Jan. 8, 1946. H. C. VAN AUKEN 2,392,436

LOW ALTITUDE BOMBSIGHT

Filed July 26, 1939 2 Sheets-Sheet 1

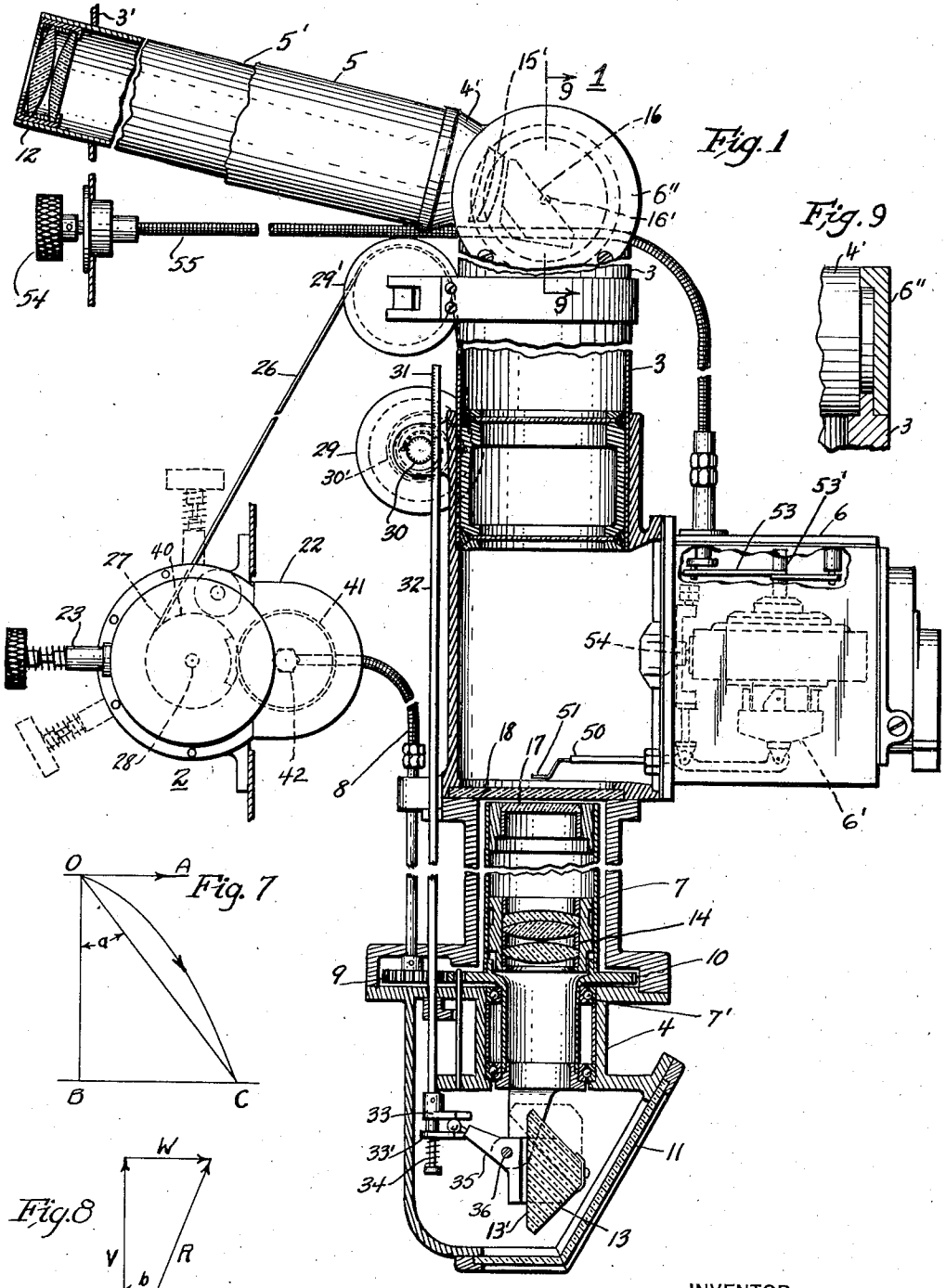


Fig. 1

Fig. 9

Fig. 7

Fig. 8

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Fig. 4

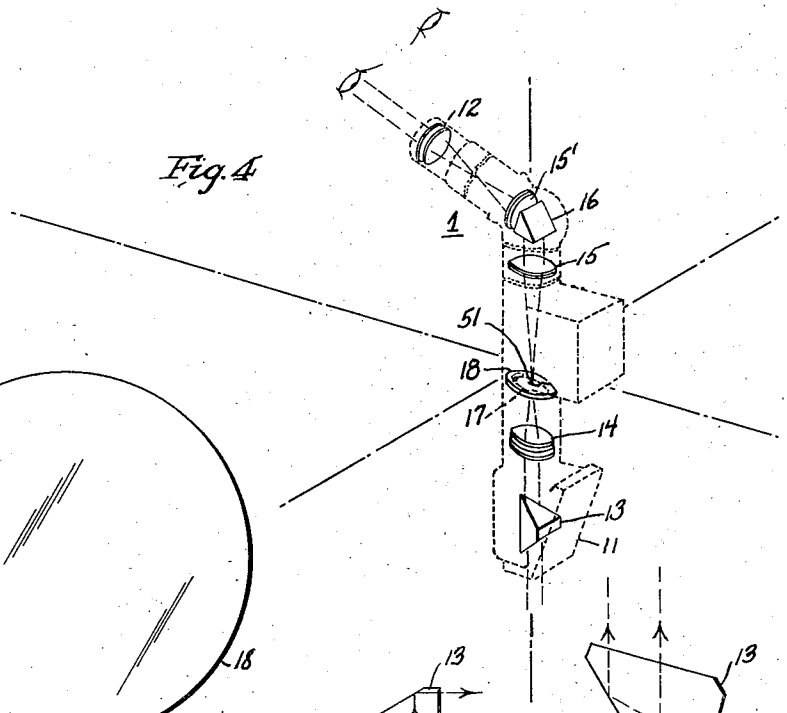


Fig. 6

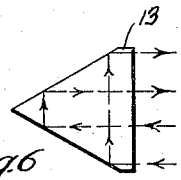


Fig. 5

Fig. 3

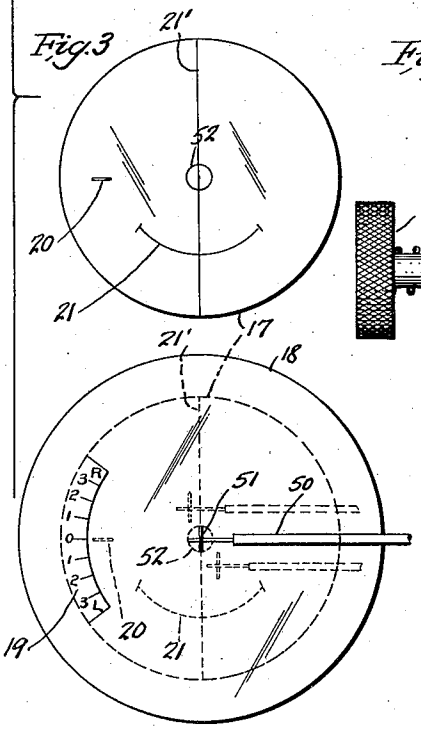
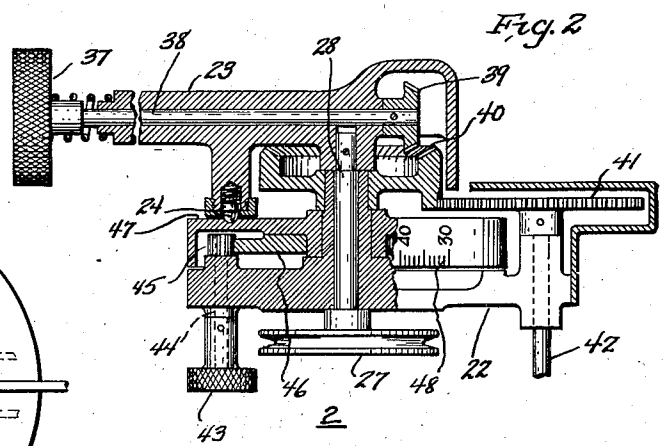


Fig. 2



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LOW ALTITUDE BOMB SIGHT

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Application July 26, 1939, Serial No. 286,535

6 Claims. (Cl. 88—1)

This invention relates to sighting devices such as are used in the dropping of bombs or other objects from aircraft and it refers, more particularly, to bomb sights adapted for low altitude bombing which can be operated by the pilot of the craft without assistance.

Sighting devices designed primarily for high altitude service are unsuitable for use on fast low flying craft because of the rapid angular displacement of the line of sight which makes necessary a larger angle of view and higher tracking speeds than are usually provided for in instruments of this type, while at low altitudes the short time of flight of the bomb or other object makes unnecessary many features of a sight designed for use at higher altitudes. Furthermore, when simultaneous guidance of the craft and operation of the sighting device by one person is required, as in single seater military planes, the manipulation and adjustment of the device must be reduced to a minimum and the necessary indications for flight control must be visible at the same time that the target is being observed.

In the present invention these requirements are met by providing a sighting telescope having an objective with a large angle of view and a relatively large eye piece through which the pilot may look with one eye placed at some distance therefrom while observing flight instruments with the other eye. As a further aid to piloting the craft while tracking a target, there is provided as a part of the sighting device a gyroscopically stabilized index whose relative position with respect to a cooperating marking in the reticle of the telescope gives an indication of the attitude of the craft in the same field in which the target image appears.

A simplified control unit for manipulating the sighting device is provided in which are united the means for presetting the range angle and for compensating for drift of the craft as well as a tracking handle, thereby positioning all sighting controls for convenient operation with one hand, and leaving the other hand free for guiding the craft.

One object of this invention is to provide simplified control for a bomb sight which may be operated with one hand.

Another object is to provide a bomb sight suitable for use at low altitudes which is adapted for rapid tracking and has a large field of view.

A further object is to provide a bomb sight providing an indication of the attitude of the craft on which the same is mounted.

Still another object is to provide a bomb sight in which the range angle may be preset so that no adjustment is required at or near the time the bomb is released.

Other objects and advantages of this invention will become apparent as the description proceeds.

Referring to the drawings,

Fig. 1 is an elevation, partly in section, of the sighting telescope of the present improved form of bomb sight.

Fig. 2 shows in detail the control unit and adjustments thereon.

Fig. 3 shows separately and in combination the reticle disc of the telescope and a cooperating transparent disc on which an angular drift scale is engraved.

Fig. 4 is a diagram illustrating the path of light rays through the optical system of the sighting telescope and shows the alignment of this telescope with respect to the three axes of the craft.

Figs. 5 and 6 show the path of light rays in two planes through one of the prisms of the optical system.

Fig. 7 is a diagram illustrating the downward path of an object dropped from a moving craft.

Fig. 8 is a diagram illustrating the action of a cross wind in causing an aircraft to drift.

Fig. 9 is a partial section along the line 9—9 of Fig. 1.

The sighting apparatus comprises an elbow telescope to which reference number 1 is generally applied and a control unit which may be mounted remote therefrom and to which reference numeral 2 is generally applied. Telescope 1 comprises a substantially tubular housing 3 constructed in several sections at the lower end of which is mounted window housing 4 mounting window 11 through which the target is observed, said window facing forward and downward, the emergent line of sight of the telescope being preferably in a plane perpendicular to the craft's lateral axis. At the upper end of housing 3 and rotatably mounted thereon is tubular member 5 within which slides a second tubular member 5', the two said members forming a tube of adjustable length whose axis is at an angle with that of housing 3. Member 5' projects through and is supported by the instrument panel 3' of the airplane and the sight as a whole is stationary relative to the craft, tracking being accomplished by positioning one of the optical members of the telescope. Housing 6 attached to tubular housing 3 mounts a stabilizing gyroscope.

Within tubular housing 3 and coaxial therewith is lens mounting 7 of tubular form mounted for rotation on anti-friction bearings 7' seated in window housing 4. The rotation of mounting 7 is controlled by the rotation of flexible shaft 8 on one end of which is mounted pinion 9 engaging gear teeth 10 cut on a flange of mounting 7. The amplitude of this rotation is approximately 60° which allows a rotation of 30° to either side of a central position. For initially adjusting the sight to fit the structure of a particular airplane the angular position of tube 5, 5' is adjustable by virture of its rotatable mounting on housing 3, pref-

erably through an arc of approximately 15° with respect to the axis of tubular housing 3 in the plane of the axes of the two members which is the vertical plane through the fore and aft axis of the craft. The rotatable mounting of tube 5 which has been referred to, may be carried out by the use of any suitable type of swinging connection between tube 5 and tubular housing 3. A preferred construction is seen in the sectional view of Fig. 9, wherein an end portion 4' of tube 5 is shown journaled on a split extension of housing 3 formed by a removable front plate 6'' fastened by screws to the body of the housing and a similar rear plate (not shown in the figure) integral with the housing. The range of adjustment may be limited by the form of the swiveling members and connection to the aircraft structure may be utilized to hold the members in the set angular relationship. Said limited angular adjustment of tube 5, 5' and the adjustment provided by sliding member 5' within member 5 allows eye piece 12 to be adjusted to a convenient location relative to the pilot's position in different aircraft.

The optical system of telescope 1 comprises a roof prism 13 rotatably mounted on an extension of lens mounting 7 for displacement about a normally horizontal axis, an object lens 14 in said mounting, said prism and lens rotating with the mounting about a normally vertical axis, a pair of erecting lenses 15 and 15' mounted within tubular housing 3 (lens 15 not shown in Fig. 1), direction changing prism 16 mounted on the same member and eye piece 12 mounted within member 5'. Prism 16 is preferably mounted on pivots 16' to permit a limited angular adjustment about the swinging axis of member 3, it being known that an adjustment of the elbow angle of an elbow telescope or like device requires a corresponding change of position of the elbow prism for purposes of collimation. Means (not shown) may be provided for making such adjustment, one form of which is to be found in the patent to Akeley #1,310,776, dated July 22, 1919. At the focal plane of objective 14 is located reticle disc 17 mounted in lens mounting 7, while directly above it a transparent glass disc 18 is mounted on tubular member 3, said disc bearing on its lower side drift scale 19 readable on index 20 of the reticle, the proximity of scale and index tending to reduce the error due to parallax. On the reticle disc there is an arcuate range mark 21 for determining the position of bomb release and a course line 21'.

Control unit 2, shown more particularly in Fig. 2, comprises a housing 22 adapted for convenient mounting on the frame of the craft adjacent the pilot's position, and carries rotatably mounted tracking handle 23. A detent for handle 23 is provided by spring loaded ball 24 in cooperation with a spherical indentation in the web of range dial 47. The rotation of tracking handle 23 is transmitted to telescope 1 for tilting prism 13 by flexible cable 26 attached to and passing over pulley 27 mounted on shaft 28, said shaft being pinned into and rotating with tracking handle 23. At the telescope, cable 26 passes over idler pulley 29' and is attached to pulley 29 mounted for rotation on tubular housing 3, a flat spiral spring 30' acting on said pulley to maintain cable 26 taut. Mounted for rotation with pulley 29 is pinion 30 engaging rack 31 on push rod 32. Rod 32 carries at one extremity a pair of guide members 33, 33', member 33 being pinned to rod 32 while member 33 is axially slidable thereon in response to pressure exerted by spring 34. Between said two guide members lies the ball-shaped end of prism tilting lever 35 pivoted at 36 on an extension of lens mounting 7 for tilting prism 13 about a normally horizontal axis through an arc of approximately 45° to provide a tilt of the line of sight in a vertical plane as hereinafter described, said prism being free to rotate in a horizontal plane, that is, about a vertical axis, without changing the angle of tilt. It will be recognized by those skilled in the art that, because of the known form and optical properties of roof prisms, the maintenance of this constant tilt of the line of sight while the prism is rotated horizontally requires that the roof line of the prism be parallel to or intersect the axis of rotation and that this axis be substantially coincident with the axis of collimation of the vertical portion of telescope 1, that is, the prism roof must remain at all times in a plane which includes the axis of collimation.

Carried by tracking handle 23 of control unit 2 is drift setting knob 37 mounted on shaft 38, the rotation of which is transmitted through bevel gears 39 and 40 and spur gear 41 to rigid shaft 42 connecting with flexible shaft 8 for rotating lens mounting 7. The rotation of mounting 7 rotates reticle disc 17 carried thereon and thereby rotates course line 21'. At the same time, prism 13 carried by an extension of mounting 7 is rotated with the reticle about the axis of collimation. In operation line 21' is rotated in accordance with the drift of the craft, that is the angle between the heading and ground path of the craft, the angular displacement being readable on "Drift angle" scale 19 on disc 18, which disc is stationary in housing 3, by means of index 20 on recticle disc 17.

Also a part of control unit 2 and mounted for rotation on housing 22 is range angle setting knob 43 on shaft 44, said shaft carrying pinion 45 engaging gear 46 for rotating range angle dial 47. Dial 47 has a scale of range angles on its periphery graduated from −8° to +82° readable on an index (not shown) carried by body 22. The rotation of dial 47 positions the spherical indentation in the web of said dial with respect to stationary housing 22 in correspondence with the range angle read on scale 48 so that when spring loaded ball 24 drops into said indentation the emergent line of sight from telescope 1 is at an angle with the vertical corresponding to the preset range angle.

Stabilizing gyroscope 6' has a rotor spinning in a horizontal plane about a vertical axis and mounted in a gimbal suspension for the purpose of stabilizing index 51, carried by member 50, in the field of view. This gyroscope is of the known type whose spinning axis is maintained vertical by erection means indicated at 7' and may have a structure and mode of operation similar to that disclosed in U. S. Patent #1,982,636 to B. G. Carlson, dated December 4, 1934. Said index is preferably in the form of a cross which is read in relation to circular marking 52 on reticle disc 17 to determine the attitude of the craft. A horizontal attitude is indicated by a central position of index 51 with respect to marking 52, which position is shown in full lines in the lowest of the three views of Fig. 3. In this view, disc 18 appears superimposed on reticle disc 17, the individual discs being shown in the two upper views. Departure from a horizontal attitude is indicated by a relative displacement of the cruciform index and circle as illustrated by the two dotted

line positions shown in the combined view of Fig. 3. The direction of the displacement of the index with respect to the circle is such that, if the plane is controlled by a stick or other attitude controlling device movable along two perpendicular axes, the motion of the cross in returning to its central position corresponds in direction with the motion of the stick. The index is connected to the rotor bearing casing by a parallel motion mechanism which is free to turn with the casing about the gimbal axis in the plane of its links.

When it is desired to render gyroscope 7 inoperative, said gyroscope may be caged by means of caging fingers 53 which close upon and engage pin 53' on the spin axis of the gyro and which are operated by turning caging knob 54, the motion of said knob being transmitted to the fingers by flexible cable 55.

The path of light rays through the optical system of telescope 1 will now be described more particularly with reference to Fig. 4. Light rays from terrestrial objects, such as a target object, enter the telescope through window 11 and reach roof prism 13. This prism is a type of totally reflecting prism well known in the optical art as a "roof" prism in which total reflections may occur in two mutually perpendicular planes. An image formed after the passage of rays through such a prism is reversed in two directions so that right-hand portions of an observed object appear at the left and upper portions at the bottom and vice versa.

The elevation of prism 13 shown in Fig. 5, which shows the prism in a position for displacing the line of sight from the vertical through an angle of about 60°, illustrates, by tracing the paths of two parallel rays, image reversal in a vertical plane. In the plan view of prism 13 shown in Fig. 6, the paths of two parallel rays illustrate image reversal in a horizontal plane. Prism 13 is rotatable about pivot point 36 for shifting the line of sight in a vertical plane through an arc of 90° from a normally vertical to a horizontal direction. In the position illustrated in Figs. 1 and 4, light rays after passing through prism 13 emerge in a direction parallel to their original paths but when the prism is tilted from the position illustrated, the entering and emerging paths are at an angle. Due to the reflection of the rays this angle changes twice as rapidly as the angle of tilt of the prism. Thus, by tilting prism 13 in a vertical plane through an arc of 45°, the apparent line of sight may be directed toward objects varying in position from those directly beneath the plane to those on the forward horizon. The rotation of roof prism 13 in a horizontal plane, as in setting the drift angle, in no way affects the image formed by light rays passing through said prism. The image remains stationary and unaltered in size with such rotation and the angular movement of the line of sight produced by a given rotation of prism 13 about pivot 36 is independent of the vertical plane in which such movement occurs, which is characteristic of a roof prism but not of the more generally employed types of prisms and is of considerable importance in an optical arrangement of the type herein described where the telescope housing remains stationary and the exit prism is rotatable within its housing as a compensation for drifting flight.

The doubly reversed rays emerging from prism 13 pass to objective 14 and are brought to a focus to form an image in the plane of the upper surface of reticle disc 17. Passage of the rays through objective 14 again causes reversal of their relative position in two directions so that the components of the image at the reticle are again in their original relationships. After diverging from the focus, the rays pass through a pair of erecting lenses 15 and 15' before converging to a focus in front of eye piece 12. Between lenses 15 and 15' the paths of the rays are parallel to one another. This distance, therefore, may be adjusted to suit the construction and mounting of the telescope without affecting its optical properties. At the "elbow" of the telescope, between lenses 15 and 15', the rays pass through direction changing prism 16 which is a roof prism similar to prism 13 in which two total reflections and two reversals of image rays occur as has been described, the double reversal of the position of the rays compensating for the similar reversal occurring in their passage through lenses 15 and 15'.

Preferably the optical system is of nearly unit power, that is, little or no magnification of the apparent size of an object occurs, since with low magnification or without any magnification a wide field of view may be obtained and a large aperture eye piece used. Another feature of the present system is that the normal distance of the eye from the eye piece in looking through the telescope is large, for example, of the order of six inches. The combination of large aperture eye piece and large eye distance allows the pilot to make observations through the sight without effort while flying the plane and makes unnecessary holding the eye in an exact relationship to the eye piece as is necessary with the usual small aperture lenses.

The operation of the device is as follows: The operator first adjusts the angle of course line 21' in accordance with the drift of the craft due to cross wind. The effect of drift is illustrated in Fig. 8, in which figure the vector V represents the velocity of the craft in the direction of its fore and aft axis; W represents the velocity of the cross wind at right angles thereto; while R represents the resultant of the two velocities and is at an angle "*b*" with the direction of the fore and aft axis. The motion of the craft relative to the ground will be in the direction of the resultant velocity R, the trace of this motion on the ground being known as the ground course of the craft.

Assuming the course line 21' to be originally parallel to the craft's fore and aft axis and that a cross wind is blowing, the images of terrestrial objects in the field of view will initially appear to move at an angle "*b*" with respect to course line 21'. By rotating knob 37, reticle disc 17, carried by lens mounting 7, is rotated as hereinbefore described to bring reference line 21' into a position which is parallel to the apparent path of images of terrestrial objects. The rotation of disc 17 rotates index 20 carried thereby with respect to scale 19 on disc 18, the position of said index furnishing an indication of the drift angle "*b*."

Having set drift angle "*b*" the next operation is to preset range angle "*a*." The meaning of the term "range angle" is illustrated in Fig. 7 in which O represents the position of an aircraft travelling along the line OA in the direction indicated and the curved line OC represents the trajectory of an object dropped from the craft when at the position O, the point C being the point at which the object strikes the ground.

The straight line OC represents the line of sight from O to C. The distance BC is termed the "range" and is the horizontal distance between the projected position of the craft when the object is dropped therefrom and the point at which the object strikes the ground. Angle "*a*" which is the angle between the line of sight to the target and the vertical is the "range angle." For a given type of bomb, "range angle" is a function of the velocity of the craft and of its height above the target. In the use of the simplified bombsight disclosed herein, the craft's velocity is assumed to be substantially constant and known, in which case the angle "*a*" becomes solely a function of altitude. Knowing the altitude, therefore, range angle "*a*" may be readily computed or read from an suitable scale or table. By rotating knob **43**, range dial **47** is rotated until the calculated range angle as read on scale **48** appears against an index on stationary member **22** (not shown). The positioning of range angle dial **47** positions the spherical indentation into which spring loaded ball **24** drops. Tracking handle **23** may then be rotated and prism **13** thereby tilted until ball **24** drops into the depression in the web of dial **47** at which time the line of sight is set at the selected range angle. The proper time for releasing a bomb will, under these conditions, be indicated by the image of the target crossing range line **21**.

The presetting of the range angle leaves the operator free to search in a vertical plane by rotating tracking handle **23** until the target appears in the field of view. If the proper drift angle has been set, the target will then appear to travel along or parallel to reference line **21'** in a direction toward range mark **21** until it crosses said mark, at which time the operator presses a button or otherwise operates the bomb release. The line of collimation of telescope **1** between the objective and the first erecting lens is perpendicular to the plane of the lateral and longitudinal axis of the craft. "Range angle," however, is computed with respect to the true vertical and therefore it is extremely important that at the time the bomb is released, the perpendicular to the craft's two axes coincides with the vertical, which position is indicated by the gyroscopically stabilized index. After the detent in range dial **47** is engaged, the pilot is free to observe the position of index **51** in relation to circular marking **52** and to readjust the attitude of the craft if the cruciform index is not centered on the circle. Range mark **21** is in the form of a circular arc. In order to make a satisfactory approach which will cause the ground course to intersect the target, the pilot should set the course of the craft so that the target image travels along course line **21'**. However, due to slight inaccuracies in setting the drift angle, the image may depart slightly from this line while in the field of view. By the use of an arcuate form for range mark **21**, the crossing of this mark by the target image will indicate the correct time of bomb release even if this crossing does not coincide with the intersection of lines **21** and **21'**, provided the craft is maneuvered to cause the target image path to pass through the center about which circular arc **21'** is drawn, which is also the center of the field of view.

As 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.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In a bombsight for use on moving aircraft, a sighting telescope comprising a housing adapted to be mounted stationary with said craft with its optical axis substantially perpendicular to the normally horizontal plane of said craft, an eyepiece at one end of said housing, a support at the other end of said housing mounted for rotatable adjustment about the optical axis of said housing, a light deflecting member pivotally mounted on said support for adjustment about an axis substantially perpendicular to said optical axis, said member being arranged to deflect an image into said telescope, cooperating drift indicating means on said telescope and support located in the line of sight through the telescope, control means for rotatably adjusting said support for introducing a drift angle component into said bombsight, and range angle setting means for adjustably pivoting said member on said support for obtaining a range angle setting in said bombsight.

2. The bombsight defined in claim 1, wherein said support is rotatably mounted on said other end of said housing.

3. The bombsight defined in claim 1, wherein said light deflecting member is a roof prism.

4. The bombsight defined in claim 1, wherein reticle means is mounted in said housing for rotation about said optical axis with said light deflecting member.

5. In a bombsight for use on moving aircraft, a sighting telescope adapted to be mounted stationary with said craft, reticle means within said telescope rotatably adjustable about the optical axis of said telescope, a drift scale within said telescope, means for rotatably adjusting said reticle means with respect to said scale for introducing a drift angle component into said bombsight, and a gyro-stabilized index extending into said telescope for cooperation with said reticle means, said reticle means and index providing an indication of the attitude of said craft.

6. In a bombsight for use in moving aircraft, a sighting telescope, reticle means in said telescope mounted for rotation about the optical axis of said telescope, a light deflecting member mounted for rotatable adjustment about said optical axis and about a second axis normal thereto, cooperating drift indicating means on said telescope and reticle means located within the line of sight through the telescope, means for simultaneously adjusting said reticle means and said light deflecting member about said optical axis for introducing a drift angle component into said bombsight, means for adjusting said light deflecting member about said second axis for varying the range angle of said bombsight, and means adjustable for presetting adjustment of said last-named means to a desired range angle setting in said bombsight.

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