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APPARATUS FOR USE IN THE FIRE CONTROL OF ANTIAIRCRAFT GUNS

Filed Feb. 16, 1925

Fig. 1.

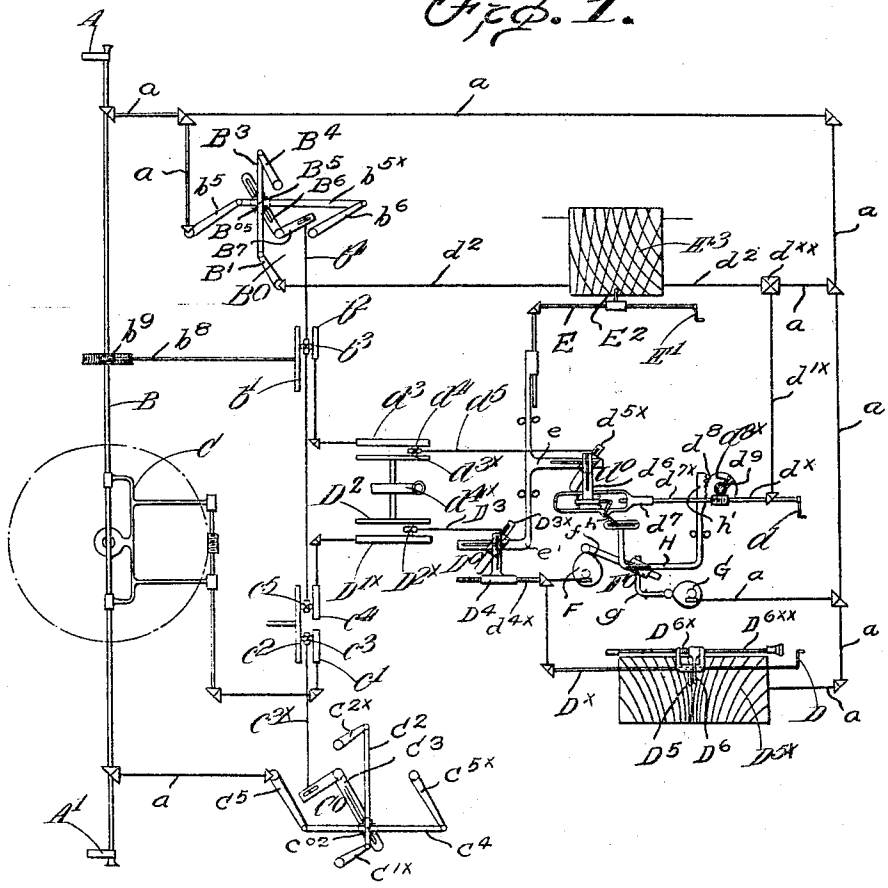
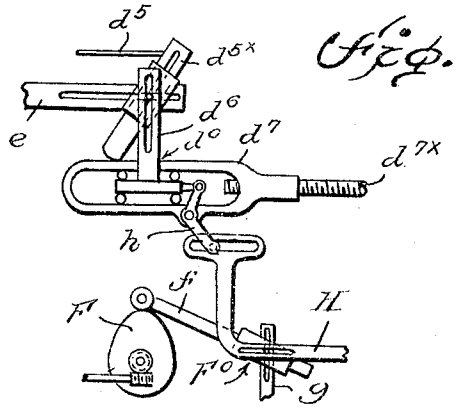


Fig. 2.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR USE IN THE FIRE CONTROL OF ANTIAIRCRAFT GUNS

Application filed February 16, 1925, Serial No. 9,375, and in Great Britain March 3, 1924.

This invention relates to apparatus for use in the fire control of anti-aircraft guns, more particularly those on ships or in fortresses.

According to the invention the apparatus comprises an infinitely variable speed device driven at a constant speed by hand or by an electric or other motor and connected to an observing sight, and an adjusting knob or handle which operates to move the adjustable speed varying element of the said device through mechanism of such a character that when the deflection setting of the said knob or handle is correct the observing sight will be elevated (or trained) at the correct rate to keep the sight line on the target. The observer alters the setting of the said knob or handle until he sees that the observing sight is accurately following the target in elevation (or in training) and the position of the said knob or handle when this condition has been attained is a measure of the vertical (or the lateral or horizontal) deflection for a given time of flight of the shell. This deflection may be indicated by a pointer operated by the knob or handle, it may be transmitted to the gun or guns or it may be both indicated and transmitted. It is preferred that the said infinitely variable speed device shall both elevate and train the observing sight (which has separate sighting elements for the elevating and training numbers) the said device in this case comprising two secondary members having separate adjustable speed varying elements one appertaining to the setting knob or handle relating to vertical deflection and the other appertaining to the setting knob or handle relating to lateral or horizontal deflection.

In order that the said invention may be clearly understood and readily carried into effect, the same will now be described more fully with reference to the accompanying drawings in which Fig. 1 shows diagrammatically a form of apparatus in accordance with this invention and Fig. 2 is an enlarged view of certain portions of the apparatus shown in Fig. 1.

The apparatus shown is intended for elevating and training a single observing sight having a sighting element A for the elevating number and a sighting element A^1 for the training number, these two elements being connected by a horizontal shaft B which is rotated about its axis for elevation in a bracket C rotatable about a vertical axis for training.

This apparatus operates according to the following formulæ:

$$(1)\quad \text{Sin } d = R_E \times T \times \frac{\sin(a \pm d)}{\sin a} - \frac{D^2}{2} \sin a \cos a$$

$$(2)\quad \text{Sin } D = R_T \times T \times \frac{\sin(a \pm d)}{\sin a} \times \frac{\cos a}{\cos(a \pm d)}$$

where

d=the deflection in the vertical plane.
R_E=the angular rate of elevation.
a=the present angle of elevation.
D=the lateral or horizontal deflection.
R_T=the angular rate of training.
T=the time of flight of the shell.

The aforesaid variable speed device is intended both for elevating and for training the sight and comprises two discs d^{3x} and D^2 driven by hand or power at a constant speed through gearing d^{4x}. The disc d^{3x} drives a roller d^3 through interposed balls mounted in an adjustable carrier d^4 connected by rod d^5 with a linkage mechanism d^0 which is associated with another linkage mechanism F^0 and with a vertical deflection handle d and a time of flight handle E^1. The vertical deflection handle d which, as will be hereinafter shown, is operated in accordance with sin d of formula (1), drives two shafts d^x and d^{1x} and the movement of the shafts d^{1x} and a are added together by the differential gear d^{xx} which operates a shaft d^2 in accordance with the sum of the two movements, i. e. in accordance with the factor $(a \pm \sin d)$ which for all practical purposes may be regarded as the equivalent of the factor $(a \pm d)$ of the formulæ (1) and (2). If required, however, suitable means such as a sine cam or arm could be provided for eliminating the sine factor.

The rotations of shafts a and d^2 are transmitted to linkage B^0, shaft a being geared to arm b^5 and shaft d^2 being geared to arm B^2, whereby these arms are given an angular

movement in accordance with the movement of the respective shafts. This arm b^5 is connected by a link b^{5x} to an arm b^6 arranged parallel to, and made of the same length as, the arm b^5. The arm B^2 being driven from the shaft d^2, the angular movement of this arm is proportionate to $(a \pm d)$; the said arm B^2 is connected by a link B^3 to an arm B^4 arranged parallel to, and made of the same length as, the arm B^2. The link B^3 and the link b^{5x} are slidably carried at right angles to each other by a block B^{05} which has a pin B^5 disposed in a slot in one arm B^6 of a bell-crank lever the other arm B^7 of which is connected to the aforesaid rod b^4. This linkage is such that the rod b^4 receives a reciprocatory movement proportionate to

$$\frac{\sin (a \pm d)}{\sin a}$$

i. e. the sine proportion of the movements of shafts a and d^2.

The vertical deflection handle d also actuates in part the multiplying linkage d^0 referred to above by imparting longitudinal movement to carrier d^7 by virtue of the screw connection d^{7x} of shaft d^x. The linkage d^0 comprises a slotted pivoted arm d^{5x} to which the reciprocatory rod d^5 is connected by a pin and slot connection, a slotted slider d^6 and a slotted bar e which is constrained to move in a path at right angles to the path of the slider d^6. The members d^{5x}, d^6 and e are associated by means of a pin carried by a block slidably mounted on the arm d^{5x}, this pin being disposed in the slots in the members d^6 and e. The travel of the bar e is made proportionate to the "future" time of flight of the projectile for which purpose it is adjusted through a screw and nut arrangement from a screw E rotated by a handle E^1. This screw carries a nut having a pointer E^2 arranged contiguous to a "height and fuse" chart E^3 driven from shaft d^2, rotating in accordance with $(a \pm d)$. The said chart has two sets of curves, one for heights and the other for fuse numbers and the handle E^1 is rotated so as to maintain the pointer E^2 on the height curve corresponding to the particular height of the target. Consequently the bar e is moved in accordance with the "future" time of flight of the projectile and the fuse number can be ascertained from the particular fuse number curve indicated by the pointer E^2. Alternatively the time of flight factor may be obtained by means of a three-dimensional cam initially set for height and moved axially or radially in accordance with $(a \pm d)$, and similar means may be employed for obtaining the fuse numbers.

The resultant motion imparted to rod d^5 locates carrier d^4 in such a position from the center line of disc d^{3x} that a proportional movement is transmitted to roller d^3 which drives the roller b^2 of a second variable speed device and the latter roller in turn drives a disc b^1 through interposed balls mounted in an adjustable carrier b^3. This carrier is connected by a rod b^4 with a linkage B^0 which accordingly actuates carrier b^3 according to the changing values of the aforesaid proportion

$$\frac{\sin (a \pm d)}{\sin a}.$$

In order that the sight A will follow the target in elevation shaft B thereof, gear b^9, shaft b^8 and disc b' must be driven at the angular rate of elevation, i. e. R_E. Accordingly roller b^2 must have a movement

$$R_E \times \frac{\sin (a \pm d)}{\sin a}.$$

Inasmuch as the bar e connected to slider d^6 is moved in accordance with the time of flight of shell or T, and since the pivoted arm d^{5x} connected to slider d^6 is adjusted from roller b^2 in accordance with the movement

$$R_E \times \frac{\sin (a \pm d)}{\sin a}$$

it follows that the travel of slider d^6 is proportional to

$$R_E \times T \times \frac{\sin (a \pm d)}{\sin a}.$$

From the aforesaid formulæ (1) it will be seen that the value of this factor increases or decreases by an amount

$$\frac{D^2}{2} \sin a \cos a$$

and two cams F and G are provided from whose rotation the values of

$$\frac{D^2}{2}$$

and $\sin a \cos a$ are respectively obtained. The cam F is rotated from a shaft D^x operated by the lateral deflection handle D and this cam bears against a pivoted arm f which therefore moves in accordance with

$$\frac{D^2}{2}.$$

The cam G is rotated from one of the shafts a and bears against a slotted slider g which therefore moves in accordance with $\sin a \cos a$. A pin on a block slidably mounted on the arm f passes through the slots in the slider g and also through a slot in a slider H which is constrained to move in a path at right angles to the slider g. The members f, g and H constitute a multiplying linkage (indicated generally by the reference letter F^0) serving to move the slider H in accordance with the factor

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$$\frac{D^2}{2}\sin a\cos a.$$

This slider operates a bell-crank lever h which is pivoted to a carrier d^7 and is connected to the aforesaid slider d^6 mounted in this carrier and the travel of the latter slider thus becomes proportionate to

$$R_E\times T\times\frac{\sin a\pm d}{\sin a}-\frac{D^2}{2}\sin a\cos a,$$

i. e. proportionate to sin d (see formula 1). The carrier d^7, as aforesaid, is operated by a screw d^{7x} on the aforesaid shaft d^x operated by the vertical deflection handle d. It therefore follows that the rotation of this handle is proportionate to sin d the value of which is indicated by the movement over a dial d^8 of a pointer d^{8x} geared to the shaft d^x. Spotting corrections can be recorded by a pointer d^9 which is frictionally connected to the pointer d^{8x}.

It is known that when lateral deflection is applied to a gun sight in the plane of the sight, the sight line is depressed as a result, this depression being known as the complementary error. The amount of this depression is equal to the amount aforesaid correcting factor

$$\frac{D^2}{2}\sin a\cos a.$$

represented by the movement of the aforesaid slider H. In order to introduce this correcting factor, the slider H has a rack member h^1 which meshes with rack teeth on the vertical deflection dial d^8 (or on a member connected to this dial) so that the zero mark on this dial is displaced from its normal position by an amount proportionate to the value of the said correcting factor.

The aforesaid factor

$$\left(\frac{D^2}{2}\sin a\cos a.\right)$$

is a close approximation to the correct expression, but if further accuracy is required, the factor would be expressed

$$\sin D\tan\left(\frac{D}{2}\right)\sin(a\pm d)\cos(a\pm d)$$

and furthermore if mathematical accuracy is required, the said factor would be expressed

$$\sin D\tan\left(\frac{D}{2}\right)\sin a\cos(a\pm d);$$

in either case the mechanism would be modified accordingly.

Accordingly it will be seen that if the handle d is adjusted so that the sight A follows the movement of the target in elevation the movement of this handle will be proportionate to the angle of vertical deflection which can be read from a dial d^{8x} or transmitted to the guns.

Referring now to the training or lateral deflection portion of the apparatus the aforesaid lateral deflection handle D drives shaft D^x, aforesaid cam F and screw threaded shaft D^{4x} which carries and actuates slotted slider D^4. Mounted in the slots of slider D^4 and in the extension e^1 of the aforesaid "time" bar e is a pivoted slotted arm D^{3x} connected to ball carrier D^{2x}. The slots in the said extension e^1 and slider D^4 are arranged at right angles to each other and the slider is constrained to move in a path at right angles to the path of the bar e. A pin on a block slidably mounted on the arm D^{3x}, passes through the slots in the members D^4 and e^1. The resultant movement of arm D^{3x} actuates rod D^3 connected to ball carrier D^{2x} in such a way that the speed of rotation of roller D^{1x} is regulated by the position of ball carrier D^{2x} in accordance with conditions to be hereinafter explained.

The roller D^{1x} drives the roller c^4 of another variable speed device and the latter roller in turn drives a disc c^2 through balls mounted in a carrier c^5 which is connected to the aforesaid carrier b^3. This disc in turn drives a roller c^1 through interposed balls mounted in a carrier c^3 connected by a rod c^{3x} to one arm C^{3x} of a bell-crank lever, the other arm C^3 of which has a slot to receive a pin c^{2x} on a block c^{02} through which the links C^2, C^4 can slide at right angles to each other. The link C^2 is interposed between two parallel and equal pivoted arms C^{1x} and C^{2x} of which the former is operated from the aforesaid shaft d^2 in accordance with the factor $(a\pm d)$. The spindle of the arm C^{1x} may be common to the aforesaid arm B^2 moved in accordance with this factor. The link C^4 is interposed between two parallel and equal pivoted arms C^5, C^{5x} of which the former is driven from one of the shafts a so that the said arm rocks in accordance with the value of a. This arrangement constitutes a linkage (indicated generally by the reference letter C^0) such that the carrier C^3 is displaced by an amount proportionate to the factor

$$\frac{\cos(a\pm d)}{\cos a}$$

of formula (2) and the sight A′ must be rotated at the training rate R_T in order to keep it on the target. Consequently the speed of rotation of the disc c^2 is proportionate to

$$R_T\times\frac{\cos a}{\cos(a\pm d)}.$$

The other carrier c^5 is connected to the previously mentioned carrier b^3 adjusted in accordance with the factor

$$\frac{\sin(a\pm d)}{\sin a}$$

with the result that the roller c^4 is caused to rotate at a speed proportionate to

$$R_T \times \frac{\sin (a \pm d)}{\sin a} \times \frac{\cos a}{\cos a (a \pm d)}.$$

As the arm D^{3x} also moves in accordance with the factor

$$R_T \times \frac{\sin (a \pm d)}{\sin a} \times \frac{\cos a}{\cos (a \pm d)}$$

being connected to roller e^4 through roller D^{1x} carrier D^{2x} disc D^2 and shaft D^3, and as the extension e' of bar e moves in accordance with the aforesaid factor T, it follows that the movement of slider D^4 is proportionate to

$$R_T \times T \times \frac{\sin (a \pm d)}{\sin a} \times \frac{\cos a}{\cos (a \pm d)}$$

which from formula (2) is seen to be equal to sin D. Consequently the rotation of shaft D^x is proportional to sin D. The multiplying linkage which effects this is generally designated D° in the drawings.

The shaft D^x which is operated by the deflection handle D is screw threaded to operate a nut carrying a pointer D^5 arranged contiguous to a chart D^{5x} provided with suitable curves from which the right and left deflection in the plane of sight can be read, this chart being operated by one of the shafts a rotated in accordance with the movements of vertical deflection handle d. The said nut carries a screw threaded sleeve D^{6x} which is slidably keyed to a shaft D^{6xx} and operates a pointer D^6 by which spotting corrections can be made. The conversion from horizontal deflection into deflection in the plane of the line of sight instead of being effected by the chart D^{5x} may be effected by a suitable linkage, a three dimensional cam or other convenient means.

In operation, the elevating and training numbers turn the handles d and D, respectively, so as to maintain the cross-wires of the respective telescopes A and A^1, upon the target. The "height and fuse" number, having previously been given the height of the target as obtained from a range-finder, rotates the handle E^1 so as to maintain the pointer E^2 on the "height curve" on the chart E^3 corresponding to the particular height of the target. The fuse setting data is obtained from chart E^3. The point at which the projectile bursts is noted and any spotting corrections necessary may be introduced by operating the pointers d^9 and D^6.

The lateral deflection may be automatically given either in the plane of sight as above described or in the horizontal plane (in which case the rack member h^1 would not be provided and the chart D^{5x} would be replaced by a plain stationary dial and rotating pointer) according to the type of sight fitted to the guns and the method of applying deflections thereto. Furthermore, the deflections may be transmitted direct to the gun stations, this transmission being additional to, or in substitution for, indicating them as hereinbefore described.

Wind and ballistic corrections, tangent elevation and other settings may also be embodied in the apparatus, and allowance may be made for the "lost time" between the setting of the shell fuse and the departure of the shell from the gun.

Instead of the linkages B° and C°, herein described, logarithmic devices, three dimensional cams or a system of variable speed devices may be employed, and instead of the linkages d°, D° and F° three dimensional cams or a system of variable speed devices may be employed.

The herein described apparatus owes its accuracy to the fact that it operates in strict accordance with mathematical formulæ expressing the relation ship between the angular rates at the moment of observation and the future position of the target. The interpretation of the formulæ is affected wholly by mechancal means, thus avoiding the disadvantages inseparable from electrical devices which are necessarily of delicate construction and are easily influenced by climatic conditions. Further, the fact of having to make electrical connections is in itself a potential source of delay and error and in the event of any part of the instrument not functioning properly the reason thereof cannot be so easily detected as in a mechanical apparatus.

Reference may be made to the accompanying copending application Serial No. 9,180 in which a similar mechanism is described and which operates upon similar mathematical principles.

I claim:

1. In apparatus for use in the fire control of anti-aircraft guns, the combination of an observing sight, an infinitely variable speed device adapted to adjust said sight at a rate to keep the sight line on the target, rate adjusting mechanism adapted to actuate the variable element of said device, a manually adjustable member for actuating said mechanism in accordance with the movement of the target, and means whereby said member indicates deflection for a given time of flight of the projectile.

2. In apparatus for use in the fire control of anti-aircraft guns, the combination of an observing sight, a variable speed device for actuating said sight, a sliding linkage for adjusting the speed varying element of said device, means for manually adjusting said linkage whereby the line of vision of said sight is maintained upon the moving target, and means connected to said means for indicating the deflection to the guns.

3. In apparatus for use in the fire control of anti-aircraft guns, the combination of a sighting instrument, an infinitely variable speed device driven at constant speed adapt-

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ed to move said instrument in elevation and train, rate adjusting mechanisms adapted to actuate adjustable speed varying elements of said device, members movable in accordance with the movements of the target whereby the line of said sight is kept on the target, and means whereby said members indicate the horizontal and vertical deflection for a given time of flight of the projectile.

4. In apparatus for use in the fire control of anti-aircraft guns, the combination of an observing sight, an infinitely variable speed device adapted to adjust said sight at a rate to keep the sight line on the target, rate adjusting mechanism adapted to actuate the variable element of said device, a manually adjustable member for actuating said mechanism in accordance with the movement of the target, means whereby said member indicates deflection for a given time of flight of the projectile, and means operated by the movement of said member for indicating fuse-setting data.

5. In apparatus for use in the fire control of anti-aircraft guns, the combination of a sighting instrument, an infinitely variable speed device driven at constant speed adapted to move said instrument in elevation and train, rate adjusting mechanisms adapted to actuate adjustable speed varying elements of said device, members movable in accordance with the movements of the target whereby the line of said sight is kept on the target, means whereby said members indicate the horizontal and vertical deflection for a given time of flight of the projectile, and means operated by the movement of said members for indicating fuse-setting data.

6. In apparatus for use in the fire control of anti-aircraft guns, the combination of an observing sight, a variable speed device for actuating said sight, a sliding linkage for adjusting the speed varying element of said device, means for manually adjusting said linkage whereby the line of vision of said sight is maintained upon the moving target, means connected to said means for indicating the deflection to the guns, and mechanism associated with said linkage for correcting the deflection for complementary errors due to an angle of the plane of the line of sight.

7. In apparatus for use in the fire control of anti-aircraft guns, the combination of an infinitely variable speed device driven at constant speed, an observing sight connected thereto, link mechanism adapted to actuate the adjustable element of said device in accordance with movement of the target whereby the sight is actuated to keep the target in its field of view, said link mechanism having predeterminedly proportioned parts, and a manually operable member for operating said linkage and whereby the deflection for a given time of flight of the projectile is indicated.

8. In apparatus for the fire control of anti-aircraft guns, the combination of an observing sight, an infinitely variable speed device driven at constant speed for moving said sight in elevation and train, adjustable link mechanisms adapted to adjust the speed varying elements of said device, manually operable members movable severally in elevation and train in accordance with the rate of movement of the target and operating said link mechanisms, and means associated with said members for indicating vertical and horizontal deflections for a given time of flight of the projectile.

9. Apparatus for use in the fire control of anti-aircraft guns, comprising in combination an observing sight, a variable speed device for adjusting said sight, a hand operated member for moving the adjustable speed varying element of said variable speed device, an element moved in accordance with the time of flight of the projectile, and means for multiplying the displacements of the speed varying element and the element moved in accordance with the time of flight of the projectile, said multiplying means being situated between said hand operated member and said speed varying element whereby when said sight is adjusted to maintain it upon the moving aerial target the position of the hand operated member is a measure of the deflection for a given time of flight of the projectile.

10. Apparatus for use in the fire control of anti-aircraft guns, comprising in combination an observing sight, mechanism for automatically varying the adjustment of said sight in accordance with a factor involved in the determination of deflection, a variable speed device for adjusting said sight through said mechanism, a hand-operated member for moving the adjustable speed varying element of said variable speed device, an element moved in accordance with the time of flight of the projectile, and means for multiplying the displacements of the speed varying element and the element moved in accordance with the time of flight of the projectile, said multiplying means being situated between said hand-operated member and said speed varying element whereby when said sight is adjusted to maintain it upon the moving aerial target the position of the hand-operated member is a measure of the deflection for a given time of flight of the projectile.

11. Apparatus for use in the fire control of anti-aircraft guns, comprising in combination with the elements claimed in claim 9, a fuse number indicating device, and means associated with the element that is moved in accordance with the time of flight of the projectile for moving part of said device.

12. Apparatus for use in conjunction with an anti-aricraft gun sight of the kind in

which the horizontal deflection is given in the plane of the sight, comprising in combination with the apparatus claimed in claim 8, means driven in accordance with said mechanism for varying the vertical deflection given by the apparatus in accordance with the complementary error.

13. In apparatus for use in the fire control of anti-aircraft guns, the combination of an observing sight and a computing mechanism, said mechanism including a variable speed device having a part driven at constant speed and a variable part, rate adjusting means adapted to actuate said variable part, a member operable manually to maintain said sight directed on the target and connected to said means for at least partially actuating the same in accordance with movements of the target, and means controlled by said member for indicating deflection.

14. In apparatus for use in the fire control of anti-aircraft guns, the combination of an observing sight, a variable speed device for actuating said sight, rate adjusting mechanism adapted to actuate the speed varying element of said device, means for manually adjusting said mechanism whereby said sight is maintained directed upon the target, and means connected to said means for indicating deflection to the guns.

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