June 23, 1953 F. A. LYON 2,642,662

VECTOR SIGHT

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Fig. 3.

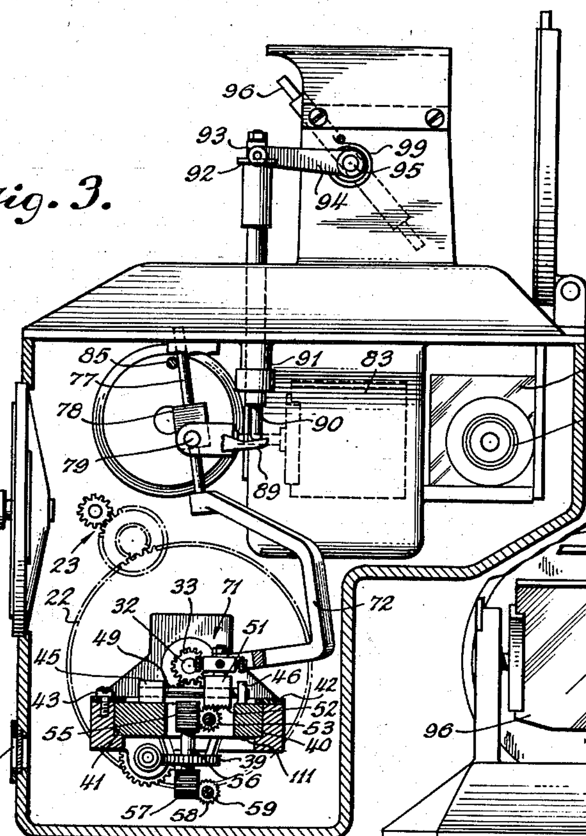

Fig. 2.

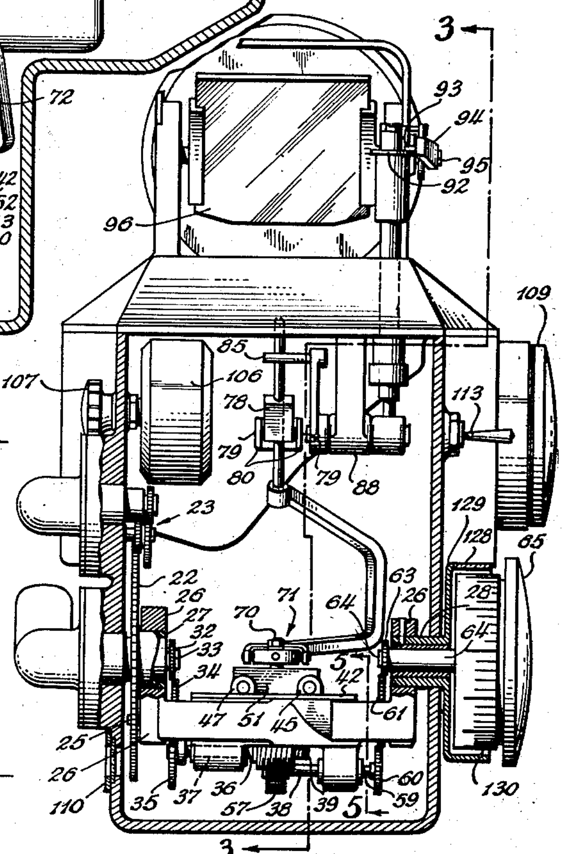

Fig. 1.

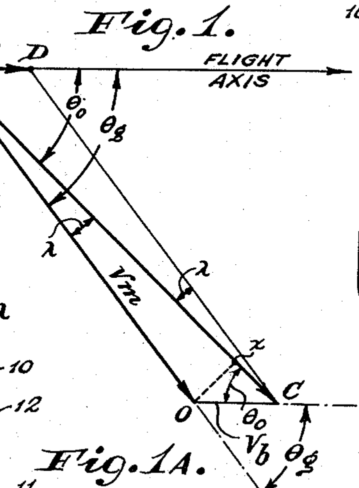

Fig. 1A.

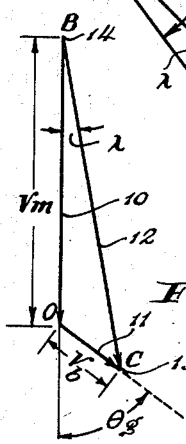

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Fig. 4.

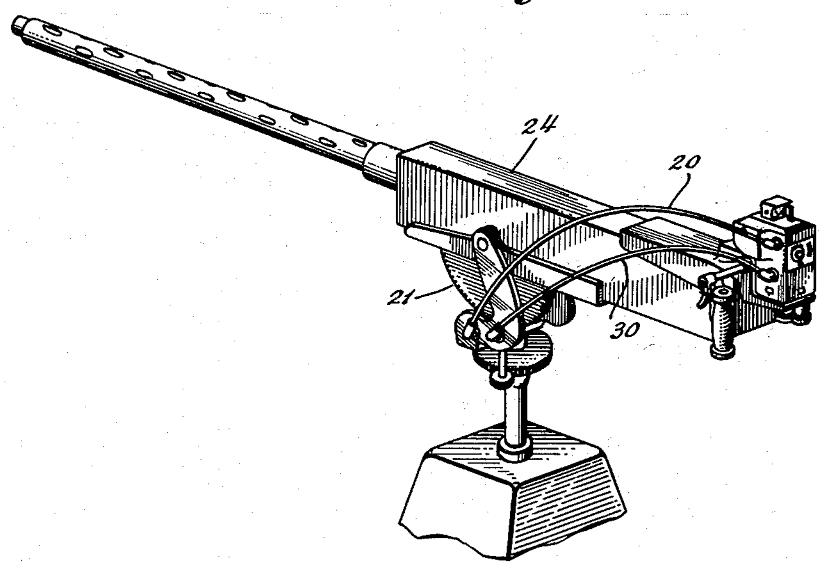
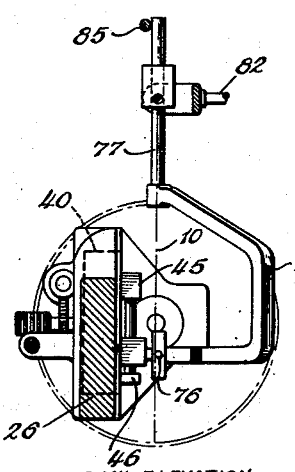


Fig. 5.



0 MIL ELEVATION

Fig. 6.

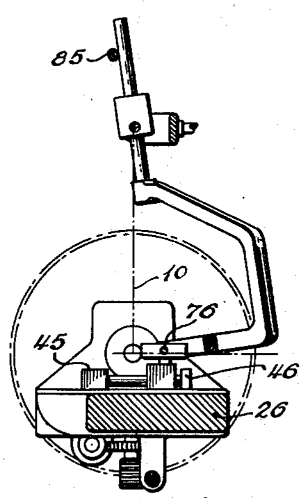


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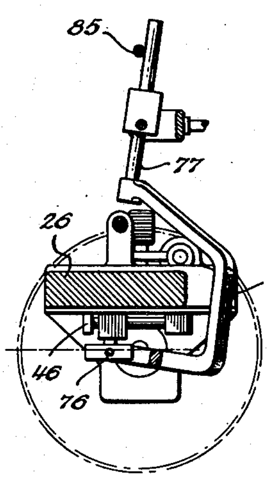
Fig. 7.



-1600 MIL ELEV.

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Fig. 8.

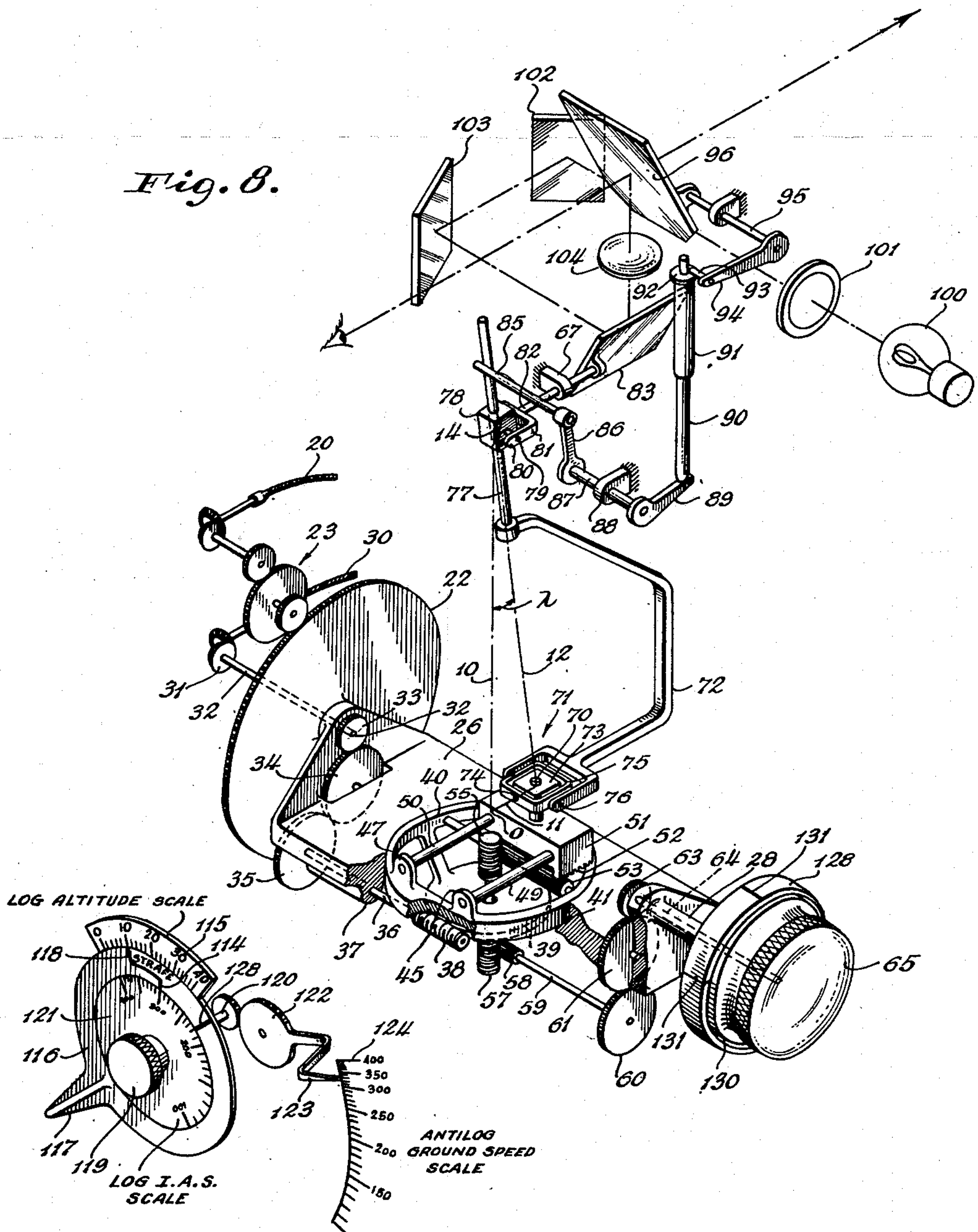

Fig. 9.

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UNITED STATES PATENT OFFICE

2,642,662

VECTOR SIGHT

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Application March 30, 1944, Serial No. 528,705

2 Claims. (Cl. 33—49)

1

This invention relates to a gun sight and more particularly to a gun sight of the displacement or disturbed type by which the bore of the gun and the line of sight are displaced as a target is being tracked so that the bore of the gun is automatically positioned according to desired lead angles whereby projectiles therefrom will strike a target in future relative positions thereof with respect to the gun bore.

An object of the invention is to provide a simplified sight of compact dimensions and light-weight which may be produced at a low cost and which at the same time is highly accurate.

Another object is the provision of a compact, light-weight sight suitable for use on an aircraft.

The invention will now be described with the aid of the accompanying drawings of which

Fig. 1 is a diagram showing the operation of the sight by means of vectors;

Fig. 1A is a schematic showing of a linkage mechanism;

Fig. 2 is a front view of the sight partly in section;

Fig. 3 is a section taken through 3—3 of Fig. 2;

Fig. 4 shows the sight mounted on a gun;

Figs. 5, 6 and 7 are sectional views taken through 5—5 of Fig. 2 showing the link mechanism in various azimuth positions;

Fig. 8 is a schematic drawing of the sight mechanism; and

Fig. 9 is a detail of a dial arrangement.

The sight of the present invention is particularly adapted for use with guns disposed anywhere on an airplane.

A novel linkage mechanism is included in the present sight for obtaining the required lead angles and it is thought that the sight will be more readily understood if the theory thereof is first discussed with reference to the vector diagram of Fig. 1.

In Fig. 1 the horizontal arrow indicates the path of an airplane B mounting a gun, while C represents a stationary target. Vector Vm represents gun muzzle velocity and vector Vb velocity of the airplane (ground speed). λ indicates the total deflection angle between line of sight and the gun bore; θg the angle between the axis of the plane and the gun bore, and θo the angle between the axis of the plane and the line of sight. The bullet fired at B has a velocity Vm along BO and a forward velocity Vb along the flight axis of the airplane. From the velocity vector parallelogram BOCD it will be seen that the path of the projectile is along the vector resultant BC of Vm and Vb.

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If OX is perpendicular to BC, then

$$OX = Vb \times \sin \theta o,$$

and

$$\sin \lambda = \frac{OX}{Vm} = \frac{Vb}{Vm} \times \sin \theta o \text{ (neglecting gravity)}$$

The gun sight of the present invention deflects the line of sight through angle λ so that when the line of sight falls on any stationary target C a bullet fired at that instant will strike C.

In theory, the sight solves for λ by means of a three bar linkage shown diagrammatically in Fig. 1A, in which link 10 has a constant length which is proportional to the muzzle velocity of the bullet. This link, as will be described farther on, is fixed with respect to the sight case which moves with the gun.

Link 11 is pivoted to link 10 at 0 and is moved through the slant angle θg with respect to link 10 by means of a gun azimuth and gun elevation responsive mechanism. The length of link 11 is varied directly in accordance with a ground speed value Vb of the airplane.

Link 12 is connected to link 11 by a universal joint 13, and is connected to link 10 through a universal joint 14 which is slidable along link 12.

With the linkage arrangement just described link 12 moves through the total deflection angle λ with respect to the sight case, effecting thereby a corresponding displacement of the sighting elements which are mounted on the case with respect to the bore of the gun which is necessary due to the relative motion of the airplane and the target. The angle λ lies in a plane defined by the velocity direction of the airplane and the gun bore.

In order to operate conventional sighting devices, it is necessary to resolve this angle into a vertical component and a lateral component as will be described further on in detail.

The sight of the present invention will now be described with particular reference to Fig. 8 which shows the link mechanism more specifically in connection with the rest of the sight mechanism.

A suitable mechanism, such as flexible shaft 20 driven from sector 21 of the gun support, Fig. 4, turns gear 22 by means of an appropriate gear train 23 in one direction or the other in proportion to the movement of gun 24 in elevation in the known manner. Gear 22 is fixed by pin 25, Fig. 2, to a cradle 26 which is rotated thereby. The gear and one end of the cradle are pivotally supported on sleeve 27 while the opposite end of the cradle is secured to the outer surface of a sleeve 28 which turns with the cradle in a suitable bearing in the frame. Sleeve 28 is used to position an index mark on the outside of the frame which will be referred to in more detail further on. In actual construction, to aid in assembling, sleeve 28 is made in two sections which are not indicated in the drawings.

The movement of the gun in azimuth is conveyed to the sight mechanism by a suitable apparatus, such as flexible shaft 30, gears 31 and horizontal shaft 32 which extends through sleeve 27. A gear 33 secured to the inner end of shaft 32 drives by means of gears 34 and 35 a horizontal shaft 36 supported in a bearing 37 integral with the cradle. Shaft 36 carries a worm 38 in mesh with a worm wheel 39, coaxially disposed with respect to and supported by an annular member 40, Fig. 3, which is free to rotate in a complementary recess 41 formed in the midsection of the cradle. An annular plate 42 overlying member 40 is secured by screws such as 43 to the cradle and serves to retain member 40 within its recess where, by means of the mechanism just described, it rotates in proportion to changes in the azimuth angle of the gun.

Two pairs of lugs 46—46 and 47—48, formed integrally with annular member 40, support respectively guide rods 49 and 50 that in turn carry a block 51 provided with a depending rack 52 which meshes with a long pinion 53 which serves to reciprocate block 51 back and forth on guide rods 49 and 50. Pinion 53 is turned by a circular rack 55, Figs. 8 and 3, formed on one end of spindle 56 which also has a similar circular rack 57 formed near its opposite end. Pinion 58 on shaft 59 meshes with the latter rack and when turned, axially shifts spindle 56 thereby turning gear 53 which reciprocates block 51.

Secured on shaft 59 is a gear 60 connected by idler gear 61 to gear 63 fastened to shaft 64 which extends through sleeve 28 to the outside of the casing where a knob or hand wheel 65 is attached. As the latter is adjusted it causes reciprocation of block 51 on its guide rods. The function of knob 65 will be described further on.

Block 51 carries a stub shaft 70 that supports a universal joint 71 for a crank shaped arm 72 which is the link in the sight mechanism corresponding to link 12 mentioned in the preliminary explanation of the operation of the sight. One of the reasons for the peculiar shape of member 72 is to make it possible to turn the cradle through varying positions with respect to member 72 as shown in Figs. 5 through 7.

The universal joint 71 consists of a member 73 mounted for rotation on stub shaft 70. The member supports by oppositely disposed pivots 74 a frame 75 provided with pivots 76 passing through appropriate openings in the bifurcated ends of arm 72.

At the upper end of the arm 72 is mounted a rod 77 which is free to reciprocate as well as turn in a universal joint consisting of a block 78 provided on opposite faces with pivots 79 which are supported by the arms 80 of a bifurcated member 81 secured on a shaft 82 which is free to turn in bearings 67 attached to the frame. To the opposite end of shaft 82 is attached a mirror 83, of the sight system which is deflected thereby according to variations of the lateral lead angle.

Preferably, at a suitable distance above the universal joint, rod 77 engages a horizontal arm 85 of a crank 86 for turning shaft 87 which is supported in a bearing in bracket 88 attached to the frame. Shaft 87 carries an arm 89 that engages a plunger 90 supported for vertical reciprocation in tube 91 which extends upward through the top of the sight casing where the projecting end of plunger 90 carries an annular member 92 on which rests a pin 93 attached to crank 94 secured to shaft 95 that carries a reflex mirror 96 displaceable according to the elevation component of the lead angle. Spring 99, Fig. 3, causes arm 93 to exert pressure on plunger 90 to maintain rod 85 in contact with rod 77.

The mirror 83 and reflex mirror 96 are part of a known reflex sighting system in which a beam of light from lamp 100 shaped by reticle 101 is deflected by fixed mirrors 102 and 103 onto mirror 83 and thence through lens 104 onto reflex mirror 96 through which the line of sight passes. Turning of mirror 83 by shaft 82 produces a lateral shift of the luminous beams on glass 96 while rotation of glass 96 by shaft 95 produces a vertical movement of the beam thereon.

Rod 77 as well as arm 72 is positioned with respect to the imaginary axis 10 according to the total deflection angle by which the line of sight must be offset from the gun bore to hit the target. The axis 10 which represents the muzzle velocity vector is a fixed distance having a fixed location within the sight casing which in turn is secured to the gun. In order to offset a conventional sighting device according to the total lead angle value represented by the position of rod 77, it is necessary to resolve or segregate the azimuth and elevation components of the position of the rod relative to the case.

The elevation component of the total lead angle is derived by the tilting of rod 77 about the pivots 79 of the upper universal joint which effects a corresponding displacement of arm 85 as shown in Figs. 5, 6 and 7 which produces a corresponding deflection of elevation mirror 96. If pivot 76 of the lower universal joint were in alignment with axis 10 and not slightly offset therefrom as shown in Fig. 5 for the purpose of introducing a correction for superelevation, as will be explained later, changing gun position in azimuth would have no effect whatever in displacing arm 85 as rod 77 would merely reciprocate through the upper universal block 78. Such changes in the gun position in azimuth, however, will result in the rocking of block 78 about the axis of shaft 82 together with this shaft which is thus displaced according to the azimuth component of the lead angle, which, as described, causes corresponding displacement of the azimuth mirror. As can be seen from Figs. 5 to 7, changes in gun elevation do not displace shaft 82, since the block 78 of the upper universal rocks proportionally on its pivots 79 as gun elevation changes.

In Fig. 2 a rheostat 106 and a control knob 107 therefor are shown by which the current for lamp 100 may be adjusted.

An opening having a cover 109 is provided on the right side of the sight case to permit replacing of bulb 100.

An arc on the surface of gear 22 adjacent to the frame is calibrated in degrees of gun elevation which may be read in connection with a fixed reference through plastic window 110 in the left hand side of the sight casing.

The under surface of member 40 shown in Fig. 3, where indicated by reference character 111 is calibrated in mils. As the cradle is turned so as to approach the position shown in Fig. 5, these calibrations which represent the gun position in azimuth may be read in connection with a suitable index through plastic window 112 in the front of the sight case. Both dial arrangements just described are used chiefly for checking the position of the parts on the installation of the sight.

At the right side of the casing, a toggle switch 113 is provided for the light circuit.

As previously stated, link 11 of Fig. 1A is adjusted to have a length varied directly with a ground speed value of the airplane. Both altitude and indicated air speed are available to the gunner and the ground speed of the plane may be considered to be equal to indicated air speed multiplied by a function of the altitude. A novel dial mechanism (see Fig. 9) of the logarithmic type is provided on the front of the sight into which the gunner can set altitude and indicated air speed and obtain directly therefrom under normal conditions a close approximation of the ground speed of the airplane. The arrangement functions in the same manner as a slide rule. The dial mechanism comprises a stationary scale 115 calibrated in terms of logs of the altitude factor and a cooperating annular member 116 made, preferably of a transparent plastic, having a manually operated positioning lever 117 and an index 118, the member being turned by the lever until it coincides with the known altitude on scale 115. A knob 119 on shaft 120 coaxially positioned with respect to member 116 turns a dial 121 calibrated according to the log of the air speed in miles per hour. Dial 121 is set by knob 119 so that the known air speed coincides with a second index or lubber line 114 on rotary member 116. A gear on shaft 120 drives a gear 122 carrying a pointer 123 that cooperates with anti-log scale 124 calibrated according to the ground speed of the airplane. With the arrangement just described it will be understood that when the calibrated members associated with lever 117 and knob 119 are set respectively according to the altitude and indicated air speed, pointer 123 will indicate on scale 124 a ground speed value of the plane. The arrangement for setting the speed value thus obtained into the sight will now be described.

Sleeve 28 attached to the cradle extends out through the right side of the casing. A cylindrical transparent index sleeve 128 is secured to flange 129 attached to sleeve 28. Knob 65, carries a cylindrical scale 130 which turns within the transparent index sleeve. The scale is calibrated according to ground speed, and the gunner can set the ground speed obtained from scale 124 into the sight by positioning knob 65 so that the proper value on scale 130 is aligned with index 131 on the transparent sleeve 128. Knob 65 causes the shifting of block 51 back and forth on its supporting rods through a train of mechanism already described.

Referring back to the linkage shown in Fig. 1A, the relative position of this linkage in the present sight is indicated by dash dot lines bearing corresponding numerals in Fig. 8. Link 10 previously described as having a fixed length and being fixed to the casing is effectively duplicated by the sight mechanism shown in Fig. 8 where dash dot line 10, which represents the link, is perpendicular to the axis of the cradle which is fixed with respect to the sight casing, and extends upward to the center of the universal joint which also is fixed with respect to the frame by the bearing 67 for shaft 82. Link 10 or V*m* has a fixed length proportional to gun muzzle velocity.

Link 11 is the distance between the intersection of link 10 with the axis of the cradle and the axis of universal joint 71, and the angle link 11 makes with link 10 is the angle between the gun bore and line of flight or a very close approximation thereof.

Link 12 is the distance from the axes of universal joint 71 to the upper end of link 10.

When the cradle is as shown in Figs. 2 and 6 the sight is positioned at about 1600 mils elevation. In Fig. 5 the cradle is in zero elevation position and in Fig. 7 the cradle is positioned for approximately a 1600 mil depression of the sight.

The rotary member 40 is shown in Fig. 8 in the zero azimuth angle position and block 51 appears to be located for a ground speed of about 400 miles per hour. As knob 65 is turned in a counterclockwise direction in adjusting the sight for a lower ground speed, the gearing is such that the long pinion 53 will be turned in the same direction, which moves block 51 toward the center of annular member 40 and link 11 which corresponds to V*b* or ground speed is thus proportionately shortened reducing the magnitude of λ.

The superelevation angle (ϕ_s) may be assumed to be equal to the product of the cosine of gun elevation and a constant K where K equals the gravity drop at 800 yards range and 15,000 feet altitude. This constant is put in as a correction to the vertical component of the prediction angle λ by locating pivot point 76, Fig. 5, which corresponds in this figure to pivot point 13 of Fig. 1A, to the right of imaginary axis 10 by an amount equal to K mils elevation deflection when the gun is at zero degrees elevation. As the cradle goes up or down with gun elevation, the gravity drop changes very nearly as the cosine of gun elevation, and thus the line of sight assumes the slant angle λ with respect to the gun plus a vertical correction for the gravity drop of the bullet.

Link 12 which is embodied in arm 72 and rod 77 has its effective length altered both by changes in the length of link 11 due to adjustment for ground speed and by changes in the angle θ at the junction of links 10 and 11, due to turning of the cradle with changing gun elevation.

In Fig. 5, the cradle is at zero elevation or in other words the gun is in a level position. As best shown in Fig. 5, as annular member 40 is turned for changes in azimuth, arm 72 and rod 77 are caused to turn about the axis of shaft 82, rocking the latter and effecting a corresponding adjustment of the line of sight in azimuth. If the ballistic correction mentioned above were not present, pivot point 76 would lie on the imaginary axis 10 and rod 77 would be perpendicular to the axis of shaft 82 and therefore under these conditions no deflection of arm 85 which moves the line of sight vertically, would occur. Due to the ballistic correction, however, the pivot 76 is offset slightly from axis 10 causing rod 77 to be tilted a trifle from the perpendicular with respect to the axis of shaft 82, with the result that even when the gun is positioned at zero elevation as shown in Fig. 5, an adjustment of the member 85 controlling the vertical displacement of the line of sight is made as the gun is turned in azimuth.

If the rod be visualized as being tilted to a much greater extent with respect to axis 10 as will occur when the gun is elevated proportionately, the effect of the tilted position of the rod on the mechanism for adjusting the line of sight can be readily understood. Adjustment of annular member 40 with changing position of the gun in azimuth causes the part of rod 77 below the upper universal joint to describe a limited, approximately conical path about the axis 10 while the section of rod 77 above the upper universal joint also describes a path of identical shape which is at an angle closely approximating angle λ with respect to a projection of link 10. Since arm 85 of crank 86 follows the movement of rod 77, the elevation mirror 96 as well as the azimuth mirror will be proportionately tilted causing the line of sight to be offset from the gun bore in accordance with the magnitude of angle λ. The line of sight is adjusted to an actual value of λ. The angular position of rod 77 with respect to axis 10 has been made an approximation of this angle in the present embodiment of the invention only because the specific form of sighting mechanism employed has some inherent error, and this is compensated for by the approximation.

The sight is to be used for strafing stationary targets when adjusted as described with reference to indexes 114 and 118.

When used for defensive fire, the sight computes automatically deflections similar to those used in the "zone system of aiming." Member 116 has a second index 128 used when the target is an attacking fighter plane.

In computing the deflection angle for defensive fire against a fighter plane, it is assumed that an attacking craft follows a predetermined curved path in order to maintain its nose continuously directed approximately toward the position of the defending craft, which is flying in the direction of a line forming its longitudinal axis.

The necessary deflection angle is determined in the same manner as that for the strafing solution except that *Vb*, the velocity of the airplane, is multiplied by a constant K. This velocity value is obtained by using a different index 128 on member 116 as a lubber line; in which case index 128 is positioned in alignment with the proper altitude indication on scale 115 and dial 121 is set with the proper air speed value opposite index 128. A corrected air speed value is then indicated by pointer 123 on scale 124 which is set into the sight mechanism by knob 65 as already described. When an air speed value so derived is set into the sight, the sight automatically calculates the lead necessary to hit attacking pursuit planes having fixed or semi-fixed guns and which is flying a typical course, that is, with its nose continually pointed in the approximate direction of the ship being attacked.

All corrections can be removed from the sight, except gravity drop, by adjusting knob 65 to position scale 130 at zero miles per hour. The sight can then be used as a straight reflex sight.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a device of the character described, a

mechanism for deflecting a line of sight in two dimensions by means of a single member comprising a rod having a support at one end variably moved about two axes responsive to changes in elevation and azimuth, a support comprising a universal joint disposed near the opposite end of the rod actuated by the movement of the rod for separating the elevational and azimuth components of the movement of said rod, said universal joint comprising a member provided with an opening in which the rod is free to turn and reciprocate, oppositely disposed pivots on said member, a shaft provided with a bifurcated end for supporting the pivots, the arrangement being such that the shaft turns in accordance with an azimuth component of the movement of the rod, a crank disposed to engage said rod and follow the movements thereof about said pivots, a shaft turned by said crank according to an elevation component, and adjustable means for defining a line of sight controlled by the respective shafts.

2. In a gun sight of the displaced type wherein the line of sight is displaced from the bore of a gun according to lead angles, a device for computing lead angles automatically as the gun is aimed comprising a member supported for rotation about two intersecting axes, a universal joint adjustably positioned on said member in spaced relation to the intersection of said axes, means for adjusting the spacing of said universal joint from the intersection of said axes according to a function of the speed of the supporting craft, means controlled by the aiming movements of the gun for turning the member as well as the universal joint about the respective axes in proportion to the displacement of the gun in elevation and azimuth, an arm supported by said universal joint adapted to move therewith in accordance with the movements of said member, a second universal joint including a pivoted guide in which said arm is free to turn and also reciprocate, linkages connected to line of sight elements actuated directly by the movements of said arm, said guide being pivotally supported by a shaft forming one axis of the second universal joint, and said shaft having a line of sight reflecting element connected thereto and being adapted to be turned by rotary movements of said arm thereby to deflect the line of sight in one dimension.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,962,590	Haubroe	June 12, 1934
2,183,530	Alkan	Dec. 19, 1939
2,264,662	Donitz	Dec. 2, 1941
2,372,613	Svoboda	Mar. 27, 1945
2,407,191	Tear et al.	Sept. 3, 1946
2,414,102	Hull et al.	Jan. 14, 1947
2,547,654	Moore	Apr. 3, 1951
2,550,482	Johnson	Apr. 24, 1951

FOREIGN PATENTS

Number	Country	Date
211,675	Switzerland	Dec. 16, 1940
546,552	Great Britain	Aug. 10, 1942
859,265	France	June 3, 1940