E. M. HEWLETT ET AL

SYSTEM OF AND APPARATUS FOR GUN FIRE CONTROL

Filed April 9, 1924

3 Sheets-Sheet 1

inventors: Edward M. Hewlett, Waldo W. Willard,

by

Their Attorney
This invention relates to the control of guns and the like, more particularly to the control of such devices on ship-board, and has for its object the provision of a system of and apparatus for controlling guns and the like whereby corrections may be introduced accurately without reference to the inclination of the ship's deck or other support for the gun.

In the directing of guns it is customary to introduce adjustments or corrections for range and deflection without taking into consideration the angular position of the elevation and train axes of the gun. Now the range correction, which is a function of the range, as calculated is an angular adjustment to be applied in a vertical plane. That is, for a definite range the gun must be adjusted to a definite angle with the horizontal to compensate for curvature of the trajectory. In a similar manner the deflection correction is calculated from the velocity and direction of the wind, drift, speed and direction of the ship and target, etc., and as calculated is an angular adjustment to be applied in a horizontal plane. When the ship's deck or other support for the gun is inclined, it is obvious that the train and elevation axes of the gun are not respectively vertical and horizontal. Clearly under these conditions the range and deflection corrections cannot be correctly introduced if applied about the train and elevation axes of the gun, since these corrections which are calculated in true horizontal and vertical planes would then be introduced in quite different planes.

In carrying out our invention we provide means whereby the range and deflection corrections may be actually applied in vertical and horizontal planes.

For a more complete understanding of our invention, reference should be had to the accompanying drawing in which Fig. 1 is a diagrammatic view showing the principles of operation of our invention; Fig. 2 is a diagrammatic view showing a system of gun fire control embodying our invention; Figs. 3 and 4 are diagrammatic views showing the motion transmitting instruments; Fig. 5 is a fragmentary elevation view, taken partially in section along the line 5—5 of Fig. 6 looking in the direction of the arrows, showing apparatus for introducing corrections embodying our invention; Fig. 6 is a fragmentary plan view of Fig. 5; Fig. 7 is a diagrammatic view of a gear train; Fig. 8 is a single line diagrammatic view of the electrical connections of the control system shown in Fig. 2; while Fig. 9 is a fragmentary plan view showing details of construction.

Referring to Fig. 1, guns, sighting devices, and the like are ordinarily mounted to have freedom of movement about two axes at right angles to each other. For example, the gun 10 is adjustable about a train axis $a-a$ and an elevation axis $y-y$ which are at right angles to each other. It will be observed that these train and elevation axes are respectively vertical and horizontal only when the ship 11 on which the gun is mounted is on an even keel as indicated in dotted lines. When the ship rolls to one side, as shown, then the training of the gun about the axis $a-a$ does not take place in a horizontal plane and the elevation of the gun about axis $y-y$ does not take place in a vertical plane. The train and elevation movements of the gun, therefore, may or may not take place in respectively horizontal and vertical planes depending on the position of the ship. With the ship in the position shown, suppose for example that the gun is to be given an adjustment in elevation for the range of the target represented by the vector $a-b$ and a deflection adjustment in train represented by the vector $b-c$. This range adjustment $a-b$ is calculated from range tables and its value is based on the assumption that it will be applied in a vertical plane. The deflection adjustment $b-c$ is calculated from the observed direction and velocity of the wind, direction and speed of the ship and target, etc., and its value is based on the assumption that it will be applied in a horizontal plane. It would obviously be impracticable to attempt to calculate range and deflection corrections to correspond with the angular position of the ship, since it is impossible to foretell the exact position of the ship.
when these corrections are to be introduced. With the ship in the position shown, if the range correction is applied by adjusting the gun about axis $y - y$ then the correction actually introduced would be represented by the vector $a - c$ and, likewise, if the deflection correction is applied by adjusting the gun about the axis $x - x$, the correction actually introduced would be represented by the vector $c - f$. It will thus be observed that the corrections introduced under these conditions as affecting the position of the gun are entirely different from those which it is desired to introduce. It will also be observed that the corrections may be correctly applied by moving the gun about its train and elevation axes if the gun is adjusted about the axis $y - y$ by an amount represented by the vector $a - g$ and about axis $x - x$ by an amount represented by vector $g - c$. The vectors $a - g$ and $g - c$ are obviously entirely different from the calculated vectors $a - b$ and $b - c$.

By means of our invention, the calculated corrections represented by vectors $a - b$ and $b - c$ are applied to suitable mechanism and actually introduced in the respective vertical and horizontal planes for which they were calculated. It is the function of the mechanism to regenerate these corrections in terms of coordinates which may be directly applied in adjusting the gun in elevation and train. That is, under the conditions assumed in Fig. 1, the corrections $a - b$ and $b - c$ will be introduced in the mechanism in respectively vertical and horizontal planes whereby the mechanism is caused to generate the vectors $a - g$ and $g - c$ which are then applied to the gun by moving it about its train and elevation axes.

Referring to Fig. 2 of the drawing we have shown our invention in one form as applied to a system of gun fire control comprising a telescope or sighting device 12 for directing the gun 13 shown as mounted in a turret 13b. Associated with the sighting device 12 are motion repeating instruments for transmitting its angular movements in train and elevation. For the purpose of illustration we have shown the sighting device 12 in diagrammatic form as mounted on a supporting pedestal 12a which is movable with the sighting device about the train axis of the sighting device. It will be understood that the sighting device and gun are each mounted as described in connection with Fig. 1 to rotate about train and elevation axes. The train axes of the sighting device and the gun are fixed and parallel with each other, while the elevation axes of the sighting device and gun are rotatable about their respective train axes but are constrained to thus rotate in parallel planes. Geared to the pedestal 12a are the motion transmitting devices 14 and 15 in train. Preferably two motion transmitting devices operating in high and low speed ratios are used, as shown, for the purpose of obtaining greater accuracy, the transmitting device 14 being direct connected to the pedestal so as to transmit the angular movements in train of the sighting device in a 1:1 ratio, while the transmitting device 15 is geared to be operated at a high speed ratio, for example, 72:1, so that on revolution of the transmitting device 15 will correspond to five degrees movement of the pedestal. To effect the transmission of the movements of the sighting device 12 in elevation, an elevation gear sector 16 may be carried by the sighting device, geared to which are two transmitting devices 17 and 18 similar to transmitting devices 14 and 15. Transmitting device 17 is connected to be operated at a high speed 72:1 ratio with the sighting device while the device 18 is connected through gearing 10 so as to be operated at a low speed 1:1 ratio therewith.

The output circuits of the transmitting devices 14, 15 and 17, 18 are connected respectively through a suitable switch 20 to two sets of busses 21 and 22 by means of which the outputs of the transmitting devices are transmitted first through an intermediate device 23 in which range and deflection corrections are introduced and thence by way of two sets of busses 24 and 24a to the turret 12. In the turret, the outputs in train as modified by instrument 23 are transmitted through transformers 25 and 26, and thence to an indicating device 27 adjacent to the gun and in position to be easily observed by the gun trainer. In like manner, the outputs in elevation as modified by instrument 23 are transmitted through transformers 28 and 29 in the turret and thence to an indicator 30 similar to indicator 27. The transformer 26 is connected through a pinion 31 to the turret training rack 32 so as to be operated at a high speed 72:1 ratio with the movement of the gun in train, while transformer 25 is connected with transformer 26 through a gear train 33 to operate in a 1:1 ratio with the turret. In a similar manner the transformer 28 is geared to the gun so as to be operated at a high speed 72:1 ratio with its movement in elevation, for example, by means of a pinion 34 meshing with an elevation gear sector 35 on the gun slide while transformer 29 is connected therewith through a gear train 36 to operate in a 1:1 ratio with the movement of the gun in elevation. If desired, an auxiliary sighting device or director may be provided in case of damage to the first. This auxiliary director may be connected to the busses 21 and 22 by means of a switch 20.

Although any suitable system may be used for transmitting the movements of the sighting device 12 and for reproducing or repeating these movements at the gun, preferably
an alternating current system is used. Briefly such a system may consist of a transmitting device and a reproducing or receiving device of similar construction, each comprising an armature winding preferably on the stator member and a field winding preferably mounted on the rotor member. Thus, as shown in Fig. 3 the transmitting devices 14, 15 and 17, 18 may each comprise a three-circuit armature winding 36 on its stator member and a field winding 37 on its rotor member. The field winding of each transmitting or receiving device is supplied with alternating current from a suitable source and therefore induces voltages in the circuits of its cooperating armature winding, the relative magnitude of the voltages depending on the angular relation of the windings. As connected in a system, like that of Fig. 2, the armature windings of the two transmitting and receiving devices are interconnected so that when the rotors of the two are in angular agreement the voltages induced in the armature windings are opposed and balanced, but upon angular movement of the transmitter rotor the voltages are unbalanced and an exchange of the current results between the armature windings whereby a torque is applied to the rotor of the respective receiver causing it to follow and reproduce the movement applied to the transmitter. In the arrangement shown, the transmitter 14 is connected through instrument 23 and transformer 25 to operate a receiver 14a in the indicator 27 which receiver turns a coarse reading dial 27a of indicator 27, while transmitter 15 is similarly connected through instrument 23 and transformer 26 to operate a receiver 15a of indicator 27, which receiver turns a second coarse dial 27b of indicator 27. In like manner the transmitters 17 and 18 control the receivers 17a and 18a respectively of the indicator 30, these receivers turning fine and coarse reading dials 30a and 30b respectively of the indicator 30. In the particular system disclosed, however, the transmitters 17 and 18 are not electrically connected to the receivers 17a and 18a, various mechanism of instrument 23, being interposed, as will be hereinafter described in detail. The receivers 17a and 18a, however, are responsive to movement applied to transmitters 17 and 18.

The correcting devices or transformers 25, 26 and 28, 29 are similar in construction. As shown in Fig. 4, each comprises two three-circuit cooperating armature windings 38 and 39, one of which is rotatably mounted. When the windings 38 and 39 are in corresponding positions, the movements transmitted by the transmitting devices will not be affected by the transformers and under these conditions the dials of the indicators 27 and 30 will show the total movements required to be applied to the gun. When the pointer and trainer adjust the gun, as directed by the indicators, the movements of the gun are applied to the rotating elements of the respective transformers in such direction that the displacement of the windings 38 and 39 of each transformer caused thereby results in a shifting of the voltages applied to the receiving devices such that the dials of the indicators are turned back toward zero. When the dials are on zero the operator knows that the gun is in the position designated by the sighting device as modified by instrument 23.

The instrument 23 comprises mechanism by means of which the range and deflection corrections may be introduced in true vertical and horizontal planes and automatically regenerated or modified in terms of elevation and train components which are superimposed either mechanically or electrically on the elevation and train outputs sent out from the sighting device. Referring to Figs. 5 and 6, this instrument is provided with a pilot gun 40 the angular position of which when properly adjusted is an indication of the desired angular position of the gun. In construction, the pilot gun takes the form of an inverted U, the lower ends of which are pivotally mounted on bearing posts 41 and 42. These bearing posts are supported on a plate or platform 43 which is secured to the upper end of a tubular support 44 and held concentric with a supporting pedestal 45 of the instrument by means of suitable bearings one of which is indicated by numeral 46. The plate 43 is supported on a ball bearing 48. The upper end of the pilot gun 40 has a pivotal connection 49 with a member 50, consisting of two adjustable parts 50a and 50b, these parts being pivotally mounted on a member 52, constituting a mimic sighting device, so as to be rotatable about an axis s—s of member 52, which axis intersects the trunnion axis of the pilot gun, i.e., the axis of support on posts 41 and 42. Member 52 is pivotally mounted on bearing posts 53 and 54 so as to be rotatable about an axis perpendicular to axis s—s. The bearing posts are mounted on an upper table or plate 55. This table 55 is supported on a suitable bearing 56 on the upper end of tubular member 44 and is held concentric with member 44 by suitable bearings one of which is indicated by numeral 58. The bearing axes of the two pairs of posts 41, 42 and 53, 54 lie in the same plane and are intersected at a common point by the axis s—s and also by the axis of pivot 49 which is at right angles to the axis of the bearing posts 41 and 42. The axis s—s is at right angles to the axis of the bearing posts 53 and 54 on which the member 52 is mounted. This axis s—s is the line of sight of the mimic sighting device 52. The axis of rotation of the tables
43 and 55 is parallel with the train axes of the sighting device and gun.

A spirit level 60 and a gyroscopic level 61 are mounted on part 50 to facilitate the accurate adjustment of the part 50 about axis $z$ to a vertical position. This adjustment may be effected by means of a hand crank 62, mounted on member 52, driving a suitable worm 62 which cooperates with an elevation worm gear sector 63 carried by part 50. When the part 50 is tilted out of a true vertical position due to rolling or pitching of the ship, the operator turns crank 62 so as to bring member 50 back to a vertical position as indicated by the levels. It is contemplated that the more accurate gyroscopic level will ordinarily be used.

A gear sector 64 is secured to the pilot gun and moves with the pilot gun about its trunnion axis. This gear sector is connected through gear train 63 and bevel gears 66 to a transmitting device 67, which is operated thereby in a 72:1 ratio with the angular movement of the pilot gun about its trunnion axis. A second transmitting device 68 is connected through a gear train 69 to the transmitting device 67 so as to be operated in a 1:1 ratio therewith. The transmitting devices 67 and 68 thus transmit in their respective ratios, the angle of elevation of the pilot gun. They are electrically connected by way of buses 24 and through transformers 28 and 29 to the receivers 17 and 18 respectively of indicating device 90. These transmitting devices together with the gear train 69 are mounted on the table 43. Suitable apertures 70 and 70' are provided in the upper table 55 through which the bearing posts 41 and 42 and the gear train 65 extend.

As the member 50 is moved to bring part 50 from an inclined to a vertical position, it will be observed that the table 43 is moved slightly with relation to table 55 about their common train axis. This relative motion of tables 43 and 55 is applied to two transformers or corrective devices 71 and 72 mounted on a supporting plate 73. The supporting plate 73 is hung on table 55 by means of suitable spring supports 74 which are provided for the purpose of absorbing shocks. A similar mounting may be provided for transmitters 67 and 68. Secured to the table 43 is a horizontal gear sector 75 to which the rotatable members of the transformers 71 and 72 are connected. This connection is effected through a gear sector 76 cooperating with gear sector 75, shaft 77, gear sector 78 and gear 79 to shaft 80. From shaft 80 motion is transmitted through a suitable gear train 81 to transformer 72 in a high speed 72:1 ratio and from shaft 81 through gear train 71 in a low speed 1:1 ratio. The transformers 71 and 72 are electrically connected respectively between the transmitters 14 and 15 in the control station and the transformers 25 and 26 in the turret. Any movement of the table 43 with relation to the table 55 is thus applied to the transformers and introduced as a correction in the train output of the sighting device transmitted to the turret.

To provide for the introduction of the deflection corrections in a true horizontal plane, the part 50 is secured to part 50 by means of a swivel connection, it being mounted at one end on a pivot 83, the axis of which is coincident with the axis of table 43. It will be understood that the part 50 is pivotally mounted on member 52 so as to be rotatable about the axis $z$ of member 52. The other end of part 50 is slidably connected to part 50. As shown in Fig. 9 this end may be provided with an arc shaped arm 84 at right angles with part 50, which arm is adjustable in a slot 85 in the member 50. The part 50 may be adjusted about its pivot 83 by means of a knob 86 turning a worm 87, carried by the part 50, which cooperates with a worm 88 secured to arm 84. It will be observed that this adjustment, which is in a horizontal plane, since part 50 is maintained in a vertical position, causes rotation of table 43 in the train movement which is applied to transformers 71 and 72 and is the train component of deflection. To facilitate the deflection adjustment a suitable scale 86 may be provided on the knob 86 and a fixed mark 86 cooperating with the scale.

In order to permit the introduction of range corrections in a true vertical plane, the part 50 is formed with a gear sector 90 which is maintained vertical. This gear sector is described about the point of intersection of axis $z$ and the trunnion axis of the pilot gun as a center. Pivoting and slidably mounted on the gear sector 90 is a guide member 91 to which the upper end of the pilot gun is connected by the pivot 49. The axis of pivot 49 extends along a radius of gear sector 90 and is the line of fire of the pilot gun. Carried by the guide member 91 is a gear 92 which meshes with the gear sector 90. This gear 92 is secured to a shaft in common with a worm gear 93, cooperating with which is a worm 94 which may be turned by means of a knurled knob 95 whereby the gear 92 is turned and thus caused to travel on the gear sector 90 to effect the range adjustment of the pilot gun in a vertical plane. The range correction may thus be introduced by turning knob 95. Preferably a suitable scale 96 secured to the knob and cooperating with the transformers 71 and 72 are provided to facilitate the adjustment.

The mimic sighting device is adjusted in train into angular agreement with the sight-
and the table 43 together as a unit on the supporting pedestal 45 until axis $z-z$ has the same direction in train as the sighting device 10. This movement in train of the tables on the pedestal is effected by turning a handwheel 96 carried by table 55, which handwheel has a driving connection through a gear train 97 with a stationary ring gear 98 mounted on the upper end of the pedestal 45. The movement thus directly applied to table 55 is transmitted through the mechanical connection formed by the pilot gun to the table 43 so that the two tables are moved together. For controlling the amount of this adjustment two correcting devices or transformers 99 and 100, carried by table 55, are connected through suitable gear trains forming a part of gear train 97 so as to be driven respectively in a high speed 72:1 ratio and a low speed 1:1 ratio with the table 55. These transformers have the construction shown in Fig. 4 being provided with two relatively rotatable three-circuit armature windings. They are electrically connected in circuit between the transmitting devices 14 and 15 and receiving devices 101 and 102 driving indicating dials 101a and 102a respectively. Thus, as the sighting device 10 is adjusted in train the dials 101a and 102a will show the amount of this angular movement and the operator will thereupon adjust the table 55 in train by means of handles 16 sliding the dials back to zero. It will be understood that in making this adjustment the windings of the transformers are displaced with relation to each other so as to neutralize the movements transmitted by devices 14 and 15, as in the case of the transformers at the turrets. Preferably the transformers and gearing are mounted on a supporting plate 103, resiliently hung on the table 55 in the manner of support 73.

Referring to Fig. 7, showing in diagrammatic form the gear train 97, under normal operating conditions, motion is transmitted from the handwheel 96 by way of bevel gears 105, shaft 106, spur gear 106a, spur gears 107 and 108 which are secured together and rotatably mounted on shaft 109, gear 110, shaft 111, gear 112 and gear 113 to the transformer 99, and from gear 114 secured to shaft 111, through gear 115, shaft 109, gears 116 and 117; shaft 118, gears 119 and 120, shaft 121, and gears 112 and 123 to transformer 100. Gear 124 meshes with the pedestal gear 98 and is rigidly attached to shaft 118 so as to be turned thereby and move the tables 43 and 55 around the pedestal. The spur gears 117 and 125 are rotatably mounted on shaft 118. One or the other of these gears may be connected to shaft 118 as desired by means of a clutch comprising two sleeves 126 and 127.
turning handwheel 130 to apply this movement to the mimic sighting device 52, and hence to the dummy gun, so affects the transformers 133 and 137 as to cause the dials to be moved back to zero.

As has been seen, the adjustment of member 52 is such that the axis 2—2 is maintained exactly parallel with the line of sight of the sighting device and thus represents the line of sight to the target. The elevation correction given the pilot gun 40 by means of knob 95 is made with respect to axis 2—2. It will be observed that when part 50a is adjusted about axis 2—2 to a vertical position the pilot gun is thereby moved about axis 2—2 so as to describe a cone.

Tracing briefly the electrical connections of the system as shown in single line diagram in Fig. 8, it will be observed that the transmitters 14 and 15 in train feed respectively through transformers 71 and 72 in instrument 23, by means of which the deflection corrections are introduced and thence to the turret and through transformers 25 and 26 in the turret to receivers 14a and 15a. The transmitters 14 and 15 feed also through transformers 100 and 109 respectively to the receivers 102 and 101 all in the instrument 23 whereby the instrument 23 can be adjusted in train. In elevation, the transmitters 17 and 18 feed respectively through transformers 133 and 137 in instrument 23 to receivers 139 and 140 in this instrument. As has been previously explained, this elevation output of transmitters 17 and 18 is applied to the apparatus of the instrument 23 and regenerated as modified by the range correction by transmitters 67 and 68. These latter transmitters feed respectively through transformers 29 and 29a in the turret to receivers 17a and 18a.

In the operation of our invention, the operator in the control station adjusts the sighting device 12 in elevation to such position that the sighting device will be directed on the target in the particular part of the roll in which it is desired to fire the guns. The sighting device is then held fixed in elevation and the guns fired when it rolls on the target. In train, the sighting device is maintained directed on the target in all positions of the ship. These elevation and train movements thus applied to the sighting device are thereby applied to the respective transmitting devices, whereby the dials 101a, 103a, 133a, 140a on the instrument 23 are turned to indicate the amount and direction of the movements. The mimic sighting device 52 of the instrument 23 is adjusted in elevation and train by turning handwheels 96 and 130 in the direction and amounts indicated by the dials, the dials being thereby turned back to zero. The range having been determined by means of suitable range finders or otherwise and the range correction determined, the range correction will be applied to the pilot gun in a true vertical plane by means of knob 95, it being understood that part 50a is held vertically by means of crank 62. Likewise, the windage drift, speed of ship, etc., having been determined and the deflection correction determined therefrom, this deflection correction will be introduced in a true horizontal plane by means of knob 86. The train components of the range and deflection corrections thus generated are applied to the transformers 71 and 72 and thereby introduced into the train output of transmitters 14 and 15, while the elevation components of the range and deflection corrections together with the elevation of the mimic sighting device are applied to the transmitting devices 67 and 68. In the meantime the gun is adjusted as directed by dials 14a, 15a and 17a, 18a, these dials being maintained on zero. As the ship rolls and pitches the elevation and train components of range and deflection will obviously vary with the position of the ship but these changes are automatically taken care of by the act of maintaining part 50a vertical. Thus as the part 50a is moved about axis 2—2 to a vertical position it will be observed that the elevation of the pilot gun and also its train will be changed to correspond with the new position of the ship. These changes are the changes required to correct the introduced range and deflection corrections for the new position of the train and elevation planes of the gun. This change in elevation is applied to transmitting devices 67 and 68 while the change in train is applied to transformers 71 and 72. The train output of transmitting devices 14 and 15 will also vary as the sighting device is moved in train. Assuming given range and deflection corrections, the gun will, therefore, be adjusted in both train and elevation in accordance with the change in the elevation and train components of these corrections, and the change in train of the sighting device. The gun trainer and pointer, however, have only to adjust the gun so as to maintain the indicators 27 and 30 on zero.

For the purpose of simplicity we have disclosed our invention without reference to mechanism for introducing corrections for parallax in either elevation or train. It should be understood, however, that our invention is equally applicable to systems wherein mechanism for introducing corrections for parallax may be used. The introduction of parallax corrections in no way affects the operation of our invention.

While we have described our invention as embodied in concrete form and as operating in a specific manner in accordance with the provisions of the patent statutes, it should be understood that we do not limit our invention thereto, since various modifications...
thereof will suggest themselves to those skilled in the art without departing from the spirit of our invention, the scope of which is set forth in the annexed claims.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. The combination with a gun, of a mount thereon on which the gun is adjustable in a set of planes varying in angular position with the angular position of said mount, and means for generating corrections with reference to said planes in their various positions, said corrections being applied to said means with reference to a set of fixed planes.

2. The combination with a gun, of a mount thereon on which the gun is adjustable in a set of relatively fixed planes varying in angular position with the angular position of said mount, and means whereby corrective movements applied to said means with reference to a set of fixed planes are regenerated with reference to said relatively fixed planes in their various positions.

3. The combination with a gun, of a mount thereon on which the gun is adjustable in elevation and train planes varying in angular position with the angular position of said mount, and means for generating corrections with reference to said elevation and train planes in their various positions, said corrections being applied to said means with reference to a vertical and horizontal plane.

4. The combination with a gun, of a mount thereon on which the gun is adjustable in elevation and train planes varying in angular position in accordance with the angular position of the said mount, and means operated by the application of corrective movements to said means in vertical and horizontal planes for regenerating said corrective movements in terms of movement of said moving elevation and train planes.

5. A system of gunfire control comprising in combination with a directing device and a gun mounted on a common moving support and each adjustable in elevation and train planes, means for transmitting the movements of said directing device to said gun, and means for introducing corrections in said transmitted movements in terms of equivalent components in said moving elevation and train planes.

6. A system of gunfire control comprising a sighting device and a gun mounted on a common moving support and each adjustable in elevation and train planes, means for transmitting the movements of said sighting device to said gun, and means for regenerating and introducing corrections in said transmitted movements, said corrections being applied to said corrective means with reference to fixed planes and regenerated and introduced by said corrective means in terms of equivalent components in said moving elevation and train planes.

7. The combination with a gun, of a mount thereon on which the gun is adjustable in a set of planes varying in angular position with the angular position of said mount, and means for generating corrections with reference to said set of planes in their various positions and subsequently varying said generated corrections upon changes in the angular position of said planes due to angular movement of said mount, said corrections being applied to said means with reference to known fixed planes.

8. A system of gunfire control comprising in combination with a sighting device and a gun mounted on a common moving support and each adjustable in elevation and train planes, means operated by movement of said sighting device for generating corrections with reference to said planes in their various positions and subsequently varying said generated corrections upon changes in the angular position of said planes due to movement of said support, said corrections being applied to said correcting means with reference to known fixed planes.

9. A system of gunfire control comprising in combination with a gun mounted on a moving support and adjustable in elevation and train planes varying in angular position with the angular position of the support, means for generating corrections in terms of movement referred to said elevation and train planes in their various positions and subsequently varying said generating corrections in response to and in proportion with changes in the angular position of said planes due to movement of said support, said corrections being applied to said correcting means with reference to vertical and horizontal planes.

10. A system of gunfire control comprising in combination with a sighting device and a gun mounted on a common moving support and each adjustable in elevation and train planes, means for transmitting the movements of said sighting device in said planes to said gun, and means for varying said transmitted movements in accordance with changes in the angular position of said elevation and train planes.

11. A system of gunfire control comprising in combination with a sighting device and a gun mounted on a common moving support and each adjustable in elevation and train planes, means for transmitting the movements of said sighting device in said planes to said gun, and means responsive to angular movement of said support for varying said transmitted movements in accordance with changes in the angular position of said elevation and train planes.
12. A system of gun fire control comprising in combination with a sighting device and a gun mounted on a common moving support and each adjustable in elevation and trunnion planes, means for transmitting the movements of said sighting device in said planes to said gun, and means for introducing corrections in said transmitted movements with reference to said elevation and train planes in their various positions, and subsequently varying said introduced corrections in accordance with changes in the position of said elevation and train planes due to movement of said support, said corrections being applied to said corrective means with reference to known fixed planes.

13. The combination with a gun, of a second member in accordance with the inclination of said train axis, means for applying said train component to the gun, and means for maintaining said first member in a horizontal plane independently of changes in the inclination of the trunnion axis of the gun whereby said train component is varied in accordance with changes in the inclination of the trunnion axis of the gun.

14. The combination with a gun, of a second member in accordance with the inclination of said train axis, means for applying said train component to the gun, and means for maintaining said first member in a horizontal plane independently of changes in the inclination of the trunnion axis of the gun.

18. The combination with a gun, of a second member in accordance with the inclination of said train axis, means for applying said train component to the gun, and means for maintaining said first member in a horizontal plane independently of changes in the inclination of the trunnion axis of the gun.

19. The combination with a gun, of a second member in accordance with the inclination of said train axis, means for applying said train component to the gun, and means for maintaining said first member in a horizontal plane independently of changes in the inclination of the trunnion axis of the gun.

20. The combination with a gun, of a second member in accordance with the inclination of said train axis, means for applying said train component to the gun, and means for maintaining said first member in a horizontal plane independently of changes in the inclination of the trunnion axis of the gun.
means for maintaining said first member in a vertical plane independently of changes in the inclination of the trunnion axis of the gun whereby said elevation component is varied in accordance with changes in the inclination of the trunnion axis of the gun.

21. The combination with a gun, of a member maintained in a predetermined angular position in space independently of the inclination of the trunnion axis of the gun, a second member, means for adjusting said second member in accordance with the range, means for applying deflection corrections to said second member, a driving connection between said members whereby said second member is moved in elevation and train in accordance with the inclination of the trunnion axis of the gun, and means for applying the movements of said second member to the gun.

22. A system of gun fire control comprising in combination with a gun mounted on a moving support and adjustable in elevation and train planes varying in angular position with the angular position of said support, a pilot gun mounted on said support and adjustable in elevation and train planes, a single means for moving said pilot gun in its elevation and train planes to maintain it in a predetermined vertical plane independently of the position of said support, means for adjusting said pilot gun in its elevation and train planes so as to apply thereto in respectively vertical and horizontal planes the range and deflection corrections calculated for the gun, and motion transmitting means associated with said pilot gun for transmitting its movements to the gun.

23. A system of gun fire control comprising a sighting device, a gun, means for transmitting the movements of said sighting device to said gun, a mimic sighting device, means for applying the movements of said sighting device to said mimic sighting device, a pilot gun, means for maintaining said pilot gun in a vertical plane making a predetermined angle with a vertical plane passing through the line of sight of said mimic sighting device, and means for introducing the movements of said pilot gun as corrections in the transmitted movements of said sighting device.

24. A system of gun fire control comprising in combination with a sighting device and a gun mounted on a common moving support and each adjustable in elevation and train planes, a mimic sighting device and a pilot gun mounted on said support and adjustable in elevation and train planes, said train planes being parallel, means for adjusting said mimic sighting device to a position of parallelism with said sighting device, means for giving said pilot gun an elevation adjustment to be given the gun, means for maintaining said pilot gun in a vertical plane making a predetermined angle with a vertical plane passing through the line of sight of said mimic sighting device, and means for introducing the movements of said pilot gun as corrections in the transmitted movements of said sighting device.

25. A system of gun fire control comprising in combination with a sighting device and a gun mounted on a common moving support and each adjustable in elevation and train planes, a pilot gun and a mimic sighting device mounted on said support and each adjustable in elevation and in train planes, said train planes being parallel, motion transmitting means driven by said sighting device, motion receiving means adjacent said mimic sighting device electrically connected to said transmitting means, means for adjusting said mimic sighting device to a position of parallelism with said sighting device as indicated by said receiving means, means for adjusting the pilot gun in its elevation and train planes to apply the range and deflection correction calculated for the gun, a single means for moving said pilot gun in its elevation and train planes to maintain it in a vertical plane making a predetermined angle with the vertical plane passing through said mimic sighting device, and means associated with said pilot gun for transmitting its movements to the gun.

26. Gun directing apparatus comprising a pilot gun, a mimic sighting device mounted in such relation with said pilot gun that its line of sight intersects the line of fire of said pilot gun, a connecting member forming a pivoted link between said pilot gun and sighting device, and means for adjusting said connecting member about its pivot on said mimic sighting device to a predetermined angular position whereby said pilot gun is moved in its elevation and train planes.

27. Gun directing apparatus comprising a pilot gun, a mimic sighting device mounted in such relation with said pilot gun that its line of sight intersects the line of fire of said pilot gun, a connecting member pivotally mounted on said mimic sighting device so as to be movable about an axis coincident with the line of sight thereof, a pivotal connection between said member and said pilot gun having for its axis the line of fire of said pilot gun, and means for maintaining said connecting member in a predetermined angular position.

28. A system of gun fire control comprising in combination with a sighting device and a gun mounted on a common moving support and each adjustable in elevation and train planes, a pilot gun mounted on said support and adjustable in elevation and train planes, said train planes being parallel, a mimic sighting device mounted on said sup
port so that its line of sight intersects the line of fire of said pilot gun, a connecting member pivotally mounted on said sighting device so as to be movable about the line of sight thereof, a pivotal connection between said member and pilot gun having for its axis the line of fire of the pilot gun, means for adjusting said member about its pivot on said mimic sighting device to a predetermined angular position whereby said pilot gun is moved in its elevation and train planes, means for adjusting said mimic sighting device to a position of parallelism with said sighting device whereby similar movements are applied to said pilot gun, and means associated with said pilot gun for transmitting its movements to the gun.

29. Gun directing apparatus comprising a support, a member rotatably mounted on said support, means for adjusting said member in accordance with the movements of a remote sighting device, a second member rotatably mounted on said support, a connecting member pivotally connected to said first and second members, means for maintaining said connecting member in a predetermined angular position so that said second member is moved in accordance with the adjustments given the first member, and means for adjusting said second member with relation to said connecting member to apply the elevation correction calculated for the gun.

30. Gun directing apparatus comprising a pedestal, a supporting member mounted on said pedestal so as to be rotatable about a train axis, a second supporting member mounted on the first so as to be rotatable about said train axis, a pilot gun mounted on said first member, a mimic sighting device mounted on said second member, said pilot gun and mimic telescope being mounted on said supporting members to move about intersecting elevation axes at right angles to said train axis, a connecting member pivotally connected to said pilot gun and mimic sighting device, and means for adjusting said connecting member with relation to said mimic sighting device to a vertical position whereby said supporting members are relatively rotated.

31. A gun directing apparatus comprising a pilot gun, a mimic sighting device mounted in such relation with said pilot gun that its line of sight intersects the line of fire of said pilot gun, a connected member comprising two relatively adjustable parts forming a pivoted link between said pilot gun and said sighting device, means for maintaining one of the parts of said connecting-member in a predetermined angular position, means for adjusting said pilot gun with relation to said connecting member to apply the elevation correction calculated for the gun, and means for adjusting the parts of said connecting member with relation to each other to introduce the deflection correction calculated for the gun.

32. A gun directing apparatus comprising a pilot gun, a mimic sighting device mounted in such relation with said pilot gun that its line of sight intersects the line of fire of said pilot gun, a connecting member comprising first and second parts pivotally connected to said pilot gun and sighting device respectively, an adjustable connection between said parts permitting relative movement between them in a plane at right angles to said first part, means for adjusting said connecting member above said mimic sighting device to maintain said first part in a vertical position, means for adjusting said pilot gun with relation to said first part to introduce the elevation correction calculated for the gun, and means for adjusting said parts with relation to each other to introduce the deflection correction calculated for the gun.

33. Gun directing apparatus comprising a pedestal, a supporting member mounted on said pedestal so as to be rotatable about a train axis, a second supporting member mounted on the first so as to be rotatable about said train axis, a pilot gun mounted on said first member, a mimic sighting device mounted on said second member, a connecting member pivotally connected to said pilot gun and mimic sighting device, means for adjusting said pilot gun with relation to said connecting member to introduce elevation corrections, and means for adjusting said connecting member with relation to said mimic sighting device to a predetermined angular position whereby said supporting members are relatively rotated about said train axis.

34. Gun fire control apparatus comprising a pedestal support, a sleeve rotatably mounted about a train axis on said support, a second sleeve mounted on the first and rotatable about said train axis, a pilot gun mounted on said first sleeve and rotatable about an elevation axis perpendicular to and intersecting said train axis, a mimic telescope mounted on said second sleeve and rotatable about an elevation axis perpendicular to and intersecting said train axis and intersecting the elevation axis of said pilot gun, a connecting member comprising a part pivotally mounted on said mimic telescope about the line of sight thereof, means for adjusting said part about its pivot and for holding it in adjusted position, a second part of said connecting member mounted on said first part so as to be adjustable with relation thereto about an axis perpendicular to the line of sight of said mimic sighting device, a pivotal connection between said pilot gun and said second part having for its axis the line of fire of said.
pilot gun, means for adjusting said first connecting part on said mimic sighting device so as to maintain said second connecting part vertical, means for adjusting said second part about its axis with relation to the first to introduce deflection corrections, and means for adjusting the pilot gun with relation to said second member to introduce elevation corrections, whereby said pilot gun is moved about its elevation and train axis.

In witness whereof, we have hereunto set our hands this 8th day of April, 1924.

EDWARD M. HEWLETT.

WALDO W. WILLARD.