July 24, 1951 J. S. HELLEN 2,561,924

GUN SIGHT

Filed Sept. 15, 1942 5 Sheets-Sheet 1

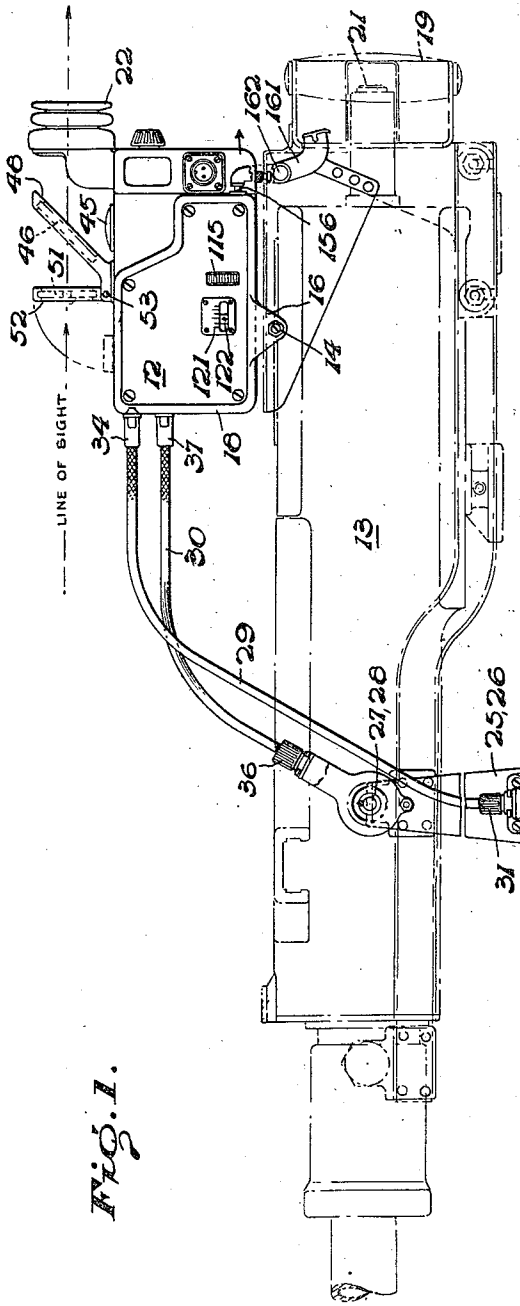


Fig. 1.

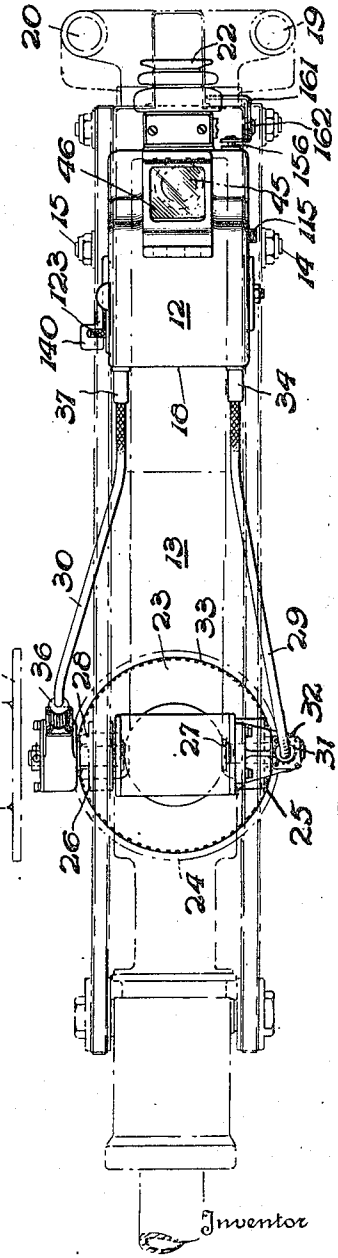


Fig. 2.

Inventor

James S. Hellen.

By Stephen Cerstvik Attorney

July 24, 1951 J. S. HELLEN 2,561,924

GUN SIGHT

Filed Sept. 15, 1942 5 Sheets-Sheet 2

Fig. 4.

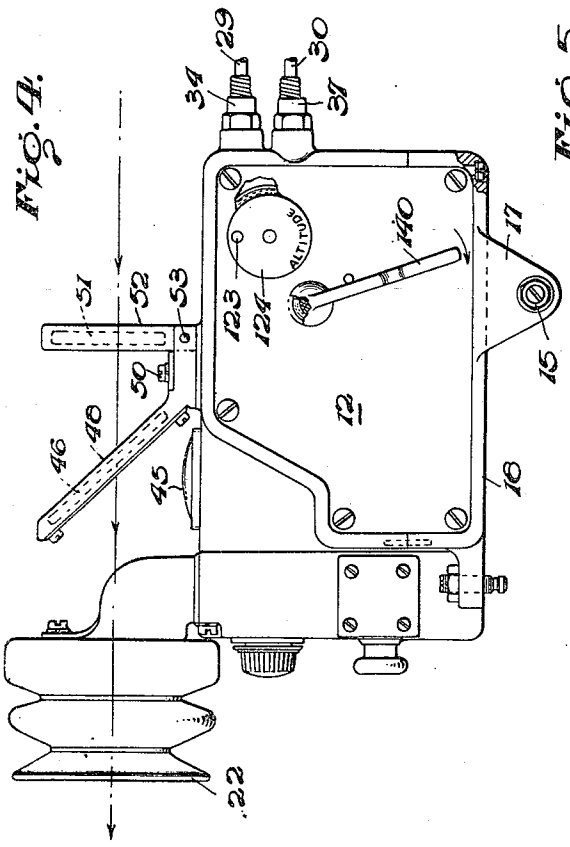


Fig. 5.

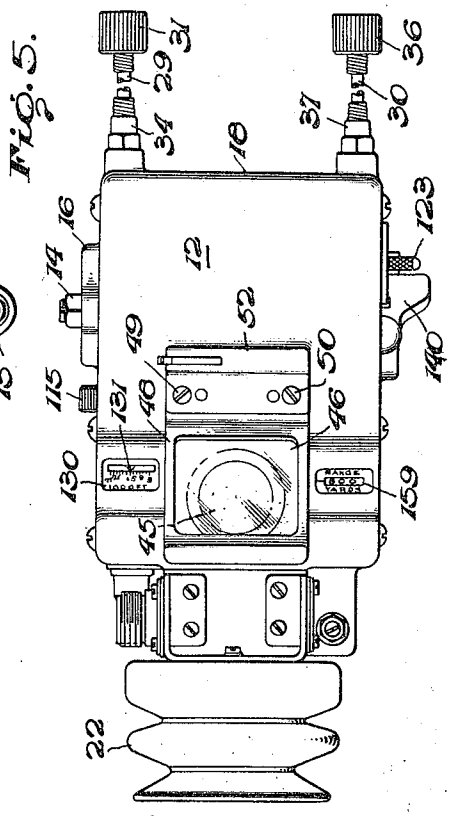
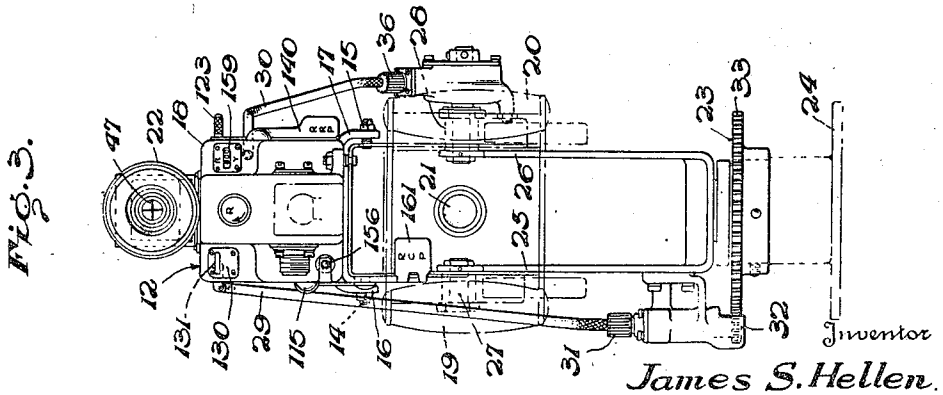


Fig. 3.



Inventor

James S. Hellen.

By Stephen Cerstvik

Attorney

July 24, 1951 J. S. HELLEN 2,561,924

GUN SIGHT

Filed Sept. 15, 1942 5 Sheets-Sheet 3

Fig. 6.

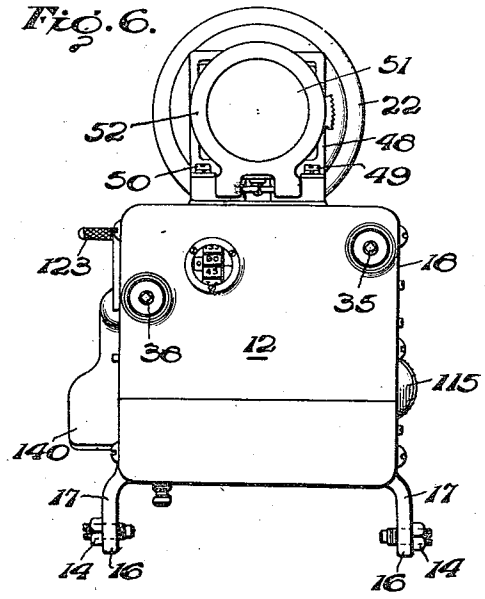


Fig. 8.

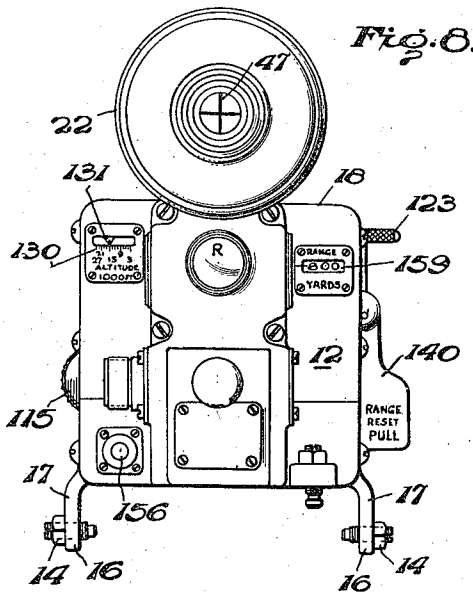
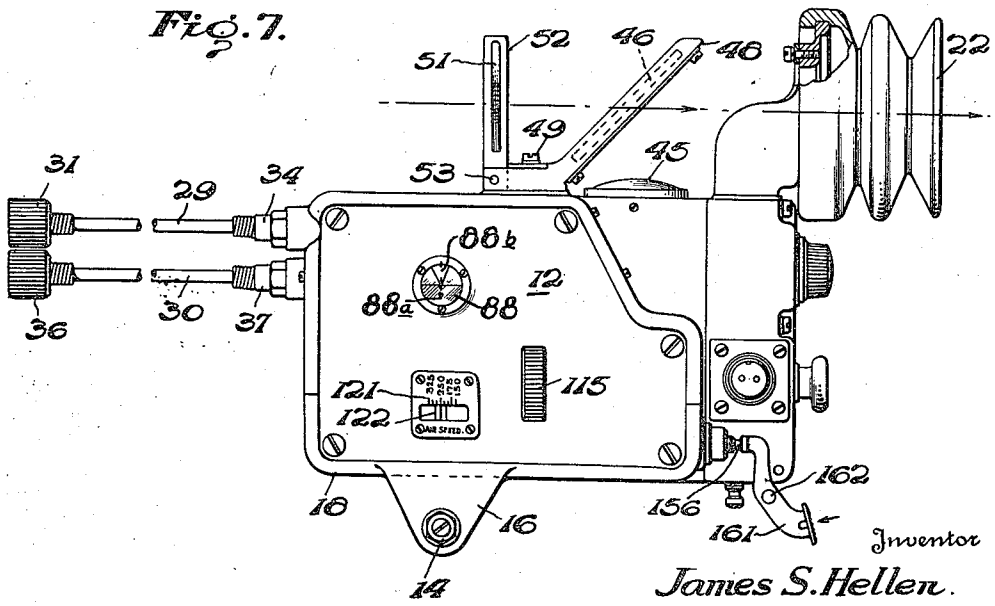


Fig. 7.



Inventor
James S. Hellen.

By Stephen Cerstvik
Attorney

July 24, 1951 J. S. HELLEN 2,561,924

GUN SIGHT

Filed Sept. 15, 1942 5 Sheets-Sheet 4

Fig. 9.

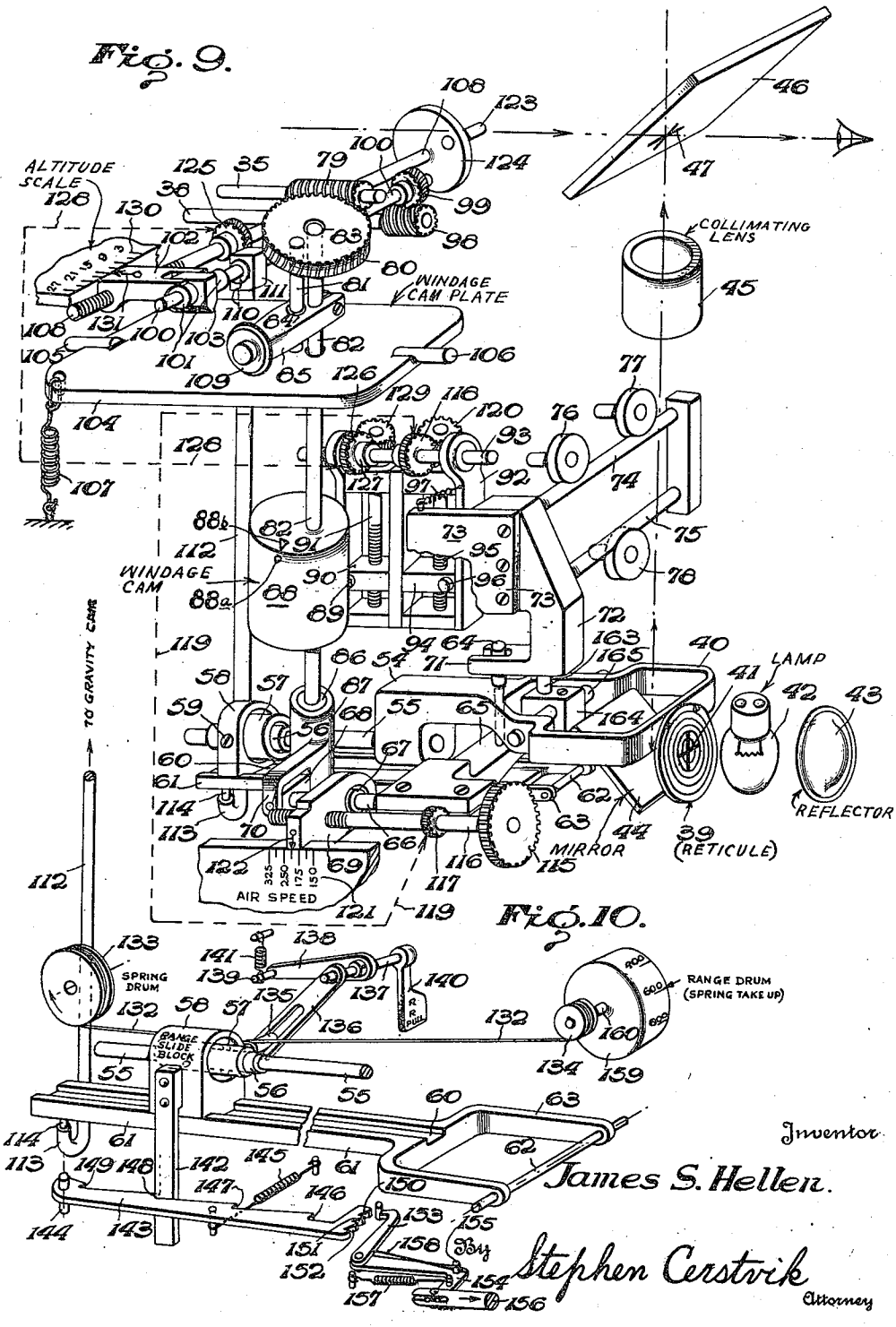


Fig. 10.

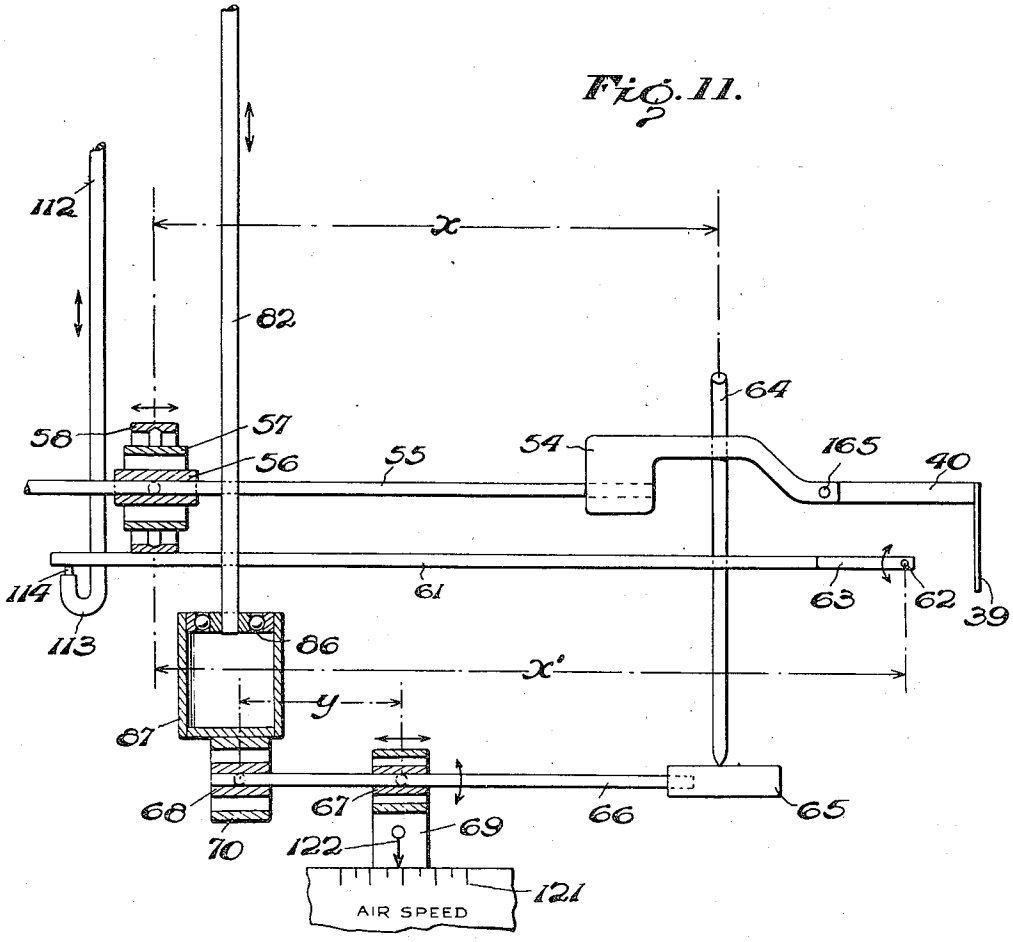
Inventor
James S. Hellen.
Stephen Cerstvik
Attorney

July 24, 1951 J. S. HELLEN 2,561,924

GUN SIGHT

Filed Sept. 15, 1942 5 Sheets-Sheet 5

Fig. 11.



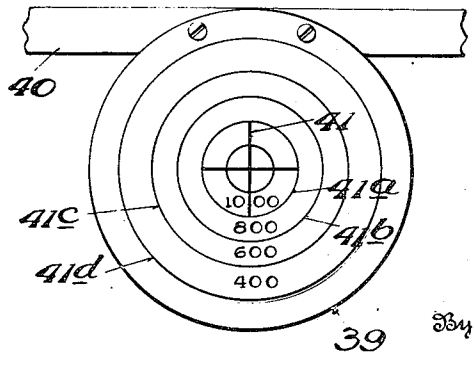


Fig. 12.

Inventor

James S. Hellen.

By Stephen Cerstvik

Attorney

Patented July 24, 1951 2,561,924

UNITED STATES PATENT OFFICE

2,561,924

GUN SIGHT

James S. Hellen, Ramsey, N. J., assignor to Bendix Aviation Corporation, Bendix, N. J., a corporation of Delaware

Application September 15, 1942, Serial No. 458,370

3 Claims. (Cl. 33—49)

1

The present invention relates to gun sights, and more particularly to a novel gun sight for machine guns or cannon mounted on aircraft, including novel means for compensating ballistic errors due to airspeed and altitude of the craft for all directions of firing at any one of a plurality of ranges of the target to be fired upon.

Heretofore, gun sights for aircraft machine guns or cannon have been provided having compensating means for compensating ballistic errors due to airspeed of the craft for different directions of firing, but only at one fixed range, and no means were provided for compensating ballistic errors due to changes in altitude of the craft. See, for example, the patent to Robert Alkan, No. 2,183,530, dated December 19, 1939.

Although such sights as that disclosed in the aforesaid Alkan patent adequately served their purpose and enabled the pilot or gunner to fire quite accurately at relatively low altitudes up to possibly 3000 feet and at a range of about 400 yards, they proved to be inadequate at ranges of 800 and 1000 yards and at different and relatively higher altitudes between 3000 and 27,000 feet at which modern bombing aircraft fly.

Accordingly, one of the objects of the present invention is to provide a novel ballistically compensated gun sight for aircraft machine guns or cannon, whereby the inadequacies and disadvantages of prior gun sights are overcome so as to provide much greater accuracy of firing in any direction at any airspeed or altitude of the aircraft and at any one of a plurality of ranges of the target.

Another object of the invention is to provide a novel aircraft gun sight capable of automatically correcting, for any direction of firing, ballistic errors due to the airspeed and the altitude of the craft and at several different ranges of the target.

Another object is to provide in an aircraft gun sight, novel means for producing the necessary aiming corrections of the gun by compensating, at several different ranges of the target, the ballistic errors caused by the airspeed and the altitude of the craft on which the gun is mounted, without changing the relative position of the gun sight with respect to the gun, so that the aim of the gun will be correct regardless of the airspeed or altitude of the craft or the range of the target.

A further object of the invention is to provide, in combination with an aircraft machine gun mounted for angular movement in azimuth and elevation, a novel gun sight of the collimator type adapted to be rigidly mounted on the gun for angular movement as a unit therewith in azimuth

2

and elevation, including means for correcting the aim of the gun for ballistic errors by moving an element such, for example, as the reticule of the optical system of the sight, vertically and laterally, in accordance with the angular movements of the gun in azimuth and elevation, and modifying the movement of said element for different airspeeds and altitudes of the aircraft and for different ranges of the target, whereby the accuracy of fire from the gun is much greater than with gun sights of types known heretofore.

Still another object is to provide, in combination with an aircraft gun mounted for angular movement in azimuth and elevation, a novel gun sight of the collimator type adapted to be rigidly mounted on the gun for angular movement as a unit therewith in azimuth and elevation, having an optical system including a reticule and means for forming an image of said reticule in the field of view in which the target is observed, and means for compensating the ballistic errors due to the airspeed and altitude of the aircraft by moving the image of said reticule in accordance with the angular movements of the gun in azimuth and elevation, and modifying the movements of said image for different ranges of the target and for different airspeeds and altitudes of the aircraft, whereby the aim of the gun is made accurate regardless of the airspeed or altitude of the craft and regardless of the distance of the target from the craft within several predetermined ranges.

A still further object of the invention is to provide, in an aircraft gun sight of the class described, novel means for compensating said sight for ballistic errors due to the airspeed and altitude of the aircraft, at several different ranges of the target, by moving the reticle of the sight vertically and laterally with respect to said sight in accordance with the angular movements of the gun in azimuth and elevation, modifying the vertical and lateral movements of said reticule for different airspeeds and altitudes of the aircraft, and further modifying the vertical movement of said reticule for different ranges of the target and for the effects of gravity on the bullet or shell fired from the gun, whereby the aim of the gun is made accurate regardless of airspeed, altitude or range.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein one embodiment of the invention is illustrated by way of

example. It is to be expressly understood, however, that the drawings are for purposes of illustration only and are not to be construed as defining the limits of the invention, reference being had for this purpose to the appended claims.

In the drawings, wherein like reference characters refer to like parts throughout the several views:

Fig. 1 is a side view, in elevation, of an aircraft machine gun mounted in a universal gun mount for angular movement in azimuth and elevation and having the gun sight of the present invention rigidly attached to the top thereof at the breech end;

Fig. 2 is a top plan view of the gun and gun sight shown in Fig. 1;

Fig. 3 is an end view of the gun and gun sight of Fig. 1, as viewed from the right of the latter figure and as seen by the gunner when firing the gun;

Fig. 4 is an enlarged side view, in elevation, of the gun sight of the invention without the gun, and gun mount;

Fig. 5 is an enlarged top plan view of the sight shown in Fig. 4;

Fig. 6 is an end view, in elevation, of the sight as viewed from the right hand end of Fig. 4;

Fig. 7 is another side view of the sight, in elevation, as viewed from the opposite side of that shown in Fig. 4;

Fig. 8 is another end view of the sight, in elevation, as viewed from the right hand end of Fig. 7;

Fig. 9 is an isometric view, more or less diagrammatic, of the internal mechanism of the sight embodying the present invention, with the range setting and re-setting portion thereof omitted;

Fig. 10 is another isometric view, also more or less diagrammatic, of the range setting and re-setting mechanism of the sight;

Fig. 11 is a diagram showing the pivot points and fulcrums about which vertical and lateral movement of the reticule takes place to provide ballistic compensation of the sight in accordance with the present invention; and

Fig. 12 is an enlarged view of the reticule.

Referring now to the drawings, the gun sight, indicated in general by the reference numeral **12**, is shown in Figs. 1, 2 and 3 as rigidly mounted on an aircraft machine gun **13** near the breech thereof by means of bolts **14** and **15** which pass through lugs or ears **16** and **17** of the casing **18** containing the internal mechanism of the gun sight. The gun **13** is provided with the usual grips or handles **19** and **20** by means of which the gun is aimed and held in firing position when on the target, the firing button or trigger being shown at **21** and located between the grips **19** and **20** so that it may be easily actuated by the gunner by pressing his left or right thumb thereon while firmly holding the grips **19** and **20** with his hands and while observing the target through the eyepiece **22** of the sight.

In order to provide for angular movement of the gun **13** in azimuth and elevation for aiming it at the target, the gun is mounted in a universal gun mount comprising a stationary horizontal circular platform **23** carried by a fixed support **24** which may be any fixed part of the aircraft on which the gun is carried. Mounted on the platform **23** for rotation thereon are a pair of spaced uprights or vertical arms **25, 26** which are adapted to rotate about the vertical axis of the craft, the gun proper being journalled in these uprights about a horizontal axis by means of suitable

bearings **27, 28** for angular movement in elevation.

In accordance with the invention, means are provided for transmitting the movements of the gun in azimuth and elevation, i. e. about the vertical axis and the transverse horizontal axis, to the internal mechanism of the gun sight to obtain corresponding movement of the image of the reticule for purposes of compensation, as will be explained hereinafter. In the form shown, said means comprise a pair of flexible shafts **29** and **30**, shaft **29** being connected at one end by means of a coupling **31** to a pinion **32** which meshes with and is driven by a gear **33** provided on the periphery of platform **23** when the pinion **32** is revolved about said gear **33** upon rotation of the gun **13** about the vertical axis on said horizontal platform **23**. The other end of flexible shaft **29** is connected by means of a coupling **34** to a driving shaft **35** (Fig. 9) of the internal mechanism of the gun sight **12**.

Shaft **30**, on the other hand, is connected at one end by means of a coupling **36** to a bevel gear and bevel gear shaft (not shown) driven by the movement of the gun **13** in elevation. The other end of shaft **30** is connected by means of a coupling **37** to a driving shaft **38** (Fig. 9) of the internal mechanism of the gun sight **12**.

Referring now to Fig. 9 of the drawings, the optical components and the internal mechanism, including the compensating means of the invention, comprise, as shown, a reticule consisting of a glass disc **39** attached to a vertically and laterally (horizontally) movable frame or carrier member **40**. One side of said glass disc is first silvered and painted and then cross lines **41** and range circles **41*a***, **41*b***, **41*c*** and **41*d*** (Fig. 12) are engraved on the treated surface so as to permit light rays from a suitable light source such as an electric lamp **42**, after reflection by a reflector **43**, to pass through said engraved cross lines in a horizontal direction and onto a reflecting surface such as a mirror **44** located in back of the reticule disc **39** just slightly below the reticule carrying frame or carrier member **40**.

The light rays which strike the reflecting surface **44** are reflected vertically upward into a collimator lens **45** which forms an image **47** of the reticule lines **41** and projects it onto the underside of a reflector plate **46** made of suitable transparent material such as polarized glass and placed in the line of sight of the observer so that the latter may view the target through said plate **46** and at the same time see the image **47** of the reticule cross lines **41** in the same field of view in the eye piece **22**.

The plate **46** is mounted in a frame **48** attached to the top of the casing **18** of the gun sight in any suitable manner as by means of a pair of screws **49, 50**, as shown in Figs. 4, 5 and 7. A rotatable polarized shade glass **51**, carried by a circular frame **52** pivoted at **53**, is positioned ahead of the plate **46** in the path of the light rays coming from the target so that the latter may be observed even when it is in the sun. Since the shade glass **51** is pivoted at **53** it may be lowered from the vertical position shown into a horizontal position parallel to the top of the casing **18** of the gun sight so as to be removed from the line of sight when there is no sun to produce glare, as at night, for example.

As shown in Fig. 9, the reticule frame **40** is attached to or formed integrally with a tail piece **54** having rigidly attached thereto a shaft or rod **55** which projects rearwardly of said tail piece. The projecting end of said shaft or rod **55** passes

through a sleeve 56 and is slidable therein, said sleeve 56 being pivoted inside of another sleeve 57 about a vertical axis so that said tail piece 54 and reticule frame 40 may move laterally in a horizontal direction to the left or right of the initial position shown. The sleeve 57 is, in turn, pivoted inside of another member 58 about a horizontal axis represented by the screw 59, so that said tail piece 54 and reticule frame 40 may move vertically up and down about said axis 59. Thus, the sleeves 56, 57 and member 58 form a universal mount providing a fulcrum point about which the frame 40 and, hence, the reticule 41 may be moved vertically and horizontally.

As shown in Figs. 9 and 10, the member 58 is in the form of a slide block mounted in a guide track 60 formed on the upper surface of a table 61 which is also pivoted at one end on a pivot shaft 62 by means of a fork 63 attached to or formed integrally with the table 61. The pivot shaft 62 is attached at its ends to the casing of the gun sight and is stationary, while the fork 63 and table 61 are adapted to rock about said stationary shaft as a pivot.

A vertical pin 64 is provided in and rigidly attached to the tail piece 54 so as to project from the top and bottom thereof, by means of which vertical and lateral movement may be imparted to the reticule frame 40 and, therefore, to the reticule 41 about the fulcrums formed by the sleeves 56, 57 and slide block 58.

In order to obtain vertical movement of the frame 40 and reticule cross lines 41, the bottom of the pin 64 is made to rest on a lift plate 65 extending transversely of and under said frame 40 and carried at an edge thereof by one end of a shaft or rod 66, the other end of which passes through a sleeve 67 slidable thereon and into a block 68 in which said end is rigidly secured. The lift plate 65 projects outwardly from the rod 66 in a direction at right angles thereto, said rod constituting the sole support for said lift plate.

The sleeve 67 is pivoted about a transverse horizontal axis in a vertical plate member 69 movable longitudinally of the shaft or rod 66 to provide a shiftable fulcrum about which the lift plate 65 may be rocked vertically up and down by actuating the rod 66 at its other end by means of a vertically movable bracket 70 within which the block 68 is also pivoted about a horizontal transverse axis in order to permit rocking movement of said rod 66 about the shiftable fulcrum provided by the pivoted sleeve 67 and plate member 69.

The lift plate 65 and the bottom of the pin 64 are maintained in engagement by means of a suitable spring (not shown) such as a C-shaped spring extending from the top of the tail piece 54 around the end of the latter and under the lift plate 65.

In order to obtain horizontal lateral movement of the reticule frame 40 and, hence, of the reticule cross lines 41, the top of the pin 64 is engaged by a fork 71 formed in the bottom of a reverse C-shaped laterally movable bracket 72 to the front side of which is attached a plate 73, the lateral horizontal movement of said bracket 72 being guided by means of a pair of round rods or guides 74, 75 projecting laterally from said bracket and engaging a pair of upper guide rollers 76, 77 and a lower guide roller 78, respectively. As the frame 40 is moved laterally by means of the pin 64 and bracket 72, the bottom of said pin slides along the top surface of the lift plate 65.

In accordance with the present invention means are now provided for obtaining lateral actuation of the frame 72 by means of the shaft 35 in accordance with the movement of the gun 13 in azimuth to obtain the desired movement of the reticule cross-lines 41 in azimuth. To this end, the azimuth shaft 35, which is driven by flexible shaft 29 upon movement of the gun 13 in azimuth, has attached thereto a worm 79 which meshes with and drives a worm gear 80 to which is rigidly secured a driving and guide pin 81.

The worm gear 80 is journalled on a vertical shaft 82 which is permitted to pass freely through a central opening 83 in the gear 80 in order that said shaft may be moved axially up and down while also rotating, for a purpose which will presently appear, and the drive and guide pin 81 passes vertically downward through an opening 84 provided in a driven arm 85 rigidly attached to the vertical shaft 82 to rotate the latter by means of said pin 81 upon rotation of the worm gear 80 by the worm 79 and azimuth shaft 35.

The other end of shaft 82 is journalled in a ball bearing 86 contained in a vertical cylindrical member 87 attached to or formed integrally with the bracket 73, whereby the latter may be moved up and down upon vertical movement of said shaft 82 and at the same time permit rotation of said shaft in the ball bearing 86.

Attached rigidly to and rotatable with the vertical shaft 82 is a so-called "windage" cam 88 which is eccentric of said shaft and bears against a follower pin 89 attached to a vertically movable plate 90 carried by a vertical threaded shaft 91 journalled in a rocking frame 92 pivoted on a horizontal shaft 93. The surface of the cam 88 is so shaped as to compensate for errors due to windage according to known ballistic tables. The initial position of cam 88 with reference to the fore and aft position of the gun is indicated by a zero mark 88a near the upper periphery of said cam, said mark 88a being visible through a circular opening provided in the side of the casing of the gun sight as shown in Fig. 7, and cooperating with a fixed index 88b provided at said opening.

Adjacent the vertically movable plate 90 is a second vertically movable plate 94 carried by another vertical threaded shaft 95 which is also journalled in the rocking frame 92, said second plate 94 having a pin 96 attached thereto which bears against the inner surface of the plate 73 carried by the laterally movable bracket 72. The pin 96 is maintained in engagement with the plate 73 by means of a suitable spring 97 one end of which is attached to the rocking frame 92 and the other end to the plate 73.

It will thus be seen that as the worm gear 80 is rotated by the worm 79 and azimuth shaft 35 in accordance with the movement of the gun 13 in azimuth, the pin 81 rotates the arm 85 and shaft 82, thereby rotating the eccentric windage cam 88. As said cam rotates, the rise and fall of its cam surface is followed by the follower pin 89 so that the latter is actuated in a direction away from or toward the axis of rotation of the shaft 82, thereby rocking the frame 92 about the shaft 93. Since the frame 92 is resiliently connected to plate 73, the latter will likewise be actuated laterally to move bracket 72 accordingly, thereby moving the reticule frame 40 and reticule cross-lines 41 laterally by means of the fork 71 and pin 64.

The amount of lateral movement of the follower pin 89 by the cam 88 for a given rise of the cam surface is varied in accordance with the vertical distance of said pin 89 from the shaft

93 as determined by the amount of rotation of the vertical shaft 91, the rotation of which causes vertical movement of the plate 90 and pin 89 longitudinally thereof. On the other hand, the amount of lateral movement of the bracket 72 by the plate 73 and, hence, of the reticule frame 40, is varied in accordance with the vertical distance of pin 96 from the shaft 93 as determined by the amount of rotation of the vertical shaft 95, the rotation of which causes vertical movement of the plate 94 and pin 96 longitudinally thereof.

For the purpose of obtaining vertical movement of the reticule frame or carrier member 40 and of the reticule 41 in accordance with the movement of the gun 13 in elevation, means are provided for actuating the lift plate 65 accordingly. To this end, the elevation shaft 38, which is driven by flexible shaft 30 upon movement of the gun in elevation, has attached thereto a worm 98 which meshes with a worm gear 99 secured to one end of a shaft 100, thereby rotating the latter. Also attached to said shaft 100 at the other end thereof and rotatable therewith is a cylindrical elevation cam 101 which is eccentrically mounted on said shaft and arranged for rotation inside of a cam rider 103 having an eccentric bore through which the cam 101 extends so that the cam rider may slide thereon longitudinally thereof by the action of a forked guide member 102, as will appear hereinafter, while said cam is being rotated in said cam rider by the shaft 100, said cam rider 103 being positioned between the two fingers of said forked guide member 102.

The cam rider 103 has on its under side a knife edge which bears against a "windage" cam plate 104 to rock the latter about its trunnions 105, 106 against the tension of a spring 107, one end of which is fixed and the other end of which is attached to said windage cam plate. Thus, as the shaft 100 is rotated by the worm 98 and worm gear 99 upon angular movement of the gun 13 in elevation, the cam plate 104 is rocked about its trunnions 105, 106 by the knife edge of the cam rider 103 by virtue of the rotation of the cam 101 in said cam rider due to the fact that said cam is eccentric of said shaft 100. The forked guide member 102 also has a threaded shaft 108 passing therethrough, which serves to cause longitudinal movement of said guide member and rider along the shaft 100 to vary the distance between the knife edge of the rider 103 and the pivot axis 105, 106 of the cam plate 104 for a purpose which will be described later.

This rocking movement of cam plate 104 is used to impart a lifting movement to the shaft 82 at the same time as the latter is rotated by means of worm 79 and worm gear 80 through the pin 81 and arm 82. For this purpose, the arm 85 is provided with a roller 109 at its outer end so that said roller rolls over the surface of the plate 104 as said arm rotates. If the plate 104 were always horizontal, no lifting of the shaft 82 would take place, but, as previously pointed out, said plate assumes various tilted positions about its trunnions 105, 106 due to its actuation by the cam 101 through cam rider 103. Accordingly, when the cam plate 104 is tilted, the arm 85 with its roller 109 will be lifted when the roller is rolling on the upwardly inclined portion of the cam plate and will be lowered when said roller is rolling on the downwardly inclined portion of said cam plate. Since the arm 85 is attached to the shaft 82, the latter will likewise be raised and lowered with said arm 85 and roller 109.

As the shaft 82 is moved vertically up and down, it lifts the bracket 70 to cause a rocking movement of the rod 66 about the fulcrum formed by the pivotal axis of the sleeve 67 in the plate member 69, thereby rocking the lift plate 65 to cause the latter to lift or lower the reticule frame 40 and reticule 41 by means of the pin 64 since the latter rests on said lift plate 65.

Means are also provided for modifying the vertical movement of the reticule 41 to correct for the action of gravity on the projectile fired by the gun. In the form shown, said means comprise a second and so-called "gravity" cam 110 which is also attached to the shaft 100 eccentrically thereof and is rotatable therewith inside of a block 111 having a central bore therethrough which is coaxial with the shaft 100, whereby said block is caused to rise and fall by the action of the cam 110 when the latter is rotated by the shaft 100.

Attached to the under side of said block 111 is a lift rod 112 which is curved at its lower end to form a hook 113 which engages a pin 114 provided at the bottom of the track table 61 near the outer end of the latter for lifting said table to impart thereto a rocking movement about its pivot shaft 62 upon vertical axial movement of said lift rod 112 due to its actuation by the gravity cam 110. Thus, the track table 61 and, hence, the slide block 58, is raised or lowered during rotation of the shaft 100 by the worm 98 and worm gear 99 during the elevation or depression of the gun 13.

The lifting and lowering of the track table 61 about its pivot 62 causes a rocking movement of the tail rod 55 by means of the slide block 58 carried by said table and, therefore, a rocking movement of the reticule frame 40 since the latter is attached to the tail rod, with the pin 64 acting as a fulcrum for such movement, thereby causing a vertical movement of the reticule 41 in such a manner that as the table 61 moves upward or downward, the reticule moves downward or upward, respectively, the extent of movement of the reticule being varied by varying the distance of the slide block 58 from the pin 64 for the purpose of correcting the gun sight for different ranges of the target, as will be explained hereinafter.

Pursuant to the objects of the present invention, means are now provided for producing the necessary aiming corrections of the gun with the use of the gun sight of the invention, by compensating the sight, at several different ranges of the target, for the ballistic errors caused by the airspeed and altitude of the aircraft on which the gun is mounted, without changing the relative position of the gun sight with respect to the gun on which it is mounted, so that the aim of the gun, when the reticule is on the target, will be correct regardless of the airspeed or altitude of the aircraft or the distance of the target from the gun within several predetermined ranges. In accordance with the illustrated embodiment of the invention, such means are constituted by three separate adjusting means for performing the following respective functions:

(1) Modifying the vertical and lateral movements of the reticule for different airspeeds of the aircraft;

(2) Modifying the vertical and lateral move-

ments of the reticule for different altitudes of the aircraft; and

(3) Modifying the vertical and lateral movements of the reticule for different ranges of the target.

Referring again to Fig. 9 of the drawing, the means for modifying the vertical and lateral movements of the reticule for different airspeeds, and, therefore, of its image in the field of view in which the target is observed, comprise, as shown, a manually rotatable knurled wheel or knob 115 secured to or formed integrally with a threaded shaft 116 engaging the vertical plate member 69 in a threaded opening therein, whereby, upon manual rotation of said threaded shaft 116 by the knob 115, said plate member 69 will be moved longitudinally along rod 66 which carries the lift plate 65, to thereby shift the fulcrum formed by the horizontal transverse pivot axis of the sleeve 67 within said plate member 69. It will be apparent, by reference to Fig. 11, that such shifting of this fulcrum, varies the distance between it and the bracket 70 which is the point at which the lifting movement is applied to the rod 66 by the shaft 82, thereby varying the vertical movement of the lift plate 65 and, hence, of the reticule frame 40 and reticule 41, about said fulcrum, for a given vertical movement of the shaft 82 as determined by the amount of tilt of the cam plate 104 caused by the cam 101 and cam rider 103 upon rotation of the shaft 100 during movements of the gun in elevation.

Mounted on and rotatable with the manually operated shaft 116 is a pinion 117 which is drivably connected, either directly or through intermediate gears, to a worm gear 118 secured to the rotatable shaft 93 on which the frame 92 is pivoted, for rotating said shaft 93 simultaneously with the manual rotation of shaft 116. This driving connection is shown diagrammatically in Fig. 9 by the dotted line 119. The actual connection (not shown) between pinion 117 and worm gear 118 consists of a shaft having a worm at each end thereof and so arranged and located that one worm is engaged by pinion 117 and the other worm engages and drives worm gear 118.

The worm gear 118 meshes with and drives another worm gear 120 which is secured to the rotatable threaded shaft 95 for rotating the latter, thereby causing the plate 94 and pin 96 to move vertically up and down to vary the distance of said pin 96 from the shaft 93. It will be seen that this distance constitutes the lever arm for the point at which the pin 96 applies the lateral pivotal movement of the frame 92 to the plate 73 and bracket 72, and if the lever arm is long, a greater lateral movement will be imparted to the frame 72 and, hence, to the reticule frame 40 and reticule 41, than when said lever arm is short, for a given pivotal lateral movement of the frame 92 caused by the rotation of cam 88 and shaft 82 during angular movement of the gun in azimuth.

The longitudinal movement of the plate member 69 along the rod 66 is calibrated in terms of airspeed of the craft on which the gun and gun sight are mounted, i. e., for a given airspeed, the plate member 69 is moved a certain predetermined amount and for another and different airspeed, said plate member is moved a different amount. The vertical movement of the plate 94 and pin 96 is also calibrated in like manner so that for different airspeeds, the pin 96 will be at different distances from the shaft 93. The plate 94 and pin 96 move downward for increasing airspeed and upward for decreasing airspeed. The

airspeeds for which the calibrations are made are indicated on a fixed scale 121 by means of a suitable arrow 122 provided on the outer vertical edge of the plate member 69. In the present embodiment, the calibrations are made for airspeeds from 150 to 325 miles per hour.

The manually operated wheel or knob 115 is made accessible to the pilot or gunner from the exterior of the casing 18 of the gun sight, namely, on the left side of the casing when the operator is looking through the gun sight, as shown in Figs. 1, 2, 3, 5, 6, 7 and 8. Likewise, the scale 121 and pointer 122 are made visible from the exterior of the casing on the same side thereof, as shown in Figs. 1 and 7.

Thus, the vertical and lateral movements of the reticule 41 caused by movements of the gun in elevation and azimuth are modified for different airspeeds of the craft to compensate for ballistic errors in elevation and azimuth produced at such airspeeds.

The means for further modifying the vertical and lateral movements of the reticule for different altitudes comprise, in the form shown, a crank consisting of a manually operable handle 123 near the periphery of a wheel 124 attached to the threaded shaft 108 which threadedly engages the cam rider 103, whereby, upon manual rotation of said threaded shaft 108, the cam rider 103 is caused to move longitudinally along said shaft and along the shaft 100 since rotation of said rider with the shaft 108 is prevented by the shaft 100.

It will be seen that the longitudinal movement of the cam rider 103 varies the distance of the knife edge from the axis of trunnions 105, 106 of the cam plate 104, thereby varying the amount of tilt of said cam plate about its trunnions for a given amount of vertical movement imparted to the cam rider 103 by the cam 101 and shaft 100 during angular movement of the gun in elevation. For example, if the knife edge is nearer the axis of the trunnions, the tilt of the cam plate 104 will be greater for a given vertical movement of the rider 103 by the cam 101, than when said knife edge is further away from said axis.

Also attached to and rotatable with the manually operable threaded shaft is a pinion 125 which is drivably connected, either directly or through intermediate gears, to a worm gear 126 provided on and secured to a sleeve 127 through which the shaft 93 passes freely, whereby said gear 126 is caused to rotate simultaneously with the rotation of pinion 125 upon manual actuation of the threaded shaft 108 by the crank handle 123 and wheel 124. The driving connection between the pinion 125 and worm gear 126 is shown diagrammatically by the dot-dash line 128. The actual connection (not shown) between pinion 125 and worm gear 126 consists of a shaft having a worm at each end thereof and so arranged and located that one worm is engaged by pinion 125 and the other worm engages and drives worm gear 126.

The worm gear 126 meshes with and drives another worm gear 129 which is secured to the vertical threaded shaft 91 for rotating the latter, whereby vertical movement along said threaded shaft is imparted to the plate 90 and the follower pin 89 which rides on the cam surface of the cam 88, rotation of said plate 90 by said shaft 91 being prevented by means of guides (not shown) formed on the side edges thereof. Pin 89 and plate 90 move downward for increasing altitude and upward for decreasing altitude.

From the foregoing it will be seen that the ver-

tical movement of the plate 90 and follower pin 89 along the threaded shaft 91 varies the distance between said pin and the shaft 93 on which frame 92 is pivoted for lateral movement, said distance being the lever arm of the point at which the lateral movement is imparted to said frame 92 by the rotation of cam 88 and shaft 82 during angular movement of the gun in azimuth. Thus, for a given amount of rotation of cam 88, i. e., for a given position of the gun in azimuth, the amount of lateral movement of the frame 92 by the cam 88 will be greater when the distance between the pin 89 and shaft 93 is shorter than when said distance is greater. As previously pointed out, this lateral movement of the frame 92 is imparted to the frame 72 through the pin 96 and plate 73 and, therefore, to the reticule frame 40 and reticule 41 by means of the pin 64.

The rotation of the threaded shafts 108 and 91 is calibrated in terms of thousands of feet altitude so that for a certain altitude the cam rider 103 and the pin 89 will be moved certain predetermined amounts and for other altitudes said rider and pin will be moved correspondingly different predetermined amounts to correct the ballistic errors produced at such altitudes. The altitudes for which the calibrations are made are indicated on a fixed scale 130 by means of a suitable pointer or arrow 131 provided on the cam rider 103. In the present embodiment the calibrations are made for altitudes from 3000 to 27,000 feet.

The crank handle 123 for manually rotating the shaft 108 is made accessible to the pilot or gunner from the exterior of the casing 18 of the gun sight on the right hand side thereof when the pilot or gunner is looking through the sight, as shown in Figs. 2, 3, 4, 5, 6 and 8.

Likewise, the altitude scale 130 and pointer 131 are made visible from the exterior of the casing 18 of the gun sight at the left of the front end of the sight when the operator is at the eye-piece of said sight, as shown in Figs. 3, 5 and 8 of the drawings.

Thus, the vertical and lateral movements of the reticule 41 caused by movements of the gun in elevation and azimuth are further modified for different altitudes of the aircraft to compensate for ballistic errors in elevation and azimuth produced at such altitudes.

The means for still further modifying the vertical and lateral movements of the reticule for different ranges of the target are shown diagrammatically in Fig. 10. As illustrated, said means comprise, in the form shown, a wire or relatively thin cable 132 having one end attached to a rotatable drum 133 and its opposite end to a second rotatable drum 134. Both of said drums are biased by internal coil springs (not shown) and in angular directions such that when the wire or cable 132 is pulled to the right by hand, as viewed in Fig. 10, the coil spring in drum 133 will be wound up and the one in drum 134 will become unwound, and when the manual pull on the wire or cable 132 is released, the wound spring in drum 133 will automatically pull said wire to the left, thereby winding the cable on said drum 133 and unwinding it from drum 134 while, at the same time, winding up the spring in drum 134.

Also, the spring of drum 133 is made stronger than the spring of drum 134 so that the latter acts merely as a take-up drum for taking up the slack in wire 132 as the latter is manually pulled to the right, while the drum 133 functions as a driving drum to pull the wire back to the left when the manual pull thereon to the right is released.

The above-described action of the drums 133 and 134 is utilized to slide the range slide block 58 along its track 60 on the table 61 to vary the distance between the pin 64 and the fulcrum provided by the transverse horizontal pivot axis of sleeve 56 in the member 57, thereby varying the amount of vertical rocking movement of the reticule frame 40 and reticule 41 about the pin 64 as a fulcrum for a given amount of lift of the table 61 by the hook 113 of the lift rod 112 during angular movement of the gun in elevation, and also varying the amount of both lateral and vertical movements of the reticule frame about the fulcrums provided in the members 58 and 57. For this purpose, one or two turns of the wire or cable 132, intermediate the ends thereof, are wound around a pin 135 which projects from one side of the range slide block 58, so that when said wire or cable is manually pulled to the right against the tension of the coil spring of drum 133, said range slide block will be moved to the right along its track 60 and the slack in the wire will be taken up by the take-up drum 134, and when the manual pull to the right is released, the range slide block will be moved to the left by the force of the spring of drum 133. The distance between the pin 64 and the fulcrum provided by the transverse horizontal pivot axis of sleeve 56 in member 57 (distance X in Fig. 11) is decreased for increased range and increased for decreased range.

In order to facilitate the manual manipulation of the wire 132 for moving said range slide block 58, the pin 135 is arranged to be engaged by and between the ends of a forked member 136 which is pivotally mounted on a shaft 137 for angular movement thereon. Rigidly attached to and rotatable with said shaft 137 is an arm 138 having a pin 139 at its end for engaging the forked member 136 when said shaft is rotated in a counterclockwise direction, as viewed in Fig. 10, by means of a manually operable lever 140 attached to the other end of said shaft 137. A coil spring 141 is provided for opposing the movement of the arm 138 upon rotation of the shaft 137 by the manually operable lever 140, one end of said spring being fixed and its other end being attached to the pin 139, so that when the lever is pulled to the right to actuate the arm 138 into engagement with the forked member 136 against the tension of said spring, the latter will pull said arm 138 away from the forked member 136 after the lever 140 has been released.

From the foregoing it will be seen that as the manually operable lever 140 is pulled to the right, the range slide block 58 will be moved to the right along its track 60 against the pull of the spring of drum 133, and when the lever is released, the pull of said spring will move the slide block 58 to the left.

Means are provided for controlling the movement of the range slide block 58 and to stop it at predetermined points along the track 60 so that the amount of vertical and lateral movement of the reticule will be different at different positions of said slide block for the same increment of vertical movement of the table 61 by the lift rod 112, and of the lift plate 65 by shaft 82, and for the same increment of lateral movement of the frame 72 by cam 88, each position representing a different range of the target. In the form shown, said controlling means com-

prise a downwardly extending tail member 142 attached to the opposite side of said block and arranged to be engaged by a notched arm 143 which is pivoted at one end thereof at 144 and urged into engagement with said tail member 142 by means of a spring 145 having one end thereof fixed and its other end attached to said notched arm 143.

In the present embodiment, the notched arm 143 is shown as having four notches 146, 147, 148 and 149 along its inner edge for sequentially engaging the tail member 142 and stopping the block 58 as it is moved to the left by the spring of drum 133. The other end of the notched arm 143 is provided with a set of three notches 150, 151 and 152 aligned in a direction transversely of the length of said arm and arranged for successive engagement by a pawl 153 pivoted on one end of a bell-crank 154 which, in turn, is pivoted at 155, the other end of said bell-crank having a pull-rod 156 attached thereto for actuation of said pawl 153 and bell-crank 154 against the tension of a spring 157 one end of which is fixed and its other attached to the bell-crank. A leaf spring 158 is also provided for biasing the pawl 153.

To operate the range setting mechanism, the lever 140 is manually pulled to the right as far as it will go, thereby moving the range slide block 58 against the pull of the spring of drum 133 until the tail member 142 of said slide block is engaged by the notch 149 of arm 143. This position of the slide block represents the maximum range which, in the present instance, is 1000 yards. The lever 140 is then released, but the slide block will be held in its reset position by means of the arm 143. To move the slide block to the left to its next position to establish the next lower range of say 800 yards, the pull rod 156 is pulled to the right to actuate the bell-crank 154, which brings the pawl 153 into engagement with the notch 150 at the end of the arm 143 and pushes said arm away from the tail member 142 just enough to permit the slide block to move to the left by the action of drum 133 until the tail member 142 strikes the notch 147. The set range will now be 800 yards.

If the pull rod 156 is actuated two more successive times, the slide block will be moved to its next two successive positions represented by the notches 148 and 149 on the arm 143, said two positions representing, in the present instance, ranges of 600 and 400 yards, respectively.

The ranges for which the movement of the range block 58 is calibrated are indicated on a drum dial 159 attached to and rotatable with a shaft 160 to which the drum 134 is also attached.

The range re-setting lever 140 is made accessible to the pilot or gunner from the exterior of the casing 18 of the gun sight on the right hand side of said casing, as shown in Figs. 2, 3, 4, 5, 6 and 8.

The pull-rod 156 is also made accessible for actuation from the exterior of the casing at the lower left front of the latter, as shown in Figs. 1, 3, 7 and 8, and in order to facilitate the actuation of said pull-rod 156 while the gun is held by means of the handles or grips 19 and 20, a bell-crank 161 is provided which is pivoted at 162 and has one end thereof connected to the pull-rod 156 (Figs. 1 and 7), the other end being arranged for actuation by pushing thereon with the thumb of the left hand by which the grip 19 is held.

The range drum 159 is also made visible from the exterior of the casing of the gun sight at the upper right hand corner of the front of the casing as shown in Figs. 3, 5 and 8.

Thus, the vertical and lateral movements of the reticule 41 caused by the angular movements of the gun in elevation and azimuth, are further modified in accordance with the range of the target to be fired upon, thereby correcting the ballistic errors regardless of the distance of the target from the gun within certain predetermined ranges such, for example, as 400 yards, 600 yards, 800 yards and 1000 yards.

In order to stabilize the lateral and vertical movements of the reticule frame 40 and reticule 41, the frame 72 has a vertical pin 163 attached thereto at the bottom thereof projecting downwardly into a block 164 and slidably movable up and down therein, said block being attached to a rod 165 which slides at its ends in the frame 40.

For a clearer understanding of what fulcrums are affected by movement of the airspeed slide 69 and range slide 58, reference is especially made to Fig. 11 wherein x is the distance varied between pin 64 and the fulcrum within the slide block 58, x' is the distance varied between pivot 62 of table 61 and said fulcrum, and y is the distance varied between the fulcrum in slide 69 and the fulcrum in member 70.

There is thus provided a novel aircraft gun sight capable of automatically correcting, for any direction of firing, ballistic errors due to the airspeed and the altitude of the aircraft and at several different ranges of the target, whereby the aim of the gun is made accurate regardless of the airspeed or altitude of the craft and regardless of the direction of the target with respect to the aircraft or the distance of the target within several predetermined ranges.

Although only one embodiment of the invention has been illustrated and described by way of example, various changes in the construction, form and relative arrangement of the parts, which will now become apparent to those skilled in the art, may be made without departing from the scope of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

I claim:

1. Sighting means for a gun mounted on an aircraft for movement in azimuth and in elevation, sighting means comprising an optical system including a reticule and means for forming an image of said reticule in the field of view in which the target is observed, an adjustable universal fulcrum, a carrier member carrying said reticule and pivotally mounted on said adjustable universal fulcrum for vertical and lateral horizontal rocking movements about said fulcrum to impart corresponding movements to said reticule, a pin attached to said carrier and extending above and below the same, laterally movable means engaging the top of said pin for moving said carrier laterally about said fulcrum, means responsive to the movement of said gun in azimuth for actuating said laterally movable means, a lift plate mounted on a second adjustable fulcrum for vertical rocking movement about the same, said lift plate being positioned beneath said carrier with the bottom of the pin resting thereon, whereby vertical movement of said lift plate is imparted to said carrier and reticule, means responsive to the movement of said gun in elevation for actuating said lift plate, manually operable

means for adjusting the fulcrum of said lift plate and for simultaneously adjusting the movement of said laterally movable means for different airspeeds of the aircraft, second manually operable means for adjusting the universal fulcrum of said reticule carrier for different ranges of the target, means responsive to the movement of said gun in elevation for moving the universal fulcrum of said reticule carrier vertically and including means for modifying said movement for the effects of gravity on the projectile fired from said gun, and third manually operable means for adjusting the vertical movement of said lift plate and for simultaneously further adjusting the lateral movement of said laterally movable means for different altitudes of said aircraft, whereby said reticule is moved laterally and vertically in coordination with the movement of said gun in azimuth and elevation and its movements are modified for different airspeeds and altitudes of the aircraft and for different ranges of the target.

2. Sighting means for a gun mounted on an aircraft for movement in azimuth and in elevation, said sighting means comprising an optical system including a reticule and means for forming an image of said reticule in the field of view in which the target is observed, an adjustable universal fulcrum, a carrier member carrying said reticule and pivotally mounted on said adjustable universal fulcrum for vertical and lateral horizontal rocking movements about said fulcrum to impart corresponding movements to said reticule, a pin attached to said carrier and extending above and below the same, laterally movable means engaging the top of said pin for moving said carrier laterally about said fulcrum, means responsive to the movement of said gun in azimuth for actuating said laterally movable means, a lift plate mounted on a second adjustable fulcrum for vertical rocking movement about the same, said lift plate being positioned beneath said carrier with the bottom of said pin resting thereon, whereby vertical movement of said lift plate is imparted to said carrier and reticule, means responsive to the movement of said gun in elevation for actuating said lift plate, manually operable means for adjusting the fulcrum of said lift plate and for simultaneously adjusting the movement of the laterally movable means for different airspeeds of the aircraft, and second manually operable means for adjusting the universal fulcrum of said reticule carrier for different ranges of the target, whereby said reticule is moved laterally and vertically in coordination with the movement of said gun in azimuth and elevation and its movements are modified for different airspeeds of the aircraft and for different ranges of the target.

3. Sighting means for a gun mounted on an aircraft for movement in azimuth and in elevation, said sighting means comprising an optical system including a reticule and means for forming an image of said reticule in the field of view in which the target is observed, an adjustable universal fulcrum, a carrier member carrying said reticule and pivotally mounted on said adjustable universal fulcrum for vertical and lateral horizontal rocking movements about said fulcrum to impart corresponding movements to said reticule, a pin attached to said carrier and extending above and below the same, laterally movable means engaging the top of said pin for moving said carrier laterally about said fulcrum, means responsive to the movement of said gun in azimuth for actuating said laterally movable means, a lift plate mounted on a second adjustable fulcrum for vertical rocking movement about the same, said lift plate being positioned beneath said carrier with the bottom of said pin resting thereon, whereby vertical movement of said lift plate is imparted to said carrier and reticule, means responsive to the movement of said gun in elevation for actuating said lift plate, manually operable means for adjusting the fulcrum of said lift plate and for simultaneously adjusting the movement of the laterally movable means for different airspeeds of the aircraft, second manually operable means for adjusting the universal fulcrum of said reticule carrier for different ranges of the target, and third manually operable means for adjusting the vertical movement of said lift plate and for simultaneously further adjusting the lateral movement of said laterally movable means for different altitudes of said aircraft, whereby said reticule is moved laterally and vertically in coordination with the movement of said gun in azimuth and elevation, and its movements are modified for different airspeeds and altitudes of the aircraft and for different ranges of the target.

JAMES S. HELLEN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,067,859	Bacon et al.	July 22, 1913
1,481,248	Sperry	Jan. 15, 1924
2,183,530	Alkan	Dec. 19, 1939
2,399,726	Doyle et al.	May 7, 1946
2,408,681	Pontius et al.	Oct. 1, 1946

OTHER REFERENCES

Coast Artillery Field Manual, pages 11 to 13, Vol. II, Antiaircraft Artillery, Part 2, Technique (1933).

Certificate of Correction

Patent No. 2,561,924 July 24, 1951

JAMES S. HELLEN

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 14, line 53, before "sighting" insert *said*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of October, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

Certificate of Correction

Patent No. 2,561,924 July 24, 1951

JAMES S. HELLEN

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 14, line 53, before "sighting" insert *said*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of October, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.