Sept. 1, 1931.

G. GARDNER

1,821,431

DIVING BOMB SIGHT

Filed July 31, 1924

3 Sheets-Sheet 1

FIG. 1.

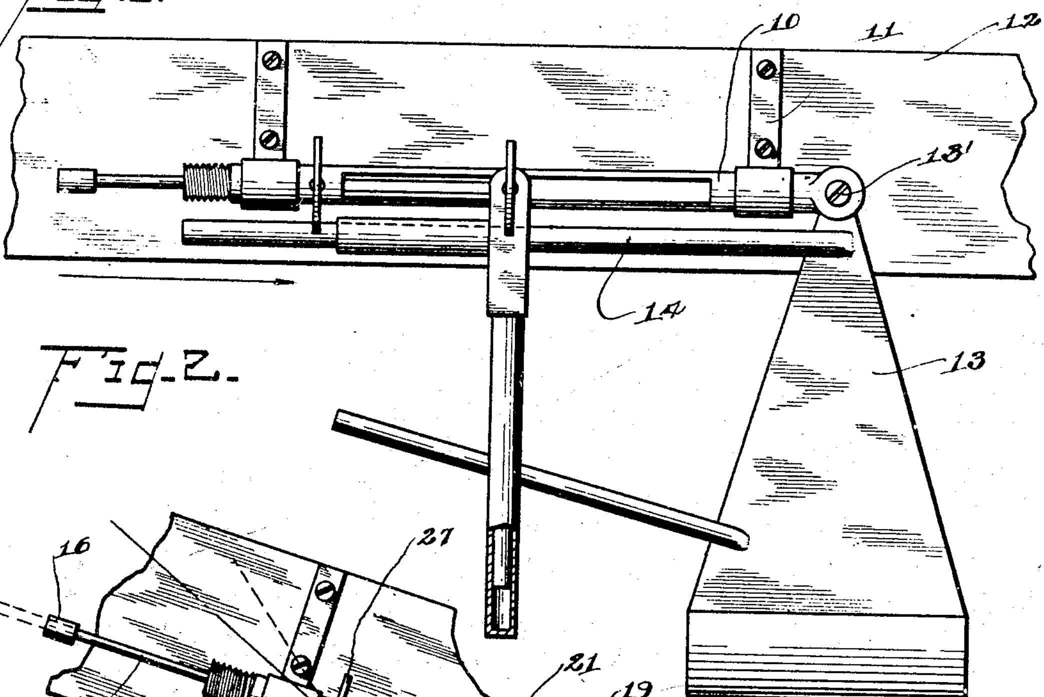
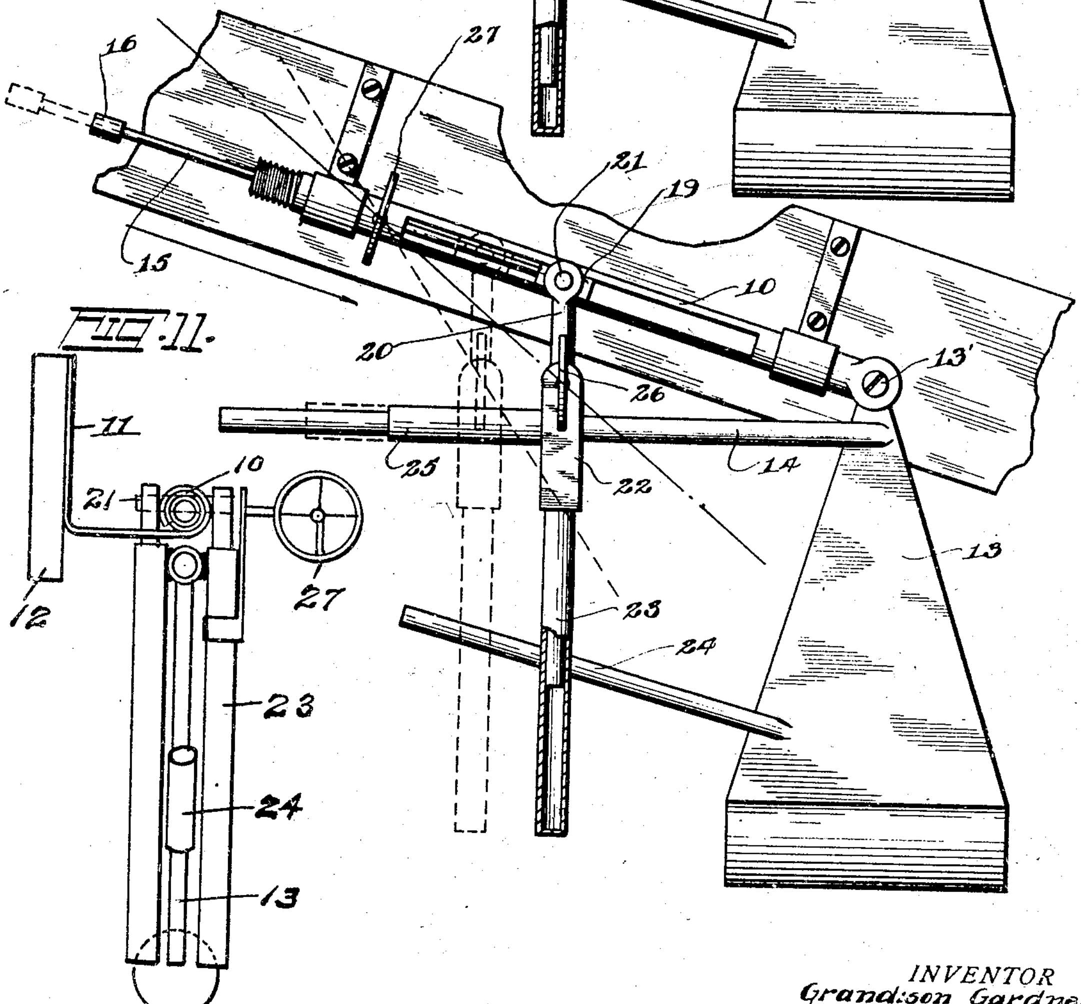


FIG. 2.



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3 Sheets-Sheet 2

FIG. 4.

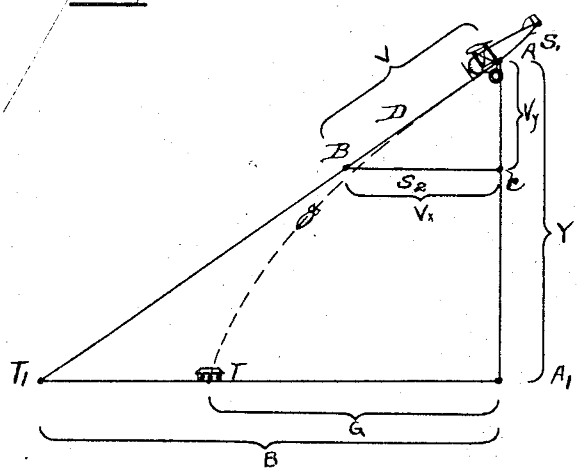


FIG. 7.

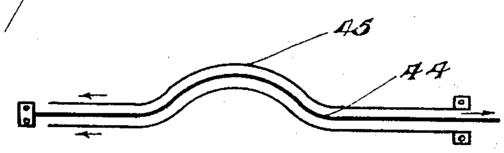


FIG. 5.

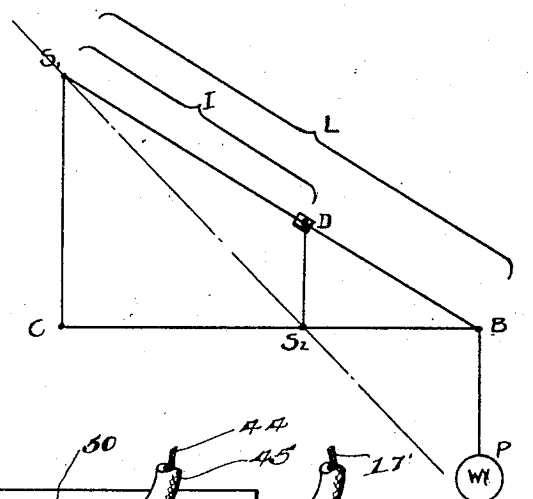


FIG. 6.

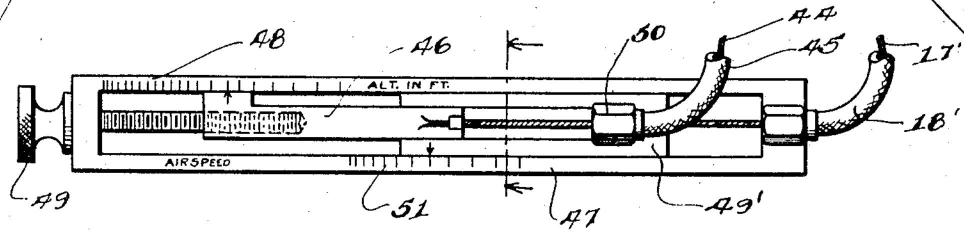
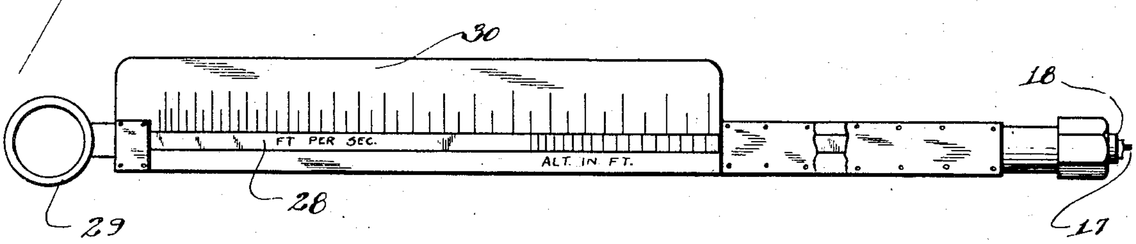


FIG. 3.



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Filed July 31, 1924 3 Sheets-Sheet 3

FIG. 8.

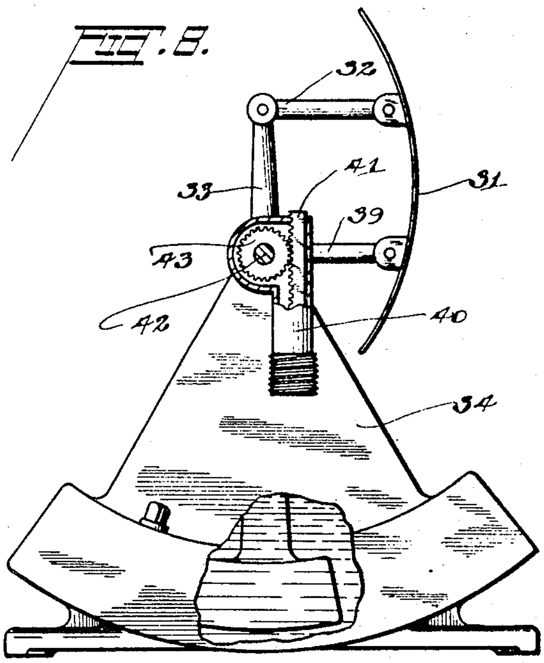


FIG. 10.

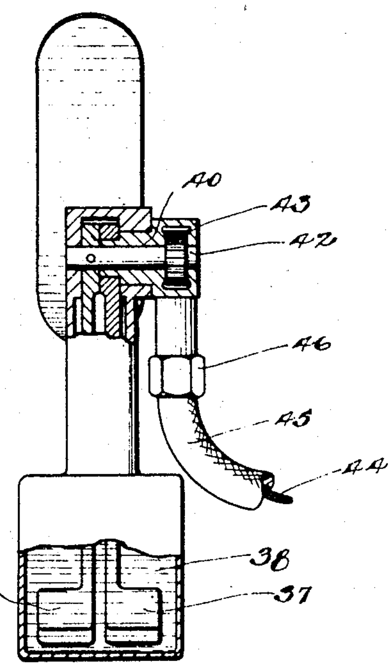
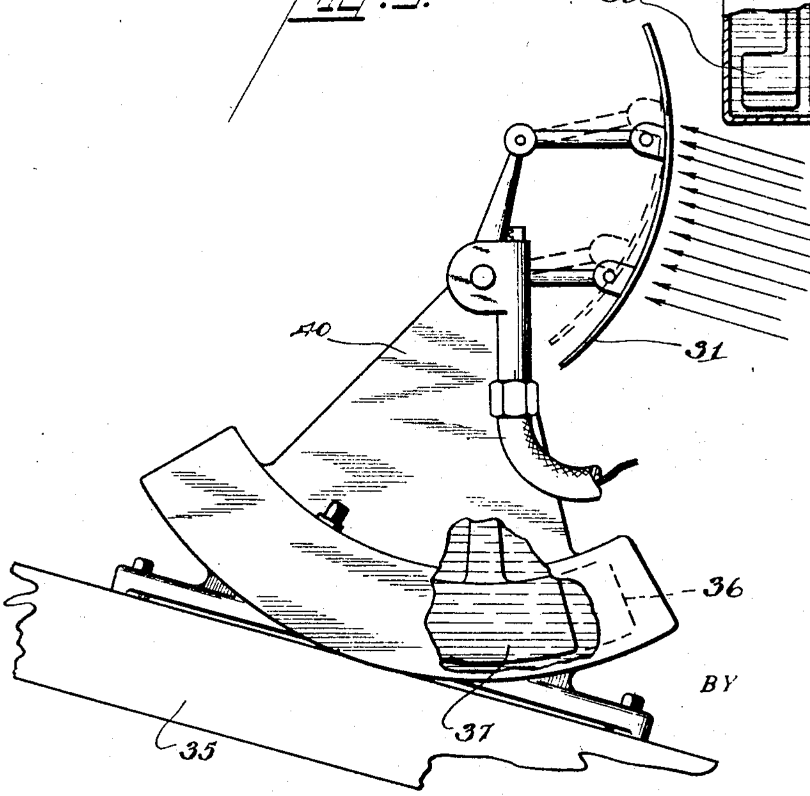


FIG. 9.



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Patented Sept. 1, 1931 1,821,431

UNITED STATES PATENT OFFICE

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DIVING BOMB SIGHT

Application filed July 31, 1924. Serial No. 729,389.

This invention relates to bomb sights and is particularly concerned with a sight to be used on airplanes for bombing in the act of diving.

Bomb sights at present in use, or used heretofore, can be used only in clear weather when high altitudes can be attained and visibility is good. But to increase the effectiveness of aircraft for bombardment purposes, it has been found necessary to provide a sight that can be used at low altitudes under clouds. The danger of low altitude bombing introduced by anti-aircraft defenses requires that the bombing planes remain concealed in the clouds and descend for very short intervals in dropping the bombs, so that a sight capable of operation in the act of diving and which necessarily requires little or no time to operate, is essential. Since ordinary methods of bombing, involving horizontal flight, secure such flat trajectories at low altitudes that adequate forward vision is impossible for calculating proper timing and so forth preliminary to dropping the bomb, it is obvious that bombs must be dropped while in the act of diving. In this way, a straightened trajectory and a short range are secured so that trail errors are negligible. The high vertical speed given the bomb initially greatly reduces the time of fall and lessens errors due to lag and drift. The steeper the dive, the more accurate is the bombing and it is a part of the present conception also to use the bomb sight in clear weather at high altitudes where very steep dives are possible.

The present invention provides a diving bomb sight incorporating a fixed rear sight and a movable front sight adjustable in proportion to the altitude and airspeed, since these are the only corrections necessarily involved where a sight is used in diving.

A special feature of the invention consists in the provision of an automatic airspeed adjustment operated by air impingement when the plane is diving to compound an airspeed correction on the correction for altitude, thus making it necessary for the pilot to make only the one adjustment for altitude previous to entering into a dive.

The invention is described in detail in the accompanying specification, in which reference is made to the accompanying drawings, wherein:

Fig. 1 is a side view of a bomb sight constructed in accordance with the invention shown as it is mounted on the airplane fuselage.

Fig. 2 is a similar view illustrating the relative positionment of the parts when in use with the plane diving.

Fig. 3 is a view of a manually adjustable control for adjusting the position of the movable sight.

Figs. 4 and 5 are diagrammatic views to illustrate the principle on which the sight operates.

Fig. 6 is a view similar to Fig. 3, of a modified form of control for adjusting the position of the movable sight.

Fig. 7 is a diagrammatic view of the control transmission for the device shown in Fig. 6.

Fig. 8 is a side view, partly in section, of the air vane means for correcting the position of the movable sight according to airspeed.

Fig. 9 is a similar view showing the device as it is mounted, on a part of the plane, and indicating the manner of operation when the plane is in a dive, and

Fig. 10 is a rear elevation, partly in section, of the device shown in Figs. 8 and 9.

Fig. 11 is a front view corresponding to Fig. 1.

Referring to the drawings and, for the present, particularly to Figs. 4 and 5, from which may be gathered a general understanding of the problems in aircraft bombardment dealt with in the present invention: In Fig. 4 a plane is shown diagrammatically in the act of diving along the line A—T_1. A bomb released from the plane has an initial velocity equal to the speed of the plane and would, without acceleration, hit the ground at T_1 but, due to the vertical acceleration of gravity, the bomb travels the vertical distance Y with a higher velocity, while its horizontal velocity is unaffected except for air resistance, and consequently the bomb strikes at T. For the purposes of the present explanation, it will be expedient to disregard air resistance. A correction for air resistance is made along with the correction for altitude, as will be described presently. Briefly, the present bomb sight operates in the manner indicated; the pilot of the airplane, by sighting on point T, automatically dives toward the point T_1. If this is done accurately, the bomb released while the plane is kept on the dive with the target in view will reach the target and the plane, after the release of the bomb or bombs, climbs again to safety.

Fig. 5 is a diagrammatic view of the mechanical structure of the bomb sight shown in Figs. 1 and 2 and will serve to give an understanding of the principle of operation therein involved. A side L of a fixed length is mounted parallel to the axis of the airplane, and to A—T_1 of Fig. 4. A pendulum P maintains a vertical and horizontal, keeping the bar B—C horizontal. The rear sight S_1 is fixed on the end of L and the front sight S_2 is movable along the horizontal bar B—C, so that a line of sight, approximating the line A—T, is determined thereby.

The mathematical relations (as follows) are maintained in the construction and operation of the sight, calculations being made without consideration of air resistance which is included hereinafter as a correction. Legends corresponding to those used in Figs. 4 and 5 are used in the mathematical analysis of the principle on which the sight operates.

$$\frac{CS_2}{CB}=\frac{A_1T}{A_1T_1} \quad (1)$$

$A_1T=V_xt$ (t being falling time and V_x the horizontal component of the velocity of the bomb.) (2)

$$\frac{A_1T_1}{Y}=\frac{V_x}{V_y} \text{ or } A_1T_1=\frac{YV_x}{V_y} \quad (3)$$

(V_y=initial vertical velocity of the bomb.)

Substituting in Equation (1) values of A_1T and A_1T_1 found in (2) and (3)

$$\frac{CS_2}{CB}=\frac{V_xtV_y}{YV_x}=\frac{V_yt}{Y} \quad (4)$$

Since L is fixed, CB decreases as the dive becomes steeper and consequently CS_2 must be changed in proportion, but by dividing L at D by a perpendicular through S_2 and designating section S_1D by I,

$$\frac{I}{L}=\frac{CS_2}{CB}=\frac{V_yt}{Y} \text{ or } I=\frac{LV_yt}{Y} \quad (5)$$

Then, I must be varied continuously as V_y and Y vary (t being a function of Y and V_y)

$$t=\frac{V_y}{g}\sqrt{1+\frac{2gY}{V_y^2}}-1 \quad (6)$$

(g being the acceleration constant).

$$I=\frac{2L\sqrt{1+\frac{2gY}{V_y^2}}-1}{\frac{2gY}{V_y^2}} \quad (7)$$

D is moved along L by an auxiliary scale setting device, and a slide moving on rods BC and S_2D keeps these rods always perpendicular to each other and the pendulum keeps BC horizontal so S_2D must then remain vertical.

Returning to Equation (7), it is noted that I must be set for each of an infinite number of values of V_y and Y but this is done automatically by an auxiliary scale setting device. It will be noted that the fraction

$$\frac{2gY}{V_y^2}=\frac{Y}{V_y^2/2g}$$

occurs in both numerator and denominator and that its varying value may be kept continuously set on a special slide rule of which one scale is calibrated proportionally to log Y and the other scale proportionally to log

$$\frac{V_y^2}{2g}.$$

The second scale is marked with the values of V_y corresponding to the various values of log

$$\frac{V_y^2}{2g}.$$

The distance left on the Y scale after the log

$$\frac{V_y^2}{2g}$$

corresponding to the value of V_y has been subtracted from log Y is K log of the fraction (assuming the scale to be graduated to values of K times the logarithm.) Assuming that V_y will not exceed 250 feet per second below 1000 feet altitude and will not be less than 100 feet per second at 10,000 feet altitude the standard slide rule will cover the entire range, but the scale can be modified to suit wider variations if necessary.

Though it is not evident from the mathematical expressions, it is found by plotting values of I against values of log

$$\frac{2gY}{V_y^2}$$

that the rate of change of I with respect to the log of the fraction is nearly constant and with small error except at extreme positions, changes of I can be taken as equal to changes in K times log of the frac ion, providing K is properly chosen. Thus it becomes possible to move D directly with the V_y scale of the slide rule.

Referring now to Figs. 1 and 2, a support 10 is shown swivelled in brackets 11 on a convenient part 12 of the airplane fuselage to rotate on an axis parallel to the longitudinal axis or axis of flight of the airplane. A pendulum 13 pivoted at 13′ to the end of the support 10 maintains a vertical and keeps a bar 14 extending from one side thereof, in a true horizontal position in all inclinations of the plane in flight. The angle included between the bar 14 and the support 10 is thus the angle of dive of the plane. The support is tubular and receives a control wire 15 having a head 16 which connects with a flexible wire 17 (see Fig. 3) extending through a flexible casing 18, for adjusting the position of a slide 19 in the support 10. The slide 19 has a pair of bars 20 pivoted at 21 and depending vertically at right angles to the bar 14 from opposite sides of the support 10. The bars 20 extend into openings in a guide block 22 which has cylindrical dashpots 23 in which the reciprocation of the bars 20 is dampened in any well known manner. A prong 24 projecting from the pendulum 13 comes between the cylinders 23 and prevents la eral displacement thereof relative to the pendulum 13. The block 22 also provides a guide 25 for the horizontal bar 14. Since the guide 25 and the dashpots 23 are disposed at right angles, a true right angular relation is maintained between the bars 20 and the bar 14 in accordance with the mathematical relations above referred to and shown diagrammatically in Fig. 5. The block 22 carries the movable front sight 26. The fixed rear sight 27 is carried on the support 10 and in the various positions of the movable sight 26, as indicated by the dotted and full line positions shown in Fig. 2, different lines of sight at angles with the line of dive of the plane are determined, the target being sighted on a line through the two sights in the usual manner.

The position of the slide 19 is adjusted to determine the position of the adjustable front sight 26 to correct for altitude and airspeed. A rod 28 having a finger piece 29 thereon is slidable in a scale 30 and has the wire 17, previously referred to, connected to the end thereof. The rod 28 is marked in units of airspeed, such as feet per second, and the proper value for airspeed is set adjacent a graduation for the proper altitude on the scale 30. The graduations in each case are determined mathematically or by experiment, or both. The altitude considered is the approximate altitude at which the bomb is dropped after loss of altitude in diving. The approximate airspeed is set adjacent the altitude reading and the pilot is in readiness to dive and drop bombs.

In operation, the target is picked up through the rear sight 27 in flying toward the target, and the proper angle of dive is secured at which the line of sight through the sights 26 and 27 gives a view of the target. Then, according as the setting of altitude was made, the pilot descends to the proper altitude and releases the bomb, assuming that the target was kept in view through the sights in diving. Immediately upon releasing the bombs, the plane can zoom up out of danger, and, since the operation mentioned required but a few seconds, it is clear that no considerable danger of being brought down by anti-aircraft fire is involved. The use of a sight of this kind has the decided advantage for accuracy in that the initial velocity of the bomb is great so that the time of fall is diminished and drift and lag errors are negligible.

Partly with a view to simplifying the operation of setting the sight and partly with a view to increasing the accuracy of setting, it is contemplated to have the correction for airspeed compounded automatically on the altitude setting. An air vane 31 (see Figs. 8, 9 and 10) is pivoted by a link 32 to an arm 33 projecting vertically from the top of a casing 34 secured to a convenient part 35 of the airplane. The air vane is operated by the impingement of air thereon in flight, and is arranged to be affected by the same degree of airspeed as affects the bomb released from the plane, and for this reason, the casing 34 carrying the vane 31 is conveniently mounted on one of the wing surfaces out of the propeller slipstream so that the movement of the vane is affected only by the air impinging on it due to the relative movement of the plane through the air. A pair of pendulums 36 and 37 are pivoted in the casing 34 and operate preferably in an oil bath, as indicated at 38, to dampen their oscillation. A link 39 is pivoted to the vane 31 similarly as the link 32 and is rigidly affixed to the pendulum 36 so that the latter is swung to the dotted line position from its vertical depending position when the vane 31 is deflected from its full line position to the dotted line position shown in Fig. 9, due to the action of the impinging air represented by the series of arrows in Fig. 9. The pendulum 37 is secured to a small housing 40 which serves as a guide for a rack 41 reciprocable vertically. The housing 40 always assumes a vertical position with the pendulum 37 in all inclinations of the plane in diving, as indicated in Fig. 9. The housing is pivoted with the pendulum 37 on a short shaft 42 and in the side wall of the casing 34, as shown in Fig. 10. The shaft 42 has the pendulum 36 pinned or otherwise fixed thereon, and carries a pinion 43 meshing with the rack 41. It will thus appear that the pendulums 36 and 37 normally always assume a vertical dependent position and no movement is communicated to the rack 41, except when the vane 31 is deflected by the action of the impinging air in a dive.

In the deflection of the vane 31 and the accompanying swinging of the pendulum 36 from its vertical position, the shaft 42 is rotated slightly and with it the pinion 43. The rack 41 is thereby moved and communicates a pull on a wire 44 extending through a flexible casing 45 attached to the housing 40 by the nut 46. The wire 44 extends through the casing 45 to an adjustable block 46 (see Fig. 6) in a scale 47, the latter being located at some point in the cockpit preferably, where it is within convenient reach of the pilot for manual control. The scale 47 is graduated in units of altitude as shown at 48, and an adjusting screw 49 serves to set the block 46 with its index mark adjacent the proper altitude reading, corresponding with the altitude at which the bomb is to be dropped after loss of altitude in diving. The wire 17′ corresponding with the wire 17 in Fig. 3, extending through the casing 18′ to the slide 19, is attached to a slide 49′ operating in the scale 47 and having the end of the casing 45 fixed thereon as at 50. When the rack 41 is moved to transmit a pull on the wire 44, movement is communicated to the opposite end of the casing 45 to move the slide 49′, and in turn communicate a pull on the wire 17′ and change the position of the movable sight 26, in the movement of the slide 19 produced by the corresponding movement of the slide 49′.

With the foregoing arrangement, the pilot need only make a setting for altitude and he is ready to enter into a dive to drop bombs. In the diving, the action of the impinging air produces a deflection of the vane 31 and, as a result, the slide 49′ is moved along the airspeed scale readings shown at 51, and a proper correction of the position of the movable sight 26 is made. Assuming that the original definite manual setting may be represented by the full line position of the sight 26 in Fig. 2, the dotted line position will represent on an exaggerated scale the corrected position of the movable sight.

Fig. 7 illustrates diagrammatically the manner in which the cable and wire transmission for the control device of Fig. 6 operates. It will be noted that one end of the wire 44 and one end of the casing 45 are fixed and the other ends are movable, the movable end of one being at the fixed end of the other. The small arrows are used to represent the direction of movement produced or the direction in which the pull is communicated to produce movements at the other end of the cable or casing, depending on whether the cable or casing is the part operated. Thus, if the right hand end of the wire 44 in Fig. 7 is pulled to the right according to the small arrow, the left hand end of the casing 45 is caused to move to the left as shown by the arrow. This is due to the presence intermediate the ends of the casing 45 of a free bend, as indicated. The pull on the wire tends to straighten out the bend and as a result, the free end of the casing 45 is moved as the casing straightens. If, instead of a pull, a push were exerted on the free end of the wire 44 at the right hand end, the free end of the casing 45 at the left would be moved to the right opposite the direction of the force acting on the wire.

I claim:

1. A diving bomb sight for use on aircraft comprising a front and a rear sight, said rear sight being in the line of dive of said aircraft and means responsive to fore and aft tilt of the craft for displacing said front sight below the line of dive.

2. In a diving bomb sight a rear sight in the line of dive of an airplane, an adjustable front sight movable fore and aft relative to said rear sight and correcting means responsive to fore and aft tilt of the craft for automatically positioning said front sight relative to said rear sight to determine the line of sight to the target.

3. In a diving bomb sight, a pair of sights, and gravity controlled means to adjust one of said sights relatively to the other and to the line of dive to correct for the initial vertical speed of bombs dropped in the dive.

4. In a diving bomb sight comprising the combination with a pair of sights, of gravity controlled means to adjust one of said sights relatively to the other and to the line of dive to correct for the approximate altitude from which the bomb is to be dropped and manually controlled means to relatively adjust said sights to correct for air speed.

5. In a bomb sight, a support, a rear sight adjacent said support, a bar transversely pivoted on said support and adjustable toward and away from said rear sight, a pendulum pivoted on said support having a second bar extending therefrom at right angles to said first bar in a horizontal position, a front sight, and a guide block carrying the same having openings therein extending at right angles to receive said bars respectively.

6. In a bomb sight, a support, a rear sight adjacent said support, a bar transversely pivoted on said support and adjustable toward and away from said rear sight, a pendulum pivoted on said support having a second bar extending therefrom at right angles to said first bar in a horizontal position, a front sight, and a guide block carrying the same having openings therein extending at right angles to receive said bars respectively, one of said openings being closed at the far end to provide a dashpot action when the bar reciprocates therein.

7. In a bomb sight, a support, a rear sight adjacent said support, a bar transversely pivoted on said support and adjustable toward and away from said rear sight, a pendulum

pivoted on said support having a second bar extending therefrom at right angles to said first bar in a horizontal position, a front sight, a guide block carrying the same having openings therein extending at right angles to receive said bars respectively, and means for adjusting the fore and aft positioning of said first bar according to air speed and altitude.

8. In a bomb sight, a support, a rear sight adjacent said support, a bar transversely pivoted on said support and adjustable toward and away from said rear sight, a pendulum pivoted on said support having a second bar extending therefrom at right angles to said first bar when said support is in a horizontal position, a front sight, a guide block carrying the same having openings therein extending at right angles to one another to receive said bars respectively and means operated by the impingement of air when the plane is in flight for adjusting the fore and aft positioning of said first bar.

9. In a bomb sight, a support, a rear sight, adjacent said support, a bar transversely supported on said support and adjustable toward and away from said rear sight, a pendulum pivoted on said support having a second bar extending therefrom at right angles to said first bar when said support is in a horizontal position, a front sight, a guide block carrying the same having openings therein extending at right angles to one another to receive said bars respectively, and means for adjusting the fore and aft positioning of said first bar for altitude and compounding on this adjustment a correction for airspeed.

10. In a bomb sight for aircraft, in combination, a swivelled support arranged to turn on an axis parallel to the longitudinal axis of the plane, a rear sight thereon, a pendulum pivoted on one end of said support on an axis transverse thereto, a bar extending horizontally therefrom at right angles thereto, a pair of bars extending vertically at right angles to said horizontal bar pivoted to and adjustable along said support fore and aft, a guide block having a front sight thereon and having openings extending at right angles to one another for receiving said bars respectively, and a prong projecting from said pendulum between said last-mentioned pair of bars.

11. In a bomb sight for aircraft, in combination, a swivelled support arranged to turn on an axis parallel to the longitudinal axis of the plane, a rear sight thereon, a pendulum pivoted on one end of said support on an axis transverse thereto, a bar extending horizontally therefrom at right angles thereto, a pair of bars extending vertically at right angles to said horizontal bar pivoted to and adjustable along said support, fore and aft, a guide block having a front sight thereon and having openings extending at right angles to one another for receiving said bars respectively, a prong projecting from said pendulum between said last-mentioned pair of bars, and a pair of dashpot cylinders on said guide block receiving the said pair of bars.

12. In a bomb sight, a support, a rear sight, a bar adjustable on said support toward and away from said rear sight, a pendulum pivoted on said support having a second bar extending therefrom at right angles to said first bar in a horizontal position, a front sight, a guide block carrying the same having openings therein extending at right angles to one another to receive said bars respectively, and means for adjusting the fore and aft positioning of said first bar, comprising an air vane, and means connecting said vane with said first bar.

13. In a bomb sight, a pair of sights one of said sights being adjustable relative to the other sight to correct for air resistance, and means to adjust said sight comprising an air vane, a pair of pendulums normally in a dependent vertical position, a link connecting one of said pendulums to said air vane, said pendulum being deflected by air impinging upon said vane, a rack having connection with said sight to move the same, a guide therefor carried by the other of said pendulums, and a gear driven by the first pendulum on deflection thereof meshing with said rack to move the same.

In testimony whereof I affix my signature.

GRANDISON GARDNER.