Oct. 9, 1951 P. R. WHEELER 2,570,298

GYROSCOPICALLY CONTROLLED ELECTRICAL GUN SIGHT

Filed Dec. 19, 1945 4 Sheets-Sheet 1

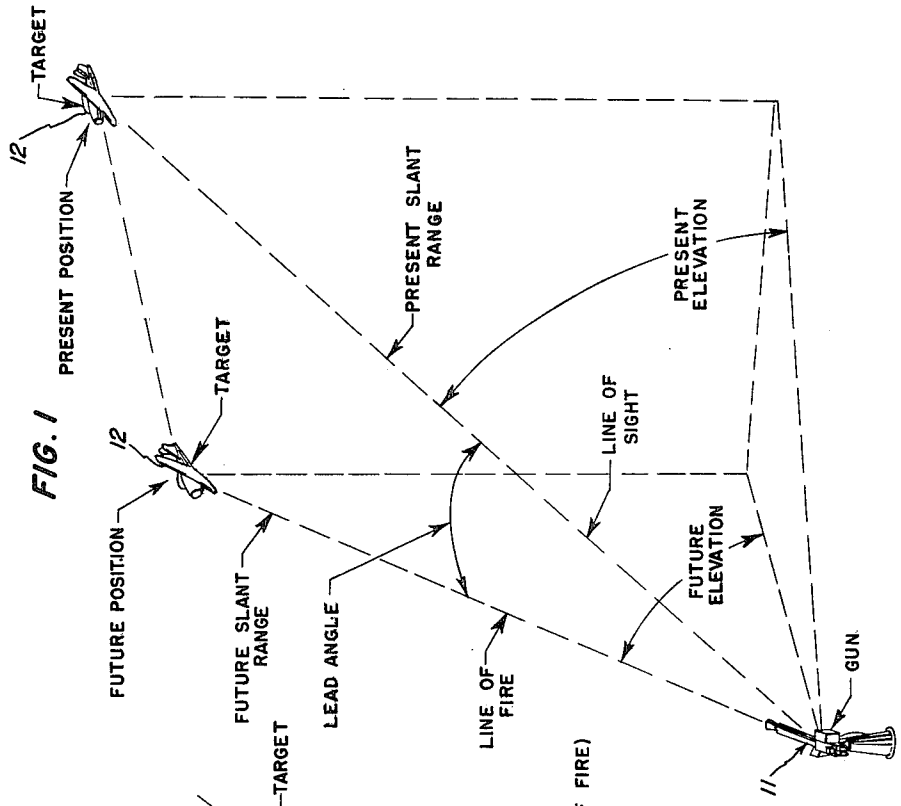


FIG. 1

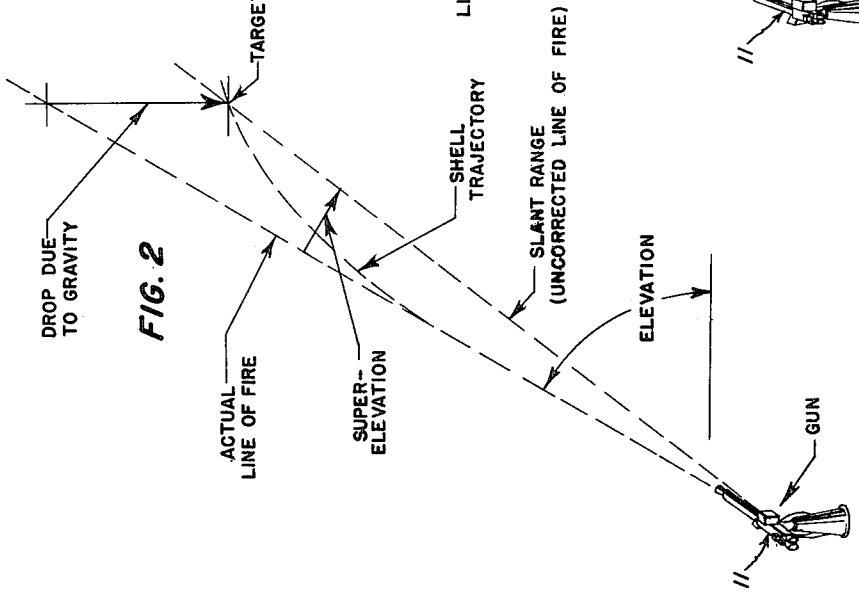


FIG. 2

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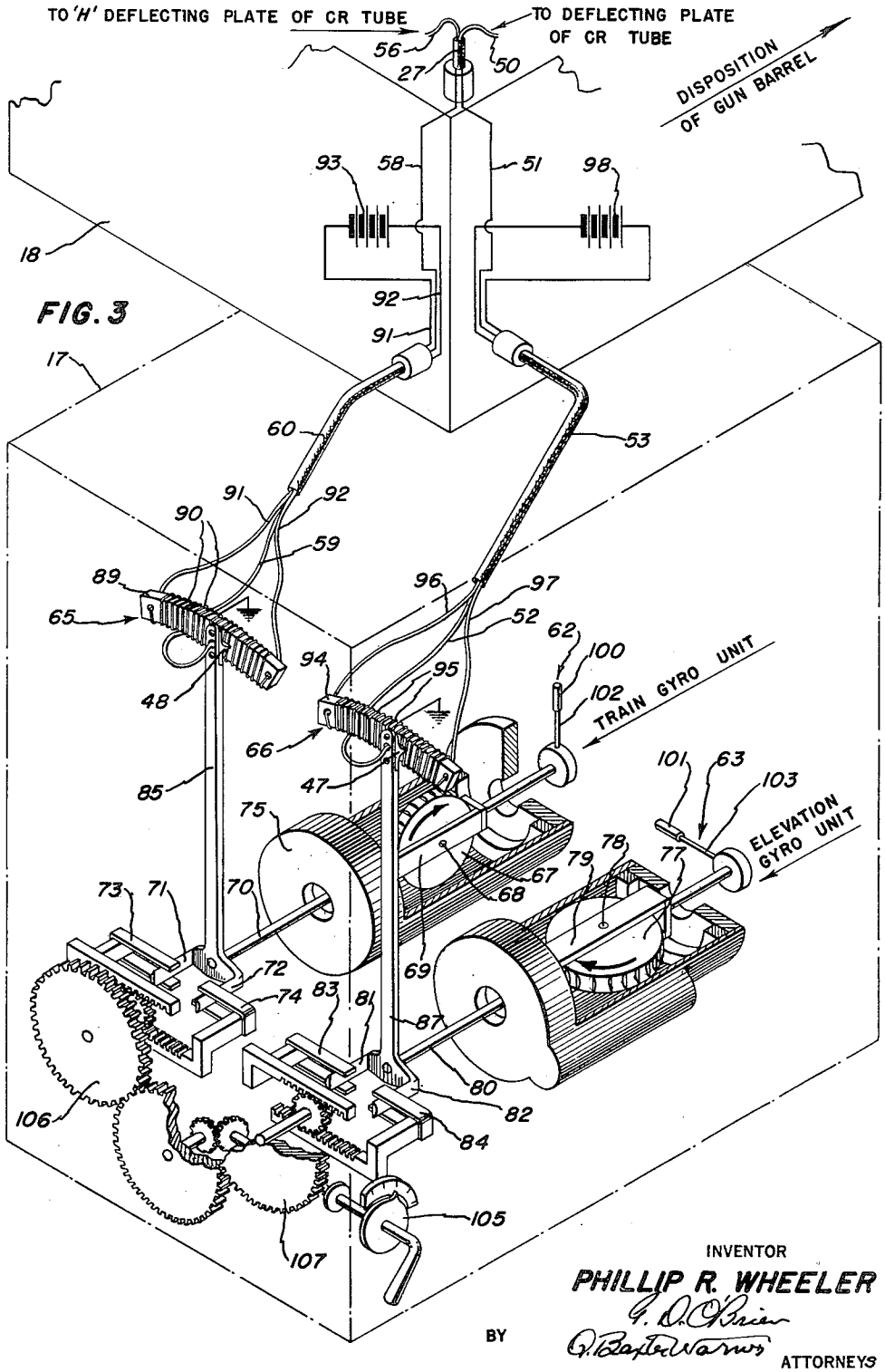


FIG. 3

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GYROSCOPICALLY CONTROLLED ELECTRICAL GUN SIGHT

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FIG. 5

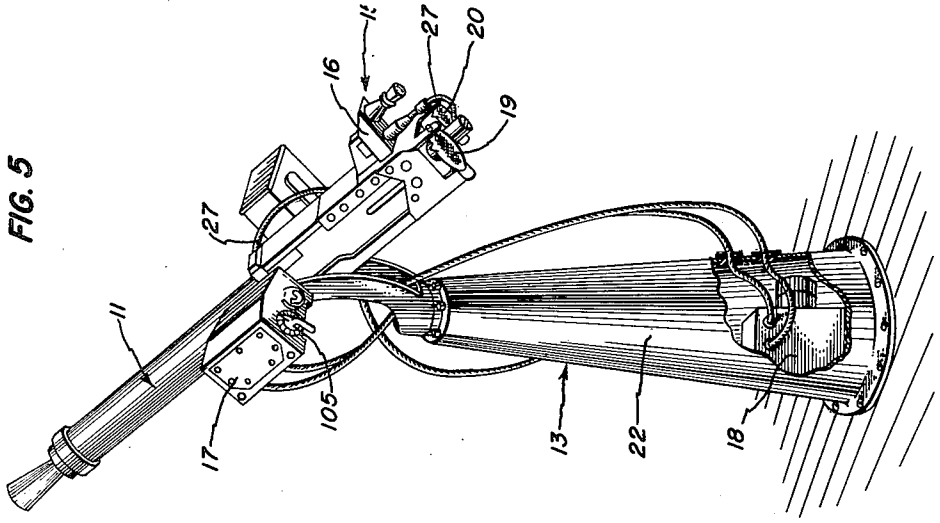
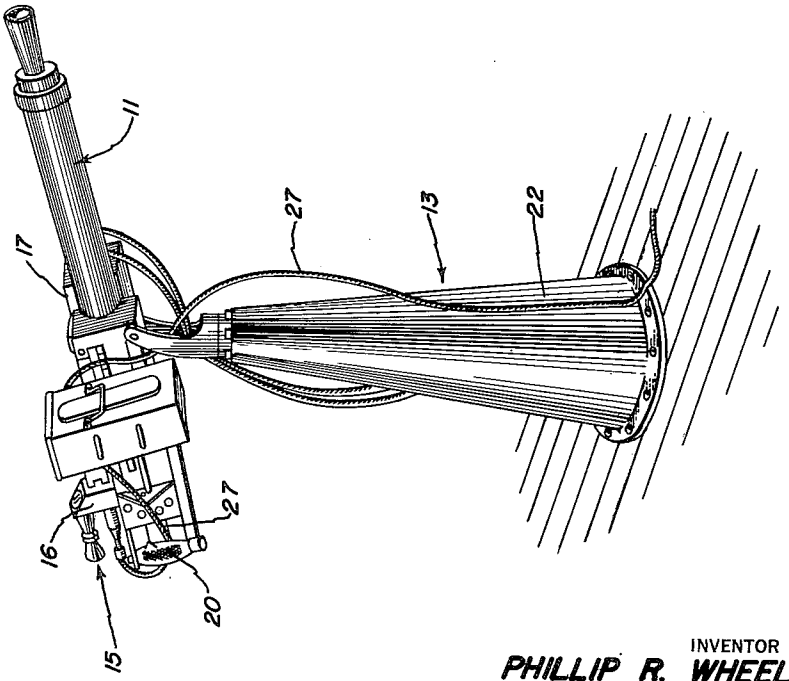


FIG. 4



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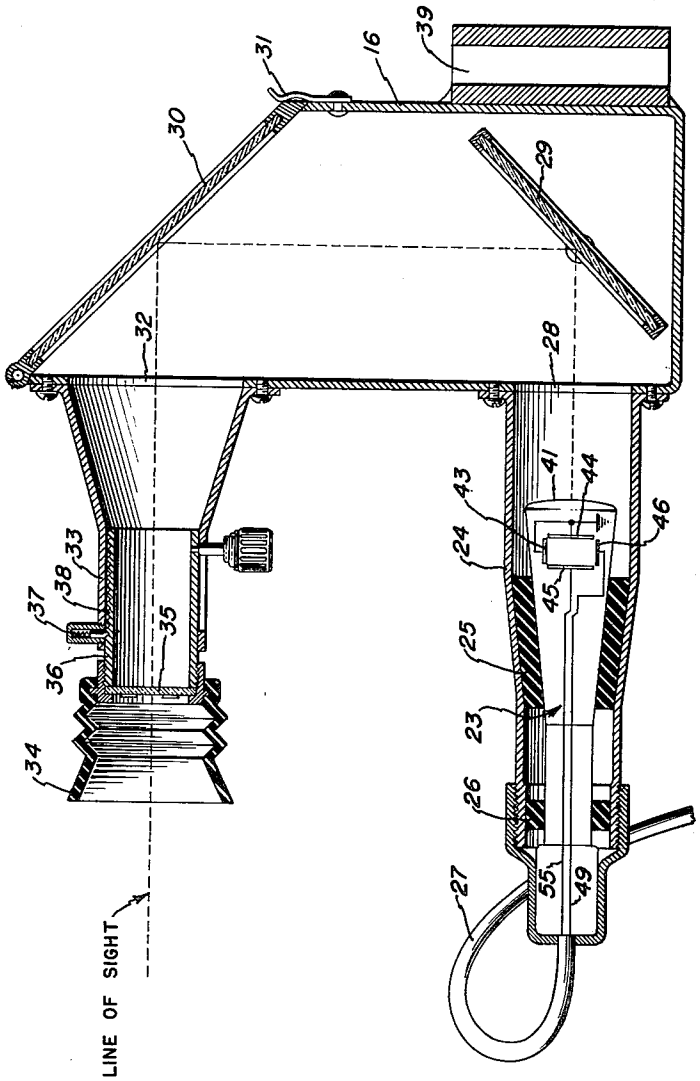


FIG. 6

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Patented Oct. 9, 1951

2,570,298

UNITED STATES PATENT OFFICE

2,570,298

GYROSCOPICALLY CONTROLLED ELECTRICAL GUN SIGHT

Phillip Rood Wheeler, Alexandria, Va.

Application December 19, 1945, Serial No. 636,048

6 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 present invention relates to electrical gun sights and particularly to a novel and improved electrical gun sight of the type which does not require a stabilized supporting reference plane.

This application is a continuation-in-part of my copending patent application, Serial No. 510,403, entitled "Cathode Ray Gun Sight" and filed in the United States Patent Office on November 15, 1943 now abandoned. In my copending patent application Serial No. 636,047 entitled "Cathode Ray Tube Gun Sight" and filed in the United States Patent Office on December 19, 1945, now Patent 2,459,206 granted January 18, 1949, claims are addressed to those features of my improved gun sight which are disclosed in Fig. 6 herein.

My invention is of particular utility as embodied in gun sights operating on the disturbed-line-of-sight principle. Sights of this general character are described in the following United States Patents: 1,322,153, J. S. Wilson and W. E. Dalby, issued November 18, 1919; 2,183,530, Robert Alkan, issued December 19, 1939; 1,724,093, Robert Kauch and Charles L. Paulus, issued August 13, 1929.

When a gunner establishes a line of sight on a moving target he must "lead" the target by a suitable angle. That is, the weapon must be so pointed that the line of fire leads the line of sight. Otherwise the projectile would fall behind the target. The lead angle depends on the target velocity and the time of flight of the projectile. This "leading" is accomplished by the "target velocity" corrections of the sight setting. The gunner must allow for the effect of gravity on the projectile. In other words, he must elevate the gun above the direct line of sight to the target to allow for the drop of the projectile after it leaves the gun muzzle. This is accomplished by the superelevation corrections of the sight setting. Superelevation is functionally related to range and it varies as the cosine of elevation. In gun sights which operate on the disturbed-line-of-sight principle the gunner maintains the line of sight on a target by tracking the target as he manually positions the gun and sight. The lead angle or target velocity corrections and the superelevation corrections furnish a basis for angularly so disturbing the line of sight with respect to the line of fire that when the line of sight is maintained on the target the line of fire is appropriate to score a hit.

It is an object of the present invention to provide an improved and simple electrical arrangement for automatically applying target velocity

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and superelevation corrections to a gun sight of the type having a displaceable reference mark, in such a manner that the accuracy of the sight is not appreciably affected by roll, pitch, yaw or linear acceleration of the ship or other supporting frame on which the gun is mounted.

For a better understanding of the present invention, together with other and further objects thereof reference is made to the following specification, to the claims appended thereto and to the accompanying drawings, in which:

Fig. 1 comprises a geometrical presentation of the lead angle computation;

Fig. 2 comprises a geometrical presentation of the superelevation computation;

Fig. 3 comprises a perspective view of the gyroscopic control mechanisms included in my improved sight;

Fig. 4 and Fig. 5 comprise perspective views of a gun and mount showing my improved gun sight in place; and

Fig. 6 comprises a sectional view of the cathode ray tube arrangement for providing a displaceable reference image or mark, including a schematic showing of the arrangements for displacing the mark.

Fig. 1 shows the essential features of the short-range fire control problem. A gun 11 is fired at an airplane 12. At the instant of fire the airplane is in a position called the "present position." The gun should be pointed at some later or predicted position of the target called the "future position," such that the projectile will reach the future position at the same time as the target. The angle between the line from the gun to the present target position or (line of sight) and the line from the gun to the future position (or line of fire) is the lead angle.

The angular velocity of the target as observed from the gun is the angular movement of the target about the gun per second of time. The time of flight is the time taken by the projectile to reach the target. The total angular motion of the target (or lead angle) during the time of flight is equal approximately to the angular velocity of the target at the present position multiplied by the time of flight in seconds. Other quantities involved in the lead-computing fire control problem, such as present and future slant range, are appropriately labeled in Fig. 1.

If the gun bore were pointed at the future position of the target without further correction the projectile would then fall below the target because of the downward force of gravity. To compensate for this undesired effect of gravity the

gun elevation is increased by an additional angle called the superelevation angle as illustrated in Fig. 2. The superelevation angle required is dependent upon (*a*) the ballistics of the gun and projectile, (*b*) the time of flight of the projectile to the target, (*c*) the cosine of the angle of gun elevation. The ballistics of any given gun can be considered constant over short ranges and therefore the superelevation angle is calculated with the reasonable approximation according to the following equation:

Superelevation = constant × time of flight × cosine of gun elevation.

The above mentioned United States Patent No. 1,322,153 discloses means for establishing a line of sight and electrical-generator-means for angularly disturbing the line of sight with reference to the gun bore axis or line of fire by an amount functionally related to the rates of tracking of a target in train and in elevation, whereby the line of sight is disturbed by an amount functionally related to the speed of the target so that the proper lead angle is introduced when the gunner maintains the line of sight on a target by swinging the gun in elevation and in azimuth. This sighting arrangement is premised on the functional relationship which exists between target velocity and tracking rate when the gun is mounted on a stable reference or supporting frame. However, when the gun and sight are mounted on a supporting frame (such as the deck of a ship) which is subject to roll, pitch, yaw and linear acceleration, the functional relationship between this relative motion (between gun and supporting frame) and velocity of the target no longer holds. Further the functional relationship between the relative positions (of the gun and supporting frame) and the elevation of the target no longer holds. Therefore, these factors (rolls, etc.) introduce errors in both the target velocity and superelevation corrections. Each of the generators disclosed in United States Patent No. 1,322,153 measures a rate of motion of the gun relative to the supporting frame. In accordance with my invention I provide gyroscopic arrangements for disturbing the line of sight and I measure the absolute rate of motion or tracking rate of the gun relative to an imaginary fixed or stable frame of coordinates.

In Fig. 4 there is illustrated, in combination with a universal gun mount **13** carrying a gun **11** for movement in elevation and in azimuth, a novel sighting arrangement generally indicated at **15**. This arrangement comprises the elements included within the housings indicated at **16**, **17** and **18**. Housings **16** and **17** are secured to the gun and move with it in elevation and in azimuth as the operator, in using handles **19** and **20** swings the gun and sight in tracking a target. Housing **18** is mounted inside the stand **22** (Fig. 5). This arrangement comprises means for establishing a line of sight as indicated at **16** and specifically shown in Fig. 6. The cathode ray sighting arrangement illustrated in Fig. 6 is claimed in my copending patent application Serial No. 636,047 entitled "Cathode Ray Tube Gun Sight" and filed in the United States Patent Office on December 19, 1945. This sighting arrangement includes a cathode ray tube **23** for providing an electrically displaceable reference image or mark. The tube is mounted in a cylindrical housing **24** by means of suitable positioning elements **25** and **26**. The tube is connected by means of a cable **27** to the electrical units within

housing **18**. The cylindrical housing **24** is attached by screws or other suitable means to the lower end of the main housing **16** which has an opening **28** at the point of attachment. A reflecting mirror **29** is located in the lower end of the housing **16** at an angle of approximately 45 degrees to the horizontal. Pivoted to the upper end of the housing **16** is a semi-reflecting flat glass plate **30** which is inclined at an angle of approximately 45 degrees to the horizontal and which may be lifted upwardly on a pivot for purposes of cleaning the inside of the housing. A suitable catch **31** is provided for holding the glass **30** in position. In the upper end of the rear wall of the housing **16** is an opening **32** which provides communication between the interior of housing **16** and the interior of the eye-piece support **33**, which is attached to the housing by means of screws or other suitable means. A rubber eye piece **34** and a peep **35** are mounted on a tube **36**, which is slidably mounted in the outer end of support **33**, the position of the tube in the support being adjusted by means of a spring-pressed plunger **37**, which cooperates with notches **38** on the tube. A mounting bracket **39** or other suitable expedient is attached to the front wall of the housing **16** in order to provide means for mounting the unit securely on the gun.

The cathode ray tube employed in the sight is a conventional type having a suitable electron gun structure for projecting an electron beam from its cathode onto a flourescent screen **41**. Vertical and horizontal pairs of electrostatic beam deflecting plates are provided in the tube for positioning the electron beam, as is common practice in the cathode ray tube art. Plates **43** and **44** are grounded (Fig. 6) and plates **45** and **46** are connected to sliding contacts **48** and **47** (Fig. 3), respectively. The circuit from plate **46** proceeds through conductor **49**, one of the conductors **50** of cable **27**, conductor **51** and one of the conductors **52** of cable **53** to contact **47**. The circuit from plate **45** proceeds through conductor **55**, one of the conductors **56** of cable **27**, conductor **58** and one of the conductors **59** of cable **60** to sliding contact **48**.

In the cathode ray tube of the sighting arrangement illustrated in Fig. 6 an image such as a spot or circle is formed on the screen **41** and is reflected upwardly by mirror **29** and rearwardly by the semi-reflecting piece of glass **30** to the eye of the gunner positioned behind the rubber eye-piece **34**. The gunner looking into the sight through the rubber eye-piece sees the image of the spot or circle created by the cathode ray tube and reflected by the optical elements **29—30** into the sight line and at the same time views the target through this piece of glass **30**. The gun is aimed by centering or effectively superimposing the reflected image as a sighting reference on the target. By means of the electrical controls for the cathode ray tube which are presently described, the image on the tube screen is moved about to provide the various corrections. Movement of the image on the screen produces a corresponding movement of the image or reference reflected into the gunner's sight line by the optical elements **29—30** so that a new line of sight is established to enable the gunner to adjust the position of the gun to correspond to the sighting corrections put into the cathode ray tube.

Due to the fact that the line of sight is defined by the image reflected by the optical elements **29—30** into the operator's field of view

and by the peep located in the rubber eye-piece the amount of correction of the line of sight by a given movement of the image depends upon the position of the peep in the eye piece with relation to plate 30. The rubber eye piece and the peep are shown adjustable so that this correction can be calibrated by movement of the eye piece and the peep in and out of the support 33.

In attaching the cathode ray tube unit to the gun, the unit 16 is conveniently placed as near the trunnions of the gun as possible so that the eye of the gunner may remain on approximately the same height for all angles of elevation of the gun. In Figs. 4 and 5 the cathode ray unit 16 of the type shown in Fig. 6 is shown mounted on an antiaircraft machine gun.

Referring now specifically to Fig. 3 there are illustrated the gyroscopic arrangements for controlling the position of the reference image provided by the cathode ray tube 23. These gyroscopic controls automatically control the position of the reference mark and disturb the line of sight so that the line of fire established by the sight will lead the line of sight by an amount proportional to the angular rate of movement of the gun with respect to an imaginary fixed or stable reference in space in following the target. Mounted within the housing 17 are a train or azimuth rate gyro unit 62 and an elevation rate gyro unit 63. The train gyro unit measures the rate of the train component of angular movements of the gun and causes the output voltage of train or azimuth potentiometer 65 to be representative thereof. Similarly, the elevation gyro unit 63 measures the rate of elevation component of angular movements of the gun and causes the output voltage of elevation potentiometer 66 to be representative thereof.

The train gyro unit 62 comprises a gyro wheel 67 mounted for spinning on a shaft 68 journaled in a gimbal frame 69. This frame has a shaft extension 70. Rigidly secured to extension 70 are knife edges 71 and 72. The arrangement of elements 67 to 72, inclusive, is such that range springs 73 and 74 tend to restrain gyro wheel 67 so that it will spin in the plane of elevation. The gyroscope unit 62 is mounted in a casing 75 secured by appropriate means (not shown) to housing 17. Similarly, the elevation gyro unit 63 comprises a gyro wheel 77, a shaft 78, a gimbal frame 79, a shaft extension 80, knife edges 81 and 82 and range springs 83 and 84, inclusive, so arranged that the restraining influence of springs 83 and 84 tends to restrain the gyro wheel 77 so it will spin in the plane of train. The gyro wheels are actuated by any suitable means such as air jets (not shown).

Shaft extension 70 of unit 62 is secured to a lever 85 which lever includes the knife edges 71 and 72 and a suitably insulated sliding contact 48 on the voltage divider 65. Likewise, shaft extension 80 of unit 63 is rigidly secured to a lever 87 which includes knife edges 81 and 82 and a suitably insulated sliding contact 47 on potentiometer 66.

Potentiometer 65 comprises an insulating form 89 rigidly secured to housing 17 by any suitable expedient (not shown). Wound on form 89 is a resistor 90 which is connected by conductors 91 and 92 to the output terminals of any suitable voltage source 93. As lever 85 causes contact 48 to move along resistor portion 90, that portion of the potential of battery 93 which exists between sliding contact 48 and ground is applied, through conductor 59, to deflecting plate 45 of cathode ray tube 23. Similarly, potentiometer 66 comprises an insulating form 94, rigidly secured to housing 17 by any suitable expedient (not shown). On the form is wound a resistor 95 the terminals of which are connected by conductors 96 and 97 to a battery 98. The arrangement of potentiometer 66 is such that the voltage between contact 47 and ground is applied, through conductor 52 to vertical deflecting plate 46 of tube 23.

Wheel 67 of the train gyro unit 62 precesses whenever the housing 17 is moved by absolute movement of the gun in train. Additionally, wheel 77 of elevation gyro unit 63 precesses when the housing 17 is moved absolutely in elevation with the gun. Units 62 and 63 are so arranged that the precession of each gyro wheel is proportional to the rate of angular motion of the gun in train or in elevation, as appropriate. The precession or deflection of the gyros causes changes in the positions of levers 85 and 87 and appropriate changes in the positions of contacts 48 and 47, with the result that voltages applied to the deflecting plates of the cathode ray tube throw the reference image and line of sight out of alignment with the gun bore axis. Thus, as the gunner keeps the sighting reference image and line of sight on a moving target, the gun is advanced automatically by the proper lead angle so that the projectile should strike the target.

In order to introduce the superelevation corrections superelevation weights 100 and 101 are individually mounted in the front gimbal suspension systems of the gyro unit. The weights are mounted on arms 102 and 103, respectively. Arm 102 is disposed in the plane of rotation of wheel 67 and arm 103 is disposed in the plane of rotation of wheel 77. When the gun is in a horizontal position the deflection of the gyro wheel 77 caused by weight 101 is a maximum. As the gun is elevated the effect of weight 101 decreases, becoming zero when the gun is pointed to the zenith, (where the trajectory drop is zero). The weight 100 for the train gyro 62 is directly above the gimbal axis when the gun bore is horizontal. This construction makes it practicable for the two gyro units 62 and 63 to interchange functions, so far as superelevation is concerned, if the housing 17 in which the gyros are mounted is rotated about an axis parallel to the gun barrel. Such rotation or elevation axis tilt occurs when a ship rolls or pitches. The superelevation correction is introduced independently of the lead angle. If the gun sight is stationary, the reference image is positioned according to the correction for superelevation alone. When the sight is moved, as in following a target, the gyro wheels are deflected by additional mounts corresponding to the rates of movement. The resultant position of the reference image then represents a combination of superelevation and lead angle corrections.

Range adjustments are made in the sight by turning the range knob 105 (Fig. 3). This adjustment causes equal rotation of the two range gears 106 and 107, one at each gyro unit. Each range gear causes its associated set of range springs 73—74 or 83—84 to move in or out and thereby offer more or less resistance to deflections of the gyro wheels. When the range knob is turned to a lower range setting, the range springs are shifted toward the center and the resulting gyro deflections due to movement of the gun sight case are small. Thus, the deflection of the reference image is small and the resulting lead angle is relatively small. When the range

knob is turned to a high range setting, the range springs are shifted away from the center and the gyro deflections are large. This gives a large lead angle as required for the greater range. The range setting also affects the superelevation components. Thus when the range knob is turned to a low range value the range spring positions are such as to permit small deflections of the gyros due to the superelevation weights. This gives a small superelevation component. When the range knob is turned to a high range value, the range springs permit larger deflections of the gyros due to the superelevation weight. This gives a larger superelevation component as required for the greater range.

Thus it will be noted that the range fire control datum is introduced into the sight by manual adjustment of knob 105. The target velocity fire control data are introduced into the sight by the rate-of-turn-indicators 62 and 63. The superelevation fire control data are introduced into the sight by the superelevation weights 100 and 101.

As indicated in Fig. 3 batteries 93 and 98 are located in housing 18 which may be placed within stand 22 of the gun (Fig. 5).

In explaining the operation of the above-described sighting arrangement, it will be assumed that the interior and exterior ballistics of the gun and projectile have been determined, that range tables are available, that all of the characteristics of the gun and the projectile are known, and that a selected stationary target is depressed from the supporting plane. For purposes of simplicity it will be assumed that there is no trunnion or elevation axis tilt and that the target position is such that a hit is mathematically predictable if the line of fire is horizontal. Under that assumed condition, gravity is exercising its maximum effect on the projectile. The sight is so adjusted under this condition that superelevation weight 101 then exercises maximum turning moment on shaft 82. The sight is then so adjusted that sliding contact 47 is at such a point on resistor 95 as to cause to be applied to the vertical deflecting plates of the cathode ray tube a voltage appropriate to align the peep 35, the reference image, and the target. The line of sight is then on the target, although disturbed from the line of fire by the amount of the superelevation correction, and a hit should be scored when the gun is fired. The operation of the superelevation weight is such as to disturb the line of sight to a maximum extent for any given range under this condition. Now let it be assumed that fire should be directed to another stationary target which is located immediately above and at 90 degrees of elevation with respect to the gun. Under that condition the turning moment of weight 101 about the gimbal frame of wheel 77 is at a minimum and the contact 47 is at the center or grounded point of resistor 95. Under that condition the reference mark is vertically centered and the line of sight is not disturbed at all.

The distance from the gun to the target may be regarded as infiinite with respect to the distance between casing 17 and the gun. Between these two terminal conditions (i. e. when firing on stationary targets between the zero and 90 degrees of elevation) one component of the voltage appearing between conductor 52 and ground is trigonometrically functionally related to and varies as the cosine of the angle of elevation. As indicated, the range adjustment for both superelevation and lead angle is provided by knob 105 and the mechanisms actuated by that knob.

In practice, the ballistics of the gun and the projectile are obtained from range tables. The fire control problem is capable of mathematical solution and the characteristics of the train and elevation rate gyro units 62 and 63, the range adjustment mechanism, the potentiometers 65 and 66, the sources 93 and 98 and the cathode ray tube 23 are mathematically determinable, so that specific second parameters are a matter of individual engineering design and depend upon the specific characteristics of the system to be used, as will be clearly understood by those skilled in the art.

The operation of the superelevation weight 100 will become clear if it be assumed that the supporting frame on which the gun and sight are mounted turns by 90 degrees about the gun trunnion or elevation axis. In that case, the superelevation correction voltage is applied to plates 45 and 44 and the train gyro unit 62 performs the function of providing the superelevation correction. Under that assumed condition weight 100 would be asserting its maximum turning moment about gimbal frame 69. At zero degrees of pitch weight 101 controls the superelevation correction while at 90 degrees of pitch weight 100 controls the superelevation correction. Between these two terminal conditions, both weights cooperate to supply the required superelevation corrections.

When both bore and trunnion axes are horizontal, the train weight has no effect, while the elevation weight has maximum effect. This is apparent from the fact that the train weight is on a vertical line through its gimbal shaft, and therefore has no leverage and cannot apply a turning effort or torque. At the same time, the elevation weight has its maximum leverage, and thus applies its greatest torque.

When the trunnion axis tilts, leverage is acquired by the train weight and lost by the elevation weight, and each gyro unit computes part of the superelevation. The sight construction is such that the resultant electrical potentials caused by the superelevation weights displace the reference mark only in a vertical plane, regardless of the trunnion-axis inclination.

As the bore elevates above the horizontal, both weights lose leverage and their effects decrease, becoming zero when the bore axis is vertical. The range springs resist the torque applied by the weights just as they resist the precession due to tracking. Since the springs are most stiff when adjusted for short ranges, the gimbal-shaft rotation caused by the weights varies in the same manner as superelevation, namely: (1) maximum for horizontal firing and decreasing as target elevation increases; (2) maximum for long ranges and minimum for short ranges. Thus, with the weights properly designed and adjusted for a particular gun, superelevation compensation is automatically introduced at any elevation and range, and the correction is independent of trunnion or elevation axis tilt. Since the lead angle computation is also correct for any value of trunnion tilt, it is evident that no separate trunnion-tilt corrections are needed.

Let it now be assumed that fire is being directed on a moving target such as an airplane. The superelevation correction is functionally related to the position of the airplane and not to its velocity and the arrangement for applying that correction has already been described. The operator swings the gun and sight in tracking the

moving airplane. Gyro wheels 67 and 77 precess by amounts functionally related to the train and elevational components, respectively, of the target velocity. Levers 85 and 87 are accordingly displaced by the operation of unit 62 and its range springs and unit 63 and its range springs, respectively, by such an amount as to cause to be applied to the cathode ray tube 23 voltages respectively proportional to the product of target azimuthal velocity and range and to the product of target elevational velocity and range, respectively. Thus the lead angle corrections are provided.

Although it has been assumed in the preceding discussion that the projectile velocity remains constant for all ranges, this is of course not exactly true and the decreasing projectile velocity with increased range is a factor which should be considered in a rate sight. As the range increases the average velocity of the projectile decreases and the lead angle should be increased slightly with increased range to compensate for this loss of projectile velocity. This correction is sometimes called a "time of flight" correction, and should be considered in the range setting device hereinabove described. As is obvious to those skilled in the art this is accomplished by appropriate shaping and adjustment of the range springs. Thus, the final correction made in the position of the reference image in the sight by the adjustment of the range control knob 105 is functionally related to time of flight, which, as indicated, does not vary precisely linearly with range.

While there has been shown what is at present considered to be the preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the true scope thereof, and it is, accordingly, intended in the appended claims to cover all such changes and modifications as fall within the true scope of the invention and without the proper scope of the prior art.

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. In combination with a gun movable in planes of elevation and train, a gunsight adapted to move in unison with said gun and comprising a cathode-ray oscilloscope having vertical and horizontal cathode-ray deflecting plates for providing a reference mark, optical means for imposing an image of said mark in the line of sight of a gunner whereby the image may be moved simultaneously with a target, a first rate gyroscope responsive to movement of said gun in train including a gyroscope rotor mounted for spin in a plane normal to the plane of train of said gun, a second rate gyroscope responsive to movement of said gun in elevation including a gyroscope rotor mounted for spin in a plane normal to the plane of elevation of said gun, means mounting said rotors for freedom of movement about parallel axes each normal to the axis of spin of its respective rotors whereby the rotors of said first and second gyroscopes will be free to turn respectively about said axes in a direction determined by the direction of movement of said gun in train and elevation and through an angle the magnitude of which is proportional to the rate of movement of said gun in train and elevation, potentiometers for the train and elevation gyroscopes each having a movable contact, means connecting said contacts respectively to the horizontal and vertical deflecting plates of said cathode-ray oscilloscope, and means for moving said contacts responsive to the movement of their respective rotors about said parallel axes whereby said image will be displaced in a plane normal to said line of sight in a direction and an amount proportional to the direction and rate of movement of said gun in elevation and train to provide a proper lead angle when optically tracking a target.

2. A gun sight comprising means for providing a sight line, an azimuth rate gyroscope mounted for movement with said sight line means and for resisted precession in response thereto, an elevation rate gyroscope similarly mounted, an azimuth potentiometer controlled by precession of said azimuth gyroscope, an elevation potentiometer controlled by precession of said elevation gyroscope, a cathode ray tube, rate signals obtained from said two potentiometers being applied across two pairs of opposite beam deflecting plates of said tube to provide indications of the rates of angular movements of said sight line means relative to a stable reference in space, means for representing said indications as a sighting reference in the sight line, means for adjusting the resistance to gyroscope precessions in accordance with a chosen target's range, and means cooperating with said gyroscopes to provide additional angular deflections thereof about their precession axes in accordance with the sight line means angle of elevation and elevation axis tilt, thereby providing for azimuth and elevation lead and superelevation compensation in the position of said sighting reference when movements of a target are tracked.

3. A gun sight comprising means for providing a sight line, an azimuth rate gyroscope mounted for movement with said sight line means and for resisted precession in response thereto, an elevation rate gyroscope similarly mounted, an azimuth potentiometer controlled by precession of said azimuth gyroscope, an elevation potentiometer controlled by precession of said elevation gyroscope, a cathode ray tube, rate signals obtained from said two potentiometers being applied to the beam deflecting means of said tube to provide indications of the rates of angular movements of said sight line means relative to a stable reference in space, means for representing said indication as a sighting reference in the sight line, and means for adjusting the resistance to gyroscope precessions in accordance with a chosen target's range, thereby providing for azimuth and elevation lead compensation in the position of said sighting reference when movements of a target are tracked.

4. A gun sight comprising means for providing a sight line, an azimuth rate gyroscope mounted for movement with said sight line means and for precession in response thereto, an elevation rate gyroscope similarly mounted, an azimuth variable electrical signal means controlled by precession of said azimuth gyroscope, an elevation variable electrical signal means controlled by precession of said elevation gyroscope, and an electrical signal responsive indicator means, rate signals obtained from said two signal means being applied to said indicator means to provide indications of the rates of angular movements of said sight line means relative to a stable reference in space, and means for representing said indications as a sighting reference in the sight line, said

indications thereby providing for azimuth and elevation lead compensation when movements of a target are tracked.

5. A gun sight comprising means for providing a sight line, a rate gyroscope mounted for movement with said sight line means and for resisted precession in response thereto, a potentiometer controlled by precession of said gyroscope, a cathode ray tube, rate signals obtained from said potentiometer being applied across beam deflecting means of said tube to provide indications of the rates of angular movements of said sight line means relative to a stable reference in space, means for representing said indications as a sighting reference in the sight line, and means for adjusting the resistance to gyroscope precessions in accordance with a chosen target's range, thereby providing for appropriate lead compensation in the position of said sighting reference when movements of a target relative to the gun sight are tracked therewith.

6. A gun sight comprising means for providing a sight line, a rate gyroscope mounted for movement with said sight line means and for precession in response thereto, a variable electrical signal means controlled by precession of said gyroscope, an electrical signal responsive indicator means, rate signals obtained from said signal means being applied to said indicator means to provide indications of the rates of angular movements of said sight line means relative to a stable

reference in space, and means for representing said indications as a sighting reference in the sight line, said indications thereby providing for appropriate lead compensation when movements of a target relative to the gun sight are tracked therewith.

PHILLIP ROOD WHEELER.

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