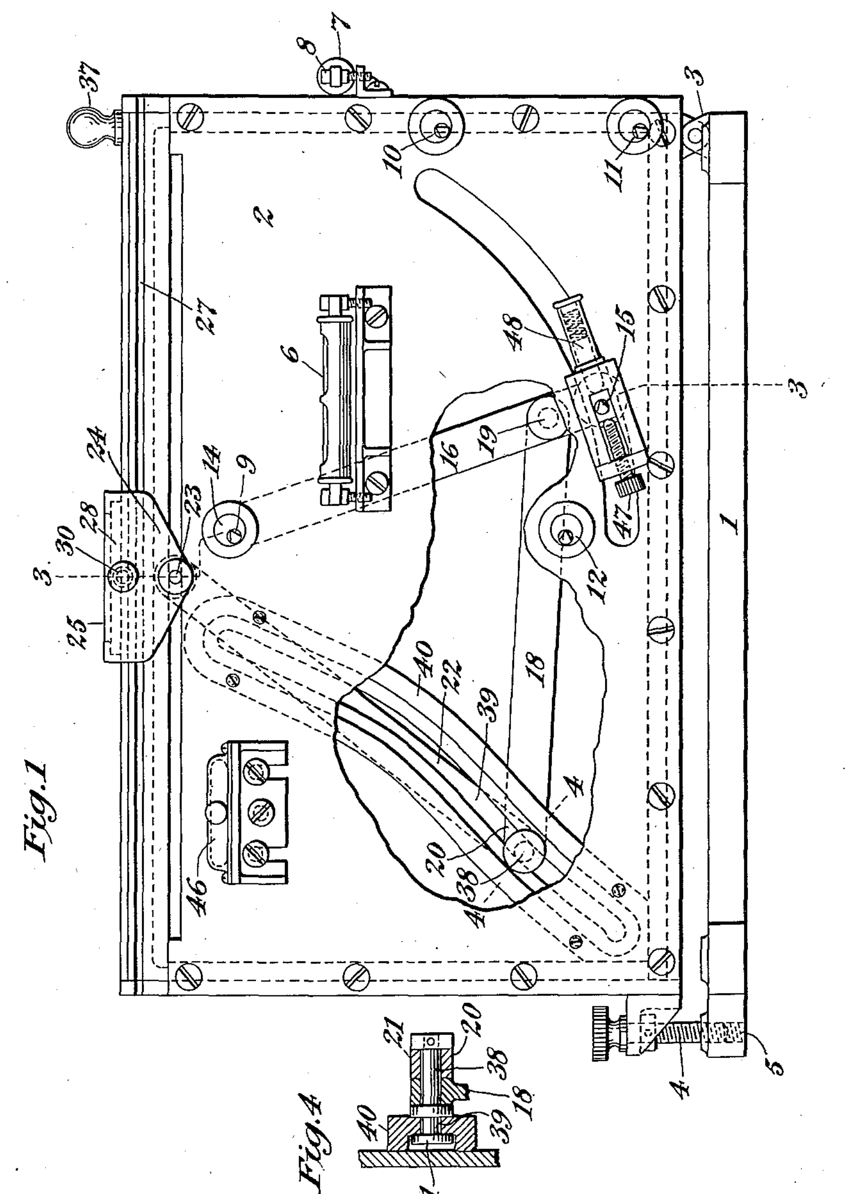
G. E. BEGGS.

AEROPLANE BOMB SIGHT.

APPLICATION FILED MAR. 29, 1918.

1,383,969. **Patented July 5, 1921.**

4 SHEETS—SHEET 1.



Inventor

George Erle Beggs.

By his Attorney

Andrew Wilson.

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4 SHEETS—SHEET 2.

Fig. 2

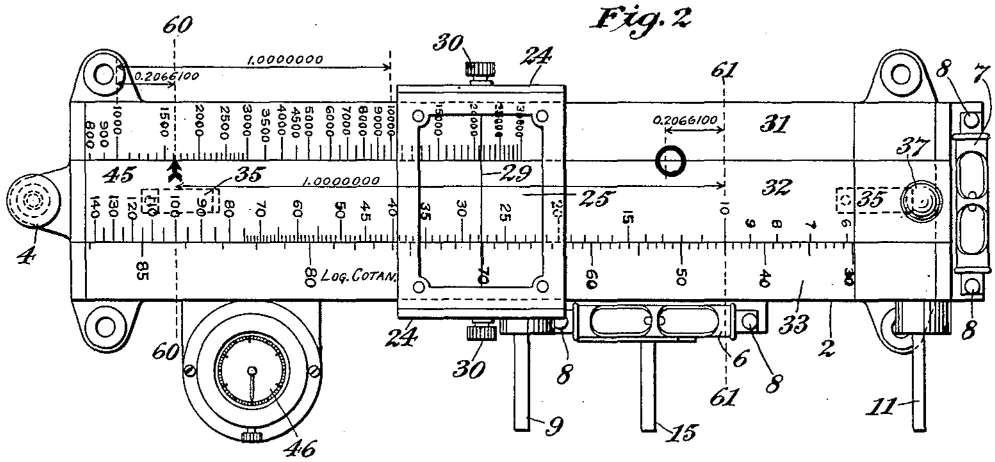


Fig. 3

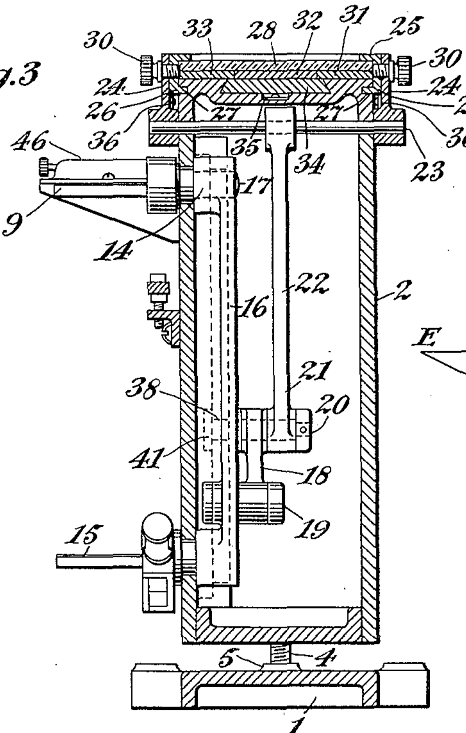


Fig. 9

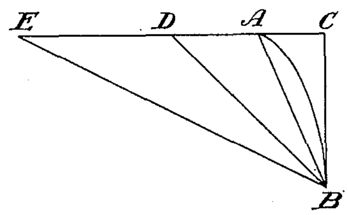
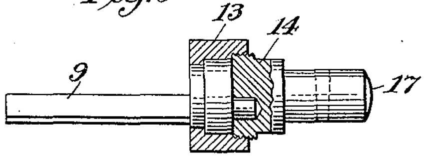


Fig. 5



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4 SHEETS—SHEET 3.

Fig. 6

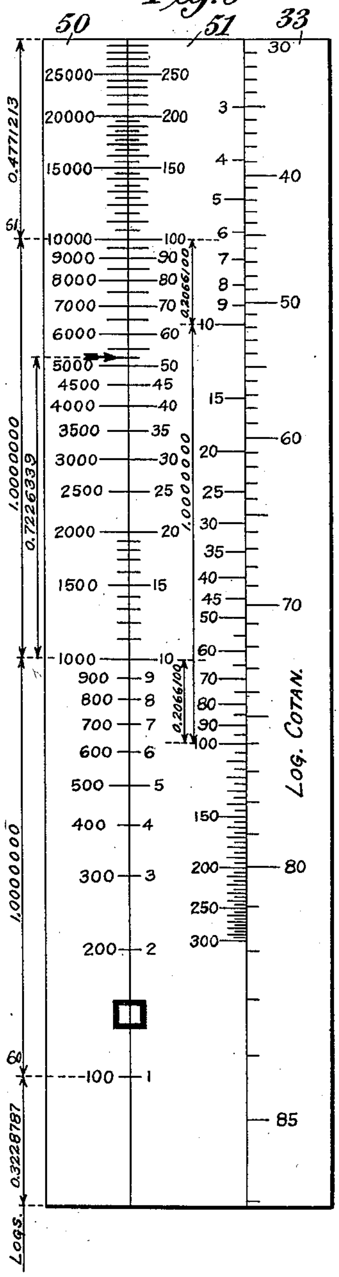


Fig. 7

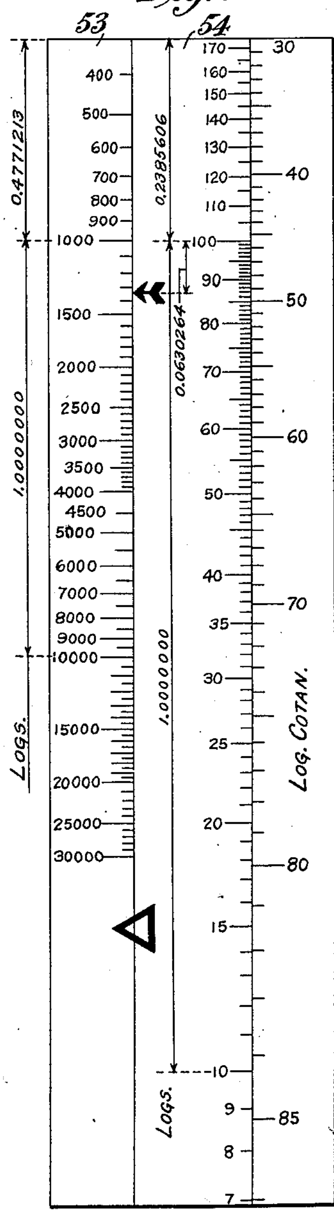
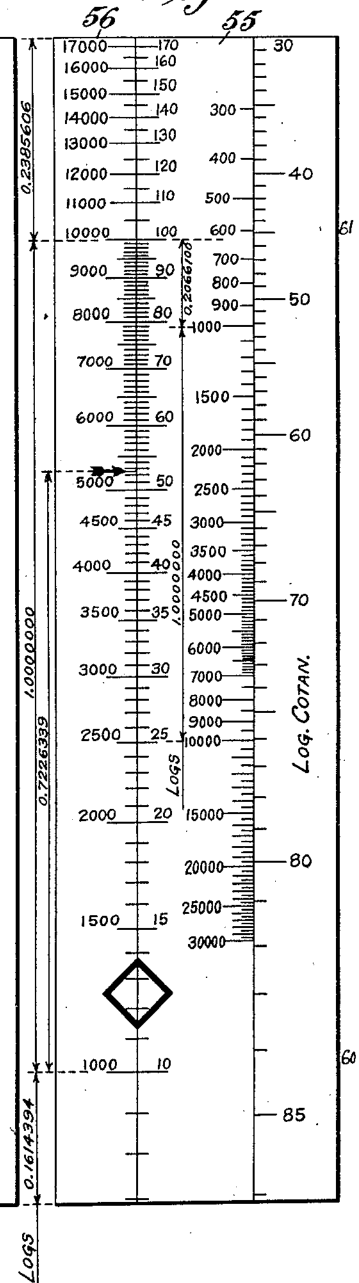


Fig. 8



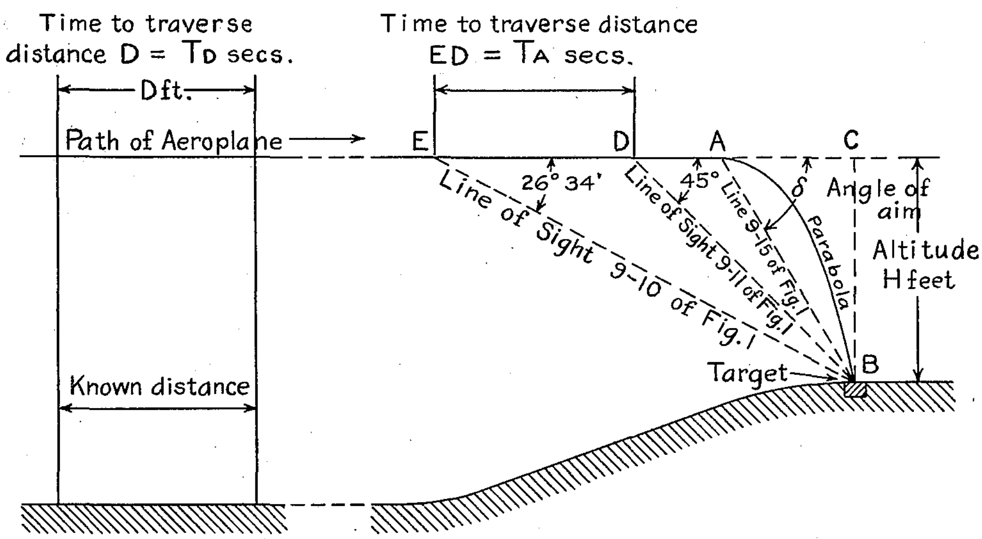
Inventor

George Erle Beggs.

By his Attorney

Andrew Wilson.

Fig. 10



v_G = ground-speed of aeroplane in miles per hour.
g = acceleration of gravity = 32.184 ft/sec^2 at Paris.

Equations for Angle of Aim δ

For Set of Scales in	Expressed Algebraically	Expressed logarithmically
Fig. 2	$\cot^2\delta = \frac{H}{(\frac{1}{2}g)\,T_A^2}$	$2\log.\cot.\delta = \log.H - 1.20661 + \text{colog}.T_A^2$
Fig. 6	$\cot^2\delta = \frac{D}{T_D T_A(\frac{1}{2}g)}$	$2\log.\cot.\delta = \log.D - \log.T_D + \text{colog}.T_A - 1.20661$
Fig. 7	$\cot^2\delta = \frac{v_G^2}{(\frac{g}{2}\cdot\frac{225}{484})H}$	$2\log.\cot.\delta = \text{colog}.H - 0.87395 + 2\log.v_G$
Fig. 8	$\cot^2\delta = \frac{D^2}{T_D^2\cdot H\cdot(\frac{1}{2}g)}$	$2\log.\cot.\delta = 2\log.D - 2\log.T_D + \text{colog}.H - 1.20661$

Inventor
George Erle Beggs.
By his Attorney
Andrew Wilson.

UNITED STATES PATENT OFFICE.

GEORGE ERLE BEGGS, OF PRINCETON, NEW JERSEY.

AEROPLANE BOMB-SIGHT.

1,383,969. Specification of Letters Patent. Patented July 5, 1921.

Application filed March 29, 1918. Serial No. 225,467.

To all whom it may concern:

Be it known that I, George E. Beggs, a citizen of the United States, residing at 73 Jefferson road, county of Mercer, Princeton, New Jersey, have invented certain new and useful Improvements in Aeroplane Bomb-Sights, of which the following is a specification.

My invention relates to mechanism adapted for use in adjusting sighting points carried upon an aeroplane for the purpose of ascertaining by reference to said sights the correct time, during the flight of an aeroplane, at which to release a bomb or other missile or package in order to have it strike a selected objective.

When a missile or other package is dropped from a moving aeroplane, the course which it will follow in its fall will be substantially determined by the momentum which it has acquired from the moving aeroplane, and by the attraction of gravitation. If, for instance, the aeroplane is flying in a horizontal plane, the missile, when released, will tend to continue forward in the same direction, but will be pulled down with increasing rapidity by the attraction of the earth. This being so, the point A (Figure 9) at which the missile begins its fall, and the point B at which it reaches the ground, will be at the respective ends of the hypotenuse of a right angled triangle the perpendicular of which is a vertical line B, C, and the base of which is the line A, C.

Therefore, if the altitude of A, and therefore the length of the line B, C, is known, the time which it will take the missile to fall from A to the ground may be readily computed; and, if the initial horizontal speed of the missile is also known, the extent of its forward movement, during the time of its fall, in other words the length of the line A, C may also be determined. And, if the aeroplane carrying the missile is moving in a horizontal plane at a substantially uniform speed, the inclination of the line A, B may be determined in advance, and mechanical sights adjusted to that angle of inclination, so that if the missile is released when the objective point is seen from the aeroplane to be at B of the line A, B, its curve of flight will be such as to cause it to strike at B, proper allowances being of course made for air resistance and other minor modifying conditions.

Because of the rapidity of flight of aeroplanes, the conditions under which the aviators operate, and the difficulties which are often encountered in seeing an objective, it is of great importance to make the necessary observations, calculations and adjustments for sighting, not only accurately but rapidly, and so far as possible automatically. And it is to means for securing these ends that my present invention is particularly directed, these means embracing means for ascertaining altitude and speed, and by relatively adjustable computing members mechanically determining the angle of inclination of A, B from the horizontal and automatically setting adjustable sights at that angle, as I will now proceed to explain, referring, in so doing, to the drawings, which illustrate a preferred form of my invention, and in which Fig. 1 is a side elevation, partly broken away for clearness; Fig. 2 is a top view; Fig. 3 is a cross sectional view on the line 3—3 of Fig. 1 looking to the left; Fig. 4 is a detail on the line 4—4 of Fig. 1, looking up; Fig. 5 is a detail of the rotatable sight; Figs. 6, 7 and 8 illustrate modifications in the computing scales for use under varying conditions, Fig. 9 is a diagram illustrating sighting angles and Fig. 10 shows, diagrammatically, the method of computing the angle of aim and the equations by which it is derived under different conditions.

A base 1 is attached to the frame work of the aeroplane in any suitable manner; and above it is mounted a case 2, which is secured to the base by pivots as 3, 3, at one end, and at the opposite end by an adjustable screw 4 threaded into the base at 5. This arrangement permits of the leveling of the case as a whole. To the case are attached spirit levels 6, 7 which have suitable adjusting screws 8, 8 threaded into brackets on the case whereby the levels may be adjusted in their relations to the case.

The object of these adjustable features is to permit the adjusting of the apparatus to the normal position of an aeroplane when flying on a horizontal plane. A rotatable sight 9 and fixed sights 10, 11 and 12 are each detachably secured to the case being attached as by means of a screw threaded cap as 13, threaded upon a stud as 14, fastened into or through the side of the case. These sights 9, 10, 11 and 12 are preferably so set that the inclination of the line 9—11 is 45 degrees below the horizontal, as DB

Fig. 9; a line through 9—12 is vertical, as CB, Fig. 9; and the base of the triangle EBC will be double that of DCB when the line E, B is taken over the sights 9—10. A movable and adjustable sight 15 is carried by mechanism within the case.

This latter mechanism embodies an arm 16 which is pivoted at 17 on the inner end of the stud 14 and swings from that stud as a center. A link 18 is pivoted at one end at 19, to the arm 16, and at its other end, at 20, to one end 21 of an arm 22 hung upon a pivot pin 23 the ends of which extend through slots in the sides of the case 2. The ends of this pivot pin 23 are carried by side flanges or lugs 24, 24 on the sides of a movable indicator 25, which is associated in a sliding relation with the top of the case 2, as by tongues 26 traveling in grooves 27 in the sides of the case. This indicator 25 is preferably provided with a glass 28 with the usual cross line 29; and the side flanges 24 may be detachably attached to the indicator as by set screws 30, 30 passing through the flanges and threaded into the indicator. This permits of the removal of the indicator by withdrawing the set screws and loosening the side flanges 24, if desired.

Upon the top of the case are carried several scales as 31, 32 and 33; the scales 31 and 33 being preferably fixed, while the scale 32 is movable longitudinally, being shown as carried upon a base 34 dove-tailed into the top of the case 2, so as to slide to and fro therein. I prefer to place flat springs as 35, 35 between the top of the case 2 and the bottom of the base 34 to press the base snugly upward in its dove-tail so as to prevent its being too readily shifted or jarred out of adjustment; and similar springs 36, 36 are preferably interposed between the side flanges 24 of the indicator 25 and the case 2, to hold the indicator against too easy displacement from the positions to which it may be adjusted from time to time.

Any suitable means, as a knob 37, may be attached to the base 34 for conveniently grasping it by the hand of the operator.

One end of the pivot 38, which connects the arm 22 and the link 18, extends through a cam slot 39 formed in a suitable guide 40 attached to the inside of the case 2, the pin 38 being provided with a head 41 which serves to prevent it from escaping from the cam slot 39.

It will be seen, therefore, that if the indicator 25 is slid forward or backward on top of the case 3 it will carry, through its flanges 24, 24 and the pivot pin 23, the upper end of the bar 22 forward or backward, and will cause its lower end to raise or lower the connected end of the link 18 along the cam slot 39, and, through the link 18, to swing the arm 16 to and fro on its pivot 17, with the result that the sight 15 will be swung forward or back in relation to the sight 9 a distance which will be regulated by the movement of the indicator 25 along the top of the case 2, the sight 9 revolving with the stud 14 so that its angular edge always maintains the same relation to that of the sight 15.

In the drawings I have illustrated my apparatus as provided with scales adapted to furnish three classes of readings. Thus the scale 31 is graduated to give barometer readings, and the scale 33 is graduated to give angle readings in degrees, while the scale 32 is graduated to give time readings in seconds. It will be understood, of course, that all these scales are graduated logarithmically. And it will be seen that the path of the cam slot 39 is plotted in such a way that the movement of the indicator 25 for any selected distance as, for instance, one degree, will produce a corresponding movement of the sight 15 relative to the sight 9, thus converting the linear movement of the indicator 25 into the angular movement of the arm 16.

The angle of aim, which governs the setting of the movable sight 15 (Fig. 1), depends primarily on the height of flight and the ground-speed (air-speed ± wind) of the aeroplane; that is the angle of aim=function of height and ground-speed. But height may be expressed trigonometrically in terms of other lengths and certain angle functions, while ground-speed may be stated in terms of distance and time. It is therefore evident that the angle of aim itself may be expressed as a function of other units than height and ground-speed, if these latter terms be replaced by expressions mathematically and physically equivalent. By making such substitutions, several algebraic and logarithmic equations have been derived which express directly and explicitly the angle of aim in such quantities as may readily be obtained by instrument observations made during flight, for example, barometer, air-speed, ground-speed, and time observations.

Four algebraic equations for this angle of aim follow below. The person familiar with the application of the laws of motion and with the equations for falling bodies, can readily check these equations.

$$(1)\quad \cot^2\delta = \frac{H}{(.5g)T_A^2}$$

$$(2)\quad \cot^2\delta = \frac{D}{T_D T_A (\tfrac{1}{2}g)}$$

$$(3)\quad \cot^2\delta = \left(\frac{1}{\frac{g}{2}\cdot\frac{225}{484}}\right)\frac{G^2}{H}$$

$$(4)\quad \cot^2\delta = \frac{D^2}{T_D^2\cdot H(\tfrac{1}{2}g)}$$

In the above equations, the notation has the meaning defined below:

δ=angle of aim in degrees.

=angle between the horizontal and the line 9—15 of the movable sight. (See Fig. 1.)

45°=angle between the horizontal and the line of the fixed sights 9—11. (See Fig. 1.)

26°—34′=angle between the horizontal and the line of the fixed sights 9—10. (See Fig. 1.)

H=altitude in feet that the aeroplane is above the elevation of target.

T_A=time in seconds between the time that target appears on the line 9—10 of fixed sights and later on the line 9—11 of fixed sights. (See Figs. 1 and 10.)

g=acceleration of gravity in feet per second squared=32.184 at Paris.

G=ground-speed of aeroplane in miles per hour=air-speed ± wind.

T_D=time in seconds for aeroplane to traverse a known distance D feet measured with reference to ground.

The four equations (1), (2), (3), (4) may be expressed logarithmically by writing the logarithmic expressions for the left hand and right hand members of said equations. This is done in equations (5), (6), (7), (8) below. The actual logarithms of all constant factors are introduced and several cologs. are employed in order to bring the expressions into the desired form for most convenient solution on special slide rules.

(5) $2 \log \cot \delta = (\log H - 1.20661) + (2 \operatorname{colog} T_A)$

(6) $2 \log \cot \delta = (\log D) - (\log T_D) + (\operatorname{colog} T_A - 1.20661)$

(7) $2 \log \cot \delta = (1 + \operatorname{colog} H) - (1.87395) + (2 \log G)$

(8) $2 \log \cot \delta = (2 \log D) - (2 \log T_D) + (\operatorname{colog} H - 1.20661)$

The derivation of the above equations is as follows (see Fig. 10):

$$ED = DC = GT_A = H \quad (1)$$

H = altitude in feet

G = ground speed in feet per sec.

V_G = ground speed in miles per hour

$$V_G = \frac{3600}{5280} G = \frac{15}{22} G \quad (1a)$$

$$G = \frac{H}{T_A} \quad (2)$$

and

DC=DA+AC (3)

DA=H—H cot δ (4)

AC=Gt (5)

where t equals the time of fall for bomb in seconds.

$$H = \tfrac{1}{2} g t^2 \quad (6)$$

whence

$$t = \left(\frac{2H}{g}\right)^{\frac{1}{2}} \quad (7)$$

From (1), (3), (4), (5),

$$H = H - H \cot \delta + Gt \quad (8)$$

$$\cot \delta = \frac{1}{T_A}\left(\frac{2H}{g}\right)^{\frac{1}{2}} \quad (9)$$

Squaring

$$\cot^2 \delta = \frac{H}{T_A^2 (\frac{1}{2} g)} \quad (10)$$

which is formula for scales in Fig. 2.

Again,

$$\frac{D}{T_D} = \frac{H}{T_A} = G \quad (11)$$

Whence

$$\cot^2 \delta = \frac{D}{T_A T_D (\frac{1}{2} g)} \quad (12)$$

which is formula for scales in Fig. 6.

Again from (11)

$$\frac{1}{T_A} = \frac{D}{H \cdot T_D} \quad (13)$$

Whence

$$\cot^2 \delta = \frac{D^2}{H T_D (\frac{1}{2} g)} \quad (14)$$

which is formula for scales in Fig. 8.

From (10) and (11)

$$\cot^2 \delta = \frac{H}{\frac{1}{2} g}\left(\frac{G}{H}\right)^2 = \frac{G^2}{(\frac{1}{2} g) H} \quad (15)$$

From (1a) and (15)

$$\cot^2 = \frac{(V_G)^2}{\left(\frac{g}{2} \cdot \frac{225}{484}\right) H}$$

which is formula for scales in Fig. 7.

The logarithmic quantities given in the brackets of equations (5), (6), (7), (8) have been laid out on the parallel scales of the special slide rules. (See Figs. 2, 6, 7, 8, respectively.)

These scales are made movable relative to each other and in such parallel juxta-position as to perform graphically the necessary addition and subtraction of the logarithmic quantities given in the brackets of equations (5), (6), (7), (8).

In this way by mechanical solution the required value of 2 log. cot. δ and the corresponding angle of aim δ are obtained. The value of this angle of aim δ is automatically transferred from the runner of the slide rule to the movable sighting arm by means of the cam and lever mechanism. (See Figs. 1 and 3.)

The set of scales shown in Fig. 2 is adapted to solve the equation given as (5) above. The algebraic and logarithmic statements of this equation and of others to follow are given in mathematical characters beneath Fig. 10, which is self explanatory.

The scales are, laid out in relation to parallel base lines 60—60 and 61—61 so that the characteristic of the logarithm of the scale 33 at the line 60—60 shall be zero, and that of the scale 31 shall be .20661; and the characteristic of the logarithm of the scale 33 at 61—61 shall also be zero, and that of the scale 31 at the line 61—61 shall be .20661.

In a similar manner the scale 32 is laid out, when in its initial position as in Fig. 2, between the lines 60—60 and 61—61, taken as bases, so that the characteristic of the logarithm of the graduation at each of said lines shall also be zero. Hence it will be seen that if the scale 32 is advanced relatively to the scale 31 so that its index arrow at zero shall be opposite any selected altitude reading on the scale 31, the graduations on the scale 32 may be read forward or added to the selected reading on the scale 31 so as to add the logarithmical reading on the former scale to that of the latter, and so that any advanced point on scale 32 will in its relation to the angle scale 33 indicate the solution of the equation above given.

My improved bomb sight may be used as follows:—

Assuming that the apparatus has been properly leveled by means of the adjusting mechanism, and that the aviator desires to release a bomb or missile or package, he first reads his altitude from the barometer, not shown, with which his machine is equipped. If, for instance, he finds that his altitude relative to his objective is sixty-three hundred feet; he moves his time slide 32 until the arrow 45 at 100 stands opposite the reading sixty-three hundred on the barometer scale 31, which results in shifting the graduations on the time scale in their relation to the graduations on the angle scale.

With the scales in this relation the aviator continues his flight until he has his objective in line with the sights 9 and 10, when he starts a timing mechanism, as, for instance, a stop watch 46, and continues his flight, as nearly as possible on the same level, until he has his objective in line with the sights 9 and 11, when he notes the elapsed time on his timing apparatus as by stopping the watch and reading it; for instance, the elapsed time might be thirty-two and four-fifths seconds which represents half the time required to cover the base line DC. He then moves the indicator until its registering line 29 stands over the graduation thirty-two and four-fifths seconds on the time scale, this results in swinging the arm 16 carrying the lower sight 15 into the angular position corresponding with the barometer and elapsed time readings, to wit, fifty-eight and nine-tenths degrees from the horizontal. He then continues his flight, always as nearly as possible at the same altitude, until he brings his objective in line with the sights 9 and 15, when he releases his missile, the result being that the initial speed of the missile derived from the aeroplane will carry it sufficiently far forward before it reaches the ground so that it shall fall at the point selected as the objective, if the calculations and release of the missile have been accurately carried out.

I desire it to be understood that suitable allowance will have been made previously for the air resistance by adjustment of the lower sight 15 forward or back by means of the set screw 47 against which the sight is pressed by a spring pressed plunger 48, as is common in transit instruments.

I have explained the operation of my apparatus when provided with altitude, time and angle scales. But I wish it to be distinctly understood that these scales can be varied and other scales substituted for them.

Thus, when it is convenient to determine ground speed by timing over known territory and when the conditions are such that timing on the target can be done with reasonable safety the barometer scale 31 would be omitted and the scales shown in Fig. 6 would be used, the scale 50 representing a scaling from the map in feet; the scale 51 being a modification of the timing scale 32; and the scale 33 remaining the same.

In this case the equation to be solved is that given as (6) above.

In this case the time is taken with the timing mechanism over sights 9 and 12 to the ground, and the time noted by moving the scale 51 until the time numeral on its left hand margin corresponding with the elapsed time is opposite the number of feet traveled on the distance scale over any known distance. The target is then sighted over sigths 9 and 10 and timed until it is taken over sights 9 and 11, and the indicator is moved until its cross line corresponds with the last elapsed time on the right hand side of the scale 51. This moves the sight 15 into the correct angular position for sighting the objective when in the proper target position. This system dispenses with the use of a barometer for altitude readings.

In the system of scales shown in Fig. 7 the barometer scale is modified as at 53, and a scale of miles per hour 54 is used. The altitude is taken from the barometer and the slide 54 is moved until its index arrow stands opposite the barometer reading. The speed is is then obtained from an air speed indicator or from any other source, as by wireless from the ground, and the indicator is then moved until its cross line stands over the numeral on scale 54 corresponding with the miles per hour.

This brings the sight 15 in proper angular position for releasing the missile when the target is sighted over sights 9 and 15.

The equation solved in this case is that given as (7) above.

In the system of scales shown in Fig. 8 the barometer scale is placed on the right side of the slide 55 which is also provided with a time scale on its left hand side. And scale 56 is for feet over a known ground distance.

The equation to be solved in this case is that given as (8) above.

The barometer is read for elevation and the barometer scale is moved, after the time figure has been taken by ground sighting, until the proper time figure on its left hand side stands opposite to the distance covered on scale 56. The indicator is then moved until it stands opposite the barometer reading and this again results in bringing the sight 15 into the proper angular position.

Each of these sets of scales is laid off upon the principle explained as governing the relative graduations on the scales of Fig. 2.

In all these systems the essential governing elements consist of elevation and speed. And the four systems of scales simply show possible variations of the method of combining the readings for speed and elevation so as to bring about an automatic adjustment of the movable sight 15 into its proper angular relation with the horizontal.

The reason for adopting several systems of scales each based on a different equation is one of military strategy. If the conditions of warfare are such that the observations which are necessary to operate any one set of scales, cannot be taken, another set of scales may be selected for use for which the necessary observations may be made more safely.

Having thus described my invention what I claim and desire to secure by Letters Patent of the United States is:

1. In an aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations, embodying a fixed scale graduated in terms of one element of the required calculation, an associated and relatively movable slide scale graduated in terms of the other elements of such calculation, coöperating means, adjustable relative to such scales, for registering the result of the calculation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of such calculation.

2. In an aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations, embodying a fixed scale graduated in terms of one element of the required calculation, an associated and relatively movable scale graduated in terms of the other elements of such calculation, coöperating reciprocating means, adjustable relative to such scales, for registering the result of the calculation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of such calculation.

3. In an aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations, embodying a fixed scale graduated in terms of one element of the required calculation, an associated and relatively movable scale graduated in terms of the other elements of such calculation, coöperating means, adjustable relative to such scales, for registering the result of the calculation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to indicate the result of such calculation.

4. In an aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations, embodying a fixed scale graduated logarithmically in terms of one element of the required calculation, an associated and relatively movable scale logarithmically graduated in terms of the other elements of such calculation, coöperating means, adjustable relative to such scales, for registering the result of the calculation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of such calculation.

5. In an aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations, embodying a fixed scale graduated in terms of one element of the required calculation, an associated and relatively movable scale graduated in terms of the other element of such calculation, coöperating means, adjustable relative to such scales, for registering the result of the calculation, adjustable sighting means and cam governed mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of such calculation.

6. In an aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations embodying a fixed scale graduated in terms of one element of the required calculation, an associated and relatively movable scale graduated in terms of the other elements of such calculation, coöperating means, adjustable relative to such scales, for registering the result of the calculation, a substantially fixed sight and swinging sight,

and mechanism actuated by said coöperating means for adjusting the sights to a line of fire corresponding to the result of such calculation.

7. In an aeroplane bomb-sighting mechanism, means of calculating and indicating the angle of aim from preliminary observations of the altitude of flight and the elapsed time between two fixed sights, embodying an altitude scale graduated logarithmically in terms of the altitude and another associated and relatively movable time scale graduated logarithmically in terms of the elapsed time, this latter scale carrying also an indicating element whose relative position depends on the physical constant in the calculation, coöperating means adjustable relative to such scales for registering the result of the calculation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of the computation.

8. In aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations of the traversed horizontal ground distance, of the time to traverse this distance, and of the time taken for the line of vision toward the target to change from one fixed angle with the horizontal to another larger fixed angle with the horizontal, embodying a ground distance scale graduated logarithmically in terms of the ground distance, associated with a relatively movable scale graduated logarithmically in terms of the two time measurements above defined, the relative displacement of the latter two scales depending on the physical constant in the calculation, coöperating means adjustable relative to such scales for registering the result of the calculation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of such computation.

9. In aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations of the altitude of flight and the ground speed of the aeroplane, embodying an altitude scale graduated logarithmically in terms of the altitude, and another associated and relatively movable speed scale graduated logarithmically in terms of the ground speed, the latter scale carrying also an indicating element whose relative position depends on the physical constant in the calculation, coöperating means adjustable relative to such scales for registering the result of the calculation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of such computation.

10. In aeroplane bomb-sighting mechanism, means for calculating the angle of fire from preliminary observations of the traversed distance, the time, and the altitude of flight, embodying a distance scale graduated logarithmically in terms of the distance, an associated and relatively movable scale graduated logarithmically in terms of the time and the altitude, the relative displacements of the graduations of the latter two scales depending on the physical constant in the calculation, coöperating means adjustable to such scales for registering the result of the computation, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of such computation.

11. In an aeroplane bomb-sighting mechanism, means for calculating and indicating the angle of fire from preliminary observations, embodying a scale graduated in terms of one element adapted to be used in each of a plurality of optional computations, a plurality of movable scales each graduated in terms of a different element of such optional calculations and each scale being adapted to coöperate separately with the first mentioned scale, coöperating means, adjustable relative to such scales for registering the result of such calculations, adjustable sighting means, and mechanism actuated by said coöperating means for adjusting the sighting means to a line of fire corresponding to the result of any of such calculations.

GEORGE ERLE BEGGS.