

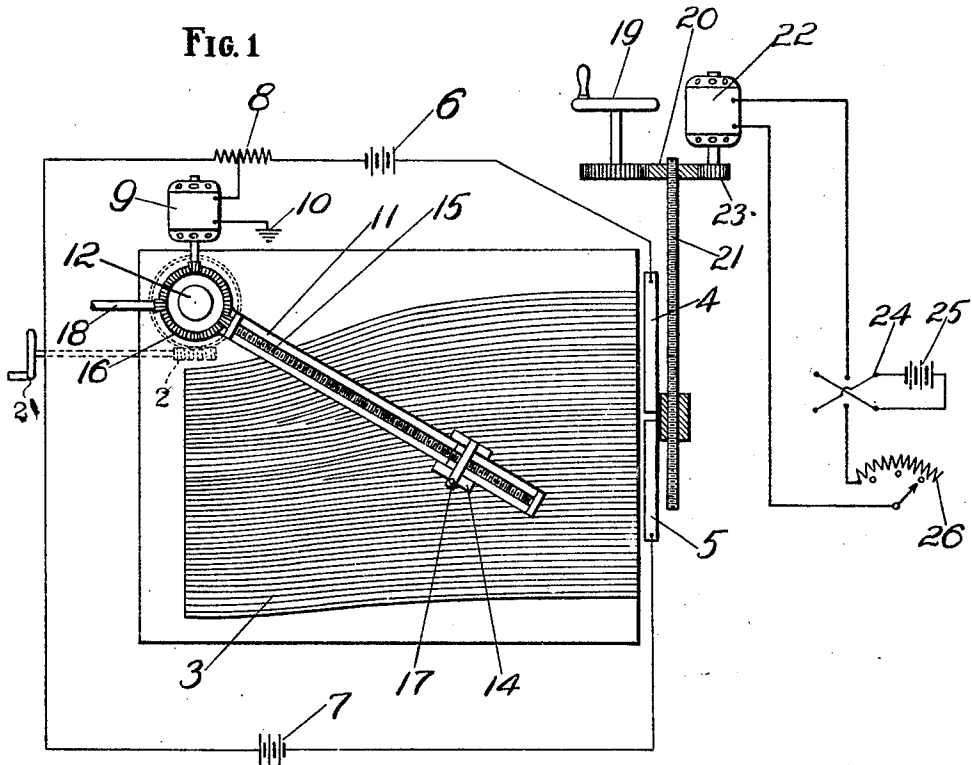
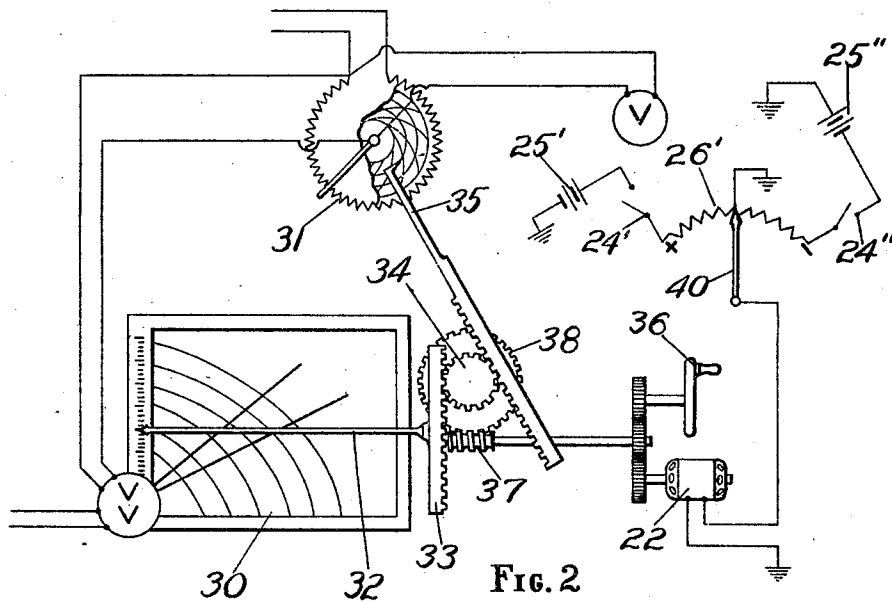
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R. V. MORSE

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ANTI-AIRCRAFT FIRE CONTROL

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Robert V. Morse

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Draftsman
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ROBERT V. MORSE, OF ITHACA, NEW YORK.

ANTIAIRCRAFT FIRE CONTROL.

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This invention relates to anti-aircraft artillery, and has for its object the improvement of automatic fire-control apparatus so that it may automatically follow the moving target wherever it flies, in the three dimensions of space. In my prior patents No. 1,343,003, issued June 8, 1920, No. 1,391,134, issued Sept. 20, 1921, No. 1,445,028, issued Feb. 13, 1923, and others, means were described whereby the ballistic settings controlling the artillery fire were automatically made and maintained wherever the target might fly, so long as it did not change its altitude above the ground. In my prior Patent No. 1,343,003, issued June 8, 1920, means were described for automatically following changing altitudes in certain special cases,—namely, when the airplane took a nose dive, or performed any maneuver in any vertical cylindrical zone. The present invention extends automatic control to any change in altitude, by whatever course accomplished, and by operating simultaneously in conjunction with the controls designed for given altitudes the altitude components may be combined with the horizontal components continuously, making it possible to automatically follow the most intricate courses. Thus contact may be maintained with a hostile airplane under conditions where the ordinary readings and settings would be so erratic as to be of little value.

It will be understood that the present invention is of general application to any form of automatic computing machine used in connection with anti-aircraft fire control apparatus and that it need not necessarily operate directly on a gun or sight but may be applied if desired to any intermediate computer or controlling mechanism involved in the general system of fire controls, such for example as a central station device which controls a battery.

Referring to the drawings, Fig. 1 is a view showing the application of the system to the type of automatic controller referred to above. The invention is, however, of general application and by way of example Fig. 2 shows another modification as applied to the Brocq type of semi-automatic apparatus.

Referring now to Fig. 1, the reference numeral 3 indicates an electric cam. This

mechanical element is described in the patents mentioned above, and generally consists of a large number of insulated conducting strips laid on edge with their bare edges exposed. These are energized by the positive brush 4 and negative brush 5, connected to the sources of electrical energy 6 and 7 respectively, which are also connected through the resistance 8 to the motor 9, whose other terminal may be grounded at 10. The arm 11 is mounted so that it can be swung about the pivot 12 in accordance with the vertical angle data which come into the anti-aircraft problem, and carries a slide 14 which can be moved longitudinally on the arm 11 by means of the screw 15, operated by the gearing 16 and motor 9. The slide 14 carries an electrical contact point 17 which touches the exposed bare edges of the conducting strips of the electric cam 3. This contact point 17 is also grounded, so that if it touches a strip connected to the brush 4 a circuit through the battery 6 is completed, so as to turn the motor 9 in one direction; while if the contact point 17 touches a strip connected to the brush 5 a circuit is completed through the battery 7, and the motor 9 is turned in the opposite direction. The system can thus be arranged to continuously maintain the contact point 17 on the boundary between the positive and negative regions of the electric cam 3, or in other words make it automatically follow the line corresponding to the gap between the positive and negative brushes. Each strip of the electric cam 3 corresponds to a different altitude, and the curvature of each strip corresponds to the variation of ballistic data with the various angles of elevation. Thus by properly laying out the cam 3, and setting the brushes 4 and 5 according to the given altitude, and following the angle of elevation with the arm 11, any desired ballistic values (such as time of flight or projectile, or super-elevation of sight) can be mechanically set by the motion of the shaft 18 driven by the gear 16.

Since the shaft 18 has a motion according to the data desired it can be connected to any desired type of instrument where this data is involved. These instruments may either be directly on a gun or be elements of a central station apparatus, as is becoming more the modern practice.

Fire control apparatus can thus operate fully automatically against aircraft so long as the altitude is not changed. The altitude is normally changed when necessary by means of some manual device such as the hand-wheel 19 operating a screw gear 20, and screw 21, so as to move the two brushes 4 and 5, so as to bring the gap between them opposite another strip on the electric cam 3. We can now automatically follow any airplane course so long as it remains in the same horizontal plane, or in two dimensions of space. In order to extend automatic control to the three dimensions of space a calibrated motor 22 with a reversible graduated control is connected to change the altitude settings of the electric cam 3, as by means of the gear 23 meshing with the gear 20. In Fig. 1 the reversible graduated control is shown by way of example as a reversing switch 24 connected to a battery 25, and a graduated rheostat 26 in series with the motor circuit. This rheostat 26 has a number of contacts or operating positions, of which three are shown. After the machine has been constructed and "run in", so that the frictional resistance and speeds of the motor 22 under various voltages can be fairly closely determined empirically, the various contacts of the rheostat 26 are adjusted so as to give rates of change of altitude in convenient units, such as for example ten meters per second, twenty meters per second, and so on, with the two extreme positions zero and full motor speed. If the apparatus is built for example into a drum controller of the ordinary kind, having notches or detents, the operator can feel the various positions without taking his eye off the airplane. If then, for example, the engagement opens and the fire is observed to be below the airplane, the operation is as follows. Seeing that the bursts of the shells are not very far below the airplane, the operator throws the controller into the first speed up, which operates the motor 22 to increase the altitude setting at the rate of say about ten meters per second smoothly and steadily. A smooth and steady change is very important for the following reason; the vertical dispersion of the shell bursts may be about one hundred meters, and the shells may be bursting at the rate of one or two per second. If the change of altitude is made abruptly, as is the tendency with a manual setting, the fire may jump from below the airplane to above the airplane without ever intercepting it. But by making the increase steadily in the mechanical manner described, with a rate of change which is not susceptible to the momentary excitement of the operator, the airplane is subjected to accurate fire within the dispersion zone for a number of seconds at least. Now assume that this fire frightens the aviator, and he seeks to escape by climbing. As soon as he tilts his airplane upward this is seen by the artillery operator, who from his knowledge of the type and speed of the airplane can immediately make a rough estimate of about how fast it is climbing. It is not necessary to make an exact estimate so long as it is somewhat greater than the actual rate of change of the airplane. This will suffice to bring it under exact fire in the following manner. Assume the actual rate of climb is 15 meters per second, and the artillery operator throws his control to 20 meters per second. At first the airplane will climb free of the fire, as there will be a certain lag in the response of the bursts to the controller. But in a few seconds the bursts will begin to climb to overtake the airplane, and the upper edge of the dispersion zone will begin to come in contact with it. Since the airplane and the dispersion zone are both climbing in the same direction, the rate of change relative to each other will be comparatively slow while both of their motions in space may be very rapid. For example, under the conditions above taken, it would require some twenty seconds for the airplane to pass entirely thru the dispersion zone, during which the guns could deliver about thirty accurate shots. During all this time the electric cam 3 is operating simultaneously and automatically on the basis of altitude planes, taking care of the horizontal components of the course of the airplane. And while it is difficult to visualize three-dimensional travel and illustrate it in a two-dimensional picture, it will be obvious on analysis that a smooth automatic control is thus extended into space. If the airplane, seeing it cannot outclimb the fire, takes a dive to escape, it will have to pass thru the dispersion zone. As soon as it points downward, if it is a nose dive the artillery operator will throw the diving switch as described in my prior Patent No. 1,343,003, issued June 8, 1920, previously referred to; but if the downward course is inclined at some more gradual angle the operator will throw his control switch to the down position and from his knowledge of the characteristics of the airplane set the rate of change in altitude somewhat greater than the actual rate. This will cause the zone of fire to overtake the airplane and maintain effective contact with it for a considerable period of time, for the reasons above described.

It will be understood of course that the gearing connected to the motor 22 is normally proportioned to give a rather high speed of rotation of the motor and a slow motion at the altitude control, in other words, that a fairly high gear reduction should be used.

The invention may be applied to any au-

tomatic or semi-automatic anti-aircraft controller operating on an altitude basis. For example, in Fig. 2 it is shown applied to a Brocq type of anti-aircraft fire control apparatus.

Referring now to Fig. 2, the range indicator of a Brocq apparatus is indicated by the reference numeral 30, and the time rheostat is indicated by the reference numeral 31.

The altitude is adjusted at the range indicator by moving the pointer 32 up or down by means of the rack 33, driven by the pinion 34. The altitude pointer 35 of the time rheostat 31 is also adjusted by a rack driven by the pinion 34. These altitude settings at the range indicator 30 and the time rheostat 31 are made manually as by means of the handwheel 36 operating thru the worm 37 and worm gear 38. The general operation of the Brocq system is not material to the present invention, and will be found described in various artillery publications. The present invention relates to the control of altitude in any anti-aircraft fire control system, and these elements relating to altitude in a Brocq system are merely used as an example of how the invention may be applied. As in the example shown in Fig. 1, the electric motor 22 is geared to turn the worm 37 and move the altitude settings of the apparatus, the motor 22 being adapted to run at certain selected rates of speed by means of the special graduated rheostat 26'. In Fig. 2 this graduated rheostat 26' is arranged so as also to reverse the rotation of the motor 22 when desired,—the motor 22 receiving no voltage when the pointer 40 is in the central position shown, and receiving various specially graduated amounts of positive voltage when moved to the left, and similar amounts of negative voltage when moved to the right. The same result can be obtained with the ordinary type of drum controller. The positive and negative electricity may be supplied by the batteries 25' and 25'' connected thru the switches 24' and 24'' respectively. The general operation will be evident from the description previously given in connection with Fig. 1.

The Brocq system, like various other semi-automatic types, involves a certain amount of manual setting, as for example the range which must be read at the indicator 30 and set at the rheostat 31. This causes certain delays and errors, so that the blending of the vertical and horizontal components is not smooth and simultaneous as in the automatic mechanical apparatus shown in Fig. 1. However, the automatic altitude control can be of considerable utility within the functional limitations of the semi-automatic type of apparatus.

In the foregoing description an electric motor has been illustrated to move the altitude settings, but any other type of motor

whose speed can be definitely regulated up and down might be used. The particular type of speed regulating devices herein illustrated need not necessarily be employed, as it will be obvious that various other arrangements and modifications of the apparatus may be used as will be evident to those skilled in the art. The particular applications described are given merely by way of illustration, and the essential features and combinations which constitute the invention are embodied in the following claims.

I claim:—

1. In anti-aircraft fire control apparatus, the combination of a control means in which altitude is employed as the linear data, motor means for changing the altitude on which the control means is operating, calibrated regulating means controlling the motor means for setting various rates of change of altitude, said motor means and regulating means operating simultaneously with the control means having an altitude basis, whereby vertical components are blended with the horizontal components to give mechanical control in the three dimensions of space.

2. In anti-aircraft fire control apparatus, the combination of a control means in which altitude is employed as the linear data, an electric motor means for changing the altitude on which the control means is operating, a speed regulator for said electric motor means, said speed regulator being graduated for various rates of change of altitude either upward or downward, whereby the altitude may be set to vary at definite rates simultaneously with the operation of the control means on an altitude basis so as to give mechanical control in the three dimensions of space.

3. In anti-aircraft fire control apparatus, the combination of a control means operating automatically on the horizontal basis of constant altitude, motor means for varying the altitude basis upon which the control means is operating, and a calibrated regulating means for said motor means for setting various rates of change in the altitude, whereby the altitude may be smoothly blended with the horizontal basis so as to extend continuous automatic control into the three dimensions of space.

4. In anti-aircraft fire control apparatus, the combination of a control means operating automatically on the horizontal basis of constant altitude, motor means for varying the altitude basis upon which the control means is operating, and a regulating means for said motor means for varying the rate of change in the altitude, said regulating means being graduated for definite rates of change of the altitude in either direction, whereby the altitude may be set to change at definite rates simultaneously with the op-

eration of the control means on a horizontal basis so as to give mechanical control in the three dimensions of space.

5 5. In anti-aircraft fire control apparatus, the combination of control means for automatically supplying ballistic data on the basis of planes of constant altitude, and calibrated mechanical means for changing the altitude setting of the control means

smoothly and steadily, so as to simultaneous- 10
ly blend the horizontal and vertical components, whereby ballistic data may be continuously obtained while following a target in the three dimensions of space.

In witness whereof I have hereunto set 15
my hand this 15th day of September, 1924.

ROBERT V. MORSE.