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 mèlees 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,

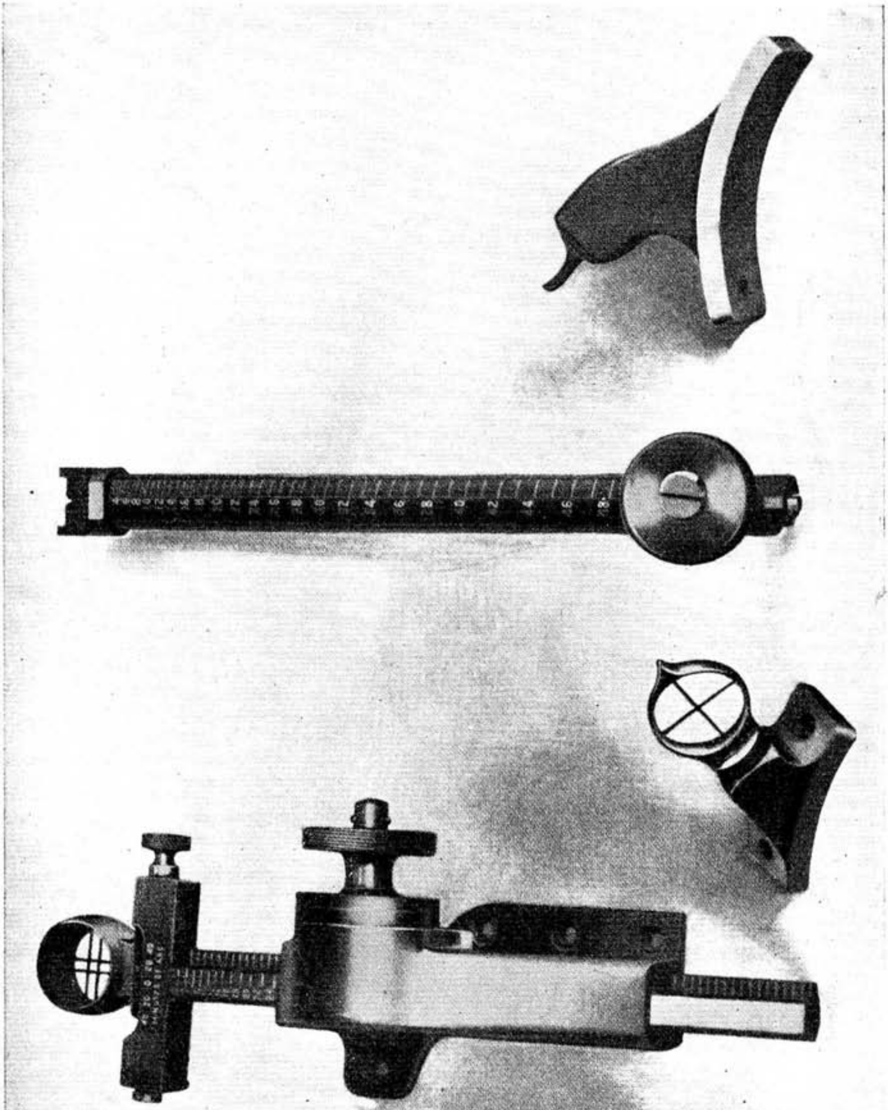
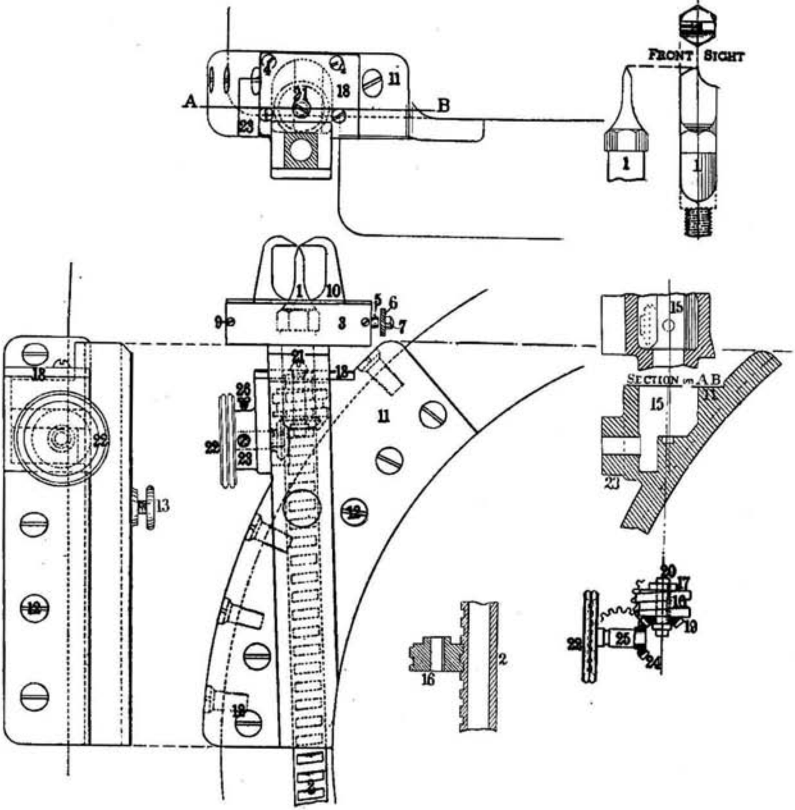


Fig. 1.
DRIGGS SIGHTS FOR 6-PDRS. Par. 6.

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.

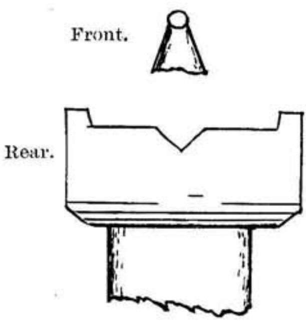


Fig. 1. Par. 5.
COMMON BAR SIGHT.

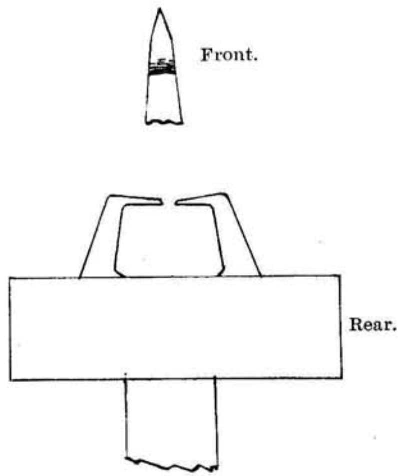


Fig. 2. Par. 5.
LYMAN SIGHT.

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

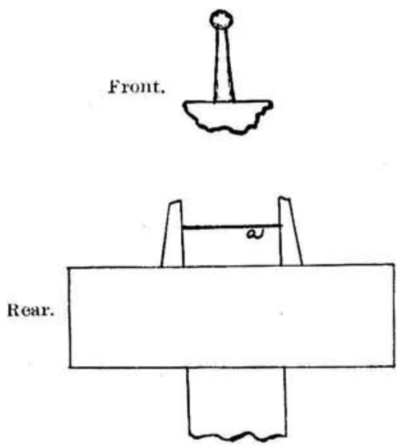


Fig. 3.

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 nack—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.

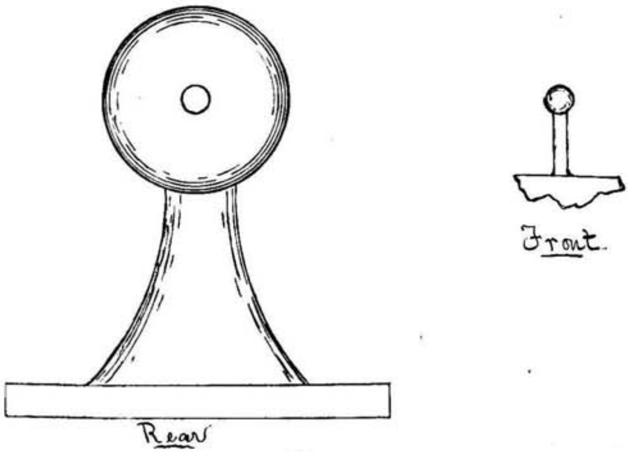


Fig. 4.
PEEP SIGHT.

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.

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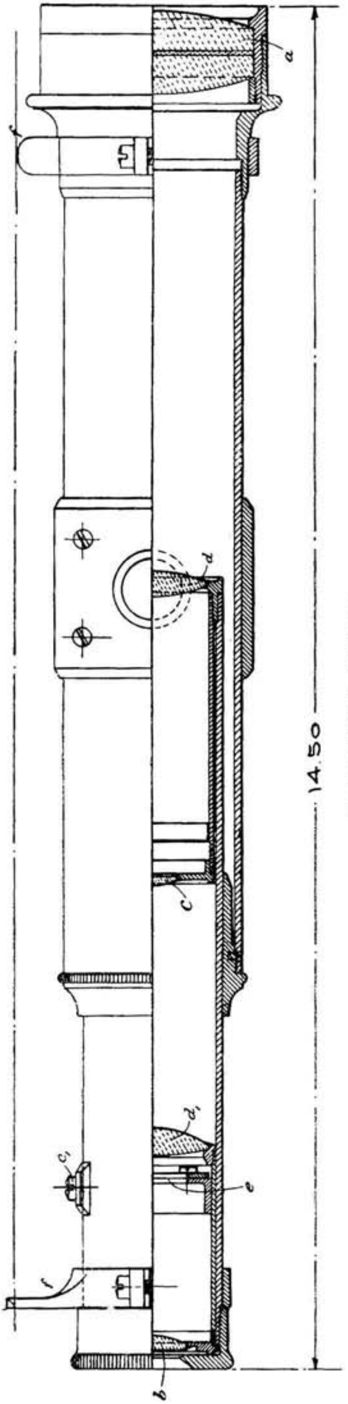
making it possible to hold the eye close to the sight, it would have been advantageous to change to peep sights. But it was the introduction of the telescope sight, with its great added advantages, that has well-nigh caused a revolution in naval gunnery. It was an improvement so great that it may well 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." *

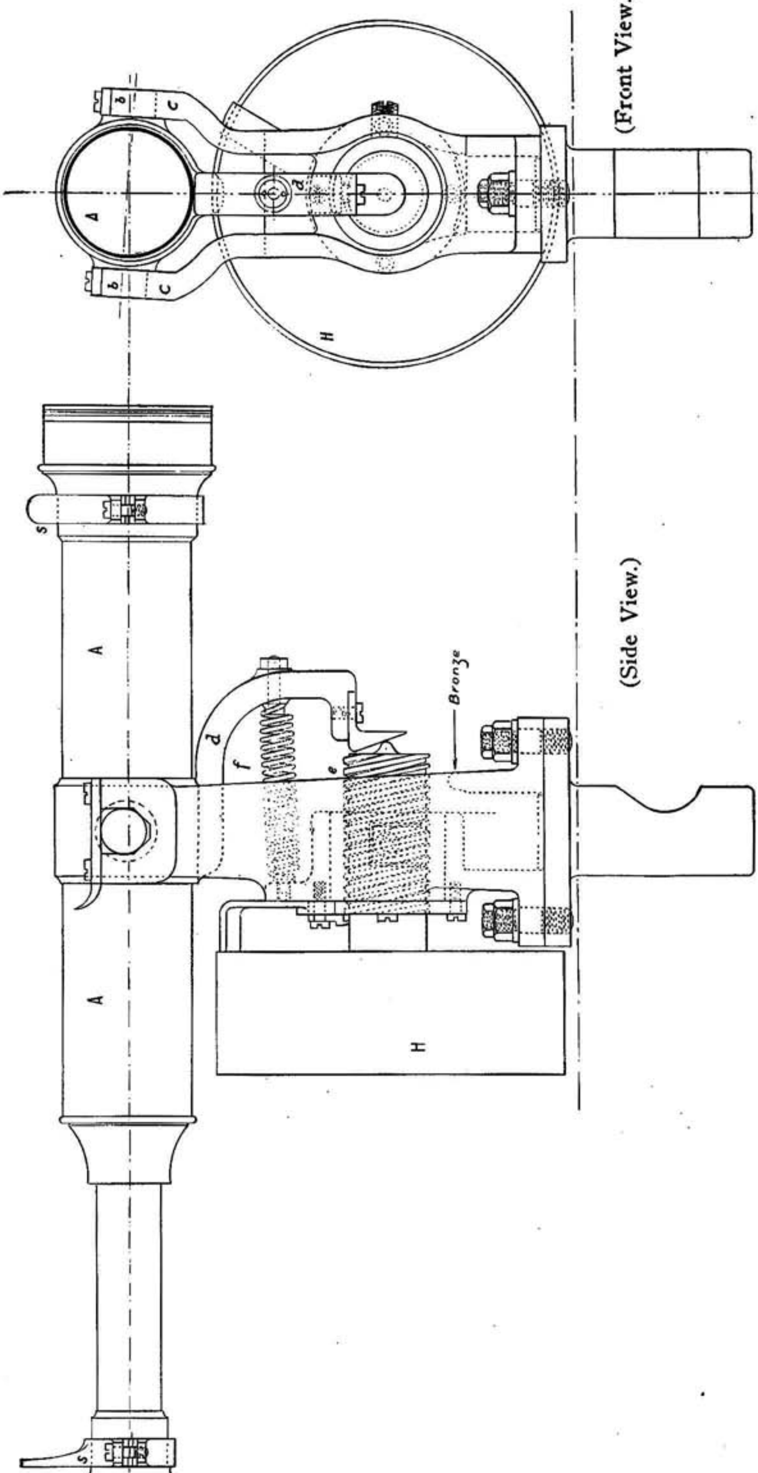
* Prof. P. R. Alger, U. S. N.

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.



(Front View.)

(Side View.)

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

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Faces Plate V, Par. 8,
Chapter XVIII

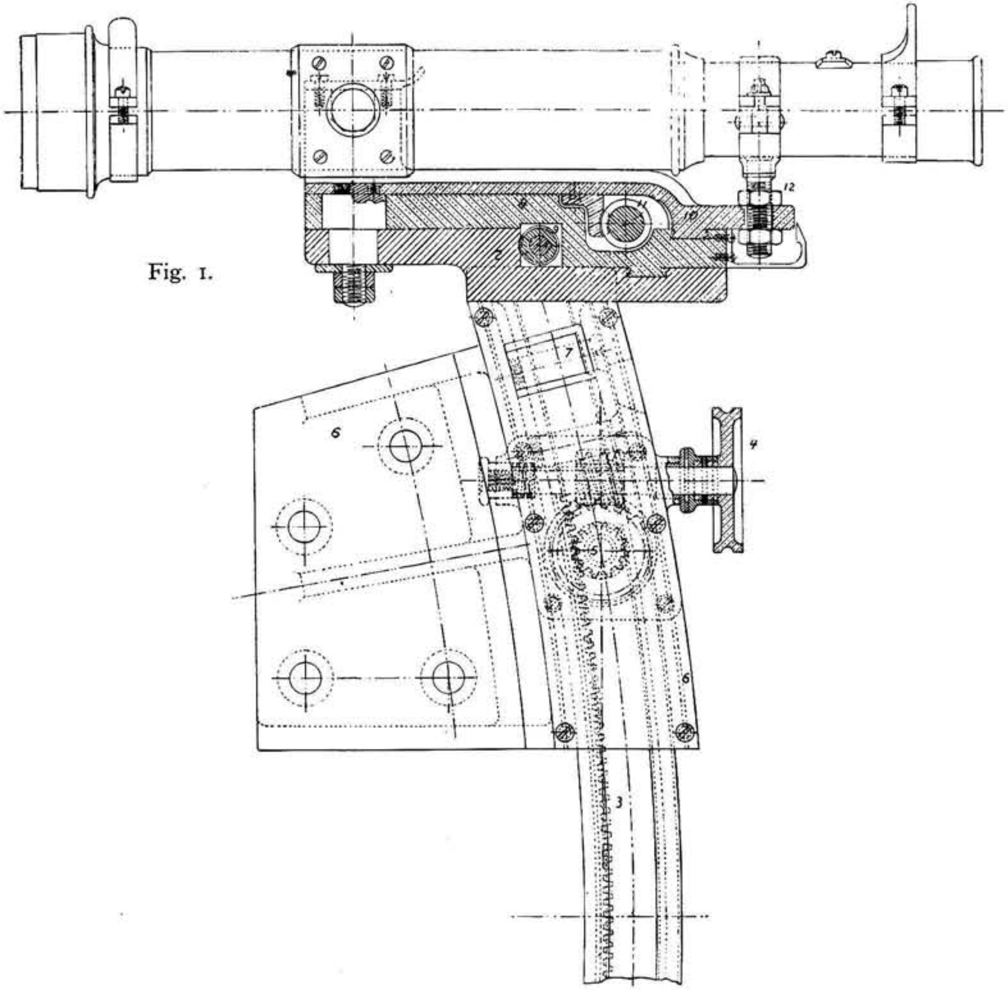


Fig. 1.

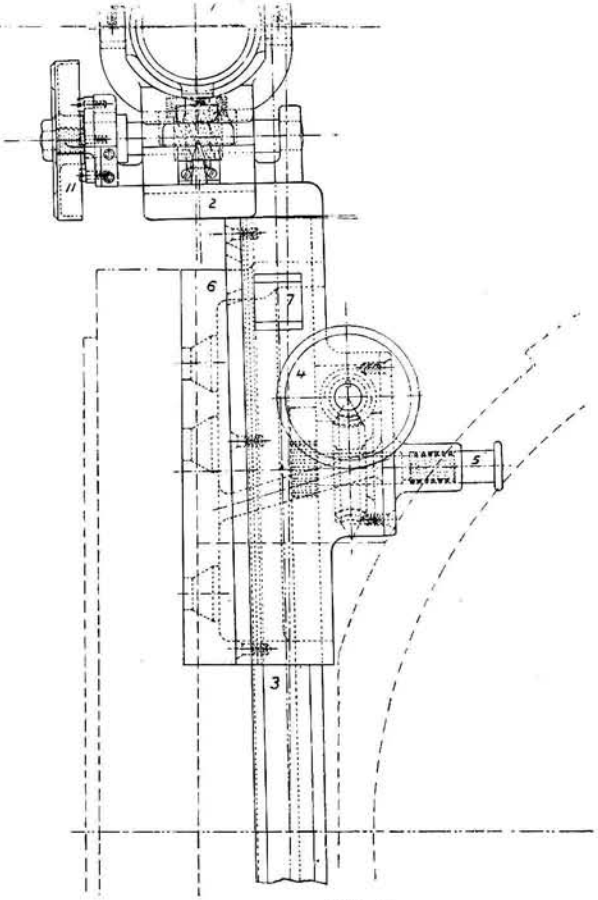


Fig. 2.

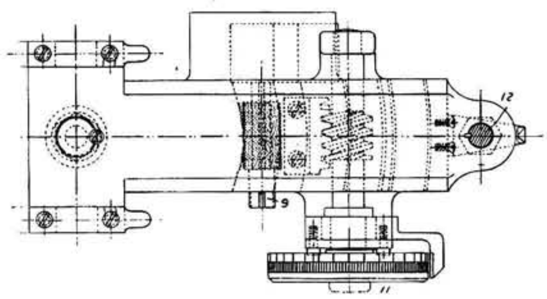


Fig. 3.

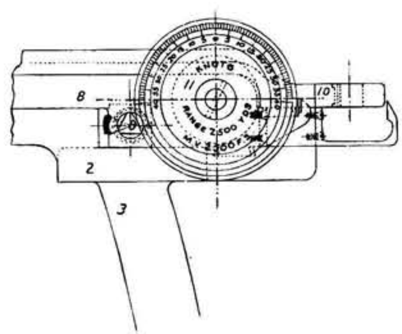


Fig. 4.

TELESCOPE SIGHT (NEW) FOR 5-INCH Q. F.

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° 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

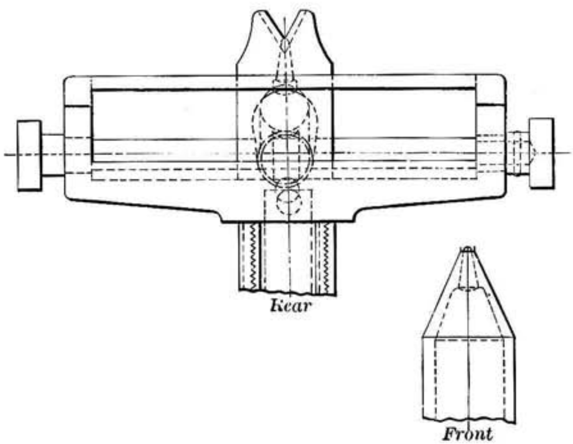


Fig. 5.

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,

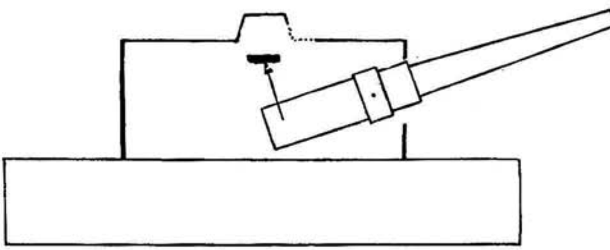


Fig. 6.

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.

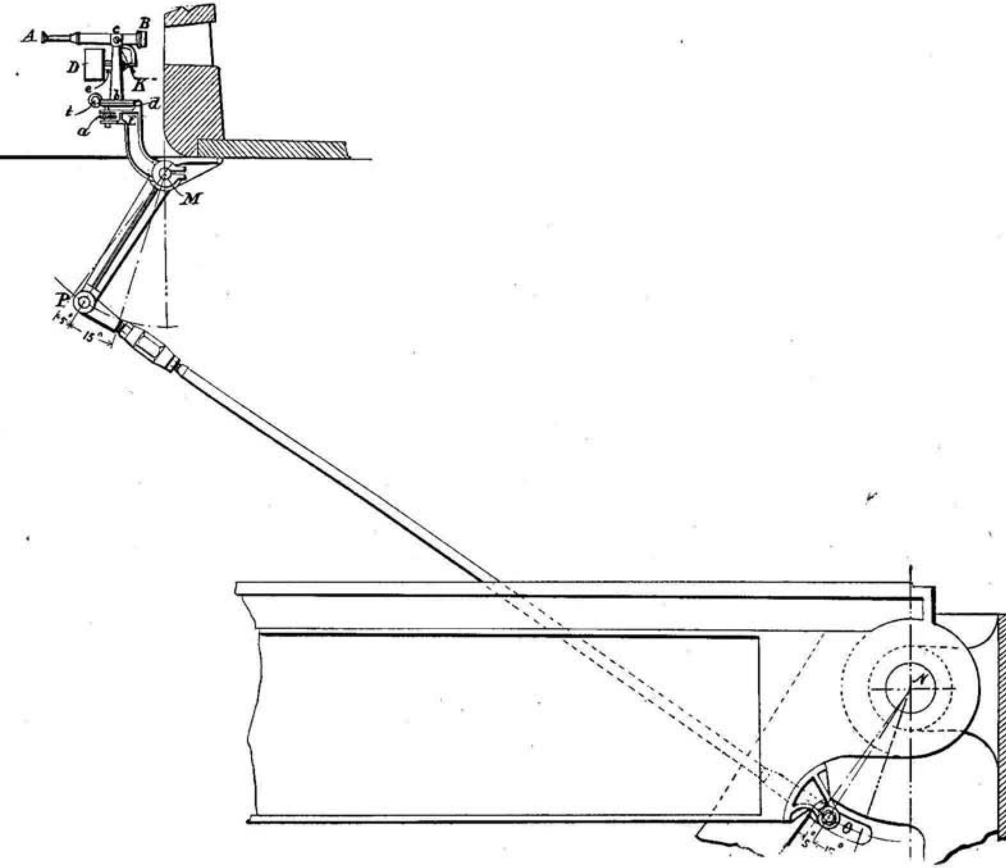
In the figure, (M) is a cross shaft whose axis of rotation is parallel to the axis of the trunnions (or pivot bolts) of the gun. Upon this shaft is keyed the arm $E\ M$ of the telescope standard $b\ c$, the latter terminating in a base b, hinged at d to the arm and capable of giving a slight permanent 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 *A B*.

Keyed to the cross shaft *M* is the arm *M P*, which is connected, by the connecting rod *P O*, to a point on the slide, at *O*. *N* is the pivot of the slide; the length of the arm *M P* = the distance *N O* and *P O* = *M N*; there is a turn buckle in *P O* to correct any lack of parallelism between *M P* and *N O*. 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 *M P* and to the telescope *A B*.

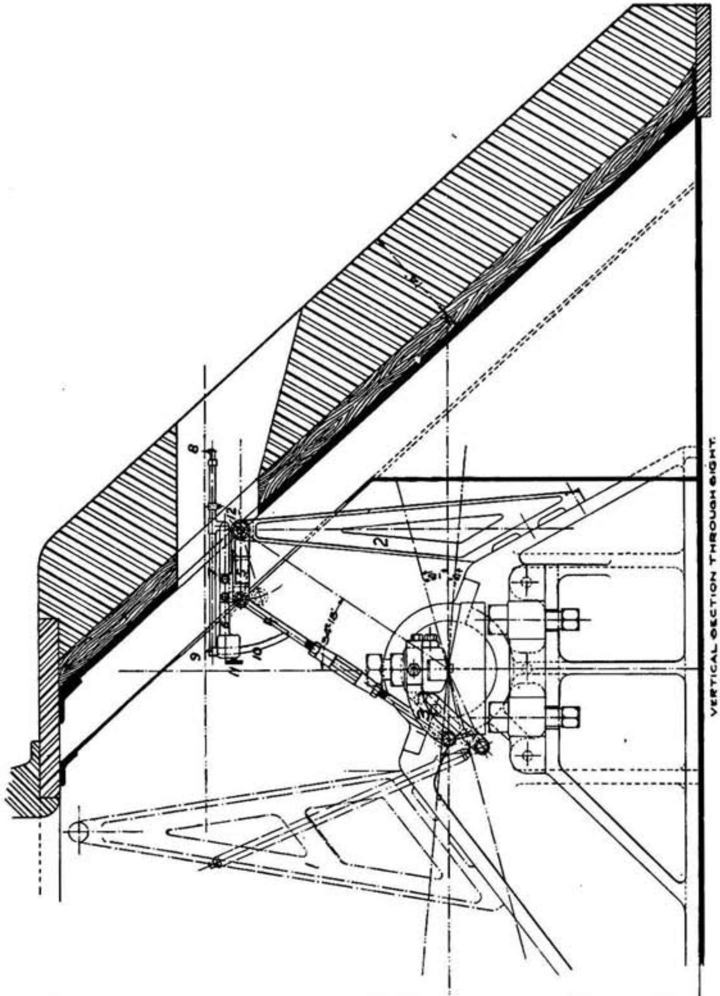
A drum *D*, graduated spirally for the range of the gun at different angles of elevation, is fitted to a three-threaded screw *e* which bears upon an arm *K* rigidly attached to the telescope, so that, by turning the drum to indicate any marked range, the telescope is depressed through the corresponding 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.

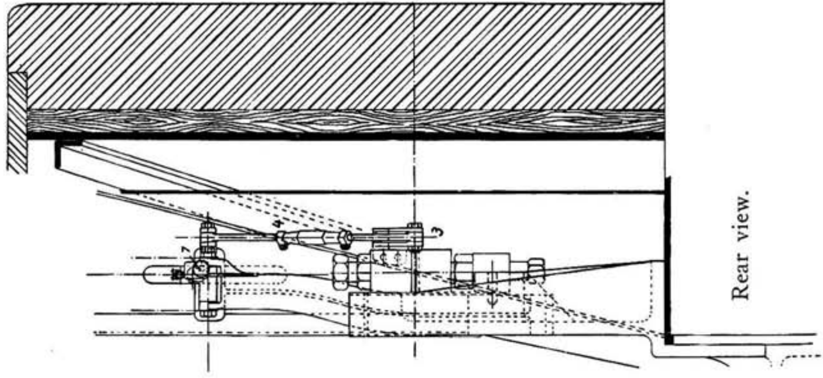
The above system of parallelism is employed for all sights that are used for pointing turret guns in elevation but the details differ somewhat; one change is to make all parts stronger and better able to withstand the severe shock of discharge. In one system, used in several turrets, the sight is not 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.



AUXILIARY AND NIGHT SIGHT FOR TURRET GUNS.



Rear view.

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.

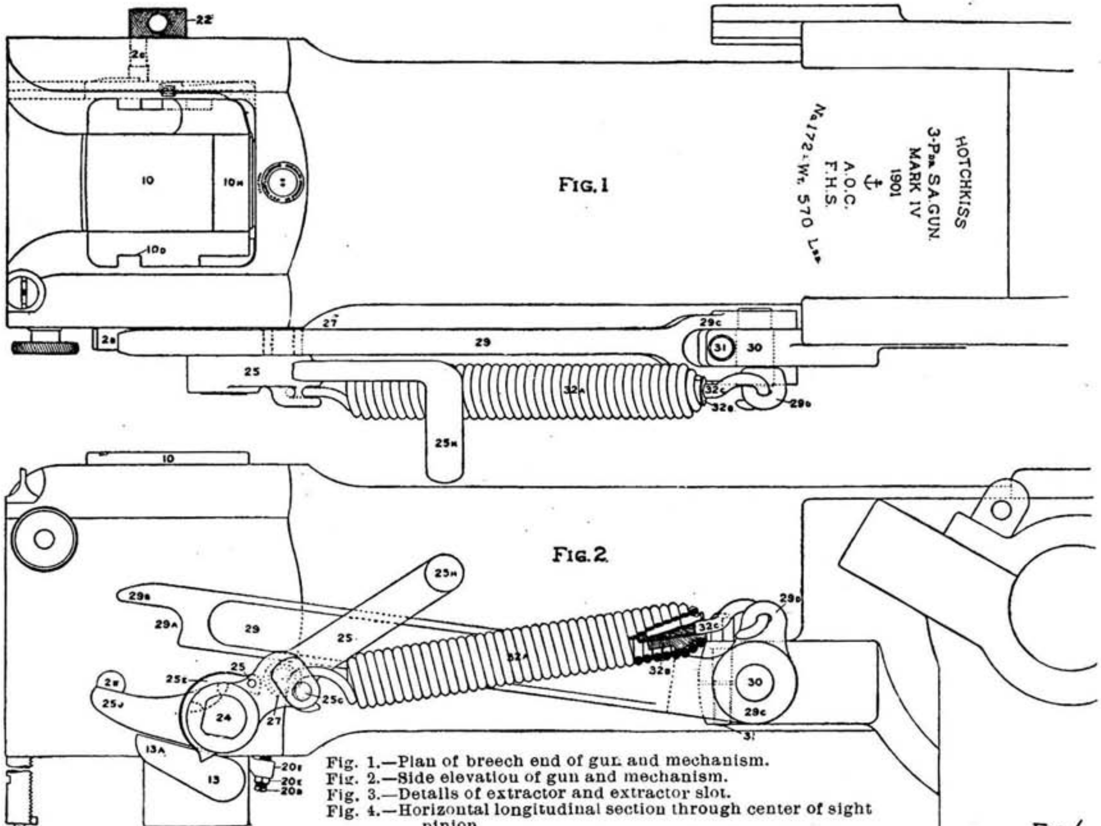
The Hotchkiss Semi-Automatic System.

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



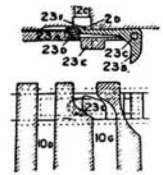


FIG. 3

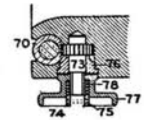


FIG. 4

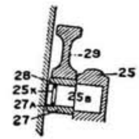


FIG. 5

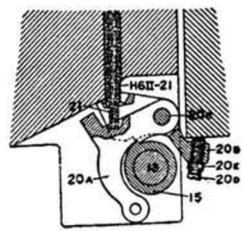
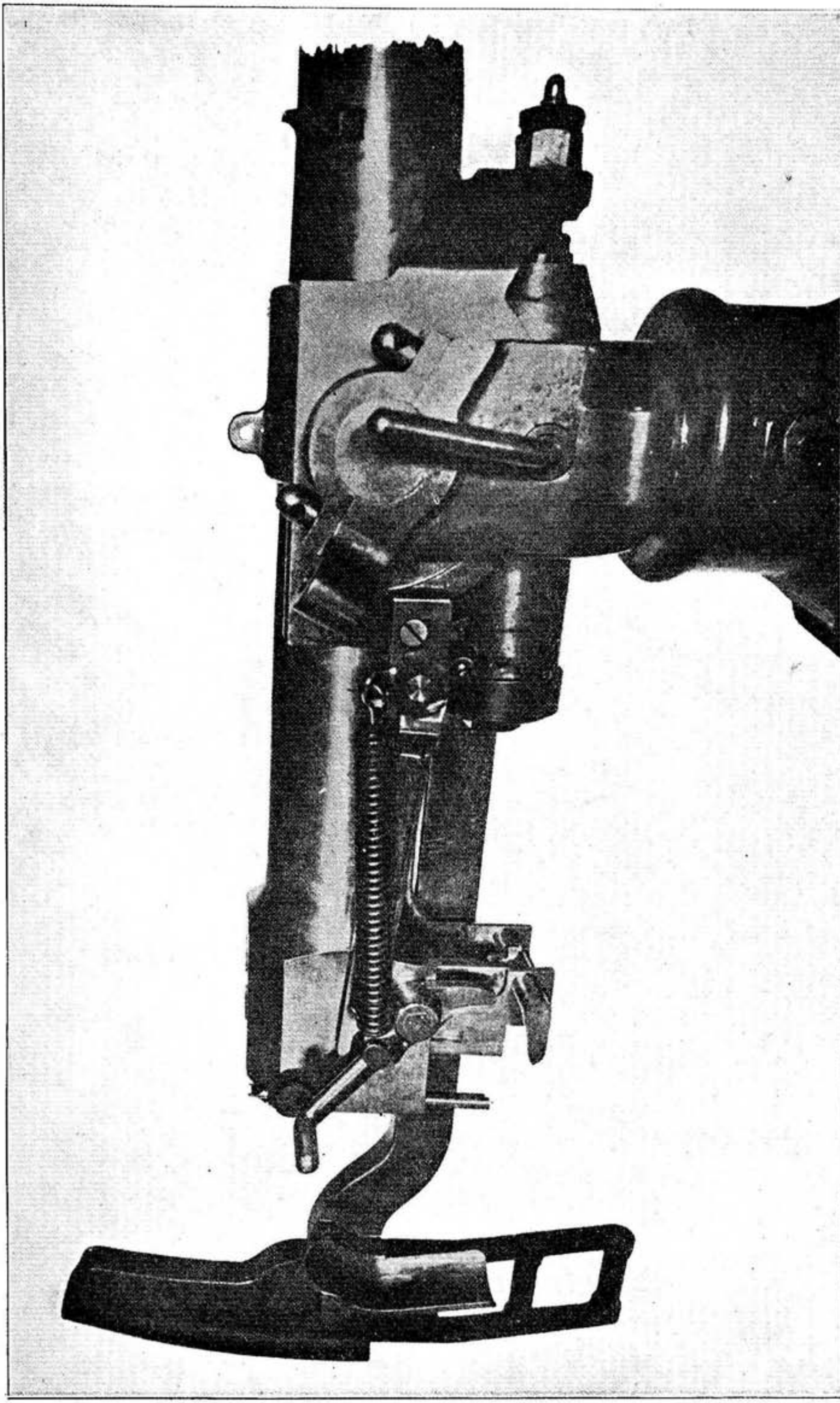


FIG. 6

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.

HOTCHKISS 3-PDR. SEMI-AUTOMATIC GUN.



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 from 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

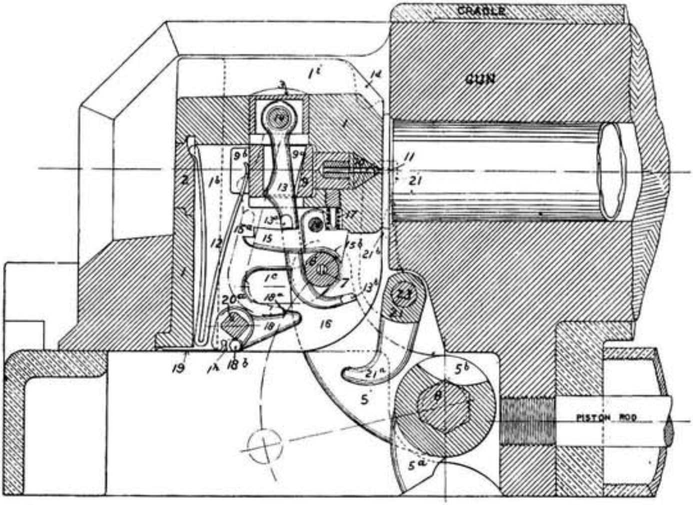


Fig. 1.

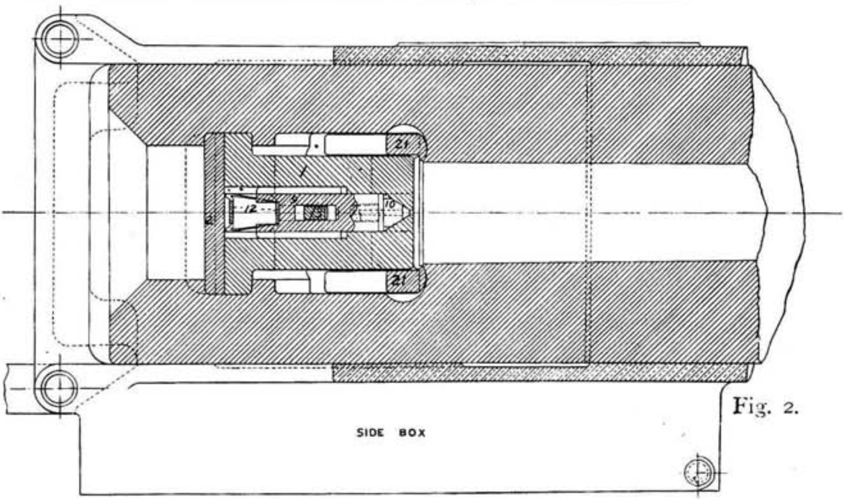


Fig. 2.

FIG. 1. VERTICAL LONGITUDINAL SECTION. BREECH CLOSED.
FIG. 2. HORIZONTAL SECTION THROUGH THE AXIS OF THE BORE.

MAXIM-NORDENFELDT S.-A. SYSTEM.

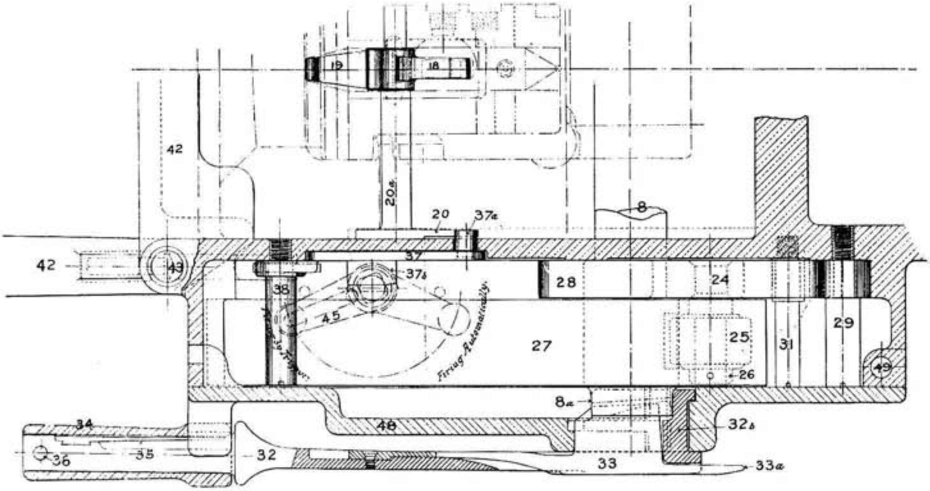


FIG. 1. HORIZONTAL SECTION ON A. B. OF SIDE BOX AND PROFILE OF BOTTOM OF BLOCK.

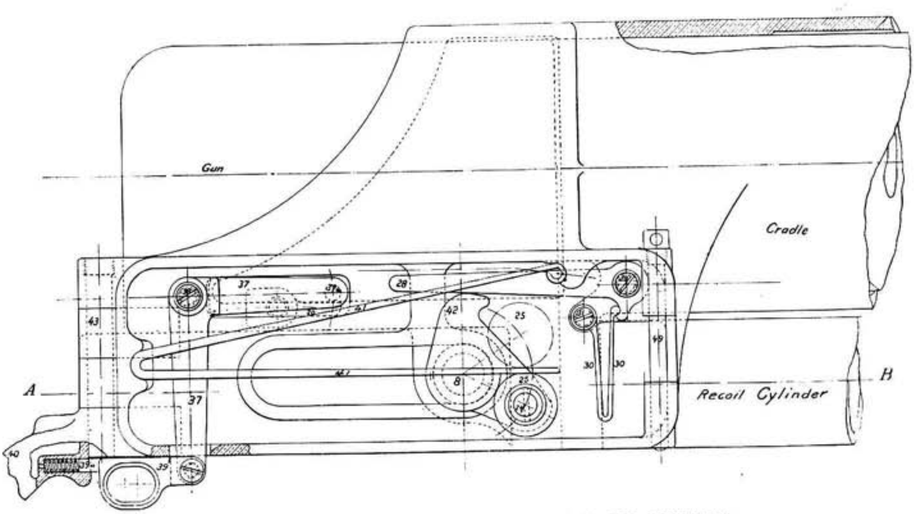


FIG. 2. VIEW OF SIDE BOX WITH COVERING PLATE REMOVED.

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 sufficiently, 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.)

CHAPTER XX.

AUTOMATIC AND MACHINE GUNS.

1. **An Automatic Gun** is one in which 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 supplied,—no manual effort, other than holding back the trigger, being necessary after the gun is once loaded and the first shot fired. Automatic guns are usually single barreled and provision is made against overheating in sustained firing. In the two systems employed in the U. S. Navy the ammunition is fed to the gun in belts. The automatic guns used by the Navy are:

(a) The *Maxim-Nordenfeldt* 37 mm., or 1-pounder, which is properly called an automatic *rapid-firing* gun. A description, with instructions on its care and manipulation, has been published by the Bureau of Ordnance.

(b) The *Colt,* of rifle calibre only. Those first constructed were of 6 mm. calibre; the later ones use the 30-calibre service rifle ammunition and the others are being converted to the same size, but will have a few minor differences in the working parts.

2. **A Machine Gun** is one in which the continuous operation of the mechanism by means of a crank or lever, worked by hand or by motive power, ejects the empty cases and loads and fires continuously as long as ammunition is supplied and the mechanism kept in operation. Thus in a machine gun, the energy which works the mechanism comes from an external source and in an automatic gun, part of the force of explosion of one cartridge loads and fires the next. A machine gun—the term is generally applied to guns of small-arm calibre only—has usually more than one barrel. Those in use in the U. S. Navy are:

(a) The *Hotchkiss revolving cannon* of 37, 47 and 53 mm. calibre. The gun has five barrels which revolve about a common axis and fire successively; few of these guns are now in use and none have been built for years.

(b) The *Gatling*, a ten-barreled gun, one of the first really successful machine guns invented, was formerly supplied as a 45-calibre gun; those now being furnished use the service rifle—calibre .30—ammunition.

3. **Machine Guns of Small Calibre** have been used with good effect in actions between ships and shore fortifications (war between Chili and Peru, and the British bombardment of Alexandria), by driving the crews of exposed guns to cover. Boarding, a prominent feature of actions held less than a century ago, is no longer thought of, and it is doubtful if ships in the future will ever approach each other, or shore batteries, sufficiently to permit the use of such guns—at least not until the latter stages of an action, when all exposed guns will have been destroyed. However, most ships carry a few automatic or machine guns, mounted in exposed places—often in the tops—which have large arcs of train. Considerable reliance is placed upon them, particularly on those firing explosive shell of 1-pound weight or upward, in repelling torpedo attack. Guns of these types are extremely valuable to small craft that closely approach the shore, or operate in rivers, in warfare with savage or semi-civilized peoples; rifle-calibred guns have been very effective in actions afloat and ashore in the Philippines.

The Colt Automatic Gun (Plate I).

(Fig. 1 is a plan, gas lever back; Fig. 2 is part in section and part in profile, gas lever closed; Fig. 3 gives a view of the working parts, the side plates having been removed, with the gas lever back.)

4. The Colt automatic gun is one in which the force required to perform the several motions of firing, extracting and loading is derived from the powder gases, a portion of those from each discharge passing through a small vent in the bore near the muzzle and actuating the mechanism of the gun through the medium of a lever or pendulum. Thus, a feed belt being entered in position, the gun loaded and the trigger pulled, the energy derived from the explosion of the first cartridge sets in motion the mechanism

which extracts and ejects the empty case, advances the feed belt one pocket, withdraws a cartridge from the belt, places it in the chamber, closes the bolt on it and fires it.

The gun consists of a single barrel (92) attached to a frame or receiver (88), the mechanism being contained in the latter and cased in by the side (89 and 90) and bottom (91) plates. The barrel is made much heavier than the barrel of the small arm, to reduce vibration, retard heating and expedite cooling; the greater mass of the barrel causes it to heat more slowly, while its greater surface facilitates radiation.

5. Fig. 2, Plate I, shows the gun closed and with empty chamber; in this state, the vent in the bore is closed by the piston (35), which fits into a recess in the gas cylinder (27); the latter embraces the barrel snugly, but is not secured to it by any fixed connection; the gas-cylinder pin (28) joins the gas cylinder and gas-cylinder bracket (33) while the front side-plate screw (55) passes through both and through both side plates.

The *piston* (35) is pivoted to the gas lever (29), by the gas lever piston pin (36), and has enough motion about this center to allow of its moving freely in and out of the recess in the gas cylinder, when the gas lever swings about its pivot at 34.

It should be noted that no parts are rigidly connected with the barrel except the receiver; consequently, when the barrel is heated by rapid firing, its expansion does not affect the relations of the other parts; it slides through the gas cylinder and bracket, which are made as light as possible so that they will expand more quickly than the barrel and allow the latter to move through them. The aperture in the gas cylinder is made of such a size and is so located with reference to the gas vent, that the latter is not masked by the expansion of the barrel. The gas cylinder and bracket, being tied together, expand in unison, while the somewhat loose expansion of the gas lever does not affect its action, as the freedom of the piston is sufficient to cause it always to enter the aperture in the cylinder.

The *gas lever* being pivoted as stated, and moving about the gas-lever bracket pin (34), is, when at rest, held as in the cut by the action of two springs (37 and 38), which are known as the retracting springs and are contained in the tubes (39 and 40).

These springs are kept in partial compression by the followers (41 and 42), and the pressure exerted by them is communicated through the retracting connection (45), the short links (49 and 50), and the long link (47), to the crank arm of the gas lever, thus keeping the latter firmly in the closed position.

If, now, the gas lever be moved about its pivot (34), its motion takes place in the vertical plane passing through the axis of the bore and the system of bell-crank lever, links, connecting rod and follower compresses the retracting springs. When the lever has been swung down until it strikes the forward end of the bottom plate (91), it can move no further, and, if released, will be thrown back to the closed position by the action of the springs as above described. The retracting-spring tubes are tenoned into the gas-lever bracket (33), as shown in the cut; their rear ends are free and open.

When the gas lever is swung down, the rod (31), called the gas-lever connection—being pivoted to the gas lever at the point 32 and to the slide (86) at the point 87—transmits the motion of the gas lever to the slide, which latter is constrained to move fore and aft in grooves in the interior walls of the receiver, and is further guided by the rectangular ends of the pin (87), which move in slots in the two side plates.

On the right side of the slide, near its forward end, are two projecting lugs, shown in dotted lines in the cut; as the slide moves to the rear, actuated by the connection (31), the forward one of these lugs strikes the free end of the feed lever (66) which pivots about its screw (67); a stud on the face of this lever, moving in a slot in the ratchet lever (71), causes the latter to swing about its screw (72); the free end of the ratchet lever rises and the pawl (73) is pressed in against the pawl spring (74), the face of the pawl being beveled so as to slide along the face of the feed wheel (61).

The front end of the latter consists of six radial teeth of peculiar form, and as the ratchet lever rises, the pawl, having reached the upper and flat side of a tooth, springs out and rests on the tooth. The slide now having reached its extreme rear position, on its return motion the rearmost of the two lugs strikes the feed lever and the ratchet lever is forced down, the projecting pawl engaging the tooth of the feed wheel and turning the latter to the right.

A spring dog (63), pivoting about a screw (64) in the bottom plate, is of such shape that it permits of the revolution of the feed wheel to the right, but prevents motion in the other direction. A device is provided for permitting the feed wheel to be turned backward when desired; it consists of a throw-off (68), (not well shown in the plate), operated by a knurled screw head (70) on the right side plate, just below the belt exit; if this screw head be pushed forward, the throw-off draws the dog out of engagement with the feed wheel, which can then be rotated backward, thus allowing of the removal of a partially empty belt.

The belt guide (59) prevents the "bunching" of the belt into the channel between the two sides of the slide. It is secured to the receiver by the screw (60) and by a tenon near its rear end.

The cartridge extractor (82) is pivoted to the slide at 83; the rearward motion of the slide causes this extractor to draw a cartridge from the feed belt and to deposit it on the carrier (21), which, at 22, is pivoted to the receiver. On the same pivot with the cartridge extractor is borne a cartridge guide (80), and when the slide is in its forward position this guide engages the cartridge, in connection with the cartridge extractor, and holds it in a central position.

The function of the *carrier* is to receive cartridges from the extractor, raise and present them in front of the breech bolt (13) for loading into the chamber. The slide in its rearward motion strikes the carrier dog (23), which pivots about its pin (24); the first effect is to compress the spring (25); when the slide has moved so far to the rear that the extractor (82) has withdrawn the cartridge entirely from the belt, the dog spring has been so far compressed that the slide passes over the dog, causing only a slight depression of the rear end of the carrier, and a corresponding elevation of the front or free end. When the cam surface of the slide lug (seen just below the number 14, Plate I) has passed over the carrier dog, the latter is freed and is sprung back to its normal position, that shown in the cut. The return motion of the slide now begins, the slide lug strikes the rear face of the dog and sharply raises the front end of the carrier, presenting the