with the name of the inventor or manufacturer.

It may be noted here that the names of the sub-divisions of the systems given above are sometimes used with reference to the manner in which the ammunition is put up or loaded. Such names give the name to the gun.

Even the gun carriage sometimes gives the name to the gun. Thus, a rapid-fire gun may be so called from the fact that fixed ammunition is used, but it would still be possible to use an ordinary system of operation of the breech mechanism, and a slow-working gun movement, and vice versa. Properly speaking, however, a rapid-fire gun would not only use fixed ammunition, but a quick-acting breech mechanism, and be mounted on a quick-working gun mount. Thus the terms "rapid-fire gun mount," "rapid-fire breech mechanism," "rapid-fire guns," have arisen.

14. Distinction between Ordinary and Quick-acting Breech Mechanism. The distinction may be said to lie solely in the movement. *Ordinary mechanisms* are operated in not less than three motions, viz., rotation, translation, and swinging, accomplished by continued revolutions of some crank, or by crank and actual hand movement in a relatively slow manner. Each motion is a distinct operation, even though accomplished by a continued movement of the crank.

Quick-acting breech mechanisms are worked by the simple swing of a lever, requiring less than a complete turn to completely

open or close the breechblock and such that the motions are quickly and continuously accomplished. There may be three motions, as in the ordinary system, but in all later-designed breech mechanisms there are but two—rotation and swinging. For heavy guns a crank may be used with interposed gearing, on account of great weight; but this crank must have only a limited movement, so that a hand lever could be substituted for it and the gearing without reducing the time of the operation, provided a corresponding direct power be applied to it.

15. Types of the Ordinary System of Operation.—There are three types: (1) Service; (2) modified Farçot; (3) improved Farçot. The difference between (2) and (3) is so slight that it is usual to class both under (2).

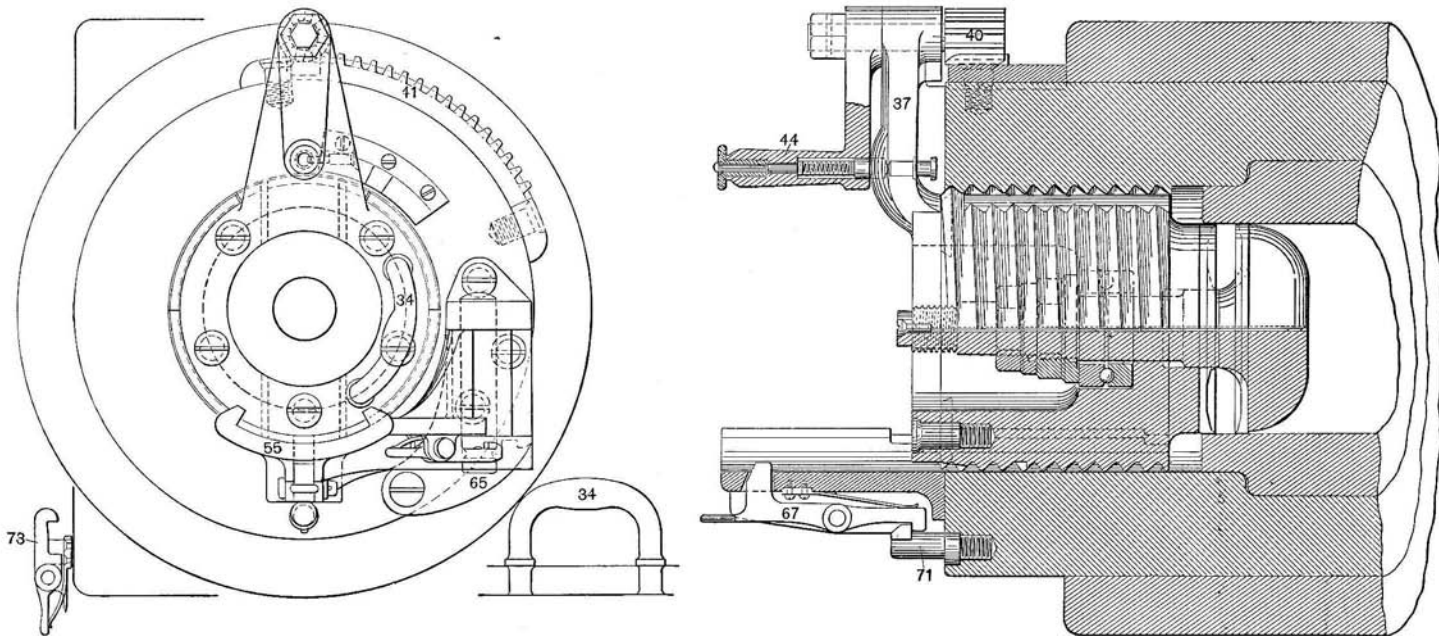
16. The Ordinary Service Types of Operation are exemplified in the 6-inch Mark III, 8-inch Mark II, 10-inch Marks I and II, and 12-inch Mark II breech mechanisms. The 6-inch and 8-inch represent one method, the 10-inch Mark I a second method, and the 10-inch and 12-inch Mark II a third.

In the first, a lever is secured to the rear face of the plug, and carries a small pinion (operated by a crank) that engages in a circular rack secured to the circumference of the breech; on turning the pinion the plug revolves, locking or unlocking the threaded sections. The plug, being unlocked, is withdrawn into a tray hinged to one side of the gun (in the 6-inch it is withdrawn by hand, in the 8-inch by a translating screw in the tray). The plug and tray are then swung clear of the screw box by hand. Other suitable mechanisms are used in connection with latching the tray, keeping the plug locked, etc. (Plate III).

In the second method, the pinion is on the breech face of the gun, and a circular rack is on the face-plate of the plug. The plug, being unlocked, is started out by a cam on a lever pivoted to the rear face of the block and working against the gun, and then withdrawn by hand onto a carrier hinged to the gun mount, the gun being at extreme elevation. The carrier or tray is then moved to one side by a hydraulic or a pneumatic motor.

Both the first and second of the "ordinary" types are being rapidly replaced by the Farçot method.

The third of the ordinary service methods is the same in principle as the modified Farçot fully described in chapter V.



"ORDINARY" BREECH MECHANISM FOR 6-INCH B. L. R., MARK III.

34. Grasp.
55. Plug tray,

37. Plug lever.
65. Hinge bolt,

40. Plug lever pinion.
67. Latch,

41. Rack.
71. Tray catch.

44. Plug lever crank handle.
73. Back latch.

17. The Modified Farçot Operating Gear.—The name Farçot is from the inventor, and the adjective “modified” is prefixed to denote that a change or improvement was made in the original.

18. The Improved Farçot Operating Gear.—This differs from the “modified” principally in that the worm wheel and pinion are in *one piece*, and are not keyed to, but turn on, the vertical shaft as an axis. This brings the crank-shaft lower down, the number of pieces is reduced, the manufacture is somewhat simplified, and it conduces to smoother working.

For the details of the Farçot gear, see chapter V.

19. Types of the Quick-acting System.—There are five principal types: (1) Rapid fire; (2) semi-automatic rapid fire; (3) automatic rapid fire; (4) quick fire; and (5) machine-gun breech action.

A *rapid-fire* breech mechanism is a quick-acting one, *without a gas check*. It is provided with an extractor and special firing mechanism for use in guns using primed metallic cartridge cases, or in other words, for rapid-fire guns.

A *quick-fire* breech mechanism is a quick-acting one provided *with a gas check* and a firing lock for use on guns where the charge is not put up in a metallic case, or in other words, when loaded in the “ordinary manner.”

There is in reality no distinction between the rapid fire and quick fire, so far as the operating gear is concerned, but the name is given because the guns differ in their ammunition, or rather the manner of putting up the same. The firing mechanism differs, no extractor being necessary for the latter.

The term *quick fire* is apparently indiscriminately used abroad for guns having a quick-acting mechanism, whether using metallic cartridge cases or powder charges in bags. It is well that a distinction should be made, as in the United States Navy.

Semi-automatic rapid-fire breech mechanisms are quick-acting, part of the operation being by hand and part automatic. This gives rise to the name; it also names the gun as semi-automatic.

Automatic rapid-fire breech mechanisms are those in which all the operations are performed automatically by utilizing the energy of recoil. The name also defines the gun.

See “Definitions of rapid-fire guns,” Chapter II.

The breech actions of machine guns are necessarily quick-acting, and they will be spoken of in the description of these guns.

20. Gas Check.—This is a device to prevent the escape of powder gas to the rear around the breech mechanism, or through the vent.

A *vent check* is used with some old guns to prevent escape of gas to the rear through the vent. No special vent check is necessary for modern guns, because in those using "firing locks" the character of the lock around the vent-sealing primer prevents escape of gas. For rapid fire guns the primer case seals all escape of gas to the rear.

21. Systems of Gas Checks (Plate IV).—There are four systems in use in the United States Navy: (1) The Broadwell ring (Fig. 1); (2) the De Bange (Figs. 2 and 3); (3) the cartridge case (Fig. 4); (4) cup gas check (Fig. 5). The second and third are used in modern guns, the cartridge case of course being for rapid-fire guns.

22. The Broadwell Ring is the invention of Broadwell, an American, and has been largely used abroad by Krupp. It consists of a ring made of copper, recessed on the forward side. The flange fits in a correspondingly shaped recess in the gun at the front end of the screw box. The flange extends a slight distance forward to give a good bearing surface in the recess. The rear face is perpendicular to the axis of the gun, has three shallow grooves to collect any residuum, and extends from 0.01 inch to 0.02 inch to the rear of the recess wall. The diameter of the inner flange is less than that of the chamber, to avoid displacement in sponging. On closing the breech, the nose of the plug, or a nose plate thereon, bears tightly on the rear face of the ring, making the joint with the gun and also the bearing with the plug gastight. On firing the gun the powder gas expands the flanges and sets the ring back hard against the plug.

This check, in our service, is used in the old 3-inch breech-loading field gun or howitzer. It is being experimented with, however, to determine whether the system, or some modification of it, may not be applicable to high-power guns. These experiments are the result of several failures of the De Bange check in recent guns using smokeless powder. It is possible that some combina-

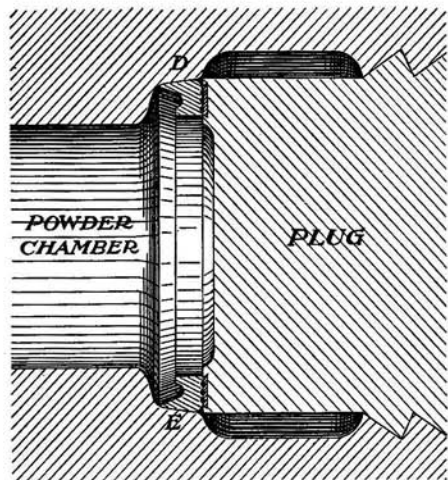


FIG. 1. D. E. Broadwell Ring.

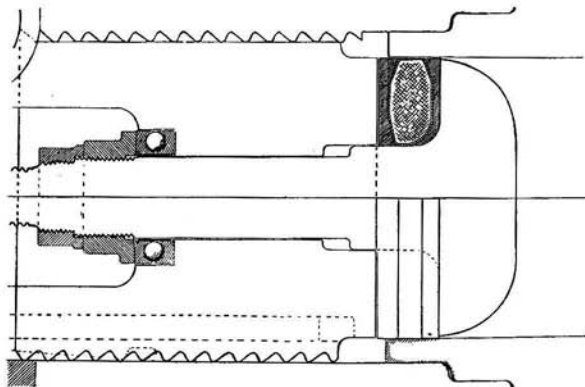


FIG. 2. The De Bange Gas Check, with Disks.

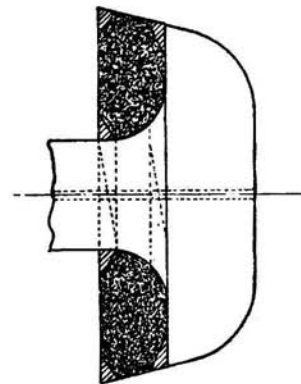


FIG. 3. The De Bange Gas Check.
Later form, showing split rings.

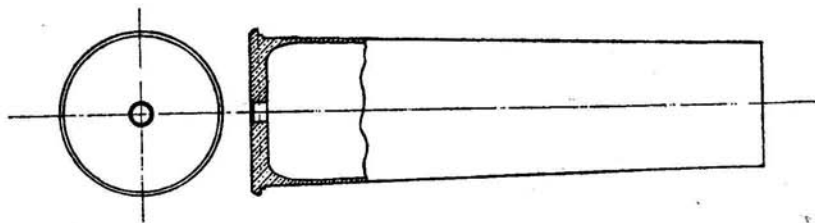


FIG. 4. Cartridge Case.

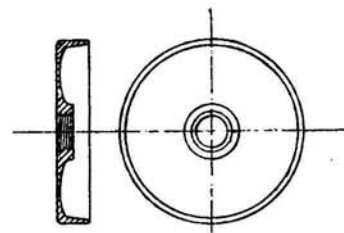


FIG. 5. Cup Gas Check.

tion of the Broadwell ring principle with the pad of the De Bange check may be adopted which will prevent the injury of the pad in the case of abnormal powder pressure.

23. **The De Bange Gas Check**, or "pad obturator," is the type used in the United States Navy for all modern guns that are not rapid fire. It is the invention of Colonel De Bange, of France, and in many special forms has been, and is, used by practically all countries. The De Bange system of breech mechanism, considered by the French as the original interrupted-screw system, does not take its name from the gas check.

The De Bange check consists of a mushroom-headed piece of steel with a shank passing through an axial hole in the breech-block. Between the rear face of the mushroom head and the nose of the block, surrounding the shank, are two steel disks or rings inclosing an "obturator pad" of asbestos and tallow within a canvas cover suitably shaped. Nuts screwed on the rear part of shank within the recess of the plug bind the parts together.

The pad and mushroom project beyond the screw box into the chamber, the front disk and pad bearing on a smooth-sloped surface of the gun chamber, called the *gas-check slot or slope*.

The action is as follows: On firing the gun, the powder gas acting on the front face of the mushroom forces it back, compressing the pad between the disks or rings against the breech plug. This causes the pad and the front disk or ring to expand radially and equally all around against the gas-check slope, sealing all escape of gas to the rear. This check is effective in large as well as in small guns, though it took many years to prove it practically. It is commonly supposed that the pad alone checks the escape of gas. This is erroneous. The front disk assists materially in checking the gas, the pad acting as a cushion, or buffer, to prevent the front disk from getting a permanent set which might result from the compression of the disk against a steel surface.

The advantages of this type are durability, certainty of action, easy adjustment, no great accuracy of fitting, and ease with which replaced. Some pads have stood a thousand rounds; all should stand two hundred.

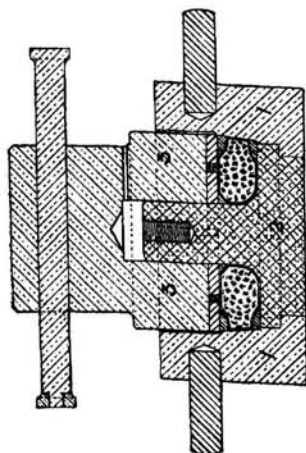
The canvas on the edges of the pad wears from the working

of the mechanism, but the cover can be replaced. It is better to put on a new cover instead of a patch.

24. Details of De Bange Gas Check.—The pad is composed of an "obturator cake" made of 65 parts of asbestos and 35 parts of pure mutton tallow contained in a linen canvas cover. The tallow is made from kidneys, tried out in pure water on a slow fire, skimming off impurities, and then straining through a muslin cloth. This operation is repeated. In making the cake the asbestos is pulverized, and the proper proportion of it and the tallow having been weighed out, the tallow is placed in a shallow pan and heated over a slow fire, or steam. The asbestos is slowly added and thoroughly mixed with a wooden spatula, and then the cake is allowed to cool. Its color is almost a dark gray. The proper amount of the mixture for the particular sized pad is now weighed out and rounded to the proper shape under a hydraulic press, called the "mould."

The *moulding apparatus* (Plate V) consists of (1) the mould, (2) the former, (3) the follower, as per figure and notation. The diameter of the mould's bore is that of the finished pad plus 0.01 inch clearance. The upper part of the "former's" flange and the spindle exactly reproduce the front gas-check disk, shank, and fillet, in the case of solid disks; where the front disk is a ring, a ring of the exact shape is let in a recess at the edge of the former's flange. The "follower" is a plunger recessed out to go over the stem of the "former," and neatly fits the mould.

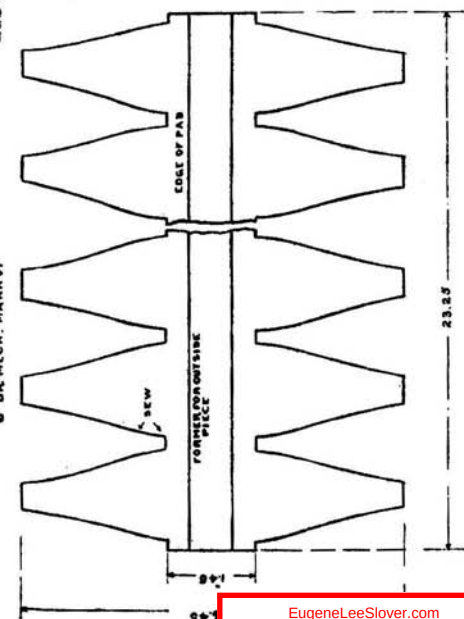
The Moulding.—The "former" being in place, a little powdered asbestos is sprinkled on the bottom, and then the warm cake mixture is put in and patted down equally all around. The rear gas-check disk is then placed over the mixture and the "follower" lowered down on top of the disk and the whole apparatus put on the table of the hydraulic press and subjected to pressure for 15 minutes to half an hour, until cool; the pressure (total) for the 6-inch is 50 tons, 8-inch 65 tons, 13-inch 75 tons, and others in proportion. The cake being moulded and its canvas cover placed on one side, with corners hauled over the opposite side and edges caught by stitches, is brought back to the press, and subjected to a pressure (total) of 100 tons for the 6-inch, 155 tons for the 8-inch, and 200 tons for the 13-inch. The pad is then taken out and



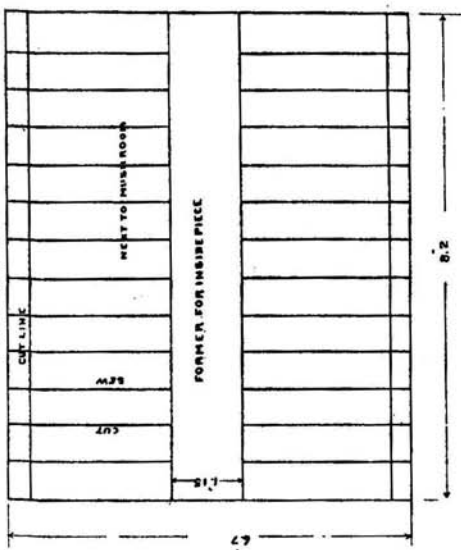
Gas check pad mould.

1-Mould
2-Former.
3-Follower.

GAS CHECK PAD FOR
6" BR. MECH. MARK VI



GAS CHECK PAD FOR
6" BR. MECH. MARK VI



MOULD AND FORMERS FOR GAS CHECK PAD.

sewed on the other side, brought back and again placed in the mould and subjected to a pressure of 50 tons for 6-inch, 65 tons for 8-inch, and 75 tons for 13-inch, when the pad is complete and ready for service. A bent blunt-pointed sail needle is used.

The *canvas cover* is made in two parts, as per figure, the canvas being cut on the bias, so that the stitch will be more uniform and the canvas less apt to pucker while making. The cover is made on a wooden disk the exact shape of the moulded cake. The ends of the long piece are sewed together, hauled over the disk, carefully centered and held by a few tacks driven in the rim of the disk. The points on one side are pulled tightly down and tacked. The short piece, ends having been sewed together, is placed in the hole of the disk and a wooden plug tapered like the mushroom shank fillet is driven in. The points of one side are brought down over those of the outer piece, held by tacks, and then the lapped edges sewed. The tacks are then removed and the cover is ready to receive the moulded cake for the first pressure.

The *disks* are made of special steel, and after being suitably shaped (see disks of gas checks in breech-mechanism drawings) as to the sides, are finely tempered. The edges, rims, or flanges are then carefully ground down to exact diameters or tapers. This is an important point in the manufacture.

All the early gas checks had solid front and rear disks, but the following is the rule at present: All 8-inch gas checks have a solid rear disk and a split front ring; all 10-inch, 12-inch, and 13-inch gas checks have the double split rings, that is, both the front and rear disks are split rings. A third ring is used in these cases around the inner end of the pad's hole for its protection and centering. It is called a "centering ring." None of the 10-inch and few of the early 12-inch gas checks up to July, 1899, were of the double-ring type, but those made after that date will be, new pads being used. In making the split ring, it is cut through broadside at an angle of 45 degrees before hardening; the ends are soldered and then it is finished to final dimensions and hardened, after which the joint is broken.

The *mushrooms* are made of special steel. Their shapes are shown in the different breech-mechanism plates. The vent is bored through the axis of all, and at the rear end of the vent the

primer seat is reamed out. The outer rear end of the shank has a round thread cut on it for attaching the "firing lock." Threads, right and left handed, on different diameters are also cut in the shank for the locking nuts. The diameter of the head is less than that for the chamber, being a loose mechanical fit therein.

A *frictionless washer* is placed between the locking nuts and a shoulder is left in the mushroom shank for all ordinary mechanism, in which the plug revolves about the shank in unlocking. The object is to reduce friction: In quick-fire guns the frictionless washer is omitted.

25. Adjustment of the De Bange Gas Check.—When properly adjusted the pad and front disk, or ring, should have a light bearing on the gas-check slope. The rear disk has no bearing. A play of about 0.005 inch is allowed; but if as much as 0.01 inch is used the pad's cover is liable to be cut by the sharp edges of the disk, in which case the filling would be blown out to the rear.

With the front disk solid, the locking nuts of the mushroom shank should be so set up as to leave a clearance forward of the plug's nose of about 0.03-inch to prevent the pad or front disk from sticking after firing. With the split ring this clearance is not so necessary.

The advantage claimed for split rings over solid disks is that the ring itself can expand more freely, assist in checking the gas, and avoid cutting the pad's cover. With the solid disk the edge may bear on the cover to some extent and possibly injure or cut the latter. The old style, however, has worked well. If the split ring be so made that in expanding it will be *circular*, it will assist more effectively in checking gas.

26. The Cartridge Case as a Gas Check (Plate IV, Fig. 4).—The metallic case used in rapid-fire guns forms a perfect gas check. The heat and pressure of the powder gas on firing expand the mouth of the case against the chamber and thus seal the escape of the gas to the rear. The mouth of the case should neatly fit in the chamber when pushed home, otherwise there may be a slight leak at first. The effectiveness of the cartridge case in checking gas and the fact that it seldom sticks, tend to show that some form of metallic gas check for quick-firing guns may be forthcoming.

When the shell is loaded into the case, the powder gas being confined, will swell the case before the shell leaves it. When the shell is separately loaded, a mouth cup, or heavy wad, is usually used to close the case, in order to confine the gas at first. This point has been fully demonstrated at the proving ground. The mouth cup also serves to retain the charge and protect it from moisture, etc.

27. The Cup Gas Check (Plate IV, Fig. 5) was fitted to the old howitzers. Though practically obsolete, it is mentioned in this connection because of the possibility that the great heat, pressure, and other conditions may in the future force a return to some form of metallic gas check.

28. Method of Operating Quick-acting Breech Mechanism.—The usual (it might be said universal) method is through the simple swing of a hand, or operating lever, through an arc usually less than 180 degrees. The lever is suitably connected to the breech plug by levers or gearing. This, of course, excludes special methods of machine and automatic guns, the rapid action of which, no matter how complicated the mechanism, entitles it to the name of quick-acting.

29. Designation or Names of Breech Mechanisms.—We have seen that there are three general systems used in connection with breech mechanisms: (a) System of breech plug, (b) system of operation, (c) system of gas check. There is still another that might be added—"the firing mechanism." As the latter two may differ in the same general make-up they are not considered. The name or designation may be given for either of the first two systems or both, or for one of their subdivisions. The general rule may be said to be: For all quick-acting breech mechanisms, the name is that of the inventor, to which may be appended whether rapid-fire, quick-fire, semi-automatic, automatic machine, etc., or simply the mark; for others, the system of breech-plug operation, followed by the particular mark, or simply the mark is given. The latter has been alluded to before. The former will follow thus: "Dashiell 4-inch rapid-fire breech mechanism, Mark III" or "Mark V," or simply "Mark III or Mark V breech mechanism, 4-inch;" "13-inch breech mechanism, Mark II," or "Mark II breech mechanism, 13-inch breech-loading rifle;" "12-inch

breech mechanism, Welin type," or "Mark VI breech mechanism, 12-inch breech-loading rifle."

30. The Names or Types of Quick-acting Breech Mechanisms in United States Navy.—(1) Hotchkiss rapid-fire, (2) Driggs-Schroeder rapid-fire, (3) Dashiell rapid-fire, (4) Fletcher rapid-fire, (5) Elswick or Armstrong rapid-fire, (6) Vickers quick-fire, (7) Maxim-Nordenfelt rapid-fire, (8) Nordenfelt rapid-fire, (9) Haeseler rapid-fire or quick-fire, (10) Lynch rapid-fire, (11) Maxim-Nordenfelt automatic, (12) Colt automatic, (13) Hotchkiss revolving cannon, (14) Gatling. In addition to the above there are now in use in the service a number of *semi*-automatic guns of the Hotchkiss, Maxim-Nordenfelt, and Driggs-Seabury types. The two latter are very similar.

Only two guns of the Lynch type have been manufactured. This system is similar to the Hotchkiss.

Of the above types Nos. 1, 2, 3, 4, 5, 6, 12 and 14 will be described in succeeding chapters. Nos. 8 and 9 are briefly described below.

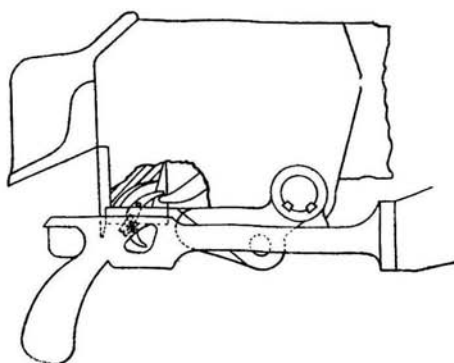
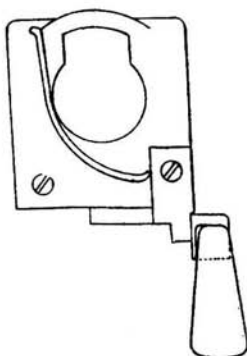
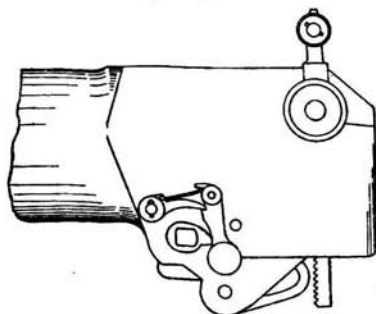
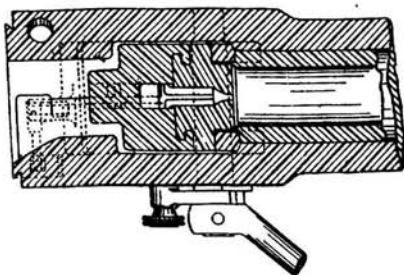
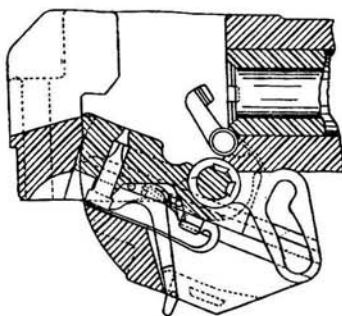
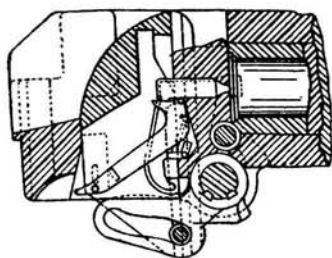
31. Nordenfelt Rapid-fire System of Operation (Plate VI).—The mechanism is made of steel, and consists of the following principal parts: Action lever, action cam, breechblock, wedge, extractor.

(a) The *action lever* has a vertical one-third circle motion from front to rear. It is one piece with the main axis.

(b) The *action cam* is connected to the main axis and has a slot, a part of which is concentric with the arc described by the action lever. On the rear upper part of the cam is a bearing corresponding to one on the under part of the trigger.

(c) The *breechblock* carries the firing pin, mainspring, and trigger. The firing pin has beveled projections or cocking lugs on its base for the wedge to act on, and on its under part is a lug by which the trigger retains it. The mainspring is flat, of great power and strength. The trigger pivots on its pins, and its motion is regulated by a safety lug, moving round a corresponding lug on the wedge. On the arm of the trigger are two lugs, one above and one below, the former is acted on by the wedge, the latter by the action cam.

(d) The *wedge* has a vertical motion in the breech. On its lower end is a pin which fits in the slot of the action cam.



NORDENFELT BREECH MECHANISM.

(e) The *extractor lever* is connected to the double extractor, working on both sides of the cartridge case. The tongue of the extractor lever abuts on the extractor cam lever, which is on the main axis.

Action of the Mechanism.—The action of the mechanism is as follows:

For opening—

First. The lever carries the action cam slot over the action pin in the part which is concentric to its own motion, and therefore no movement of the mechanism takes place.

Second. The part of the action-cam slot which is not concentric to its own motion now engages the action pin, forcing the wedge down, which, acting on the beveled firing-pin projections, forces it back and compresses the main or firing spring. When the firing-pin lug is clear of the trigger, the wedge bearing acts on the upper trigger lug, forces up the trigger, which catches and retains the firing pin.

Third. When the action pin has reached the end of the cam slot, the extractor lever begins to be forced back by its tongue, being met by the raised portion of the extractor-cam lever, and the empty cartridge case is thus slowly started. The action pin having reached the end of the action cam slot, the lever still moving back causes the breechblock to rotate and fall back to the rear, and at the latter part of this movement brings the tongue of the extractor-cam lever in contact with the extraction lever, and thus throws the empty cartridge case rapidly to the rear. The lever is now at its furthest position to the rear.

For closing—

First. The breechblock is brought up and carried forward, pushing a fresh cartridge into the barrel.

Second. The cartridge being quite home, the action-cam slot engages the action pin in the part of the slot which is not concentric, and forces the wedge up into position, the action pin then passes into the concentric portion of the action-cam slot.

Third. The forward motion of the lever continuing, the bearing on the action cam is brought into contact with the under lug on the trigger, pushing the trigger up, thus relieving the firing pin and firing the gun.

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The gun can not be fired before the breech is secured by the wedge:

First. As the inclined surface inside the wedge is formed in such a manner that the firing pin can not be made to strike the cap of the cartridge until the wedge is quite home and supported by the entire bearing surface. If the trigger is pulled before the breech is secured, the cocking lugs on the firing pin strike on the inclined surface of the wedge and the point can not strike the cap of the cartridge.

Second. The safety lug on the trigger is behind the corresponding lug on the wedge until the wedge is fully home, and consequently the sear nose of the trigger can not be forced to release the firing pin before the breech is secured.

32. The Haeseler Rapid-fire, or Quick-fire, System of Operation (Plate VII).—The spiral-threaded conical breechblock is recessed out in the rear portion. It bears on an axial stem which passes through a boss secured to the front face of the "carrier plate," by which the block is supported and on which the revolution takes place for locking and unlocking. On the outer surface of the carrier boss is a square thread (same pitch as the plug thread), which engages a female thread in a piece secured to the front end of the plug recess, so that when the plug revolves it is advanced or withdrawn to the point of engaging or disengaging the spiral threads of the plug and screw box. On the rear end of the plug's stem is keyed a pinion allowing a free longitudinal movement of the plug. The pinion works within a vertical slot in the carrier, and has no longitudinal movement. This "rotating pinion" is divided into two sections of unequal diameter; the smaller section has the larger diameter and is plain, while the larger has a periphery equal to the length of the rotation rack (about three-fourths circumference), on which are teeth. A transverse "rotating rack," having vertical teeth that engage those of the rotating pinion, slides right and left in a guide groove in the carrier beneath the center. The right end of this rack is connected to the hand lever by a horizontal link, with vertical axis. The operating lever is hinged to the right side of the carrier and has a vertical hand grasp on the left end. The carrier plate is hinged to the gun by a vertical hinge bolt.

The operation is as follows: The breech being closed, first, by pulling the hand lever to the rear, a stop bolt in the carrier is withdrawn from a longitudinal cut in the plug and screw box. (This is called "plug lock," and is designed to lock the plug to the screw box in the closed position, from any revolution.) Then the link pulls the rotating rack to the right, which results in revolving the plug to the unlocked position, at which movement the back of the lever brings up on the shoulder of the lug to which it is pivoted, the rotation is stopped, the center of motion is transferred to the carrier's hinge bolt, and both the plug and carrier swing out from the breech. The swing open is arrested by an extractor cam, rigidly fixed to the carrier, bringing up on the end of the extractor, which in the swinging open movement has been moved to the right until the edge of the extractor lock in the gun is reached. Then a lug on the extractor also brings up on the side of the gun, and is designed to relieve the extractor pin from the moment the plug is unlocked. A pin on its rear face is caught by a spring device, to prevent revolution of the plug in the carrier when out of the gun. The catch retaining the plug from rotation is not tripped until the carrier plate reaches the breech face.

The first movement of the plug to revolve, either for locking or unlocking the threads, is accomplished with great power, as the rotating rack works on the ends of the pinion's large diametrical section. The speed of revolution and amount of turn necessary to lock or unlock the plug's threads may be varied according to design.

CHAPTER V.

12-INCH BREECH MECHANISM MARK VI.

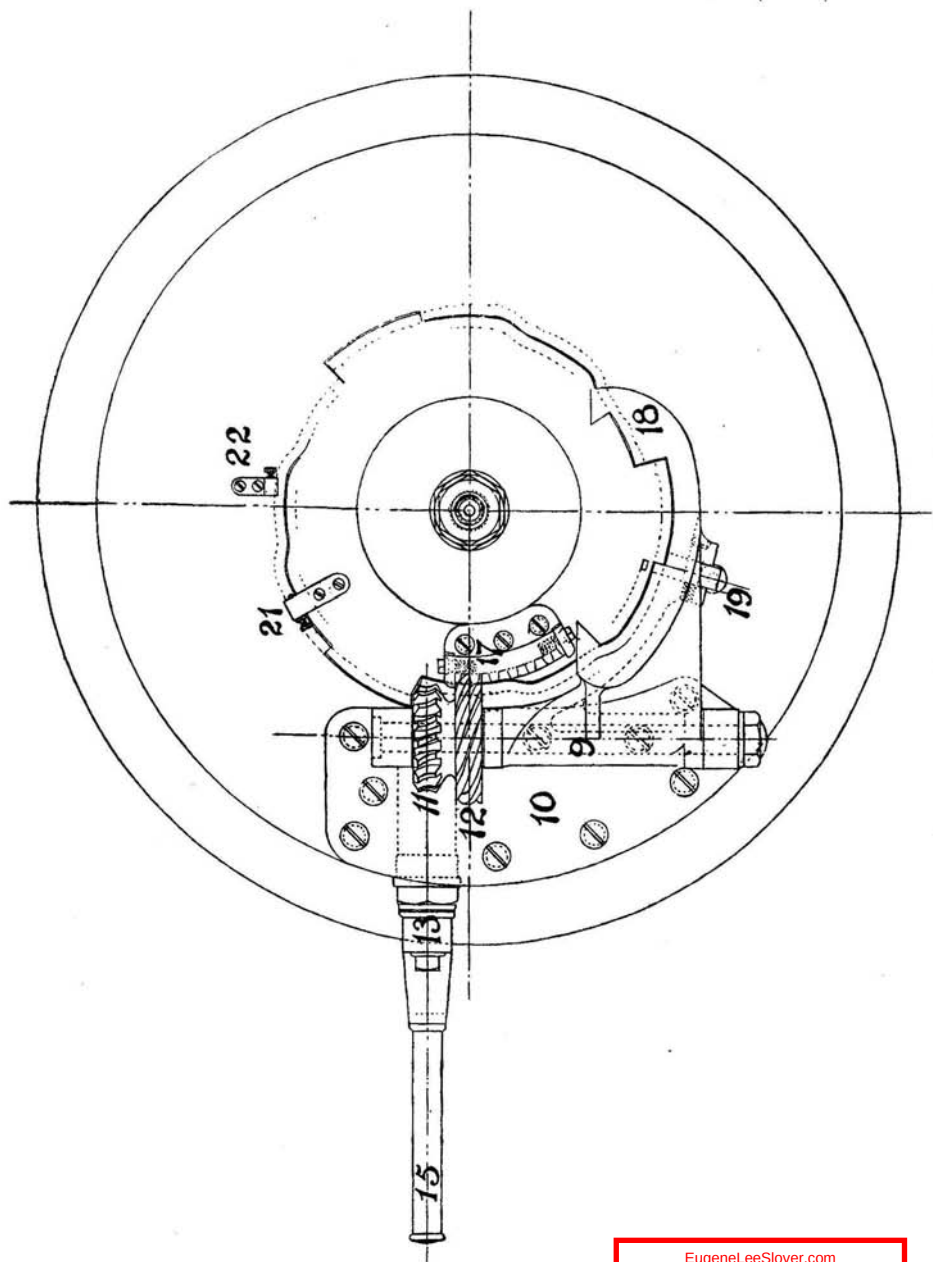
1. The Mark VI B. L. R. Breech Mechanism, known as the Vickers-Maxim mechanism, is fitted to the later high-powered guns of 8-inch, 10-inch and 12-inch calibres.

The *breechblock* (1) is of the "Welin" type, and, for the 12-inch mechanism, which is the size shown in the plates, the screw box and block are each divided into three sections; each section is divided into four steps, three of which are threaded cylindrical surfaces and the fourth a blank, thus giving the block a holding surface comprising three-fourths of its circumference. By using this, the Welin patent, a much shorter block may be used, giving greater ease of manipulation and requiring less weight both of gun and of breech mechanism. The De Bange gas check (2), with front (3) and rear (4) split rings, is used as previously described. The primer seat is in the rear end of the mushroom stem (6) on which is screwed the firing lock. The vent, or orifice through which the flame of the primer discharge reaches the powder, is through an axial hole in the mushroom stem. The mushroom (5) with gas-checking pad and rings is secured to the block by the locking nuts (7) screwed on the mushroom stem; since, during the process of locking and unlocking, the block is revolved about the mushroom stem, a ball-bearing washer (8) is inserted to reduce friction. Plates I, II and III show the block (in its unlocked position) in rear elevation, side elevation and in horizontal cross section, respectively.

2. The Operating Gear is of the system known as the "Improved Farçot Gear," which is in all the essentials the same as the "Modified Farçot"; the latter differs principally in having its hinge pin turn *with* the spiral pinion. The name *Farçot* is from the inventor; Lt.-Comdr. F. F. Fletcher worked out and adapted it to the U. S. naval guns, and it is sometimes called

the "Fletcher system." Obviously with a breechblock of large size there must be three steps in the operation while closing or while opening; (a) *rotation* about the axis which locks or unlocks the threads of the block and the threads of the screw box; (b) *translation* along the axis of the bore of the gun between the positions of locking and of swinging; (c) *swinging*, by which the block is swung on a vertical hinge into or out of the line of the bore. In this system of operating gear, the three steps are accomplished in either direction by the continuous rotation of one crank, other movements being automatic; seven turns of the crank suffice to operate a 12-inch mechanism, which is a near approach to "quick" acting.

The operation in *opening* the breech is as follows: A vertical shaft (9), also acting as a plug-tray hinge pin, is journaled in a lug on a hinge plate (10) bolted to one side of the gun's breech face; the shaft itself carries on its upper end a worm wheel (11), and, on its central part in a horizontal plane through the gun's axis, a spiral pinion (12) with teeth inclined 20 degrees to the horizontal. A horizontal crank shaft (13) is journaled in the upper end of the hinge plate, or partly in the gun, or entirely in the gun if there is no hinge plate. It has a worm (14) that engages the worm wheel, and is actuated by a crank (15) on the outer end. Turning the crank will thus turn the vertical shaft and the spiral pinion. There is a system of spiral teeth, also inclined 20 degrees, cut on a rack, part of which is longitudinal (16), dovetailed and recessed in lengthwise to the plug, and part circumferential (17), or "fan-shaped," generally extending to the rear of the plug and secured to the rear face thereof. The spiral pinion engages this rack helix. On turning the crank, if the plug be locked, the spiral pinion engaging the circumferential or segmental rack will revolve the plug to unlock the threaded sections, and when this is accomplished the rotation is stopped by a suitable stop plate secured to the segment. The continued movement of the crank will now cause the pinion to act on the longitudinal part of the rack (rotation being prevented by edge of recess), and withdraw the plug onto the tray (18). When the plug is completely withdrawn, the tray latch (19) is automatically released, at the same time locking the pulg on the tray, the movement of



MARK VI MECHANISM FOR 12-INCH GUNS.

translation is changed to swinging, and the plug and tray swing out clear of the breech about the vertical shaft, until brought up by the stop (20). The tray latch performs the double duty of holding the tray to the face of the breech while the mechanism is closed and, at the proper time, releasing it and locking the block to the tray. In *closing* the breech all the steps are carried out in the reverse order.

3. The breech mechanisms of earlier B. L. R's. are in most respects similar to the above except that the French interrupted screw or "ordinary" breechblock is used. The block is made to swing either way and in turret guns it always swings away from the center of the turret. Plate IV shows the breech mechanism of a 12-inch British naval gun in the closed and open positions. The block is also of the Welin type but the operating gear is considerably different from the one described above.

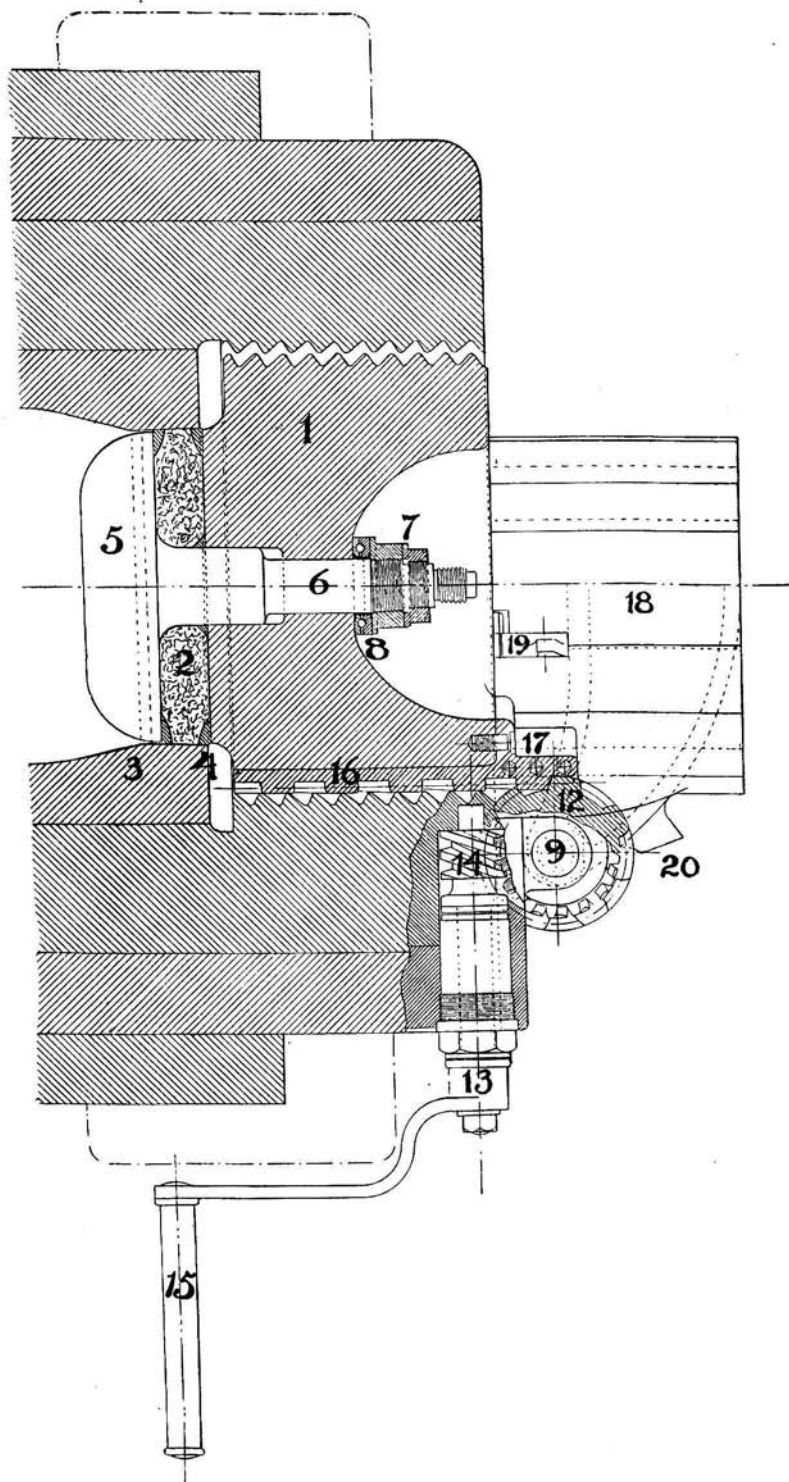
4. **The Mark VIII Firing Lock** (Plate V).—"Combination" primers, which explode either by percussion or by an electric current, are now used in all B. L. R's. and the Mark VIII lock has been designed to work in either manner without requiring changes or adjustments of any of its parts; the lock is in itself a breech mechanism of the sliding-wedge type. In the plate, Figs. 1, 2 and 3 are longitudinal sections, Figs. 4 and 5 are cross sections and Fig. 6 is a rear elevation; the lock is shown in its closed position with hammer down. A recent improvement, which precludes the possibility of the wedge being jarred open, has been given the title Mark VIII A, but it involves only a slight modification of the hammer stem.

The *receiver* (1), or main body of the lock, is screwed on the rear end of the mushroom stem and is secured by the spring locking catch (28) which enters a square slot in the stem; the primer is supported in its seat in the mushroom stem by the wedge (2) which closes behind it and is worked up or down to its closed or open position by twisting the hammer stem (6). Surrounding this stem and secured to it by a feather is a gear wheel (31) that connects through the idle gear (32) with a vertical rack on the left side of the wedge, by which the latter is operated. The friction pin (3), being pressed against the wedge by a spiral spring, drops into a recess and aids in holding the lock closed. The ex-

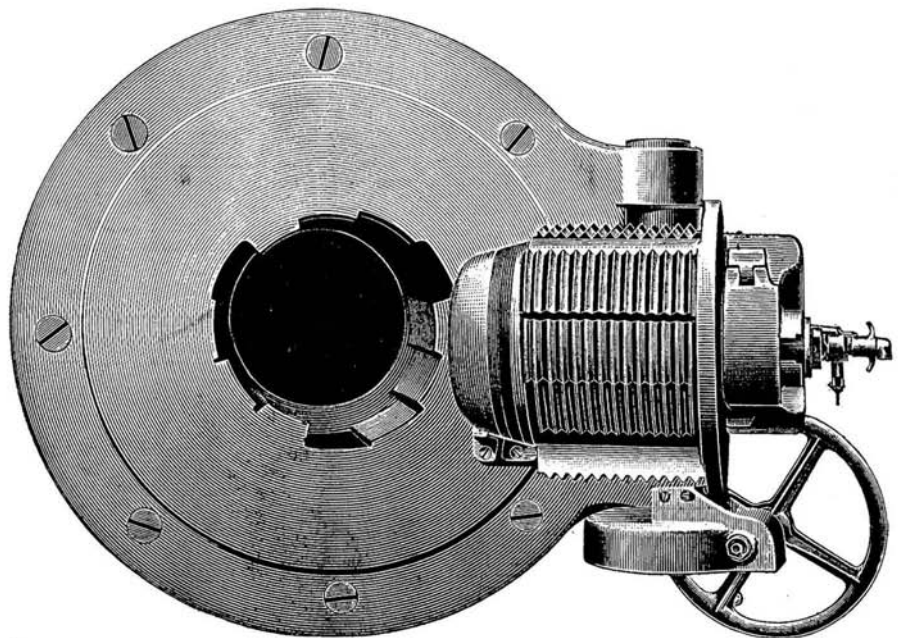
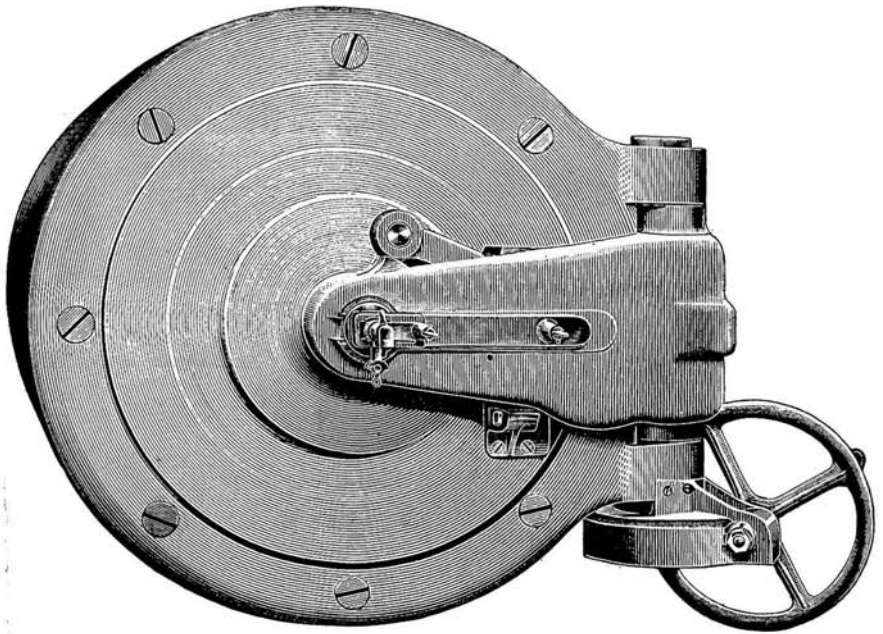
tractor (18) is normally held against the stem by its spring (19); when the wedge moves downward, the pawl (26) strikes the lower end of the extractor and ejects the primer case, after which the pawl slips by and the extractor is snapped back into place by its spring. In a recess in the wedge is placed the insulated firing pin (14) with its point resting against the primer and affording at its rear end a contact point for the hammer; the spring (37) exerts its force to hold the pin *away* from the primer.

The *hammer* (5) is mounted on the hammer stem (6), which turns in and moves back and forth in a tube cut in the left side of the receiver. When firing by percussion, the hammer, after closing the wedge, is drawn to the rear, compressing the firing spring (25) until the point of the sear (24) catches in a notch at about the middle point of the stem and holds the hammer in the cocked position. The firing lanyard is hooked to the trigger (21); no spring, other than the sear itself, is used in the sear and trigger device. The wedge cannot be operated when the hammer is cocked. When firing by electricity, the hammer is left in the position shown, after closing the wedge, thus establishing an electric connection from the contact lug (21) (Plate I), through the contact pieces (8 and 9) and the firing pin, to the primer. The sleeves of insulation (10, 11 and 17) are made of vulcanite.

A short wire makes the connection between the binding post (12) and the contact lug (21). To the other lug (22) is connected the electric firing wire; the two lugs touch and complete the circuit only when the breechblock is fully closed, and the only break in the circuit is then at the firing key. Premature firing by electricity is therefore impossible, but if the primer is put in place and the hammer cocked when the breech is open there is danger of premature discharge; for this reason, while firing by percussion at least, the gun should be primed and the hammer cocked only after the breechblock is entirely locked. Obviously this is a safe practice even when firing electrically (because of the percussion feature of the primer), and is the plan followed at present.



MARK VI BREECH MECHANISM FOR 10 INCH GUN



BREECH MECHANISM FOR 12-INCH BRITISH NAVAL GUN

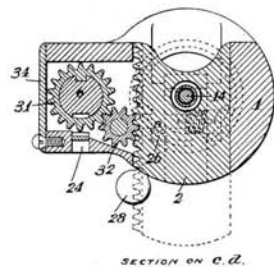


Fig. 4.

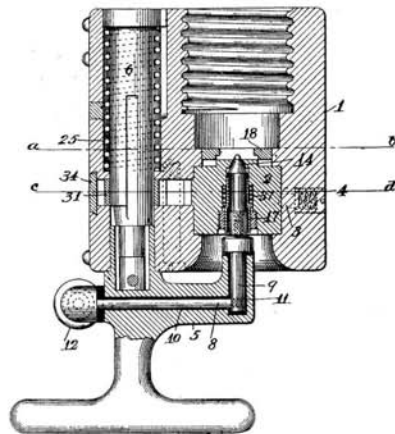


Fig. 1.

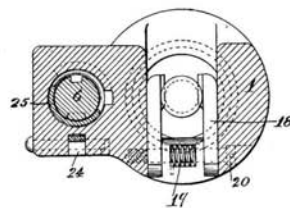


Fig. 5.

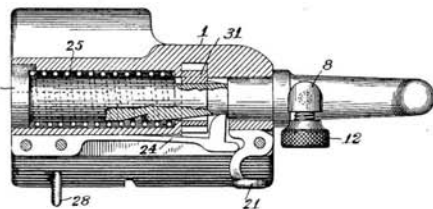


Fig. 3.

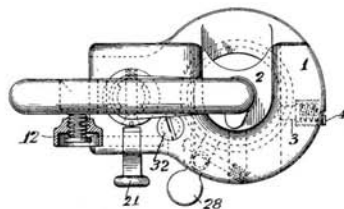


Fig. 6.

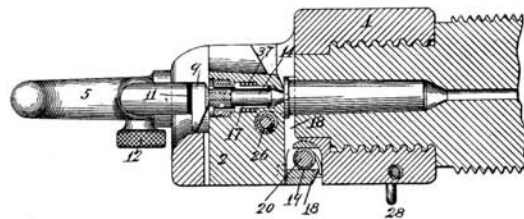


Fig. 2.

THE MARK VIII FIRING LOCK.

CHAPTER VI.

BREECH MECHANISMS FOR QUICK-FIRING GUNS.

1. The high-powered Q. F. guns at present in use or being constructed for naval purposes are of 5, 6 and 7-inch calibres; the latter being a new size. The first modern 5 and 6-inch naval guns built were also loaded separately with powder charges in bags and were fitted with the De Bange gas check, but they had slow-acting operating mechanisms; brown powder was used which necessitated considerable cleaning between rounds, and the guns were essentially "slow-firing"; (they are now as rapidly as possible being converted to R. F. guns). The "ordinary" or slow-firing guns, often called B. L. Rs., were succeeded by rapid-firing guns with a quick-acting system of operation; the 6-inch gun was still separately loaded but its powder charge and primer were put up in a cartridge case.

Cartridge cases form perfect gas checks and permit the use of any kind of powder without requiring any cleaning whatever between rounds, but, for large calibres, serious disadvantages attend their use: (a) They sometimes stick in loading or in extracting; (b) they involve an increase in the loading interval by the time consumed in removing the empty case; (c) after prolonged firing the empty cases will encumber the deck unless certain men are to be occupied in otherwise disposing of them; (d) when all the ammunition carried is considered, their weight is great; and (e) they are expensive and soon wear out. The adoption of a smokeless powder, which leaves no residue of combustion in the gun, has made it possible to discard cartridge cases and return to the former method of loading the powder charge separately in a bag,—placing the primer in the breechblock. Since a quick-acting system of operation was retained, the change has resulted in no increase in the firing interval; 6-inch Q. F. guns have fired eleven aimed shots per minute in target practice, and the disadvantages of using cartridge cases have been eliminated.

2. The quick-firing mechanisms, which are the 5-inch Mark IV, the 6-inch Mark VI and the 7-inch Mark I, differ only in minor respects. A 5-inch mechanism is shown in its closed position in Plates I and II. In Plate I, Fig. 1 and Fig. 2 show rear and horizontal profiles of the mechanism, Figs. 3 and 4 show the connection of the firing wire, and there are enlarged detached views of some of the working parts. In Plate II, Fig. 1 shows a vertical longitudinal section of the mechanism; Figs. 2, 3, 4 and 5 are views of the firing lock, being respectively a rear elevation, a horizontal section, a vertical longitudinal section, and a vertical section through the hammer stem.

The mechanism has the Welin breechblock, operated on the Vickers' system, fitted with a service designed firing lock. The principal parts of the mechanism are: The breechblock with mushroom and gas check; the carrier; the operating lever and pinion with rotating arm and rotating link; the loading tray, and the firing lock.

It is to be noted that: (a) The screw box is cut in a ring of metal (A) which screws into the jacket, abutting against the rear face of the tube, and is secured from turning by sunken screws; (b) the opening or closing of the breech involves only two steps, viz., *rotation* and *swinging*, there being no *translation*; to enable the block to swing directly in or out of place on the carrier hinge pin, the blanks of the block and screw box and, to a slight degree, the threads, are sloped away, forming curved surfaces which have the hinge pin as a center; (c) a loading tray is attached to the breech of the gun and is worked automatically by the operating gear; (d) the gun uses "combination" primers and no change or substitution is required in the firing lock when changing the method of firing; the lock is opened, closed, and the primer case ejected, automatically.

3. **The Breechblock** (1), of the Welin type, is divided circumferentially into three sections each of which are in turn divided into three steps. The lowest step, or one of least radius is left blank (3) and on the other two are cut screw threads (2) of slight pitch; a narrow gap is left between the steps for convenience in manufacture. On the rear end of the block is left a narrow collar which is of about the same radius as the highest step and is of

the same pitch as the threads of the block; it brings up against the rear thread of the screw box as the block swings into place. A circular recess is cut in the right lower edge of the block (between the blank and the thread) into which the locking-plunger is forced. The block is bored through longitudinally, forming a recess through which the mushroom stem (6) passes; the latter is in turn bored through, forming the primer seat and vent (10). The gas check, of the De Bange type with front split ring (8) and rear disk (9), is compressed between the front face of the block and the mushroom head (5). The latter is secured to the block by a nut (6a) on its stem; the spring (6b) is held between the nut and a bearing surface on the block in such a manner as to compress the gas-check pad; the compression is regulated by the amount the nut is set-up. The rear-most portion of the plug is still more cut away around the mushroom stem to receive the boss (15) of the carrier; the recess runs well into the block and has chased on its surface an interrupted thread (with two blanks), of square section which has the same pitch as have the threads of block and screw box. Four collars of square section but without pitch, also interrupted, are cut on the rear end of the mushroom stem upon which the firing lock is secured. The rotating stud (23) is screwed into the rear face of the block.

4. The Carrier (12), a brass L-shaped arm cored for lightness, is hinged to the lug (11) by the vertical hinge pin (14). It contains a slot in its right lower portion in which the operating-lever and pinion are pivoted on the vertical hexagonal bolt (19); also a recess in which the rotating arm (21) works on a horizontal pivot. Above and a little to the left is situated the locking plunger (13) which is pressed forward by a spiral spring, its motion being limited by a stop screw. From the forward side of the carrier, a boss (15) projects forward, to which the block is secured by an interrupted screw thread as described above. The boss is bored out to permit the mushroom stem to extend to the rear for the attachment of the firing lock.

5. The Operating Gear includes: the lever (16) and the rotating pinion (20) rigidly connected to each other by their hexagonal hinge pin (19) and working in the horizontal plane; and the rotating arm (21) and rotating link (22), which work in the vertical plane.

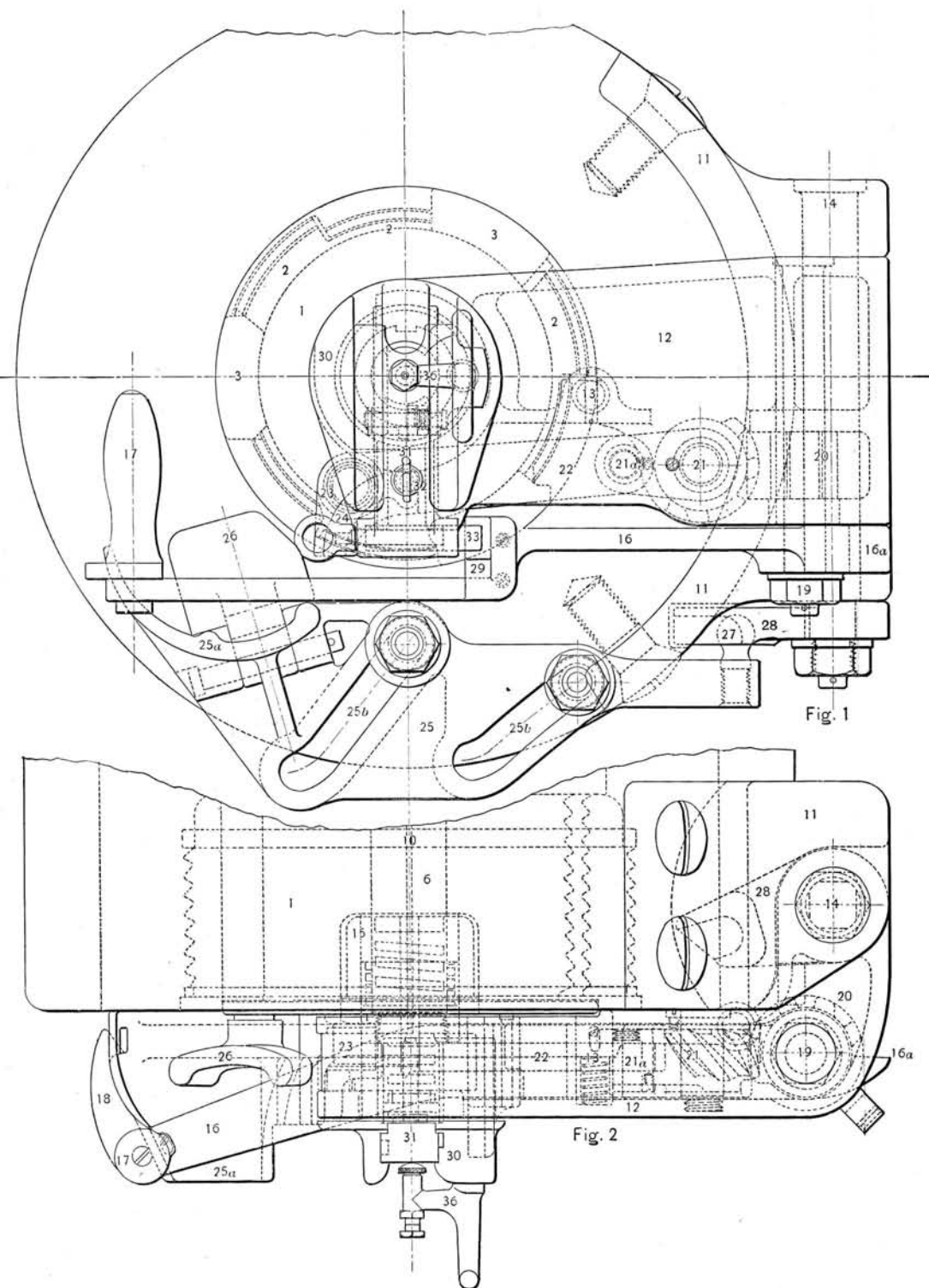
The *lever* (16) is a long steel bar, having at its left end the handle (17), within which is a spiral spring that actuates the lever lock (18) to secure the lever to the loading tray, as shown by the plates. The lever arm curves sharply at about its middle point, forming a cam groove (29) whose function lies in operating the firing lock. The *rotating pinion* (20), working on the same pivot with the lever and above it, has 45° "skew" teeth cut around the greater part of its periphery.

The *rotating arm* (21), working on a horizontal pivot, has, on its right and lower sides, "skew" teeth which gear with those of the pinion (20); its left side is drawn out into an arm two inches in length. The *rotating link* (22), entirely unattached to the carrier, is hinged to (21) by the horizontal pin (21a) and has in its left end a socket which receives the rotating lug (23). There is also a cam groove (24) in the rear face of the link which, with the cam groove (29), operates the firing lock.

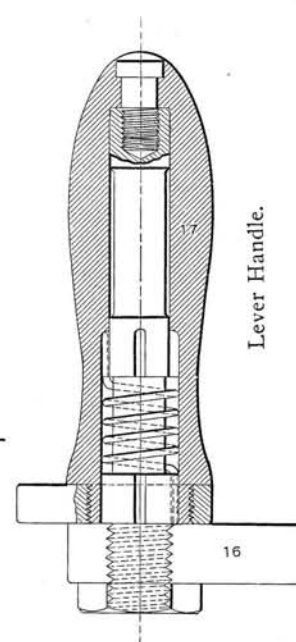
6. The Loading Tray (25) is an irregularly shaped brass casting held to the lower part of the face of the breech by two bolts working in curved slots (25b). The tray proper (25a) is at the left side of the casting—when the breech is opened it lies on a level with the bottom of the gas-check seat. The hinged lip (26) drops down, when the projectile is inserted, to protect the screw box, and automatically hinges itself up when the tray is lowered. In the left edge of (25a) is cut a notch over which the lever lock hooks. The *loading-tray lever* (28), fitting over a square section on the lower end of the hinge pin, and turning with it, has in its end a recess which engages the stud (27) of the loading tray.

7. The Operation of the mechanism, not considering the firing lock, comprises only *rotation* and *swinging*, and is performed as follows: To *open*:

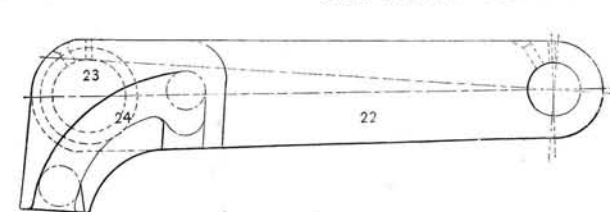
The handle of the operating lever is grasped and turned to the left, releasing the lever lock, and the lever is then swung to the right until the carrier strikes against the hinge lug (11), bringing the face of the block about parallel with the axis of the bore. *Unlocking*: As the lever is swung to the right, the pinion (20) turns with it and, gearing with the teeth on the hub of (21), throws the left end of the arm downward; this draws the link (22) and consequently the lug (23) to the right and the block is rotated



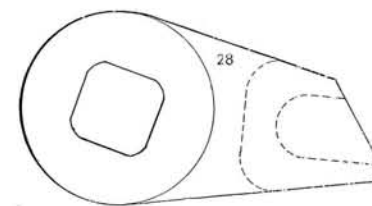
5-INCH Q. F. BREECH MECHANISM. MARK IV.



Lever Handle.



Rotating Link.



Loading Tray Lever.

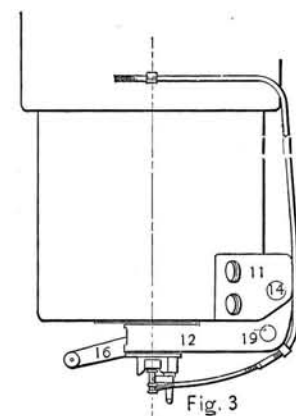
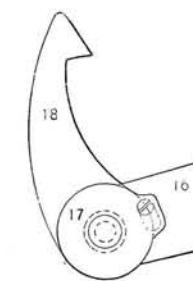


Fig. 3



Lever Lock.

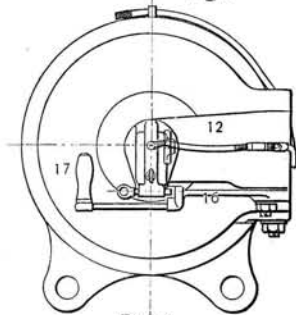
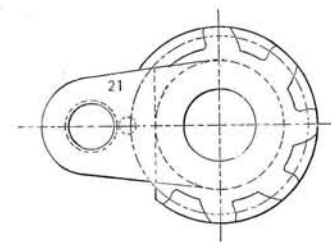


Fig. 4



Rotating Arm.

against the hands of a watch. This motion continues until the lug (16a) brings up against the carrier and the unlocking is completed. *Swinging*: The center of motion now changes to the hinge pin (14) and the block swings out of the gun on its carrier; when the latter leaves the face of the breech the locking plunger (13) springs forward into a recess in the rear edge of the block and holds it securely from further rotation while the breech is open. As soon as the block is clear of the gun, the loading-tray lever (28) engages the lug (27) and pulls it to the right; the motion of the tray being constrained by the shape of the slots (25b), it also rises, as well as moving to the right, so that, when the bottoms of the slots (25b) strike the bolts, the tray is in position for loading.

To *close*: *Swinging*. The lever being swung to the left, the loading tray is first moved down out of the way by the lever (28) before the block gets to it. At the end of the swinging movement, the rear thread of the plug strikes the rear screw-box thread, the locking plunger is forced rearward out of its recess in the block, leaving the latter free to begin—*locking*. The motion of the lever being continued on (19) as a center until it lies against the carrier and locks itself to (25a), the operating gear acts in the reverse direction to rotate the block to its locked position.

8. The Firing Lock employed on Q. F. guns, known as the Mark IX Lock, is adapted for combination primers to be fired either by electricity or by percussion; it is intended that, as far as possible, all firing be by electricity and that percussion firing be regarded as an alternative. The Mark IX lock (see Plate II) is in principle very similar to the Mark VIII lock for B. L. Rs., described in the preceding chapter, though it is greatly different in external appearance; it is, however, operated automatically instead of by hand and it is principally in this feature that the two locks differ from each other.

The receiver (30) is secured to the mushroom stem by interrupted collars, and its rear portion is larger than that of the Mark VIII lock—to accommodate a longer wedge. The wedge (31) extends well below the center of the breechblock and has in its lower portion the pin (32), which engages the cam groove (24) of the rotating link, and the pin (33) which engages the groove (29) of the operating lever. Both of these pins are held

against their cammed surfaces by spiral springs, as shown in the plate, and are so fitted that they may be retracted against their springs and turned until lugs (32a and 33a) enter grooves (31a) in the wedge by which they will be held out of action; the lock must then be operated by hand. In other respects, the wedge with its firing pin (35), extractor (34), friction pin, etc., is like that of the Mark VIII lock. The hammer (36), firing spring, sear (37), trigger (38), gear wheel and idle gear are also unchanged. The firing wire is attached to the hammer, as is shown on Plate I, Figs. 3 and 4, and the actual firing, whether by electricity or by percussion, is effected exactly as with the Mark VIII lock; the *firing* is not automatic—only the opening and closing of the lock and the ejection of the primer case.

Operation: (a) When the pins (32 and 33) are drawn in, out of action, the lock is operated by twisting the hammer to the right or left, while it is lowered. This may be done when the breech is closed or opened and the lock is to be operated in this way if it be desired to prime, re-prime after a miss-fire, or to remove the primer, *while the breech remains closed*.

(b) If the pins (32 and 33) be put in action, as is intended, the lock will be actuated automatically, as follows: Suppose the breech closed and the gun fired. As the lever is brought to the rear the cam groove (29) forces the pin (33) downward slightly, sufficiently to revolve the hammer a little, breaking the connection, but not enough to wholly open the wedge. The rotating link, moving to the right, brings (32) downward, by the action of the cam groove (24), and the wedge is lowered to its full travel and the primer sharply ejected. While the loading is being performed a new primer is placed in the lock. During the first part of the *locking* the link (22) acts in the reverse manner and partially closes the wedge, but its cam groove has not great enough travel to entirely finish the closing. However, just as the locking of the breechblock is completed and as the lever nears the end of its swing, the cam groove (29) strikes (33) sharply, closes the wedge and turns the hammer to its closed position, making the connection, and the gun is made ready for firing electrically. If it now be desired, or be necessary, to fire by percussion, the lanyard is hooked to the trigger and the hammer cocked.

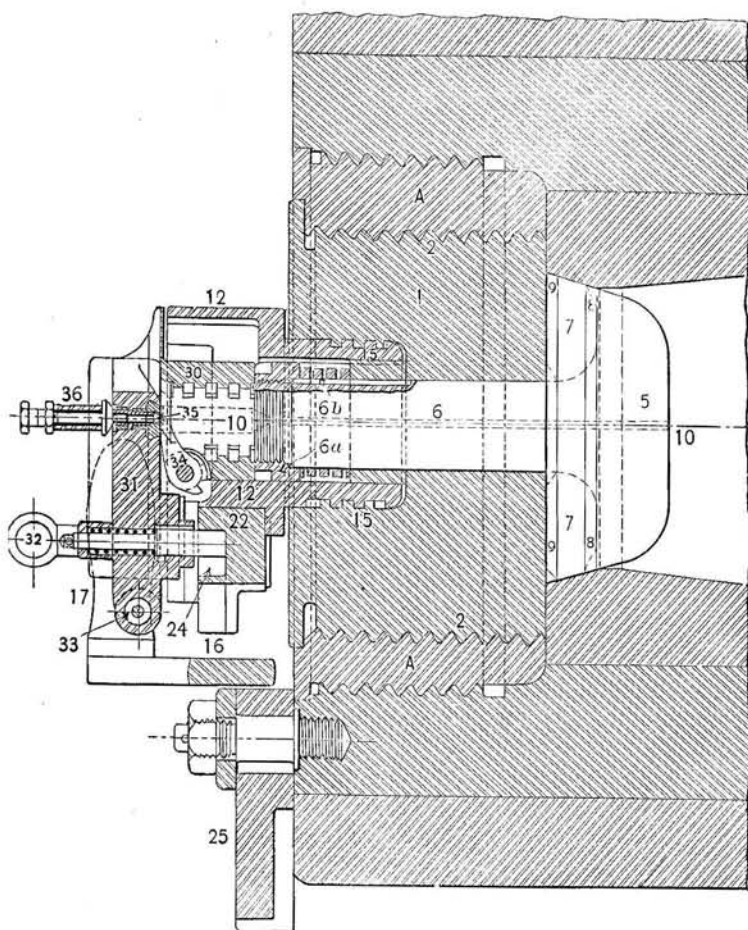


Fig. 1.

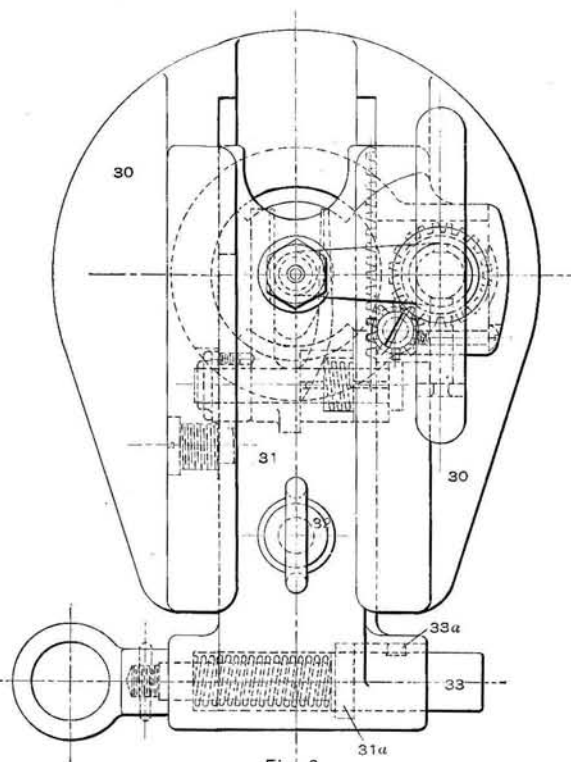


Fig. 2

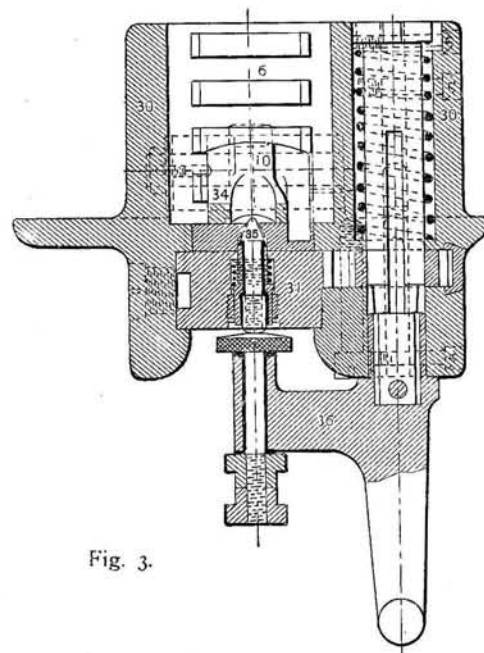


Fig. 3.

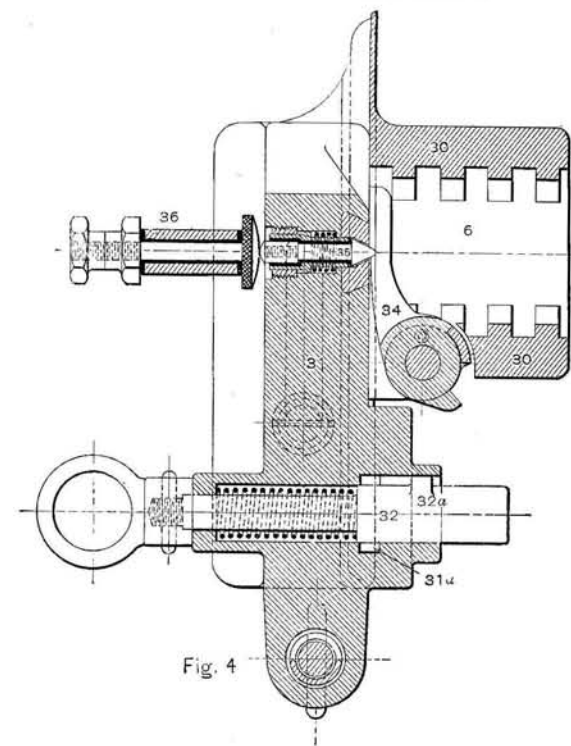


Fig. 4

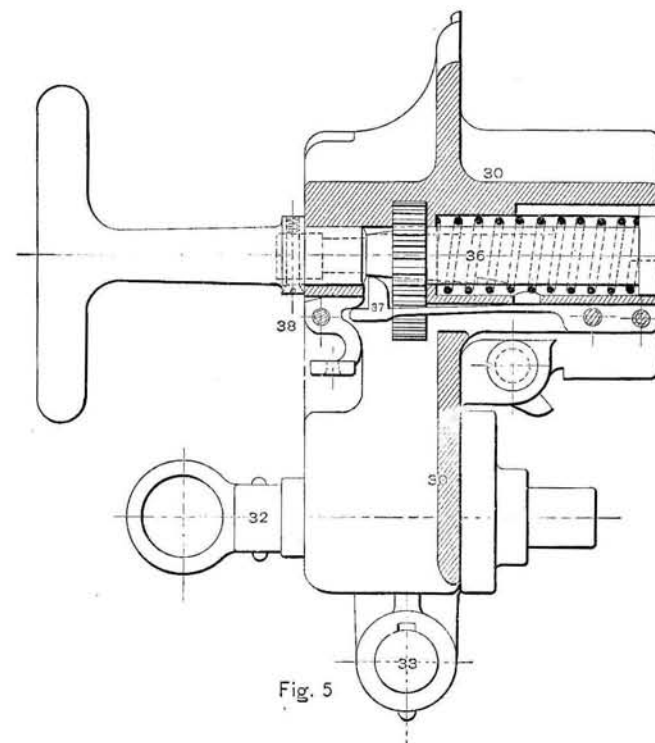


Fig. 5

VERTICAL SECTION OF BREECHBLOCK AND THE MARK IX FIRING LOCK [ENLARGED].

9. Safety.—The breechblock will not open when the gun is fired or at extreme elevation because: (a) No external force can so act on the block as to make the operating-gear work backward; (b) the lever lock prevents the operating lever from swinging open unless its handle has first been twisted to the left.

The gun cannot be fired prematurely, because: (a) The firing point is not in contact with the primer, or (b) the hammer with the firing pin, and (c) the hammer cannot be cocked, until the breech-lock is locked—as long as the lock is being worked automatically.

10. The 6-inch Q. F. mechanism is, with the exception of one or two minor details, the same as the above.

The 7-inch Q. F. mechanism is also similar except that the carrier, extending farther to the left, overlaps the block and engages a locking device on the left face of the breech, designed to secure the carrier to the gun while the block is swung into the screw box.

CHAPTER VII.

THE DASHIELL BREECH MECHANISM.

1. **The Dashiell R. F. Breech Mechanism**, named from its inventor, Lieut. R. B. Dashiell, U. S. N., belongs to the "interrupted-Screw system," and its distinctive features (barring the firing mechanism) lie in the method of operating the plug and in the extractor. The plug is supported when withdrawn from the screw box in a combined collar and tray, hinged to the gun, provided with an automatic tray latch similar to other service types. All the operating mechanism is carried on the tray casting, except the trigger, which is on the gun. The extractor is carried by the plug.

2. This type of mechanism is fitted to one 6-inch gun, 86 5-inch guns and 164 4-inch guns, and is for 5-inch guns the Mark II mechanism and for 4-inch guns the Mark III mechanism; a special firing mechanism is required for each of two varieties of primers used.

The plug (1) and screw box have four blank and four threaded sections (left-hand threads); the rear thread of the plug extends across the top blank in the locked position and acts as a stop, while pushing the plug into the screw box, by bringing up on the first screw-box thread. The following are the principal parts: Plug and face plate; combined collar and tray; tray latch and spring; hinge pin; rotating rack; translating arm and pin; operating lever and fulcrum pin; extractor and spring; firing mechanism—all made of steel. The plates show the block, in its closed position, with percussion firing mechanism; the electric mechanism is shown in a detached view.

3. **The Breech Plug** (1), threaded and slotted as above, has on its rear end a circular projection with an "undercut score" (9) for the upturned toe (44) of the translating arm. The upper and lower sections of the screw box are blanks, hence the bottom sec-

tion of the plug, in the unlocked position, is threaded. This section has a fore and aft groove cut through its center, to pass over the center tooth of the rotating rack (45).

There is a rectangular longitudinal hole (8) through the plug on the right side (in the closed position) for the extractor, a hole and dovetail (10) on the left side of the plug in the transverse horizontal plane for the sear, and a slot in the vertical plane for the cocking lever. In the axis of the plug is a longitudinal circular hole (7) for the firing pin. To the rear face of the plug is secured by screws a ring called the face plate (2), on the lower side of which, in the unlocked position, are a set of teeth (3) (to engage the rotating rack), a latch-trip toe, and a curved bearing surface on the right side to rest on the side of the tray. When on the tray the space between the left two teeth works on the guide rib (22) of the tray. To the upper rear face of the plug is secured a bracket (53) for the cocking lever.

The firing-pin hole is closed at the rear end by a nut called a "firing-pin guard" (55). This nut is threaded to screw in the plug, and on later mechanisms the screw is slotted so as to require only a quarter turn to put in place; a keep screw prevents turning. A hole is cut through the guard on the left side for the sear and a slot, for the cocking lever, in the top.

4. The Combined Collar and Tray (20) is in one casting, having on the right side two lugs (23) by which it is hinged to the gun; it supports the plug and all parts not on the gun and swings the whole clear of the breech for loading. The tray is provided on the underside with a lug (27) to carry the tray latch; on the upper left side with a guide rib (22); with a curved bearing surface on the right side to guide and support the plug; with a transverse groove (24) for the rotating rack, and with a vertical square hole near the rear end for the latch-trip toe (25).

On its right side the tray is hollowed out to admit the cogged arc of the operating lever; there is a vertical hole near the hinge, threaded on the bottom for the translating-arm pin (43), and a curved hole (29) in its bottom plate for the fulcrum pin, struck with a radius having the former pin as a center. On the upper rear face of the collar is a projection containing the cocking groove (21), the groove being undercut and closed at the top.

The two hinge lugs (23) fit over a hinge loop milled out on the right side of the gun; a vertical hole (30) being drilled through in which fits the hinge pin (32). Some of the early mechanisms had a set screw through the hinge loop which entered a recess in the pin to prevent the latter from lifting. In the closed position of the plug the center of the hinge pin, translating-arm pin, and the fulcrum pin are in a line parallel with the gun's axis,—one to the rear of the other in the above order. The right lower end of the tray projects beyond the gun and the transverse slot for the rotating rack (24) extends to the end. The lower lip or plate of this extension is joined to the tray proper and contains the curved slot for the fulcrum pin above mentioned.

5. The Tray Latch (33) is "automatic," being the pioneer of such types on United States Navy mechanisms. It is fitted to the Mark III 4-inch and Mark II 5-inch guns, as follows: The latch, pivoted on its pin (35) carried by the split lug (27) on the underside of the tray, is provided on the front end with a lever toe called the "latch catch" (33b) to engage the hook or tray catch (80) in the gun, and an upper toe or latch lock (33a) to rise in front of the plug when on the tray and prevent forward movement; and in the right lower side with a square shoulder that is engaged by the latch-lock bolt (36). On the rear end it has a hand trip (33d), and a vertical toe called the "latch trip" (33c) to be acted upon by a toe on the face plate in opening, to trip the latch. A flat spring (34) is secured by two screws to the underside of the tray, in the latch slot of the lug, the front end of which bears down on the front arm of the latch.

In the tray, at the front end on the right side of the latch, is a spiral spring surrounding a plunger (36) called "latch-lock bolt." It is provided with a small arm on the left side to secure the latch from any movement while the tray is clear of the gun, so that the plug cannot be started off by swinging over the latch lock against the tray latch spring.

6. The Operating Gear.—This consists of the rotating rack (45), translating arm (42), and hand lever (37). A rotating-rack stud (79) is screwed into the breech face of the gun to limit the movement of the rack in the operation of unlocking the plug.

7. The Extractor (75) is a flat bar, finishing at each end with

a hook or shoulder that passes through a fore and aft hole (8) in the plug, clear of the threaded parts, and is held down by a flat spring (76) on its back, bearing against one side of the hole.

The nib (75a) or front end of the extractor is broadened and suitably shaped to fit the rim of the cartridge case. A shoulder on the outer face at the forward end bears against a lug secured to the front face of the plug, when the extractor is in its forward or pulling position, so that slipping off the rim of the case is prevented; but in closing the extractor slides back to its rear position, when the nib can snap over the case's rim. An extractor-keeper screw (78) is provided, which passes through a threaded hole in the face plate and bears the rear end of the extractor toward the center to prevent the rear shoulder (75b) from ever sliding within the hole in the plug. The distance between the hooks being greater than the length of the plug, there is a certain amount of lost motion which is utilized in the extraction, for, when the plug is withdrawn, the extractor does not commence to pull on the empty case until the rear face of the plug brings up suddenly on the rear shoulder, giving a hammer effect to start the case to the rear.

8. The Percussion Firing Mechanism consists of the following principal parts: Firing pin; saddle; mainspring; cocking lever; cocking-lever bracket; releaser (sear); sear spring; and trigger mechanism, consisting of trigger box, trigger and trigger spring, all made of steel.

The firing pin (46) is a straight cylindrical piece with a cone-shaped head and point (46a). It is surrounded by a spiral spring (47) that lies between the head and a loose-fitting saddle or sleeve (48) moving fore and aft on the shank (46) of the pin. A nut (49) is screwed on the rear end of the pin. The nut has an annular groove (49a) used as a lock notch. The firing pin complete slides back and forth in the axial hole of the plug, partly guided by the firing-pin guard (55), and housed in by it.

A cocking lever (51) is pivoted on a pin in the cocking-lever bracket (53) secured to the plug above the center by four screws. Its upper end works in the cam-shaped cocking groove (21) in the collar, while the lower end is forked to fit over the saddle on the firing pin.

A sear (57) works to the right or left in a dovetail and hole in

the rear face of the plug; the inner end engages the cock groove of the firing-pin nut, while the outer end is shaped into a toe, projecting forward, that is engaged by the trigger.

The sear is guided and limited in its movement by a screw (58) passing through an elongated hole into the face plate, and is kept to its work or pressed in toward the plug's center by a flat sear spring (59) held in a dovetail in the face plate by a screw and bracket (60).

The trigger box (61) fits in a horizontal transverse slot on the left side of the gun, and is secured to the gun by screws (62). This carries the trigger (63), which is a bell-crank lever, pivoted at its elbow, the inner arm forming a rear projecting toe to engage the sear, while the outer arm is connected to the firing lanyard which leads forward so that a pull moves the inner arm or toe to the left. The trigger spring (65) is spiral, seats in a hole in the gun and bears to the rear on the trigger arm, to keep the trigger toe clear of the toe of the sear in operating the plug. Incidentally the strength of the spring somewhat regulates the amount of pull on the lanyard.

9. The Electric Firing Mechanism, designed to fit the same recess in block that the percussion mechanism is installed in, consists of a firing case, insulated firing pin, and an attachment lug. The firing case contains the insulated firing pin, and is put on the breech plug in place of the firing-pin guard, being secured by the same screws. The attachment lug replaces the trigger box, and is secured with the same screws.

The firing case (66) consists of two tubular pieces (an axial and a radial arm) made of steel. The former has its rear end enlarged, threaded, and slotted to correspond with the firing-pin guard, the front portion fitting neatly into the axial hole in the plug for the percussion firing pin. The latter piece screws into the former near the rear end and at right angles. The hole in the rear end of the axial piece, closed by a plug, is for convenience in manufacture.

The firing pin (67, 68) consists of an axial (67) and a radial (68) arm, or inner and outer piece, screwed together at right angles (near one end) after being placed within the tubular insulation (69), which is surrounded by the firing case. Each arm

consists of three parts, an inner and an outer piece joined by a spiral spring soldered over a small spindle left on each piece. The outer piece of the axial pin has the conical head and point which makes contact with the primer; the outer piece of the radial pin makes contact with the contact piece of the attachment lug, and has a shoulder (left in turning the outer part to a smaller diameter) to keep the insulation in place. The insulation is made of vulcanite or wood-fiber tubing, as per drawing.

The attachment lug (70) is bored out to contain a contact or terminal piece (73) and a spring terminal socket (72), which are screwed together and secured by the insulation (74) of vulcanite, as per figure. For guns having telescopic sights on the mount, the attachment lug has a part leading forward to contain the spring socket, which is joined at right angles to the contact piece. One end of the firing wire is pushed in the spring socket, while the other goes to the battery, one pole of which is grounded on the mount. When the breech is fully closed, the insulated firing pin makes contact with the insulated piece in the lug and only then, so that when the firing key is pressed, the circuit is completed and the primer exploded.

10. Action of the Breech Mechanism as a Whole.—Opening.—(Supposing the breech closed and the hand lever folded across the breech face.) By the continuous swing of the hand lever to the rear and right, the plug is unlocked and withdrawn on the tray; the percussion firing mechanism, if fitted, is cocked, the case extracted, and the plug and tray swung out clear of the breech.

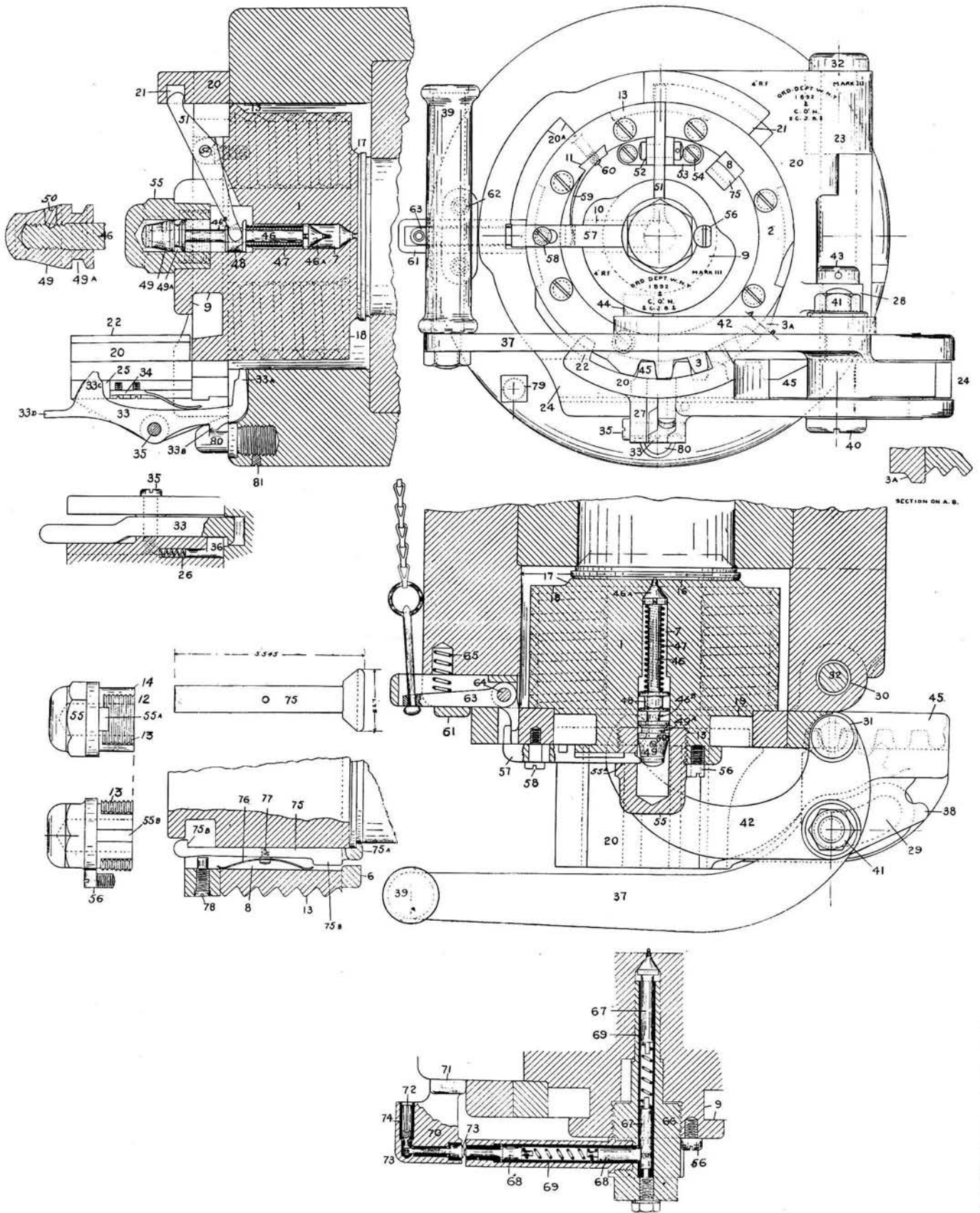
Unlocking.—The first movement of the hand lever, on the fulcrum pin as a center, through its cogged arc moves the rotating rack to the left. This revolves the plug until unlocked, at which point the rack brings up against the stud on the gun. During this revolution the upper end of the cocking lever, moving in the cocking groove in upper part of the collar, is thrown forward, which results in the forked lower end, engaging the saddle of firing pin, moving the firing pin to the rear until the groove in the nut is engaged by the inner end of the sear, the latter snapping over the nut into the groove. This cocks the mechanism. The cocking lever will now be clear of its groove in the collar.

Translation.—The center of the lever's movement is now trans-

ferred to the right cog immediately below the translating-arm pin, and a continued pull on the lever will result in the fulcrum pin moving to the right in the curved slot in the tray and carrying the translating arm with it. The hand lever and translating arm move in unison on the latter's pin as an axis, and the upturned toe of the translating arm withdraws the plug onto the tray. The plug is guided by the rib on the tray and a blank sliding on the guide surface at the right side of the tray. It is kept from any rotary movements by the threaded section and teeth on the face plate lying between the tray guides, while a groove cut in the threaded section passes over the center tooth of the rack. Near the latter part of the plug's withdrawal onto the tray, a trip toe on the face plate (beveled off to the rear in a curve) rides over the latch-trip toe, and trips the latch. The front end of the latch, on rising, is disengaged from the tray catch or hook on the gun and frees the tray. At the same time the latch hook, too, rises up in front of the plug and secures the latter from longitudinal movement on the tray, while the latch-lock bolt is forced out by its spring and engages *under* the shoulder left on the latch, preventing movement of the latter as long as the tray is clear of the gun's breech face. The movement of the hand lever and translating arm is arrested by the fulcrum pin bringing up on the end of the curved slot in the tray, at which movement the above operations have just taken place.

Swinging open.—Further movements of the lever will now result in swinging the plug and tray away from the breech on the hinge pin as an axis, until the front side of the tray's extension brings up on the side of the gun. The front face of the plug will now be in a plane parallel with the gun's axis, the breech will be clear, and the gun can be loaded after the old case has been removed. If the electric firing mechanism be fitted, the contact is simply broken when the plug is revolved. It will be noticed that the hand lever has three success centers of rotation (41, 31 and 32) during the swing to the right.

II. Closing.—*Swing and translation.*—The reverse movement of the hand will result in the reverse operations. When the tray strikes the breech face, the latch-lock bolt will be pushed to the rear to disengage the latch, and, if the hand lever is at all "smartly



Electric Firing Mechanism.

DASHIELL BREECH MECHANISM FOR 4-INCH R. F. GUNS.

worked," the plug will start into the screw box, being forced in by the translating arm, which now, with the lever, moves about the former's pin. The latch turns to engagement with the tray catch by the action of its spring the moment the plug starts to the front and clears the latch-trip toe. This frees the latch-lock toe from the plug's front face. The translation of the plug into the screw box is arrested by the last thread on the plug bringing up on the rear thread of the screw box, and the fulcrum pin having reached the end of its curved slot, it arrests the movement of the translating arm.

Locking.—The hand lever will now turn about the fulcrum pin as a center, which results in moving the rack and locking the plug; the motion is stopped by the hand lever bringing up on the tray. During the revolution of the plug, the upper end of the cocking lever, moving in the groove in the collar, is pushed to the rear. This pushes the sleeve on the firing pin forward and the firing spring is compressed. The last movement in closing brings the sear toe in engagement with the trigger toe, and until then the sear cannot be moved.

Firing.—On pulling the firing lanyard attached to the outer arm of the trigger, the sear will be moved to the left, the firing pin will be disengaged, will fly forward under the action of the spring and strike the primer of cartridge case, firing the gun. If the electric mechanism be fitted, the last movement on locking the plug results in bringing the outer arm of the insulated firing pin in contact with the contact piece of the attachment lug. If the circuit through the battery be completed, the gun will be fired, as the inner arm or point of the firing pin is in contact with the primer.

12. Safety of the Breech Mechanism.—The breech will not open on firing on account of the reaction of the operating lever, friction and shape of the screw threads, and friction of the gearing.

The gun cannot be fired until the breech is fully closed: *First*, with the percussion firing mechanism, because (a) the collar is so shaped that the sear has not sufficient movement until the plug is fully locked, when the toe on the sear comes to a cut in the collar, and this is the only position in which the trigger is engaged; (b) the firing-pin spring is not sufficiently compressed until the plug is locked; (c) the firing pin would not have sufficient throw

for the point to strike the primer until the plug is fully locked, as the cocking lever holds the saddle in some intermediate position; (d) the point of the firing pin cannot strike its primer in closing, as it is always within the nose of the plug by reason of the cocking lever bringing it to the rear in the act of unlocking. [It is possible, however, that a percussion primer may be exploded by the blow of the breechblock while closing on the base of the cartridge case; this accident has occurred abroad with serious consequences and the danger of it exists wherever percussion primers are used with swinging breechblocks of this or other types.] *Second*, with the electric firing mechanism, because (a) no contact is made between the firing pin and the attachment lug's contact pieces until the plug is locked.

13. Notes on the Dashiell Breech Mechanism.—If the cartridge case sticks so that the extractor can not pull it out, the breech may be opened by inserting a screw-driver as a pry between the rear end of the extractor and its hole. The extractor nib may be sprung over the lip of the case and the plug can be withdrawn. Then use hand extractor.

Sometimes in trying to open the plug after firing it may be found that the plug cannot be rotated by pulling on the lever. In this case, if a copper drift or piece of wood be placed against the outer end of the rack and struck a few light blows while pulling the lever, the plug will be moved.

If it be desired to see the firing point, open the breech, pull on the sear, then pull back the upper end of the cocking lever. This will push the point through the nose of the plug; but observe before closing again to push *forward* the cocking lever and cock the firing pin on the sear; otherwise the lever will not enter the groove in collar, and may be bent or broken.

CHAPTER VIII.

THE FLETCHER BREECH MECHANISM.

1. **The Fletcher Breech Mechanism** for rapid-firing guns, the invention of Lieut. F. F. Fletcher, U. S. N., belongs to the "interrupted-screw" system and its distinctive features lie in the method of operating the plug. The plug is supported when withdrawn from the gun by a collar, or carrier ring, to which it is automatically locked by a locking bolt which has other important functions as well; the extractor is pivoted in a slot through the jacket of the gun and is not carried by the plug.

The Fletcher system, which is the last in which two varieties of primers with a special firing mechanism for each is employed, is more recent and, at the time of its adoption, succeeded the Dashiell system; the operating system is distinctive and requires few parts. The Fletcher mechanism is fitted to 34 4-inch guns, known as the Mark IV 4-inch mechanism; to 113 5-inch guns, known as the Mark III 5-inch mechanism, and to 60 6-inch R. F. guns, known as the Mark IV 6-inch mechanism. All of the 4-inch and 6-inch slow-fire guns have been, or are now being, converted to R. F. guns with this mechanism. The same system of operation, considerably modified, is employed in the high power, smokeless powder R. F. guns of 3-inch and 4-inch calibre now being constructed.

The plug (1) and screw box have four threads and four blanks; the threads do not occupy the entire length of the plug, the rear part being left wholly blank for the carrier ring. The principal parts are: Plug, carrier ring, locking device, operating lever and hinge pin, extractor and pin, and firing mechanism (percussion or electric); all parts are made of steel. To obviate the necessity of forging a lug on the right side of the jacket, a hinge plate (4) is bolted to the rear face of the jacket to furnish a bearing for the hinge pin.

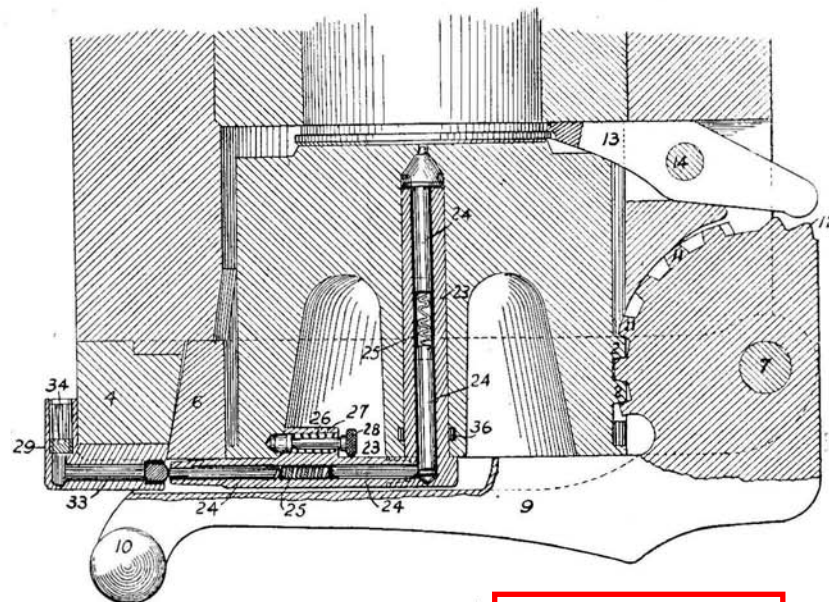
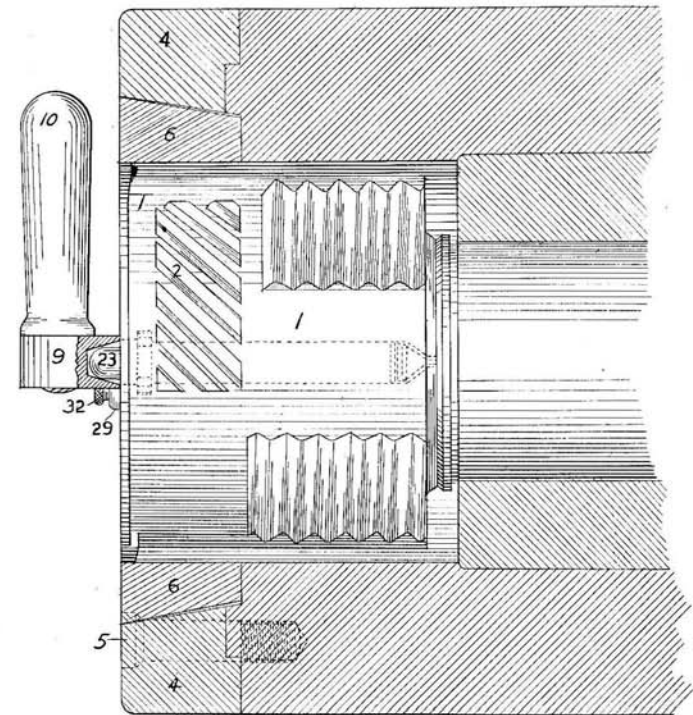
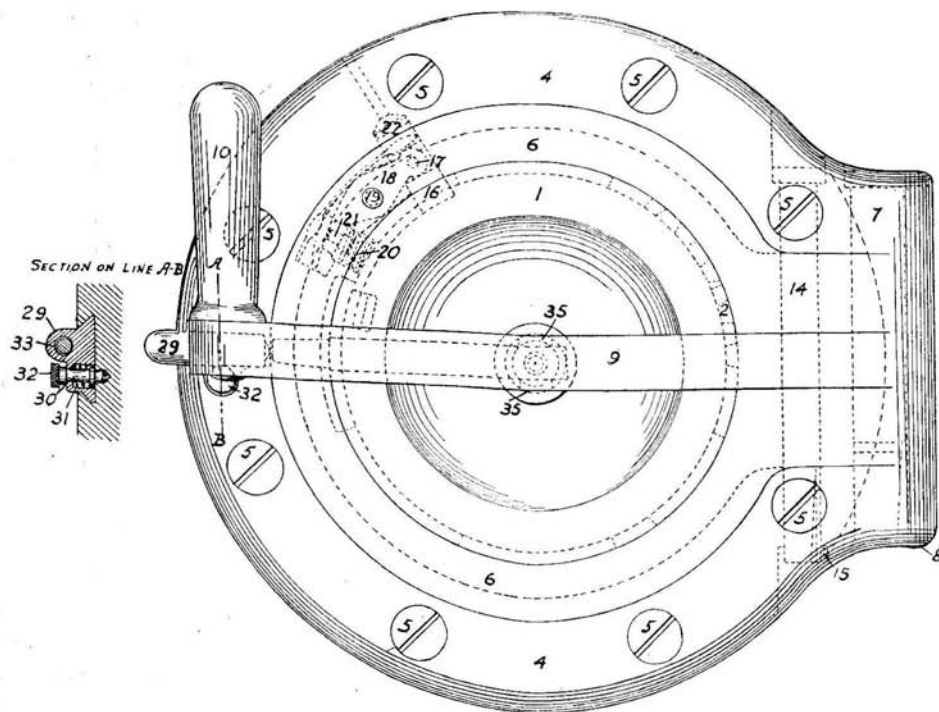
2. **The Breechblock** (1), threaded and slotted as above, has a rack (2), with teeth inclined 45° to its axis, cut on its right upper quadrant in rear of the threaded portion and extending partially around the circumference. In the left hand upper quadrant of the plug is cut a guide slot extending circumferentially 45° and continued parallel to the axis for a distance equal to the amount of withdrawal of the plug through the carrier ring; at its forward end, this slot is gradually deepened and ends in a circular depression in the plug into which the locking bolt drops as the breech is being opened. Along the axis of the plug is cut a longitudinal circular hole for the firing pin; its rear end is partially closed by an adapter nut when using the electric firing mechanism (it is not shown in Plate I, but a later model is shown in Plate II which indicates the thread for the adapter nut). The rear end of the block is also slotted through along its vertical diameter, when closed, to form a recess in which the cocking bar of the percussion firing mechanism works.

3. **The Carrier Ring** (6) hinged on the right side upon the same pin (7) around which the operating lever (9) turns, is cut on its inner circumference with blanks and raised portions to allow the plug to move forward and back in it. The carrier ring (6) is slotted through radially in the upper left quadrant for a locking device which locks the carrier ring to the gun when it is swung to and locks the plug in the carrier ring when the former is withdrawn. Thus in this system the carrier ring acts as collar and plugtray combined, and no part of the mechanism, with the exception of the operating lever, projects beyond the face of the breech when the mechanism is closed.

The cammed recesses (68) on the inside of the carrier ring receive and actuate the ends of the cocking bar as the plug is rotated.

4. **The Locking Device** in the carrier ring (6) consists of a lever (18) pivoted at its center, with a spiral spring (20) under its left end and carrying a locking bolt (16) on its right end; the upper end of the bolt locks the carrier ring to the gun when the mechanism is closed and its lower end locks the plug to the carrier ring when open.

The functions of this device are most important since, besides



performing all the duties of the tray latch in the Dashiell mechanism it also guides the plug and fixes the instant of changing the *swinging* movement to *translation*, etc.

5. **The Operating Lever** (9) has a handle (10) riveted to its left end, and pivots on the hinge pin (7) on the right side of the breech. Its rear right-hand surface is shaped to act as a cam on the outer end of the extractor (13), and its front right-hand surface is shaped into a segment of a circle and cut with five 45° teeth (11) to fit the circumferential rack teeth on the plug and four vertical teeth (12) of the same section as the *threads* of the plug.

6. **The Extractor** (13) is a lever turning about a pin (14) through its center and cut on its inner end to fit under the rim of the cartridge case.

Both hinge pin (7) and extractor pin (14) are held in place by spring locks (8, 15). In guns of the latest manufacture, however, these locks are dispensed with.

7. The operation of the mechanism in one direction comprises, as in the Dashiell system, three steps—*unlocking*, *translation* and *swinging* open, or vice versa. The action of the system, excluding, for the present, consideration of the firing mechanism, is as follows:

Opening.—The plug being closed and locked, the locking bolt (16) has its inner end at the upper end of the circumferential part of the guide slot in the plug, and its outer end engaged in a recess (22) in the hinge plate (4), thus locking the carrier ring (6) to the breech of the gun; the rear tooth on the lever (9) is engaged with the lower tooth of the circumferential rack (2) on the plug, and the extractor claw is under the rim of the cartridge case. The lever (9) is swung to the right, through an angle of 59° , thereby successively engaging its teeth (11) with those of the rack (2) on the plug and causing the latter to rotate 45° to the left, disengaging its threads from those of the screw box and leaving it free to be withdrawn. At this moment the locking bolt (16) reaches the end of the circumferential part of the guide slot in the plug and thus prevents the latter from being rotated farther. At the same instant the first of the withdrawing teeth (12) on the lever (9) has come opposite to the middle of a threaded

portion of the plug and on continuing the rotation of the lever (9) these teeth successively engage the threads of the plug and so cause the latter to move to the rear through the carrier ring (6); the locking bolt (16) now moving in the portion of the guide slot which is parallel to the axis of the plug. An angular movement of the lever of 44° completes the withdrawal of the plug. At this moment the inner end of the locking bolt (16) reaches the depression at the front end of the guide slot, the spring forces the other end of the locking lever (18) up, thereby pushing the locking bolt (16) down and disengaging it from the recess (22) in the hinge plate (4), and the plug, locked to the carrier ring (6) in its withdrawn position, is free to swing open with the latter.

A further rotation of the lever of 96° swings the carrier ring and plug clear of the breech aperture. During the last 41° of this motion the rear face of the lever (9) acts as a cam on the outer end of the extractor (13), causing it to withdraw the cartridge case, at first slowly and with great force, and then quickly.

8. Closing.—In the reverse operation of closing the mechanism, when the carrier ring (6) swings to, the beveled edge of the locking lever (18) strikes the inner surface of the hinge plate (4) and is forced down into the carrier ring (6), thereby lifting the locking bolt (16) out of its seat at the front end of the guide slot in the plug. Then as the plug moves forward, the slope of the bottom of the guide slot (3) lifts the locking bolt (16) farther and forces its outer end into the recess (22) in the hinge plate (4), thus again locking the carrier ring (6) to the breech of the gun. When the plug is closed, the teeth (11) of the lever (9) engaging the rack (2) in the plug act as an efficient lock to prevent the plug from being rotated by any pressure on its face due to firing.

9. It will be observed that in closing the mechanism the action of the locking device is positive throughout, but that in opening, a spring (20) is required to start the locking bolt from its recess in the hinge plate. To provide against the unlikely failure of this spring, a small hole is bored down through the hinge plate into the locking-bolt recess, through which any small pin or rod can reach the locking bolt and force it down in case it sticks.

10. The Electric Firing Mechanism consists of a steel case (23) formed of two parts screwed together at right angles to each

other, through which extends an insulated firing pin (24). On the radial arm of the case is a spring catch (26) for locking the attachment in place, and on the axial arm are two lugs (35). The *firing case* (23) is pushed into the plug with the radial arm vertical, the two lugs entering a slot in the face of the plug, and is then turned 90° to the left, the lugs (35) turning into a recess (36) so as to prevent the case from being blown out, and the spring catch holding it in the proper position. In the later type the recesses (36) are replaced by the adapter nut (not shown) which is to be screwed on when substituting electric for percussion mechanism. The insulated firing pin (24) consists of four parts, the two inner ones screwed together at the joint of the case, and the two outer ones separated from the inner ones by spiral springs (25) which press them against primer and attachment lug.

The *attachment lug* (29) is another steel case fitting into a dovetail in the left side of the hinge plate, and held there by a spring catch (30). An insulated circuit, with a contact piece (33) at one end and a spring socket (34) at the other, extends through it.

The operation of the electric firing mechanism is as follows: When the plug is pushed home the point of the firing pin (24) is pressed against the electric primer in the base of the cartridge case, and when the plug is turned and locked the other end of the firing pin comes opposite and is pressed against the contact piece (33) of the attachment lug, thereby giving an insulated metallic connection from the electric primer to the spring socket (34).

One pole of the electric battery is permanently connected to the metal of the mount, and the other pole is connected by an insulated wire passing through the firing key to the spring socket (34). Consequently, the connection being made, closing the firing key ignites the primer. The wire from the firing key ends in a metal cone which fits the spring socket (34), and this wire may be of a length such that the recoil of the gun breaks the connection at that point. It is evident, however, that in no case can the gun be fired electrically until the plug is completely locked, because until then the firing pin is not in contact with the attachment lug. If a blow back from the primer occurs, the escaping gas forces the

firing pin (24) back slightly, when the head of the pin seals the front end of the firing case (23) and prevents injury to the insulation.

11. **The Percussion Firing Mechanism** (Plate II), designed to fit the firing-pin recess of the block, is, like that of the Dashiell system, of the type in which the firing pin is drawn to the rear while opening the breech and the firing spring compressed as the breechblock is locked during closing. The principal parts are: The firing pin and spring, the cocking bar, the sear bar and spring, and the trigger box and trigger. The firing pin (44) has a conical head ending in the firing point (47); on its rear end is screwed a head (45) with a cannellure in which the sear is caught. The firing spring (46) surrounds the firing pin between its head and the cocking bar (43). The latter, a nearly straight bar of steel, works back and forth on the firing pin in slots cut through the plug; its extremities are rounded to fit the cammed grooves (68) of the carrier ring. The sear bar (49), bearing the sear (49a), is dovetailed in across the horizontal diameter of the plug, closed position, and the sear spring (51) forces this sear toward the firing pin and the sear bar toward the trigger (63). The trigger box (62) is of the same shape as the attachment lug of the electric mechanism and is secured to the gun in the same way; it contains the trigger pivoted at (64); the spring (65) forces the trigger in a direction opposite to that in which the lanyard, attached to the outer end, acts.

The *operation*, assuming the mechanism cocked for firing, is as follows: When the lanyard is pulled, the sear is forced to the right by the trigger until the firing pin is freed; it flies forward from the force of the firing spring and the gun is fired. As the breechblock is unlocked by turning to the right, the cocking bar also rotates, its ends move along the grooves (68) in the carrier ring, and it is brought to the rear with the firing pin; at the moment that the unlocking of the plug is completed, the firing pin reaches the limit of its rearward motion and the sear snaps over its head. Then as the translation of the plug begins, the ends of the cocking bar emerge from the grooves (68) and the mechanism is retained in this position of full cock, firing spring slack, until the last step in closing. During the relocking of the plug,

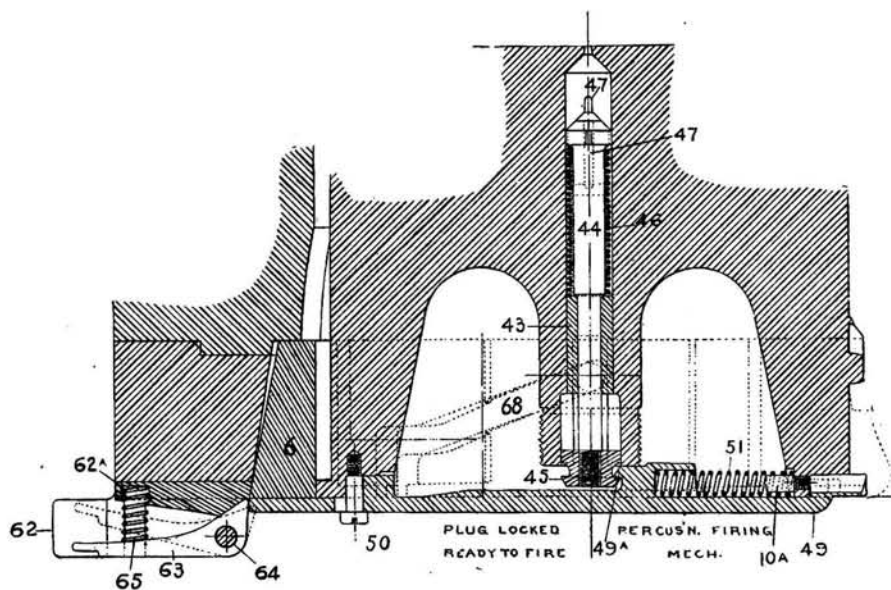


Fig. 1. Horizontal section.

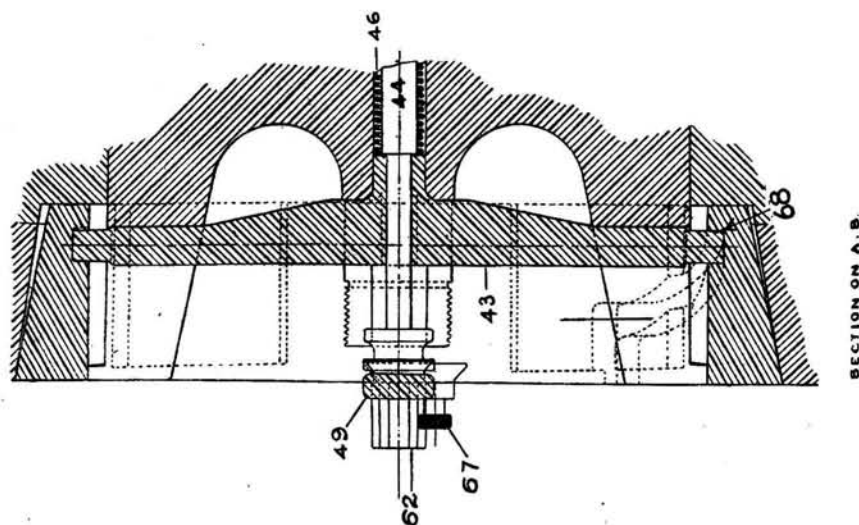
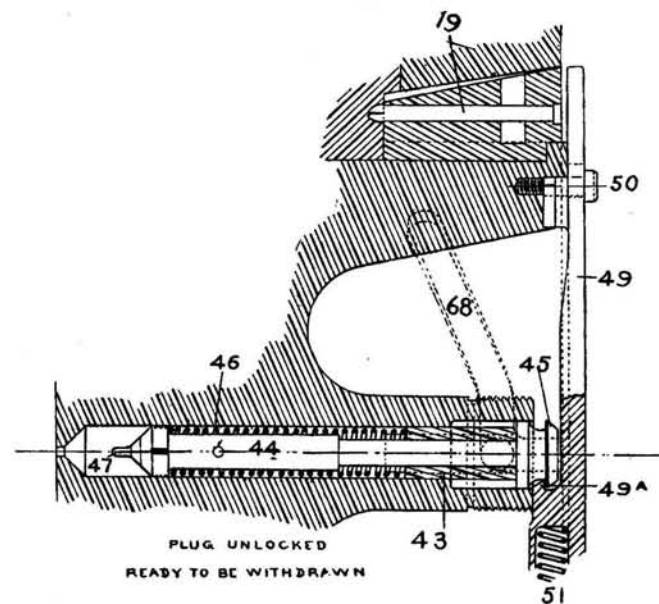
Fig. 2. Plug locked ready to fire.
Vertical section.

Fig. 3.

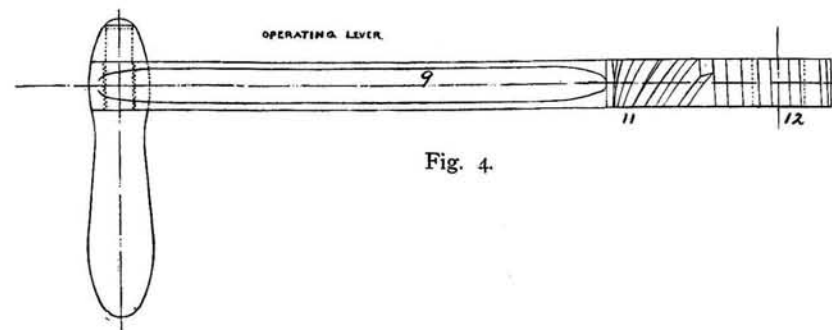


Fig. 4.

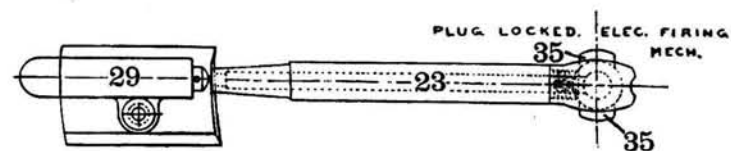


Fig. 5.

the cocking bar is forced *forward* by the grooves (68), which it has re-entered, and, the firing pin being held to the rear by the sear, the firing spring is compressed. Finally, just as the locking motion is completed, the left end of the sear bar is brought into contact with the trigger and the gun is again ready for firing.

The gun cannot be fired prematurely by percussion, because :

- (a) The firing pin, having been retracted during the opening of the plug, cannot project through the plug and strike the primer while closing unless—through weakness of the sear spring—the sear has failed to grasp and hold the head of the firing pin and even in that case a strong blow of its point upon the primer is unlikely since the cocking bar limits its throw.
- (b) The firing spring is not compressed until the plug is at least partially locked.
- (c) The carrier ring will not permit the sear bar a movement to the right sufficient to release the firing pin until the plug is completely locked. The danger of a percussion primer being exploded by the mere concussion of the breechblock against the cartridge case, while closing the breech, exists in this as in all other swinging-block systems.

The firing point may be examined while the breech is open by pushing the sear bar down and the cocking bar forward, whereupon the firing point will be projected through the face of the block; the sear must be re-engaged on the firing-pin head before closing or the mechanism will not be cocked.

CHAPTER IX.

MARK VI BREECH MECHANISM FOR 4-INCH R. F. GUNS.

1. The 4-inch Mark VI Breech Mechanism is of service design, embodying the Welin stepped-screw principle and a modification of the Fletcher operating gear, (it is sometimes called the "Modified Fletcher" mechanism), and is fitted to the 50-calibre 4-inch rapid-firing guns, Mark VII, from No. 213 upward, which are the only *main battery* rapid-firing guns building.

It embodies the following characteristics: (a) An interrupted Welin, or stepped-thread, breech plug. (b) The plug is carried by threads on a "carrier ring" hinged to the gun yoke and swings directly out from the breech, without any movement of translation. (c) The operation of locking or unlocking is performed by means of a spiral rack on the side of the plug and corresponding teeth on a segment of the hand lever hinged to the "carrier ring." (d) The firing mechanism is similar to the 4- or 5-inch Fletcher breech mechanism, but the firing pin, being insulated, is also used for electric firing,—by a simple connection with an electric-firing cable and throwing out a "percussion catch piece" on the "sear bar." (e) The extractor is carried in a longitudinal recess in the block itself, as in the Dashiell system, and its engagement with the head of the cartridge case is effected by a separate lip piece with a transverse movement. (f) The screw box is cut in a breech ring which screws into the jacket, abuts against the tube and is secured by set screws.

2. The Breech Plug (Plate I), $6\frac{1}{2}$ inches total length, has $4\frac{1}{2}$ inches of its forward part divided into six equal sections; each semicircle having a blank (2) and two stepped-threaded (3) sections. The blanks are diametrically opposite on the left and right sides, centers in horizontal axial plane, in the closed position. The stepped sections have radii of 4 and $\frac{1}{4}$ inches, the higher

diametrically opposite to the lower, and the lower step being to the right of the blanks (going with the sun and viewed from the rear); these threaded sections are separated $\frac{1}{8}$ inch for convenience in manufacture. The blanks, and upper part of teeth of first step, are cut concavely and convexly with the hinge pin as a center, to form clearances for swinging the plug in and out of the screw box. The nose of the plug is recessed (4) to the rear to form a clearance for the head of the cartridge case, the flange being left thereon as a continuation of the plug threads for strength; the right part of the recess is sloped away somewhat to avoid jamming the case, if it is not pushed home.

The rear end of the plug is left cylindrical for $1\frac{3}{4}$ inches on a diameter of $8\frac{3}{4}$ inches, and has a square left-hand thread (7) of $\frac{1}{2}$ inch pitch (same as plug thread) cut thereon for attaching to the carrier ring, except in that part where the unlocking teeth are situated. In the ENE. side of the locked position, over an arc of 60 degrees, are cut five involuted teeth inclined 45 degrees to the horizontal which form a plug rack (13) or unlocking teeth, and are engaged by those on the hand lever.

The rear end of the plug is recessed out for lightness and has an axial stem (9). Through the stem and plug's axis is drilled a hole (10) for the firing pin, conical in shape at the front end and diminishing to size of the firing point. That part of the recess in which works the "cocking bar" is enlarged, leaving a shoulder (11) there. Two vent holes (17), $\frac{1}{4}$ inch diameter, leading into the front end of the firing-pin hole and extending outward into the plug recess, provide a means for the escape of gas in case of a blow back.

A slot (12) is cut through the plug in a vertical axial plane for a short distance, forming a way for the "cocking bar." In the NNE. part (in the locked position) is cut a longitudinal extractor hole (14) inclined 15 degrees to the axis and to the front, at the front end of which is cut a transverse clearance (15) for the extractor head. In the rim of the plug are cut dovetail slots (18) for the sear-bar lug, inclined 15 degrees to the horizontal. On the left side there is a cut in the thread of the carrier ring, forming a recess (19) for the toe of the "plug retaining plunger."

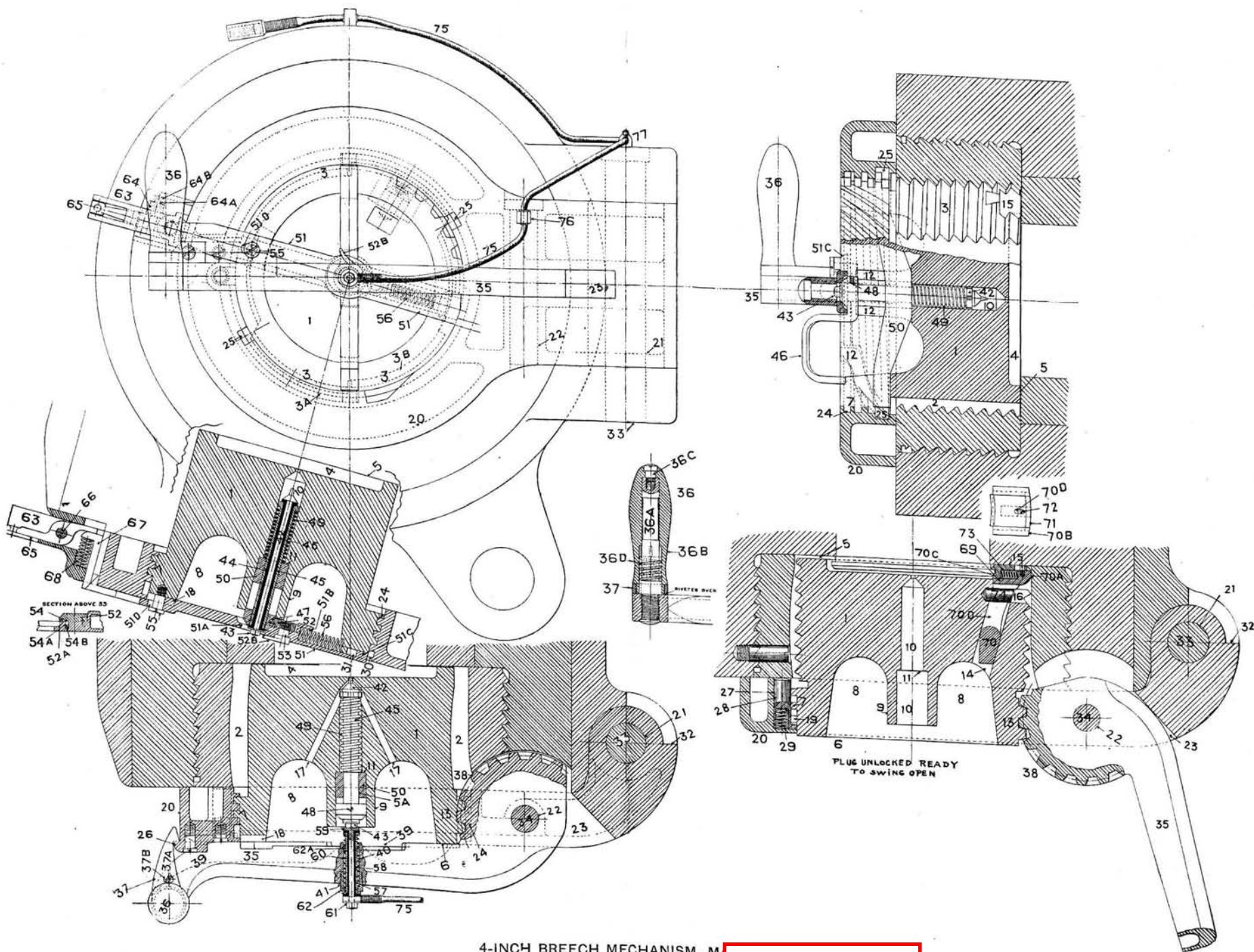
3. The Carrier Ring (20) is designed to carry the breech plug

and hand lever. It is a circular cast-steel ring, suitably hollowed out in the front side for lightness, sloped off into an arm on one side which curves to the front and has a vertical hinge-pin hole (21), center 10 inches from the center of the ring. The right end of the arm fits between hinge lugs on the right side of the gun's yoke, and the hinge pin (33), passing through the hole in the arm and hinge lugs, hinges the carrier to the gun. A boss is so cut on the arm as to leave a shoulder (32), which brings up on the yoke, limiting the extent the plug is opened, viz., at a right angle to the gun's axis. A slot (23), center in horizontal axial plane, is cut through the ring, and a vertical hole (22) passing through its arm is for the operating-lever pin (34).

The inner surface of the ring has cut therein a square left-hand thread (24), into which screws the corresponding thread of the plug. A camgroove (25) for the cocking bar is cut within the ring, in the threads, on diametrically opposite sides, opening at points 60 degrees to the right of the vertical line. There is a recess (27) for the plug-retaining plunger (28). One-half inch above the horizontal axial plane, on the left side, is secured the "hand-lever catch piece" (26). At (30) and (31) are clearance cuts for the sear bar, for firing and cocking, respectively.

4. The Operating Lever (35) is a flat bar, provided with a vertical handle (36) on the left end, and a segment of a circle on the right, in which is a hole for the lever pin which pivots it to the carrier ring. On the front and inner surface (in closed position) are cut eight 45-degree teeth (38), which engage the plug's rack teeth (13) and by which the plug is rotated to lock or unlock. The front edge of the bar is cut out (39) to clear the sear bar when closed and is scored for lightness; near the center the lever has its full width and a longitudinal hole (40) is drilled for the "electric contact sleeve."

The handle (36) consists of a stud (36a) screwed into the left end of the lever, over which works a sleeve (36b). The lower end of the sleeve is screwed into a lever catch (37), which surrounds the stud next to the lever. A helical spring (36d), with one end fitting into a groove in the sleeve and the other in the stud, always tends to revolve the lever catch to the right. The end of this catch is provided with a hook, which will engage the



4-INCH BREECH MECHANISM, M

lever-catch piece on the carrier when the hand lever is fully closed. A small limiting slot (37a) in the catch and a pin-screw stud (37b) screwing into the lever prevent undue revolution of the lever catch.

5. The Firing Mechanism consists principally of an insulated firing pin, firing-pin sleeve, cocking handle, firing-pin spring, a cocking bar, sear bar, trigger mechanism, and electric contact connections. The firing pin (42) is a straight circular rod with the usual conical head and point, threaded at the rear end for a nut (43), and is surrounded by a vulcanite bush (44) and a vulcanite washer against the head and in front of the nut. A steel sleeve (45), with a collar at the front end and threaded at the rear end, surrounds the insulation and lies between the two insulating washers; this sleeve, with the insulation, is kept in place by the nut (43) screwed on the rear end of the firing pin.

A *cocking handle* (46) is screwed on the rear end of the sleeve and is retained there by a set screw (48). On the right side of the handle's hub (in the assembled position) is a cock notch (47) for the sear bar. The end of this handle works in the lower cut for the cocking bar in the plug rim and acts as a guide to keep the cock notch in the proper position. The (spiral) *firing spring* (49) surrounds the sleeve and lies between the collar on the latter and the cocking bar.

The *cocking bar* (50) is quite similar to the 4- and 5-inch Fletcher; it works over the firing-pin sleeve, forward of the cocking handle, and its ends take in the cocking grooves (25) in the carrier ring. The insulated firing pin, sleeve, firing spring, cocking bar, and cocking handle are assembled as *one piece*, as in the 4- or 5-inch Fletcher mechanism, the spring being under a slight initial compression.

The *sear spring* (56) and *sear bar* (51) are very similar to those of the 4- and 5-inch Fletcher mechanism, and work in the same way. There is an oblong hole (51a) near the center of the bar through which the rear end of the firing-pin sleeve passes; it is recessed out to clear the hub of the cocking handle. There is a separate piece on the front side of the bar to right of the hole, to form a "cocking catch" (52) or lip for percussion firing, which is retained and pivoted on the bar by a screw (53). This catch

may be turned up 90 degrees (by turning it with the finger) so that the cock notch of the firing pin will not be engaged, when it is desired to use the electric firing mechanism. To keep this cocking catch piece in either position, there is provided a lock (54) consisting of a small spring plunger (54a) seating in a hole on the front side of the bar, and worked by a spring (54b); this plunger will enter a recess in the cocking catch in the two 90-degree positions. The left end of the sear bar, when the plug is closed, slides behind a lip on the lever catch piece (26), and prevents rear displacement by the trigger bar; the left edge of the bar is beveled for the sliding trigger bar.

The trigger mechanism consists of a box (63) held in a dovetail groove cut in the gun on the left side, on a line 15 degrees above the horizontal by a spring bolt (64a) entering the recess. A "trigger lever" (65) is pivoted near the middle within the box, its inner end bearing on the foot of the trigger bar (67), which slides fore and aft in a dovetail groove, and has a foot against which bears a spiral spring (68), seated in a recess in the box, tending to keep it in its forward position; on the after end of the trigger bar is a beveled surface. When the outer end of the trigger lever is pulled forward, the bar is moved aft, and its beveled surface bearing on the sear bar moves the latter to the right far enough to disengage the firing pin.

The electric firing wire is connected to a contact piece, so carried in the operating lever that it will lie in the axis of the bore when the breech is closed. The wire is secured to the rear end of a contact piece (59) which is held in an insulated sleeve (58); this sleeve is capable of considerable longitudinal motion against the action of a spring (60). The spring will, when the firing pin is not cocked, press the contact piece against its head, completing the electric circuit; when cocked for percussion firing, the spring yields enough to permit the lever to close. Thus the same firing mechanism is used both for percussion and electric firing and the gun may be fired by either means without dismounting anything. Combination primers are used.

6. The Extractor (69) consists of a lever (70) or tail, lip piece (71) and screw (72), spiral spring (73) and retaining pin. The front end of extractor has a double-lipped guide slot for the lip

piece (71) at right angle to the tail. The tail of the extractor works within the inclined hole (14) in the plug, which keeps the extractor in the plug. A lip piece, sliding in the lipped groove on the front end of the extractor tail, has a small right and left movement, and is retained by a screw pin (72) through an oblong hole. A spiral spring (73) is placed in a recess on the underside of the lip piece and bearing on the end of the groove. The extractor tends always to keep the lip piece engaged under the rim of the case. A longitudinal slot (70d) is cut in the tail, through which passes a pin (74) at the front end of the extractor hole and enters a recess in the plug.

7. The Action of the Breech Mechanism.—(Supposing the breech closed). *To open:* Grasp the handle of the operating lever, turn it to the left to disengage the lever catch from the carrier, then pull to the rear. The spiral threads on the lever engaging those of plug rack will rotate the plug to the right to unlock. While the plug is being unlocked, the ends of the cocking bar working in the grooves of the carrier ring will move the bar to the rear, and with it the firing pin, until the cock notch is engaged by the catch on the sear bar. The latter is able to move to the right sufficiently to allow the lip of the catch to ride up the bevel of the notch by means of the cocking clearance (31) in the ring. At the moment the plug is unlocked, the upper end of the square threads for the carrier will bring up on the top of the lever segment and stop the rotation, and the lever, plug, and carrier will then swing out together on the hinge pin as an axis. As soon as the carrier clears the breech face, the plug-retaining plunger (28) springs forward and its toe enters the cut (19) in the plug, preventing any movement of rotation of the latter within the ring when the direction of the lever's movement is reversed. As the plug swings out from the screw box, the extractor's tail, working in the inclined hole in the plug, will cause the extractor to move about its fulcrum, bearing on the side of screw box, throwing the inner end of the lip piece to the rear and prying out the case with great power. As soon as the plug has traveled to the rear the length of the slot in the extractor lever, the extractor brings up on its keep pin (74) and the plug and extractor move in unison to the rear, withdrawing the case until the lip piece slips off the

rim of the cartridge case. When the lever has swung about 190 degrees, the shoulder (32) on the carrier brings up on the hinge yoke and stops the movement. The rear face of the plug is then parallel to the axis of the bore.

To close: The movement of the lever is the reverse. When the retaining plunger (28) in the carrier ring strikes the breech, its toe moves to the rear and releases the plug, and as soon as the carrier strikes the breech face of the gun, the center of movement of the lever is transferred from the hinge pin to the lever pin, and the spiral teeth of the lever rotate the plug to the left, locking the same into the screw box. During the plug's rotation, the cocking bar is moved forward by the grooves (25) in the ring and, the firing pin being held by the sear bar, the firing-pin spring is compressed. When the plug is fully locked, the operating lever is latched to the carrier by the catch (37) engaging that on the carrier, and the left end of the sear bar is in contact with the trigger bar. To change from percussion to electric firing when the firing pin (42) is cocked *without opening the breech*, first pull the cocking handle (46) a short distance to the rear to release the cocking catch piece (52) from the safety notch (52a) so as to clear the cock notch on firing pin, then allow the firing pin to go forward slowly. If it had been intended in the first place to fire by electricity, the cocking catch should have been pushed to the right before closing the breech; then the sear bar would not have held the firing pin and it would have been merely pushed against the primer by the cocking bar without compressing the mainspring. Now if it be desired to change to percussion firing, without opening the breech, it is only necessary to push the cocking catch over to the left, grasp the cocking handle and pull it to the rear, compressing the firing spring, until the sear bar snaps over the firing pin head. Obviously there can be no electric connection to the primer when cocked for percussion firing, and when the firing pin is forward in contact with the primer the main spring is not compressed.

The electric contact piece (59) in the lever should always remain in the same place, as it requires no adjustment when changing from percussion to electric firing.

To fire: If the percussion mechanism is used, pull on the lan-

yard attached to the outer end of the trigger lever. The trigger bar will move to the rear, and its beveled surface will move the sear bar to the right sufficiently to disengage the firing pin, which will fly forward under the action of the compressed spring and strike the cap of primer.

8. Points of Safety.—The gun cannot be fired before the plug is fully locked: first, because the sear bar cannot move to the right to disengage the firing pin until the firing clearance (30) in the carrier ring is reached, except in the unlocked position when there is no compression on the firing spring; second, if the electric mechanism is used, there is no contact between firing pin and primer or between contact piece and firing pin until the operating lever is fully closed.

The plug will not unlock on firing; first, because the position of the lever is beyond the center of movement to the rear; second, the hand-lever catch prevents the lever the movement which is necessary if the plug rotates.

The firing mechanism will not be injured if an escape of gas occurs, as gas vent holes (17) are provided in the plug to relieve the firing pin.

3-inch R. F. Breech Mechanisms.

9. There are now in service or under construction 261 3-inch R. F. guns; at the time of writing it is intended to build all subsequent 3-inch guns on some semi-automatic principle. While 3-inch guns are properly designated as secondary-battery guns, their breech mechanisms are more in resemblance with those of the main battery. Mark I 3-inch mechanism is a Fletcher mechanism fitted to the field pieces. Mark II has a modified Fletcher operating gear similar to the 4-inch mechanism described above and is fitted to 161 50-calibre 3-inch guns. Mark III has a system of operation somewhat resembling the Dashiell system and is fitted to 100 3-inch 50-calibre guns built by the American Ordnance Company. All 3-inch guns are fired only by percussion.

10. 3-inch B. M. Mark II (Plate II).—This mechanism is similar to the 4-inch mechanism just described but differs principally as follows: (a) The breechblock is of the ordinary or unstepped type; (b) the block, instead of being held inside the

carrier, is screwed *over* a boss projecting from its surface, in which the cocking bar works in the same manner; (c) opening or closing is likewise accomplished in two motions, *rotation* and *swinging* (portions of the block and screw box being sloped away to permit it), but the operating lever is pivoted on the carrier hinge pin and only one center is used; (d) the hinge pin, trigger box, etc., are held by a hinge plate (A) bolted to the breech of the gun; (e) the extractor is like that of the ordinary Fletcher mechanism.

11. The Breech Plug (1) is chased with a left-hand abutment thread, divided into six equal sections, three of which are planed out to form blanks (3). The threaded sections (2) are on the left, upper right, and lower right quadrants in the closed position. The left blank of the plug and the two left blanks in the screw box are cut away to form a clearance (4) for swinging out on the hinge pin (25) as a center. The rear part is hollowed out axially to form a cylindrical recess (11), the bore of which is chased with a square left-hand thread of the same pitch as the plug thread; the boss of the carrier plate screws into this thread (19). On the right side of the rear face of the plug is bolted a separate segment covering 60 degrees of arc, on the surface of which are cut 45-degree angle teeth, forming the rotating segment (14) and rotating teeth (14a); diametrically opposite is cut a circular groove, center in axis of plug, called the safety groove (9), in which enters the safety toe (41b) of the sear bar to prevent firing the gun in any but the fully closed position of the breech plug. This is accomplished by having the groove run in radially to the recess in the plug only at the two ends of said groove. A recess for the plug-retaining catch (10) is provided on the left side of the rear face, so that when the plug is rotated to the unlocked position, the plug-retaining catch (22), carried by the carrier plate, springs in and secures the plug from any rotation during the "swing" out or in, with the carrier (15), on the hinge pin (25). The axial firing-pin hole (13) and stem (12) are similar to the Fletcher type.

12. The Carrier (15) is a flat circular plate having two jaws on the right side containing the hinge-pin hole; it is hinged by the pin (25) to the hinge plate (A), the slot (17) between the

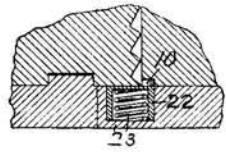
jaws being for the operating lever. On the forward side in the center is a cylindrical boss (19) having cut thereon a square left-hand thread, of plug thread pitch, on which is screwed the breech plug. The boss is hollow and has cut in its inner surface two diametrically opposite cocking-cam grooves (20) for operating the cocking bar (40) of the firing mechanism, (similar to the Fletcher 5-inch). In the horizontal center line a slot (18) is cut through, partly dovetailed at the right and left ends, in which works the sear bar (41), and on the right side is formed a seating for the sear spring as per figure. On the rear face, left side, just above the sear bar, is a catch (24) for the operating lever's latch. On the forward side, opposite to the upper end of the left screw-box thread, is a recess containing a plug-retaining catch (22) within which is a spiral spring (23) which operates the former, so that when the plug is unlocked and the carrier swings from the breech face, the plunger (22) is forced into the recess (10) in the plug.

13. The Operating Lever (26), working on the (carrier) hinge pin (25) within the jaws of the carrier, is provided with a segment (30) on the right inner side of which are cut a number of 45-degree angle teeth (30a) to engage those of the rotating segment (14) on the plug, and by which the plug is locked or unlocked. The back of the lever at the right end forms a cam surface (28) for operating the extractor (35) as in the case of the Fletcher breech mechanism; underneath this surface is worked, solid with the lever, a lug (29), which, bringing up on the outer surface of the gun when the breech is opened, acts as a stop and prevents a blow on the extractor pin. On the left end of the lever is a handle (31) or hand grasp; the handle is provided with a (bell crank) lever latch (32) pivoted at the bend, which snaps over the catch (24) on the carrier when the breech is fully closed, through the action of the spiral spring (33) and plunger (34), as per figure. This prevents the breech from opening at any elevation, shock of the charge, or accident, and therefore must be deliberately freed by pressure of the hand when it is desired to open the breech.

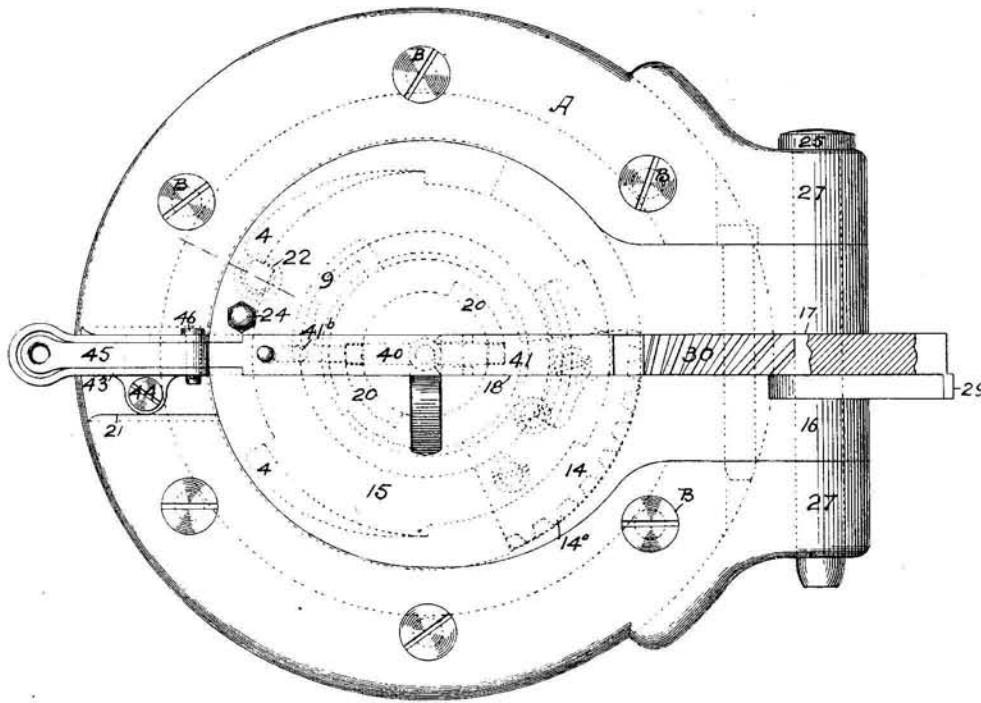
The extractor (35) is similar to the Fletcher, though somewhat more bent, and is placed and operated in a similar manner.

14. The Firing Mechanism—percussion firing is exclusively used—consists of firing pin, firing spring, cocking bar, cocking handle, sear bar with sear and sear spring, and trigger box, and is very similar to that of the 4-inch Mark VI mechanism. The firing pin has the usual conical head (37) and on its rear end is screwed a nut (38) which is provided with a cock notch and a cocking handle (38a), extending to the rear through a guide-slot in the carrier, which prevents its turning. The firing spring (39) surrounds the firing pin between its head and the cocking bar (40) which lies in a slot through the stem (12) by which it is forced to rotate with the block; its ends engage the cam grooves (20). The firing pin may be eased down from the position of full cock, when the breech is closed, by the cocking handle or the mechanism may be recocked by it, without opening the breech. The sear bar (41) slides to the right and left, against its spring (42), within a slot in the carrier and its only connection with the block is by the safety toe (41b); the sear (41c) engages the firing pin when cocked and releases it when the trigger presses the bar to the right. The safety toe is a projection on the left forward side of the sear bar which works in the safety groove (9) of the plug in such a manner that the sear bar can be forced to the right, only in the fully closed position, to permit firing and, in the unlocked position, to permit the sear to snap into the cock notch of the firing pin. The trigger mechanism is quite similar to that of the 5-inch Mark II breech mechanism (Fletcher No. 2) except that the trigger box (43) is secured by a screw (44) instead of a spring catch.

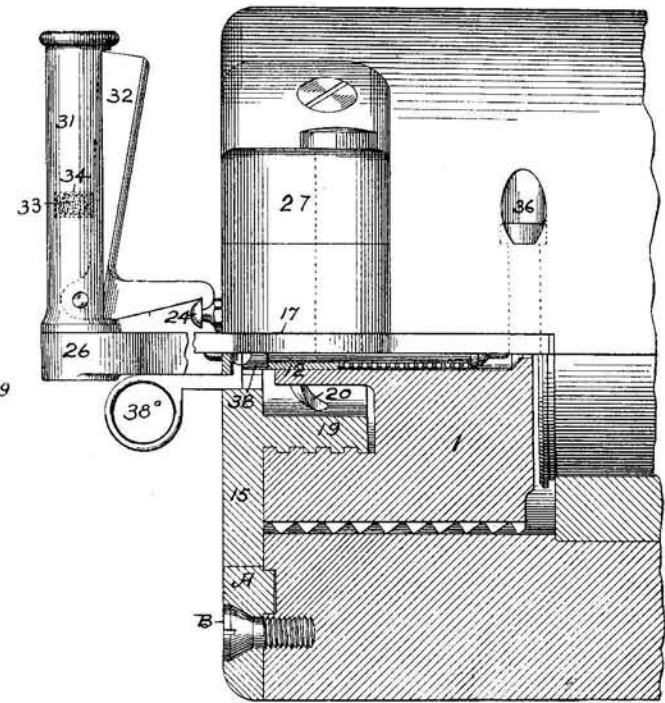
15. The Operation of the Mechanism is as follows: The breech being closed, *to open*, grasp the handle of the operating lever, compressing the upper arm of the lever latch to release the same from the catch on the carrier, then swing smartly to the right until the stop (29) brings up on the right side of the gun. When the lever has swung 61 degrees the rotating teeth have revolved the plug to the unlocked position, the rotation being stopped by the lower edge of the plug's rotating segment striking the end of the circular cut in the screw box, provided as a clearance for it; the plug-retaining catch is now directly in line with the recess in the plug. During the rotation the cocking bar is brought to the



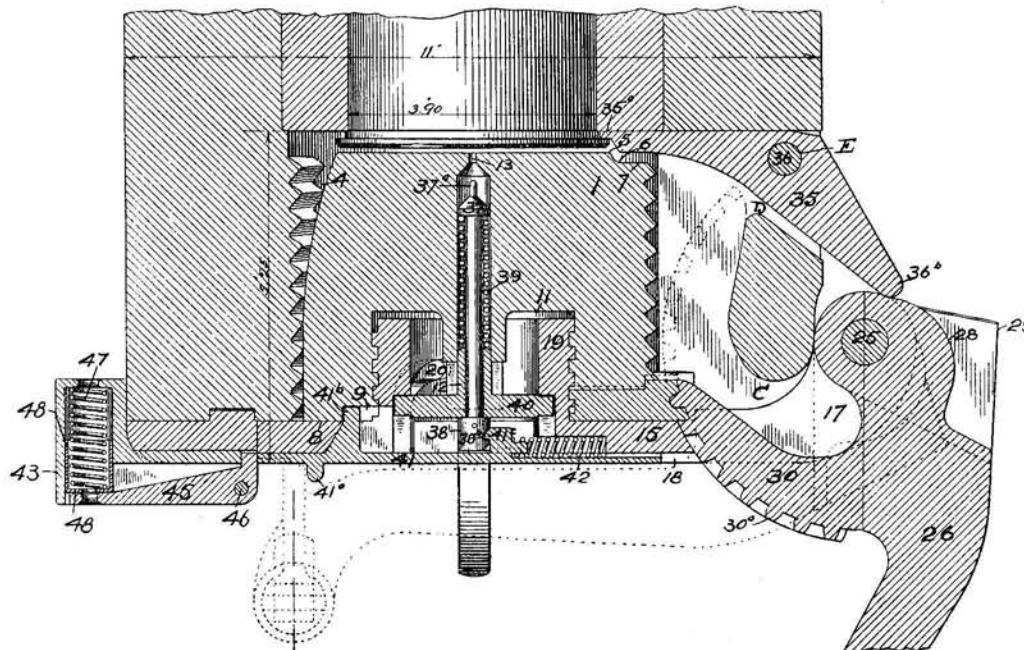
Plug retaining catch.



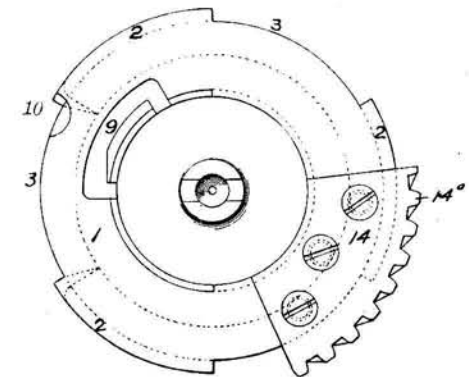
PLUG UNLOCKED



PLUG LOCKED



3-INCH BREECH MECHANISM,



rear through the action of the cam grooves (20), as it is forced to turn with the plug by reason of the guide slots on the plug stem, and with the cocking bar comes the firing pin until the cock notch (38b) engages the nib (41c) of the sear. The further swing of the lever of 100 degrees swings the carrier and plug out from and clear of the screw box, and the moment the carrier leaves the face of the breech the retaining plunger springs into the recess (9) in the plug, locking the latter from movement on the carrier boss. The extraction takes place during the whole of the swing-open movement, slowly at first, then more rapidly.

To close: The reverse movement is given to the operating lever until the lever is folded across the breech and held by the latch. The plug-retaining catch releases the plug the moment it strikes the face of the breech, permitting the plug to revolve to the locked position; during the revolution the cocking bar is moved forward, compressing the firing-pin spring (39). When the breech is fully closed the plug is locked in the screw box, the lever is latched to the carrier, the left end of the sear box is in line with the trigger, and the safety toe (41b) is opposite one of the cuts in the safety groove.

To fire: On pulling the lanyard attached to the outer arm of the trigger the sear bar is moved to the right, releasing the firing pin, which flies forward under the action of its spring and strikes the primer of the cartridge case. The sear spring returns the sear bar to the original position. Should a missfire occur, the firing pin may be recocked by pulling to the rear on the recocking handle.

16. Safety.—(a) Premature discharge is impossible because the firing spring is not compressed and the sear bar cannot release the pin, until the breech is fully closed; (b) the breech will not open at any angle of elevation because of the hand-lever latch, nor can it be accidentally opened; (c) the breech will not open on firing, because of the reverse action of the lever on recoil as well as the natural friction of the plug and spiral threads.

The Mark III 3-inch Breech Mechanism.—(Plate III gives various complete and partial sections. Plate IV shows the entire mechanism dismounted, and Plate V shows the assembled mechanism closed and open.)

17. The Mark III mechanism has little similarity with that of other R. F. guns, but has an operating gear somewhat like the Dashiell system. It is to be noted that: (a) The block is secured to a boss on the carrier as in the Mark II mechanism, and after *rotation* also *swings* open on the carrier hinge pin; (b) the extractor is not a part of the block; it is secured by the carrier hinge pin, but does not swing on it as a center; (c) the cocking and the compression of the firing spring are both accomplished during *opening*.

The principal parts of the mechanism are, the breechblock with rotating, locking and stop studs, the carrier, the operating lever and lock, the extractor and cam and the firing mechanism, (percussion firing only is employed).

18. **The Breechblock** (10) has four threads and four blanks; the blanks are, when the block is locked, at top, bottom and sides. The right and left blanks of the screw box are curved as shown in order to permit *swinging* without *translation*. The breechblock is hollowed from the rear to receive the firing case, and is provided with a suitable bayonet joint in which the corresponding lugs on the firing case lock. On the inner surface of the block is the cocking cam (10 D) seen in projection Fig. 6, Plate III. On the rear face of the block hub is the block safety lug (10 E), seen in Fig. 5, Plate III, and in Plate IV. The threads on the block, seven in number, are blanked to correspond with the threads in the screw box; the rear thread of all is left continuous and acts as a stop thread. A small recess (10 H) is cut in this thread for the block-locking plunger. The block-stop stud (10 B), and block-rotating stud (10 C), are screwed in to the rear face of the block.

19. **The Hinge Plate** (12) is secured to the right side of the gun by four large screws. The hinge pin (17) passes through the upper carrier hinge lug (11 B), the upper hinge-plate lug (12 A), the extractor (18), the extractor cam (19), the lower hinge-plate lug (12 A), the operating lever (16), and the lower carrier hinge lug (11 B).

The *carrier* (11) has on its lower side a transverse horizontal recess (11 D), the rack slot; above the rack slot is the extractor cam seat (11 C) (Fig. 4, Plate III). The carrier is bored through its rear face at a point concentric with the bore of the gun

FIG. 1

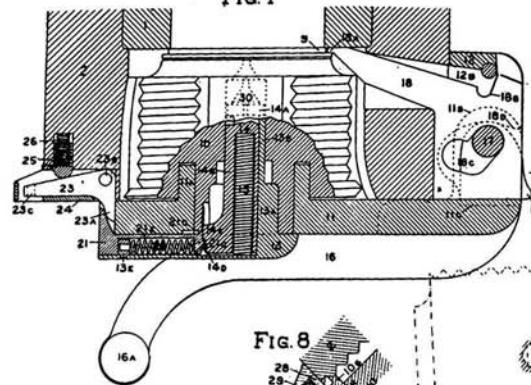


FIG. 2

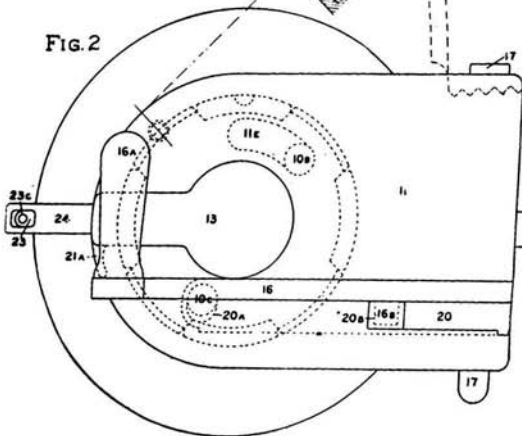


FIG. 8



FIG. 3

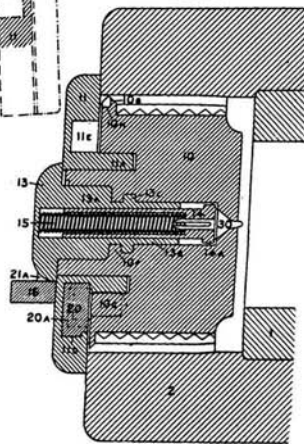


FIG. 5

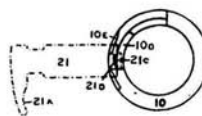


FIG. 6

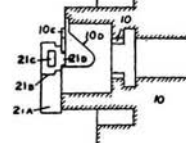


FIG. 7



FIG. 4

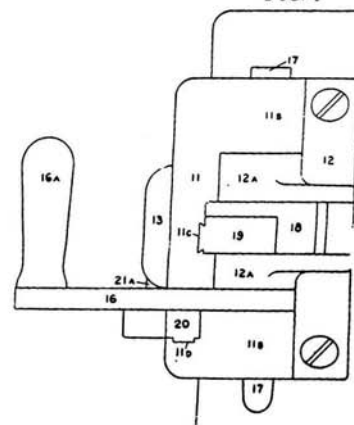


Fig. 1.—Horizontal section through center of breech of gun, and a partial section of the breechblock.

Fig. 2.—Rear elevation of breech.

Fig. 3.—Vertical longitudinal section through center of breechblock.

Fig. 4.—Side elevation of breech mechanism.

Fig. 5.—Outline sketch of rear elevation of sear and hub of breechblock.

Fig. 6.—Side elevation of same.

Fig. 7.—Vertical transverse section through bayonet lugs of firing case and through firing pin.

Fig. 8.—Longitudinal section through center of block-locking plunger. This section is inclined 45° from the vertical.

Fig. 9.—Breech open.

to receive the breech-block hub, and has on its forward face a boss (11 A) which assembles in a corresponding annular recess in the rear face of the block. On the rear face of the carrier and to the left of the hole for the breechblock hub is a shallow clearance cut for the sear safety lug; this cut is seen to the left of (21 D) (Fig. 1, Plate III). On the left side of the carrier is a longitudinal slot in which the toe of the sear rests (see Plate IV). On the forward face of the carrier is the block-stop slot (11 E) and in the upper left hand side, a seat in which rests the locking bolt (11 F); this bolt, pressed forward by its spring, drops into a recess in the block as the unlocking is completed.

20. The Operating Lever (16) is a long arm, without a handle-locking device, pivoted on the hinge pin in a slot in the lower part of the carrier; it has a stud (16 B) on its lower side which operates the rack. The rack (20) is attached to the breechblock by the stud (10 C) which works in a slot (20 A) in its left end by which, when the rack is moved to the right or left, the block is rotated.

21. The Firing Case does the double duty of containing and guiding the firing mechanism and of securing the block to the carrier. The head of the case is made large to give it a bearing on the carrier; it passes through the latter and, engaging the bayonet joint of the block, locks the two firmly together. (Since there is no screw thread action in this device the carrier will move up to or away from the gun as the block is rotated.)

The *firing case* (13) is a stepped cylinder, hollowed out to receive the firing pin (14) and the firing spring (15). On its rear end it has a projecting lug which is slotted to receive the sear (21); the cylindrical portion is slotted for the firing-pin guide rib. On the stem of the case are two bayonet lugs which serve to lock it to the block; in the sear slot there is a lug which furnishes a bearing for the outer end of the sear spring (22).

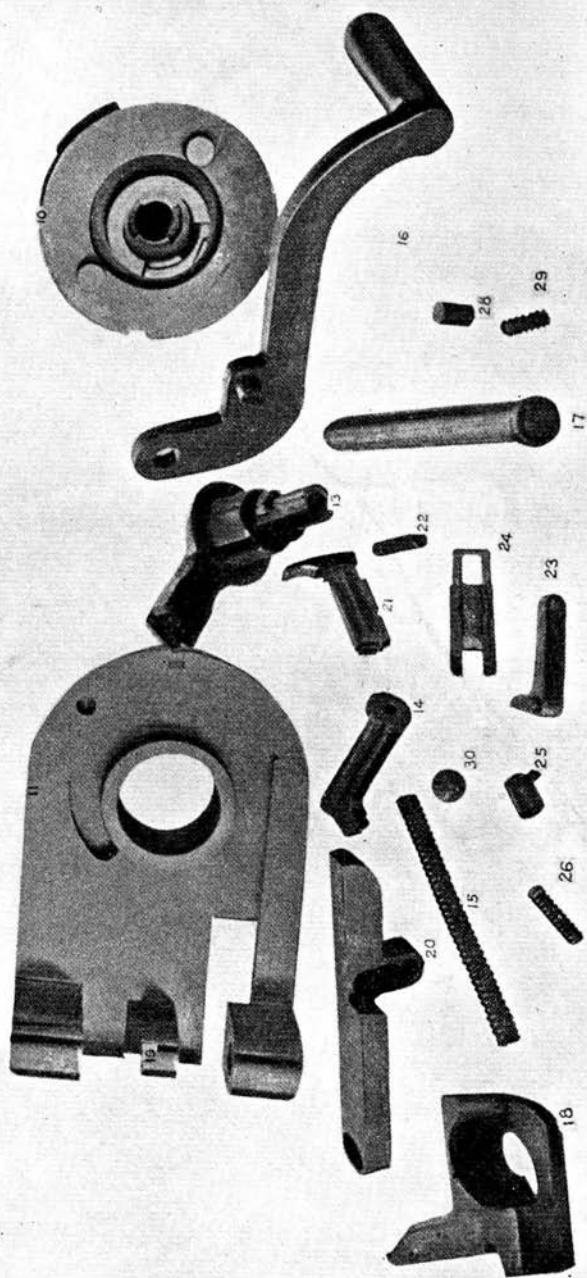
The firing pin (14) is a hollow cylinder, partially closed at its forward end and having a guide rib (14 B); this guide rib, toward its rear end, projects into a lug on which is the cocking-lug (14 C) and the cock notch (14 D). The firing point (30) has a split shank and is assembled with the firing pin by simply pushing the shank into the firing-pin head (14 A). The firing spring (15) is spiral;

its forward end abuts against the forward end of the cylindrical recess in the firing pin, its after end abuts the after end of the firing-pin recess in the firing case.

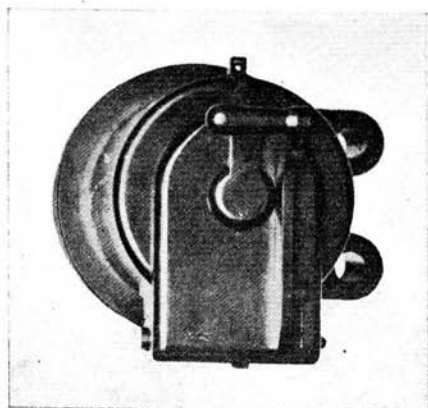
The sear (21) is shaped to travel in the sear slot in the firing case. It is hollowed out to receive the sear spring (22), one end of which abuts against the lug in the firing case, as before described, and the other end of which abuts against the inner end of the sear-spring recess in the sear. The sear-guide ribs (21 B) travel in corresponding ways in the firing case, and prevent the displacement of the sear. On the inner forward side of the sear is the sear safety lug (21 D) which, when the block is not completely closed, engages the block safety lug (10 E) (Plate III, Fig. 5), and prevents the sear from being withdrawn far enough to release the firing pin. The sear cock notch (21 C), the sear toe, which engages the trigger toe (23 A), and the sear finger catch are plainly shown in the plates. The firing case is inserted at an angle of 90° to its final position, pushed in until the bayonet joint "takes" and then turned to the left until its toe snaps into the slot in the edge of the carrier.

22. The Extractor (18) is best shown in Fig. 1, Plate III, and in Plate IV. The hinge pin passes through the extractor guide slot (18 C); the under side of the extractor, contiguous to the extractor guide slot, is cut away to the extractor cam surface (18 D). On the forward side of the extractor is the extractor pivot groove (18 B). The *extractor* cam (19) is shown in Plate IV assembled with the carrier; it is held in place by the hinge pin which passes through it. It has no motion relative to the carrier, and its outer surface bears against the extractor cam surface.

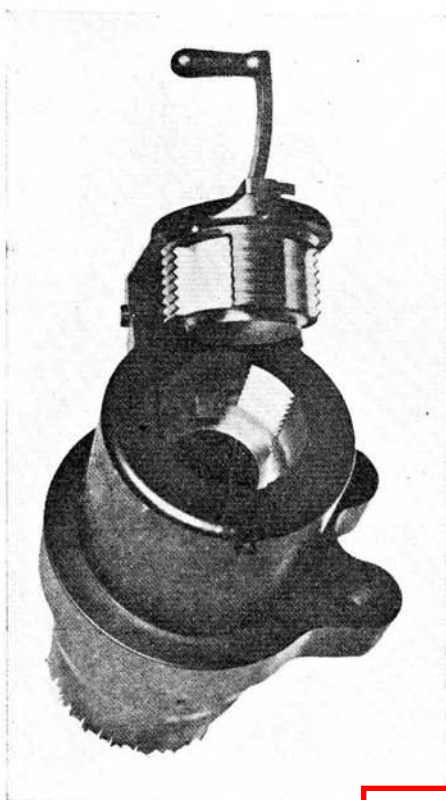
23. The Operation of the Mechanism is as follows: *To open:* The gun having been fired, the first movement of the operating lever causes the operating lever rack stud (16 B) to press against the corresponding slot (20 B) in the rack and produce a movement of the rack to the right. The rack being in engagement with the block-rotating stud, the block rotates until the block-stop stud (10 B) brings up against the end of the block-stop slot (11 E), so that the block can rotate no farther; the rotation of the block is to the left and about the firing case, which remains rigid with the carrier. The cocking lug on the firing pin lies, during the rotation



PARTS OF MARK III 3-INCH BREECH MECHANISM.



REAR END OF GUN, BREECH CLOSED.



REAR END OF GUN, BREECH OPEN.

of the block, against the cam on the inner surface of the block hub. The rotation of the block, therefore, carries the firing pin to the rear, compressing the firing spring and camming out the sear until it engages the firing-pin cock notch (14 D) (Fig. 1, Plate III). After the rotation of the block is arrested, the further movement to the right of the operating lever causes the carrier, and with it the block and firing case, to swing clear of the breech.

As soon as the carrier leaves the breech, the block-locking plunger (28) (Fig. 8, Plate III) springs into the recess in the block-stop thread and locks the block against rotary movement until the carrier is again swung to.

As the carrier revolves away from the breech end of the gun, the extractor cam, working on the cam surface of the extractor, causes the outer end of the extractor to move forward. The extractor then acts with great leverage on the cartridge head, the fulcrum being the forward inner edge of the extractor mortise (see Fig. 1, Plate III). The carrier swinging still farther to the right, the outer end of the extractor is pushed so far forward that the fulcrum shifts to the extractor pivot (12 B). This results in less leverage and more velocity on the nib of the extractor; the final movement of the extractor nib is its swiftest movement and results from the shape of the extractor cam 19.

To close: The first movement of the operating lever to the left swings the carrier to until the stop thread of the block brings up against the first thread of the screw box. The block-locking stud at the same time strikes the edge of the screw box and is forced to the rear, releasing the block. A further motion of the lever will now rotate the block until the block-stop stud reaches the other end of the slot and the block will be in its locked position with the sear engaged with the trigger. (The trigger and its box are similar to that of the Mark II mechanism except that the motion of the sear in firing is *outward*.)

24. Safety.—Premature firing is impossible because: (a) The block safety lug (10 E) lies to the left of the sear safety lug, preventing release of the firing pin by any cause, and the sear is not engaged with the trigger, until the plug is locked. (b) If, through the breaking of the sear cock notch, firing-pin cock notch, or either of the safety lugs, before the breech is fully closed, the firing pin

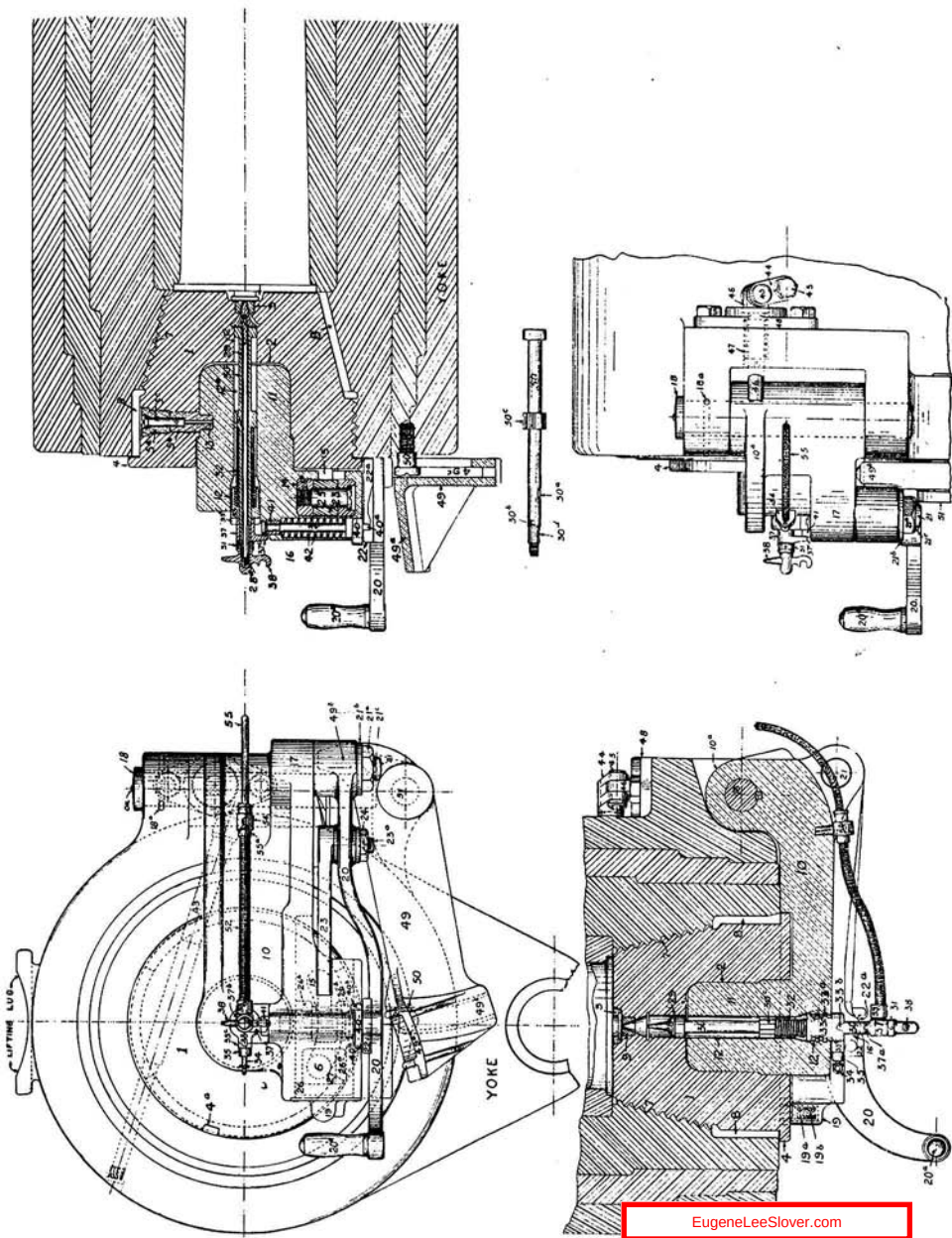
is released, the firing-pin cocking lug (14 C) will bring up on the cocking cam (10 D) before the firing point touches the primer.

25. The English-built cruisers "Albany" and "New Orleans" at present are armed with Elswick 4.7-inch and 6-inch R. F. Guns. Their breech mechanisms are operated in a manner which to some extent resembles that of the 3-inch Mark III described above. The system is briefly described as follows: (See Plate VI.) The conical breechblock is supported by and turns on a forward projecting circular boss of the carrier, the plug being recessed for the purpose. The carrier is hinged to the right side of the gun. A guide-bolt stud passing through the plug into a groove in the boss prevents the plug from coming off and limits the rotation.

A horizontal hand lever having a handle on the left end is hinged at the right end by a vertical pin to a lug on the carrier. In a transverse slot in the carrier beneath the boss slides a block, in which fits a rear projecting "rotating pin" on the rear face of the plug. The block is connected to the hand lever by a short link, called the "rotating link."

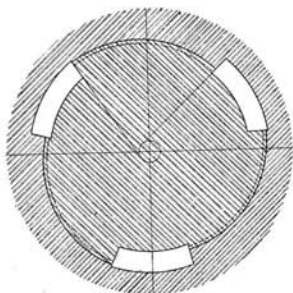
The breech being closed, by pulling the hand lever to the rear, first, the rotating link pulls the sliding block to the right, and thus revolves the plug on the carrier's boss to the unlocked position, the revolution being stopped by the plug's guide bolt; second, the center of movement is now transferred to the carrier's hinge pin and the plug and carrier then swing out clear of the screw box on the hinge pin as an axis. At the moment the carrier clears the breech face of the gun, the plunger of a spring catch, contained in a box on the left side of the carrier, is freed and the latch enters a cut in the plug rim, preventing any revolution of the plug in the carrier while out of the screw box.

26. The cruiser "Baltimore" is to be armed principally with 6-inch R. F. guns constructed by the Bethlehem Steel Co. The breech mechanism, called the Bethlehem Breech Closure, employed in these guns, is operated by a gear somewhat similar to that of the 3-inch Mark III mechanism. The breechblock, as in the Vickers' mechanism, has a holding surface comprising about two-thirds of the circumference, and it is slightly coned to facilitate swinging without translation. The blank portions of plug and screw box are cylindrical, but the threaded portions are involutes



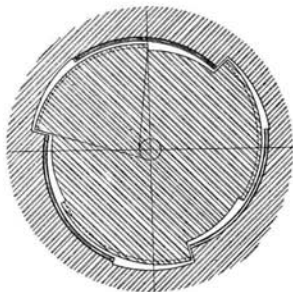
ELSWICK BREECH MECHANISM.

of circles which insures a firm and even contact. The threads have no pitch, or are collars, and hence give no motion of withdrawal to the block while rotating; this motion is obtained from the form of thread on the hub of the carrier by which the block is secured. This is possible only because the collars begin to disengage as soon as they start to revolve and may move to the rear



BREECH CLOSED.

Collars on Block and Gun Engaged.



BREECH OPEN.

Block Free to Swing.

slightly even when the unlocking is only begun; this feature should also eliminate much friction and make rotation easy. An advantage claimed for this form of block is that it has no tendency to unscrew with ordinary or even excessive powder pressures; this is evidently the case since the normals to the threads are parallel with the axis of the bore and there can be no rotating moment.

CHAPTER X.

THE DRIGGS-SCHROEDER R. F. BREECH MECHANISM.

1. The Driggs-Schroeder mechanism belongs to the rotary block system of breech closure in which the block rotates on a horizontal transverse axis, the upper part of the block falling to the rear; a slight vertical motion is required in locking and in unlocking, in which respect the system is the same as that of the sliding wedge.

The Driggs-Schroeder mechanism is used in the service in 1-pounder, 3-pounder, 6-pounder, and in two 4-inch R. F. guns, all of which use the service ammunition. As all secondary battery guns to be built in the future will be of the semi-automatic or automatic type, no more D.-S. guns are being constructed. There are three marks; the first two differ considerably, while Mark III differs from Mark II only in the operating lever. All three are shown on Plate I.

The principal parts of the mechanism are: the breechblock; the guide bolts; the axial bolt and main cam; the operating lever with its locking device; the extractors; and the firing mechanism.

2. **The Breechblock** (1), an irregularly shaped piece of steel, houses in the rear end of the gun's jacket, which is open at the rear and the under sides only; the sides of the housing, called the curtains, extend downward and terminate in the plug rest (23). The locking is effected and the shock of discharge taken by the engagement of the bands (1 A) in corresponding grooves in the sides and top of the housing. The bands of the plug and the grooves of the jacket are inclined about $2\frac{1}{2}^{\circ}$ to the front so that as the block is pushed up into position in locking it is also pressed forward, forcing the cartridge case home, and in unlocking it readily detaches itself from the case. The top of the innermost band is sloped away in order that the block may unlock and swing backward with a minimum of downward motion. The firing pin

recess (1 D) is mortised out from the front and below, and, connecting with it by a narrow groove, a cavity is cut in which the main cam (9) operates; the surfaces (1b) on which the cam bears, are essential to the operation of the block, as is the rounded portion (2); (1c) is a three-cornered piece of steel riveted in place and the cam bears on its upper surface during the first step in unlocking.

The front face of the block is closed by the dove-tailed face plate (3); in the Mark I mechanism it is retained in place by the screwed plug (4); in subsequent marks the straight sear spring (21), being inserted from the front through block and face plate, serves as a face-plate keeper as well as a sear spring. The sear (19) works in a vertical slot in the rear face of the block which in the Mark I mechanism also affords a recess for the *spiral* sear spring (21). The *guide bolts* (8) are screwed through the curtains of the breech and their ends take in the guide-bolt grooves (1g) of the block; these grooves are cammed surfaces so shaped that the guide bolts give proper direction to the motion of the block induced by the main cam; in most mechanisms the grooves are continued to the front of the block (as shown in Mark II), and in no case do the guide bolts retain the block in place in the gun, that being a function of the axial bolt; in the Mark II type and in many of the Mark I mechanisms the block may be dismantled without screwing out the bolts.

3. The Axial Bolt (5) is cylindrical except for the hexagonal portion that engages the main cam—the right end of the bolt is of greater diameter than the left end. The bolt passes through both curtains of the breech and through the block; the hole in the latter is lengthened in a nearly vertical direction to permit the block to descend in unlocking. The main cam (9), an irregularly shaped piece of metal, rotates with the axial bolt; its working surfaces are on its rear and upper sides and the notch (9b) catches the rounded portion (2). The top is slotted out to form a cammed groove which presses the firing pin rearward by acting on its projecting portion (15b).

4. The Operating Lever (7), on the left of the breech, differs in the three Marks, in its locking device; in Marks I and II, it has from the closed position a slight free motion before the axial bolt starts.

In the Mark I device, the lever-locking piece (11) is secured to the left curtain of the gun; it contains the locking pin (12), with its head (12b) and lug (12a), all pressed inward by a spiral spring. The operating lever, with (10), is secured to the axial bolt by a split pin (6); the lever has a little lost motion in (10) but the latter is however rigidly held to the axial bolt by a feather. When the breech is closed, the end of the locking pin rests in a recess in (10) and the bolt cannot be rotated except by its lever, the tail (7a) of which must first disengage the locking pin by pressing outward on (12a). In closing, the pin is snapped into place in a similar manner and the lever is brought up by its stop (10b); the weight of the lever in all Marks aids in retaining the breech closed.

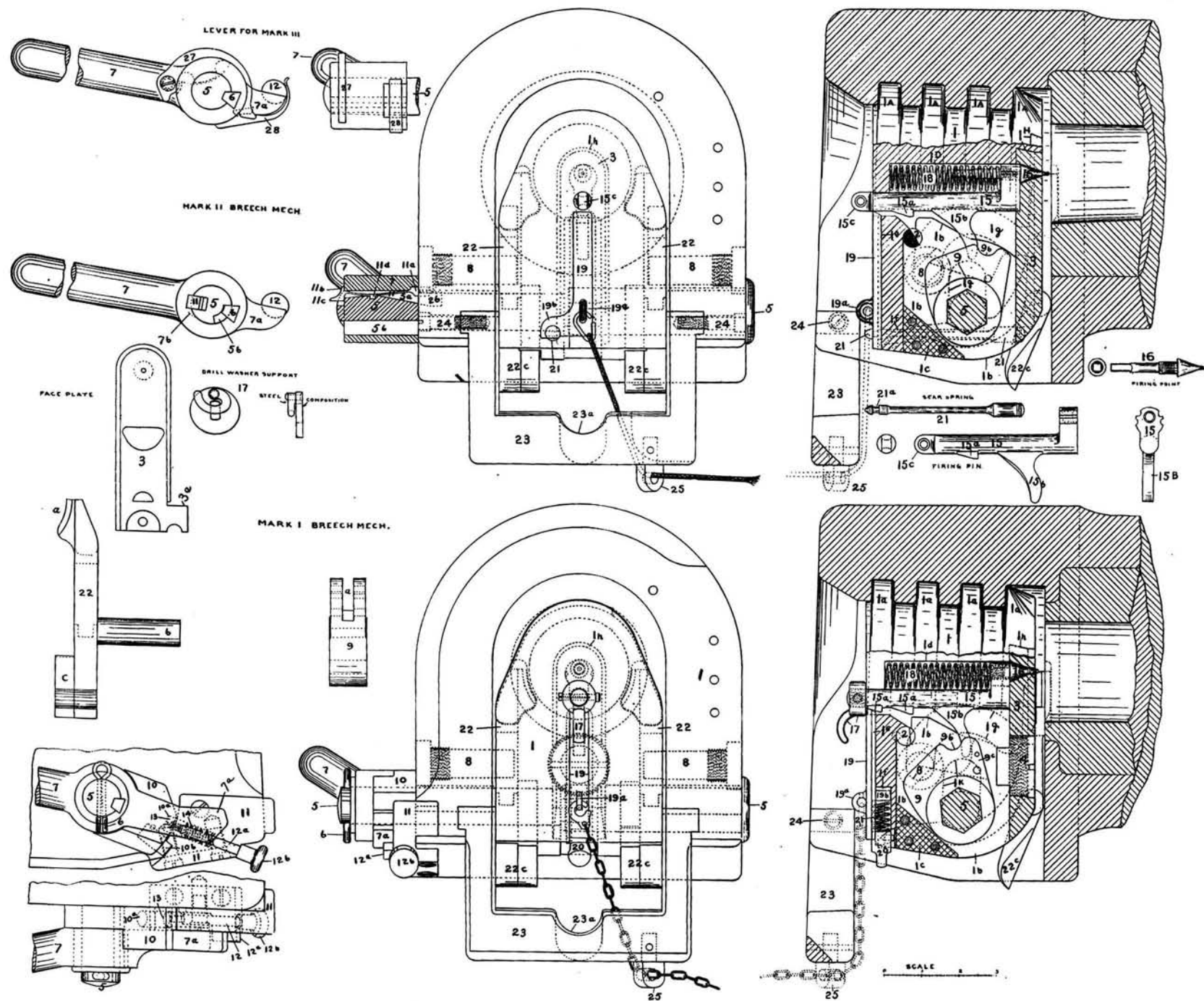
No locking device is employed on the Mark II operating lever which, in place of a split pin, is secured by a spring catch (11) lying in a recess in the axial bolt; as far as (11) is concerned the lever turns freely on the bolt, but the feather (6), working in a slot wider than itself, limits the scope of this free motion. The lever is brought up when the breech is closed by the stop (12) which is screwed into the curtain.

The lever of the Mark III mechanism is keyed to the axial bolt without lost motion and is secured by the lock (27) which snaps over the hub of the lever and enters a slot in the end of the axial bolt. The locking device consists simply of a spring (28) secured to the hub which slips over the stop (12).

5. The Extractors (22), pivoted from the inside to the curtains of the breech, rest, when the breech is closed, with their upper ends grasping the rim of the cartridge case; their lower ends (22c) are so formed that, as the breech is opened, the lower side of the block will cause them to move forward at first slowly then abruptly, whereupon their upper ends will forcibly eject the case from the gun. One extractor will as a rule eject satisfactorily when it becomes necessary.

6. The Operation of the mechanism, not considering the firing mechanism, is as follows. (The description is given for the Mark I mechanism from which later Marks may be readily understood.)

Opening, in which the weight of the block materially assists: The operating lever having free motion, its first movement unlocks



the axial bolt and main cam which it then rotates. As the main cam moves rearward, its upper corner leaves the surface (1b) by which it had held the block upward; then the cam's rear surface presses downward on (1c) and the block drops downward, freeing the bands. This vertical motion is stopped by the axial bolt, the guide bolts change it to a rotary one and the cam engages (2) and presses it rearward until the block lands in a horizontal position on its rest (23). The lower side of the block is slightly eccentric with the bolt and during the latter part of opening it cams the tails of the extractors forward at first slowly and with great leverage, starting the case from its seat, then more quickly, causing complete ejection.

Closing, in which the weight of the block is raised: The cam being still engaged with (2) and the rear part of the surface (1b), which has followed it down, as the lever is thrown forward, the block is rotated until it strikes the cartridge case and forces it, with the extractors, nearly to its seat; at this moment the guide bolts reach a vertical (nearly) portion of their grooves and the rotary motion is changed to a vertical one. The cam now leaves (2) and its upper corner follows along the surface (1b) and presses the block upward until locking is effected. During the last part of the cam's rotation its upper corner moves along a part of (1b) which is concentric with (5); no motion of the block results from this but the upper corner of the cam is brought forward of the center of rotation and the weight of the block then tends to force it still farther in the same direction. This provision, added to the weight of the operating lever, its inertia in recoil and its locking device, if used, effectually prevents the breech from being opened by other means than the operating lever.

7. The Firing Mechanism consists of: the firing pin with firing point and support; the firing spring; the sear and firing lanyard; and the sear spring. The firing pin (15) is inserted from the face of the plug into a recess in which it operates; it projects through the rear of the block. The firing point (16) is screwed to a lug on the end of the firing pin and the firing spring lies in a recess directly in rear of it. The cocking notch (15a), (there is a half cock notch in the Mark I mechanism), is on the under side of the pin and the tail (15b), by which the mechanism

is cocked, projects downward and bears on the main cam. A thick rubber "drill washer," designed to receive the blow of the firing pin in exercise, is secured to the firing pin by the drill washer support (17). In the Mark I mechanism, the support is left on in firing and a finger catch is added for convenience in easing down the firing pin and recocking. In later Marks the support is removed before firing and a hook from the accessory box must be used if the firing pin is to be handled while the breech is closed. The sear (19) is a thin bar working in a dovetailed groove in the rear face of the block. The firing lanyard hooks to an eye (19a) on its surface, thence passes through the leader (25) to the trigger on the shoulder stock. The sear spring of the Mark I mechanism is spiral and is compressed between a plug (20), closing its recess, and the lug (19b) of the sear. The sear spring of the later marks, serving also as a face-plate keeper, is a slender rod inserted from the face of the block and bearing on an extension (19b) of the sear.

The cocking of the mechanism is accomplished while the block is being unlocked; the main cam, by a cammed groove cut in its upper end, presses the firing pin to the rear by the projection (15b) until the sear snaps over the notch (15a). The firing point is drawn inside the face plate and the cocking nearly completed before the block starts downward.

Safety.—Although the firing pin is cocked and the firing spring compressed before the breech is closed, a premature discharge with D.-S. mechanism is impossible because: (1) The main cam is in a position to arrest the blow of the firing pin, until the locking is completed. (2) Even if the firing pin be sprung forward or be projecting its point through the face plate during closing, because of an injury, or other reason, it is impossible for it to strike the primer, as its point is not in line with it until the block is very nearly locked. However, it is possible to swing the block upward forcibly enough to give the base of the cartridge a severe blow that might explode the primer by concussion.

8. The following advantages are claimed for the D.-S. mechanism over other R. F. breech mechanisms.

(a) The lightness of the mechanism and the rotary system of operation conduce to a greater rapidity of fire; it also permits a

greater length of bore for the same weight which results in greater muzzle velocity.

(b) One man is able to load and at the same time operate the block; for this purpose the lever is placed on the left side and the loading operation does not obscure the gun pointer's view of the sights.

(c) There is no opening in the top of the breech through which rain and dirt may enter the mechanism.

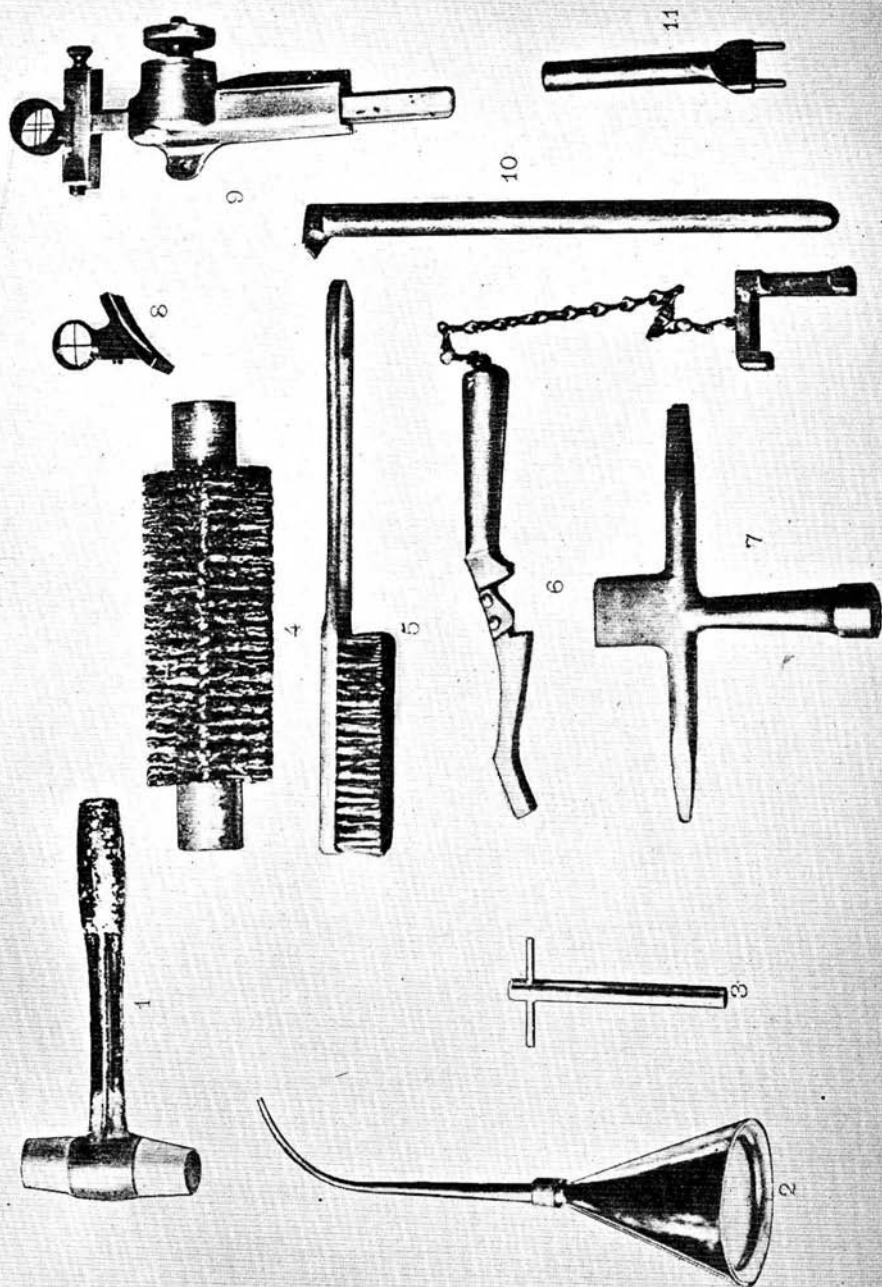
(d) With the breech open as well as with it closed, the block and entire mechanism, save the lever, remain within the curtain and are entirely protected.

9. Plate II shows the Mark I mechanism disassembled. Plate III shows the construction of a D.-S. gun and its drill cartridge. Notes on dismounting and assembling and hints on the care and handling are given in the Gun and Torpedo Drill Book (Edition of 1900, pages 54 and 115-118 inclusive).

An *accessory* box is furnished with every pair of guns and contains the following:

Accessories.—Hand extractor, combination screw driver and wrench, babbitt-metal mallet, face-plate drift, oil can, firing-pin wrench, cleaning brush, bristle-bore brush, block support, drill washers and, for Marks II and III guns, a hook for handling the firing pin.

Spare Parts.—Firing pin, firing springs, right and left extractors, sear, sear springs and a set of gun screws. (Plate IV shows the sights and accessories for a Mark I gun.)



SIGHTS AND ACCESSORIES FOR MARK I DRIGGS-SCHROEDER GUN.

1. Babbitt Mallet. 2. Oil Can. 3. Firing Pin Wrench. 4. Sponge Brush. 5. Cleaning Brush. 6. Block Support. 7. Combination Screw-Driver. 8. Front Sight. 9. Rear Sight. 10. Hand Extractor. 11.

CHAPTER XI.

HOTCHKISS BREECH MECHANISM.

1. **The Hotchkiss Breech Mechanism** for rapid firing guns belongs to the sliding-wedge system of fermeture—the block or wedge is lowered to open the breech. This mechanism is very generally used for United States naval guns, being employed in the 1-pounder, 3-pounder, 6-pounder, 9-pounder and 14-pounder calibres. The mechanisms of these various sizes differ in the details—the two 9-pounder, the three 14-pounders and many guns of the other calibers having been purchased from French and British firms. However, there are but two standard navy types—Marks I and II; the latter, which has spiral instead of flat springs, is often called “the 1893 model.” The mechanisms for 3-pounder and 6-pounder guns are in all respects similar in their working parts except as regards size; that for 1-pounders has minor differences which will be described. Since secondary battery guns to be built in the future will be semi-automatic, the construction of Hotchkiss mechanisms of the ordinary R. F. type is discontinued, but the system is readily adapted to work semi-automatically as will be described in a subsequent chapter.

The principal parts of the mechanism are: the block; the crank with crank stud and operating handles; the stop bolt; the extractor; and the firing mechanism consisting of hammer, rock shaft, firing point, firing spring, sear and sear spring.

2. **The Hotchkiss Mechanism for 6-pounder R. F. Guns, Mark I (Plate I).**—**The Block** (1) is a rectangular wedge-shaped piece with rounded corners, hollowed out to contain the firing mechanism, that moves vertically in the breech mortise of the gun, being guided by a groove (4) on each outer side working on ribs in the sides of the mortise. These ribs are slightly inclined, upward and to the front. The front face of the block is perpendicular to the axis of the gun, while the rear face is inclined down-

ward and to the rear, so that in opening, the block has a slight movement to the rear, and, in closing, to the front, thus giving great power in the first part of extracting or last part of loading. The upper side is hollowed out to uncover the bore in opening, and to form a loading trough; and the front upper edge is beveled to facilitate pushing the cartridge into the chamber. On the right side, in a nearly fore and aft direction, is cut the "crank slot" (2), a groove running out to the front face of the block; the front part is concentric with the crank stem, while the remainder is cammed. On the left side is the vertical (nearly) "stop-bolt groove" (5), in which the end of the stop bolt engages, to guide the block and prevent its dropping out of the gun in opening, and the "extractor groove" (3), the lower part being inclined upward and to the rear, while the upper part makes a sudden turn to the rear. On the front face is a dove-tail groove, for the "face plate" (6). When the block is closed its rear face fits tightly against the rear face of the breech mortise, removing all strain from the guide ribs on firing. The *recoil or face plate* (6) is a hardened steel plate, dovetailed from the bottom into the front face of the block and held by two screws (7). It covers the bore of the gun when the block is held up, and takes the direct recoil of the cartridge. It is pierced with a hole for the firing pin's point that is in the axis of the gun when the breech is closed.

The *stop bolt* (31) is a threaded bolt which screws through the left cheek of the mortise. Its inner end works in the vertical groove (5) on the left face of the block, and prevents the latter from dropping out of the mortise. The outer end is shaped into a rectangular head, which bears against the gun when screwed up. A hole through the head is used for the dismounting pin. This bolt was made of sufficient length to pass through the "stock handle" on the non-recoil-mounted guns.

3. The *Crank* (8) is in one with the crank stud (9) and stem (10). It is worked by the crank handles and is journaled in the right cheek of the mortise. The arm lies within the mortise and a stud in the end works in the crank slot of the block and gives to the latter the vertical drop (or lift) movement. The stud is flat on top to prevent undue wear, and, when the breech is fully closed, lies past the center of movement and supports the block.

The crank handles (11), or *operating levers*, (two in number in one with a boss) and a toe are carried on and keyed to the crank stem outside the gun and are secured to it by the lock (13) which is pivoted to the boss at one end and snaps down over it, engaging a recess in the crank stem. A split pin lock is employed in some of the earlier guns. The toe (12), known as the "cocking cam," projects downward and to the rear, and bears on the rocking shaft or "cock toe," when the hammer is not cocked. Thus the movement of the handles to the rear will in the first place result in cocking the hammer, while the continued motion lowers the block. A flat spring with a rib on the inner side, called the "crankhandle spring catch" (14), is held by a screw in a groove on the inner side of the cocking cam. When the breech is closed this spring latch seats itself in a small hollow in the cheek of the gun and holds the handle in the locked position. It requires a deliberate movement of the handle to the rear to unseat the latch.

4. The Extractor (28) is a straight flat bar, shaped on its upper and lower edges to slide in a longitudinal T-shaped groove in the left cheek of the gun's mortise. The forward end is bent inward to form a claw or "nib" (29) to take under the lip of the cartridge case. On the inner side is a beveled "stud" (30) that travels in the extractor groove (3) of the block, by which a fore and aft movement is given to the extractor, when the block is moved up or down. The stud keeps the extractor in the gun.

5. The Firing Mechanism.—The hammer (15), of the old gun-hammer style, is in one with a hollow shaft (16) or axis. It is mounted in the middle line of the block's cavity on the "rock shaft" (21), and is actuated by the latter, working freely in the block's cavity. The firing point is made detachable, but was formerly in one piece with the hammer. A cock notch is provided on the axis for the "sear."

The stirrup (19) is hinged to the hammer axis, front side, in the center line, and is provided with an arm on each side to form a rest for the end of the lower branch of the "main spring," which is split. Part of the stirrup, of segment shape, normally projects through a slit into the hollow of the hammer axis, fitting in a slot (23) on the rock shaft to lock together the hammer and shaft and prevent the latter from coming out. This locking is in effect

as long as the main spring is in place holding the stirrup in the proper position.

The firing pin (20c) is a conical point with a split shank (a) forming ears (b) which fit over a groove in the front end of the hammer, and is held in place by the spring action of the ears. Thus a new firing point can readily be put in place in case of breakage.

The rock shaft (21), a transverse horizontal shaft, carrying on its right end the "cocking toe" (22), journals in the lower forward part of the block, and, where passing through the hammer axis, is made hexagonal. The toe, being pushed downward by the cam (12) on the operating handle, turns the shaft to the rear about its axis and hence moves the hammer to the rear, (cocking it over the sear), and compresses the main spring.

The main spring (24) is a double-branched flat spring, more or less V-shaped, the bend seating in a rest in the middle of the block, the open end forward. The end of the upper branch is shaped into a roll seating in the after side of the hammer axis in a jog (18) while the lower branch's end is split and rounded out to pass over the arms of the stirrup forward of the hammer axis. When so placed, with the hammer forward, the spring is in slight tension, which keeps it in place. On moving the hammer to the rear, the two branches of the spring are brought together, which gives the force or tension to throw the hammer forward about its axis when released.

The sear (25) is a small thin bar of steel pivoted on a stud (26) in the right forward corner of the block's cavity, and has a rib or claw which engages the cock notch on the hammer axis when the hammer is drawn fully to the rear. The after end of the sear projects slightly to the rear of the block, where it is engaged by the trigger arm. A small groove on the lower face forms a seat for the front end of the sear spring.

The sear spring (27) is a thin bar seating in a dovetail in the lower face of the block. The forward end is thinned and bears on the sear to keep it in position to hold the hammer cocked.

The trigger (32).—A bronze "pistol grip" (33), secured to the rear of the gun on the right side, carries a loose trigger (32) (viz., one without a spring), which is a bell crank pivoted at the

bend. The front end is in contact with the sear when the block is closed, while the rear end projects downward to form a finger grasp, which, if pulled to the rear, results in forcing down the sear to release the hammer, and thus fires the gun. On guns beyond No. 53 the pistol grip with loose trigger is replaced by a "trigger box" (38), secured to the gun by one long and one short screw, which contains a trigger pull (35) actuating a trigger lever (36) which bears on the sear. The lever has a flat spring (37), the rear end of which bears on the hub of the trigger, with a little boss that takes in a cut in the trigger when it is desired to turn up the latter for safety.

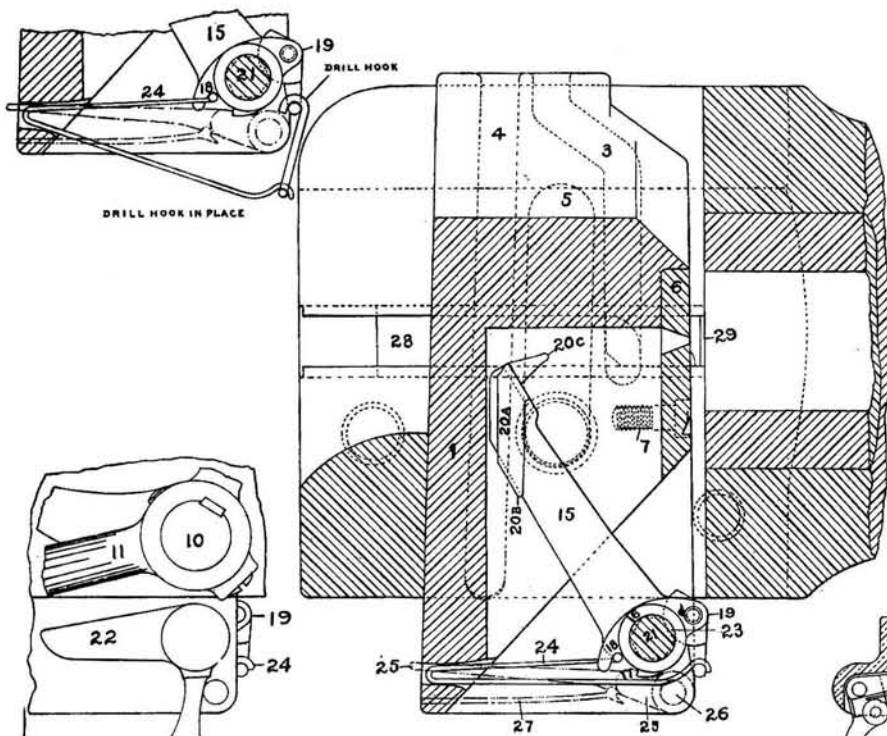
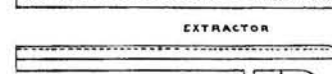
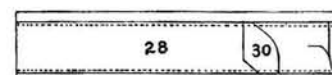
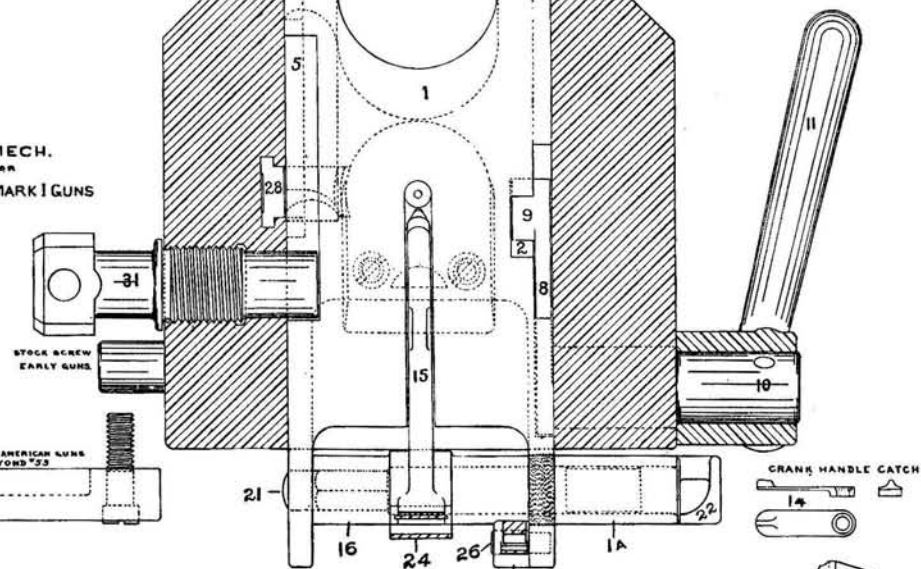
On recoil-mounted guns a lanyard is attached to the trigger, going through a hole in handle of pistol grip, if provided.

6. The Drill Hook for the Mark I 6-pounder and 3-pounder Hotchkiss Breech Mechanism is made of round wire, open at the top, the arms being bent to form hooks. It is designed to relieve the mechanism from strain when snapping the gun on drill; to protect the point from being injured by its shoulder striking heavily on the face plate, which tends to crystallize the metal; and to relieve the main spring from strain on ordinary occasions. It hooks to the stirrup and the lower branch of the main spring, which is unshipped from the stirrup. On "casting loose" for actual firing, the drill hook is removed and main spring hooked to stirrup. For subcalibre practice, however, the hook is left on, as the blow of the firing pin will be sufficiently strong.

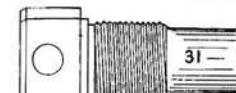
7. The Action of the Mark I Breech Mechanism is as follows (suppose the gun fired and an empty case in the chamber):

Opening.—The breech is opened by pulling the crank handles to the rear. The crank stud moves to the rear in the groove, the block descends by the cam action of the inclined part of the groove and by its own weight, until arrested by the stop bolt, when the bore of the gun is completely unmasked.

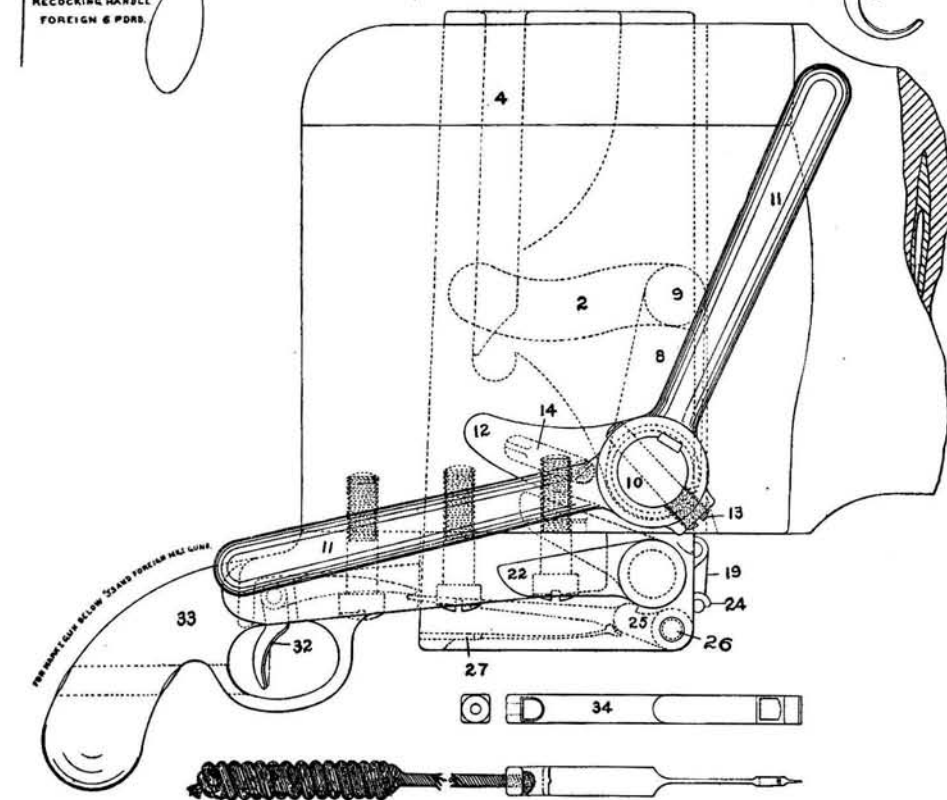
Cocking.—As the crank begins to move to the rear, its stud first passes over that part of the groove which is concentric with the crank stem; hence no motion results to the block. But during that period the cocking cam bears down the cocking toe, turns the rock shaft to the rear about its axis, and cocks the hammer, which is held cocked by the cock notch being engaged in the sear. The main spring is also compressed at the same

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Extraction.—As soon as the block begins to descend it moves slightly to the rear, due to the inclination of the guide ribs; hence the extractor moves slowly to the rear with great leverage and the case is started from its seat. When the block has descended sufficiently to unmask the bore, the abrupt change of the extractor groove to the rear gives a violent motion to the extractor which ejects the cartridge case.

Loading.—The cartridge is entered in the chamber until the rim of the case strikes the extractor's nib. On closing or raising the block, the beveled upper corner shoves home the cartridge and the extractor moves to the front.

Closing.—The breech is closed by moving the crank handles forward. When closed, the crank bears against the face of the gun tube, beyond the center of motion, and its stud supports the weight of the block. The face of the block now bears closely against the head of the cartridge.

Firing.—The breech being closed, the cocking cam and cocking toe are separated. By pulling the trigger (or lanyard attached to it), the trigger arm bears down on the rear projecting end of the sear and releases it from engagement with the hammer, which now flies forward under the action of the compressed main spring; the firing point, passing through the hole in the face plate, strikes the primer cap, which explodes and thus fires the gun.

8. The Hotchkiss Mark I Mechanism for 1-pounders (Plate I) is in its interior parts the same as for the heavier guns except that there is no drill hook. There is but one crank handle instead of two; in the rock-shaft cocking toe is set a "fly" (22) on which the cocking cam bears. The fly is used to prevent too great friction, since the sweep of the lever in cocking is very great. The trigger is held in a pistol grip, for the light 1-pounder or non-recoil mounts. For heavy 1-pounders, the trigger and trigger box are like that for the 6-pounder guns beyond No. 53.

9. The Hotchkiss Mark II 6-pounder Breech Mechanism (Plate II).—*The block* (1), with all its moving parts as a whole, is interchangeable in the breech mortise of the Mark I gun. It is of the same general shape as the Mark I, but differs as follows: There is a vertical circular hole (6) open at the bottom, forming a pocket for the spiral main spring (25), on the left side, and a

similar, but smaller, pocket (7), on the right side, for the sear spring (32), both opening into the lower face of the block. Near the bottom of the former is an annular groove for the lip of the main spring lock (27). To the left of the block's central cavity is cut a groove into the main-spring pocket to permit the engagement of the main-spring sleeve on the hammer shaft. On the right of the plug's central cavity, a sear stop plug (16) guides the movement of the sear and is screwed into the plug, remaining as a permanent fixture. It also prevents the sear from coming off its pin, in the usual position. "The crank slot" (2) has an indentation on the upper forward end (in some of the blocks) in which the stud (11) of the crank rests when the breech is closed.

The stop bolt (34) is not threaded, but is provided with a milled head on the outer end and a "spring lock" (35). This lock consists of a hollow sleeve, within which is a spiral spring, seating in a vertical hole in the head of the stop bolt, and an arm, in one with the sleeve, which lies in a longitudinal cut in the bolt. The inner end of the arm has a toe which engages in one of two annular grooves cut in the stop-bolt hole. The lock is retained on the bolt by a ring called "lock-bolt washer" (36). To operate the lock, it is only necessary to press down on the sleeve, which moves the lock and will disengage the toe from the one of the grooves in the stop-bolt holes. These grooves are so arranged that when the toe is in the outer one the stop bolt is just clear of the block, while if engaged in the inner one the bolt enters the groove in the plug. This facilitates mounting or dismounting the block.

The crank handles (13) are held on the stem of the crank by means of a feather and "crank-handle lock" (15), as described in the Mark I mechanism.

The extractor is also the same as previously described except that the claw is detachable and made of tempered steel, to make it more elastic.

The hammer (17) has a rearward projecting lug (19) on its axis on the left side, which bears on the toe of the main-spring sleeve; this lug receives the push of the main spring to rotate the hammer about its axis for firing. The cock notch (20) is on the right side.

The firing point differs from the Mark I in being a conical point

with a split shank having two lugs. In entering, these lugs are placed opposite grooves in the hole in end of hammer, when by pushing it in, and then giving a partial turn with the dismounting tool, the lugs will engage behind the hammer head, being sprung apart by the spring of their arms.

The rock shaft (22) projects through the block on the left side and is provided with a spring catch (24) to hold it on (necessary because there is no stirrup to hold the shaft in place as in Mark I). This catch is a flat spring lying in a longitudinal slot on left end of the shaft; it has, on the outer end, a lug that slips over the edge of the hole in the block when the shaft is in place, preventing movement to the right.

The main spring (25) is a strong spiral spring which seats in its sleeve and is retained in the block by the "main-spring lock" (27) at the bottom.

The main-spring sleeve (26) is a hollow steel cylinder, partially closed at its upper end, provided with a toe on the lower end which projects forward to engage the lug on the hammer axis. Holding the main spring, it slips in a vertical pocket (6) in the plug, and is kept in place by the "spring lock."

The main-spring lock (27) is a bolt with head cut away on opposite sides to form lips, and a slot cut in its top for the dismounting tool. It is put in place by passing the shank of the bolt up inside the main spring and, with the dismounting tool engaged in the slot, pushing downward to compress the spring, and then turning to the right or left a quarter turn so that the lips enter the annular groove in the block. The pocket is slotted on opposite sides to form the annular groove which permits the lips of the lock to be entered or withdrawn, and thus a bayonet joint is formed.

The sear (28), of peculiar shape, is pivoted by a pin (31) on the side of the block as in Mark I. There are two arms, one thick and heavy and provided with a shoulder to engage the cock notch on the hammer axis; the other, or firing arm (30), has in its extremity an eye for attaching the firing lanyard, and thus acts also as a trigger.

The sear spring (32) is spiral and seats in its pocket (7) in the block, pushing down directly on the upper arm of the sear

to keep the latter engaged in the cock notch of the hammer when retracted.

10. DIFFERENCES BETWEEN MARKS I AND II 6-POUNDER HOTCHKISS BREECH MECHANISMS.

Part.	Mark I.	Mark II.
Block	As described.	Has two vertical holes in after part for main and sear springs.
Crank handle.	Attached to crank stem by a feather and keep screw, taper pin or spring catch.	Attached to crank stem by a feather and spring catch.
Hammer.....	Has a stirrup and sear for a flat main spring.	Has a cocking lug which bears on toe of main-spring sleeve.
Firing point..	Has rear projecting spring ears clasping end of hammer.	Has spring split shank resting in rear of hammer.
Rock shaft...	Held to hammer shaft by a projector lip on the stirrup.	Held in block by a spring catch on the left end.
Main spring..	Double-branched flat spring, ends held on opposite side of hammer shaft.	Spiral spring which acts on lug of hammer through toe on sleeve.
Sear spring...	Flat, free arm bearing on the sear.	Spiral, bears on arm of sear when in place.
Extractor	In some, nib and body in single piece; others like Mark II.	Nib separate from body to assist in extraction by spring temper and for strength.
Stop bolt	Screws into seat.	Held in seat, and also when partly out, by a spring catch working in annular groove in stop-bolt hole.
Trigger	Ordinary bent lever held in pistol grip, one arm resting on free end of sear.	No trigger. Firing lanyard hooks in arm of sear.

11. The Hotchkiss Mark II Mechanism for 1-pounders (Plate II) employs a block similar to that for the 6-pounder gun except that the face plate is secured by a "lock button" instead of screws.

The crank handle and appendages differ somewhat from those of the Mark II 6-pounder. The cocking toe projects upward. The crank handle revolves freely on the stem, but in a boss on the outer side of the toe is a "runway" or slot (14a) in which plays a stud of the carrier (15). The "carrier" takes the place of the fly in the rock-shaft toe of other models and is an extra appendage. It is kept from turning on the shaft by a feather, and from coming off by the carrier lock (16) (similar to the 6-pounder crank-

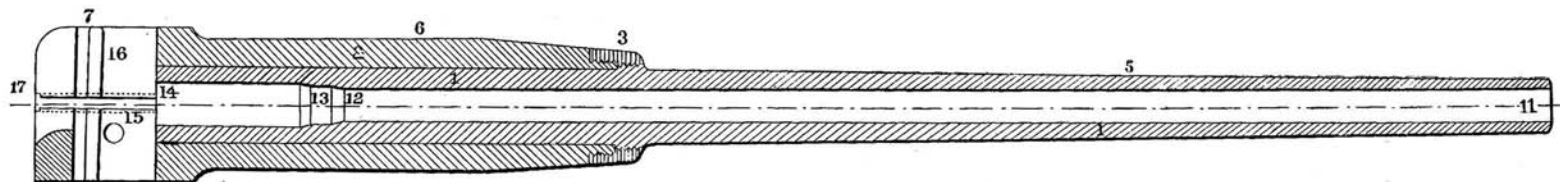


Fig. 1.

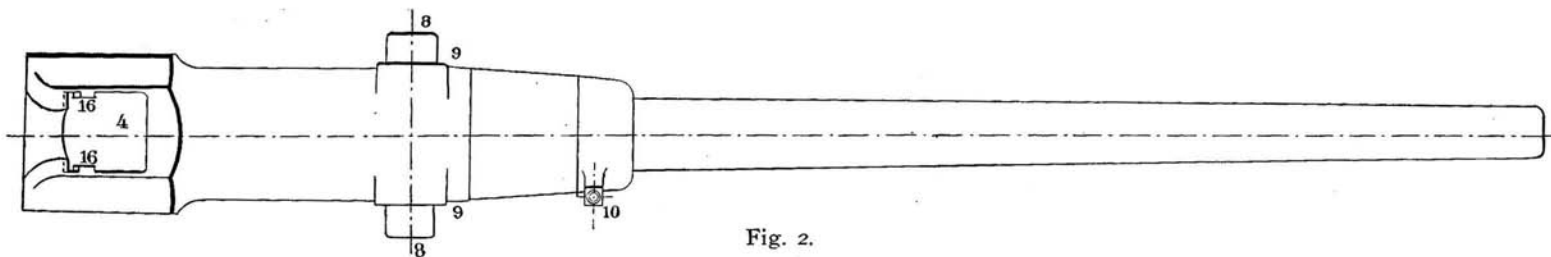


Fig. 2.

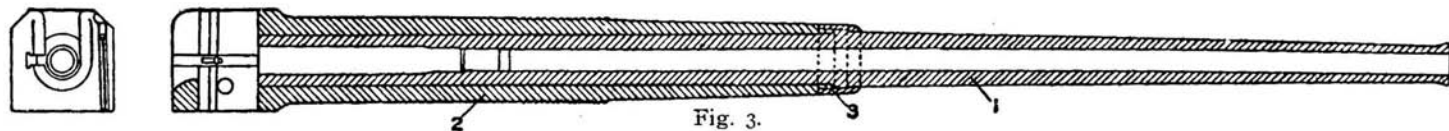


Fig. 3.

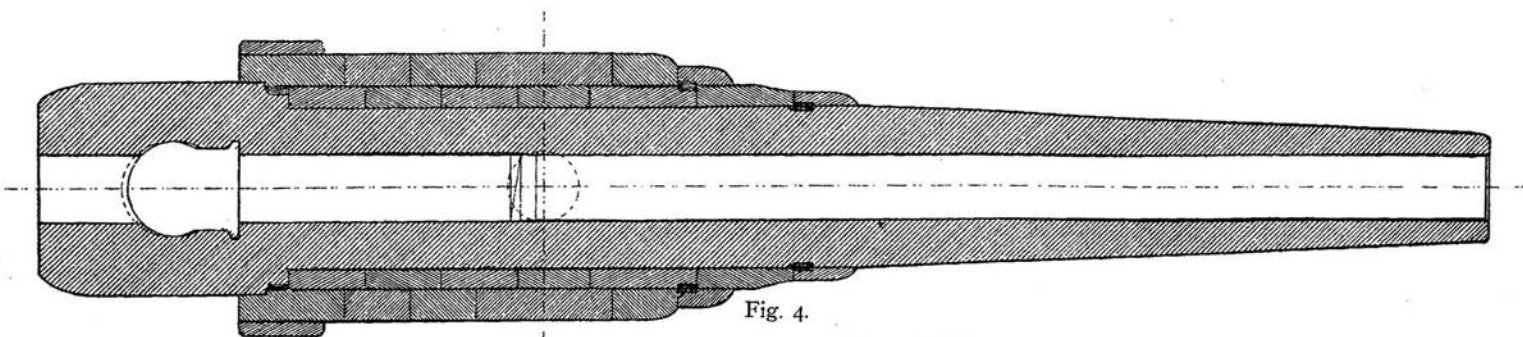


Fig. 4.

HOTCHKISS AND KRUPP SYSTEMS.

handle lock). The runway in the cocking cam is of such length that, in turning the crank handle to the rear, the overrun permits the engagement of the two cocking toes before the crank itself moves at all, and vice versa; the hammer is left undisturbed in closing.

The rock-shaft toe is upturned and moves to the rear in cocking. The rock-shaft catch is similar to that of the 6-pounder Mark II.

The stop bolt works similarly to the 6-pounder Mark II, but the catch differs. It consists of a conical plug, having a spring extension, with a lug on its inner end that takes in the annular grooves in the stop-bolt hole. The catch lies parallel with the axis of the bolt,—a taper hole being cut through the head of the bolt.

As in the Mark II 6-pounder, there is no trigger; the free arm of the sear acts as such, the hook of the lanyard being attached to it. The extractor is in one piece.

(Detail notes on the care and handling, dismounting and assembling, may be found in the Gun and Torpedo Drill Book of 1900, pages 53 and 115 to 118, inclusive.)

12. The Safety of the 6-pounder Mark I Hotchkiss Breech Mechanism lies in the following:

As to Opening when Fired.—The block is held closed—first, by its own weight pressing down on the crank beyond its center; second, by the reaction of the crank handles, the tendency being for them to fly forward; and third, by the small spring catch on the crank-handle toe seated in a notch in the gun.

As to Firing before Breech is Closed.—It is impossible to fire the gun—first, because the firing pin would not be in line with the primer; second, the cocking toe would strike the cocking cam before the firing pin could attain its full throw, or reach the primer.

As to Firing by Shock in Closing.—It is impossible to do so, as the block slides along the cartridge head, and hence gives no blow, which gives the sliding-wedge system an advantage.

13. Plate III gives various guns to which the Hotchkiss system is applied; Figs. 1 and 2 show an old style trunnioned 6-pounder built up with a tube and jacket which are held together by the *screwed* locking ring (3), which also bears the front sight. Fig. 3 shows a 3-pounder of recent construction, trunnionless, with much longer jacket. Fig. 4 is an old style 10-inch Krupp gun to which

the sliding-wedge system is applied. This system, is of all types of breech closure, the most universally used and is employed in the navies and armies of nearly all nations. It is particularly a favorite with the Germans, for whom it is successfully applied to all sizes of guns by the Krupp factories. In the gun shown in Fig. 4, and usually in all main battery guns, the block works horizontally instead of vertically, so that its weight may be more easily handled, and the mortise is kept as small as possible and is closed to the rear, leaving an aperture for loading. As may be seen, the system has the disadvantage of heaviness,—the block is heavier than that of most other systems and its housing must extend some distance to the rear, contributing greatly to the weight of the gun itself.

14. With each Hotchkiss gun in the U. S. Navy is furnished an *Accessory Box* containing:

Spare Parts.—Stop bolt, hammer, firing points, main spring, sear, sear spring and an extractor.

Accessories.—Sponge brush, cleaning brush, oil can, combination dismounting tool (a different kind is used for the two marks), dismounting pin, monkey wrench, hand extractor (except for 1-pounder), drill hook (for 3- and 6-pounder, Mark I), and lanyard.

CHAPTER XII.

GENERAL DISCUSSION ON GUN MOUNTS.

1. The term "gun mount" is, in the naval sense, applied to a structure that carries a gun, provides for pointing and sighting it in azimuth and in elevation, and checks and controls its recoil. Rapidity and accuracy of fire depend on the excellence of the mount, which is second in importance only to the gun itself.

2. The principle requirements of a modern gun mount are: (a) safety under all conditions, which necessitates proper design and requisite strength of materials; (b) rapidity, ease and smoothness of working; (c) durability; (d) simplicity; (e) gradual absorption of the shock of recoil and its dispersion over a sufficient area of the ship to prevent injury to the latter; (f) good control of the motive power, which, whether it be hand or other power, should be powerful and reliable; (g) provision for substituting hand power, as far as practicable, if other motive power is ordinarily used; (h) interchangeability of parts of mounts of same mark.

3. All modern gun mounts give the gun an arc of elevation of from 15° to 25° and the train is usually limited only by the form of the gun emplacement; mounts are conveniently divided into classes according to the kind of recoil mechanism used. These classes are (a) non-recoil mounts, (b) hydraulic-recoil spring-return mounts, (c) hydraulic-recoil and return mounts, and (d) hydraulic-recoil and gravity-return mounts; to which must be added (e) field mounts. In all recoil mounts means are afforded for returning the gun to battery, i. e., its initial position; this mechanism usually *assists* in checking the recoil. In all but the smaller mounts, buffers of some form are provided for cushioning the counter recoil. The gun recoils in the line of fire except in mounts of class (d).

4. A Non-Recoil Mount is one in which the gun cannot recoil

except in so far as the elasticity of the metal permits it to; obviously, this class can be used only for very light guns.

5. A Hydraulic-Recoil Spring-Return Mount, (all modern mounts are of this class), is one in which the recoil is checked by hydraulic cylinders, closed and kept constantly filled with a "recoil liquid" (glycerine and water), the gun being returned to battery by the extension of spiral springs, also inside the cylinders, which are compressed during recoil. The cylinders are usually secured to a stationary part of the mount and the piston rods to the gun, though in some mounts the reverse obtains. During recoil the pistons move along the cylinders and the recoil is checked by the friction of the liquid as it passes from one side of the piston to the other through apertures of variable area. The apertures consist of shallow grooves in the cylinder, not filled by the piston, and the variable area is obtained by tapering the width of the grooves, which finally disappear when the limit of safe recoil is reached; when the gun is in battery, the position of the piston is at the widest part of the grooves, which are from three to five in number. During the counter-recoil the liquid again passes over the pistons, aiding in controlling the counter recoil. The counter-recoil springs surround the piston rods, being held between the piston and cylinder head under initial compression to keep the gun in battery as the ship rolls. Thus, when the recoil is checked, the springs are highly compressed and immediately shoot the gun out to battery. The counter recoil is violent, and in large gun mounts a "counter-recoil check" is fitted which may consist of spring buffers or of hydraulic checks. In the latter case, an extension of the piston rod beyond the piston enters a tapered hole in the front cylinder head, or, vice versa, a rod projecting inward from the cylinder head enters a tapered counterbore in the piston rod, which hole, of course, fills with liquid at the beginning of the counter recoil and acts in the same manner as the main cylinder, when the gun nears its position in battery.

6. A Hydraulic-Recoil and Return Mount, to which class the earlier turret mounts belong, is one in which the recoil is checked as in (5), the gun being returned to battery by hydraulic motive power. The recoil cylinders may be independent of the hydraulic system, or they may act also as motor cylinders. In the first case,

the recoil is checked exactly as in (5), and the gun is returned by separate motor cylinders, connected with the hydraulic system, whose piston rods act on the gun cradle. In the second case, during recoil the piston rods are driven *into* the cylinders, which are connected to the hydraulic system through check valves at the opposite ends; during recoil these valves close and the cylinders act as in (5), the water displaced by the piston rods escaping through valves which are spring-weighted to the pressure of the hydraulic system. After recoil, the check valves open and the hydraulic pressure, acting on the effective area of the piston rods, returns the gun to battery; as this is done comparatively slowly, spring counter-recoil checks are sufficient. The 13-inch mounts of the "Indiana" are of this latter class and the 12-inch mounts of the "Texas" of the former.

7. A Hydraulic-Recoil Gravity-Return Mount, is one in which the gun recoils up inclined rails *not* in the line of fire; recoil being mainly checked by closed hydraulic cylinders acting as in (5), and the gun sliding back down the inclined rails to its position in battery by force of gravity. The gun, by its trunnions, is secured to a movable part of the mount, (comprising the cylinders), that slides on and is held to the inclined rails of a lower carriage; the piston rods are secured to the lower carriage at the bottoms of the inclined rails. The counter recoil is checked by spring buffers on the lower carriage. These mounts were fitted to the main battery guns of our first steel ships, but are now obsolete and are no longer being fitted; the 8-inch turret mounts of the "New York" are of this class.

8. A Field Mount is one intended for shore use, and consists essentially of an axle mounted on two wheels, bearing a trail piece with a small trail wheel and a socket, to which is secured the gun mount proper. Except for machine guns, which have non-recoil mounts, hydraulic-recoil spring-return mounts are used. Train is effected mainly by swinging the whole mount on its wheels; the elevating gear is fitted to the non-recoiling part of the mount. The general navy method is to carry ammunition on the gun mount, as a combination of "limber" hooked to the trail of the mount is too heavy to be dragged by men.

9. A Turret Mount is one in which one or two,—usually two

in U. S. ships,—heavy guns of at least 6-inch calibre are mounted in an armored structure which is revolved on rollers by suitable machinery, the guns being elevated independently of the structure.

10. The Gun Slide is a general term applied to that non-recoiling part of a gun mount which provides surfaces on which the gun and recoiling part of the mount travel during recoil. Being constructed in many different forms, it may consist of simple rails, as in gravity-return and hydraulic turret-mounts; but in recent ones, the slide is identical with the sleeve which fits around the gun body. The recoil cylinders and the trunnions are parts of the slide, the elevating gear raises and lowers its breech end and, in all but secondary battery and turret mounts, the gun sights are fitted to it.

11. The Gun Cradle or Saddle is, in general, a term applied to that part of the mount which contains the trunnion seats. The elevating gear is secured to it, and the gun is trained by revolving it on roller or ball bearings; the lower part is called the pivot. In turret mounts, the *deck lugs*, a part of the permanent structure of the turret, contain the trunnion seats.

12. The Training Gear, hand or power, is the machinery that revolves the movable parts of the gun mount, to which parts it is, in all except turret mounts, secured.

13. The Elevating Gear, hand or power, is that machinery secured to the saddle which, working on the breech end of the gun slide, elevates or depresses the gun's muzzle. On firing, the gun's muzzle makes a violent effort to move in the vertical plane, describing a small angle which is called the *jump*. The gun being pivoted at its trunnions, the jump brings a strain upon the elevating gear, which is relieved of the shock by (1) spring buffers or by (2) friction disks. In the first method, a worm which is indirectly secured to the saddle, gears in an arc which is part of the slide; this worm works on its shaft by a feather, being capable of longitudinal motion along it and is supported from below by a spiral spring surrounding the shaft. When the jump occurs, the worm is forced downward and the spring takes up the shock without injury to the mechanism and returns the gun to its first position. In heavy turret mounts, the same principle is applied in a different manner, and a hydraulic cylinder called the "dash

pot" is associated with the spring. In the second method of controlling the jump, the gun slide and saddle are connected by rack and pinion gearing instead of worm gearing. The elevating pinion is not secured directly to its shaft but is held to it by two friction disks which *are* so secured and hold the pinion between them by friction alone. When the jump occurs these disks permit the pinion to slip around between them, as long as the elevating arc puts sufficient pressure on its teeth, and thus cushions the shock. In this latter method the gun will not return to its former position, but will be elevated (usually) a few degrees above it after firing; that is a disadvantage, but since the spring method violently strains the connecting parts, the friction device is preferred.

14. The Pivot Stand is that part of the mount which is strongly bolted to the structure of the ship, inside of which the pivot fits and on which the gun and upper carriage rest; ball or roller bearings being interposed to reduce friction; the training rack is secured to the pivot stand (except in turret mounts in which the training gear is stationary). The pivot stand is often called the "pedestal," from which comes the name "pedestal mount" for rapid-firing guns. The term "central pivot mount" was formerly of much significance, but of course all modern mounts are central pivot mounts. The term "top carriage" usually includes all parts of the mount above the pivot stand, but occasionally it is,—much less properly,—applied to the slide or saddle alone.

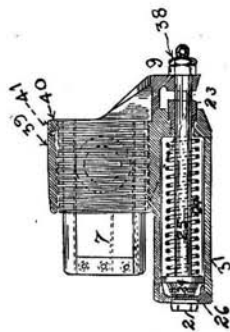
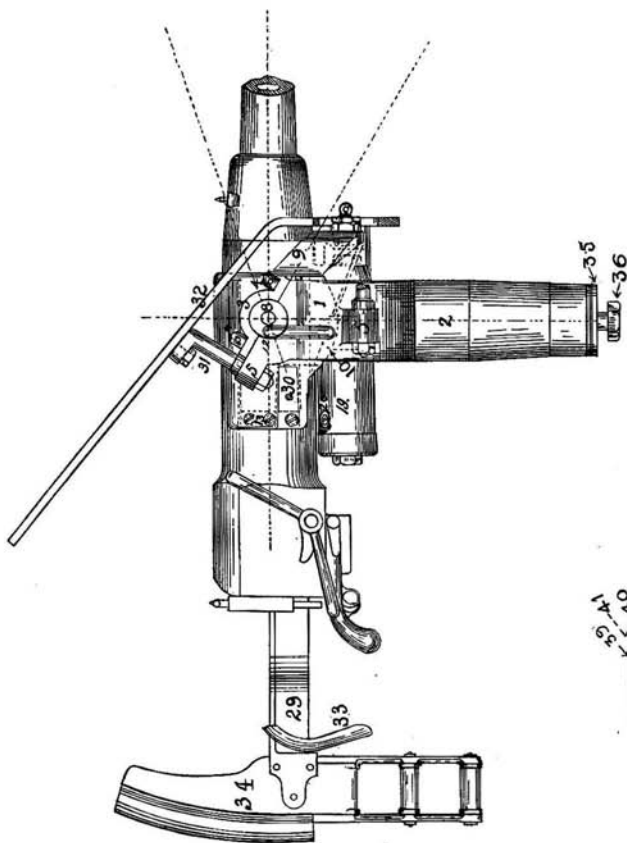
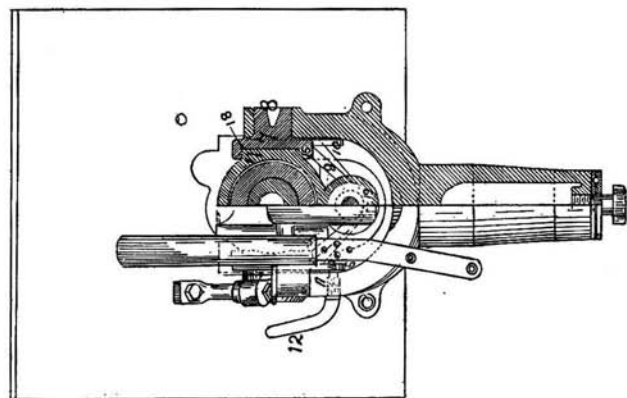
15. Metals used in Gun Mounts.—Gun-metal is commonly used for most parts of all 6-pounder and smaller mounts. For larger mounts this metal is not reliable, particularly for the large parts, such as the pivot stand, saddle, etc., for which parts cast steel of good quality is used. The castings are made by private contractors and, after being tested, inspected and passed upon by the government inspectors, are sent to the Naval Gun Factory at Washington, D. C., where the parts are machined and assembled. The principle in designing is to avoid having steel on both sides of a working surface; this is accomplished by making one of the parts of gun-metal if small, or, if both parts are large, by bushing one of them with it. For example, the insides of the sleeve and trunnion seats are so bushed in recent mounts and the pistons of gun-metal work inside cast steel recoil cylinders.

6-pounder Mount, Mark III.

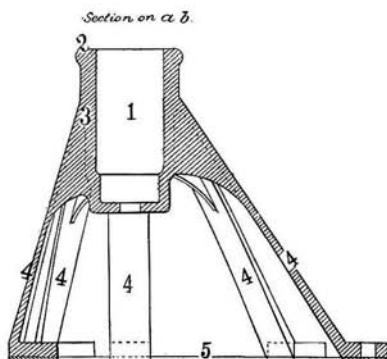
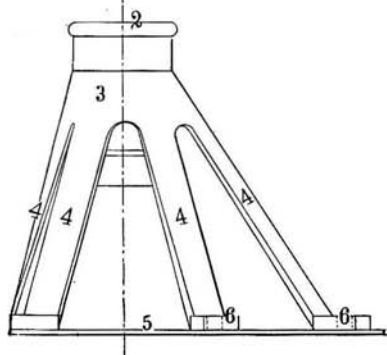
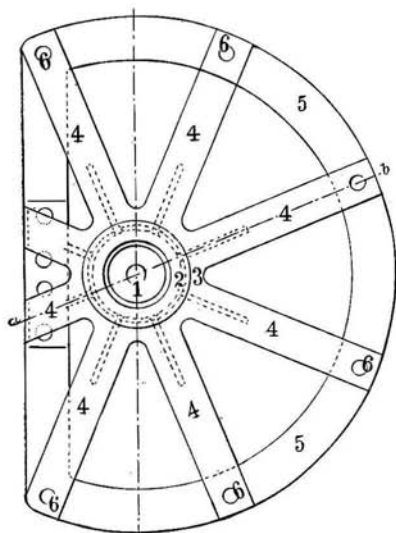
16. The Mark III mount is a hydraulic-recoil spring-return mount for trunnionless R. F. 6-pounders, in which the recoil cylinder and sleeve, with which it is combined, recoil with the gun, the piston rod being secured to a stationary part of the mount; the principal parts, with the exception of the cage stand which is of cast steel, are machined from bronze castings. The mount shown in Plate I is adapted for Hotchkiss R. F. 6-pounders; with the exception of a different form of shoulder bar secured to the *right* side of the slide, the mount for trunnionless Driggs-Schroeder R. F. 6-pounders is in all respects the same (see Plate III).

17. The **Sleeve** (17) and **Recoil Cylinder** (19).—The gun, which is threaded on the outside, screws into the sleeve (17) and is secured by the key (40) inserted from the forward end. Suitable surfaces for fitting into the slide guides (16) of the oscillating slide are machined on each side of the sleeve. Cast in one with the sleeve is the recoil cylinder (19), closed at its rear end by a bonnet (21) and having at its forward end a stuffing box (23), through which the piston rod (25) passes. Upon the inside surface of the cylinder are cut the recoil grooves (37), three in number, which taper rapidly from a wide opening at the normal position of the piston to nothing at the limit of recoil. The cylinder is filled with the recoil liquid through the plug (20). The piston rod, secured by locking nuts at its forward end to the oscillating slide transom (9), carries the piston on its inner end. The counter-recoil spring (27) is held in a state of initial tension between the front cylinder head and the piston; there is no counter-recoil check.

18. The **Oscillating Slide** (7) is fitted with trunnions (8) which rest in the trunnion seats of the saddle and are there secured by the cap squares (3). The slide transom (9) connects the two sides of the slide and affords a non-recoiling place for attaching the piston rod. The recoil stops (13) are secured by screws to the rear ends of the slide guides, at the extreme limit of recoil. The shoulder bar (29), by which the gun is pointed in train and in elevation, is dovetailed to the left outer part of the slide; the gun pointer grasps the handle at the lower end of the bar and



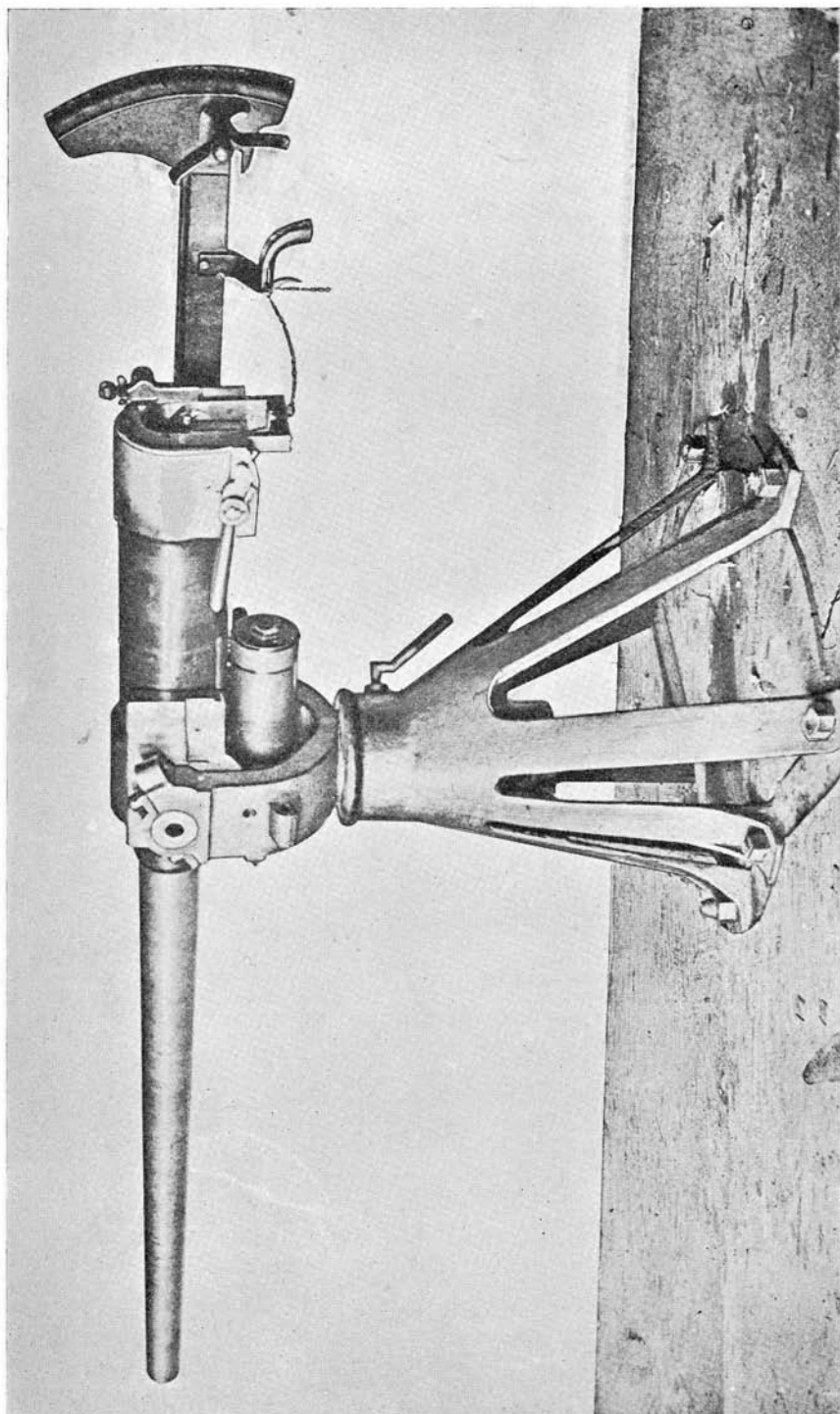
HYDRAULIC RECOIL MOUNT FOR 6-POUNDER D-S. AND H. GUNS, MARK III.



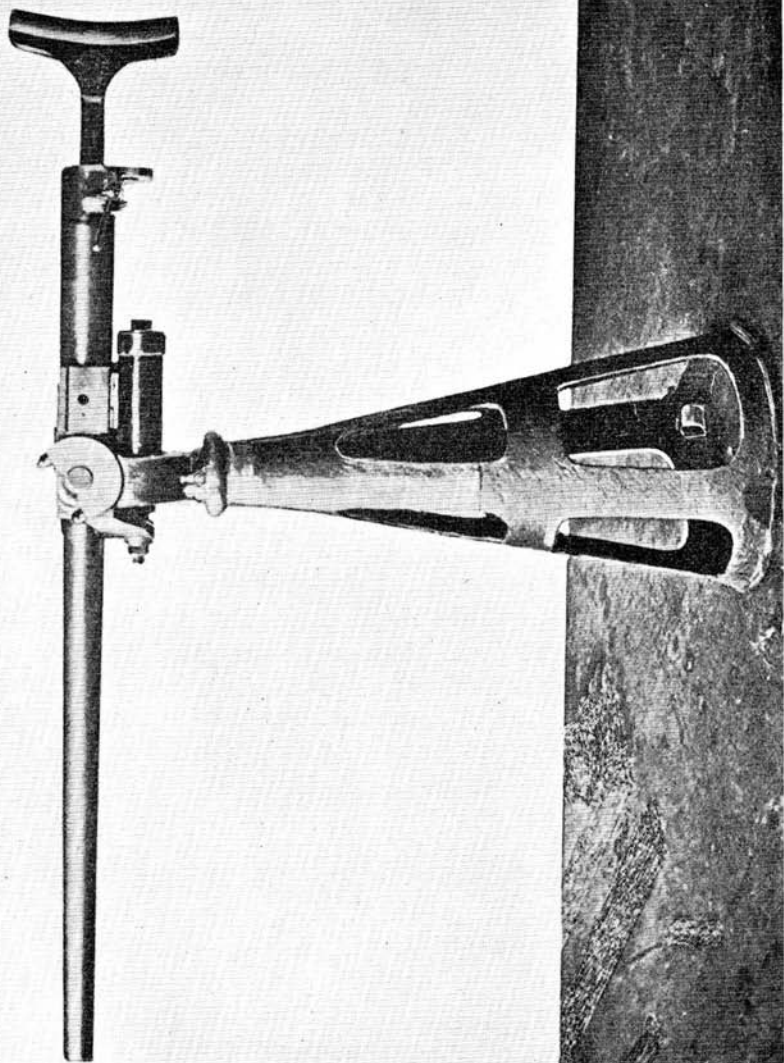
STEEL CAGE STAND FOR 3-POUNDER AND 6-POUNDER
RAPID-FIRING GUNS.

Nomenclature.

1. Pivot Socket. 2. Cage Head. 3. Cage Body. 4. Cage Legs. 5. Cage Deck Plate. 6. Cage Deck Fastenings.



DRIGGS-SCHROEDER 6-POUNDER RAPID-FIRING GUNS.
On Mark III Mount.



DRIGGS-SCHROEDER 1-POUNDER RAPID-FIRING GUN,
On Recoil Mount.

rests his shoulder on the rubber buffer (34); the deflector (33) throws the ejected cases downward.

19. The Saddle (1) is a Y-shaped casting having the trunnion seats on its arms and the pivot (2) forming its lower part. The shield (32), a $\frac{1}{2}$ -inch forged steel plate, is, when used, secured to the lugs (5) by the shield supports (31). The slide clamp (12) passes through the saddle, and, when set up, bears firmly against the slide, locking the two parts together. The surfaces of the *pivot* (2) are accurately machined to fit the socket of the pivot stand; the securing bolt (36) is inserted through the bottom of the socket from beneath and screws into the lower end of the pivot. The weight of the gun and movable part of the mount rests directly upon the bottom of the socket through the frictionless washer (35), which contributes to ease in training.

20. The Pivot Stand (Plate II).—The pivot stand for a gun mounted on the rail is simply a socket built into the rail; for a gun mounted on deck, a cage stand as shown in the plate is used. The stand is secured to the deck by eight bolts through the deck plate (5), and the pivot rests in the socket (1). The pivot clamp (not shown) screws through the top of the pivot stand, and, when set up, bears firmly against the pivot and locks the two together.

21. All recoil mounts for 1-pounders are similar to the above (see Plate IV); Mark I and Mark II mounts are designed for trunnioned R. F. guns, and, except in the mode of securing the gun to the mount, are similar to the above Mark III mount.

CHAPTER XIII.

3-INCH AND INTERMEDIATE GUN MOUNTS.

Battery Arrangement.

1. The composition and arrangement of ships' batteries is a matter of perhaps more rapid and constant evolution than any other in the whole subject of Ordnance and Gunnery. In matters of detail, such as breech mechanisms, projectiles, powder, etc., the practice of all the great navies is much the same, but, in this other broader subject, the widest divergence of opinion exists; it is needless to say that upon it the whole design of ships largely depends. The proportion of displacement to be given to armament and ordnance stores having been decided upon in the preliminary design, it remains to determine the number, sizes and arrangement of the guns of her battery with the view of delivering the greatest possible *effective* fire; it is usual to follow a fixed rule as to the number of rounds per gun to be carried by each size.

Within limits for a given weight of armament, the smaller the calibre of the guns, the greater will be the weight of the projectiles that the battery will deliver per minute; or, to express it differently, 100 tons of secondary battery guns will fire several times the weight of metal per minute that 100 tons of main battery guns will—and the muzzle velocity may be the same for all sizes. However, there is neither space nor crew enough for the great number of say 6-pounders that such an arrangement would call for. Besides, it is the greatest *effective* fire that is sought after and not merely getting overboard great quantities of metal that will do but little damage even if it does find the enemy's side,—which would not be likely. The policy of most navies at the time of writing, to which there is little objection from authoritative quarters, is to divide the weight of the battery into the largest guns that can be readily handled, keeping in view the desirability of having several units, for all sizes and classes of ships. For ships of the line, the

great extent of armored side of recently built ships, which may be their opponents, forces the above policy, since a gun below seven inches in calibre will not, under battle conditions, do effective work against moderate armor; the value of the policy is enhanced by the fact that it entails such advantages as increased accuracy over small guns, because of flatter trajectories; better protection; a smaller number of gun-pointers who should consequently be, on the average, more expert; fewer and better communications and easier fire control; an easier system of ammunition supply which is also simplified if but two or three calibres are used on the same ship. It is the same policy that in 1812 opposed the 18-pounders of the enemy's frigates with 24-pounders on slightly heavier vessels, and was a factor that largely contributed to our success.

2. In determining the battery arrangement of a ship there must be kept in mind: (a) The conflicting problems of mounting the guns at a fair height above the waterline, where they will not be interfered with by seas, and at the same time retaining the proper stability of the ship; (b) the facility of ammunition supply; (c) the necessity for gaining the best protection for the guns on the allowed weight of armor; (d) the desirability of large arcs of fire for all guns without undue "interference"—the blast of any gun seriously disturbing the crew of another. The latter problem is the subject to be now considered, as concerned with the battery arrangement of battleships and armored cruisers.

In the present development of naval tactics, it is evident that the favorite formation for fleet actions is in column, or "line ahead," as it is sometimes called; this and the fact that a ship is several times as long as she is broad and that we cannot, without great sacrifices, have many tiers of guns, makes it inevitable that most of the guns shall be mounted in broadside—able to fire over a small part of the circle on each beam. The same conditions obtained on the sailing battleships, and the largest of them were able to point as many as 60 guns on the broadside, but they could rarely fire dead ahead with more than four, or perhaps six; structural requirements for one thing, then, forced such a condition. In steam ships, the structural difficulties can be overcome to as great an extent as desired; but the possibilities in the case are approached only to a moderate degree, on the principle that, while

end-on fire is valuable, what is really essential is broadside fire with the greatest number of guns possible.

It may readily be seen that a gun mounted amidships, able to fire on both sides, is practically two guns; when first so installed, they were called *pivot guns* and were the most important pieces in the battery; this is still the case. Theoretically then, the best arrangement, as giving the heaviest broadside fire, is with all the guns on the center line and able to fire on each side; practical considerations such as boat stowage, fire- and engine-room hatches, etc., prevent this arrangement and we are limited to two positions, at bow and stern, for "pivot" guns. But we make the most of it by installing a turret at each of these two positions, each containing two of the heaviest guns in the battery. The only practicable extension of the principle is to use another middle line turret position, as has been tried in a class of German battleships which originally carried six 11-inch guns each; also the U. S. battleships which have turrets, containing 8-inch guns, superimposed on the 12- or 13-inch turrets. Guns of 8-inch or larger calibre, other than those in the main turrets, are as a rule installed on each side in turrets, which, next to the midship guns, have the largest arcs of fire. Coming next under consideration in the assignment of gun positions, as being next in importance, is that part of the battery known as the "*intermediates*"—guns of from 4- to 7-inch calibre. Their mounts are generally hand worked and they are mounted in broadside in armored positions. The favorite system is to mount four that may fire from dead ahead to a few degrees abaft the beam, the same number firing from right astern to a few degrees forward of the beam and the remaining ones with arcs of about 100 degrees on each beam. The principal purpose of the secondary battery is to repulse torpedo attack; 3-inch guns may be relied upon to do some effective work against any variety of ship, but the others will probably be put out of action anyhow long before the enemy is within their effective range. Being then the least important guns in the battery, they are given whatever room is left for them after the main battery is arranged; they are placed under the main deck in the unarmored ends, along the superstructure rail, on the bridges and in the fighting tops. In their proper role, meeting torpedo attack, they will not be subjected to gun fire and

hence need not be protected; in battle, they need not be manned, save perhaps with the exception of the 3-inch guns, which are often protected by thin armor.

The requirements for an unarmored ship's battery are, in the main, very similar; these ships have no turrets and their main battery guns are about alike in size. As a rule, two of the largest guns are installed amidships in bow and stern and have the same large arcs of fire of turret guns—250 degrees or more; all the other guns are arranged, as far as possible, as are those of the armored ships.

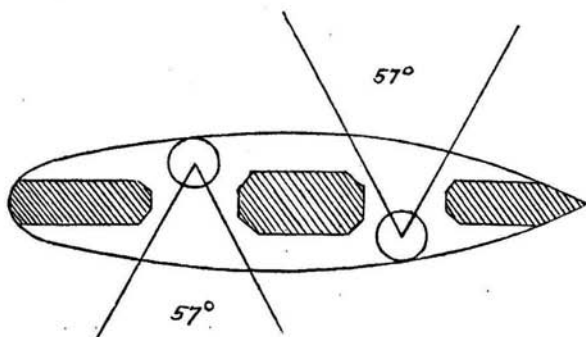


Fig. 1.

Two or three decades ago, the idea was prevalent that the advent of steam propulsion had set tactics back to the days of Grecian supremacy on the seas; it was held by many, in whose minds the battle of Lissa was fresh, that the ram was the supreme weapon and that, as with the fighting galleys, the best defensive and offensive fleet formation was in line abreast. As long as the idea held sway, end-on fire, particularly ahead, was sought after at the expense of broadside fire and ships were built which were able to fire as many guns ahead as on the beam. The "echelon" arrangement of the two main turrets was then a favorite one. The figure, which is a plan of the "Maine" that was blown up in Havana harbor, shows it. The upper works are cut away to permit each turret to fire forward and astern and, for a small arc, across the deck. This fallacy endured for but a short time, however, as it was found that column is the easiest fighting formation

to maintain and that the arrangement gives a fire on bow or quarter from only one turret. Besides, there remains no good place for the large intermediate battery needed and the blast of the turret guns, when used as designed, makes such positions as do remain untenable; the superstructure, unless unnecessarily strong, will not bear the blast of the turret guns when fired in line with the keel, or across the decks. The "Texas" is the only armored ship in the U. S. Navy with the echelon arrangement.

3-inch Mount Mark III. (See Plate I.)

3. **The Mounting** resembles a Mark III 6-pounder mount to which is added a geared elevating device; the main difference is that the gun recoils through a sleeve, drawing the pistons through the recoil cylinders, which are stationary. The principal parts are: the combined slide and recoil cylinders; the saddle and pivot; the elevating gear; the cage pivot stand.

The *slide* (73), of cast steel, is cast in one with the two recoil cylinders; a large hole on each side in rear of the trunnions is for lightness and its whole inner surface, on which the gun slides, is bushed with bronze—in the bushing are cut spiral oil ways. The gun has ribs on top and bottom which fit wide longitudinal grooves in the slide and prevent the gun from turning. There is a lifting eye on the top of the slide which is directly in line with the trunnions (76); the latter are bushed with bronze, as are all the working surfaces. The elevating arc (53) is bolted to a heavy projection, on the left rear side, in which is machined the box for the sight (3); the front sight is also secured to the slide (the sights shown are night sights,—the wires are shown leading to the battery box on the right side). The two hydraulic recoil cylinders (79) are rifled as heretofore described,—the ends are closed by bonnets. The cylinders are filled through the holes (78) which are in line with the equalizing pipe (77) which connects the two cylinders and makes the pressure, during recoil, uniform; the recoil liquid may be removed through the plugs (71). The piston rods (89), with the pistons (88) on their forward ends, pass through stuffing boxes in the rear bonnets and are secured by heavy nuts to a steel yoke (2) around the breech of the gun. The counter-recoil springs (85) are each in two sections separated by disks; they are

assembled under initial tension and hold the gun in battery. The counter-recoil check (81) is a device in each cylinder which cushions the counter recoil in the same way that the cylinder checks the recoil—by the friction of the liquid in passing a small orifice. The piston rod projects through the piston and at the end of the counter recoil enters a tapered hole in the front bonnet and forces out the liquid.

4. **The Trunnions** are held in the *saddle* (12) by cap squares (13). The *pivot* (5), a part of the saddle, fits the cavity of the pivot stand only at top and bottom, where the surfaces have bronze bushings. The entire upper mounting may be raised by the lifting screw (6) working through a bronze cap bolted to the stand; the screw also holds the parts together. Friction in training is reduced by the conical rollers (8) through which the weight of gun and upper mounting rests on the stand. The rollers are spaced by floating rings on their axles; their upper and lower paths are separate steel pieces set into saddle and stand. The rollers may be removed for cleaning and lubrication by raising the saddle a few inches by means of the lifting screw (6). The pivot clamp (4) sets up, through a lug on the saddle, to the pivot stand.

5. **The Elevating Bracket** (39), a part of the saddle, bears the training and elevating mechanism. It has been decided that the 3-inch gun is not too large to be *trained* by a shoulder bar on the saddle. To point the gun in *elevation* in the same manner, however, would involve fitting the bar to the slide and the gun is too heavy and the shock of recoil too great for this; besides, a gun may be pointed more accurately by gearing, and it has been proposed to give even smaller guns regular elevating gears. The shoulder bar ships in a socket in the projection (17) of the elevating bracket. An upright (19) bears the shoulder piece which the gun-pointer holds under his right arm-pit; as may be seen in the plate, the shoulder piece may be adjusted and secured at the most convenient height by the clamp (18). To keep the pointer from leaning against the gun and being injured by its recoil, the brass guard plate (14) is bolted to the slide.

The *elevating wheel* (40) turns a horizontal shaft on which a worm (46) is held between two frictionless washers (59). The worm gears with a worm wheel on the cross-shaft (45) on the

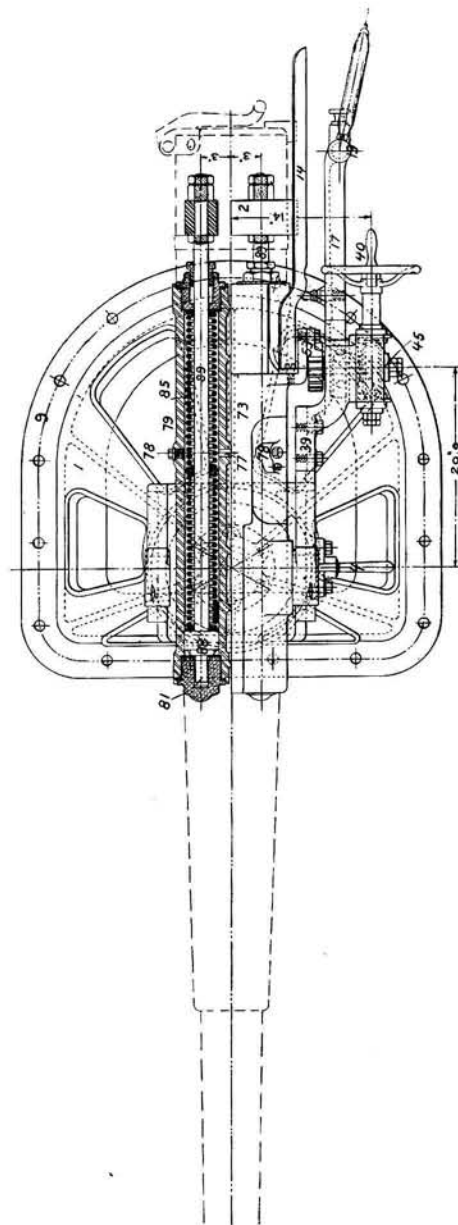
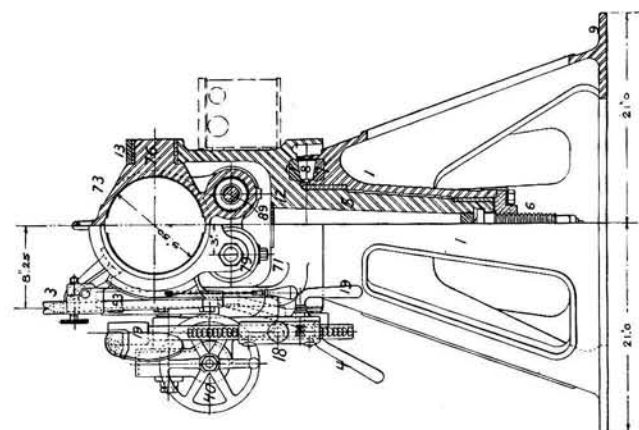
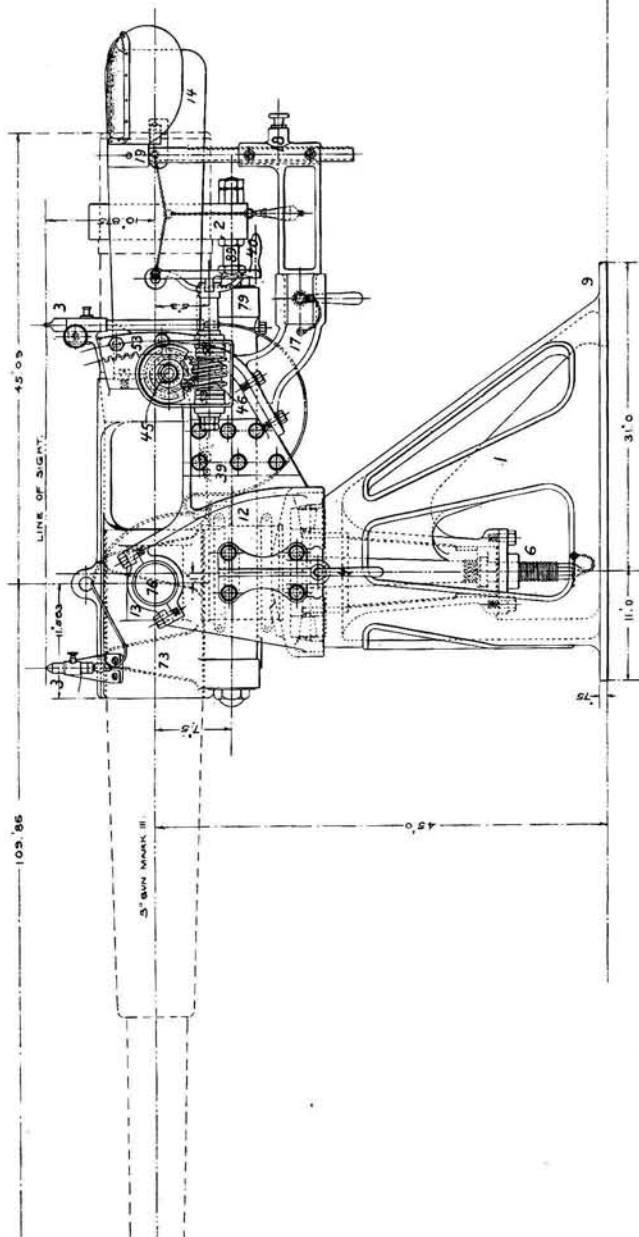
other end of which is a pinion gearing in a rack on the *concave* side of the elevating arc; it has been found that the strain on the elevating gear during firing is greater if the rack is cut on the convex side. To cushion the jump, the worm wheel is held between friction disks on the cross-shaft (45) instead of being directly secured to it; (a few 3-inch mountings of this type have been built with geared training as well as elevating devices).

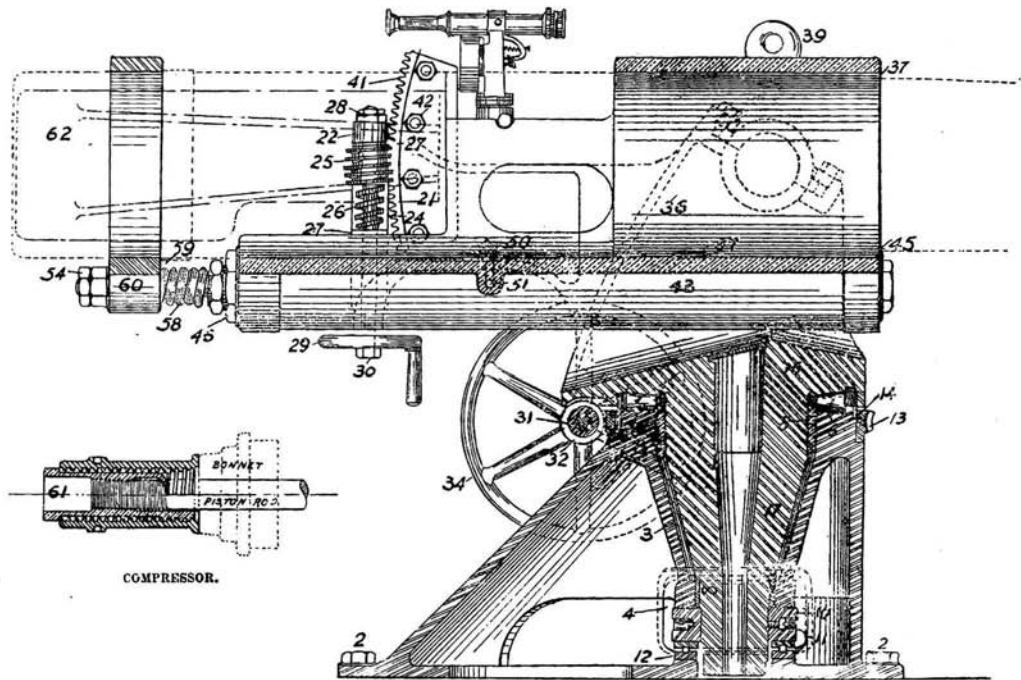
6. The Pivot Stand (1), of cast steel, is designed with a view toward lightness; in other services, cone stands, without lightening holes, are largely used for secondary battery guns. The inner portion of the stand is supported by deep webs running out to the legs of the cage; the entire mounting is secured to the deck by bolts through the deck circle (9).

"Pedestal" Mounts. (See Plates II, III and IV.)

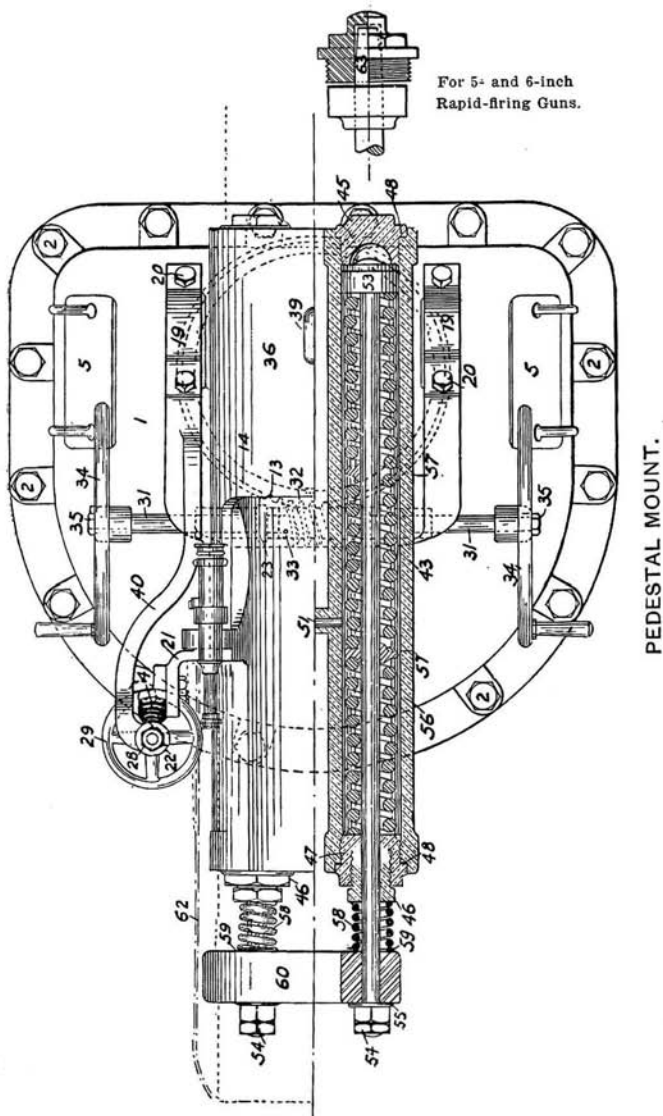
7. These mounts were so named because of the pedestal form of the pivot stand, which permits mounting the gun close to the side, thereby keeping down the size of the straight gun port for a prescribed arc of train. All mounts are now designed to this end and are "pedestal" mounts, but it was formerly not the case, and the center of motion in training used to be much farther from the gun port. To obtain a fair arc of fire, the port then had to be circular, or very large, and guns were mounted in *sponsons*; these latter project inconveniently from the side, are expensive to build and their use has been abandoned.

The pedestal mounts for 4-, 5- and 6-inch R. F. guns are similar in their principal features; the one shown in the plates is for a 4-inch gun. The slide, recoil mechanism, saddle and pivot are, in general, like those of the recently designed 3-inch mounts. The *bronze* slide did not extend far to the rear and has in some cases proved too weak; hence a strengthening band running from the elevating arc over the gun to the opposite recoil cylinder has been added. The counter recoil is cushioned by buffer springs (58); in the 6-inch, and in most of the 5-inch mountings, dash-pot checks in the forward bonnet are employed instead. The outside of the pivot stand is solid in all mounts of 4-inch and larger guns. The nut (10), screwed on the lower end of the pivot, serves to lock the top carriage to the stand or to raise it, giving access to the rollers





PEDESTAL MOUNT—4-INCH RAPID-FIRING GUN.



(7); to do this, remove the water-tight doors (5), insert heavy rods into the holes (11) in the nut and turn it in the proper direction—after removing the set screw. The frictionless washer (12) is interposed between the nut and the deck plate of the stand to facilitate the operation.

All main battery guns are trained by gearing; the training rack (13) is secured to the pivot stand—a general rule. The training shaft (31), turned by hand wheels, rests in bearings on the saddle and its worm engages the rack. The elevating shaft (24) of the 4-inch mount is vertical and carries a worm (25) which gears in a worm rack (41), cut on the *convex* side of the elevating arc. The worm is loose on its shaft, but is constrained to turn with it by a feather; it is held upward in position by a spring (26) which permits it to slip downward, cushioning the jump as the gun is fired, and then forces it back to its former position.

8. At the time the first pedestal mounts were designed, it was intended that the gun-pointer do all the work of pointing, sight setting and firing,—assisted in training if necessary. To this end, the elevating and training gears were arranged on several different plans; one way placed the elevating wheel on a sleeve around the training shaft and the two wheels were concentric and close together. It was found, at about the same time in other services, that the best results are not obtained in this way and that pointing in elevation and firing are quite enough for one man. In the division of duties, the *trainer* has to do solely with lateral pointing,—he may work from the left side conned by the pointer or he may use the training gear and sight on the right side. Good results may be obtained in either way.

Under the modern requirements, in which the sights are to be held on the target throughout a string of shots, fired while the ship is rolling, the pointer has the most difficult and fatiguing duty, and the elevating wheel should be placed advantageously for him. With it fitted as in Plate II, it is nearly impossible to maintain a "continuous aim" for any length of time. The proper place for the elevating wheel is a little below the pointer's shoulder with its plane vertical and nearly parallel to the vertical plane through the axis of the bore; all future mounts will fulfill this condition; those pedestal mounts otherwise constructed are rapidly being converted.

The installation of the training wheel is not of so great importance, but any hand piece, which controls the pointing of a heavy gun, needs great leverage to obtain the delicate movements required.

In the future the elevating and training gears will be installed as follows:

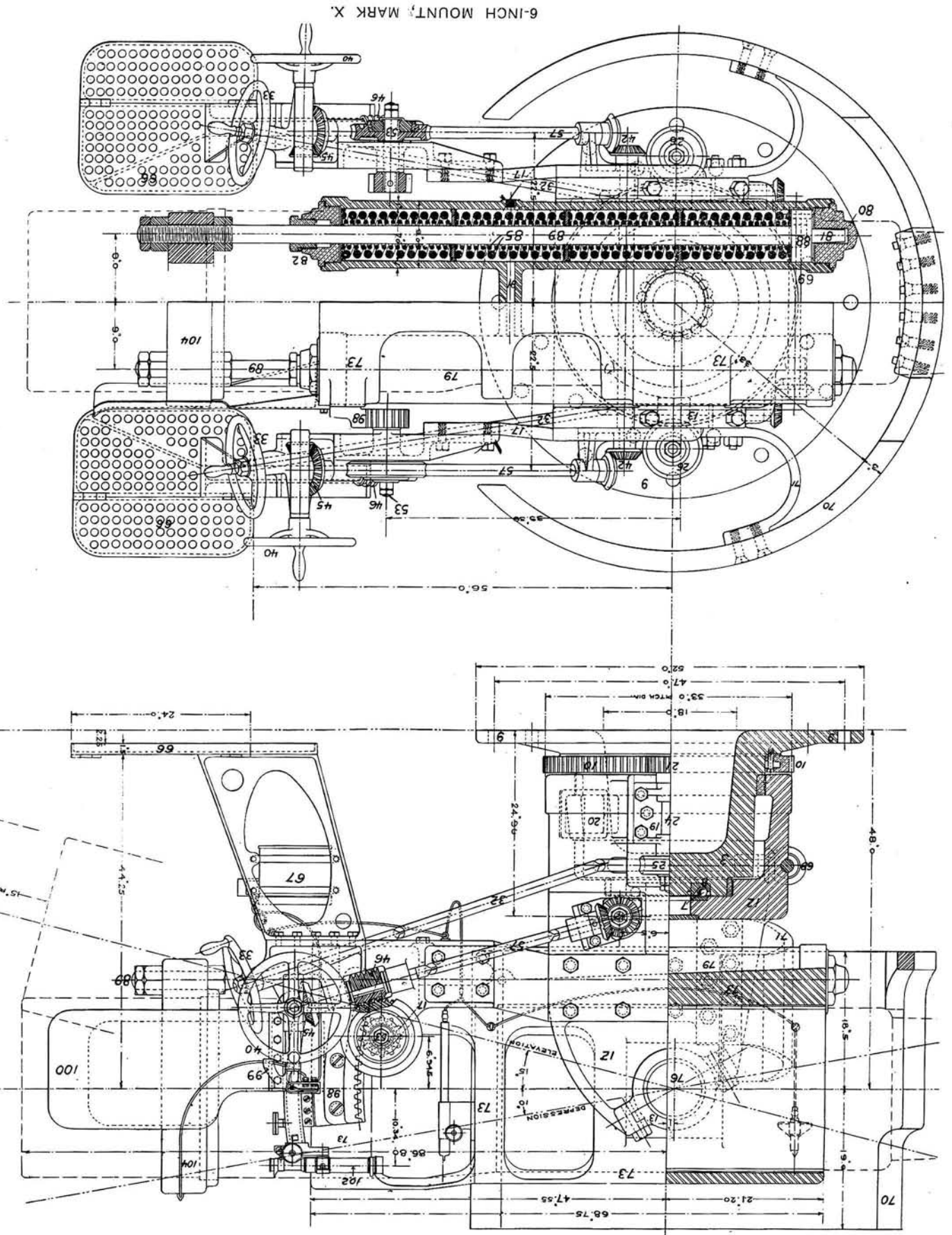
Size.	Elevating arc.	Elevating wheel.	Training wheel.
3-inch.....	Left side.	Left side.	None.
4 "	" "	" "	Both sides.
5 "	" "	" "	" "
6 "	Both sides.	Left side (usually).	" "
7 "	" "	Both sides.	" "

9. A Compressor, for use in dismounting or assembling recoil cylinders, is supplied to all ships (see Plate II). In dismounting, detach the gun from its piston rods and run it in out of the way. Screw the compressor on the end of the piston rod until it brings up against the rear bonnet of the cylinder. Then an inner sleeve, which has engaged the thread on the rod, is screwed to the rear by a threaded shaft and brings the rod with it, compressing the springs. When the piston is clear of the forward cylinder bonnet, the latter may be removed; the compressor is then worked backward, easing the piston rod through the cylinder until the springs are fully extended, whereupon the compressor is removed and the recoil mechanism withdrawn.

6-inch Mount Mark X. (See Plates V and VI.)

10. This mount, constructed for the "Maine" and class, is designed to meet modern requirements. The left elevating wheel is often omitted; if retained, it may be readily disconnected, as may either training wheel. It is to be noted that: (a) Ball bearings instead of rollers are employed; (b) the trainer and pointer stand on platforms hung from the saddle instead of having to walk along the deck as the gun is trained; (c) the saddle is not formed into a pivot which fits a socket in the stand, but embraces it as a huge collar fitting around it.

The *slide* (73), recoil, and counter-recoil, mechanism is like that



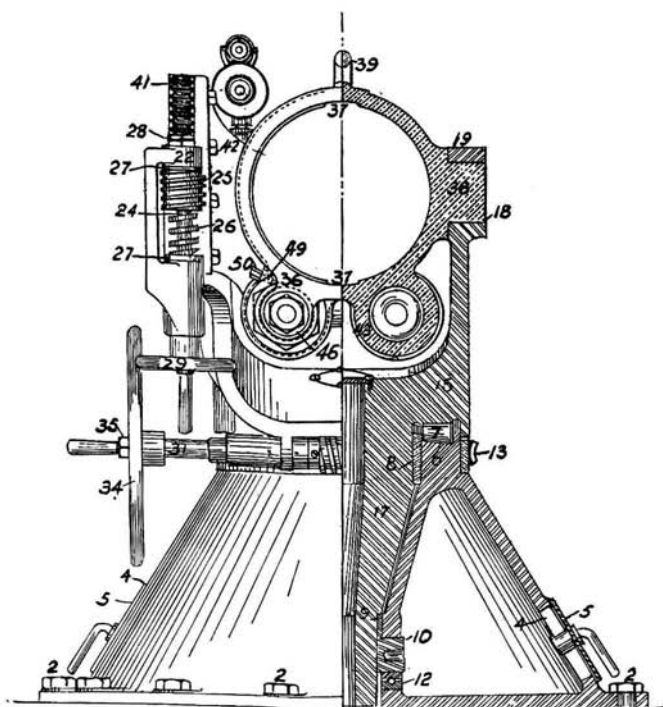
of the 3-inch mount; the counter-recoil springs are double, divided by disks into four sections in each cylinder. There is an elevating arc (98) bolted to the slide on each side; the three sets of sights are also secured to the slide; in Plate V, the night sights are shown on the left side with the leading wires connected to the firing battery (67).

The upper part of the saddle (12) is of the usual form; an elevating bracket (17) is bolted on each side; they support the pointing gear, the firing key (99) and the platforms (66). The lower part of the saddle is socketed over the stand; the two vertical bearing surfaces, rings at the top and bottom, are bushed with bronze. The ball bearings (8) travel on top of the stand in a hard forged-steel trough and an upper path, also of hardened steel, is set into the saddle. The cast steel pivot stand (3) is a short thick column held to the deck by bolts through the deck circle (9); the training rack (10) is secured to the stand.

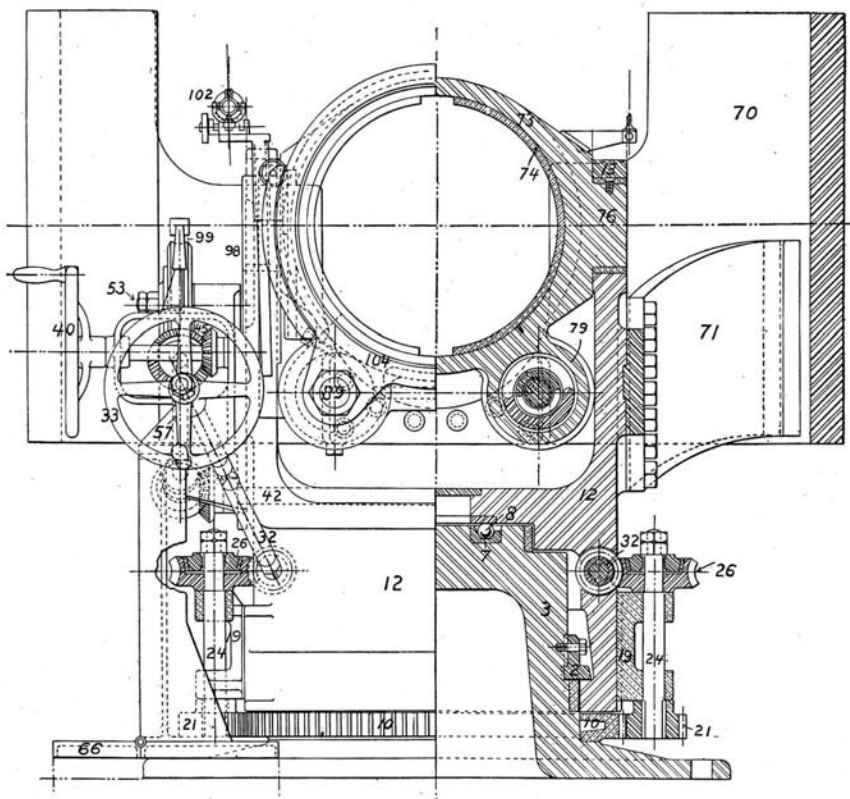
11. The vertical training shafts (24) turn in bearings in lugs (19) bolted to the saddle. They bear pinions (21), gearing in the rack, and worm wheels (25) which are turned by worms on the training shafts (32); the latter, turned by hand wheels (33), have bearings in the saddle and are cross-connected by the shaft (69), through bevel gearing. Knuckle joints are placed in the four elevating and training shafts.

Turning in bearings in each elevating bracket, is a horizontal elevating shaft (53) which has at one end a pinion, gearing with the elevating arc, and holds a worm wheel between friction disks at the other. These worm wheels are turned by worms (46) on the elevating shafts (57), which are connected to each other by the cross-shaft (42) through bevel gearings; they are turned, through similar gearing, by the hand wheels (40) working in the vertical plane. Ball-bearing frictionless washers are interposed between the ends of all four worms and their thrust bearings.

12. In addition to the stationary armor around the gun emplacement, the gun is protected by a 3-inch cylindrical shield secured to the saddle by the U-shaped brackets (71); the latter are arranged to give as much cushioning under a blow as possible. The shield, training with the saddle, is concentric with the mount and completely closes the gun port. The only opening is the port through the middle of the shield, which is only sufficient to

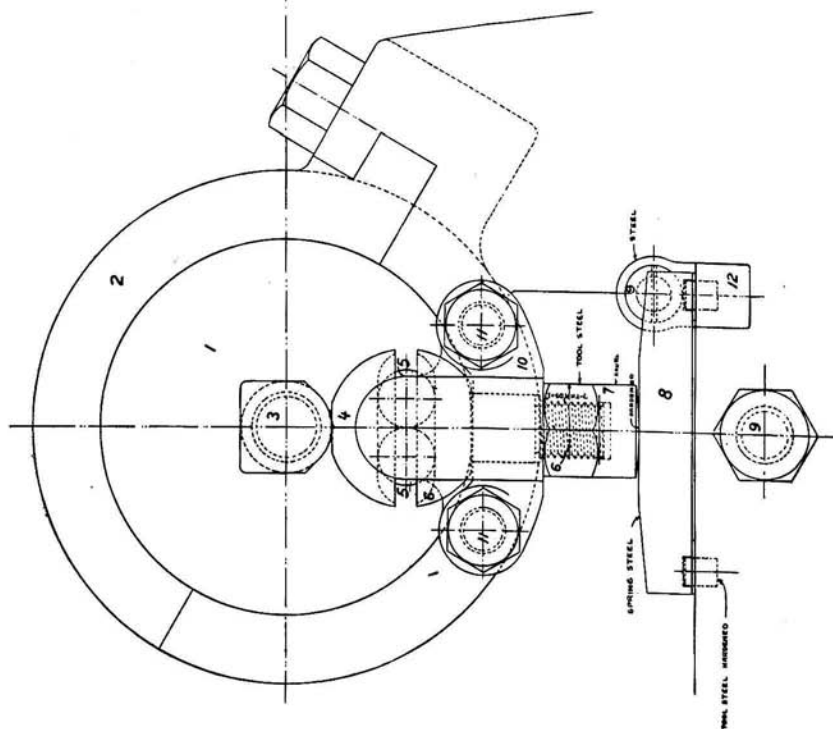


PEDESTAL MOUNT.



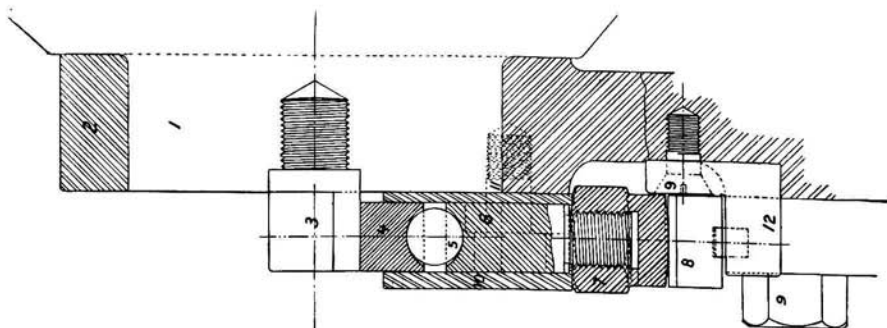
6-INCH MOUNT, MARK X.

Rear view.



Side View.

FRICTION TRUNNION DEVICE.



Section through Center.

permit the gun to be elevated through its prescribed arc and give the pointer an opening to see through. Shields of various forms, designed to protect the mounting and gun servants from small projectiles, are in many cases supplied to unarmored ships as well. They are built on the deflective system with the thickest portion normal to the line of fire; obviously, shields must be attached to the *saddle*.

Frictionless Trunnion Bearings. (See Plate VII.)

13. We have seen how friction in training is greatly reduced by suitable bearings; the same weight, less that of the saddle, has also to be moved in elevation and, since a great deal of elevating is required in maintaining a "continuous" aim, an arrangement that will minimize friction at the trunnions is also needed. A device which utilizes spherical rollers has recently been adopted and will be fitted, to intermediate mounts at least.

A small supplemental trunnion (3), with rounded lower side, is screwed into the slide trunnion (1) which is held to the saddle by an ordinary cap square (2). The small trunnion bears on a shelf (4) which in turn rests on two hard steel balls in a shallow trough (6), which is supported from the saddle. While the gun is being worked, its weight is to rest on the shelf (4) which is moved back and forth on the rollers by the motion of (3), the lower side of which is *not* at the center of rotation of the trunnion,—as may be seen in the plate. The saddle and cap square embraces the slide trunnion closely and, when the gun is fired, the elasticity of the parts of the frictionless device permits most of the shock of recoil to be received by these heavier parts.

The trough (6) rests on an elastic steel bar (8) which is secured to the saddle by lugs (12) and tap bolts (9). The trough is held from turning or falling outward by a bracket (10) secured to the saddle by bolts (11). The height of the shelf must be such that all the weight rests upon it; the adjustment is made by the nut (7) which raises or lowers the trough by its support. In making the adjustment, the rule is to raise the shelf until a thin piece of paper can be inserted under the slide trunnion—about the same space should be left all around it. Another device, that came into use several years ago, the "knife-edge" trunnion, will be described in a subsequent chapter.

CHAPTER XIV.

10-INCH TURRET MOUNT MARK II.

1. (Plates VIII and IX give general arrangement of a turret containing two 10-inch guns.) The Mark II turret mount, usually called the hydraulic turret mount, is a hydraulic recoil and return mount in which one cylinder serves to check the recoil and to return the gun to battery; all the gun working machinery, except the turning engine, is actuated by hydraulic power. The 10-inch and 12-inch guns of the monitors "Monterey," "Monadnock," "Amphitrite" and "Puritan" are installed on this type of mount as are the 13-inch guns of the battleships "Indiana," "Massachusetts" and "Oregon;" the description is written for the "Indiana."

The hydraulic systems of the two turrets are connected and power at 600 lbs. pressure is maintained in the piping by powerful steam pumps located below the armored deck. Each turret has its own magazines and shellrooms, which are under the charge of the turret officer, opening into a handling room from which the hydraulic hoists convey the ammunition to the guns.

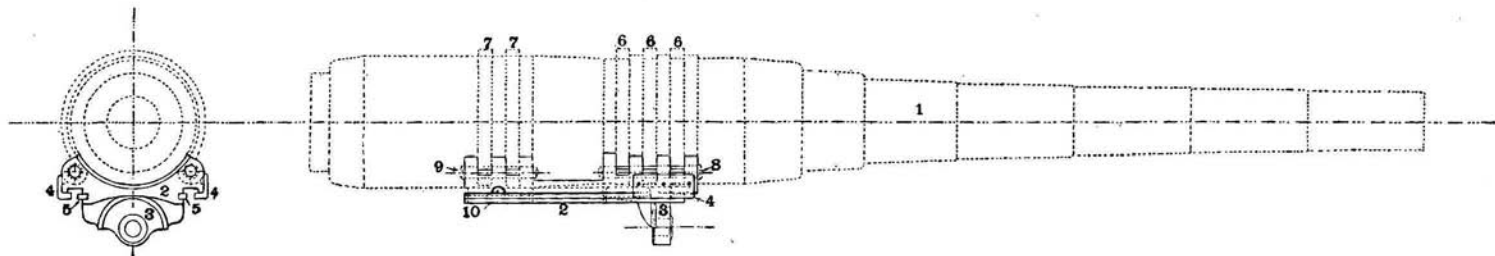
The *turntable*, or main foundation for all the revolving parts of the turret, is built up of steel plates and angle irons and is arranged to rotate on live rollers (67) which travel on a roller path (68) built into the barbette structure well inside the armor; the rollers are spaced by floating rings secured to their axles. The weight of the revolving part of the installation, about 490 tons, for 13-inch guns, rests upon these rollers and the horizontal thrust of the guns in recoiling is transmitted to the ship by their flanges. The circular barbette (69), 17 inches in thickness, extends from the armored deck well above the turntable, while the guns and upper parts of the mountings are protected by a 15-inch vertical-sided turret, resting on the turntable and extending a little below the top of the barbette. The turntable is revolved by a two cylinder steam

turning engine in a compartment directly below the handling room; hand turning gear, which can be connected only after disconnecting the engine, is fitted in the same compartment. The pinion of the training shaft, which is actuated by the turning engine through connecting shafting, gears in the circular training rack of the turntable; there is a suitable friction band on the training shaft which yields when one gun of the turret is fired, thus protecting the training gear from the distortion that would be caused by the severe lateral jump of the turret,—the line of recoil being outside the center of rotation. When not in use, the turret is secured by: (1) locking bolts, which set up through the turntable to a bearing on the barbette; (2) outside turnbuckles, securing turret armor to barbette armor; and (3) wedges, setting up between upper inside edge of barbette and lower outside edge of turret. (None of the training or of the securing gear is shown in the plates.) The main pressure pipe (61) conveys the water from the pump to the water section (60) only part of which is stationary, the revolving part furnishing pressure to all the hydraulic machinery of the turret. The exhaust is conveyed from the turret to the feed tank through (60) and (61) in a similar manner. The principal parts of the mounting are:

Gun and Saddle, Plate I.	Elevator, . . . Plate V.
Recoil Check, " II.	Ammunition Hoist, " VI.
Gun Slide, . . " III.	Rammer, . . . " VII.
Deck Lugs, . . " IV.	

2. **The Saddle** [Plate I (2)] is a large bronze casting to which the gun is secured by three front (6) and two rear (7) collars which fit in recesses machined in the gun body; a key, fitting in grooves between gun and saddle prevents the gun from turning. The saddle rests on and is held to the slide rails by clips (4) and (5). The piston rod is secured to the lug (3) and recoils with the gun and saddle.

3. **The Recoil Check** (Plate II) is of the hydraulic type, one cylinder being used both to check the recoil and to return the gun to battery. The cast-steel recoil cylinder (11), rifled with three tapered grooves, is bolted between the rails at the after part of the slide. It receives hydraulic pressure through (14) from a pipe

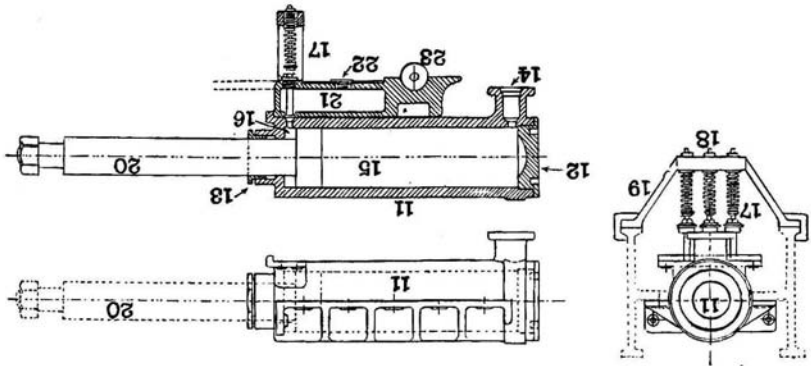


SADDLE AND GUN 10-INCH TURRET MOUNT, MARK II.

- 1. 10-in. B. L. R.
- 2. Saddle.
- 3. Recoil lug.
- 4. Holding down clips.

- 5. Holding down gibs.
- 6. Front straps.
- 7. Rear straps.

- 8. Front saddle bolts.
- 9. Rear " "
- 10. Hole for locking bolt.



RECOIL CHECK, 10-INCH TURRET MOUNT, MARK 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. Relief valve spring.

- 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.

leading from the water collar [Plate IV (29)] at the trunnions. A check valve in the pipe at (14) closes and prevents the escape of water through it during recoil. The three relief valves (16) are spring weighted to 600 pounds and open downward to the overflow chamber (21). The piston rod (20) is of forged steel, partly bored out for lightness; it enters the cylinder through the stuffing box (13) and bears the piston, which is shown in its "run out" position.

When the gun is run out and in position to be fired, the piston rod is drawn out of the recoil cylinder to its full length, and the latter would consequently be full of water, as the pump must be in operation and the cylinder and hydraulic system filled, before the gun can be fired. The pumps are to be kept in operation during the firing. The walls of the recoil cylinder being cut with rifled grooves, the pump pressure is exerted on both sides of the piston, and the fluid would escape through the three spring valves (17) at the front end of the cylinder were the springs not set up sufficiently to resist the pump pressure, which is required to be maintained at 600 pounds per square inch.

Water is admitted to the recoil-cylinder only at the rear end, through the aperture (14), and can escape only at the front end, as there is a check-valve in the supply pipe (14), which closes when recoil takes place; otherwise the pipes or pump would be burst by the violent and sudden pressure due to recoil. When the gun is fired the piston rod is driven into the recoil cylinder, and consequently must displace a quantity of water equal to the volume of the entering piston rod. The fluid thus displaced escapes by the spring valves (17) into the overflow chamber (21), and thence by a flexible hose attached to the opening (22) to the exhaust or waste pipe, and back to the tank.

Recoil is taken up by the restriction of the fluid in passing from the pressure to the reverse side of the piston by means of the grooves in the cylinder, and, while the spring valves are on the reverse side, the tension on their springs does, in a manner, affect the recoil, and if they are set up too tightly, the length of recoil will be reduced. These springs should be set up so that the valves will be tight under the normal pressure of 600 pounds per square inch and no more. Care should be taken to see that the valves

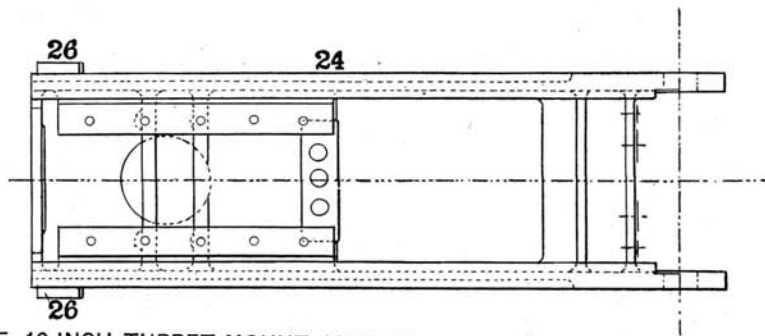
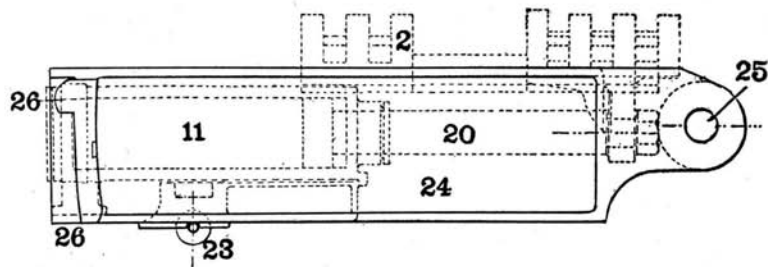
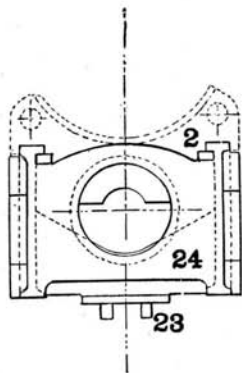
have a lift of not less than three-fourths inch, as this is necessary to give a proper valve opening for the escape of the water when the gun is fired.

When recoil takes place the check valve in the pressure pipe closes, but as soon as the gun is at rest the relief valves close, pressure is admitted to the cylinder and its action on the rear face of the piston returns the gun to battery. The effective area for doing this work is the area of the piston rod, since the same pressure acts on both sides of the piston.

In securing the turret for sea, the guns are secured in the loading position, at 10 degrees elevation, and are run in on the slides the full distance. This is done by closing the valve in the pressure pipe, opening the central relief valve, which is specially fitted for the purpose, and then raising the muzzle a few degrees whereupon the gun will run in by gravity; if it starts in too rapidly, its velocity may be checked by quickly lowering the muzzle. To run out again, see the springs of all relief valves set up and open the valve in the pressure pipe, whereupon the gun will be forced out as in its counter recoil.

4. The Slide (Plates III and IV) is a large steel casting with rails planed to fit the saddle which, with the gun, is held to and rests upon them. It is trunnioned by the bolts (32) to the *deck lugs* which are securely bolted to the turntable. The recoil cylinder is bolted to the after end of the slide and bears on its lower side the lug (23) to which the connecting rod of the elevator is secured. The locking lugs (30), or rest lugs, are operated by the hand lever (31), and bear upon the stop piece (26). The gun has two locking positions; level, as shown, for use when ship is in port, and the loading position at 10° elevation; in the latter position the bearing surface near the top of (26) rests on the lug. The gun must be unlocked before firing.

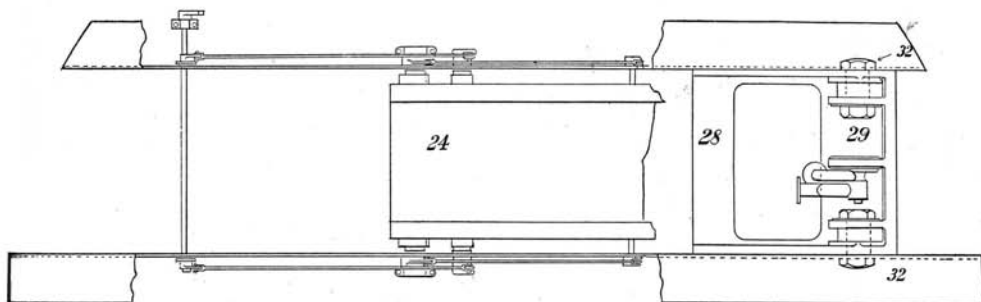
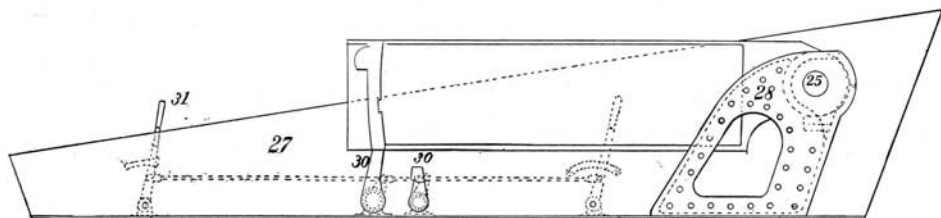
5. The Elevator (Plate V) consists of a heavy cylinder (33) suspended from the turntable, beneath the rear end of the slide. The connecting rod (35) is bolted at its upper end to lug (23) and its lower end rests in a ball and socket joint in the leather packed ram (34); the elevator cylinder has a ring around its top (inside) which prevents the ram from being raised too high. A pipe connects the lower end of the elevator with the valve (36) which is



SLIDE, 10-INCH TURRET MOUNT, MARK II.

24. Slide.

25. Holes for pivot bolts.

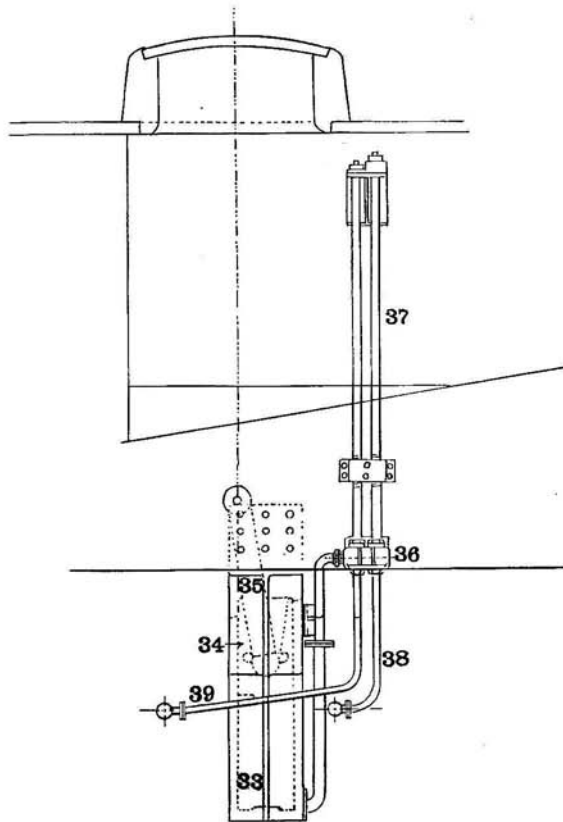
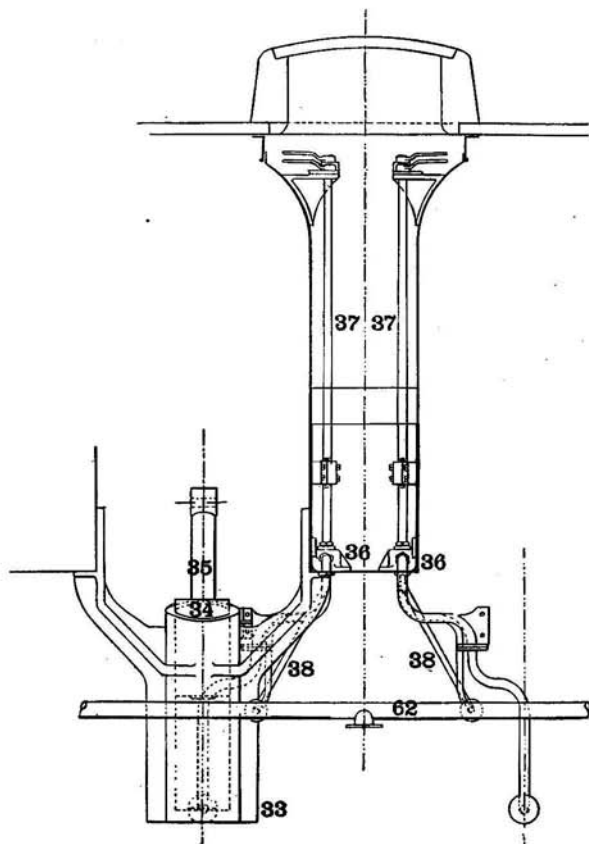


DECK LUGS AND LOCKING LUGS, 10-INCH TURRET MOUNT,
MARK II.

27. Turret girders.
28. Deck lugs.

29. Collar for pressure pipe.
30. Locking lugs.

31. Locking levers.
32. Pivot bolts.

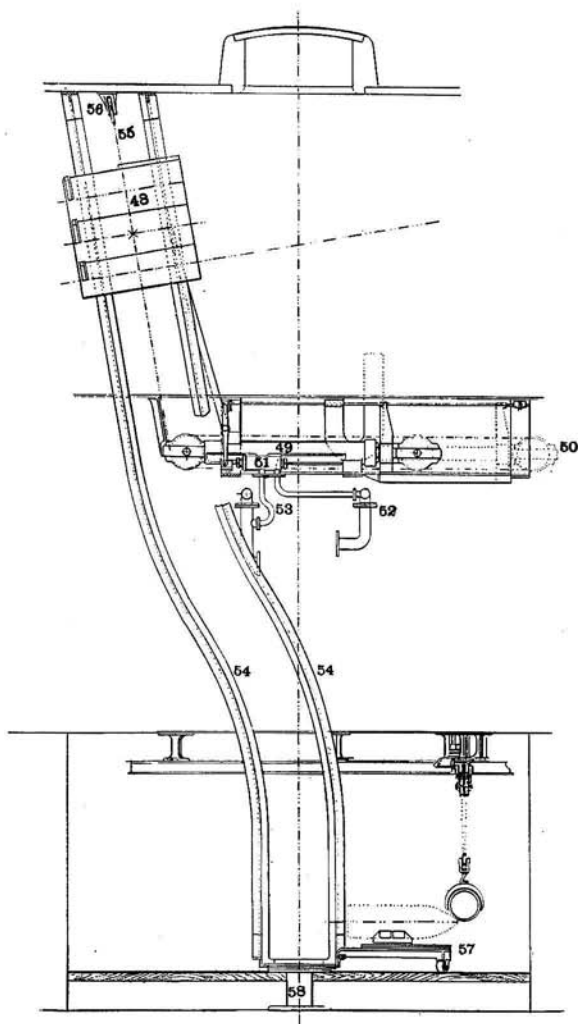


ELEVATOR, 10-INCH TURRET MOUNT, MARK II.

33. Elevator.
34. " piston.
35. " connecting rod.

36. Elevator valves.
37. " valve rods and levers.

38. Elevator pressure pipe.
39. " exhaust pipe.



AMMUNITION HOIST, 10-INCH TURRET MOUNT, MARK II.

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

operated by levers from the central sighting hood. The pressure pipe (39) and the exhaust pipe (38) lead to this valve, by which either may be connected with the elevator cylinder. If pressure is turned on, the ram will raise the breech of the gun; if the cylinder is opened to exhaust, the gun, being mounted breech heavy, will be elevated.

6. The Ammunition Hoist (Plate VI), of which there is one for each gun, is operated by the hydraulic motor (49), the controlling lever of which leads upward in rear of the gun. The motor is, in effect, a three-fold purchase worked backward, thereby gaining motion and losing power in the proportion of six to one. The outer end of the piston rod and the closed end of the cylinder bear three sheaved blocks through which the wire fall of the hoist is rove. The standing part is secured to the motor and the other end reeves through the block (56), thence downward and is secured to the car (48); when power is turned on the motor, the blocks are separated, the cable "overhauls" through the sheaves and the car is hoisted; the hoist of the car is to the extension of the motor piston rod as six is to one. When for any reason there is not power enough to hoist the car, the fall may be unrove from one sheave, making the above proportion five to one and gaining power accordingly. When the motor is opened to exhaust, the piston rod is forced in and the car descends by its own weight. The guide rails (54), on which the car travels, train with the turret and are curved to bring the car to the proper position for loading. The car (48) has three compartments, the two upper ones for powder, the lower one for the projectile; there are latches for preventing the contents from falling out when the car is inclined during hoisting. Stops, or hooks on the guide rails, fix the position of the car in loading, and each compartment is in turn brought in front of the rammer. The car travels on the guide rails by its rollers, and has pawls which will catch projections on the inside of the guide rails in the event of any accident which would cause the car to fall.

The powder is brought from the magazine and placed in the car by hand; each gun having its own magazine and shellroom on the same level with, and opening into, the handling room. Overhead trolley rails lead from each shell room to the ammunition

hoist; the projectiles are handled by differential purchases, the upper blocks of which are hooked to cars travelling on the trolley rails. From the purchases the projectiles are landed on the car (57) which is wheeled around a track, by hand or hydraulic power, until the projectile is pointed fairly into its compartment, when it is forced in by hand power.

7. The Rammer (Plate VII) is secured to the turntable in rear of the gun in such a position that it delivers its stroke along the axis of the bore, when the gun is in its loading position. In the 10-inch turret mounts, the rammer is, after loading, turned on its trunnions (44) into a vertical position to keep it clear of the recoil. The rammer, worked by hydraulic power, is telescopic; the sections are packed with U-shaped leather washers—one at the forward and two at the after end of each. The rammer head is borne on the inmost section, which has the greatest travel. The controlling valve (45), actuated by the hand lever (46), is a piston valve with pressure space at each end and an exhaust space in the middle; it operates as follows in extending and retracting the rammer. When the valve is moved forward, pressure is admitted through the right trunnion, while the contents of the rammer exhaust through the left trunnion, as shown by the arrows; this pressure, acting on the combined area of the rear ends of all the sections, extends the rammer with great force—each section starts as it feels the pressure, not being constrained by the others as to time of moving. To retract the rammer, the valve is moved aft, opening the right trunnion to exhaust and the left one to pressure; each section has a collar around its rear end which affords the effective area for the pressure to act upon in retracting, since the pressure admitted through the left trunnion acts in both directions but upon different areas.

The high pressure of 600 pounds gives this type of rammer very severe shocks, similar in effect to water hammering, particularly when the projectile suddenly stops on reaching its seat. Serious break downs have been the result, and in some turrets, hydro-pneumatic rammers, working on the same principle but having the advantage of air cushioning, have been substituted.

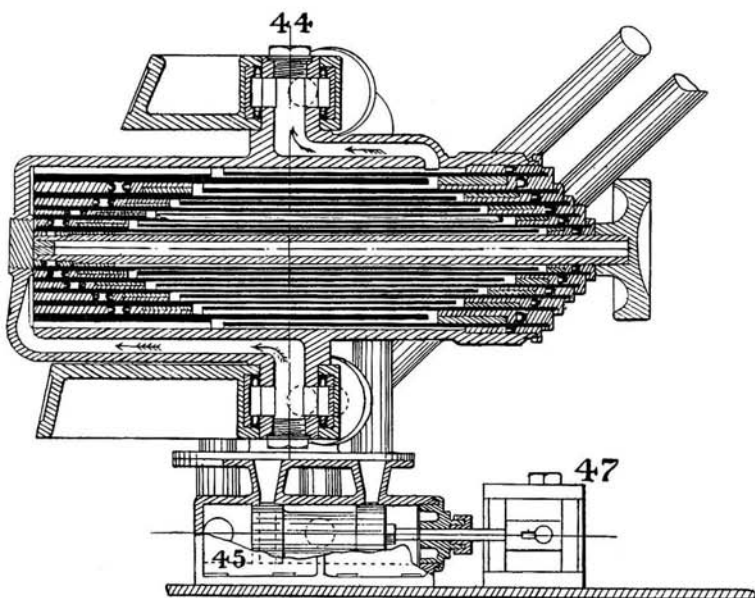
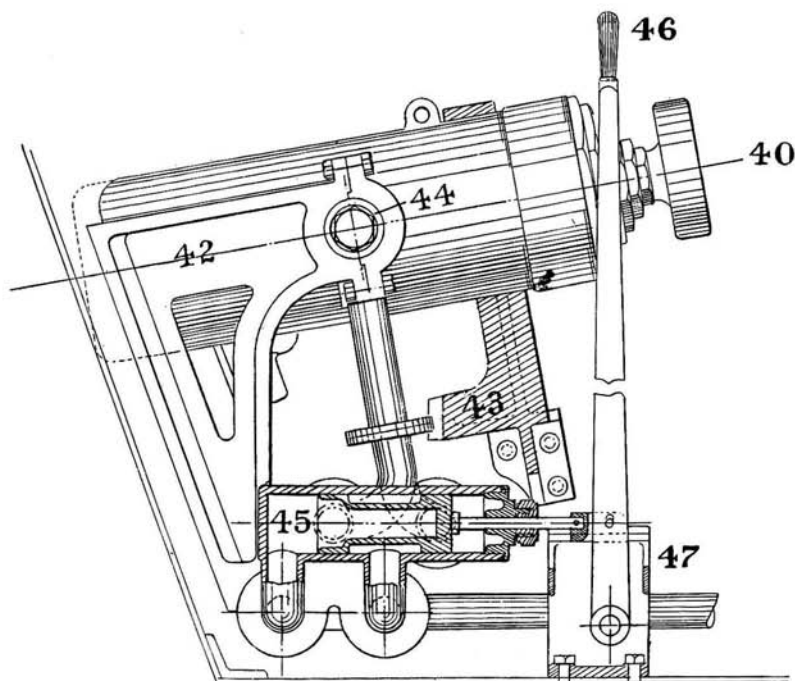
8. Miscellaneous Fittings.—The turret is covered with three-inch armor plates, built in which are the sighting hoods with plat-

forms directly below,—on which the trainer and the gun pointer stand. The training hood, situated forward, outside the left gun, contains the trainer's sight and a control lever for the turning engine. The gun-pointer's hood, usually occupied by the turret officer, is between the guns, near the center of the turret. This station contains a control lever for the turning engine and a clutch for connecting and disconnecting it and the lever in the training hood, both of which cannot be in operation at the same time; a speaking tube to the training hood; a telescopic sight and a firing key for each gun; and the control levers for the elevators.

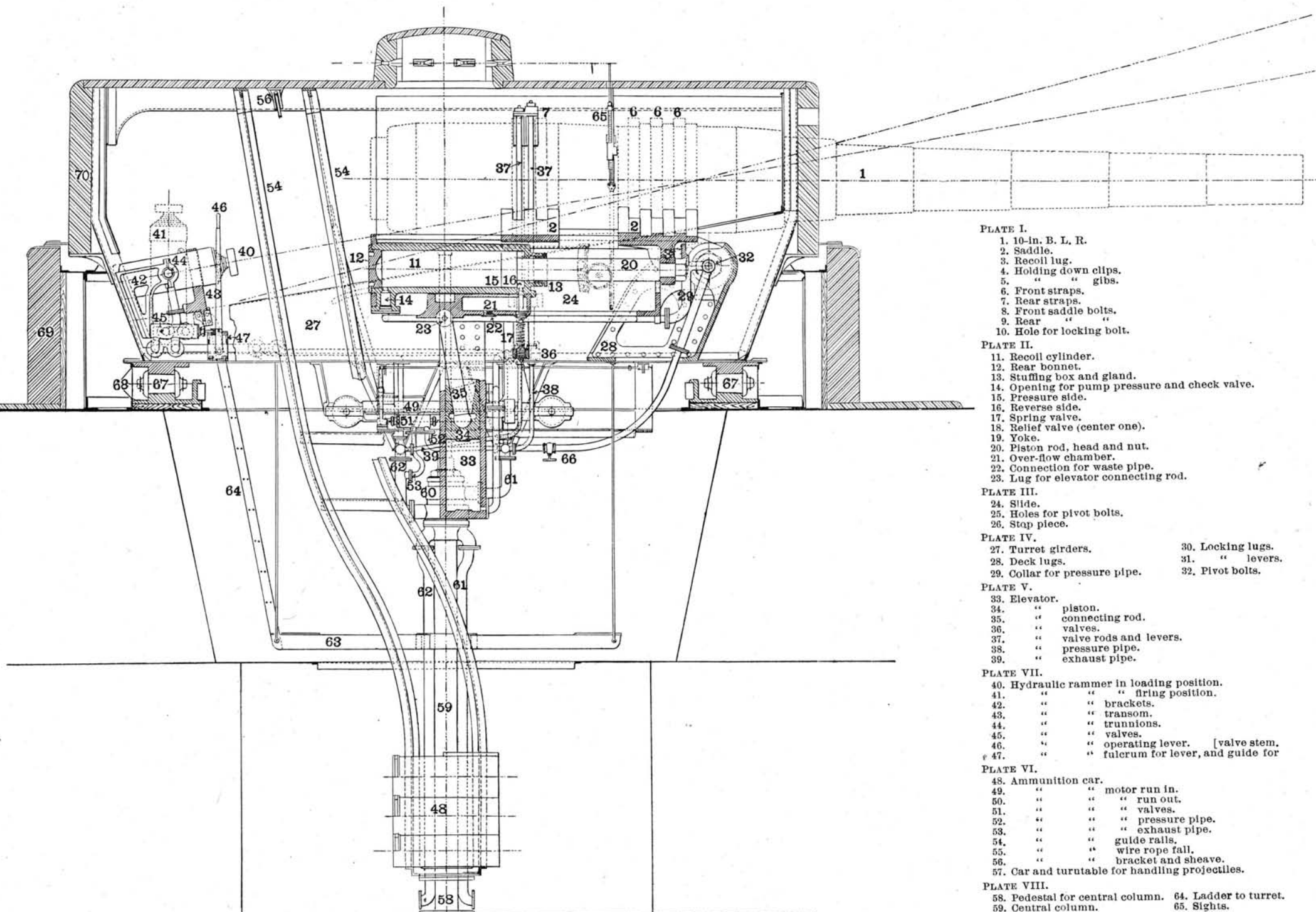
An electric fan is placed behind each gun to drive the smoke out of the turret. A hinged grating, on which the loader stands when performing his duties, covers the opening up which the ammunition car passes; it must be hinged up when the car is raised. There are suitable ladders for gaining access to the handling room; an opening on each side of the turret roof is protected by armor gratings; hand gear is fitted only to the turning gear. Valves are placed in each exhaust and pressure pipe in the turret as well as in the main exhaust and pressure pipes.

The 12-inch turret mounts of the U. S. S. Texas have a closed recoil cylinder and two auxiliary running out motors for each gun; the auxiliary or gun working motors have no part in checking the recoil.

(The "Special Notes on Turret Mounts," pp. 101 to 114 inclusive, in the Gun and Torpedo Drill Book (Edition of 1900), apply very extensively to the Hydraulic Turret Mount.)



HYDRAULIC RAMMER, 10-INCH TURRET



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. Stop piece.

PLATE IV.

27. Turret girders.
28. Deck lugs.
29. Collar for pressure pipe.

PLATE V.

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

PLATE VII.

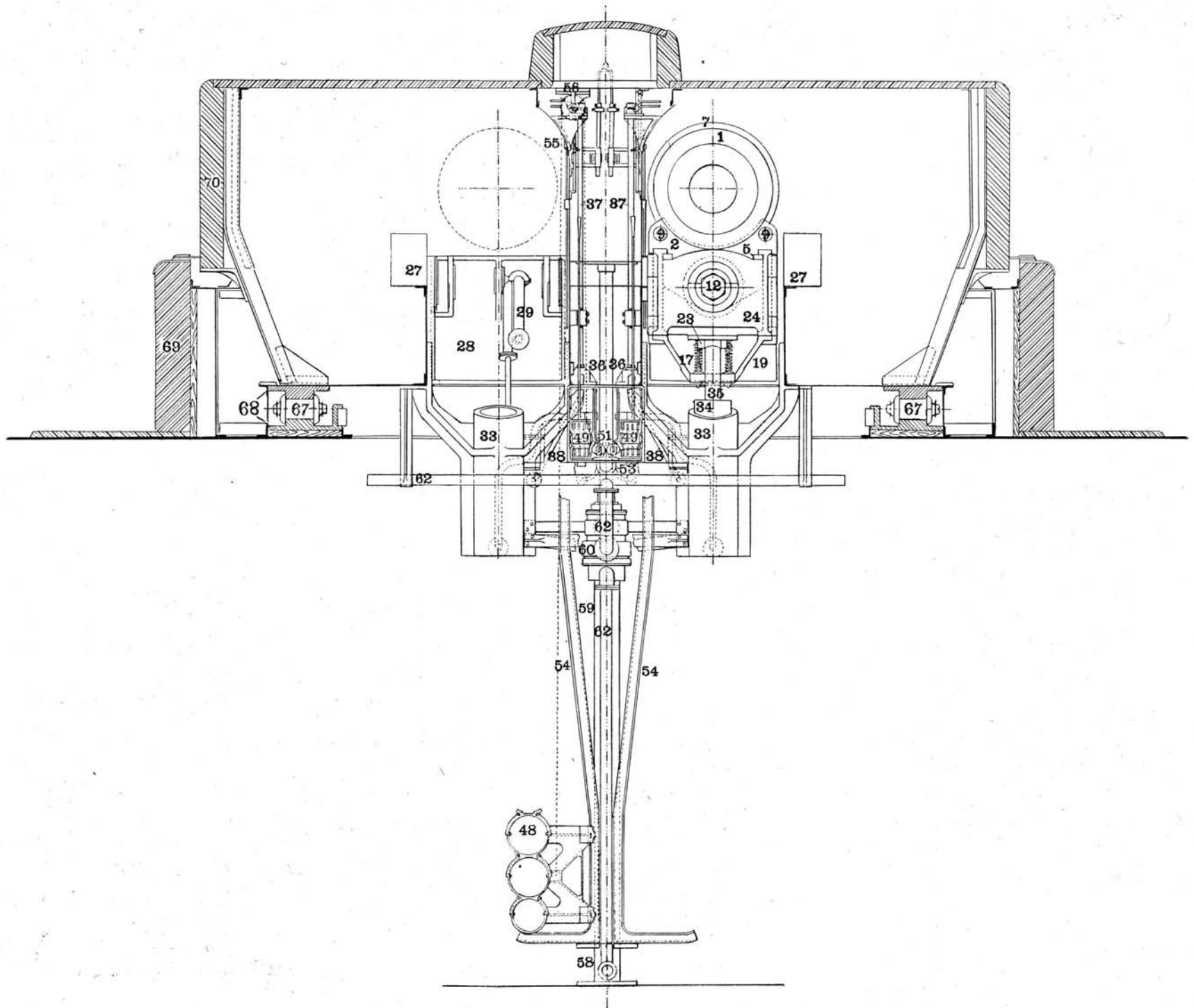
40. Hydraulic rammer in loading position.
41. " " firing position.
42. " " brackets.
43. " " transom.
44. " " trunnions.
45. " " valves.
46. " " operating lever. [valve stem.
47. " " fulcrum for lever, and guide for

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.

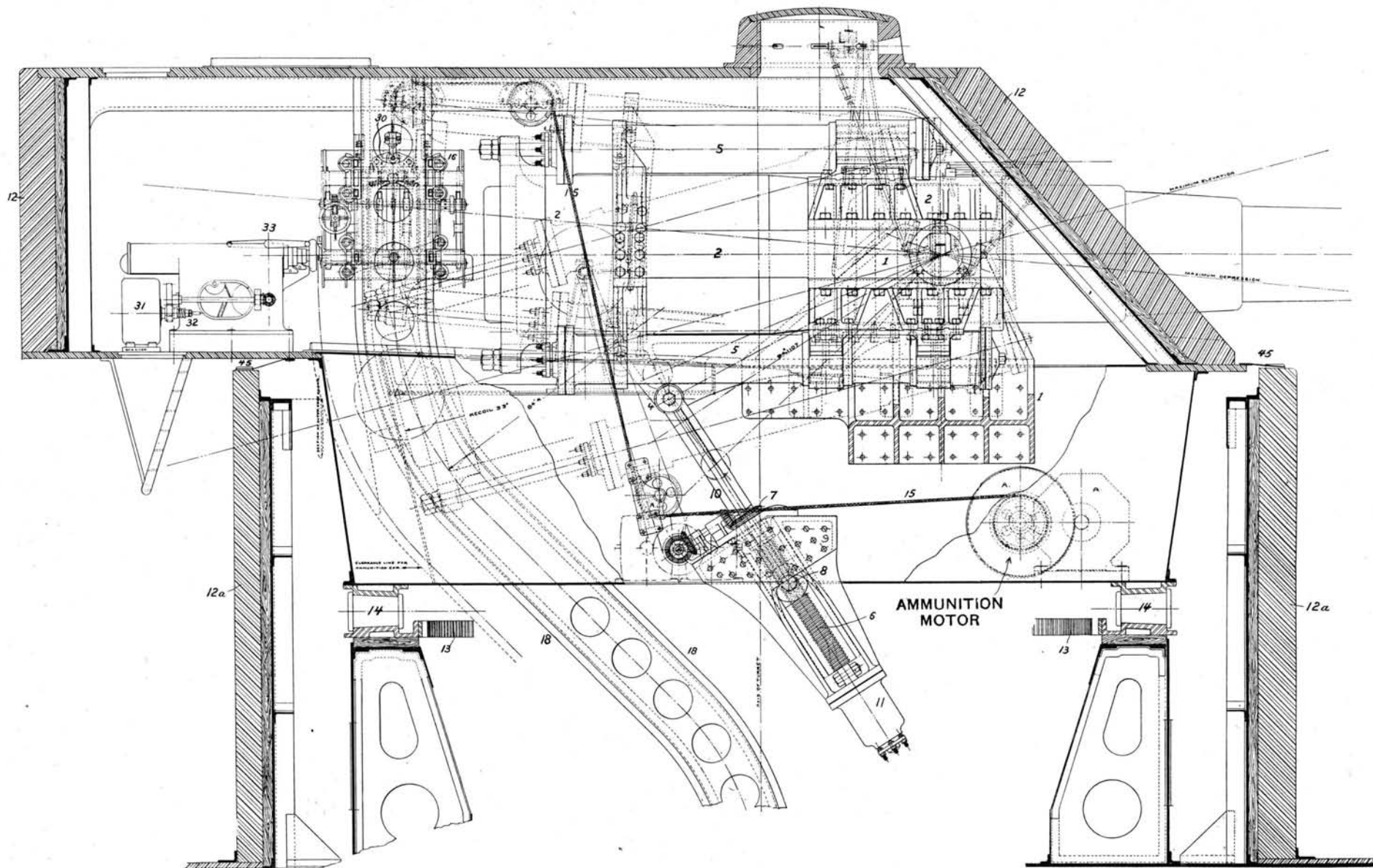
12-INCH TURRET MOUNT MARK IV.

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.

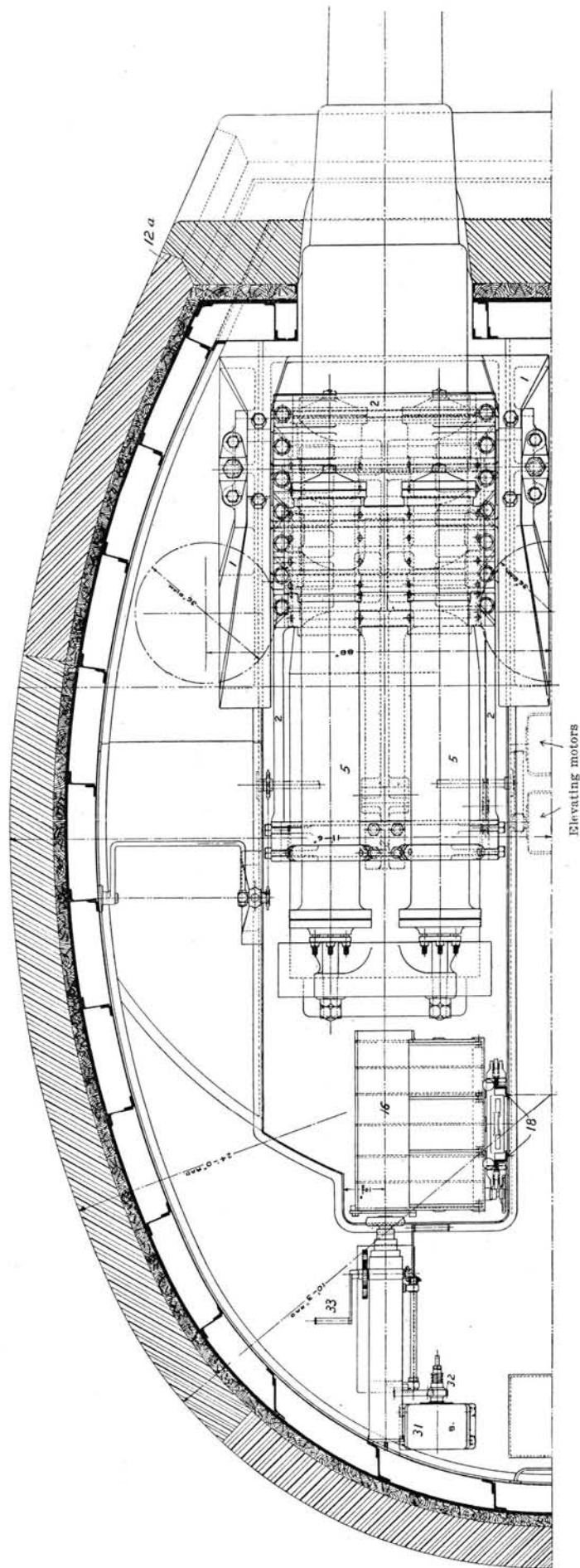
Plate I is a vertical longitudinal section between the guns showing the left mounting in profile. Plate II is a plan of the left half of the turret (section taken at the level of the trunnions). Plate III is a cross section of the left half of the turret showing the

recoil cylinders and gun slide in profile and in section. (The description is written for the turret of the "Arkansas.")

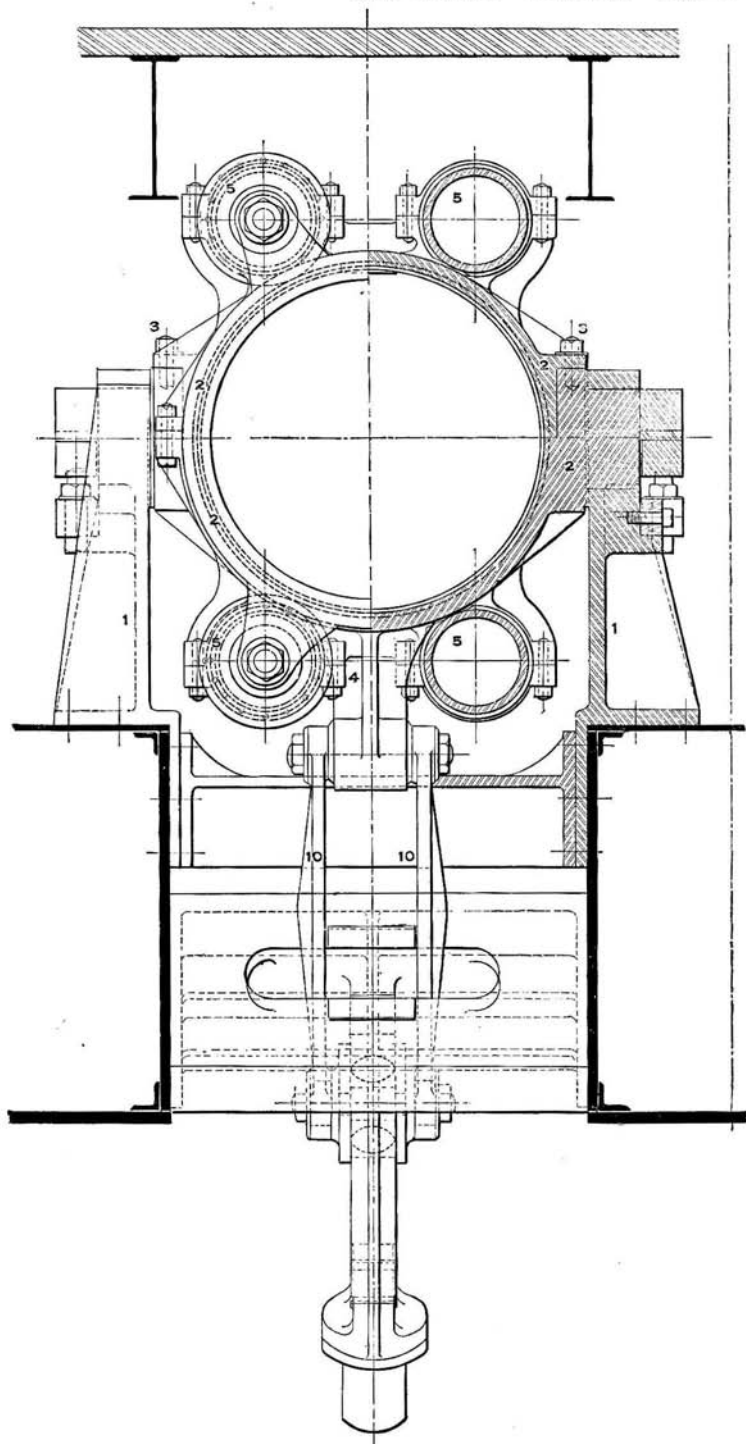
The *turntable*, to which the turret armor and all revolving parts of the mounting are secured, is built up of steel plates and angle irons and rotates on live rollers (14), which travel on a roller path built up inside the barbette framing. The cone-shaped rollers are spaced by two floating rings which 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



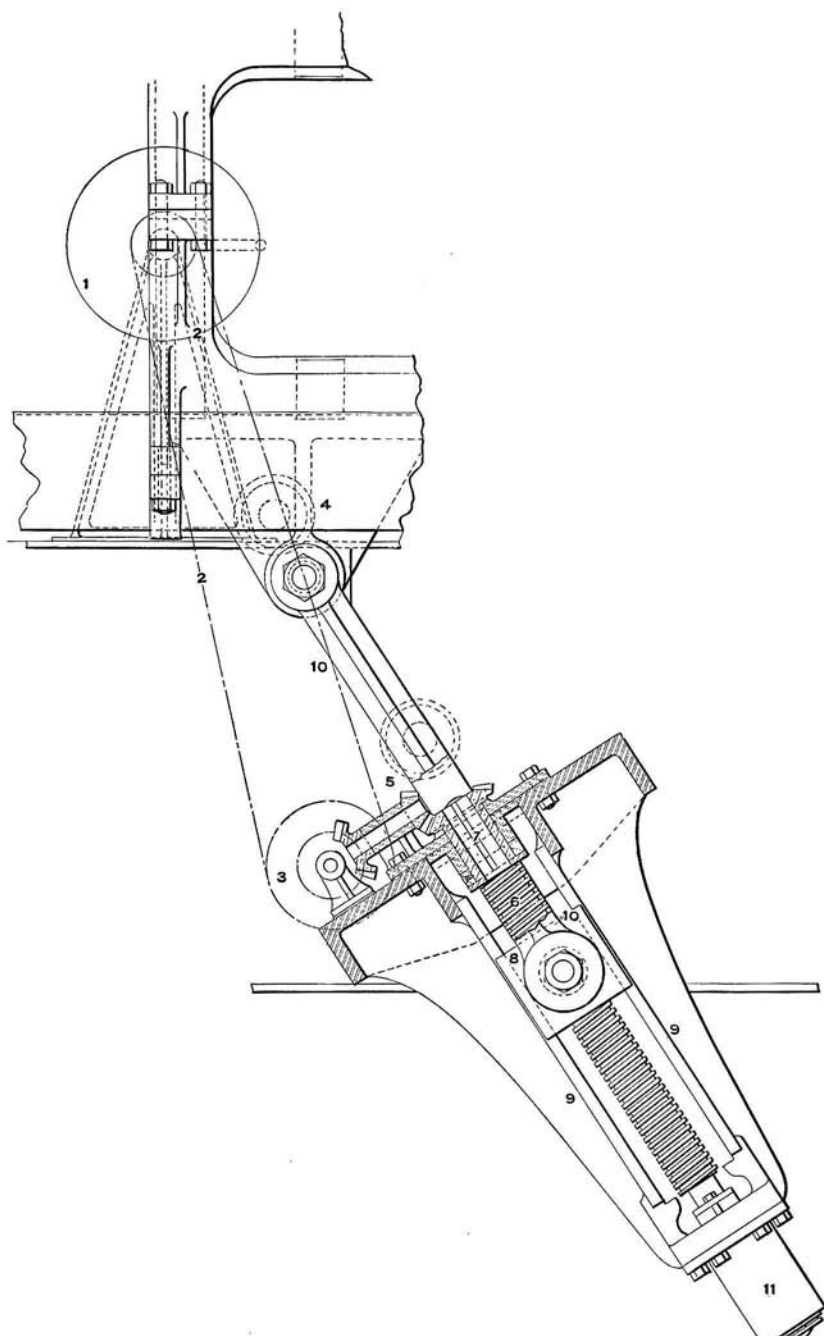
12-INCH TURRET MOUNT, MARK IV.



12-INCH TURRET MOUNT, MARK IV.



12-INCH TURRET MOUNT, MARK IV



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.

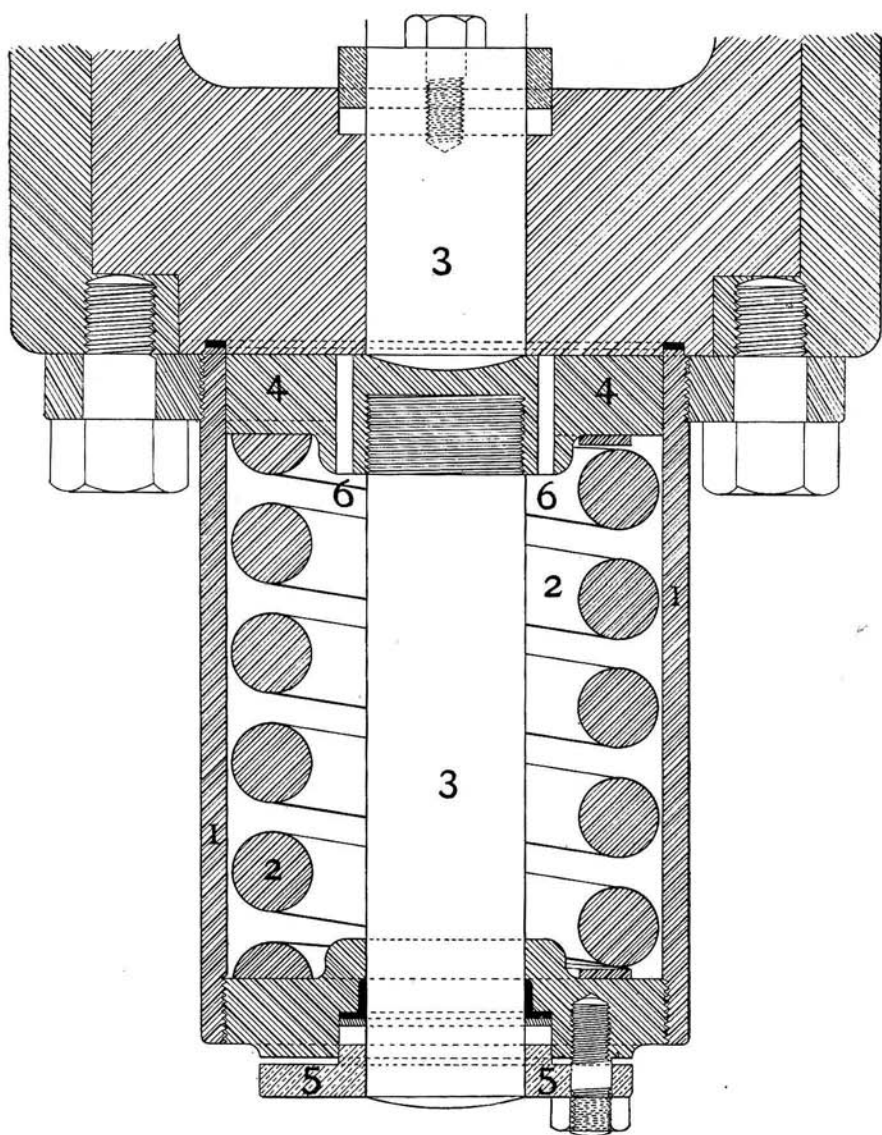
The *deck lugs* (1), which bear the trunnion seats and cap squares, are heavy steel castings bolted to the turntable.

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.



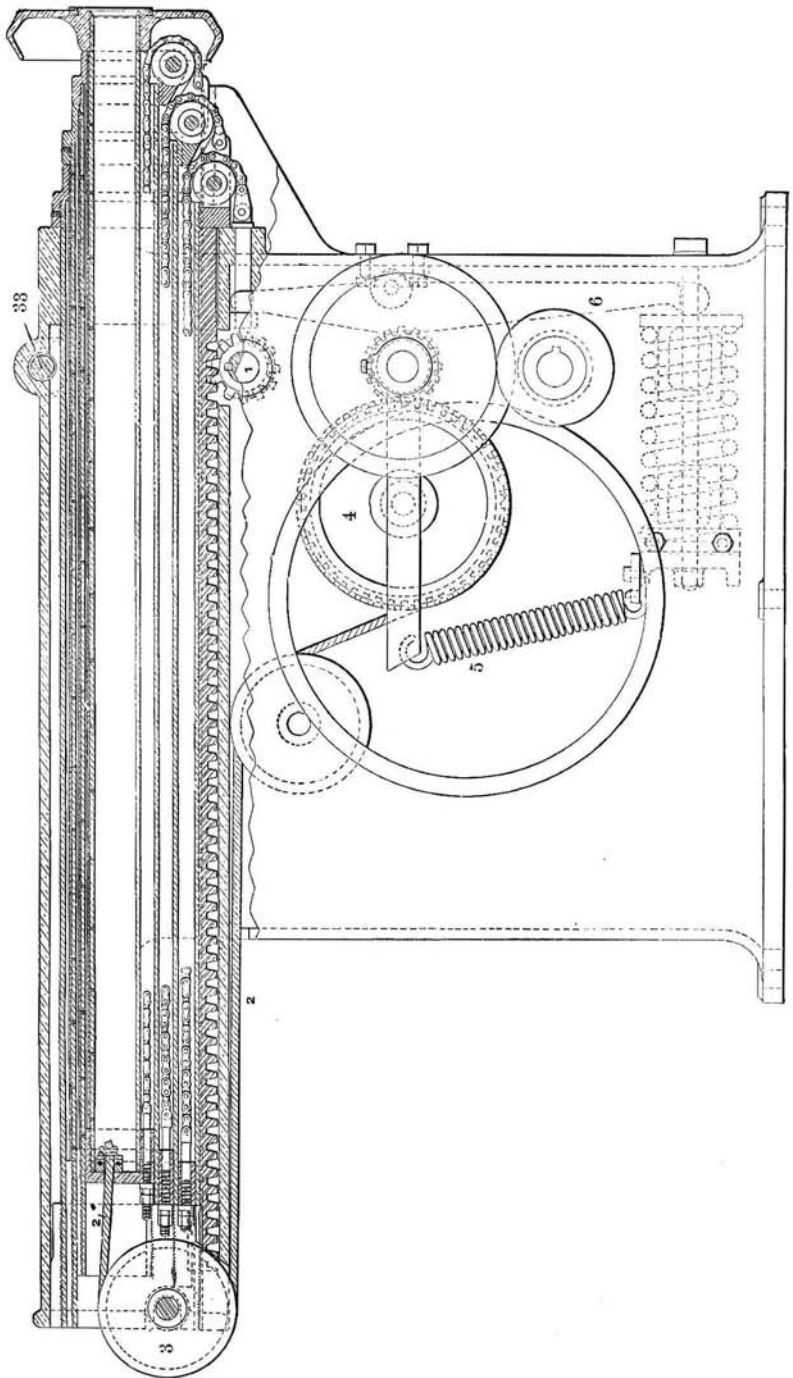
rolled to the handling room on overhead trolleys and landed on the handling room car from which they are pushed by hand into the ammunition car. The powder charge is made up in four sections and is transferred from magazine to car by hand.

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 $2\frac{1}{2}$ 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 $\frac{3}{8}$ -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.

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.)

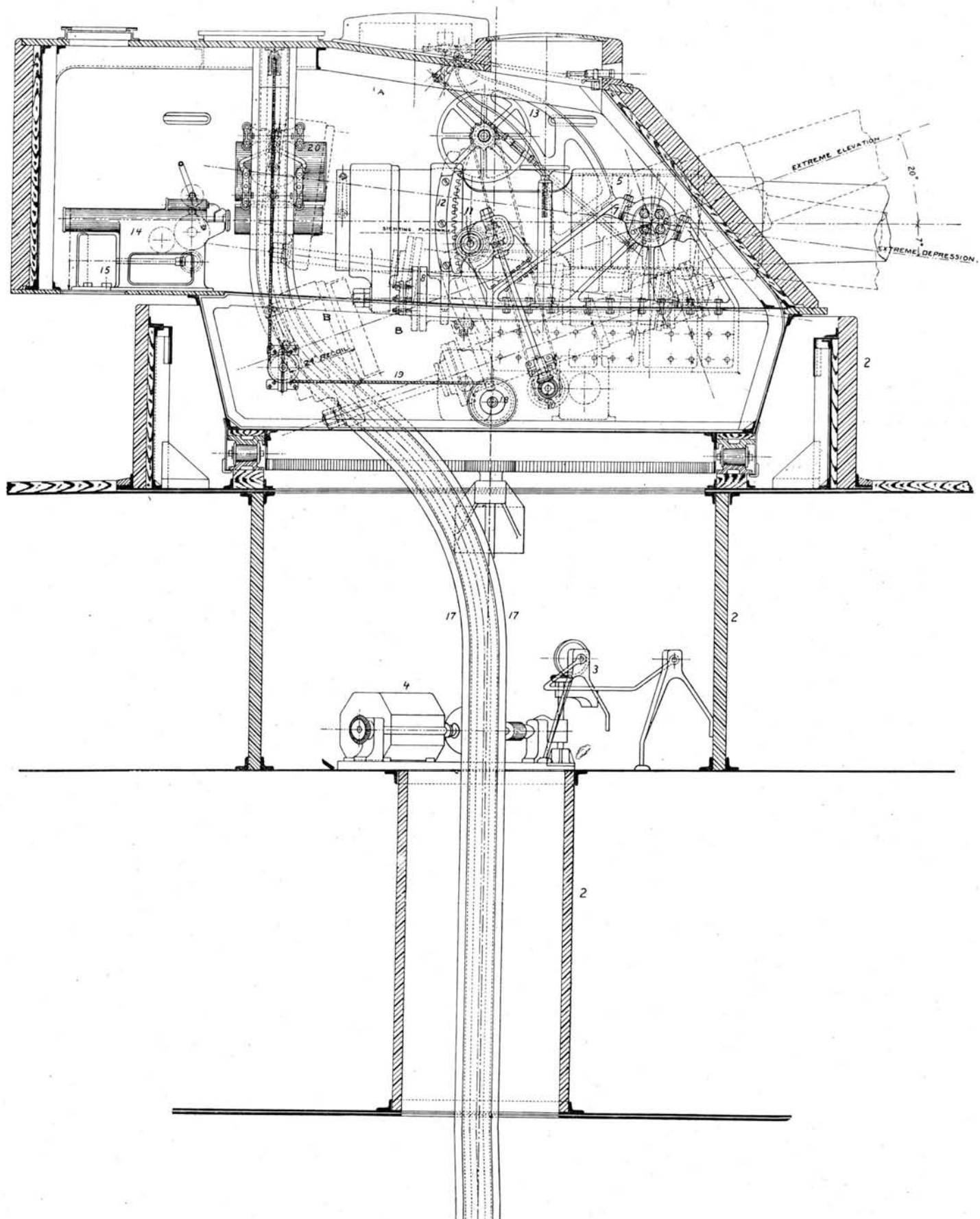
CHAPTER XVI.

8-INCH TURRET MOUNT MARK XII.

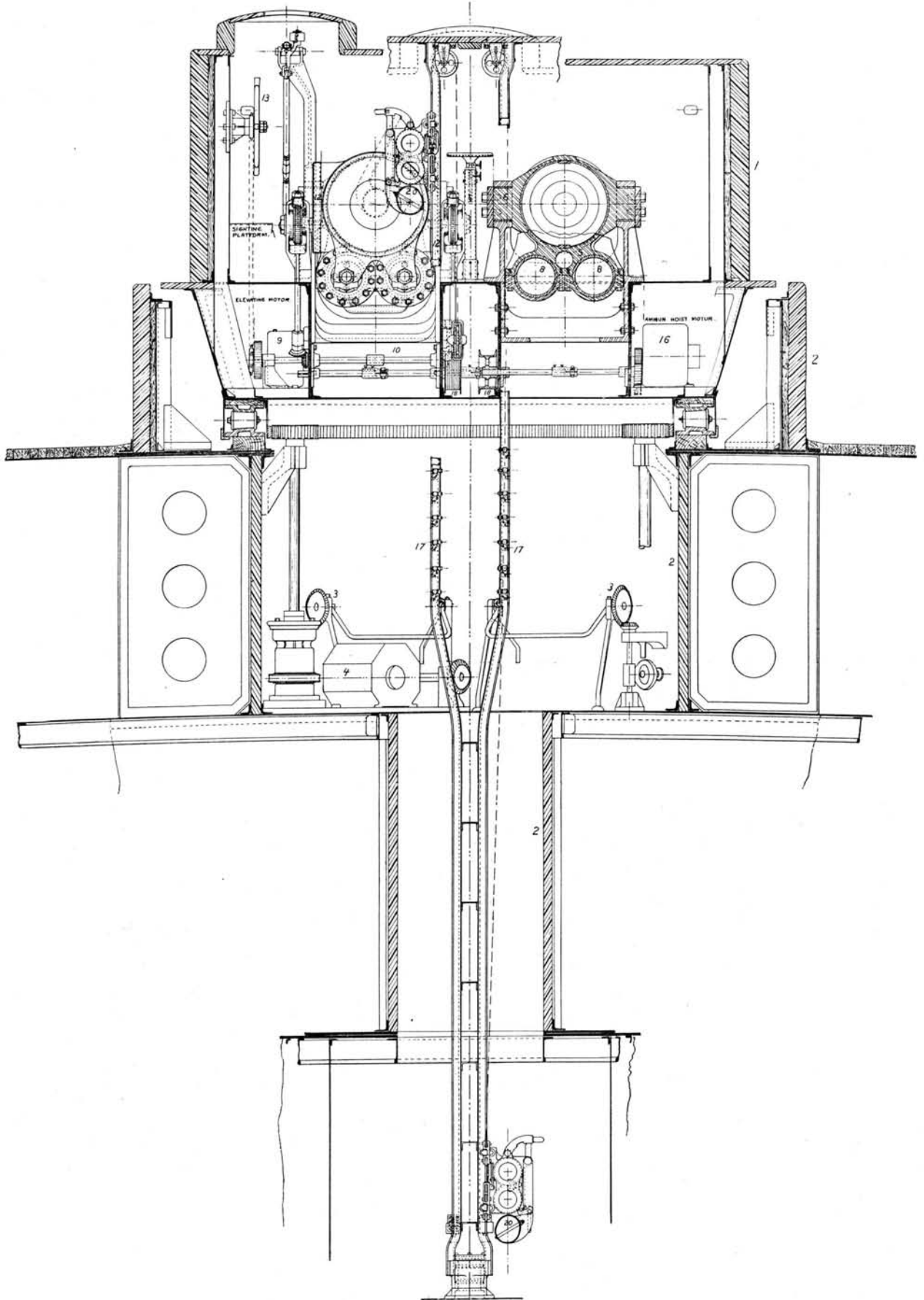
1. The Mark XII mount is a hydraulic-recoil, spring-return, electrically operated and controlled mount, and, as installed on ships of the "Pennsylvania" class, is in most respects similar to the 12-inch Mark IV mount described in the preceding chapter. Plate I is a vertical longitudinal section; Plate 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.

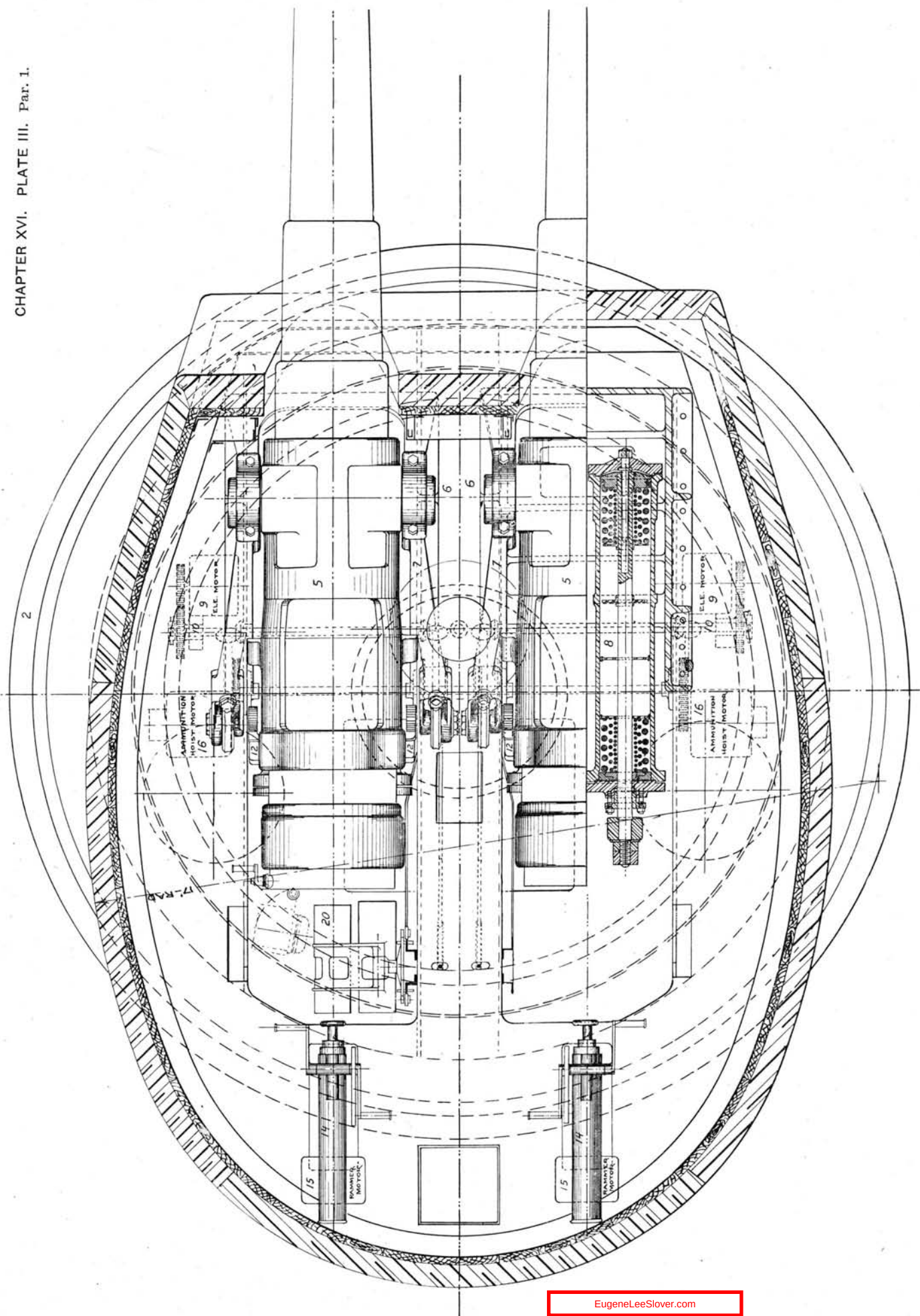
2. The **Elevating Gear** of each gun is actuated by an electric motor (9) placed under the turret floor outside of the gun. The armature shaft is geared to a cross shaft (10) which is in turn



8-INCH TURRET MOUNT, MARK XII.



8-INCH TURRET MOUNT



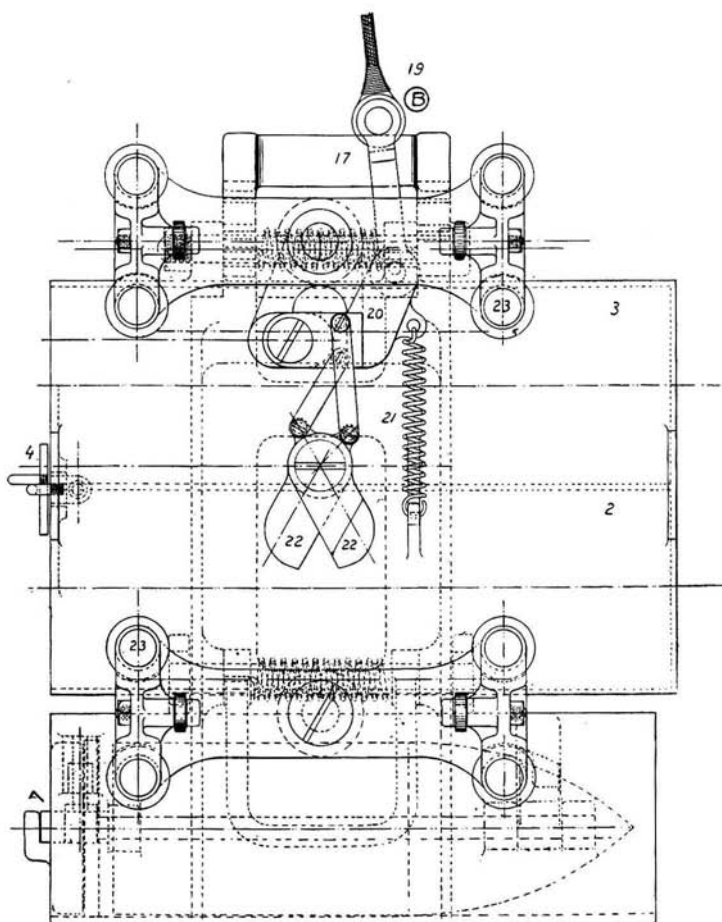
8-INCH TURRET MOUNT, MARK XII.

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.

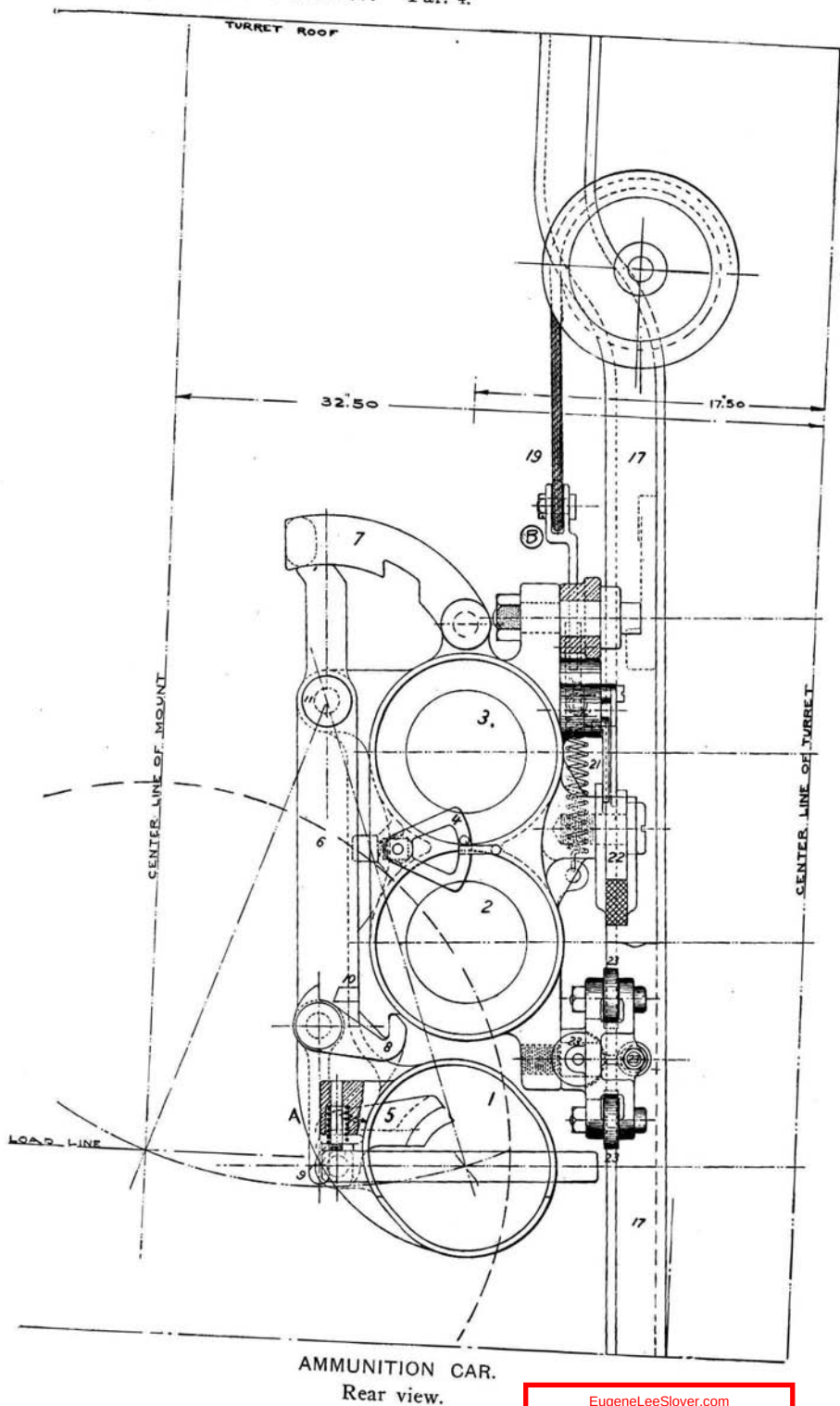
3. **The Rammers** (14) are of the chain telescopic type, driven by motors (15) placed beneath the rammer casing. The rammers work in about the same manner as do those of the Mark IV 12-inch installation; the different sections, however, are not concentric and the driving chains are placed on their tops. 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



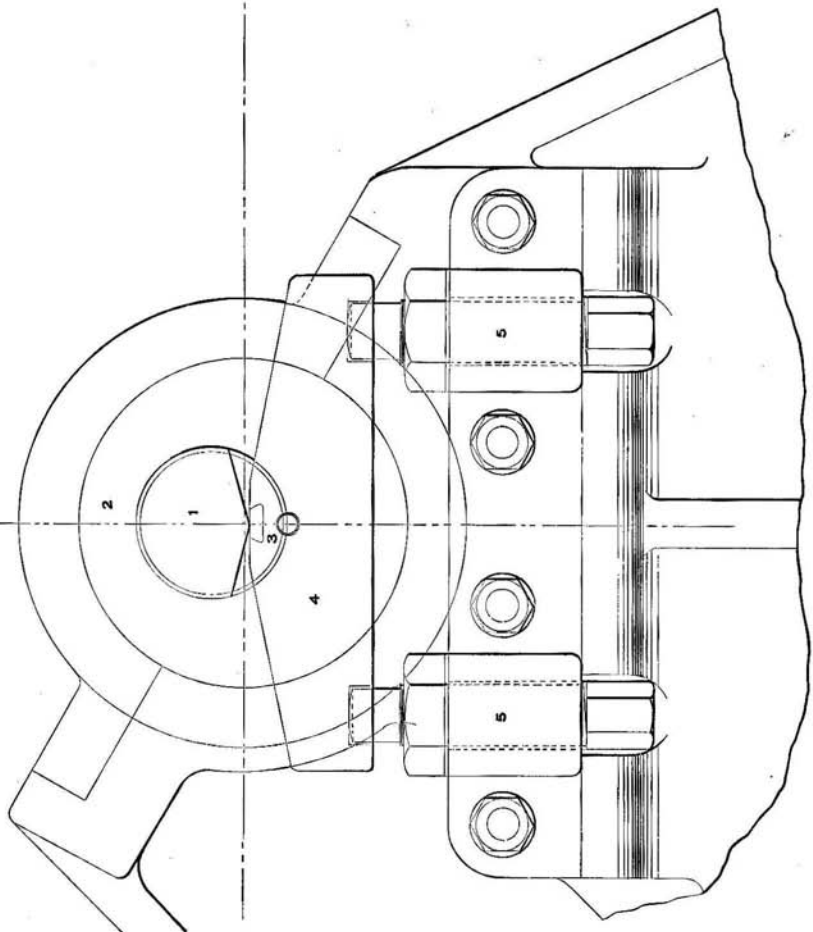
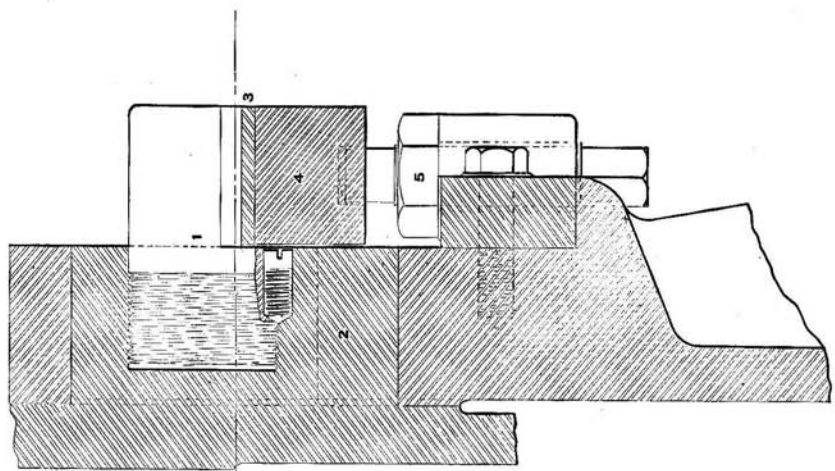
AMMUNITION CAR.
Back.



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.

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 bar-bette 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.

No.	MOUNTS.						GUNS.			RECOIL SYSTEM.						OPERATING MECHANISM.										REMARKS.	No.						
	Vessel.	Mark of mount.	Type of mount.	Loading point.	Depression.	Elevation.	Train.	Number of Gun.	Caliber.	Recoil.	Breech mech., mark.	Recoil, how checked.	Method of returning Gun to battery.	Counter recoil check.	CYLINDERS.				TRAINING GEAR.		ELEVATING GEAR.		AMMUNITION HOIST.		RAMMER.								
															No.	Feet.	Steech.	Springs number of	Liquid Gallons.	H. P.	Power.	H. P.	Power.	Method of relieving shock.	H. P.			Power.	Type of Car.	H. P.	Power.	Type.	
																																	Upper.	Lower.	Upper.	Lower.
1	Illinois	13" Mark IV	Spring Ret. H. Bal.	2° Elevation	5°	15°	270°	29 to 32	35	39"	II	Springs & Liquid	Springs	Plunger on Head	4	1000	8	12	40	49	50	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Mark III and IV Motors are 80 Volts.	1
2	Wisconsin	13" Mark IV	Spring Ret. H. Bal.	2° Elevation	5°	15°	270°	25 to 28	35	39"	II	Springs & Liquid	Springs	Plunger on Head	4	1000	8	12	40	49	50	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Triple Recoil Springs in 13" Mounts Mark III and IV.	2
3	Alabama	13" Mark IV	Spring Ret. H. Bal.	2° Elevation	5°	15°	270°	21 to 24	35	39"	II	Springs & Liquid	Springs	Plunger on Head	4	1000	8	12	40	49	50	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Mark III Hoist Motors are 160 Volts.	3
4	Kentucky	13" Mark III	Spring Ret. H. Bal.	2° Elevation	5°	15°	270°	17 to 20	35	39"	II	Springs & Liquid	Springs	Plunger on Head	4	1000	11	11	44	44	50	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	First Mount having "wave," or "Kearsarge," Car.	4
5	Kearsarge	13" Mark III	Spring Ret. H. Bal.	2° Elevation	5°	15°	270°	14, 15, 16, 33	35	39"	II	Springs & Liquid	Springs	Plunger on Head	4	1000	11	11	44	44	50	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Mark II—Turret secured by chocks when at sea.	5
6	Oregon	13" Mark II	Hydraulic	10 Elevation	5°	15°	270°	5 to 8	35	52	I	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	13" Mounts:—Right-hand are even numbers.	6
7	Massachusetts	13" Mark II	Hydraulic	10 Elevation	5°	15°	270°	9 to 12	35	52	I	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	..	7
8	Indiana	13" Mark II	Hydraulic	10 Elevation	5°	15°	270°	..	35	52	I	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	..	8
9	Georgia	12" Mark V	Spring Ret. H. Bal.	..	..	..	..	..	40	..	..	Springs & Liquid	Springs	..	..	..	..	..	..	..	..	Electric	..	..	..	..	Electric	..	..	..	..	..	9
10	Nebraska	12" Mark V	Spring Ret. H. Bal.	..	..	..	..	..	40	..	..	Springs & Liquid	Springs	..	..	..	..	..	..	..	..	Electric	..	..	..	..	Electric	..	..	..	..	..	10
11	New Jersey	12" Mark V	Spring Ret. H. Bal.	..	..	..	..	..	40	..	..	Springs & Liquid	Springs	..	..	..	..	..	..	..	..	Electric	..	..	..	..	Electric	..	..	..	..	..	11
12	Rhode Island	12" Mark V	Spring Ret. H. Bal.	..	..	..	..	..	40	..	..	Springs & Liquid	Springs	..	..	..	..	..	..	..	..	Electric	..	..	..	..	Electric	..	..	..	..	..	12
13	Virginia	12" Mark V	Spring Ret. H. Bal.	..	..	..	..	..	40	..	..	Springs & Liquid	Springs	..	..	..	..	..	..	..	..	Electric	..	..	..	..	Electric	..	..	..	..	..	13
14	Ohio	12" Mark IV	Spring Ret. H. Bal.	Level	..	15°	270°	..	40	33	VI	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5	35	Electric	3 1/2	Motor & Hand	None	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	..	14
15	Missouri	12" Mark IV	Spring Ret. H. Bal.	Level	3	15°	300	..	40	33	VI	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5	35	Electric	3 1/2	Motor & Hand	None	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	..	15
16	Maine	12" Mark IV	Spring Ret. H. Bal.	Level	3	15°	300	23 to 26	40	33	VI	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5	35	Electric	3 1/2	Motor & Hand	None	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Mark III and IV Motors are 80 Volts.	16
17	Nevada	12" Mark IV	Spring Ret. H. Bal.	Level	3	15°	300	19 and 20	40	33	VI	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5	35	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Last Mount having Elevating Dash Pots.	17
18	Florida	12" Mark IV	Spring Ret. H. Bal.	Level	3	15°	300	21 and 22	40	33	VI	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5	35	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Triple Recoil Springs in 12" Mounts Mark III and IV.	18
19	Arkansas	12" Mark IV	Spring Ret. H. Bal.	Level	3	15°	300	17 and 18	40	33	VI	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5	35	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	Last Mount having Heart shaped Trunnions.	19
20	Wyoming	12" Mark IV	Spring Ret. H. Bal.	Level	3	15°	300	15 and 16	40	33	VI	Springs & Liquid	Springs	Plunger on Head	4	1000	7	9	34	37.5	35	Electric	3 1/2	Motor & Hand	Dash-Pots	20	Electric	"Kearsarge"	5	Motor & Hand	Chain	..	20
21	Iowa	12" Mark III	Spring Ret. H. Bal.	3 Elevation	4	14°	270	9 to 12	35	38	V	Springs & Liquid	Springs	Plunger on Head	5	3500	12	12	35.7	35.7	..	Hydraulic	..	Hand	Dash-Pots	..	Hydraulic	3 Cylinder	..	Motor & Hand	Rotary	1000 lbs. Working Pressure.	21
22	Texas	12" Mark II	Hydraulic	Level	4	15°	..	3 and 4	35	48	III	Hydraulic	Gun Motor	Buffer Springs	1	3500	..	None	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	"Kearsarge"	..	Hydraulic	Hydro-Pneumatic	12" Guns:—Right-hand even numbers.	22
23	Puritan	12" Mark I	Hydraulic	9 1/2 Elevation	3	15°	270	5 to 8	35	48	IV	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	..	23
24	Monterey	12" Mark I	Hydraulic	9 1/2 Elevation	3	15°	270	1 and 2	35	48	II	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	..	24
25	Terror	10" Mark IV	Pneumatic	Any	3	13°	270	17 to 20	30	40	IV	Pneumatic	Pneumatic	Buffer Springs	2	3500	..	..	..	..	..	Pneumatic	..	Hydro-Pneumatic	None	..	Pneumatic	"Kearsarge"	..	Pneumatic	Telescopic	40 Atmospheres for Recoil Cylinders, 11 for Elevating &c.	25
26	Monadnock	10" Mark II	Hydraulic	10 Elevation	3	15°	270	13, 14, 21, 22	30	40	V	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	All Hydraulic Pressures are 600 lbs. sq. in.	26
27	Amphitrite	10" Mark II	Hydraulic	10 Elevation	3	15°	270	7, 8, 11, 12	30	40	V	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	Mounts in Forward Turrets Lowest number.	27
28	Monterey	10" Mark II	Hydraulic	10 Elevation	3	15°	270	5 and 6	30	40	II	Hydraulic	Hydraulic	Buffer Springs	1	3500	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	10" Mounts:—Right-hand are even numbers.	28
29	Miantonomoh	10" Mark I	Hydraulic	13 1/2 Elevation	3	13 1/2°	270	1 to 4	30-34	40	I	Hydraulic	Hydraulic	Buffer Springs	1	6000	..	..	..	..	..	Hydraulic	..	Hydraulic	None	..	Hydraulic	3 Cylinder	..	Hydraulic	Hydro-Pneumatic	No rifling in Recoil Cylinders—12 Relief Valves.	29
30	Georgia	8" Mark	Superposed	..	..	..	..	..	45	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	30
31	Georgia	8" Mark	Spring Ret. H. Bal.	..	..	..	..	..	45	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	31
32	Nebraska	8" Mark	Superposed	..	..	..	..	..	45	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	32
33	Nebraska	8" Mark	Spring Ret. H. Bal.	..	..	..	..	..	45	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	33
34	New Jersey	8" Mark	Superposed	..	..	..	..	..	45	..	..	..	..	..																			

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:

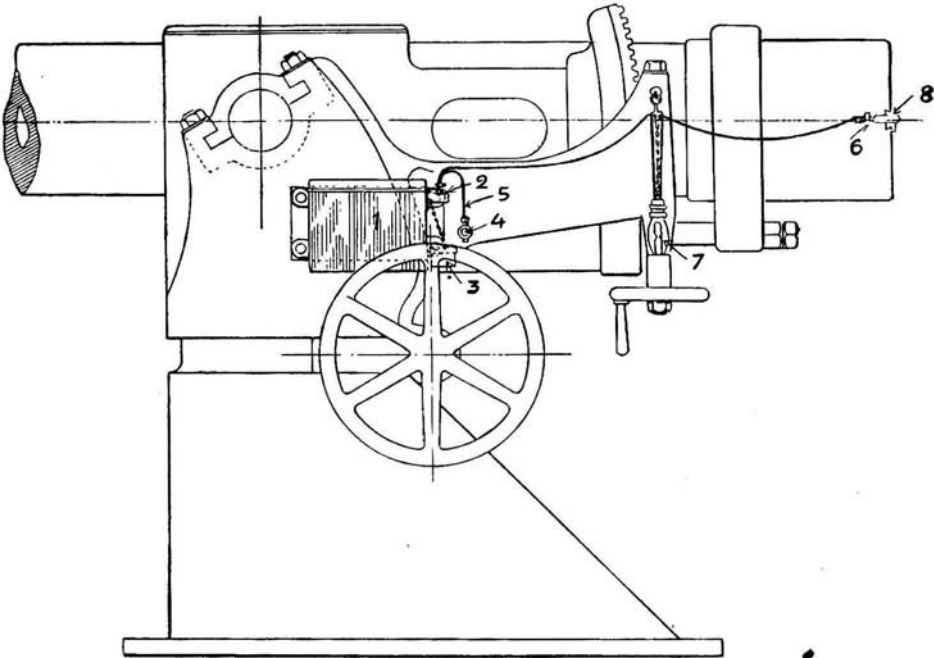
(a) Electric primers are less liable to cause accidents than are percussion or friction primers containing fulminate of mercury; the electric firing circuit may have as many "breaks" as are considered necessary, which are automatically closed only when the gun is in all respects ready for firing, thus 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 $\frac{1}{10}$ 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

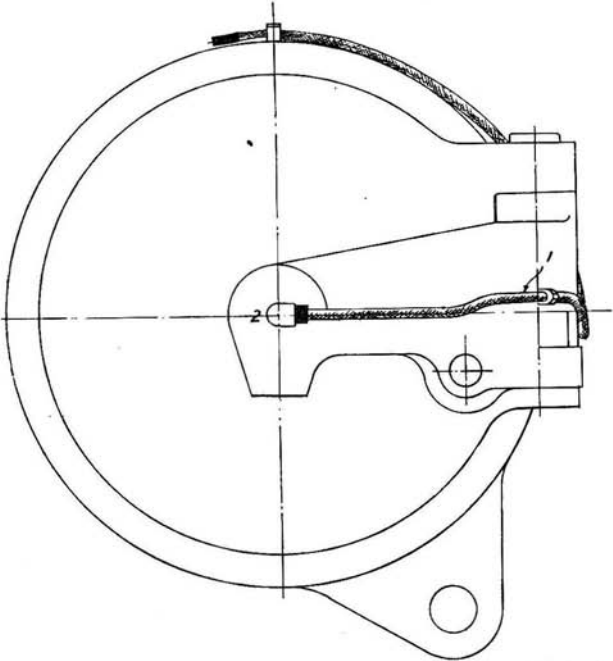
the travel of the projectile along the bore and by the mechanical action of the firing devices. With electric primers, the pointer's muscles act through a less distance and the passage of the current is more nearly instantaneous than is the action of the lock lanyard, sear, hammer, etc., and this part, 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.

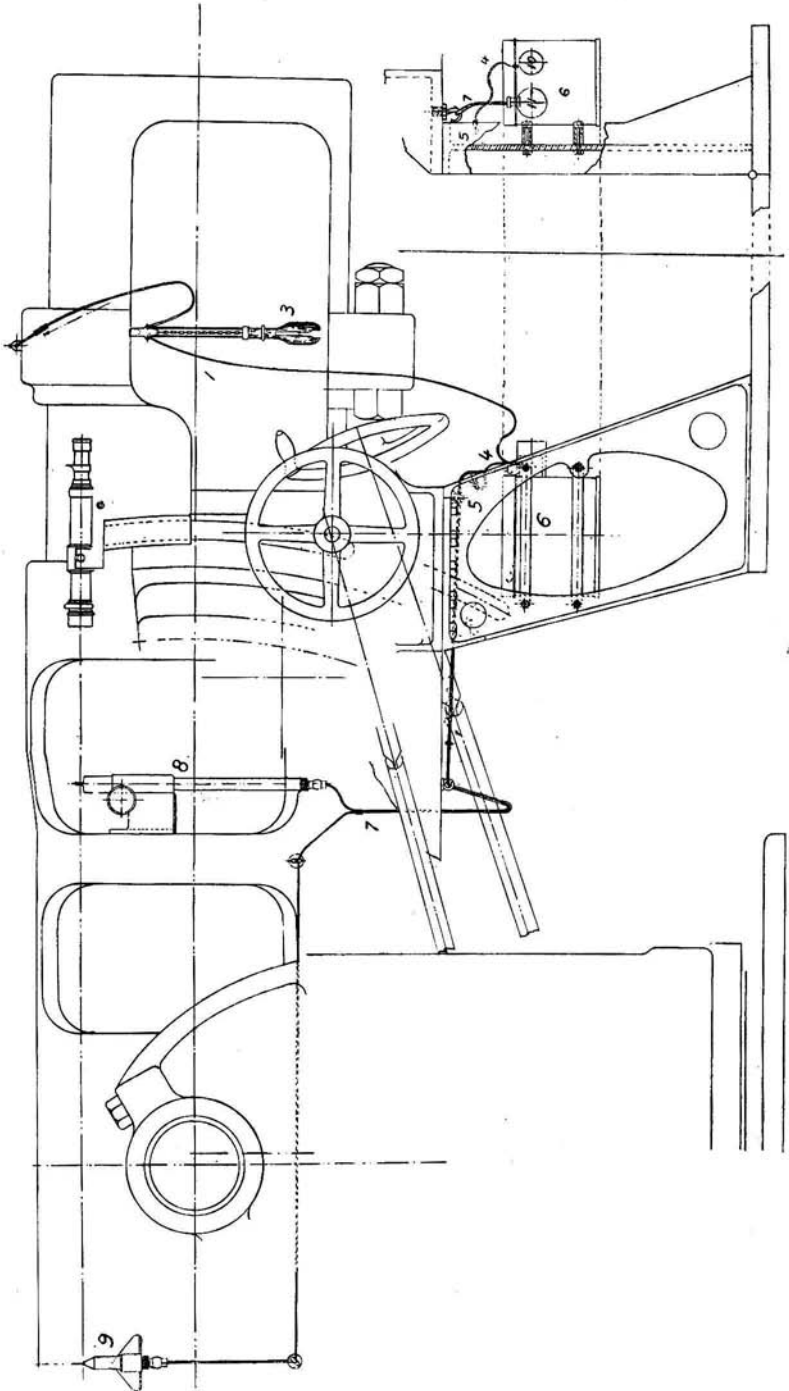
2. **Percussion firing** for the main battery guns is now retained only as an alternative when the electric current fails. Formerly (until 1899), separate primers were employed for the two kinds of firing and changing primers also necessitated changing from percussion to electric firing mechanisms and 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),



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





ELECTRIC FIRING ATTACHMENTS OF 6-INCH Q. F.

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

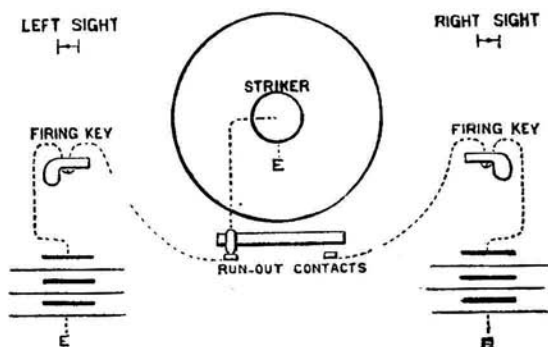
The *battery* consists of a number of Mesco dry cells connected in series—each cell sealed with pitch; the battery, having an average E. M. F. of 4 or 5 volts, resistance 1 ohm, is put up in a tightly covered “battery box” which is secured to a training part of the mount or turret. The poles are connected 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

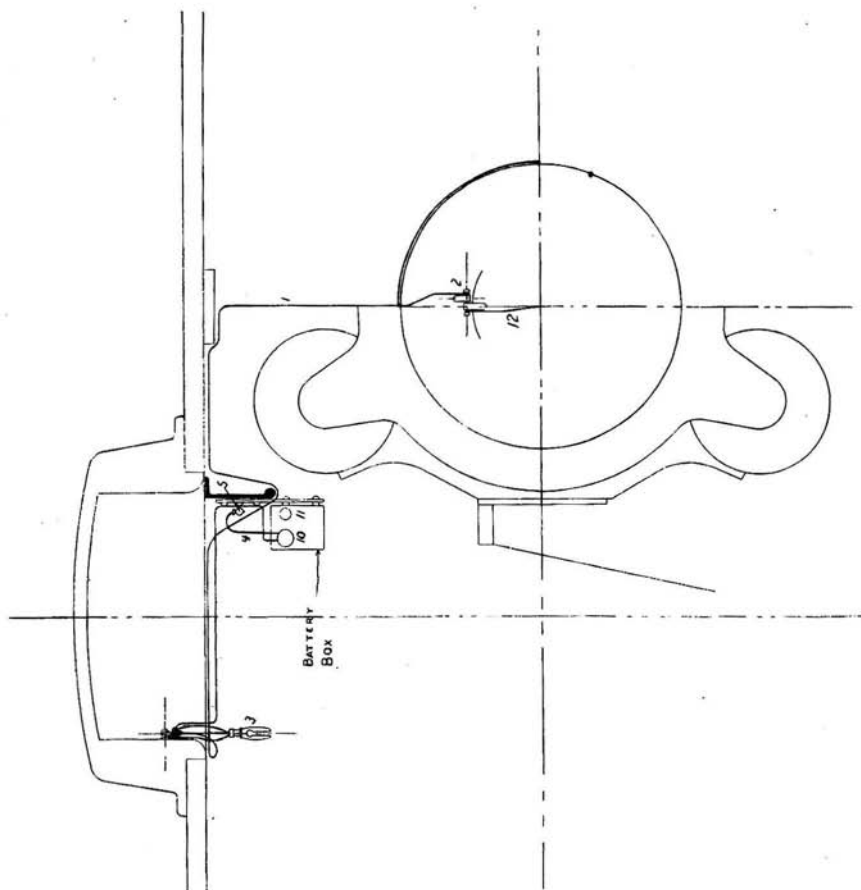
made only on completion of the fermeture. In turret guns, as is shown in Plate V, a short wire (12) leads from the contact lug (2) to the lock, at which the connection is made by closing the wedge of the lock. The contact points at (2) must touch before the circuit is completed, and this occurs only 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.



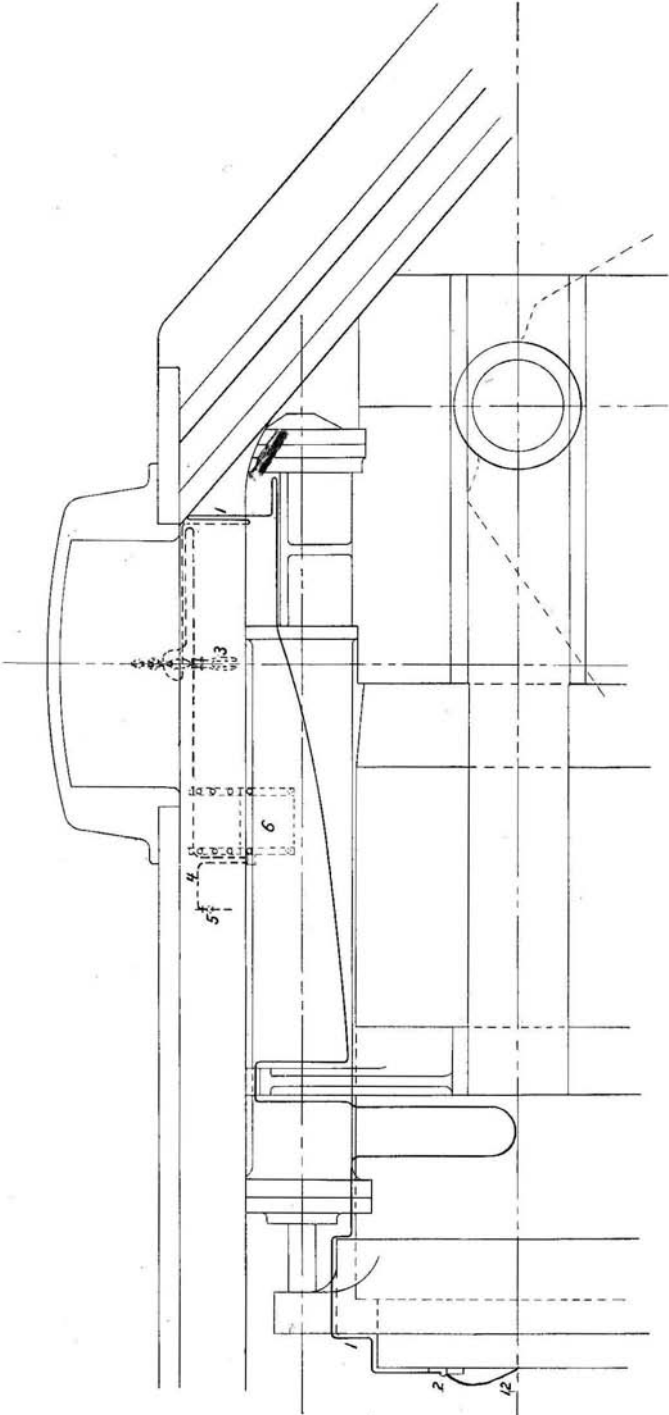
6-INCH RAPID-FIRE GUN CIRCUITS.

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.

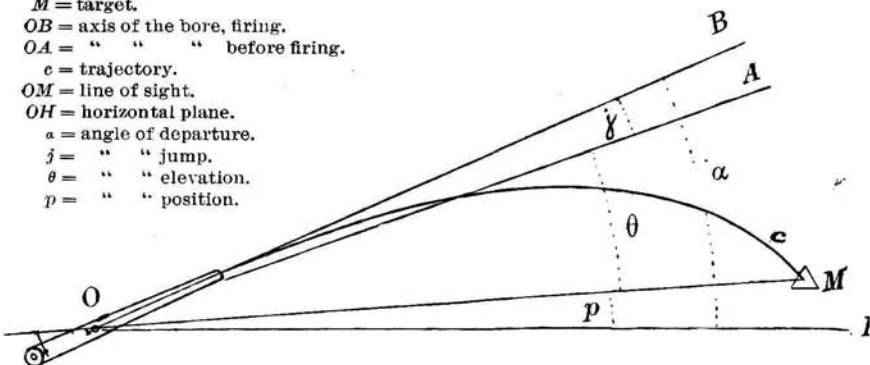
The *jump* is the small vertical angle, usually upward, which the axis of the bore describes in the act of firing; it is due to the straining of the mount. It is determined experimentally and is applied as an index correction in marking the sights.

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.

M = target.
 OB = axis of the bore, firing.
 OA = " " " before firing.
 c = trajectory.
 OM = line of sight.
 OH = horizontal plane.
 α = angle of departure.
 j = " " jump.
 θ = " " elevation.
 p = " " 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 tompons 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

of elevation and heights of sight bar are taken off the range curve and marked on the sight bar. To compensate for drift, the plane in which the line of sight is revolved while raising the sight, is inclined to the left by an angle of from one to three degrees to the vertical plane through the axis of the bore. The mechanical devices to attain this will be given in greater detail. The ranges are marked in small increments, usually 100 yards, on a part of the sight which is in plain view. Each sight also shows for what weight of projectile and muzzle velocity it is graduated. Whenever practicable, the elevations and times of flight for the different ranges are also marked on the sight; the time of flight being thus easy to obtain, when cutting or setting time fuzes. The elevation in degrees is sometimes marked on the elevating arc as well.

The above mentioned preparations are in the province of the designer; it remains for the officer in control of the fire, when beyond point-blank range, to direct the proper setting of the sight, horizontally and vertically, so that the projectile will hit the target if the line of sight is accurately directed by the gun pointer. Of the errors that occur in firing, the vertical ones are the more serious. The target,—the enemy's ship—has its least dimension in this direction. It is long enough to be hit by a comparatively wild shot, but it is often of little height. Mistakes in measuring or estimating ranges cause only vertical errors. Since telling how much too high or too low a shot goes by noting its point of fall in the water is very difficult, it is harder to correct vertical errors; the motion of the gun is more rapid and irregular in the vertical plane, hence vertical errors in *pointing* are also the more frequent. In setting the sights, the range, effect of the wind and of the motion of the gun and target are to be considered.

The effect of the wind is not great except when strong winds act on the light projectiles of the secondary battery; its force can only be estimated, and its effect depends also on its direction; when at right angles to the trajectory it will cause only lateral deviations. Only experience, coupled with good judgment, is of practical value in compensating for the wind effect; however, it is responsible for only minor errors, when compared with those due to other causes.

The motion of the gun is known in speed and direction, while

that of the target may only be estimated; the two may tend to neutralize each other, or they may combine to cause an enormous lateral or vertical error, or both. Here again, experience and judgment only are of practical value. Fire control, of which sight setting is a part, constitutes a problem so intricate and extensive that it should be treated as a science in itself. The combined effects of these separate causes having been determined as far as possible, the vertical component is applied to the range and the sight is set to correspond; the lateral component is applied to the line of sight as well, with the result of swinging it through a small horizontal angle. The sight being correctly set, use is now to be made of the skill of the gun-pointer.

4. Until 1801, nearly 500 years after the introduction of cannon, no sights of any kind were used in pointing guns; up to that time the men were instructed to look along the "line of metal," or exterior of the gun, and aim at some point of the enemy's ship above that to be hit. When first introduced, both front and rear sights were fixed and merely gave a line parallel to the axis of the bore; this innovation was strongly objected to by many prominent naval officers, Lord Nelson among them. It was not until much later that a French army officer succeeded in introducing movable rear sights graduated to cable lengths. Until the beginning of the last century it would perhaps have been superfluous to have introduced accurate sighting methods when the gun element had contributed so little to accuracy. The guns were smooth bored and were single shotted, double shotted or loaded to the muzzle with grape, with little thought of the effect on the trajectory. Then, too, the powder charge was roughly measured out, and if it was thought that the powder had deteriorated, a quart or so more was thrown in. Under such conditions, the gun had to be very close to the enemy to have a reasonable chance of hitting him; fleet actions were *mêlées* and single ships sometimes decided the issue only after hours of fighting while lashed alongside each other. The British generally won in these "yard-arm to yard-arm" affairs, and other great navies tried to follow the fashion set by them; it was even hinted that fighting at long range, even if skillfully done, was cowardly. Under the circumstances, the execution done by the guns of the day was quite sufficient,

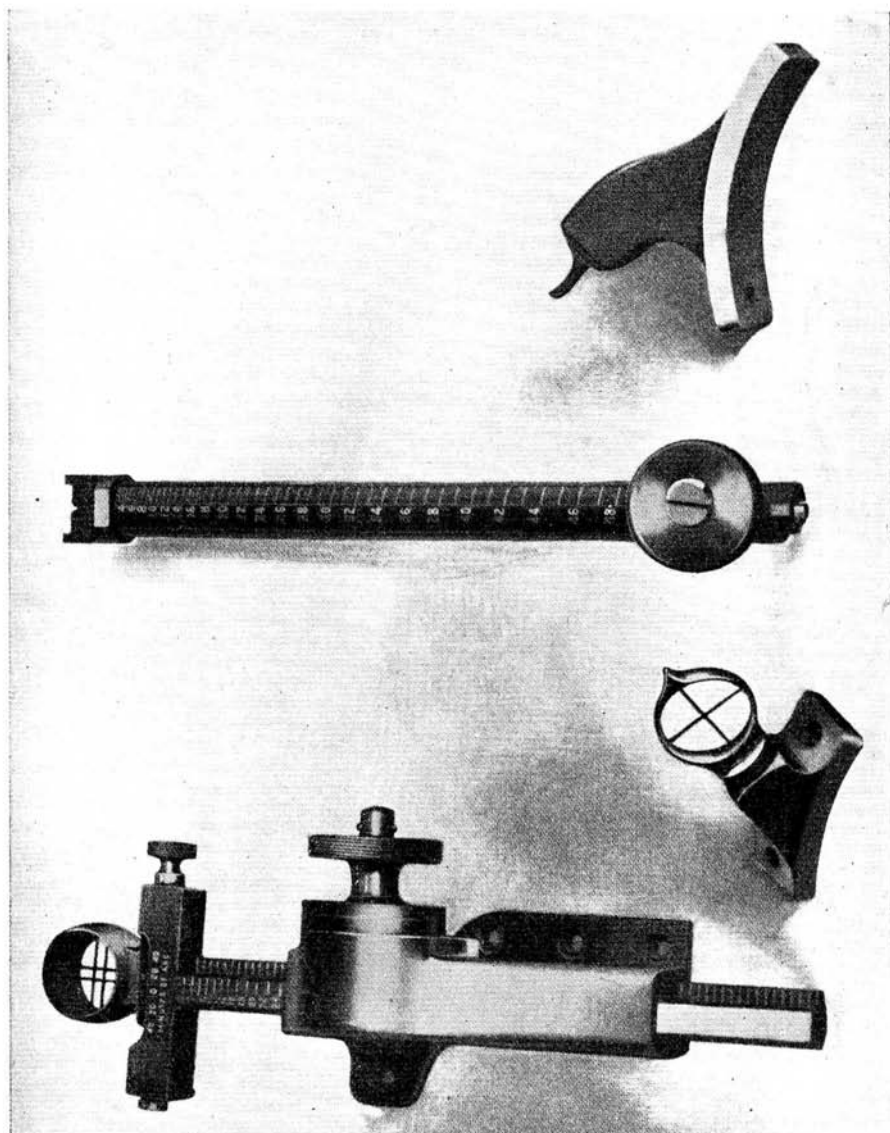
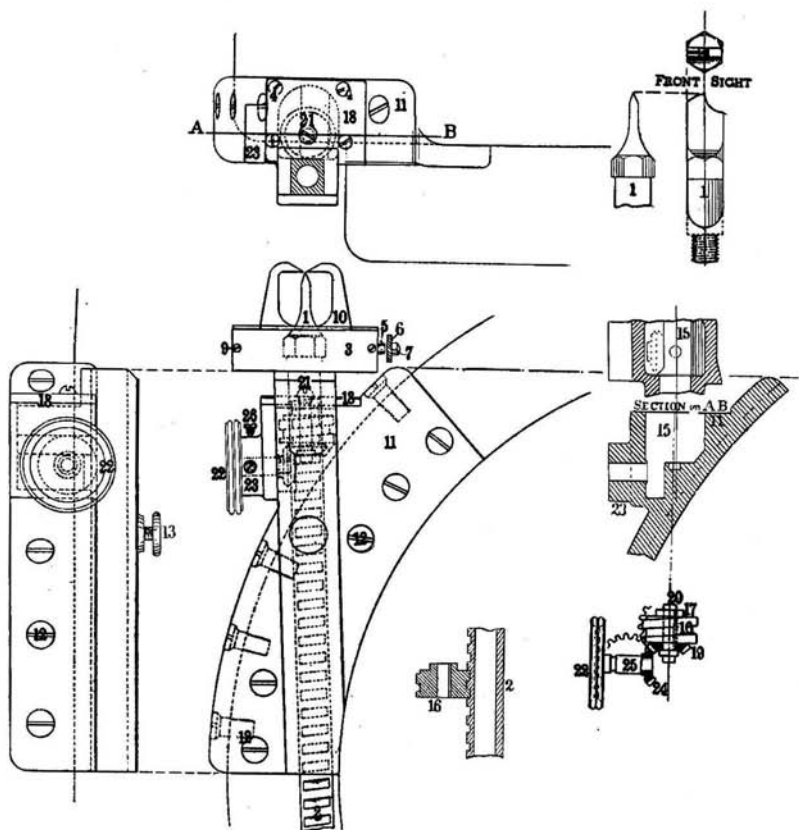


Fig. 1.

DRIGGS SIGHTS FOR 6-PDRS. Par. 6.

Fig. 2.

PARKHURST SIGHTS FOR 6-PDRS. Par. 5.



SIGHTS AND SIGHT BOX FOR OLD STYLE 8-INCH B. L. R.

and pieces of greater accuracy were neither needed nor often considered.

However, those conditions exist no longer, and the torpedo alone will compel the decisive parts of future actions to be fought outside 1000 yards. The gun has so progressed in accuracy that it is now its sight that is to blame for most of the errors due to defective materiel. The greatest errors of all, supposing the sight to have been set with reasonable accuracy, are due to the difficulty in pointing the line of sight at the target and then holding it there long enough to fire the gun. There are nearly numberless patents on devices for overcoming the *visual* difficulty in this operation, but, for our purposes, they may be divided into three classes, viz.: the ordinary *open* sight; the *peep* sight; the *telescope* sight.

Open Sights.

5. The Common "Bar" Sight (see Fig. 1), with notched rear sight and more or less cumbersome front sight point, is the oldest form known and is still the one most widely used. The aim is obtained by bringing the bottom of the notch, tip of the front sight and target in line. In the naval service, it is used on all small arms and on most secondary battery guns, as well as the modification of it employed as an auxiliary sight for main battery guns. The sight shown by Fig. 2, Plate I, called the Parkhurst sight, is the one in general use on Hotchkiss R. F. guns. The front sight mass, bearing a roughened point, is screwed to the locking ring of the gun. The bar is held and guided by a deep groove cut in the right side of the face of the breech; when raised, it is clamped by a milled head—shown at the bottom of the bar. The sight bar is inclined to the left at a small permanent angle—depending on the size of the gun—as a drift compensation; thus the drift, increasing with the range, is corrected by the motion of the rear sight to the left, given it by raising the bar, which also increases with the range. With this sight, no lateral correction can be applied to the line of sight to compensate for deflections caused by the wind, speed of target, etc., and the errors can only be corrected by directing the line of sight to one side of the mark. A disadvantage of this particular form of the open sight is that

the target is too much concealed by it, particularly when the target is below the line of sight; when the gun is depressed to bring the mark into view it suddenly appears above the front sight and the gun must be elevated again. For this reason the form shown diagrammatically in Fig. 1 is, theoretically at least, the least satisfactory form of the open sight.

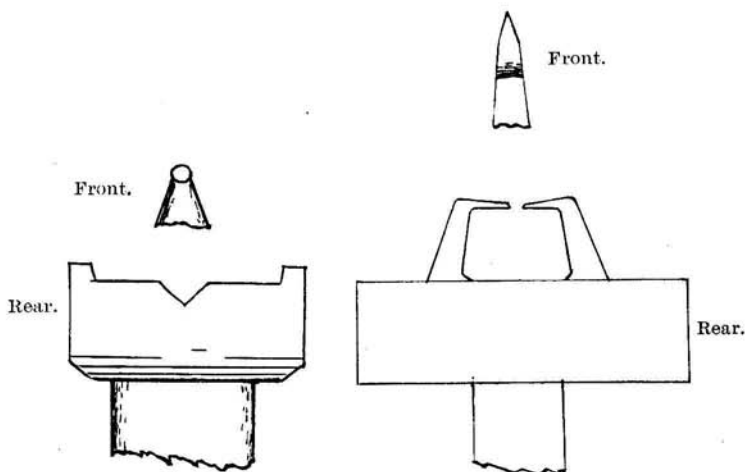


Fig. 1. Par. 5.
COMMON BAR SIGHT.

Fig. 2. Par. 5.
LYMAN SIGHT.

The open sight shown in Fig. 2, a form of the Lyman sight, was, before the adoption of the telescope sight, largely used on main battery guns. In aiming, the tip of the front sight is seen midway between, and on a line with, the two rear sight points; the sights then are less likely to obscure the target when it is below or to one side of the line of sight. To this end the front sight should be as slender as is practicable. A sight of this kind is shown by Plate II; the front sight (1) is secured to the gun near the trunnion. The rear sight bar (2) rests in a box (11) screwed to the breech of the gun, and is raised and lowered by the hand wheel (22), through pinion and worm gearing designed to prevent the sight from jarring down. The sight box is inclined to the left to compensate for drift. The rear sight (10) is mounted on the "sliding leaf" (8) by which it is given lateral movement in the horizontal plane by a threaded shaft which runs through it

and is turned by the milled head (6). This device makes lateral adjustment of the line of sight possible and lateral deflections from any cause may be corrected. The rule in moving the sliding leaf to correct the deviation noted by the fall of the preceding shot, is to "*move the leaf in the direction you wish the shot to go*" in order to bring it on the target. To set it for the first shot, move the leaf *against* the motion of the gun, *against* the wind or *with* the motion of the target.

The "H" sight, shown in Fig. 3, is a form of the open sight used on the Maxim-Nordenfeldt automatic and semi-automatic

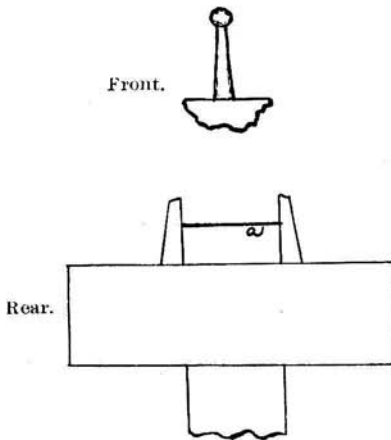


Fig. 3.

guns and on some of the British built guns of other classes. In pointing, the front sight point is seen at the middle of the wire (a) which is stretched between the uprights of the rear sight; the latter is secured to a sliding leaf. The graduations of the scale on the leaf of the various sights are not uniform, and it may be found that the divisions represent millimeters, minutes of arc, knots speed of gun or target at a distance of 2500 yards with motion perpendicular to the line of fire, etc. However, this is not a great drawback, since an officer who knows the graduations will order the sights set at so many divisions to the right or left, after estimating the compensation required, and a subsequent correction

will be by comparison. As has been indicated, horizontal errors are least troublesome, but combinations of them that will produce a large total error are liable to occur, and it is important to be able to correct them even if small. To this end, all sights are fitted, or will be modified, to permit the lateral adjustment of the line of sight; when the above is not the case, the only method is to aim to one side of the target. The "H" rear sight gives a good view of the target, and for this reason the front sight should be long and slender; some of those now fitted are very low cones of large diameter.

Many of the open sights in the service are secured to the gun or a recoiling part of the mount and, obviously, the gun pointer's eye cannot be placed very near the rear sight. In using the ordinary notched open sight and, to a greater or less degree, all of its modifications—only two of which have been touched upon—the following visual difficulties in correct pointing present themselves:

(a) At the same instant, the eye must clearly see, in their true shapes, three objects: rear sight, front sight and target, all at different distances. While the eye will readily focus itself at any distance, it is impossible for it to adjust itself for even two objects, one of which is a few inches distant and the other hundreds of yards away; if any one of three is seen clearly, the others will at best appear only as blurred outlines.

(b) The two sights must be seen as points and the same portions of them aligned on the target irrespective of changes in the intensity or direction of the source of light. The sights have certain dimensions, and even if their central portions can be seen as points, they will appear to move vertically, as the intensity of light changes and laterally, as its direction varies.

(c) The eye must be held accurately in the line of sight and, to obtain the best results, at the same distance from the rear sight. The latter condition can be fulfilled, but it is an inconvenience to have to do it. While the body may be able to hold the eye in the line of sight for a short interval, it is exceedingly difficult under conditions found at sea.

In the face of these disadvantages, a man with good vision is able to make a compromise effort to see the three objects at the same time and to align them more or less accurately. A considerable visual error is bound to occur; it is made up of two parts, one showing itself as a displacement of the mean visual line from the true line of sight, the other as a dispersion of successive visual lines under equal conditions. The second may be reduced by practice, as is shown in "aiming drill." The first is natural to each man and probably cannot be corrected; moreover, its amount varies extensively under different conditions of light, etc. For those who obtain good results, it is largely a matter of knack—which many can never acquire; for those who do, it is at the expense of long practice—mere eye exercise—coupled with such peculiar natural qualities that it has well been said that a good shot, like a poet, is born and not made. Everyone who enters the naval service can, and is required to, attain a measure of proficiency in the art, but for the extreme accuracy desired in heavy gun pointing, we should be sure that the angle between the line of sight and the axis of the bore is exactly what the sight calls for and not dependent on the personality of the pointer; there are enough causes of error without this one. Recent improvements in sights, which amount to a revolution, make it so easy to see and direct the true line of sight on the target that visual difficulties are eliminated, and anyone with fair eyesight can do it. The day of the rare "crack shot" is about over—at least as concerns heavy guns.

Peep Sights.

6. The "Peep" Sight was invented for use on rifles, and has given good results. It has various forms, one of the simple ones being shown diagrammatically in the figure. The rear sight is a blackened disk, concave to the rear, with a very small peep hole in its center; the front sight is a small bead on an upright support which must be of the least possible diameter. In aiming, the eye is held close to the rear sight, and the target and front sight are seen in line through the peep hole. Thus, whenever the target can be seen through the hole it is insured that eye and rear sight are in line, and it remains only to bring the bead on the same line. Hence two objects instead of three must be seen at a time. Of

course, this cannot be done; one of them is bound to be blurred, but it is more nearly possible than in the case of the open sight, and the visual difficulties are less. The Driggs sights, fitted to Driggs-Schroeder guns, are the only ones used by the Navy that may be properly placed under this head; see Fig. 1, Plate I. The peep hole is formed by double cross wires and the front sight by the intersection of single wires. The front sight is screwed to the locking ring of the gun. The rear sight is mounted on a sliding leaf; its bar works in a sight box on the face of the breech of the gun; drift is compensated for by inclining the bar to the left.

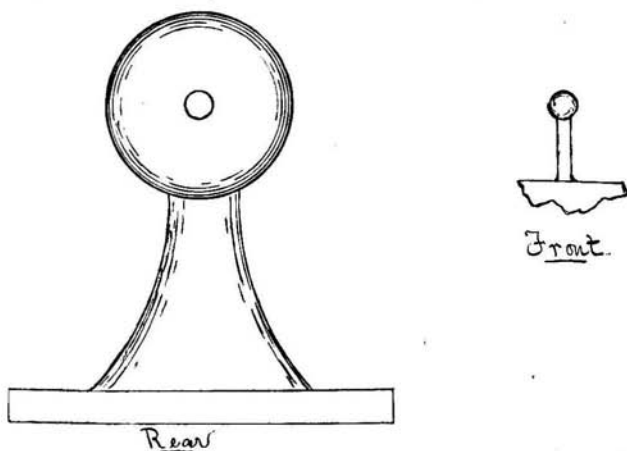


Fig. 4.
PEEP SIGHT.

The bar is raised and lowered by a rack and pinion device arranged to prevent the bar from jarring down; the hand wheel has to be pulled to the right before it can be turned backward. Since this sight, as at present fitted, is attached to a recoiling part, the eye cannot be brought close to the rear sight and must attempt to focus its wires as well as the front sight and target. For this reason, its use has so far resulted in no improvement over ordinary open sights, though its natural advantages are considerable.

The Telescope Sight.

7. As long as sights were fitted directly to the gun, the recoil forced the use of the ordinary "bar" sights. When the principle of placing sights on a non-recoiling part of the mount was adopted

ADDENDUM.

Par. 7, page 223, Text-Book of Ordnance and Gunnery, 1903, "The Telescope Sight."

It is but just to Lieutenant (now Commander) Fiske to state that to him belongs the credit of first demonstrating the fundamental advantages of this type of sight over all kinds of open sights for naval use.

Following the patent of 1890, he obtained four patents between 1891 and 1895 in which he provided for attaching the telescope to the gun sleeve and for making compensation for drift and speed; and he proved the practicability of using this form of sight for naval guns by official tests at sea during the years 1892, 1893, and 1894.

The Bureau of Ordnance of the U. S. Navy was the first to recognize the value of this invention; and it is plain that the essential principles of the latest type of naval telescope sight do not differ from those covered by Lieutenant Fiske's patents, which were embodied in his original instruments.

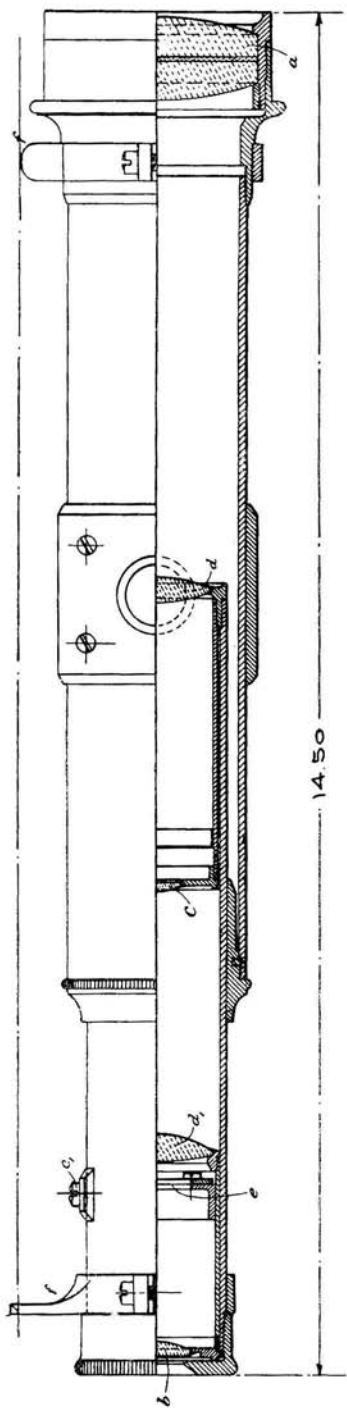
making it possible to hold the eye close to the sight, it would have been advantageous to change to peep sights. But it was the introduction of the telescope sight, with its great added advantages, that has well-nigh caused a revolution in naval gunnery. It was an improvement so great that it may well be ranked with such as the change from smooth-bored to rifled guns. The United States Navy has led in the general adoption and improvement of this sight and now possesses it in more general use than does any other navy.

The telescope sight was introduced into the British army as long ago as 1857 by Captain Younghusband, and came into extensive use in 1875. Major Scott was then its sponsor, and his device, which is still in use on some guns, provided for removing the telescope after the gun was laid and before firing. In 1890, Lieut. Fiske, U. S. N., obtained a patent on a telescope sight which secured to the gun shield and depended more or less on the roll of the ship to bring the target into its field. The introduction of mounts in which the gun recoils in a sleeve in the line of fire removed the difficulties which had hitherto defeated all attempts to sight ship's guns by means of telescopes. This permits mounting the sight to all intents and purposes on the gun itself, which can be elevated and depressed without disturbing the setting of the sight, yet the latter partakes of all the movements of the gun except recoil, and the eye need not be removed from the sight while firing; indeed, under some circumstances, the pointer can watch the flight of the projectile through the telescope. The telescope retains and adds to the good qualities of the peep sight; the eye is applied to a small hole in the same way, but, instead of having to attempt focussing target and front sight, it sees both of them, that is, the image of the target and the cross wires, *in the same plane* at the focus of the eye-piece lens; the latter, in itself, contributes to accuracy in the proportion of its magnification. The optical axis of the telescope is then *the* line of sight and is so unmistakably defined and easy to see that all visual errors, formerly so fatal to accuracy, disappear. "Nerve and judgment are the only requisites to-day, and any man possessing them can become an expert gun pointer, if he has ordinarily good eyes." *

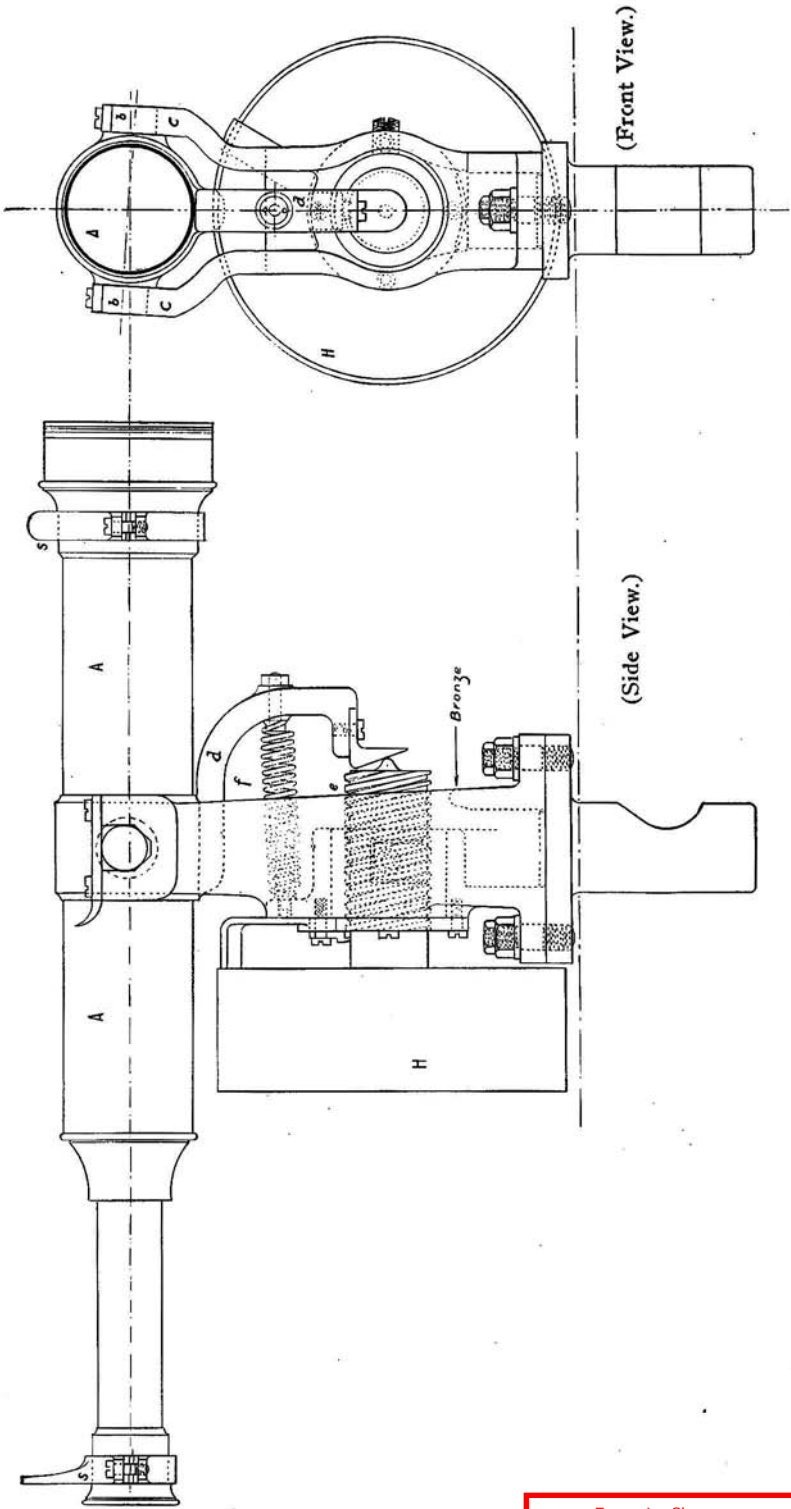
* Prof. P. R. Alger, U. S. N.

Telescope sights began to be generally used for main battery guns about 1895 and since then have been steadily growing in favor, until now the tendency is to fit them to secondary battery guns as well. The telescope (see Plate III) is of the ordinary terrestrial type, fitted with cross wires; it has an erecting eye-piece which adds two lenses, with a consequent loss of light, and increases the length, but it is highly necessary that the gun pointer shall not be confused by working with an inverted image of the target. The object glass (*a*), the eye-piece (*b*), the erecting lenses (*d*) and (*d'*) and the lens (*c*)—placed to increase the field—are firmly secured in place and no focusing for distance is necessary. The object glass is large, about two inches in diameter, to admit as much light as possible. The magnification is 2.5 and the field 17 degrees; this should be large enough to keep the target in the field throughout the roll of the ship, if the pointer is at all experienced. The power of a telescope can be increased only at the expense of reducing its field. The cross wires are at (*e*), the focus of the eye piece, and are adjusted by means of the screw (*e'*) which permits a slight movement along the axis of the telescope. In the first sights supplied, the vertical wires were double and all were made very thick with the view of using the sight at night, which has proved impracticable; the wires are now single and the effort is made to have them very fine. The open sights (*f*, *f'*) are the finding sights and, if it becomes necessary, may be used to give the final aim; but their radius is only about twelve inches, and the gun can be only roughly pointed with them. The sight being subjected to the *jump* of the gun, all its parts must have considerable strength to withstand the strain; also, the jump will cause the eye piece to give a severe blow if the eye is pressed close against it; as a protection, a soft rubber buffer, against which the pointer rests his cheek, is fitted.

If a piece of paper is held at the point at which the eye is placed, the light coming through the telescope will show as a bright spot about .2 inch in diameter, which is about the size of the normal pupil. If any portion of the pupil is coincident with the bright spot, the image of the target and the cross wires will be seen. The telescope being of good workmanship and properly adjusted, a movement of the eye across the whole coincidence of the bright



TELESCOPE SIGHT.



TELESCOPIC SIGHT FOR 4-INCH MOUNT, MARK III.

spot and the pupil will not disturb the relative position of the image. It is apparent, then, that the head may be moved through nearly 0.4 of an inch without interfering with the sighting, while with an open sight, to be accurate, the pupil must be held exactly in the line; then, too, the eye may be moved *along* the line of sight somewhat without introducing an error or interfering with the focus.

Telescope Sight Mountings for Intermediate Guns.

8. Plate IV shows one of the early telescope sights fitted to a 4-inch gun with "pedestal" mount; at present there are many of this pattern in the service on 4-, 5- and 6-inch R. F. guns. The stand of the sight mounting has a cylindrical lower end which ships into a sight box on the sleeve of the gun mount, where it is secured by a locking bolt which presses against the circular cut-away portion. Parallelism of the telescope's axis with the axis of the bore depends on accurately machining the sight box; for correcting lateral errors of workmanship, the two bolts which secure the base of the stand go through slots in the upper portion and permit a small adjustment; vertical errors can be corrected by changing the pointer of the indicator drum. There is nothing corresponding to a sliding leaf to compensate for the motion of the target, etc., and errors due to such causes have to be corrected by aiming to one side. The telescope (*A*), about 15 inches in total length, is mounted with trunnions (*b*), which rest in the forked arms (*c*) of a bronze stand. Attached to the telescope is a bent arm (*d*), the lower end of which rests against the forward end of a screw (*e*), and is held in rigid contact with it by a strong steel spring (*f*), so that any motion of the screw in the direction of the axis of the gun is followed by the bent arm, and the telescope is elevated or depressed according as the motion is to the front or rear respectively. An aluminum indicator drum (*H*), 5 inches in diameter, is attached to the rear end of the screw, and on its circumference are marked in spiral form the ranges corresponding to the different angles of elevation of the gun. The pitch of the screw is 0".50 and its total travel for 15° depression of the telescope is 1".022; if the telescope has been adjusted so that its axis is initially parallel to the axis of the gun—when the indicator

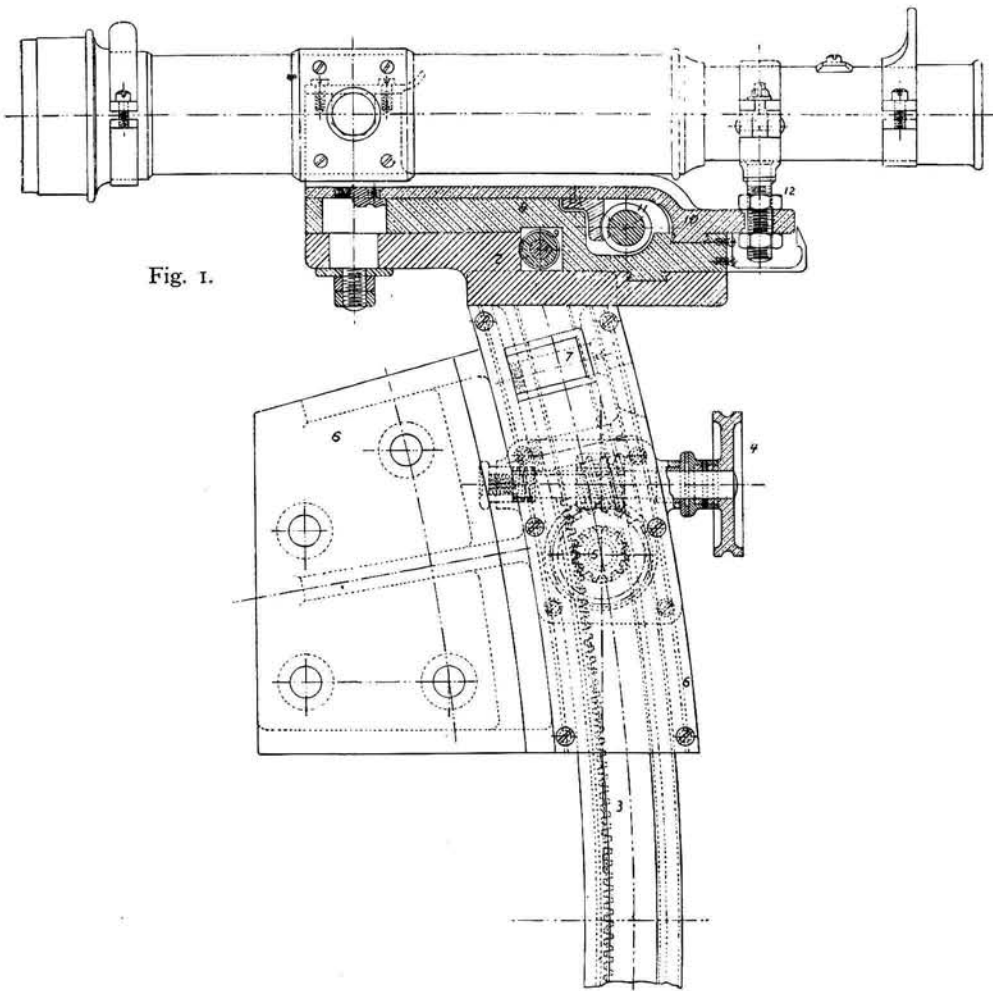


Fig. 1.

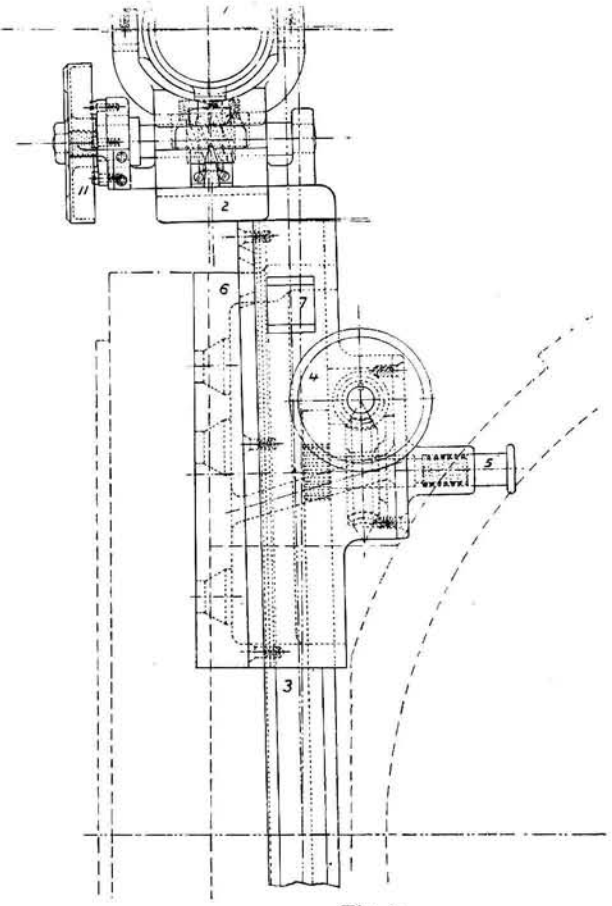


Fig. 2.

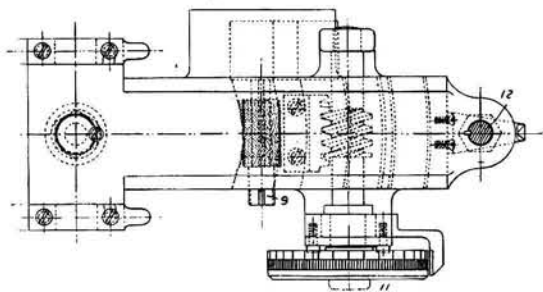


Fig. 3.

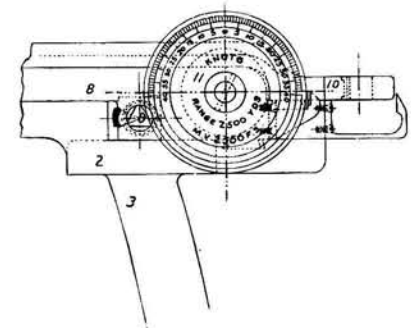


Fig. 4.

drum is turned to the left, moving the screw to the rear, the axis of the telescope will be depressed through an angle equal to that corresponding to the range mark on the circumference of the drum; then if the gun be elevated until the axis of the telescope bears on the target at the given range, the axis of the bore will be set for the elevation required to give the indicated range. To allow for drift, the line joining the axes of the trunnions is depressed to the left, looking from the rear, through an angle of $2^{\circ} 45'$, which has the same effect as inclining the sight bar to the left through that angle, in the case of bar sights.

At the time the above described sight mounting was designed, one sight was regarded as sufficient, and the gun pointer was required to keep his sight set, train, elevate and fire the gun, which obviously was too much for one man to do. At present these duties are divided into at least two if not three parts, and a man is assigned to each; and there is a more liberal allowance of sights. On the right side of the mount is placed an ordinary open sight, or a night sight of the same type, suitable for use in daylight, or a telescope sight. It has been shown that, with open sights, *vertical* visual errors are the more likely to occur and that, because of the length of the target, lateral errors are not necessarily so fatal; consequently open sights *will* answer for the lateral pointing. But the telescope sight is an essential for the gun pointer whose duty is to point the gun in elevation and fire. A recently designed sight for intermediate guns is shown by Plate V. Fig. 1 is in section and side elevation; Fig. 2, in rear elevation; Fig. 3, a plan, and Fig. 4, a view of the transversing drum. An auxiliary day and night sight, of the ordinary notched type, is used in place of the telescope while firing at night—if the telescope cannot be used.

The telescope (1) is secured to its stand by trunnions as in the older mounting, but its rear end is also secured by an upright and collar and the sight is set in a different manner. The base of the stand (2) is drawn out to form a long sight bar (3), which is an arc of a circle whose center is at the center of the trunnions; the ranges and other legend are marked on its right and rear sides as in "bar" sights. The sight bar ships in a sight box (6), bolted to the gun slide, having openings (7) near the top, through

which the ranges may be read. The telescope is given an angular motion in the vertical plane by raising or lowering the sight bar, by means of a hand wheel (4) which gears through worm and pinion gearing with the toothed rack of the bar; the worm gearing is interposed to prevent the sight from being jarred down. If a quick movement of the bar is to be made, disconnect it from its gearing by pulling the shaft (5) to the right, disengaging its spur wheel, whereupon the bar may be moved up or down by hand. To compensate for drift, the entire sight mounting is inclined to the left through one degree—the allowance now made with all main battery telescope sights. The sight is set laterally by a device corresponding to the sliding leaf of open sights. The table (10), to which the sight is directly secured, is pivoted at its forward end and its rear end has a dovetailed lip fitting in a groove in the lower table (8). The table is rotated horizontally by a double threaded worm which is turned by the transversing drum (11); the bearings of the worm, which gears in a small arc screwed to the upper table, are in the lower table and its threads are of steep pitch. The amount of offset given the telescope is indicated by a scale on the transversing drum, shown in detail in Fig. 4; a pointer extending rearward from the lower table also gives a reference mark and acts as a check on the drum. A permanent lateral correction may be given the telescope by a device similar to the above—the lower table swinging on the stand (2) on the same center; the arc however is stationary and the shaft (9) of the transversing worm, which has very low pitch, is also secured to the lower table (8); no scale, giving the permanent offset, is needed as the shaft (9) is turned by a key and cannot be moved without it. Any permanent vertical correction, necessary because of inaccurate workmanship, etc., is made by adjusting the top and bottom nuts of the threaded upright (12) which attaches the rear end of the telescope to the *upper* table; during this adjustment, and at this time only, the telescope moves on its trunnions. One great advantage of this form of mounting is that the telescope is held at the same height above the deck for great angles of elevation as for small ones.

Night Sights.

9. Associated with the gun pointer's telescope sight and so placed as to have its line of sight as near as possible to that of the telescope, a "day and night" sight is fitted to the slide of intermediate gun mounts; the parts are made of bronze. It is an open sight with notched rear sight on a sliding leaf and, in outward appearance, it is an ordinary "bar" sight (see Fig. 5). The rear sight bar, with ranges, time of flight, etc., marked on inlaid white metal strips, is raised and lowered by a device like that for the telescope

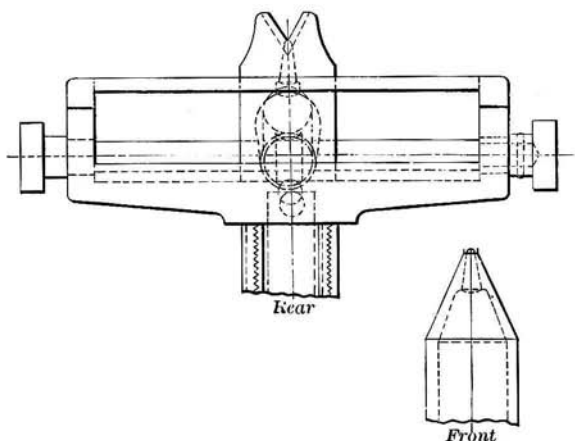


Fig. 5.

sight described above; the bar is inclined to the left to compensate for drift. Set in the tip of the front sight and in the bottom of the rear sight notch are small pieces of differently colored glass; front sight red, rear sight white or green. The sights are hollow from below and each contains an incandescent light of very low candle power which takes current from the firing battery. (A typical arrangement of the sights and the wiring for the night attachment is shown in Plate III of the preceding chapter.) When in use on a dark night, the two sights will show two small spots of light of different colors and the gun is pointed by aligning them on the target. In daylight the sight is used as an ordinary open sight, in the case of an accident to the telescope. It is in many cases

fitted as a trainer's sight for use both in daylight and at night. Where a telescope sight for the trainer is fitted, a sight of this type will probably be supplied as well.

Sights for Turret Guns.

10. All turret guns are fitted with telescope sights for the trainer and for the "pointer" of each gun, who elevates and fires; the later turrets have in addition auxiliary "day and night" sights for the pointers at least. Sights cannot be mounted directly on the gun-slide of a turret gun because too large an opening in the turret would be required when firing at an elevation; Fig. 6 illustrates this—without a much larger gun port the target will rarely be in view from the sight while the ship is rolling. To obviate this,

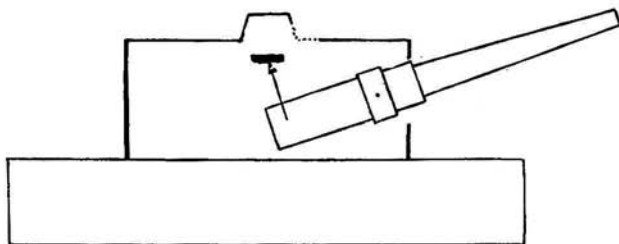


Fig. 6.

the sight is placed in a hood in the turret roof, and being close to the front side of the hood, only a small opening in it is needed. To give the telescope the same angular motion that the gun slide has, it is mounted on a table which is connected to the slide by a simple parallel motion device, upon on which the accuracy of the mounting largely depends. The arrangement in use in the earlier turrets is shown by Plate VI. The trunnions of the telescope rest in an upright like the one in Plate IV and the sight setting apparatus is also the same—there is no transversing mechanism for correcting lateral errors.

In the figure, (M) is a cross shaft whose axis of rotation is parallel to the axis of the trunnions (or pivot bolts) of the gun. Upon this shaft is keyed the arm EM of the telescope standard bc , the latter terminating in a base b , hinged at d to the arm and

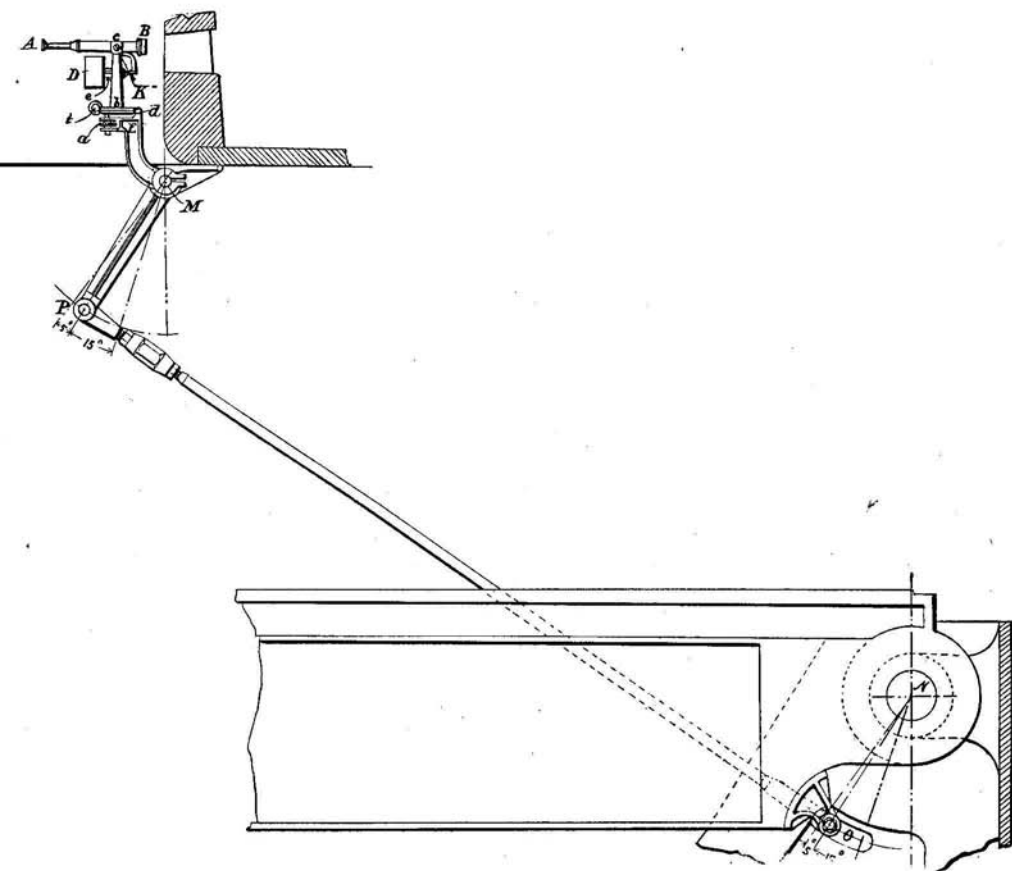
capable of giving a slight permanent adjustment to the line of sight in the *vertical* plane by means of the screw *a*. The standard is forked at its upper end to support the trunnions of the telescope *AB*.

Keyed to the cross shaft *M* is the arm *MP*, which is connected, by the connecting rod *PO*, to a point on the slide, at *O*. *N* is the pivot of the slide; the length of the arm *MP* = the distance *NO* and *PO* = *MN*; there is a turn buckle in *PO* to correct any lack of parallelism between *MP* and *NO*. The joints are all accurately finished and are locked to prevent lost motion. It is plain that any angular movement of the slide (and consequently of the gun) communicates a corresponding movement to *MP* and to the telescope *AB*.

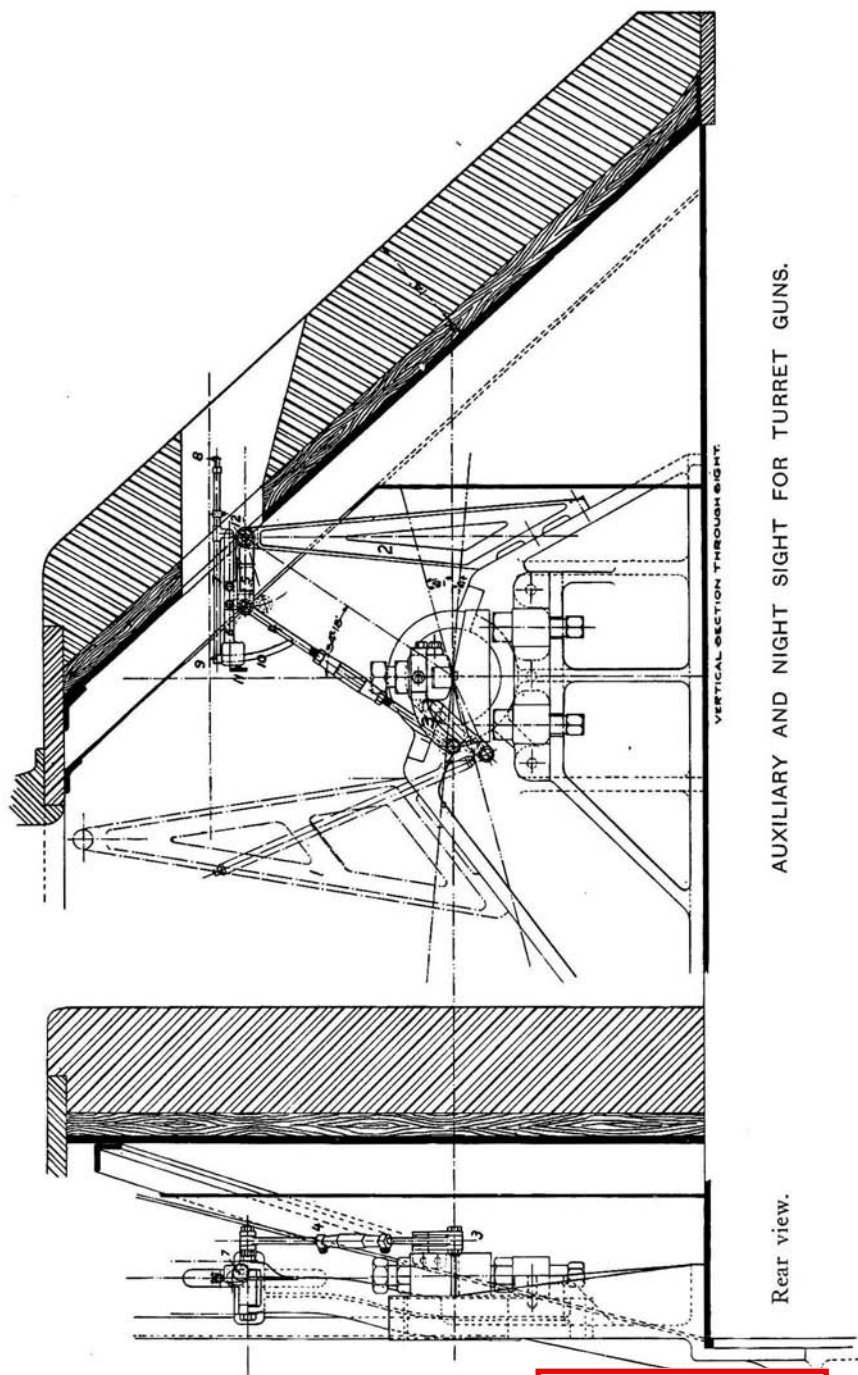
A drum *D*, graduated spirally for the range of the gun at different angles of elevation, is fitted to a three-threaded screw *e* which bears upon an arm *K* rigidly attached to the telescope, so that, by turning the drum to indicate any marked range, the telescope is depressed through the corresponding angle, and this angle of depression is the angle between axis of bore and axis of telescope,—when the system is in perfect adjustment. Therefore when the drum *D* is set for any desired range and the telescope is directed upon the target by elevating the gun, it follows that the gun is laid at the proper elevation.

The base (*b*) is made in two parts, held together by bolts which pass through slots in the upper plate and set up in the lower one. When the bolts are slackened, the upper plate may be revolved on the lower by the tangent screw (*t*) and thus make a permanent correction in the horizontal plane; this is only for adjusting the sight and is not arranged to be used as a sliding leaf. Drift is compensated by slightly lowering the left trunnion of the telescope.

The above system of parallelism is employed for all sights that are used for pointing turret guns in elevation but the details differ somewhat; one change is to make all parts stronger and better able to withstand the severe shock of discharge. In one system, used in several turrets, the sight is not attached to the turret, or sighting hood, at any point whatever but is entirely supported by a heavy bracket (*1*) that extends upward from the deck lugs and



TELESCOPE SIGHTS FOR THE EARLIER TURRET MOUNTS.



bears the cross shaft and all the sight mounting (see Plate VII). In still later turrets the mounting is secured to the inside of the hood somewhat as has been shown in Plate VI. In all of these systems, however, the range scale is marked spirally around a drum and the telescope is depressed or elevated in much the same way. An elevation indicator, which shows the elevation of the gun, in degrees, with respect to its platform, is, in all but the earlier turrets, connected to the sight mechanism and is installed in plain view of the gun pointer; he lays the gun to its loading position by it.

The *trainer's sight* is a telescope sight secured to the training hood and not connected to the guns in any way. The duty of the trainer is to keep the axis of the turret, with which each gun is parallel, in the vertical plane between turret and target; hence it is unnecessary, not to say inconvenient, to have the training sight partake of the movements of the guns. Accordingly, its trunnions are horizontal and the trainer may swing it up and down on them to keep the target in its field—its motion is in the vertical plane. There is, however, a transversing drum, marked with the ranges, and the trainer must keep it set at the range of the pointer's sight to give his sight the same drift compensation.

Night sights for turret guns are on the same principle as those for intermediate guns; those supplied to the pointer's hoods of the "Alabama" class and, many subsequent ones, are shown by Pl. VII. The sight and mounting are supported by the bracket (2) bolted to the deck lug; the sight is installed below the hood and is used through a sighting hole in the front turret armor. Parallelism between the sight base (6) and the gun is secured by the arms (5) and (3) and the connecting rod (4)—the latter is fitted with a turnbuckle by which large vertical errors of adjustment are corrected; the axis (12) must be parallel to the axis of the trunnions. The front (8) and rear (9) sight are both attached to a bar (7) pivoted at the forward end of the sight base and capable of motion in a vertical plane (corrected for drift) about its pivot. To the rear end of the bar a toothed sector (10), on which are marked the ranges, is secured; the geometrical center of the segment is the pivot of the bar. The function of the hand wheel (11) is to raise and lower the segment by connecting gearing and thus give the sight the required angle.

Adjusting Sights.

11. Unless needless errors in aiming are to be introduced, the axis of the bore and the line of sight must be parallel when the sight is set at zero. It is not likely that the workmanship in machining and installing the different parts of the sight mountings will be sufficiently accurate and, even if that be the case, a little wear or deformation of some part may affect the parallelism, and only great care and watchfulness on the part of the divisional officers will insure the efficient condition of the sights. With most sights, means are furnished for correcting the unavoidable errors of workmanship, etc.; these adjusting devices have been described, or at least mentioned, above for a few of the many varieties of sights.

The *bore sights* are supplied to ships to obtain a line in prolongation of the axis of the bore while adjusting the sights; one of them is placed in the muzzle, the other in the breech of the gun. The front sight is a bronze ring, with cross wires fixing its center, that fits neatly over the lands of the rifling; the rear sight, containing a short telescope whose optical axis is in the geometrical center of the sight ring, is placed in the rear end of the powder chamber or resting in the blanks of the screw box. The field of the telescope is at least as large as that subtended by the bore, and it is so constructed that the cross wires of the front sight and a distant object will both be in focus. With bore sights, a gun may be pointed with extreme accuracy; in testing armor, or in firing through a screen to measure the jump, the pointing is done in this way.

To test a sight of any type, direct the gun at a well-defined object, not nearer than 2000 yards if practicable, (to make parallax between the two lines inappreciable), by means of the bore sights. Then, with sight set at zero, note whether the line of sight is also directed at the target; if not, alter the sight by the adjusting screws and bolts until it does and set up hard on all nuts and set screws. When the ship is not motionless, two observers, one at the bore sights and one at the regular sights, are needed; with care they may attain a good degree of accuracy by "marking" when the sights are on the target selected. The telescope sights of all

heavy guns, and in particular those of turret guns, are subjected to severe shocks, while firing, which are likely to cause derangement, no matter how carefully the sights are adjusted. For this reason it is an advantage to have some means of readily testing the sights, at any time during the firing, without recourse to the bore sight. Of course, ingenuity in utilizing the local resources is valuable and the same ideas cannot be carried out under different circumstances; one method is to depress the telescope, the gun being level, until the edge of the turret roof can be seen; note the range that the drum is set at and project the cross wires on the turret roof in differently colored paint; then, to test the sight at any time, level the gun and set the sight at the proper range when, if the sight is still in adjustment, the cross wires will cover the painted lines. This, with other similar methods, is very rough but, even so, it is well to be able to tell instantly if the sight has changed.*

With all but turret guns, the line of sight and the axis of the bore are near enough to each other to be considered coincident. In turrets, however, where the sights are several feet above the guns, parallax will introduce a considerable error; instead of being at zero while adjusting, these sights should be set above it; for 13-inch guns, 2000 yards gives a good approximation.

An objection has been raised to the adoption of telescope sights on the plea that they are of necessity too delicate and add to the number of sensitive instruments to be cared for. It is true that they are delicate but not so much as is a sextant or a chronometer—two instruments so essential to the safety of the ship that they are under the sole personal care of one of her senior officers. In times of peace, the gun sights are perhaps not so important but under war conditions, which the navy strives to live up to, any officer would prefer losing the chronometers instead of as many turret gun sights, the latter then being the more essential to the *safety* of the ship. This being the case, a navigator's care and watchfulness over his instruments may well be lavished upon the sights of the battery by divisional officers and gun pointers. As regards care of materiel, it is their most important duty and on its thoroughness largely depends carrying out the doctrine: "*The only shots that count are those that hit.*"

CHAPTER XIX.

SEMI-AUTOMATIC GUNS.

1. A **Semi-Automatic Gun** is one in which a portion of the energy of firing is utilized to perform a *part* of the loading and firing operation for the succeeding round, the remaining part, usually comprising merely the insertion of the cartridge, being done by hand. Such guns may be constructed in any size but the different systems involving the principle are utilized mainly for secondary battery guns.

In the U. S. Navy, all one-, three- and six-pounders now building are being constructed on semi-automatic systems and probably no more ordinary rapid-firing guns of those sizes will be constructed for ship's secondary batteries. The systems in use are the Maxim-Nordenfeldt, the Hotchkiss and the Driggs-Seabury. (A few 6-pdrs. of the latter type have been built by a private firm.) It is likely that the 3-inch guns also will be "S. A." in the future.

Semi-automatic guns have well defined advantages over those of ordinary R. F. types and some S. A. systems obtain these advantages with very few added complications:—

- (a) The rate of fire is greatly augmented; unaimed shots may be fired at the rate of nearly one per second. So great is this increase that *automatic* guns, above rifle calibre, though capable of firing much more rapidly, seem no longer necessary, considering the great weight and the complicated mechanism entailed by such systems.
- (b) A portion of the labor of loading being performed automatically, one of the gun's servants may be dispensed with.
- (c) Since the block opens only during counter recoil, the danger from "hang fires" is diminished; it is only necessary to wait and the block cannot be opened prematurely, if the hand lever be let alone.

- (d) The automatic closing of the block is less likely to derange the pointer's aim—the gun being pointed by a shoulder stock—than if it be done by hand.

The Hotchkiss Semi-Automatic System.

2. This system belongs to that class in which the opening and closing of the breech are performed by energy stored during recoil in the counter-recoil and "breech-closing" spring. Besides the advantages claimed for it in the way of lightness, simplicity, accessibility of parts—none of which are complicated or delicate—certainty of operation, etc., the Hotchkiss R. F. guns now in service may be readily made semi-automatic. Guns with the device are now in service and it bids fair to be largely adopted for the one-, three- and six-pounders, and perhaps for 3-inch guns. All guns so fitted, including the one-pounders, are built up steel guns consisting of tube, jacket and screwed locking ring. (The mechanism for a 50-calibre 3-pdr. gun is shown by Plates I and II.) The range of the 3-pdrs. is 5200 yds., M. V. 2200; of the 1-pdrs. 3600 yds., M. V. 2100.

3. **The Breech Mechanism** is in all the ordinary features like the Hotchkiss Mark II mechanism described in Chapter XI, the block, stop bolt, crank, rock shaft, hammer, firing spring, etc., being the same. The differences lie in the extractor (23), the sear (20),—to which a safety device has been added,—the operating lever (25) and in the addition of the breech-closing spring (32) and the thrust rod (29).

4. **The Sear Mechanism** (20) consists of five pieces; its functions are to retain the hammer at full cock, until released by a pull on the trigger, and to prevent the release of the hammer when the breech is open; it has nothing to do with the semi-automatic part of the mechanism and can be fitted to ordinary Hotchkiss, Mark II mechanisms.

The sear trigger (20A) is pivoted on the sear pin (20C), which is held in a cylindrical hole in the right side of the breechblock. In the upper side of the trigger (Fig. 6, Plate I) is a small pocket for the end of the sear-trigger spring (21). This spring is seated, in company with the sear-pawl spring (21H, Fig. 6), in a vertical

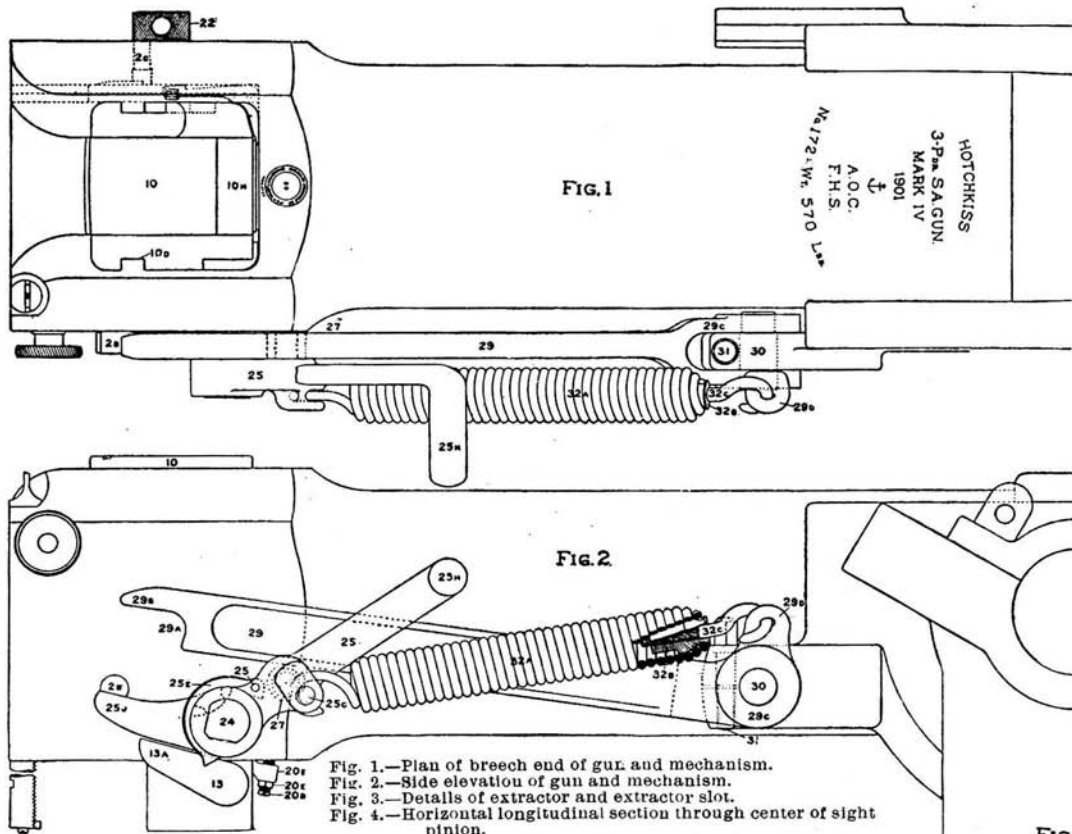


Fig. 1.—Plan of breech end of gun and mechanism.
 Fig. 2.—Side elevation of gun and mechanism.
 Fig. 3.—Details of extractor and extractor slot.
 Fig. 4.—Horizontal longitudinal section through center of sight pinion.
 Fig. 5.—Vertical transverse section through roller, roller pivot, operating lever, and thrust rod.
 Fig. 6.—Vertical longitudinal section, immediately to the right of sear, of a portion of the breechblock.

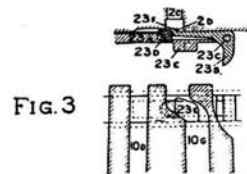


FIG. 3

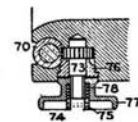


FIG. 4

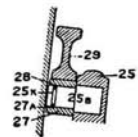


FIG. 5

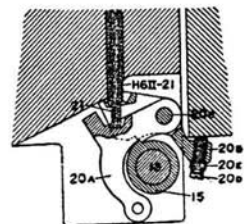
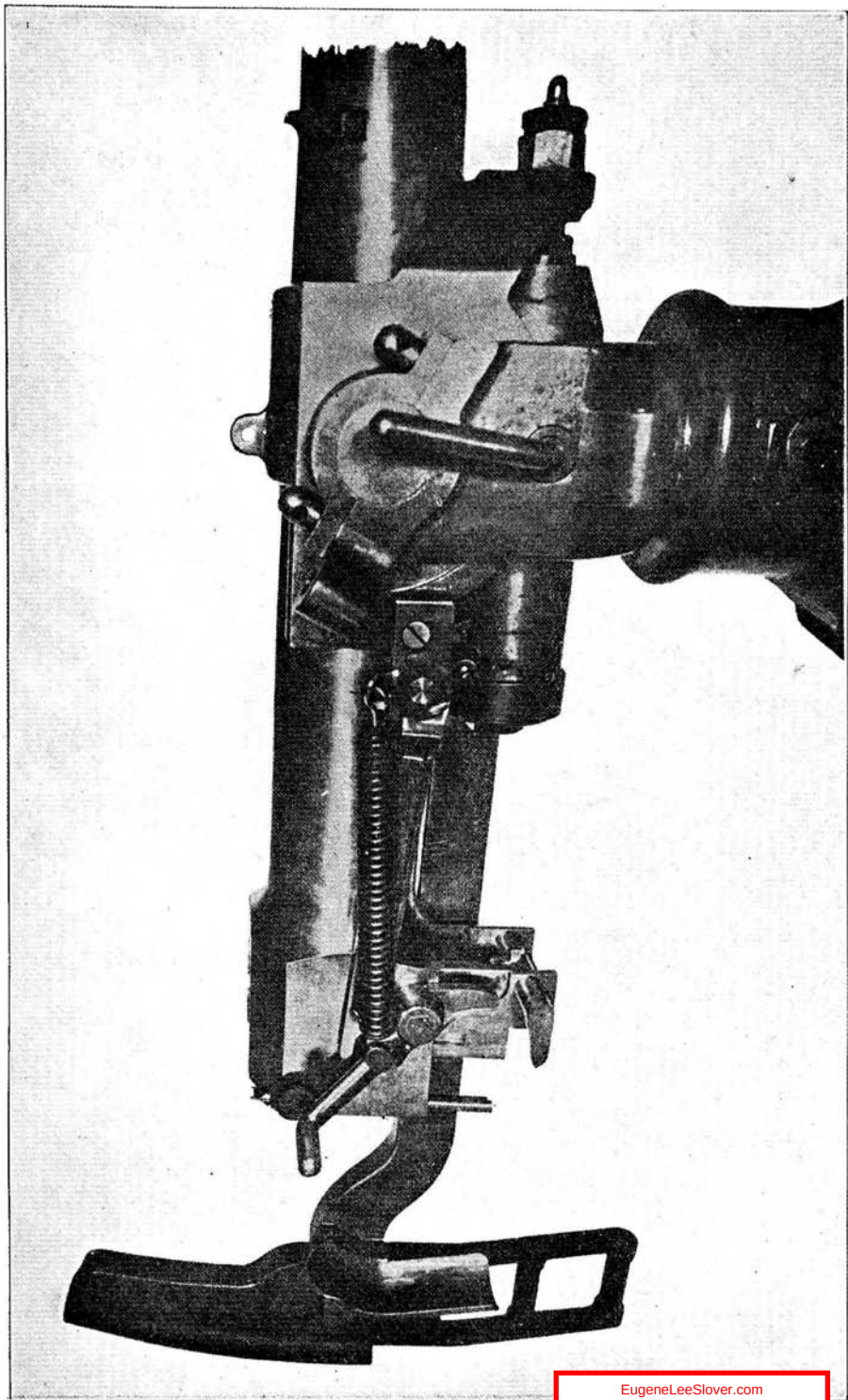


FIG. 6



POSITION OF PARTS OF 3-PDR. SEMI-AUTOMATIC MECHANISM WITH BREECH OPEN.

cylindrical pocket in the breechblock; the two springs are wound in opposite directions. Referring to Plate I, it will be seen that the cock notch of the sear trigger engages the cock notch on the hammer, the hammer being cocked. The lug on the sear trigger just below the figures 21 serves as a stop when the lanyard is pulled; this prevents the sear trigger from being pulled far enough back to actuate the sear pawl—if it were possible to actuate the sear pawl by a pull on the lanyard, then the hammer could be released with the breech open. In the lower end of the sear trigger is an eye through which the lanyard is rove.

The *sear pawl* (20B) is pivoted on the sear pin between the two legs of the trigger and has in its upper side a pocket for the lower end of the sear-pawl spring; it has a stop lug and a cock notch similar to those of the sear trigger. On its lower end are the sear adjusting screw (20D) and a locking nut (20E). The functions of the sear pawl are to hold the hammer at full cock, when the breech is open, and to release it on to the sear trigger, when closed; the function of the sear springs is to press downward on both the trigger and pawl so that the cock notches on them will engage that of the hammer whenever opportunity offers. The adjusting screw (20D) is for adjusting the pawl, so that, when the breech is closed, the adjusting screw will strike on under face of breech housing and lift cock notch on sear pawl clear of hammer. The nut (20E) serves to lock the adjusting screw in position.

To adjust the sear pawl, open the breech, come up the locking nut and partially unscrew the adjusting screw; now close the breech and hold back the trigger—it will be found that this will not release the hammer. Now screw in the adjusting screw until it takes under the face of the breech and forces the pawl down just far enough to release the hammer which, if the trigger is not held back will be caught by it, giving a slight click. This adjusting should be nicely done, so that when the breech is closed slowly the sear pawl will not fail to trip, nor trip too soon.

5. The Function of the Extractor is to eject the empty case in the usual manner and then to hold the block open until a new cartridge is inserted. (See Figs. 1 and 3, Plate I.) The extractor slides forward and backward in a T-shaped groove, being actuated by a lug travelling (relatively) in the extractor groove of the

breechblock. The stop pin (2c) passes through the curtain of the gun into the extractor housing and has a notch in its inner end. The extractor claw (23b), pivoted at the front end of the extractor, has an arm extending to the rear outside the extractor slide (23a) from which its rear end is forced outward by a small spring (23d). When the breechblock is lowered, the extractor moves to the rear and ejects the empty case; the end of the extractor claw is kept pressed against the stop pin and, as the limit of rearward motion is reached, the notch (2d) snaps over the stop pin (2c). This prevents the forward motion of the extractor, and consequently the upward movement of the block, until the extractor is released by the new cartridge striking its claw and forcing its tail inward, whereupon the mechanism is free to close. With each gun, a plain extractor is furnished for use when the gun is operated without the S. A. attachment.

6. **The Operating Lever** fits over the end of the crank shaft, to which it is secured by a lock (25e) as in the Mark II mechanism; the cocking cam also is unchanged—when the breech is closed it brings up against the stop (2B). The end of the lever is bent over at right angles, forming the handle (25h), and the breech-closing spring hooks over a pin (25c) in its side. A short projecting arm on the inner side of the lever bears a roller (27) against which the thrust rod strikes to open the breech. The breech-closing spring (32a) hooks to the lever and to a short arm of the thrust rod; its hook (32c) allows a limited adjustment in the tension of the spring.

The thrust rod (29) is pivoted to the right side of the mount slide by the pivot (30), which is held fast in the slide by the thrust-rod pivot clamp screw (31). The eye (29D) receives the hook of the breech-closing spring. The thrust-rod notch (29A) and toe (29B) will be considered when the operation of the mechanism is described.

7. **Operation of the Mechanism** (starting with the breech open).

In this position the breech-closing spring, which is attached at one end to the eye of the thrust rod, and at the other to the pin on the operating lever, is distended. The tension of the spring on the thrust rod causes it to bear with considerable force on the

roller; this pressure on the roller continues in all positions of the operating lever. The breechblock is held open by the extractor as before described. When the round is entered in the chamber, the rim of the cartridge case hits the extractor nib a slight blow; this releases the extractor claw from the extractor stop pin, and the block is closed by the breech-closing spring, the cartridge case being forced home in the chamber by the loading slope on the block.

Just before the block reaches its closed position, the sear adjusting screw takes on the under face of the breech, and, as the block closes, causes the sear pawl to revolve about the sear pin until its cock notch disengages the cock notch on the hammer; this leaves the hammer held in its cocked position by the sear trigger alone. In firing, a pull on the lanyard, which is rove through the eye in the sear trigger, causes the trigger to revolve about the sear pin until its notch disengages the hammer cock notch, when the hammer flies forward and the gun is fired.

During the recoil of the gun, the breech-closing spring is distended, and the thrust rod bears with increasing force on the roller until the gun has so far recoiled that the roller passes to the rear of the thrust-rod notch, when the rod drops until its toe (29B) rests on the roller and when the gun starts to return to battery, the roller brings up against the thrust-rod notch. The counter recoil continuing, the rod pushes the operating lever to the rear until the block is fully open, when the rod again rides up on top of the roller. This riding up of the thrust rod on the roller occurs when the operating lever has been pushed so far to the rear that the pressure of the rod is exerted at a point on the roller above the line joining the center of the thrust-rod pivot and the center of the roller pivot.

It will be seen by reference to Plate I that the downward motion of the thrust rod is limited by the operating lever, on which the under surface of the rod bears when the lever is in its extreme rear position.

To open the breech by hand, pull the operating lever to the rear; to close the breech on empty chamber, pull the operating-lever handle to the rear, then push forward on extractor claw, so as to raise its notch clear of the stop pin, then ease the block up with

the operating lever. Or, with a screw-driver handle, push forward smartly on the extractor claw and breech will close automatically. In firing with faulty ammunition, the breech may fail to entirely close; in which case, complete the operation by hand. No strain is to be kept on the lanyard when the breech is closing as this will cause the gun to fire the moment the block reaches its closed position. To remove the breech-closing spring, close the breech, raise the operating-lever lock, and remove lever front crank, when the spring may be easily unhooked and a new one substituted. The new spring should be hooked to the operating lever before reassembling the lever with the crank.

8. The following failures of the semi-automatic mechanism and their causes have been noted at the proving ground.

Failure to Eject Empty Case after Firing.—This has frequently been caused by slow counter recoil of the gun; weak recoil springs, clogged recoil grooves, or elevating clamps set up, may cause failure to eject. If empty case is held by the block so that it cannot be withdrawn by hand, the extractor has failed to hold the block open; this may mean a broken extractor claw, a broken extractor spring, or a broken extractor catch pin.

Failure of Breech to Completely Close after Loading.—This failure is usually caused by deformed ammunition, which requires more power to seat than the breech-closing spring has. Dirt, unburned powder, or other foreign substances in the chamber will cause failure of breech to close.

If the breech fully closes and the cocking cam rebounds from the operating-lever stop, the cause will be found to be extra friction of the breech-closing spring on the pin of the operating lever. The spring, where it engages the pin, may have opened or may have started to cut; this point should be kept well lubricated. When the operating lever rebounds as above described, it may cause a missfire, as the cocking toe must cam the operating lever forward before the firing point can touch the primer.

Failure of Sear Trigger to Release the Hammer when Breech is Closed.—This is caused by improper adjustment of the sear pawl.

In case the mechanism does not work freely, examine the crank head and crank slot for signs of extra friction; if it is found that

the crank head is rubbing in the bottom of the slot, ease it slightly with emery cloth.

Failure of the Breech to Open after Firing.—This may be caused by the breaking of the breech-closing spring during recoil; the spring broken, the thrust rod notch fails to engage the roller during counter recoil and the breech remains closed.

Another cause is insufficient recoil; the semi-automatic attachment is designed to operate with a minimum recoil of 3.1 inches. Increased recoil may be obtained by removing a small quantity of glycerin from the recoil cylinder.

The Maxim-Nordenfeldt S. A. System.

(See Plates III and IV.)

9. This system was devised in England and guns constructed on it by the firm of Vickers' Sons and Maxim were among the first of the successful semi-automatics. As in the Hotchkiss system, the breechblock—also of the sliding-wedge type—is forced down during the counter recoil by a non-recoiling thrust piece and a closing spring is energized; the extractor holds the block down until it is freed by the cartridge rim striking against its claws, whereupon the closing spring raises the block into its place. This action is secured in a manner different from the Hotchkiss system however; it is to be noted that flat springs are employed for most purposes. In the U. S. navy the system is fitted to three and six pounders; some of the guns are foreign built—by Vickers' Sons and Maxim—but are in most respects like those built, or in process of construction, at the gun factory.

The *mounting* consists of a non-recoiling bronze sleeve—sometimes less properly called the cradle—that completely surrounds the breech half of the gun, trunnioned into a saddle whose pivot rests in a cone or cage stand similar to that for ordinary R. F. guns. The recoil is checked and the counter recoil is effected by one hydraulic spring-return cylinder. The cylinder, also non-recoiling, is secured to a lug on the under side of the sleeve; it is filled through a filling hole in the front bonnet and its rear bonnet is fitted with a stuffing box through which the piston rod passes to the lug on the gun to which it is secured. The shoulder stock,

bearing the rear sight is secured to the sleeve which bears the front sight. The right side of the rear end of the sleeve is enlarged to form a box, known as the side box, which contains the non-recoiling operating gear, trigger, pistol grip, etc.

The guns are not "built-up" but are made from single forgings of high-grade steel. The breech is square in section for a few inches and the breech block housing extends through it from top to bottom; an opening to the rear is left for loading, below which a tie piece unites the two curtains. From the under side near the breechblock, a heavy lug extends downward, having a threaded socket for the piston rod and a hinge pin (8) for the action lever. The mechanism shown in the Plates is that of a 6-pdr., 45 calibre gun giving a muzzle velocity of 2240 f. s.

The *mechanism* includes the breechblock; action lever; action lever axis, tumbler, roller and hand lever; closing spring; thrust pawl and spring; extractor; and the firing mechanism; there is no stop bolt.

10. The Breechblock (1)—of the same general type as the Hotchkiss block—is hollowed out from the front and bottom to receive the firing mechanism. The recoil is transmitted to the gun from the rear face of the block, which is sloped slightly so that a slight horizontal motion accompanies the vertical movements of the front face; the top is cut away to give room for loading and is sloped downward to the front—to force home the cartridge while closing. There are two notches (1d) in the front upper corners by which the extractors hold the breech open; the rear lower corner forms a lip which limits the upward motion. The cam-shaped slot (1c) extends through the block from right to left; the action-lever pin (6) works back and forth in it to raise and lower the block, which is also limited in its downward motion in this way. The pins or shafts of the sear and of the cocking bar also pass through the sides of the block. A dove-tailed plate (2) gives access to the firing pin and affords a bearing for one branch of the firing spring.

The *action lever* (5) is held on and turns with its hexagonal axis (8); it has two arms which embrace the block and bear the pin (6) which is secured by a locking pin (7). The lug (5a) limits the downward swing of the lever and consequently the

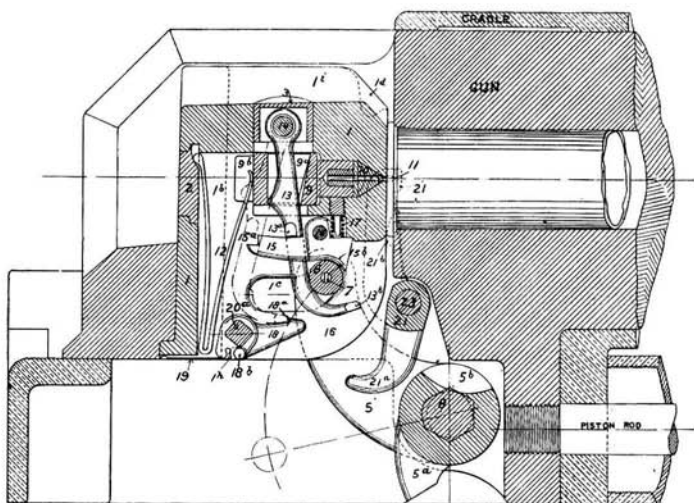


Fig. 1.

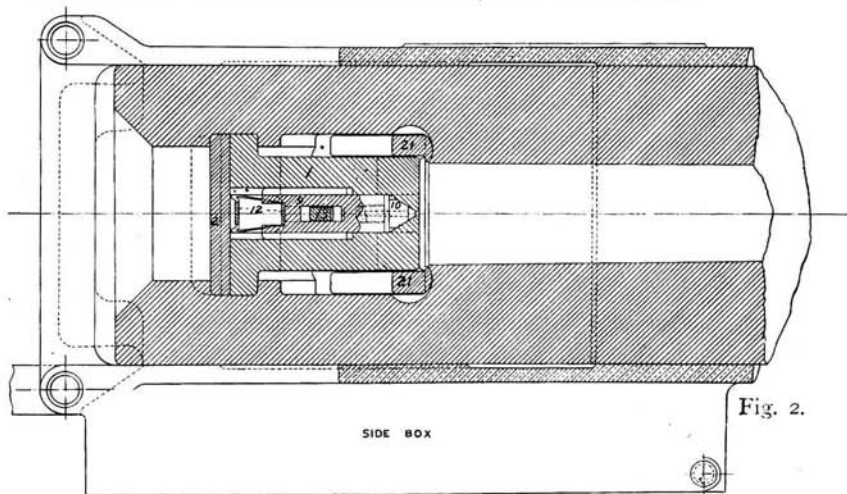


Fig. 2.

FIG. 1. VERTICAL LONGITUDINAL SECTION. BREECH CLOSED.
FIG. 2. HORIZONTAL SECTION THROUGH THE AXIS OF THE BORE.

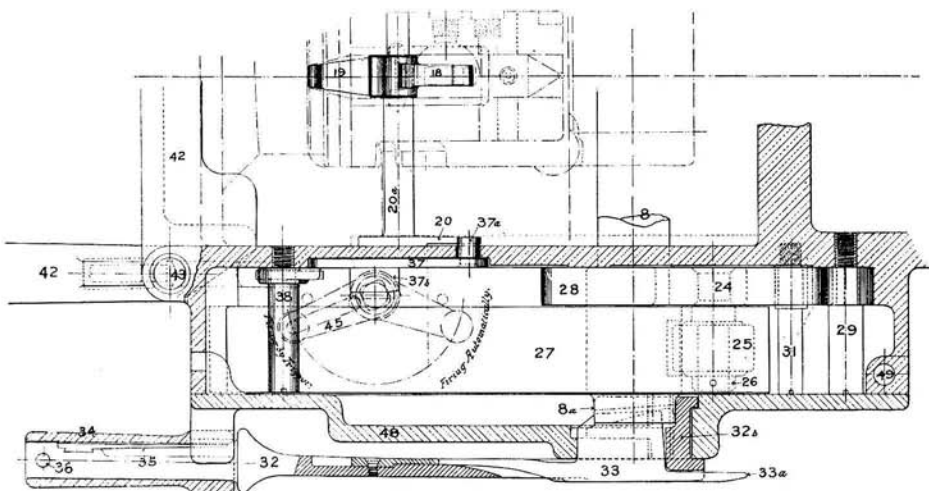


FIG. 1. HORIZONTAL SECTION ON A. B. OF SIDE BOX AND PROFILE OF BOTTOM OF BLOCK.

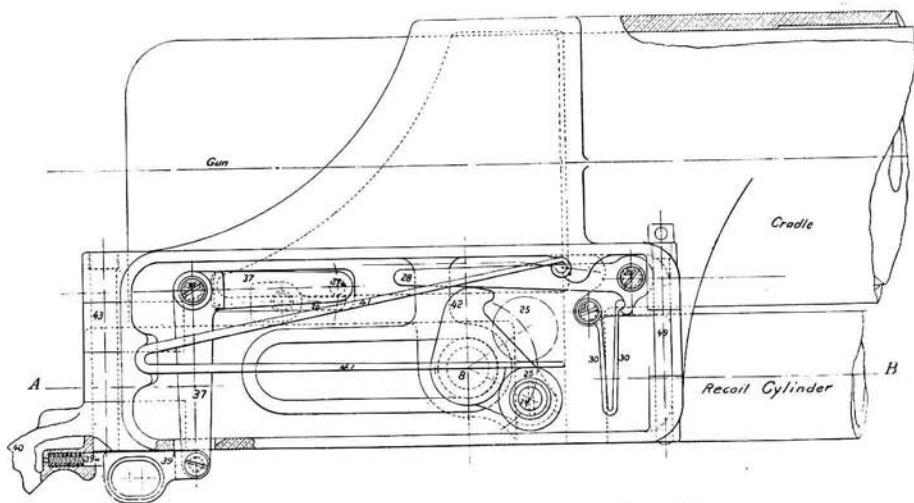


FIG. 2. VIEW OF SIDE BOX WITH COVERING PLATE REMOVED.

MAXIM-NORDENFELDT S. A. SYSTEM.

downward motion of the block. The axis (8) is inserted from the right and its round portions rest in bearings in the gun; the lever and axis move together through an arc of about 60 degrees. The tumbler (42) is a part of the axis, as are the arm and axis of the roller (25). Half of the metal of the axis under the closing spring is cut away to give the spring greater scope. With the exception of the extractor, this completes the recoiling part of the mechanism.

The *hand lever* (32) is used for opening or closing the breech when desired, as in first loading, but it has no part in the operation when working semi-automatically. The hub (32b) fits over the end of the axis and its spring key (33) engages a groove in the end. When not in use, the handle (34) rests in a shallow groove in the outside of the side box.

The *closing spring* (41), a very powerful flat spring, rests as shown with its elbow in a recess in the rear end of the side box, its upper branch in a notch in the top and its lower arm pressing on the friction roller (25), by which it exerts its force on the action lever through the axis (8).

The *thrust pawl* (28), pivoted to the sleeve, is pressed downward against the tumbler by its spring (30).

The *extractor* (21) works on its pin (23), inserted from the left side, and has two branches or arms; each arm has a flat spring on its outside which bears strongly against the curtain of the gun and prevents the extractor from moving too easily; there is the usual claw on each arm for engaging the cartridge case and also a lug (21b) by which the extractor holds the block down, when the breech is open. The tail of the extractor (21a) enters the recess in the block during the first portion of the downward motion and is forced forward, at first slowly and then abruptly, by the corner of the block which is shown in section near the lug (21b). The hub of the action lever is cut away at (5b) to permit sufficient throw of the extractor.

11. The Firing Mechanism comprises the firing pin (9), firing spring (12), cocking bar (13), sear and spring (18) and (19), safety sear (15), trigger (37), trigger lever (20) and trigger pull (39).

The heavy cylindrical firing pin (9), with a separate firing

point screwed into the end, works back and forth in a recess in the block. There is a vertical slot (9a) through which passes the cocking bar (13), pivoted at (14), the movements of which accompany the motion of the pin in firing as well as in cocking; the cocking bar has points of engagement for the sears at (13a) and (13b).

The heavy flat firing spring (12) is held in place by its own tension pressing its rear arm into a shallow recess in the covering plate (2); the other arm presses against the rear end of the firing pin. The safety sear (15)—the purpose of which is to hold the mechanism at full cock until the breech is fully closed—is pivoted at (16) and its rear arm is pressed upward against (13a) by the small spiral spring (17).

The *trigger sear* (18) is held in the block by the trigger lever shaft (20a) with which it turns; its arm is forced upward by the flat sear spring (19), which really forms one part with the sear and is assembled with it. The shaft (20a)—square in section only where it passes through the sear—rests in bearings in each side of the block; the trigger lever (20) projects forward from its right end.

The *trigger* (37), a bell-crank lever, is a non-recoiling part of the mechanism, pivoted in the side box on the axis (38); its upper arm bears on the trigger lever and the lower one is secured to the trigger pull (39). The latter is assembled with, and has fore and aft motion in, the pistol grip (40), which is a part of the gate of the sleeve; the spiral spring (39a) exerts its force to press the upper arm of the trigger upward, away from the trigger lever. When the switch (45), (which is found in two forms), is thrown into action, it holds the trigger downward so that the trigger sear is tripped and the gun fired automatically, on the completion of the breech closure.

12. The Operation of the Mechanism is as follows: Suppose the gun has just been fired and that all the parts are in the position shown in the plates:

Opening.—The gun and the recoiling parts of the mechanism move to the rear, drawing the piston rod out, which checks the recoil—the right end of the axis (8) travels in a slot in the side box. As soon as the tumbler (43) has moved rearward suffi-

ciently, the thrust pawl snaps down and lies in line with the notch on the forward side of the tumbler. During the counter recoil, the tumbler strikes the pawl and is forced backward until the notch in its edge becomes so inclined that the pawl disengages itself by slipping up; the axis, with all its parts, is revolved by the tumbler, which raises the roller and thus compresses the closing spring. The action lever (5) turning with its axis, brings the block down by the action of its pin (6) in the slot (1c); the extractor arms are forced to the rear, at first slowly, then quickly but with less power, until the empty case is ejected and the lugs (21b) are in line with and above the recesses (1d). When the thrust pawl slips off the tumbler, the closing spring raises the block slightly until it is arrested by the extractor lugs, and the breech is held open ready for loading.

As the pin (6) swings rearward it presses back the cocking arm and with it the firing pin, compressing the firing spring, until—at the moment the opening is completed—both the safety sear (15) and the trigger sear (18), forced upward by their springs, engage the lugs (13a) and (13b) respectively, and hold the mechanism in the cocked position.

Closing.—If the cartridge now be sent home sharply, its rim strikes the extractor claws, forces them forward and frees the block by disengaging the lugs (21b). The closing spring, which by pressing the roller downward has been exerting a strong force to revolve the axis (8) with the hands of a watch, now shoots the block upward by the action of the lever pin (6) in the slot; as the tumbler turns upright again the thrust pawl rides up on its end.

As the lever pin nears the end of its travel, it strikes the safety sear and disengages it from the cocking bar. The trigger is again in contact with its lever (20); when the trigger pull is pressed to the rear by the gun pointer's finger, it disengages the trigger sear (18),—through the several intermediate parts,—and the firing spring shoots pin and cocking bar forward and fires the gun,—whereupon the opening operation is repeated.

13. When the axis (8) recoils, it slips away from the hub of the hand lever,—the spring feather (33) and the slot in the end of the axis, in which it lies, being horizontal at the time. Before

the axis, brought back by the counter-recoil, again touches the hub, it has been revolved and the beveled edge on its end causes the feather (33) to ride up out of engagement, where it is ready to snap into place again when the axis revolves to the closed position. Thus, while the lever is at all times in place ready for use, it has no part in the semi-automatic operation during which it rests immovable in its retaining notch on the side-box cover.

If the switch (45) be thrown "in," or the trigger pull be held back by the gun pointer, the trigger sear and the safety sear will be tripped at the same time and the gun will fire at the moment of closing. In addition to this, an automatic loading device, or hopper feed, has been designed, which when fitted really makes the gun *automatic* in all operations.

About the same causes will produce failures in ejecting the empty case, opening or closing, as are given for the Hotchkiss system. The parts are all very strong and are not liable to give trouble.

(Notes on dismounting, etc., are given in the Gun and Torpedo Drill Book, edition of 1900, on pages 72 to 75, inclusive.)