

Oct. 22, 1946.

H. C. VAN AUKEN ET AL

2,409,648

BOMB SIGHT

Filed Jan. 25, 1941

3 Sheets-Sheet 1

FIG. 1

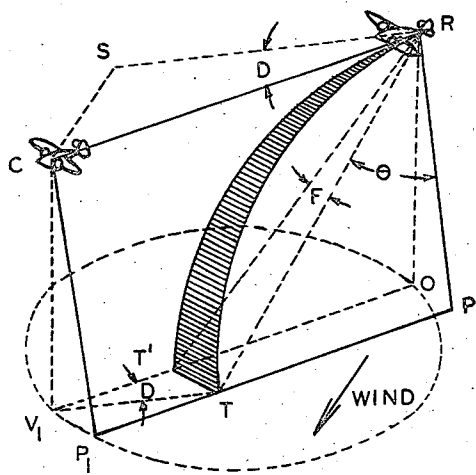
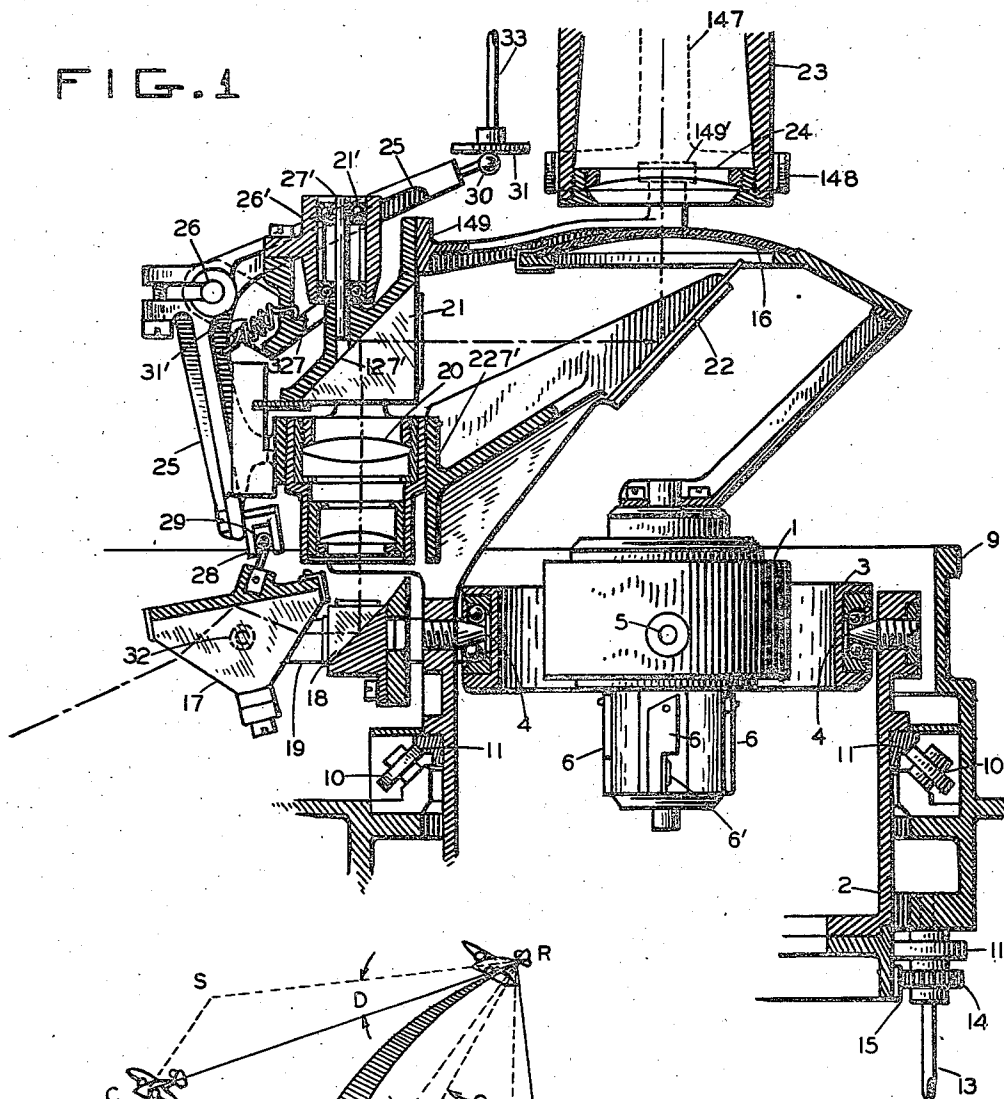


FIG. 2

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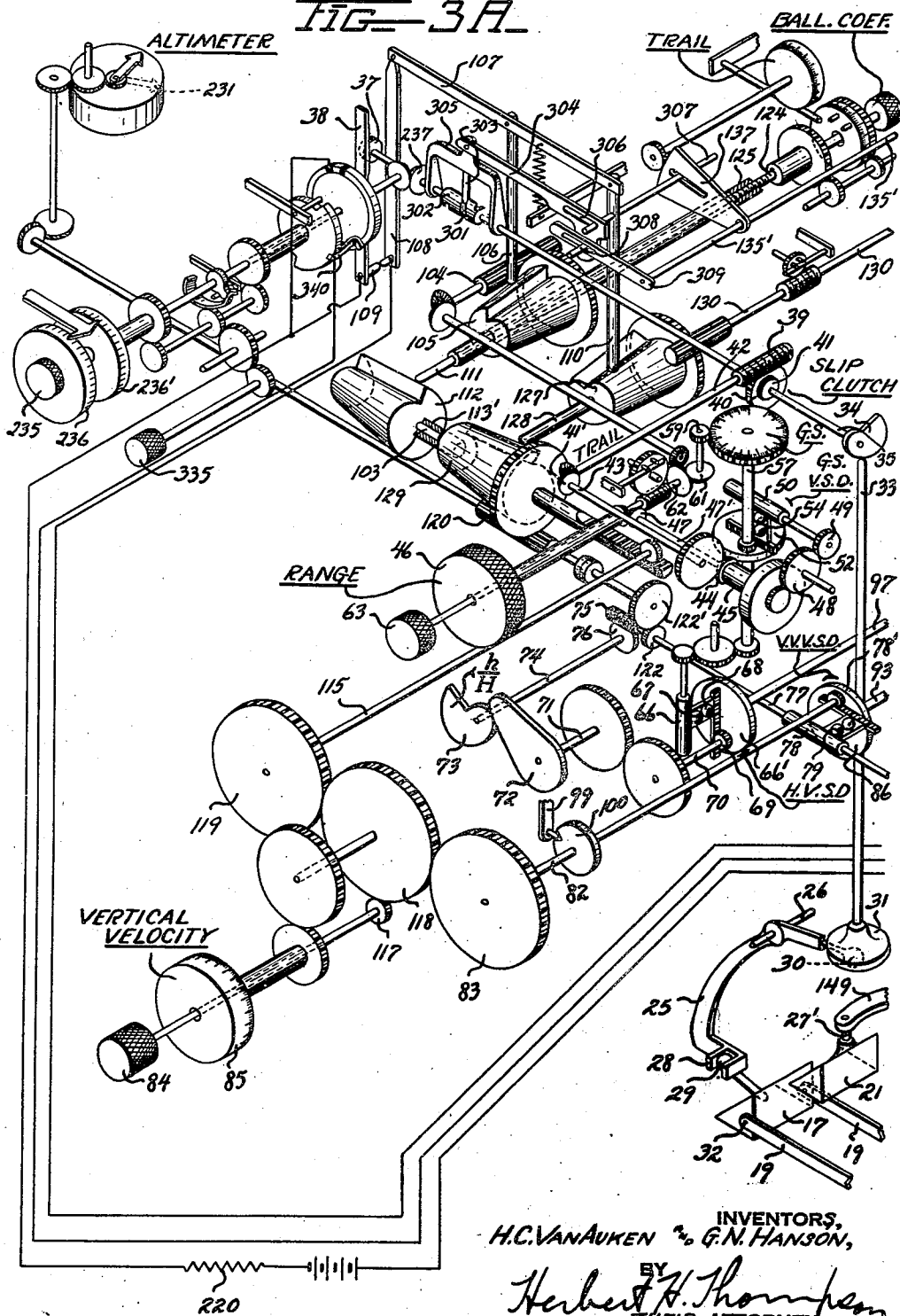
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FIG. 3A



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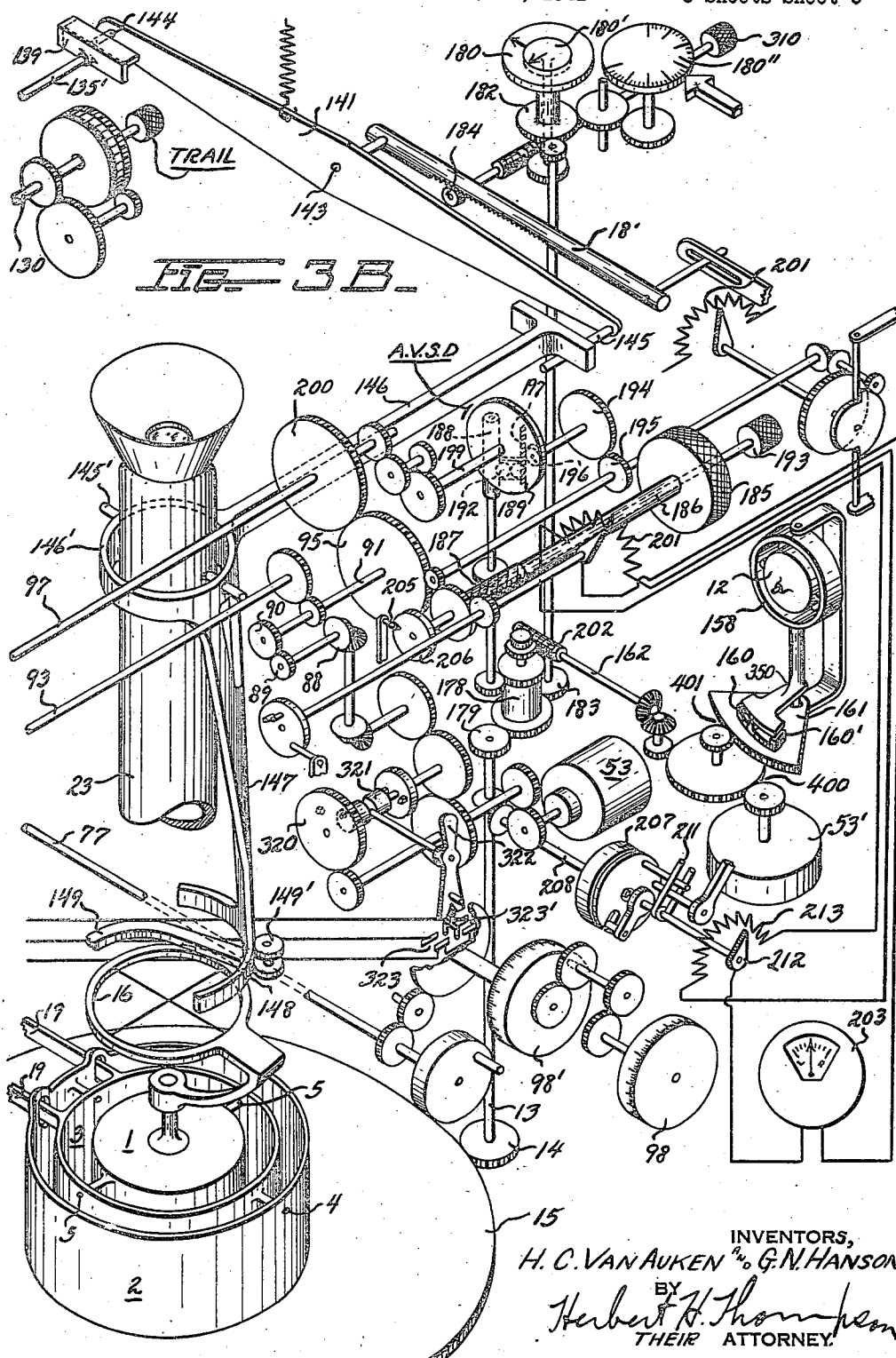
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UNITED STATES PATENT OFFICE

2,409,648

BOMB SIGHT

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Application January 25, 1941, Serial No. 375,900

8 Claims. (Cl. 88—1)

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This invention relates to bomb sights for aircraft which are designed to direct the course of the craft so that its ground track, except for offset, would pass through the target in a straight line and which determine the exact point at which the bombs should be released to strike the target. This mechanism also preferably computes and sets in automatically the amount of offset necessary to compensate for side drift due to side winds.

More particularly, our invention constitutes an improvement in or further development of the type of bomb sight disclosed in the prior patent to Howard C. Van Auken, one of the joint patentees, and Earl W. Chafee, No. 2,371,606, titled "Bomb sights." More particularly, our invention constitutes an improvement in the optical systems of bomb sights in general, and the system disclosed in the aforesaid application in particular, wherein the offset angle is set into the optics in an improved manner by adjusting a prism or reflector or other line of sight deflector mounted on an unstabilized part, about a normally vertical axis.

A further improvement consists in the provision of a means for shifting the altitude scale employed in the mechanism so that the sight may not only be used for normally high altitude bombing, say at 4000 feet and above, but so that it may also be used for low altitude bombing, i. e., under 4000 feet.

Referring to the drawings, illustrating the preferred form of our invention,

Fig. 1 is a vertical section through our improved form of stabilized sight.

Fig. 2 is a diagram illustrating the principles involved in the bomb sight in the presence of side wind.

Figs. 3A and 3B together constitute a diagrammatic layout of the computing mechanism of the sight, Fig. 3A being the left hand portion of the diagram and Fig. 3B the right hand portion thereof.

Referring first to Fig. 1, we prefer to employ an artificial horizon, such as some form of gyroscope 1, to stabilize the line of sight against rolling and pitching. As shown, the gyro rotor casing 1 is universally mounted within a supporting, universally mounted framework 2 by means of gimbal ring 3 pivoted on major axis 4—4 within framework 2 and pivotally supporting the gyro casing, in turn, on minor axis 5—5. The gyroscope is preferably mounted in neutral equilibrium, but is equipped with a suitable power actuated erection device, which may be of the standard differential air port type employing a

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plurality of pendulous shutters 6 cooperating in conjunction with air ports 6', as well understood in the art. The framework 2 is shown as mounted for rotation about a normally vertical axis within the outer fixed frame 9 by means of roller supports 10 on which a circular inclined trackway 11, secured to frame 2, rests.

The framework 2 is normally maintained fixed in azimuth from a directional gyroscope 12 (Fig. 3B), as hereinafter described, as by means of a shaft 13 carrying a pinion 14 meshing with an annular gear 15 on the bottom of frame 2, so that the entire gyroscope and its connected optics is maintained fixed in azimuth. Guide rollers 11' may also be utilized in addition to rollers 10.

On the top of the gyro casing 1 is mounted the reticle or cross hairs 16, which therefore is stabilized about all three axes. While stabilization of the reticle has been found sufficient for some purposes, we prefer to also stabilize against rolling at least the main target following reflecting prism or mirror 17 and one of the intermediate prisms (18). To this end, both of said prisms 17 and 18 are shown as mounted on forwardly extending arms 19 from gimbal ring 3, said arms passing around the forward gimbal pivot 4, as shown in Fig. 3B. Said prisms therefore are stabilized against rolling and in azimuth, although not stabilized against pitching in the form shown. Prism 17 is shown as pivoted on transverse axis 32 in said arms 19 so that it may be tilted to follow the target. By so stabilizing the reflecting prism, the apparent yaw of the line of sight caused by "false yaw" due to rolling of the craft is eliminated.

From intermediate prism 18, the line of sight passes vertically upwardly into the objective lens system 20 which focuses the image of the ground in the plane of the reticle 16, which is located above but laterally displaced from the lens. Preferably, the reticle is directly over the center of the gyroscope and the line of sight from the objective lens is displaced laterally to the center of the gyroscope and thence upwardly through reflecting prisms or mirrors 21 and 22. The objective lens and prisms are mounted on the rotatable frame 2, but are not shown stabilized from the gyroscope 1, as this is unnecessary, said parts being mounted on a bracket 327 secured to frame 2. Finally, the image projected on the reticle is viewed from a telescopic eye piece 23.

For causing the prism 17 to follow the target, we have shown a bell crank lever 25 pivoted at 26 on the frame 327 supporting the objective lens and having at its lower end a transversely posi-

tioned channel member 28 engaging a knob 29 projecting upwardly from the back of the metal mounting of the prism 17. Therefore, any movement of the bell crank lever in the plane of the paper in Fig. 1, that is, fore and aft of the craft, will rock the prism to follow the target, but rolling of the craft will not affect the prism, since the prism is stabilized from the gyroscope and the knob 29 will merely slide back and forth in the channel 28. The bell crank lever 25 is rocked by the engagement of its upper end 30 with a member 31 moved by the computing mechanism of the sight, the lever being shown as having a knob on the end thereof to be engaged by the member 31.

One of the improvements over the prior application consists in the mounting of the prism 21. According to our invention, we prefer to adjustably mount the prism so as to incorporate in the sight the offset angle F (Fig. 2). For this purpose, the prism 21 is rotatably mounted about a normally vertical axis in the fixed framework, the back 127' of the prism being shown as secured to a shaft 27' journaled in anti-friction bearings 21' in bracket 26'. Adjustment of the prism about the vertical axis is automatically accomplished by means of an arm 149 secured to the back of frame 127' and projecting laterally behind the objective lens 24 and telescope 23. The end of said arm 149 is shown as carrying a roller 149' which normally is yieldingly held against a semi-circular ring 148 secured to the bottom of an arm 147 extending downwardly from a gimbal 146' journaled on transverse shaft 145' (Fig. 3B). Said gimbal has a long laterally extending arm 146, the end of which is moved up and down by a pin 145 on a lever 141, as hereinafter described to impart the proper function of the offset angle to prism 21.

The computing mechanism is principally for the purpose of determining the point R at which to release the bomb to hit the target T at which the sight is directed (Fig. 2). The horizontal distance from the target to the projection of this point on the ground is known as the range ($\overline{PT}$), and the angle that the line of sight makes at this time is the range angle (θ). It is also for the purpose of determining the true ground course of the craft ($\overline{OV_1}$) and for directing the pilot so the bomb's trajectory (curve RT) will intersect the target T.

For turning the prism 17 about its pivotal axis 32 to maintain the same on the target, we have shown the knob engaging member 31 as moved up and down from a spring 31' and a rod 33, which rod, in turn, is moved by the rotation of the sight angle cam 34. Said cam is shown as mounted on a shaft 35 which also moves the moving contact 109 on the bomb release mechanism, said shaft being shown as having a pinion 37 thereon meshing with a vertical rack 38 carrying the contact 109. Said shaft 35 is shown as driven by means of a worm 39, a worm wheel 40 and a slip clutch 41 from shaft 42 which, in turn, is driven through bevel gears 41' from shaft 43, which in turn is driven through gears 44 from one side of the differential 45.

Initial setting of the prism 17 on the target may be accomplished by a knob 235, to which a sight angle scale 236 may be secured. Said knob is geared directly through bevel gears 237 to shaft 35 to turn cam 34. Another arm of said differential is shown as driven from gear 48, shown as driven from a pinion 49 (Fig. 3A), secured

to the driven member or cylinder 50 of the ground speed variable speed drive mechanism (GSVSD).

Since the greater part of the mechanism of the present invention, pertaining to the obtaining of the various factors in the sight, is the same as completely described in the aforesaid previous joint application Serial No. 128,034, it is thought unnecessary to burden the present application with a complete description of the same, but to enable the reader to understand the mechanism, applicants have placed the same reference characters and legends on the corresponding parts in the present application as are used in the aforesaid prior application. For instance, the four three dimensional cams 105, 112, 127 and 129 employed in the mechanism may be identical with the cams employed in the prior application. These cams may be briefly designated as the whole range cam 105, the time of fall cam 112, the trail cam 127, and the square of the time of fall cam 129.

There are also employed a plurality of power supplying variable speed drives of special construction all of which are preferably primarily actuated from the common constant speed motor 53. Said drives may be briefly identified as the ground speed variable speed drive 50, 52, 54 (GSVSD), the altitude variable speed drive 66, 67, 68 (HVSD), the vertical velocity variable speed drive 78, 79 (VVVSD), and the azimuth variable speed drive 188, 192 (AVSD). The functions of these drives are also substantially identical with similar parts described in the aforesaid prior application. The various settings for velocity of glide and ballistic coefficient, initial altitude, trail angle, and barometric or altitude setting are also substantially the same.

As before stated, however, the mechanism by which the offset angle is introduced in my present invention is different from the prior application. Referring to Fig. 2, it may be shown that the offset angle F is proportional to the offset OP multiplied by the cosine of the range angle θ or, in other words,

$$\langle F \rangle = \overline{OP} \cos \theta \quad (1)$$

but the offset $\overline{OP} = \overline{TT'}$ = the trail ($V_1 T$) times the sine of the drift angle (D), which is the angle between the heading (RS) and the actual course (RC) of the aircraft, or

$$\overline{OP} = \overline{V_1 T} \sin D$$

Therefore equation (1) may be written

$$\langle F \rangle = \overline{V_1 T} \sin D \cos \theta \quad (2)$$

From the foregoing description in connection with the prior application, it is apparent that the angular position of the cam 34 or, in other words, of shaft 35 on which it is mounted, is proportional to $\tan \theta$, and therefore the position of this shaft may be utilized to give the function cosine θ in the above equation by means of a helix 301 cut in a cylinder 302 on shaft 35, in which a pin 303 on slidable U-shaped bracket 305 engages. A lever 304 is shown as pivoted on said bracket 305 and as having a slot 306 in its outer end through which a long pin 307 freely extends. Said pin is secured to the trail lift pin 116 of the trail cam 127 so that said pin is moved in accordance with the trail $V_1 T$. The lever 304 also has a pin 308 extending laterally through a slot in a lever 309 secured to the shaft 135'. Therefore shaft 135' is positioned in accordance with a function of the trail ($V_1 T$) and the cosine of the range angle θ .

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The shaft 135' angularly positions the angle bar 139 which the pin 144 of the long member 141 adjustably engages. Said lever is shown as pivoted at 143 on a sliding rack bar 18' which, in turn, is laterally positioned in accordance with the drift angle D by setting knob 310 so that the drift angle pointer 180' matches the drift angle as observed on the drift angle scale 180. This movement moves the rack bar to the right or left in Fig. 3B and thereby shifts the position of the pin 144 on the inclined surface 139 to introduce the sine function of the drift angle. The other end of the lever 141 is provided with a pin 145 engaging the outer end of the long lever 146, hereinbefore described, to rotate the prism 21 through the arm 149 to thereby set in the aforesaid offset angle.

As hereinbefore stated, our sight is primarily designed for operation above about 4000 feet. In order that the sight may be used for lower altitudes, we have introduced a change speed mechanism interposed between the constant speed motor 53 and at least the altitude variable speed drive 56 (HVSD) and the ground speed drive 50 (GSVSD). Said mechanism is shown as involving change speed gearing 320, including a shiftable clutch 321 adapted to be thrown by a handle 322 into normal or high speed. In its normal position, the handle is positioned to close contact 323. For the high altitude position, all parts function as above described and the bomb release contacts 109 are in circuit with the bomb release mechanism 220. When the change speed mechanism is thrown to the right, however, the speed discs of the variable speed drives are driven at, say, four times the original velocity and contacts 323' are made to throw in auxiliary bomb release contacts 340.

When using the sight at low altitude, the sight proper can only be used to give on ground speed dial G. S. 53, an indication which at a predetermined altitude (say 1000 feet) shows true ground speed. It will also show ground speed at any altitude below 4000 when multiplied by the ratio of the actual altitude to 1000 (h/H'). A chart is then consulted, from which approximate data is obtained to set the auxiliary range angle scale 236' by knob 335, thereby setting the position of the contact 340. While the sight, therefore, is not fully automatic below 4000 feet, it can be used to give data from which the bomb release point may be readily obtained and it is fully automatic for 4000 feet up to the top limit for which it is designed.

It is also interesting to note that the ground speed scale may be made to read correctly without interpolation, for low altitudes if the ball carriage 68 on the altitude variable speed drive (HVSD) be moved through four times the distance it is moved for a given change in h/H , when operating in the high altitude range.

It will of course be understood that the ratio and altitude figures given above are merely by way of example and that the altitude limits may be varied greatly to meet the current requirements.

While as stated above, most of the mechanism in the present application follows closely that shown in the aforesaid prior application of Chafee and Van Auker, the stabilization or fixing of the optics in azimuth from the directional gyroscope 12 departs somewhat from the disclosure in the aforesaid prior application. In the present application, the pick-off from the directional gyroscope 12 is of the electro-inductive

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type of the type shown, for instance, in prior patent to Moseley, Cooke and Frische No. 2,139,558, for Follow-up system for gyro compasses, dated December 6, 1938, instead of being of the differential airflow type. A soft iron armature 350 is secured to the vertical ring 152 of the directional gyro 12 so that it is moved across the outer legs of a three-fingered transformer 160 and 160' to control through a suitable electronic circuit (not shown), a reversible follow-up motor 53', said motor driving through suitable gearing 400 and 401, a follow-back to the plate 161 carrying the transformer and also driving through shaft 162, worm 202, differential 178 and shaft 13, the pinion 14 which rotates the base 15 on which the entire stabilizing gyroscope and optical system, except the telescope, is mounted.

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 our invention, what we claim and desire to secure by Letters Patent is:

1. In a bombsight for aircraft, in combination with a gyro vertical, a sighting reticle mounted thereon and stabilized thereby about both fore-and-aft and transverse horizontal axes, a reflector for following the target stabilized about said fore-and-aft axes and mounted for turning about a transverse axis, and adapted to direct the line of sight horizontally along said fore-and-aft axis, a second reflector also stabilized about said axis for receiving said line of sight and directing it vertically, a third reflector for receiving the line of sight as reflected from said last-named reflector and directing the same horizontally toward the reticle, and means adapted to produce independent rotation of said last-named reflector relative to said other reflectors about a normally vertical axis to introduce the offset angle.

2. In a bombsight for aircraft, an observing eye piece, an artificial horizon such as a gyro-vertical, a reticle stabilized therefrom about a normally fore and aft and an athwartship axis, a pivoted reflector for reflecting an image of the target on said reticle and thence into said eye piece, said reflector being stabilized by said artificial horizon about said fore and aft axis, a second unstabilized reflector in the line of sight between said first reflector and said eye piece, said second reflector being mounted for rotation relative to said first reflector about a normally vertical axis, and means for adjusting said last reflector about said vertical axis in accordance with an offset angle.

3. A stabilized bombsight for aircraft including a gyro vertical having a vertical axis stabilized about both horizontal axes and also in azimuth, a reticle mounted thereon and extending perpendicular to said axis, and means for focusing an image of the target vertically upward on said reticle including a pair of 45° reflectors mounted independently of said gyroscope for displacing the vertical line of sight to one side of the gyroscope, a third 45° reflector for directing said line of sight along the heading of the craft, a fourth reflector for deflecting the line of sight on the target, and means for tilting said last named reflector about a lateral axis for following the target, said last two reflectors being stabilized in azimuth and against rolling by said gyroscope.

4. A stabilized bombsight for aircraft including

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a gyro vertical having a vertical axis stabilized about both horizontal axes and also in azimuth, a reticle mounted thereon lying in said axis, and means for focusing an image of target vertically upward on said reticle including a pair of 45° reflectors mounted independently of said gyroscope for displacing the vertical line of sight to one side of the gyroscope, means for turning one of said reflectors about a normally vertical axis for introducing the offset correction, a third 45° reflector for directing said line of sight along the heading of the craft, a fourth reflector for deflecting line of sight on the target, and means for tilting said last named reflector about a lateral axis for following the target, means for maintaining an azimuth reference line, and means for stabilizing said last two reflectors in azimuth therefrom and against rolling by said gyroscope.

5. In a bombsight for use at both low and high altitudes, rotatably mounted sighting means for following a target, variable speed driving means for rotating said sighting means according to ground speed, power means for driving a member of said variable speed drive at a substantially constant speed, a control device having low and high altitude positions, means responsive to the low altitude position of said control device for causing said power means to drive said member at a high constant speed, means responsive to the high altitude position of said control device for causing said power means to drive said member at a lower constant speed, a low altitude bomb release contact, a high altitude bomb release contact, said contacts being arranged according to changes in scale factors due to different speeds of said member, and means operated by said control device for shifting control of the bomb release mechanism between said contacts according to the position of said device.

6. In a bombsight for aircraft, in combination, a gyro, a sighting reticle supported for stabilization about two axes by said gyro, a sighting deflector mounted for stabilization by said gyro about one of said axes and pivotally supported for rotation independently of said gyro about a transverse axis, and a separate unstabilized deflector arranged in an optical system between said sighting deflector and said reticle to provide a stabilized line of sight movable in a stabilized plane to follow a target by turning said sighting deflector about said transverse axis, said unstabi-

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lized deflector being pivotally supported to turn relative to said sighting deflector and said reticle for laterally offsetting said line of sight as well as its plane of movement without disturbing the stabilization thereof.

7. In a bombsight for aircraft, in combination, a gyro, a sighting reticle supported for stabilization about two axes by said gyro, a sighting deflector mounted for stabilization by said gyro about one of said axes and pivotally supported for rotation independently of said gyro about a transverse axis, an unstabilized eye piece mounted independently of said gyro, a separate unstabilized deflector pivotally supported between said sighting deflector and said eye piece for movement independently thereof, said deflectors being so arranged with respect to said stabilized reticle to define a stabilized line of sight from said eye piece, means for turning said sighting deflector about said transverse axis to move said line of sight in a stabilized plane to follow a target, and means for turning said unstabilized deflector about its pivotal axis according to the offset angle to angularly displace said stabilized plane and said line of sight to compensate for the effect of a cross wind.

8. In a bombsight for aircraft including an optical system defining a line of sight, apparatus for correcting for the offset angle between the line of sight and a vertical plane including the line of flight of the aircraft, a member displaceable in accordance with the trail in the trajectory of the bomb as determined by the ballistic characteristics thereof, a member displaceable in accordance with the range angle of the line of sight with respect to the vertical, a multiplier mechanism operated jointly by displacement of said members for displacing an output member according to the product of the trail and the sine of the drift angle, a deflector for offsetting said line of sight to compensate for the effect of a cross wind of the trajectory of the bomb, a member displaceable according to the drift angle between the line of flight and the heading of the craft, and a multiplier mechanism operated jointly by said last named member and said output member for moving said deflector to offset the line of sight according to the computed offset angle.

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