Oct. 24, 1950 L. MACKTA 2,526,677

SIGHT FOR MOVING TARGETS

Filed April 11, 1945 2 Sheets-Sheet 1

Fig. 1

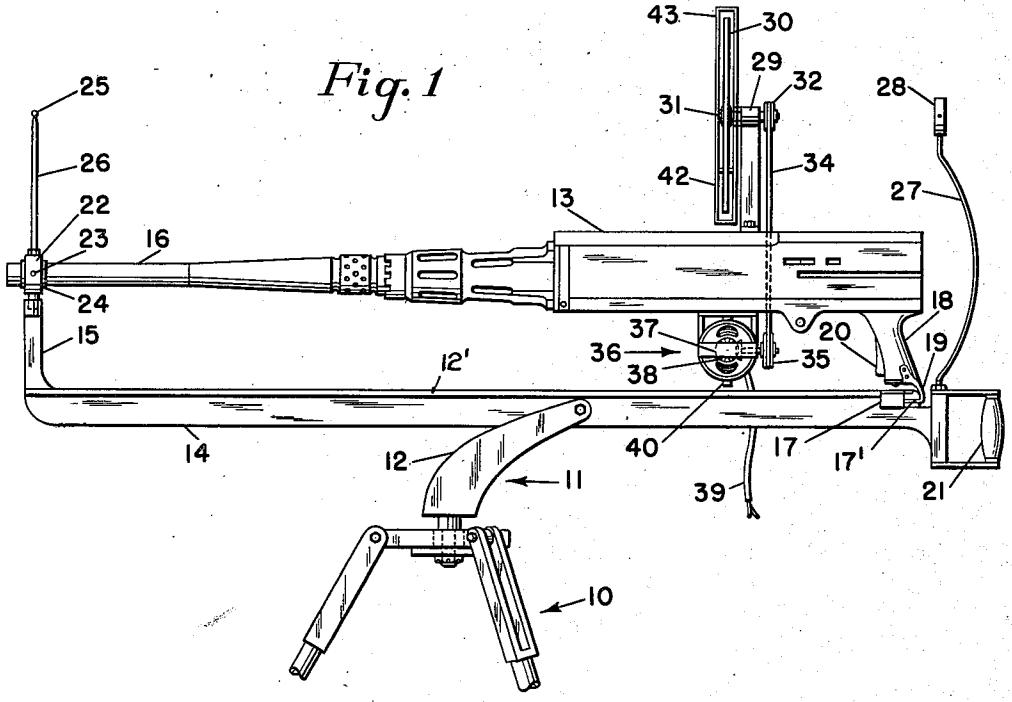

Fig. 2

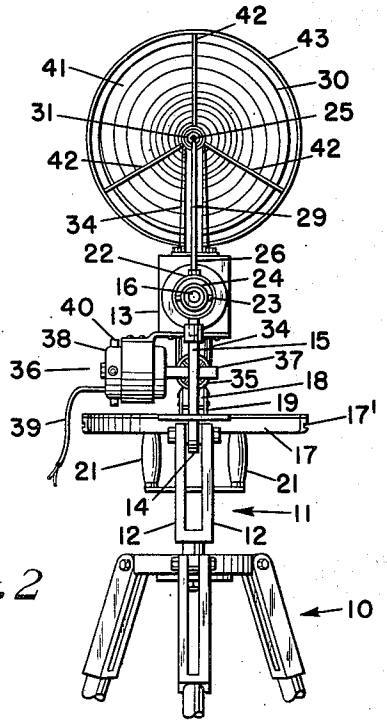

Fig. 6

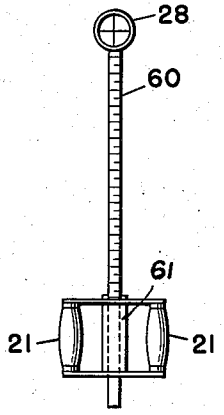

Fig. 7

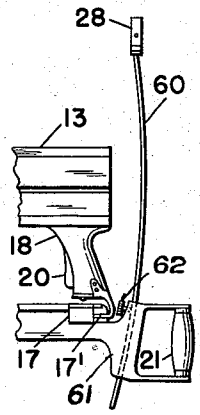

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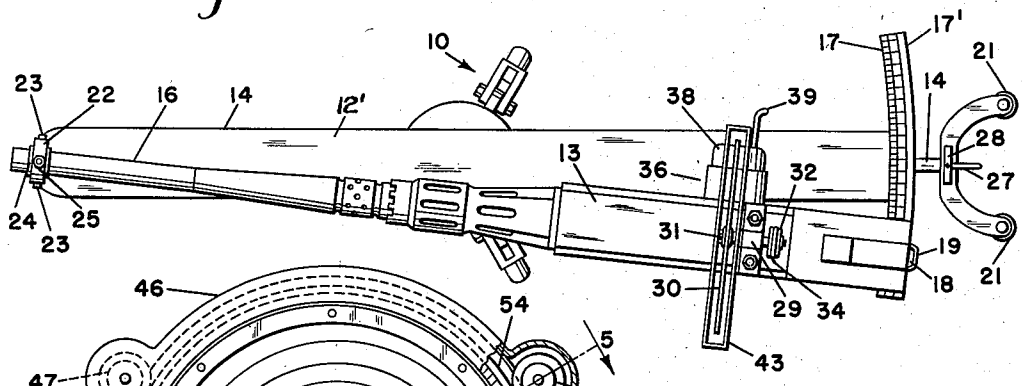
Fig. 3



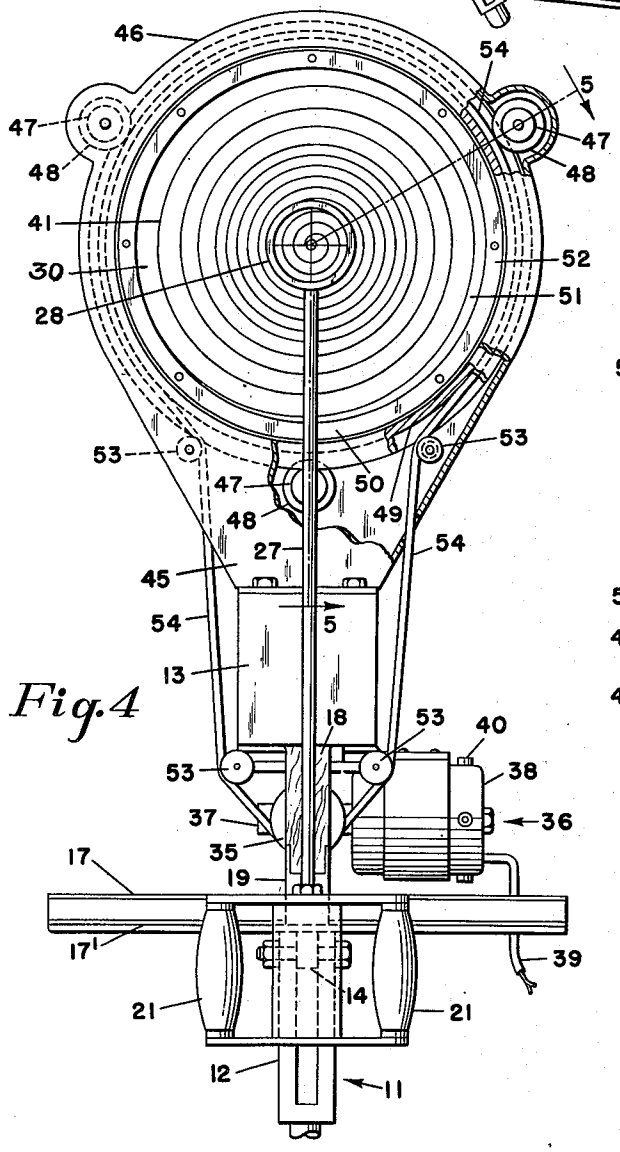


Fig. 4

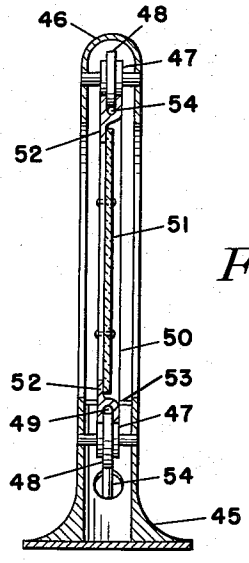


Fig. 5

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SIGHT FOR MOVING TARGETS

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7 Claims. (Cl. 33—49)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

The invention relates to a gun sight specially suitable for use on guns directed against rapidly moving targets at moderate ranges, as involved in battle with airplanes and land vehicles. The weapon usually involved is a machine gun, pivoted for direct manual transverse and elevation, known as a "flexible" gun.

In the situations which frequently develop in such actions, the necessary "lead" may ultimately be found by noting the courses of tracer bullets included in the ammunition at intervals, and swinging the gun accordingly. But ofttimes the variance between the gunner's estimate of the necessary lead and the actual requirement, together with progressively varying requirement due to target progress, results in considerable delay in getting the fire on the target; and, indeed, in many instances there is a complete failure to attain accurate fire before the target is beyond effective range. This is accompanied by great waste of ammunition, and even when the projectiles are gotten on the target, it is usually late in the period of encounter, so that effective placement is usually not accomplished. When the encounter actually occurs, the target is at close range and there are only four or five seconds within which the fire of a gun with the necessary quick traverse can be effective. Under these conditions, in prior practice when the personal factors, such as good judgment of distance, elevation, speed, and bullet times; determination of operation of the gun in traverse and elevation, operation of the trigger, psychological reactions and time factors of motor reflexes, have become manifest, there is often no possibility of accurate action of the weapon, and the fire is purely chance hit-or-miss with a general direction toward the target.

It is therefore an aim of this invention to remove from the gunner the need for basing the aim of the piece on observation of preliminary trial bursts to determine whether the necessary "lead" is included in the angular relation of the bore axis to the line of sight, so that an early placement of projectiles on the target may be effected within a short period of encounter, with correspondingly increased chances of placement in vital or crippling spots on the target.

It is a specific purpose to embody a sight device with included functions of such nature that, as to lead, the gunner only has to keep the view of

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the target within certain guide or sight elements throughout the encounter, and may devote his attention to placing his shots in particular parts of the target, rather than efforts to merely hit the target generally. An important purpose is attainment of correct lead during an increased portion of the total time of encounter which will increase the chance of effective hits.

A further aim of the invention is to enable the definite coordination of a sight element on a manually directed gun with a remote range finder controlling the function of the gun sight in a novel way.

The invention seeks also to present a novel structure in a sight for enabling the automatic assurance of correct lead if the gunner simply maintains the image of the target within simple stadia lines, which constantly move in accordance with the rate of movement of the target across the field of view in the sight device at the given range.

It is a special purpose to provide the gunner with a device coordinated with front and rear sights, which may be controlled from a range finder, a part of the device having an angular lateral movement at a rate according to the required deflection of the gun from the line of sight, coordinated with the range and speed of the target, so that the gunner need only deflect the gun until a laterally moving part in the sight remains in registry with the target in order to assure the proper lead, after which firing may be begun.

Additional objects, advantages and features of invention reside in the construction, arrangement and combination of parts involved in the embodiment of the invention, as will be apparent from the following description and accompanying drawings wherein:

Fig. 1 is a side elevation of a gun, mount, and sight system, constructed in accordance with my invention;

Fig. 2 is a front view thereof;

Fig. 3 is a top view showing the gun with the bore axis at an angle to the line of sight;

Fig. 4 is an elevation partly in section of a modified mounting;

Fig. 5 is a section on the line 5—5 of Fig. 4;

Fig. 6 is a rear elevation of an elevation tracking sight mounting;

Fig. 7 is a side elevation thereof.

There is illustrated a tripod mount element 10, which may conform to conventional practice for a gun of the caliber and weight selected for use with my invention, and on the tripod there is freely rotatable on a vertical axis a bracket 11

having upstanding arms 12 between which a cradle 12' is pivoted on a horizontal axis for elevational movement. The cradle carries a gun 13, which may be of any of several kinds suited to the use indicated, and is therefore only formally shown here, my invention being adaptable to use with the several kinds by suitable adaptation of the sight elements and supports. While I have shown the invention with a sight axis close above the gun, it will be clear that this is not essential and that the support elements by which the sight elements are mounted on the gun or cradle may be extended to permit the use of conventional magazines and shields.

The cradle includes a base bar 14, at the forward end of which an upstanding standard 15 is provided, on the upper end of which the barrel 16 of the gun is pivoted for transverse movement of the breech end on the cradle. The cradle is provided at its rear end with a horizontal sector guide rail 17 concentric with the standard 15. The gun is provided with a grip 18 on its underside, the lower end of which rests slidingly on the guide 17. The guide is grooved as at 17' on its rear edge and the grip has a retainer plate 19 fixed thereon, extending downwardly beside the guide and having an inturned flange engaged slidingly in the groove 17' to prevent the rear part of the gun from swinging loosely upward relatively to the cradle. A trigger 20 for the gun action, may be conventionally located and operative adjacent the forward side of the grip.

The cradle is provided with a cradle grip 21, fixed on the rear end of the bar 14 and projecting somewhat toward the left and rearwardly, although it may be otherwise positioned as the construction of the gun and developed firing practice may require.

The gun pivot on the cradle includes a ring 22 pivoted on the standard 15, through which the barrel extends, but is releasably secured therein by pins 23 inserted through the ring and into a collar 24 fixed permanently on the barrel. The ring has a front sight 25 comprising an upstanding tapered rod 26 set in the upper side of the ring, at the extremity of which a sight bead is fixed, constituting the front sight 25 proper in my invention.

At the rear end of the cradle a rear sight arm 27 is fixedly mounted on the rear end part of the bar, being bowed rearwardly to afford a clearance to permit a gunner at the rear of the gun to readily reach the gun grip 18 with one hand, and at the upper end of this arm a rear sight is mounted consisting of a ring sight 28 or other, suitable to the uses indicated. An example of alternative use not here illustrated, is the direct sight device such as one known as the "reflex sight," with or without the front bead 25, the "reflex sight" being of such function that the bead 25 may not be needed.

On the gun, spaced a suitable distance forwardly from the rear sight, there is mounted an upstanding bracket arm 29, on which there is revolubly mounted a stadia disc 30, which in the present instance is a simple planiform, transparent body arranged in a plane normal to the bore axis of the gun. It has a shaft 31 fixed at its center extending rearwardly and journaled at the upper end of the bracket 29. A grooved pulley 32 of as small a diameter as practicable for the use hereinafter indicated is fixed on the shaft and a flexible drive belt 34 or the like, is engaged over the pulley and extended downward to a drive pulley 35 mounted on a motor assembly

36 suitably mounted fixedly on the gun. A speed reduction element 37 is indicated as included between the motor 38 and pulley 35. Flexible electrical power and control lead-in cables 39 are indicated, leading to the motor and a motor speed control device 40, which is formally represented. It is contemplated that this control device will be remotely operated, or that the motor will be otherwise remotely controlled so that its speed will accord with a range finding made at the remote station of control and signal or control currents transmitted from the remote station; these details being well understood, forming no novel details in this invention, and therefore not illustrated.

On the disc 30 there is delineated, by marking or grooving, a volute figure, scroll or spiral 41 consisting of a continuous line beginning at or near the center of the disc and extending counterclockwise in circumvolutions of gradually increasing pitch or divergence from a concentric direction, throughout its length. Thus at the inner part, the successive convolutions are quite closely spaced, but toward the outer part of the disc the spaces between the mutually adjacent parts of the line are successively more widely spaced, until at the outermost part the convolutions are comparatively widely spaced.

When the gaze of a person is directed through the disc to a distant object, and fixed so, while the disc rotates, the spiral line on the disc will create the impression of outward or inward movement from or toward the axis of the disc according to the direction of rotation of the disc. This apparent movement may be only hazily seen, due to the observer's vision not being focused so near, but may be noted very definitely, nonetheless. It may be made more definite by including a number of radial stationary bars 42 on the bracket 29, and these may support a guard ring 43 to protect the disc 30.

It is the purpose to make this apparent lateral movement of the spiral coincide in angular rate with the angular rate of motion of a target transverse to the direction of gaze (taking the gun pivot as the center of these angular motions) when the movement of the spiral is noted through that concentric ring or zone on the disc which is located in the line of sight when the gun is moved azimuthally to the proper angle to the bore sight to give the necessary "lead" to a projectile fired during such coincidence.

With the gun stationary, this simulated lateral movement of the spiral may be in the same direction and at the same rate as those of a target viewed through the disc, and by having the pitch less than necessary inwardly of the desired zone on the disc and greater outwardly of such zone, there will be coincidence of the target movement and apparent radial movement of the scroll only when the target is seen through the limited zone where the scroll has the proper pitch. This zone may be so located or distant from the axis of the disc that at the instant of such sight coincidence, the axis of the gun will be at the proper angle to the line of sight, so that a projectile fired on the instant will reach the projected path of the target at the moment the target reaches the intersection. In effecting this function the spiral must be rotated at a rate proportionate to the known range and speed of the target and remote control means are provided to rotate the disc at speeds variable at will.

The scroll illustrated is simply suggestive and may require to be varied to fit a particular am-

munition and target, but there are certain constants affecting its form which are customarily used in computing trajectories, and by which a workable device may be embodied. Thus it is convenient to assume a target speed of 200 miles per hour as a minimum or average speed for computations to fix on a definite pitch, and a standard ammunition for antiaircraft combat involves a known muzzle speed of 2600 feet per second for the bullet, with a known deceleration and gravity drop. The latter and trajectory factor, "or harmonization," may be disregarded in the present case.

The variation in range distances for which any sight device can be effective is limited at a minimum short range, at which the decrease of range, and acceleration of relative angular rate of movement of the target, as well as changes of direction of the target, are so rapid and uncertain as to leave too little time for perception, mental reaction, and motor reflex action by the gunner. Consequently, at some point, he must abandon all attempt at use of a sight, however effective, and rely on direct observation of tracer paths and reckoned or instinctive aiming of the piece. It may be assumed for the purpose of explanation that something less than 600 feet is the minimum range to be included in my sight element, and that the speed of the bullet is as above stated.

Also, as effective antiaircraft fire with small machine guns cannot with present ammunition be effectively carried on at ranges much over 1500 yards due to deceleration of the bullet, it will be sufficient to design the device for ranges between 400 feet and about 1500 yards, or somewhat further.

On this basis, a minimum speed of rotation of the disc appropriate to the maximum range may be used, with means to increase the speed when targets at shorter ranges are fired on.

This speed may, for the purpose of exemplification be arbitrarily set as one turn per second.

This rate of rotation might be chosen for a maximum range of 1000 yards or more, but for convenience it may be assumed here that 500 yards shall be the maximum range at which an encounter will be undertaken.

On account of the highly effective flight or flat trajectory of the bullet in the ordinary ranges of battle with airplanes and tanks, there is not a change in the lead angle proportionate to comparatively wide differences in range, but there is a wide variance in the rate of movement of the target angularly, proportionate to the range. Thus the flight time of the bullet decreases so much as the range decreases, that the same or nearly the same angle of lead will be effective on the same moving target over a substantial variation in ranges, especially as experience has shown that more effective fire may be obtained by using a computing sight to simply obtain an early approximation of correct lead and thereafter to correct by observation of tracer paths.

A plane moving 200 M. P. H. at 600 feet distance moves over substantially the same angle in the time of flight of the bullet covering that distance, that the same plane would move at 400 feet distance in the shorter time of flight of the bullet over this shorter range (about 115 mils). And there is little difference in the angle of lead for such target when at a range of 500 yards.

At the 600 foot range, however, the plane moves at an angular rate of about 500 mils per second and at 400 feet moves over an angle of about 700

mils per second, and the traverse is then governed by keeping the target in the sight and manipulating the speed of the drive to the disc manually to maintain the lead at different rates, and in the same zone or area of the disc in each instance or in such other zone as required.

Thus if the disc is rotating two and one half times per second for a 600 foot range, it would be rotated three and one half turns per second for a 400 foot range. At a range of 600 feet the bullet flight would occupy 0.23 second, and a crossing target at the speed assumed would travel approximately 69 feet or over an angle of 115 mils. The target movement in one second would subtend an angle of approximately 500 mils. At 500 yards range the bullet flight time is known to be 0.6 second, the target moving in that time over a distance of 180 feet or an angle of 120 mils. The rate of movement of the target angularly would be 200 mils per second. Consequently for the latter case, assuming that the disc is to be rotated at a rate of 1 turn per second when the gun is moved in azimuth on the cradle to an angle of 120 mils with the vertical sight plane or azimuthal plane of the target, that portion or zone of the disc intersected by the line of sight at that position of the gun should have the spiral line thereon so inclined and curved eccentrically that the spacing between one and the next is 200 mils within the zone indicated, representing by rotation of the scroll the rate of angular change of position of the target at the range of 500 yards.

With such pitch in the particular part of the scroll at the line of sight, and rotating one turn per second, the intersection of the convolutions with a horizontal radius of the disc axis would move radially inward or outward (according to the direction of rotation) at the rate of 200 mils per second.

Toward the center of the disc from this zone the pitch of the spiral should be progressively less, and outwardly of the zone referred to the pitch should be increased progressively in a degree proportionate to some determined ratio between shorter range measurements and rates of rotation of the disc, and also proportionate to various target speeds at the one range. In consequence, coincidence between angular movement of the target and the apparent movement of the scroll convolutions will occur only in that zone of the disc which will define the proper angle of lead when intersected by the line of sight through the center of the rear sight ring **28** and across the bead **25**.

The ratio of change of pitch may be coordinated with movements of a target angularly when approaching on paths oblique to the line of sight, the inner part of decreased pitch serving to enable proper lead to be maintained when the path of the earget is at angles of less than 90 degrees to the line of sight. The outer part of the scroll having the greatest pitch will be useful for planes crossing at short distances or moving at greater rates of speed at greater ranges.

In Figs. 4 and 5 there is shown a mounting of the disc enabling sighting therethrough very close to its axis without obstruction by the mounting or driving pulley.

In this instance a low hollow pedestal or foot piece **45** is formed with a circular frame or ring **46** thereon having a generally U-shape in cross section. At intervals it is provided with idler rollers, two indicated at **47** in the upper part of

the ring and one centrally located at its lower part. These rollers have central ribs 48 which set in a deep circumscribing groove 49 of a mounting ring 50, supporting a disc 51 which is identical with the one 30, except that it does not have an axial mounting shaft, but is exposed to view throughout its area to the center. The disc is held by screws or other fastenings to an inwardly projected flange 52 of the ring 50. The pedestal 45 is hollow and has two idler pulleys 53 therein close to the ring 50 and the pedestal extends downward outwardly of these pulleys to respective openings in the base of the pedestal. An endless cord 54 is engaged around the ring 50 in the groove 49, passing inwardly around the idler pulleys 53, through the base of the pedestal and to the operating unit 36 before described.

That portion of the scroll line disc which at any moment is apparently moving radially at the same angular speed as the target may be considered as the stadia element for the current encounter and will be distinguished from the remainder of the scroll by its coincidence in rate of movement with the rate of movement of the image of the target, or apparent static relation to objects on the landscape.

In the use of this invention embodied as described, upon selecting a target for encounter, the gunner sets the gun at a zero traverse position, parallel with the bar 14, and centers the target in the sights by rotating the cradle in azimuth and elevation so that the line of sight passes through the centers of the ring sight 28, center of disc 30 and bead 25. Then, upon receipt of a signal that the director or other control has made range contact—that is, that a range and target lead equivalent in rate of rotation of the disc 30 has been established, the cradle is kept stationary on the bracket 11 while the gun is traversed, until the angular change of position of the target appears to be the same as the corresponding rate of apparent radial movement of the scroll. In other words, the target appears to remain for a moment in a stationary relation to one or more of the convolutions of the spiral line. Immediately then the gun is held stationary on the guide rail 17 while the cradle is moved in traverse so as to maintain the target in this relation to the scroll line, while the trigger of the gun is operated. Thereafter, pointing may be entirely or in part governed by observation of tracer paths, or further pointing may be continued with entire dependence on the scroll sight.

It may be appreciated that if traverse of the cradle is not started soon enough the target will move out of the zone of the disc 30 where the described apparent coincidence of angular rate of the scroll and target exist and the scroll will then appear to have a faster or slower angular rate than the target, according to the direction of the latter. Correction can then be accomplished by moving the cradle faster or slower than required to stop the target relatively in the zone of the disc where it was located on beginning the cradle movement, and the target will thereby be soon brought into agreement with the scroll rate in the proper zone. Corrections may also be made from time to time by swinging the cradle and gun as a unit so that the motion of the target is toward the annular medial zone of the disc (between center and primer) and then beginning tracking again as soon as fixed registry of the target and scroll line is again secured.

If desired a grip-released latch or other means, not illustrated, may be used to hold the grip 18 or plate 19 to the sector 17 releasable by gripping the grip 18 in the hand preparation to adjusting the gun in azimuth on the cradle.

For convenience in illustrating the principle of the invention, it is shown in Figs. 1 to 5 applied to azimuth tracking only which would be useful for instance against tanks on level terrain, or against naval craft from a land emplacement. Elevation functioning of the invention may be effected by adding the necessary structure to enable corresponding vertical adjustment of the sight 28 around the axis 23.

In Figs. 6 and 7, there is indicated a simplified means to import automatic elevation corrections, consisting in mounting the rear ring sight 28 on a curved bar 60 (corresponding to the arm 27) which is concentric with the pins 23, adjustable in a guide 61 on the frame of the grips 21.

This guide has a slot similarly curved with the same center, receiving the lower end of the bar 60 slidably, and by means of an adjusting knob 62 and the bar 60 may be adjusted vertically in the same manner as the azimuth adjustment is secured. Thus far an approaching target, after the equivalent of range has been established in the rate of rotation of the disc, the bar 60 is raised, while the cradle is elevated so that a line of sight is maintained on the target and the vertical apparent movement of the scroll lines finally coincides with the vertical angular movement of the target. The bar 60 is then secured and tracking proceeded with as before explained. Components of both azimuth and elevation may be obtained by utilizing the two adjustments appropriately.

I claim:

1. In a gun sighting system, a frame mounted for movement in traverse, sighting means carried by said frame to determine a line of sight to a target, a gun carried by said frame for angular movement over a limited range with respect to said frame, first means movable with said gun and defining a spiral rotatable about its origin in a plane normal to the bore of said gun, said line of sight intersecting said spiral for all angular positions of said gun and frame, and means operable to rotate said first means.

2. In combination, a azimuthally pivoted gun mount structure, a front sight thereon, a rear sight thereon, a gun azimuthally pivoted on the mount structure, a stadia sight element thereon comprising a planiform transparent disc mounted on the gun for rotation on the symmetrical axis of the disc, in a plane normal to the bore axis and spaced from the said pivot of the gun, said disc having a scroll figure formed thereon symmetrically with respect to said axis, and extending laterally to include the line of sight of the front and rear sights under lead movement of the gun on said mount, and means to rotate the disc at a predetermined speed variable at will.

3. The structure of claim 2 in which said scroll figure has convolutions progressively increased in pitch from its inner part to its outer part.

4. In a sighting system for a gun, a frame mounted for movement in elevation about a first axis, means mounting said gun on said frame for angular move in train relatively thereto about a second axis substantially perpendicular to said first axis, spaced sights carried by said frame and

defining a line of sight parallel to the bore of said gun in one position of the latter on said frame, means defining a rotatable spiral movable as a unit with said gun and interposed across said line of sight for all angular positions of said gun relatively to said frame, and variable speed means connected to effect rotation of said spiral-defining means.

5. In a lead-determining system for a gun, a transparent plate having a spiral comprising a plurality of convolutions delineated thereon, means adapted to mount said plate on said gun to lie in a plane normal to the bore axis of said gun and for rotation about an axis parallel to said bore axis, and variable speed driving means for continuously rotating said plate about its said axis at a speed variable in accordance with the range and speed of a target.

6. In a lead-determining device for a gun, a transparent disc having a spiral delineated thereon of increasing pitch from the origin outwardly, means adapted to mount said disc on a gun for rotation about an axis through the origin of said spiral, normal to said disc and parallel to the bore axis of said gun, variable speed means connected to rotate said disc, a frame, sighting means carried by said frame and determining a line of sight fixed relatively thereto, and means adapted to pivotally mount said gun on said frame at a point spaced along the bore thereof from said disc.

7. In a lead-determining sight for a gun, a frame adapted to be mounted upon said gun and including a ring adapted to lie in a plane normal to the bore axis of said gun, a transparent disc, rollers journaled at spaced points about the periphery of said ring and engaging the periphery of said disc to rotatably mount the same in the plane of said ring, said disc having a spiral delineated thereon with its origin coincident with the axis of rotation of said disc, variable speed power means, and a connection between said power means and said disc to rotate the disc at a desired speed.

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