20. The first point of superiority of the telescope as a sight is the fact that the eye is focused for only one distance, instead of successively accommodating for three, as with the open sight, or successively for two, as with the peep-sight; this is because the eye, when the adjustment of the telescope is correct and the target is at long range, sees, through the eye-piece equivalent, the intersection of the lines and the image of the target in one plane. Furthermore, under the above conditions the pencils of light that emerge from the eye-piece are parallel pencils, and the accommodation muscles of the normal eye are at rest when it is receiving such pencils. With the open sight and peep-sight, if the eye is moved off the line of sight, errors in pointing will occur; but with the telescope, motion of the eye either across or along the line of sight will not affect the accuracy of pointing, provided the telescope is properly adjusted and the target is at long range. For as long as the eye is in some position where it will receive a part of some pencil that emerges from the eye-piece after diverging from the intersection of the lines, it will see the intersection of the lines and some part of the field of view. There are limits along the axis of the eye-piece and across it within which the eye should be placed if it is desired to utilize the full field of view and receive the maximum amount of light from the target; however, the rubber buffer fitted on the eye end of the telescope makes it easy for the eye to place itself within the proper limits.

The next point of superiority of the telescope is its magnifying power; at modern battle ranges it is necessary to have an apparent enlargement of the target in order to point the gun with sufficient accuracy. Where F is the focal length of the objective equivalent, and f is the focal length of the eye-piece equivalent, the magnifying power of the instrument will be $M = \frac{F}{f}$ diameters. For instance, if F be 20 inches and f be $2\frac{1}{2}$ inches, the magnifying power will be 8 diameters. When using this telescope on a target distant 8000 yards, we can lay the gun with as much facility as we could lay it on the same target distant 1000 yards with a sight that has no magnifying power. But the in-

crease of magnifying power is attended with a corresponding decrease in the field of view; roughly, the field of view of any telescope will be 35° divided by the magnifying power. We are therefore restricted in the application of this point of advantage by the size of field of view which is large enough to permit the gun-pointer to "pick up" the target.

Another point of advantage in the telescope-sight is the fact that the size of the emergent pencils does not affect the accuracy as does enlargement of the hole in the peep-sight. When M is the magnifying power and A is the aperture of the telescope, the diameter of emergent pencils will be $\frac{A}{M}$; by making the proper relation between A and M we can utilize the full area of the dilated eye pupil at night; and so, instead of making it more difficult to pick up a target when looking through the sight than it is when looking with the naked eye, we can, with the new telescopes in service, pick up and lay on a target that is so dimly illuminated as to be invisible to the naked eye. But the proper relation between aperture and magnifying power is only one of several points in the design of our telescopes (some of which are confidential) that make them highly efficient night-sights.

21. Parallax will appear in a telescope-sight if the image of the target and intersection of cross-lines do not lie in the same plane. It is easily detected by laying the telescope on a fixed mark, keeping it in a fixed position and then moving the eye up and down or sideways across the eye-piece. If there is no apparent motion of the intersection relative to the image, they are both in the same plane; if the intersection appears to move over the image in an opposite direction to the motion of the eye, the image lies forward of the lines; if it appears to move over the image in the same direction as the motion of the eye, the image lies in rear of the lines. The second-mentioned condition would be due to incorrect adjustment of the telescope; the third condition would be due to incorrect adjustment if the mark selected for the test is more than a mile distant. When a telescope has an objective equivalent of a moderate focal length like that in our telescope-sights, and the telescope is in correct adjustment, the image of an object distant anywhere from infinity to a mile is not perceptibly in rear of the second focal plane of the objective equivalent—the position of the cross-lines. Actually, however, the image is in rear of this position a distance $Y = \frac{F^2}{X}$, where F is the focal length of the objective equivalent, and X is the distance of the object measured forward of the first principal focus of the objective equivalent. From this it is evident that, if our telescope is adjusted for long range, the image of a miniature target as close as the end of a Morris Tube boom (or in the corresponding position in a dotter), will be so far in rear of the cross-lines that it will give a very large amount of parallax. Formerly, to obviate this condition the telescope was re-focused (by increasing the distance between cross-lines and objective equivalent) to make the image of miniature target and cross-lines coincident; but this is bad practice for the reason that it involves a disturbance of the bore-sighting adjustment, which makes it necessary for the ship to go into still water, readjust the telescope for long range and bore-sight again before the gun can be fired. We now have an optical instrument called a *focusing-cap* which makes it possible to use the telescope on a near miniature target without disturbing its adjustment or the adjustment of the sight-mount for long-range firing; this is simply a positive lens combination of variable equivalent focal length, that is shipped on the objective end of the telescope, and adjusted so that its first principal focus lies in the plane of the miniature target. The divergent pencils from the miniature target are changed to parallel pencils upon emerging from the focusing-cap; they therefore enter the telescope in the same form as pencils from a distant target, and come to a focus in the second focal plane of the objective equivalent, which is the plane of the cross-lines.

22. Parallel-motion sight-mounts.—When the opening for the line of sight is in a hood on the roof of a turret, it is impracticable to attach the sight-mount directly to the slide; the pivot-bar is so far from the trunnions that elevation of the gun causes it to move to the rear and downward a considerable distance. This condition is illustrated by Figs. 14 and 15, which show,

respectively, the relative position of gun and line of sight when the gun is level and when it is elevated. In Fig. 15 it will be seen that the line of sight is below the opening in the hood, although the gun is not at extreme elevation.

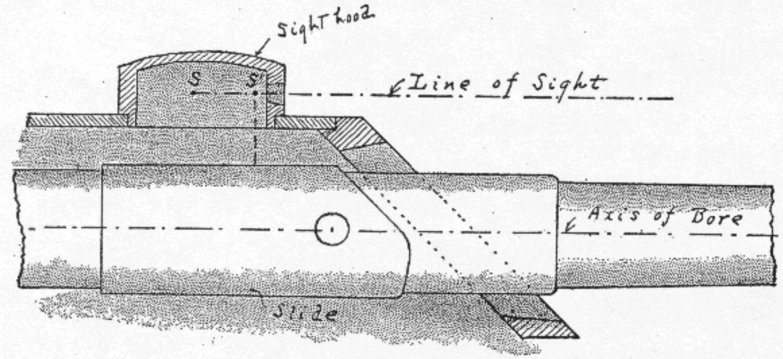

FIG. 14.

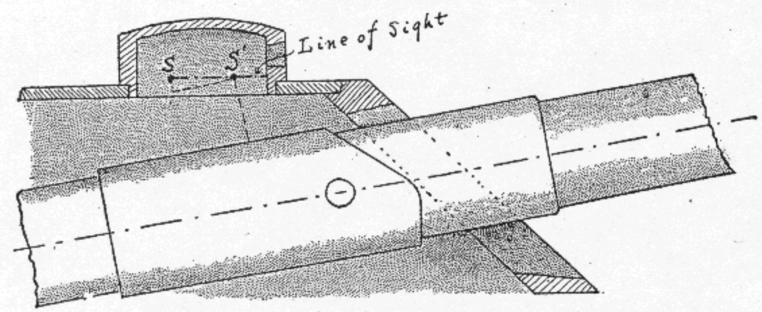

FIG. 15.

23. Roof sight-mounts are therefore indirectly attached to the slide by a parallel-motion mechanism; the pivot-bar with the fittings for its horizontal and vertical axes, the sight-bar, and sight-bar bracket are mounted on an arm, called the *connecting-arm,* that has a horizontal axis at its upper end in a fixed position with reference to the deck-lug, and is connected to the slide so that it will move in elevation with an angular motion exactly equal to the angular motion of the gun in elevation. One method of imparting this motion to the connecting-arm is shown in Fig. 16.

24. In Fig. 16 the connecting-arm pP has its fixed axis at P in the sight-bracket B, which is made up of two parts bolted to the deck-lug. At its rear end it engages the bar pt, called the *connecting-bar*, on the shaft-bolt p; this in turn is connected to the slide on the shaft-bolt t. In the parallelogram $PpTt$, the side $PT=$side pt, and side $pP=$side Tt; P and T are the fixed points of the parallel motion, T being the axis of trunnions of the gun. A *guide-block* b, which is a part of the connecting-arm, works in

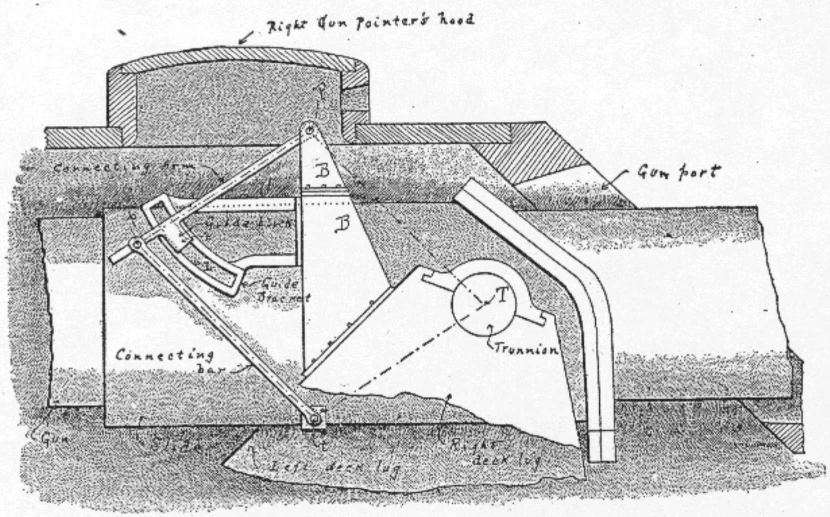

FIG. 16.

the circular slot L, in the *guide-bracket*, machined to arcs of circles centered in the axis P. The guide-bracket is bolted to the lower part of the sight-bracket; with the guide-block, it prevents lateral bending of the connecting-arm. The connecting-arm will work through angles exactly equal to angles described by the axis of the bore of the gun only when the following conditions are maintained:

(a) That the axes P, p, and t are installed exactly parallel to the axis of the trunnions.

(b) That the distance from the axis P to the axis p is exactly equal to the distance from the axis t to the axis of the trunnions T; also that the distance from the axis p to the axis t is exactly

equal to the distance from the axis P to the axis of the trunnions T.

Although the parallel motion may have been installed in conformity to the above conditions, it is evident that any bending or springing of the connecting-arm or the connecting-bar will distort the parallelogram and cause pointing-errors that may be either vertical or horizontal. A material looseness caused by

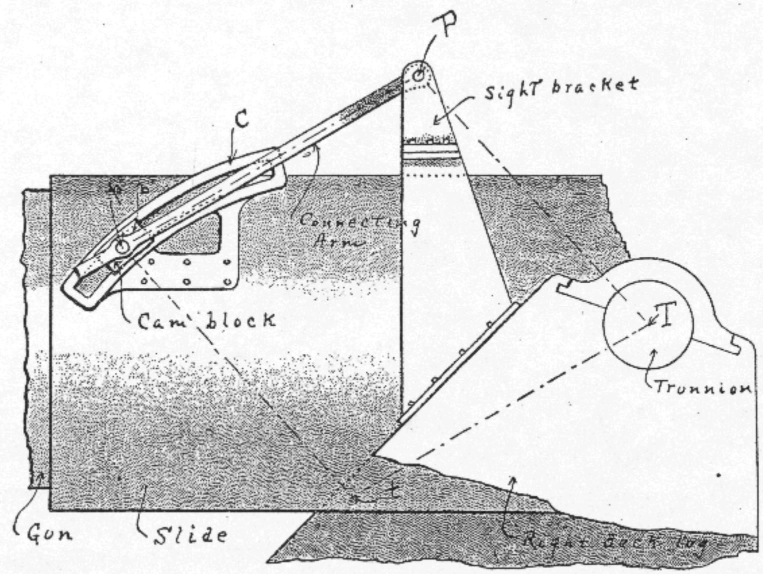

FIG. 17.

wear in the working-surfaces will result in vertical errors in pointing. Any change of the position of the trunnions with reference to the deck-lug will also distort the parallelogram. When the gun is being elevated, the slide tends to shift forward in the deck-lugs; so, if there is too much clearance in the trunnion seats, the axis of trunnions will shift forward far enough to make a material error in the parallelogram; upon depressing the gun, the shift is in the opposite direction. Naturally, any adjustment of the frictionless trunnions that is different from the adjustment at the time the parallel motion was installed will affect the parallelogram.

25. Another form of parallel motion is shown in Fig. 17. The connecting-bar *pt* and shaft-bolt *t* of Fig. 16 are replaced by the circular *cam C* that is bolted to the slide; the center of curvature of this cam is at a point *t* which is in a fixed position with reference to the slide and axis of trunnions, such that $tT=pP$

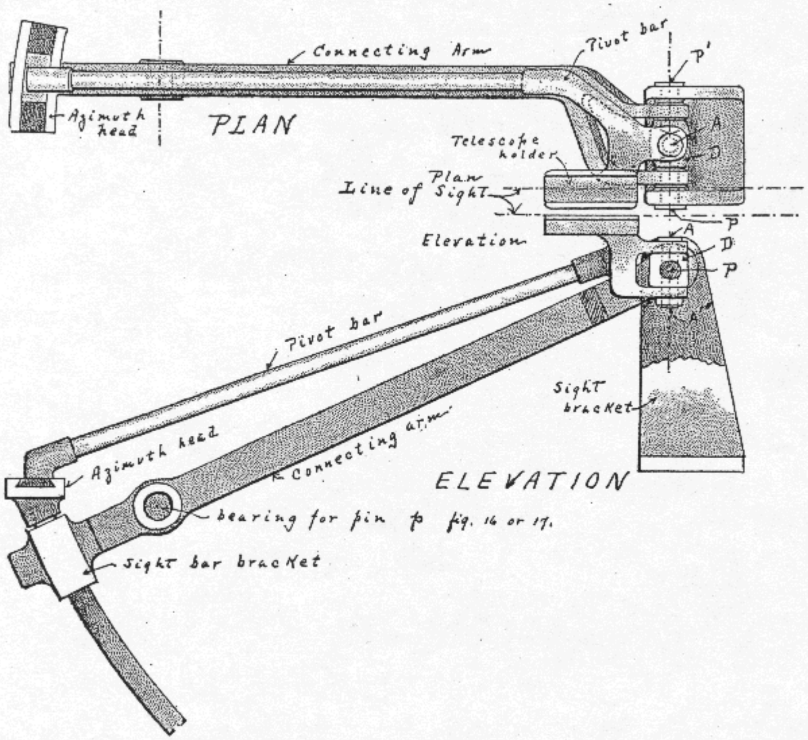

FIG. 18.

and $tp=TP$. The rear end of the connecting-arm contains a shaft-bolt *p* set up in the *cam-block b*. The flat face of the cam must be installed exactly in a plane perpendicular to the axis of trunnions; the parallelogram then is *PpTt*, as in the preceding figure. The advantages of this form of parallel motion are: no matter how long the connecting-arm may be, the cam prevents its rear end from being sprung laterally; and, as there are fewer working parts, there are fewer errors due to wear in bearing-surfaces.

26. A method of mounting the pivot-bar, sight-bar and sight-bar bracket on the connecting-arm is shown in Fig. 18. It will be seen that the horizontal sight-axis *PP'* is coincident with the upper axis of the connecting-arm. It is formed by the two trunnion-bolts *P* and *P'* tapped into the jaws of the bracket; these are the bearings for the jaws of the connecting-arm and for *D*, the *pivot-bar block,* into which is tapped the bolt *A* that forms the vertical sight-axis *AA'*. The sight-bar bracket is bolted to the connecting-arm at its rear end.

27. Tests of parallel-motion mechanism.—Two observers are required—one to look along the axis of bore, the other to look along the line of sight. First inspect for lost motion as follows: Direct the axis of bore to a distant mark by motion of the gun and direct the line of sight to the same mark by motion of the pivot-bar; move the gun to extreme elevation and then depress until the observer at the breech notes the axis of bore on the distant mark; then move the gun to extreme depression and elevate until the observer at the breech notes the axis of bore again on the mark; each time the observer at the breech is exactly on, the observer at the sight should also be exactly on. Lost motion may appear as follows: Both may be on when the axis of bore has been elevated to the mark, but the line of sight will point high after the gun has been depressed to the mark; or else both may be on when the axis of bore has been depressed to the mark, but the line of sight will point low after the gun has been elevated to the mark. The error may be due to any of the following conditions:

(a) Looseness in the bearings of the parallel motion.

(b) Bending of either the connecting-arm or connecting-bar caused by very tight bearings.

(c) Shifting backward and forward of the axis of trunnions caused by too great clearance in the trunnion-seats.

After the parallel motion has passed a thorough test for lost motion it should be tested for accuracy of the parallelogram as follows: Elevate the gun until the axis of bore is directed to the center of a heavenly body in the west, selecting a time that will give extreme elevation to the gun; simultaneously, by motion of the pivot-bar, bring the line of sight to the center of the same body. When the body is near the horizon, lay the axis of bore on its center; now if the line of sight is also on, we can be satisfied that the parallelogram is properly proportioned and that the upper axis of the connecting-arm is parallel to the axis of the trunnions. If the parallelogram is not properly proportioned, the

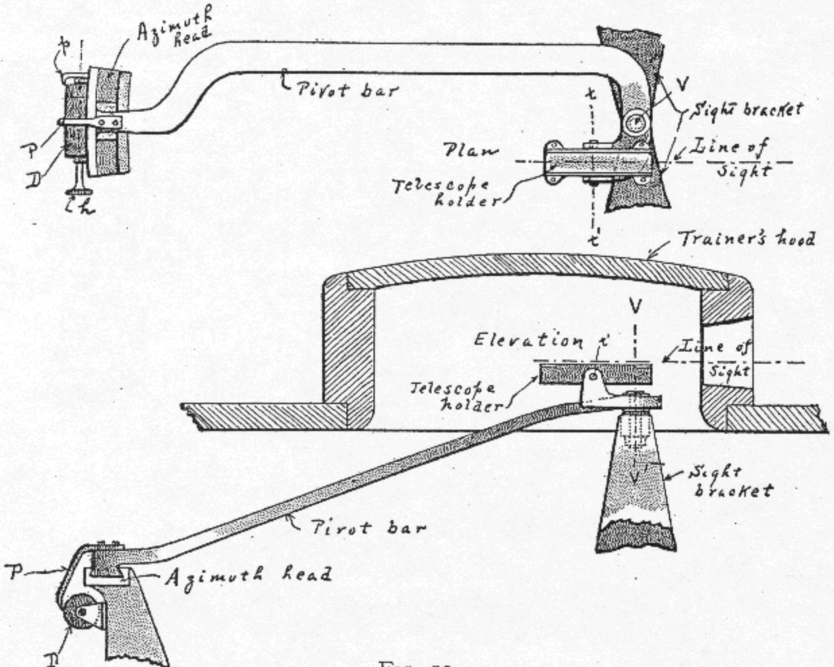

FIG. 19.

line of sight will be high or low when the axis of bore is on; if the upper axis of the connecting-arm is not parallel to the axis of the trunnions, the line of sight will point to the right or left when the axis of bore is on. It is obvious that before making this test, we should see that the frictionless trunnions are correctly adjusted to the positions they are to be in during firing.

28. Turret-trainer's sight-mount.—The trainer's sight-mount in turrets is usually placed between the two guns. It is not connected to either gun-slide but has two parts that are in a fixed position relative to the two pairs of deck-lugs. In Fig. 19 these fixed parts are the sight-bracket and the azimuth-head.

The pivot-bar is capable of motion in azimuth about the vertical sight-axis vv'. This axis must be installed exactly perpendicular to the plane of the roller path of the turret. The rear end of the pivot-bar travels in the circular slot in the azimuth-head and carries the pointer P for indicating the setting in azimuth. It will be seen that the pivot-bar has no vertical motion; therefore, in order that the trainer may keep the target within the field of view of his telescope while the ship is rolling, the telescope-holder has a

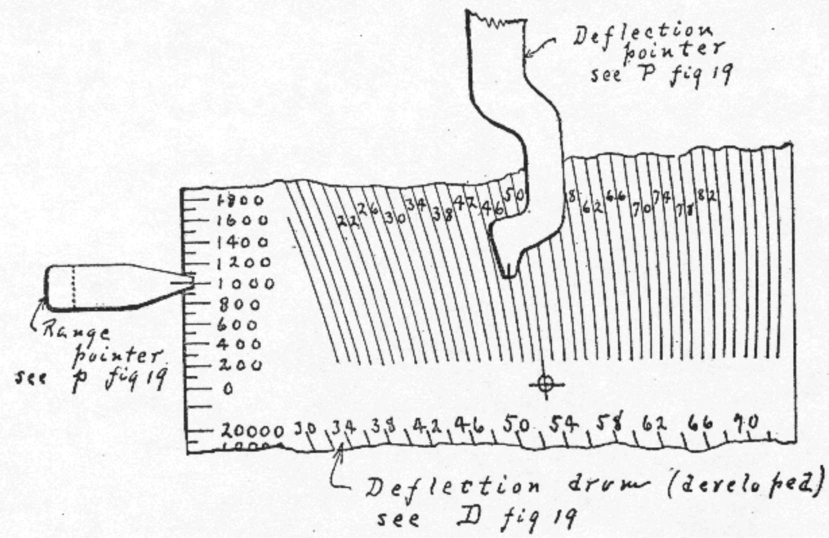

FIG. 20.

trunnion-mounting on the pivot-bar; the axis of these, tt', must be installed exactly at right angles with the vertical axis vv'. The azimuth-scale is engraved on the deflection-drum D, of which a development is shown in Fig. 20; the graduations on this drum are determined from the graduations on the azimuth-plate on the pointer's sight. In order that the azimuth changes of the trainer's line of sight shall equal the azimuth changes of either pointer's line of sight, the drum must be rotated by the handle h until the reading by the scale and small reference pointer p on the end is opposite the range-reading set on the pointer's sight; then, when the pivot-bar is moved to the left or right until the reference mark on the pointer *P* touches the speed-line that has the same number as the speed-line to which the pointer's sight is set, the azimuth change from the bore-sighting position will be the same in each sight.

29. Adjustment of trainer's sight.—Turret-guns are required to be installed so that the axes of the bores are parallel or converge slightly. In bore-sighting all three sights, if the firing is to be at longe range, the position of the trainer's line of sight should be midway between the pointer's lines of sight when all scales read zero; this of course puts both pointers a little bit off laterally when the trainer is on. At short-range firing, where this discrepancy will amount to a considerable portion of the area of the target, the trainer should lay his line of sight a certain amount to the right of the bull's-eye when the left gun is to fire, or a certain amount to the left when the right gun is to fire, the amount he is to aim off the bull's-eye being half the divergence between the two pointers' lines of sight.

30. Yoke sight-mounts.—The two lines of sight, one for the pointer and one for the trainer, with guns not mounted in turrets, are now carried on one sight-mount which is a modification of the type shown in Fig. 1. This modification, which is called the yoke-mount, is illustrated by Fig. 21.

Instead of a pivot-bar we have a *yoke Y* which amounts to a pivot-bar spread out wide enough to carry a telescope on each side of the gun; the rear end of the yoke works in the azimuth-head on the sight-bar in the same manner as the rear end of the pivot-bar in Fig. 1. The horizontal sight-axis is formed by a shaft *hh'*, called the *saddle pin*, in a casting *C* called the *saddle* and engaging a casting *R* called the *rocker;* the vertical sight-axis is formed by the pin *vv'* which centers the yoke in the rocker. The upper and lower side edges of the rocker, *a, b, c, d,* are machined to arcs of circles centered in *vv'* to a working-fit in the yoke; this gives stiffness at the positions *H* and *H'* where the castings called *telescope-holders* are connected to the yoke. The left-hand telescope-holder carries the pointer's telescope; in bore-sighting, this line of sight is adjusted to the axis of bore by motion of the yoke in the azimuth-head and by motion of the

sight-bar. The right-hand telescope-holder carries the trainer's telescope and is adjustable with reference to the yoke, so that this line of sight can be directed to the point of intersection of the axis of bore and the pointer's line of sight; the mechanism of this adjustment is not shown in the figure. The sight-bar, and sight-bar bracket, are the same in principle as those in Fig. 1.

31. Periscopic sights for broadside guns.—With the sight-mount shown in Fig. 21, the wide distance between the two lines of sight makes the opening in the gun-shield very large. Besides

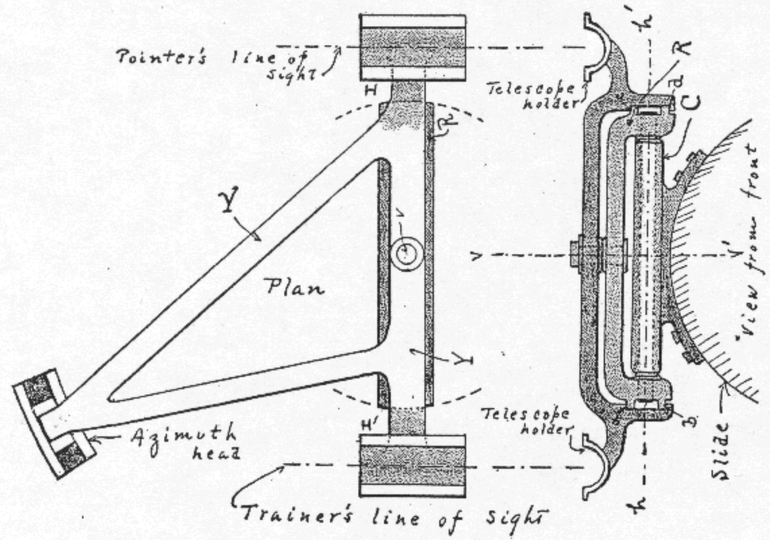

FIG. 21.

this, the effective arc of train of the gun is considerably less than the actual arc that the gun covers in moving from one edge of the port to the other; the pointer's line of sight will be masked when the gun is at extreme train left, and the trainer's line of sight will be masked when the gun is at extreme train right. These two faults are corrected by using prism telescopes in which the line of sight, in effect, is turned through two right angles, as shown in Fig. 22. The sight-mount for these telescopes is practically the same as the mount shown in Fig. 21; so it will be sufficient in Fig. 22 to show a portion of the yoke, with the telescope-