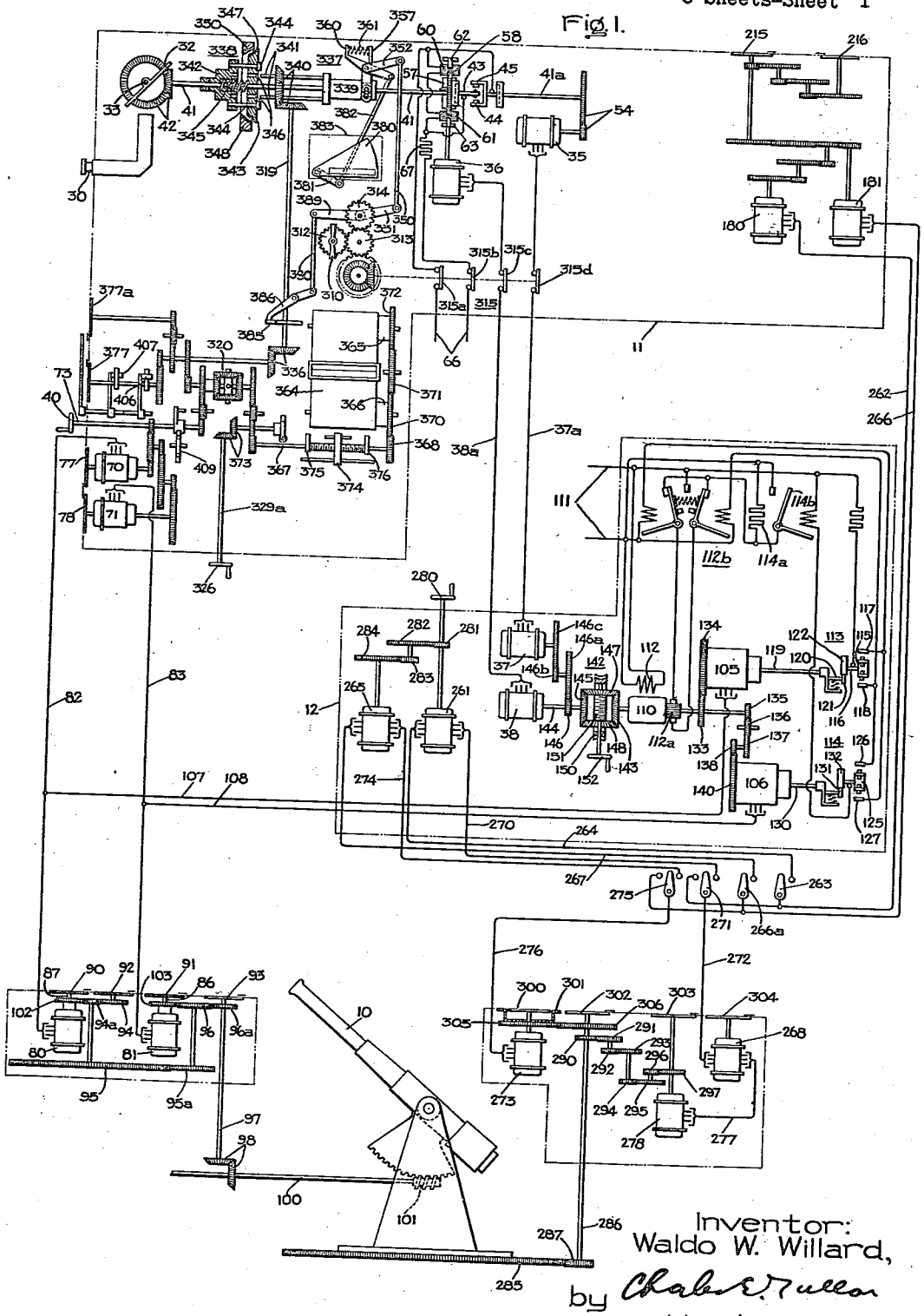
Jan. 2, 1934. W. W. WILLARD 1,942,079

SYSTEM OF AND APPARATUS FOR GUNFIRE CONTROL

Filed July 20, 1932 3 Sheets-Sheet 1

Fig. 1.



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SYSTEM OF AND APPARATUS FOR GUNFIRE CONTROL

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Fig. 2.

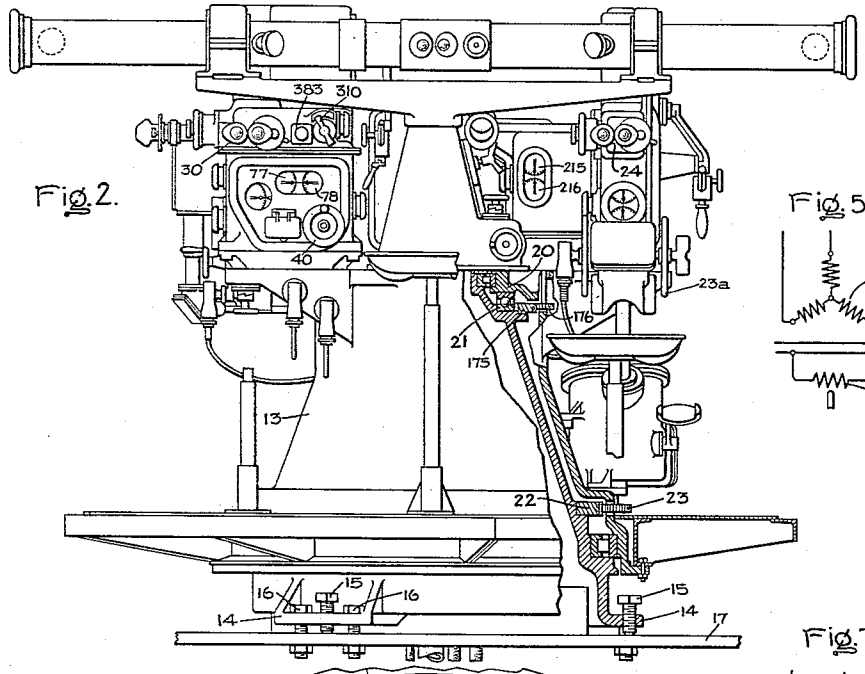


Fig. 5.

Fig. 7.

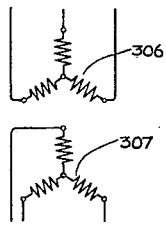


Fig. 3.

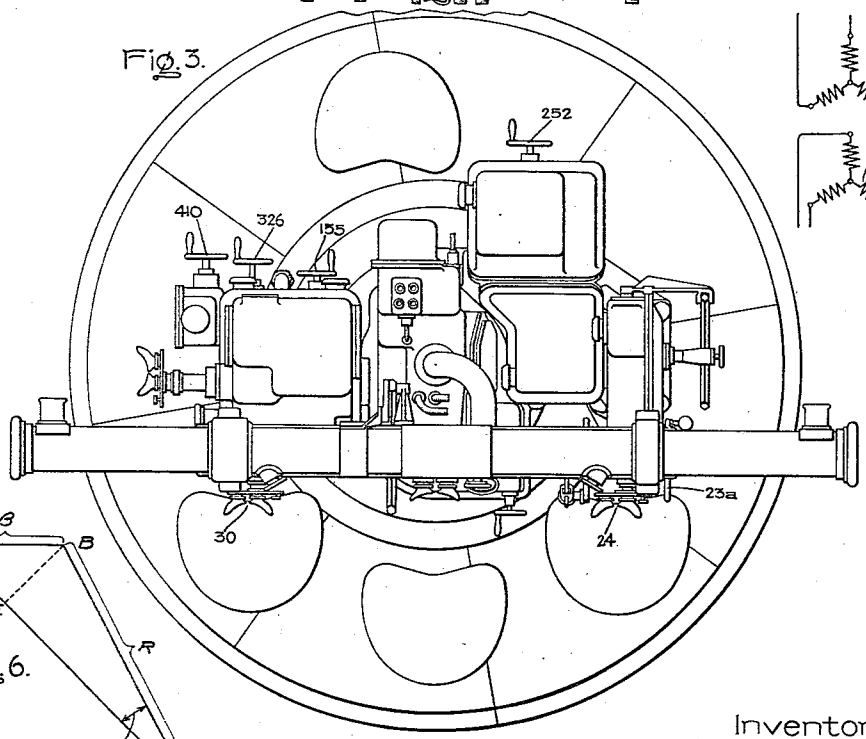


Fig. 6.

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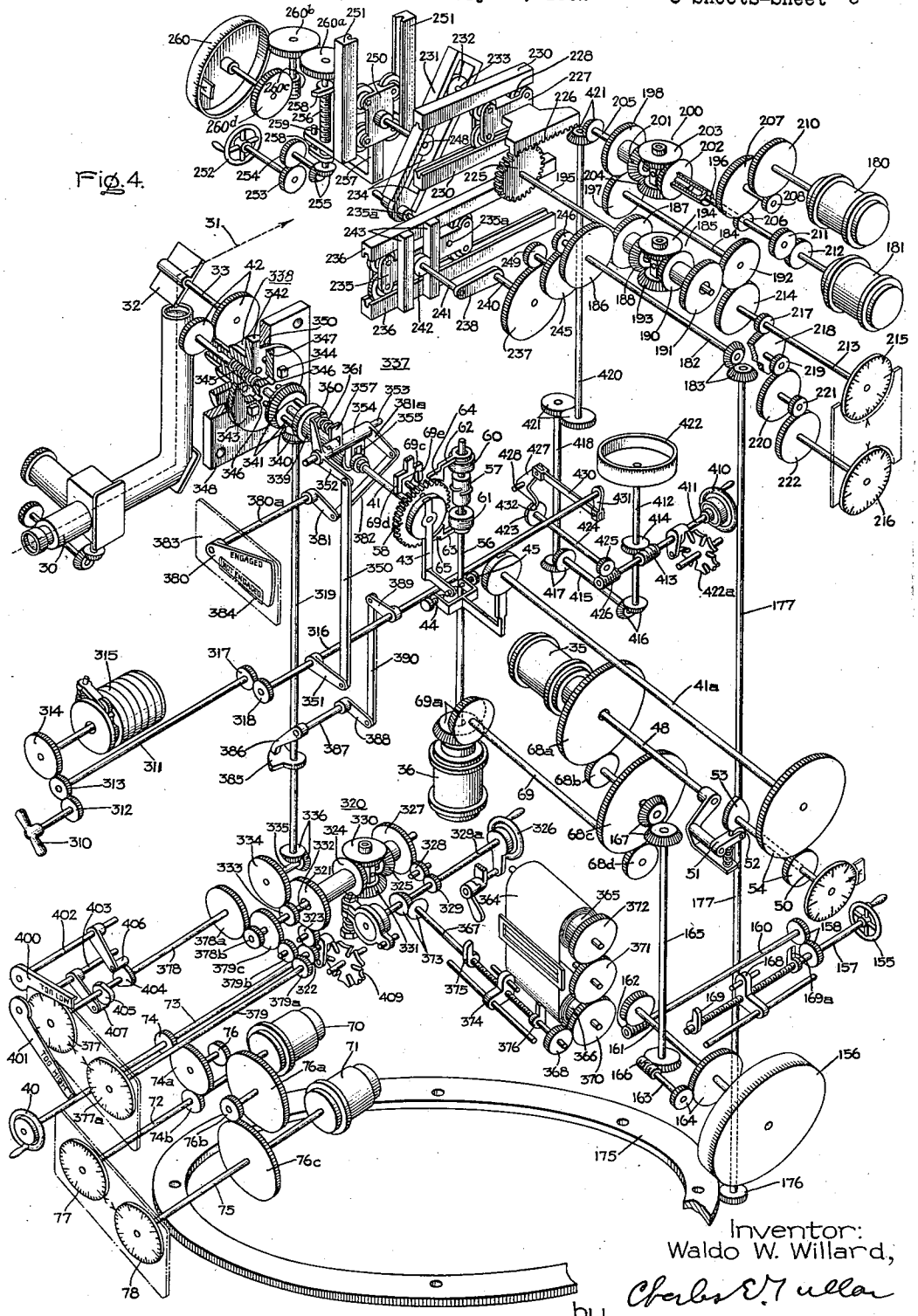
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SYSTEM OF AND APPARATUS FOR GUNFIRE CONTROL

Filed July 20, 1932 3 Sheets-Sheet 3

Fig. 4.



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Patented Jan. 2, 1934 1,942,079

UNITED STATES PATENT OFFICE

1,942,079

SYSTEM OF AND APPARATUS FOR GUNFIRE CONTROL

Waldo W. Willard, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application July 20, 1932. Serial No. 623,567

64 Claims. (Cl. 89—41)

My invention relates to the control of guns and the like and has for its object the provision of an improved system of and apparatus for controlling guns and the like from a directing instrument remotely situated with respect to the guns.

My invention, while it has more general application, is particularly useful as applied to the control of guns and the like on ship board, and has as one of its more specific objects the provision of a system and apparatus giving flexibility of control of guns of this character.

Guns on ship board are usually directed on a target in accordance with information of the position of the target received from auxiliary apparatus including a sighting device remotely situated with respect to the gun in position from which the target can be viewed.

In using the apparatus for directing guns on a target, the sighting device is brought to bear on the target and the movements generated by the sighting device when thus operated are measured and utilized for determining the train and elevation adjustments to be applied to the gun. It is usually necessary to apply various corrections to the actual movements of the line of sight of the director.

My invention contemplates the provision of an improved system and apparatus whereby the sighting device generates information which is transmitted to the guns and to auxiliary apparatus remotely situated with respect to the sighting device where certain corrections are applied so as to generate the necessary adjustments to be applied to the guns, and further, the provision of suitable means whereby all of the necessary corrections can be applied directly at the sighting device, if desired.

In carrying my invention into effect in one form thereof for the control of the guns in train, I provide a sighting device at the director station, and suitable means for training the sighting device on the target to generate its bearing. The generated bearing is transmitted to suitable auxiliary apparatus remote from the sighting device where corrections are applied for determining adjustments to be applied to the guns in train. Means are provided for disconnecting the auxiliary apparatus and for applying the necessary corrections locally at the sighting device, if desired.

Gun directing means are also provided at the sighting device for generating the adjustment to be applied to the guns in elevation. Cooperating with the gun directing means are auxiliary correction means remotely situated with respect to the sighting device for introducing corrections whereby the necessary adjustment to be applied to the guns in elevation can be determined. Means are also provided whereby the necessary corrections can be applied locally at the sighting device, if desired. In the preferred form of my invention, the auxiliary correction means will be operably associated with the gun directing means and with the sighting device in substantially the same manner as described and claimed in U. S. patent to Edward M. Hewlett and Waldo W. Willard, No. 1,650,626, dated November 29, 1927. As in this system, means are provided remote from the sighting device for applying corrections to the sighting device, which corrections may then be introduced in the gun directing means by readjustment of the sighting device if necessary.

I also provide means controlling both the local and the auxiliary correction means so as to selectively render them effective whereby the necessary corrections can be applied conveniently either directly at the sighting device or through the remotely situated auxiliary apparatus as desired.

For a more complete understanding of my invention, reference should be had to the accompanying drawings in which Fig. 1 is a diagrammatic representation of a system and apparatus for controlling guns and the like arranged in accordance with my invention; Fig. 2 is an elevation of a sighting device or director used in the system of Fig. 1 and arranged in accordance with my invention; Fig. 3 is a plan view of the director of Fig. 2; Fig. 4 is a diagrammatic perspective view showing the details of construction of the director of Figs. 2 and 3; Fig. 5 is a diagrammatic view showing a means for transmitting motion used in the system of Fig. 1; Fig. 6 is a diagrammatic view showing the principles of operation of certain correction mechanism used in my invention; and Fig. 7 is a diagrammatic view showing apparatus used in certain motion transmission systems used in my control system shown in Fig. 1.

Referring to the drawings, I have shown my invention as applied to the control of guns on war-ships. It is to be understood, however, that my invention is not limited to such applications.

As shown in Fig. 1, a gun 10 in a turret or other suitable gun mount (not shown) is controlled by means of a sighting device or "director" 11 situated aloft in some suitable position, and by auxiliary correction control means 12 located

in a suitable plotting room, which preferably will be below the deck of the ship. Usually this station or room will be remotely situated with respect to the gun 10 and the director 11. It will be understood that usually a plurality of guns will be controlled by the director and auxiliary control means, but for the sake of simplicity but a single gun is shown.

The director 11 comprises a pedestal 13 provided with three feet 14, each having one levelling screw 15 and two holding-down bolts 16. The pedestal is mounted on the deck 17 of a suitable director station.

All of the units or controlling elements of the director are supported by the pedestal 13 and are arranged to be rotated about it in a normally horizontal train plane. As shown, the controlling elements are all carried by a suitable supporting framework 20 which is freely rotatable in a normally horizontal train plane on bearings 21 carried by the pedestal.

Arranged on and carried by the lower end of the pedestal 13 is a relatively large spur gear 22 with which a spur gear 23 meshes. This latter gear is operated by suitable training mechanism (not shown) so as to rotate the frame 20 and the mechanism supported thereby in a train plane. The training mechanism comprises a training hand-wheel 23*a* connected to rotate the gear 23.

The director is provided with a training sight 24 to assist the trainer in bringing the director to bear on a target.

The elevation sighting means of the director comprises an eye piece 30 through which the target is observed, the line of sight 31 being directed to the eye-piece by an adjustable mirror 32 (Figs. 1 and 4) and a suitable prism (not shown) arranged in the eye-piece 30 to direct the path of light from the mirror 32 to a path through the eye-piece and to the eye of the observer.

Adjustment of the director in elevation is made by adjusting the angular position of the mirror 32 about an axis parallel with the train plane. The mirror, as shown, is mounted on a shaft 33 which is rotatable on an axis parallel to the train plane.

The mirror is adapted to be adjusted in elevation so that the line of sight can be adjusted to and maintained in the proper relation to the elevation of the gun.

The gun 10 preferably will be controlled in elevation by the director 11 and auxiliary control means 12 in substantially the manner described and claimed in the above mentioned United States Patent No. 1,650,626, granted to Edward M. Hewlett and Waldo W. Willard.

In accordance with the system there described, the mirror 32 is adjusted or rotated directly by means of a pair of receivers or reproducers of angular motion 35 and 36 which operate in a low and high speed ratio of 4:72 relative to each other.

These reproducers respond to or are operated by low and high speed transmitters 37 and 38 arranged in the auxiliary control means 12 (Fig. 1) and connected with the reproducers through sets of conductors 37*a* and 38*a* shown as single lines for the sake of simplicity.

Although any suitable system may be used for transmitting the angular movements between the control means 12 and the sighting device, preferably alternating current systems will be used in which the transmitting and reproducing devices are similar in construction and are each provided with a poly-circuit armature winding and a single circuit field winding. For example, as shown diagrammatically in Fig. 5, the transmitting and reproducing devices may each be provided with a poly-circuit armature winding 39, which is physically similar to a three-phase bi-polar, Y-connected armature winding and with a single circuit field winding 39*a*. The transmitters and reproducers are connected together by means of three conductors connecting like points of their armature windings. Single lines 37*a*, 38*a* shown in Fig. 1 represents the plurality of conductors. The field windings of each set of connected instruments are connected to a suitable source of alternating current supply. The field windings induce alternating electromotive forces in the currents of their respective armature windings, the relative value of the electromotive forces in the respective circuits of the armature windings depending upon the angular relation of the field winding therewith. When the rotors of the transmitter and reproducer are in angular agreement the electromotive forces induced in the various circuits of the armature windings are equal and opposite and, therefore, no current is produced. However, when the transmitter is turned and held in a new position, this voltage balance no longer exists so that currents are caused to flow and a torque is thereby exerted upon the rotor of the reproducer, which torque turns it to a position in which the voltages are again balanced when the rotors will again be in angular agreement.

The high speed reproducer 36 is provided for greater accuracy of adjustment. The low speed reproducer 35 is desirable to prevent errors due to the high speed reproducer getting out of step one or more complete revolutions.

These reproducers of angular motion and their transmitters 37 and 38 preferably will be arranged substantially as described and claimed in United States Patent No. 1,694,277, granted to Edwin J. Murphy and Leonard P. Hutt, dated December 4, 1928.

The motions of the transmitters 37 and 38, as will be pointed out in greater detail hereinafter, are controlled by the operation of gun directing means, shown as a handwheel 40, arranged in the director 11. The movements of the handwheel 40 are transmitted to the control means 12 where they are modified by the introduction of certain corrections and then transmitted to the reproducers 35 and 36.

The reproducer 35 is mechanically connected directly to the mirror. This connection comprises a pair of aligned shafts 41 and 41*a*. The shaft 41 is mechanically connected with the mirror shaft 33 by means of a pair of gears 42, the gearing interposing a speed ratio of 1:½ between the shaft 41 and the mirror shaft 33. These shafts 41 and 41*a* are connected by means of a contact arm 43 (Fig. 4) secured to and insulated from the shaft 41 and a pair of contacts 44 and 45 secured to and insulated from the shaft 41*a* and between which the contact arm 43 moves. When the shaft 41*a* turns, the contact arm may engage one or the other of the contacts depending upon the direction of rotation thereby driving the mirror 32.

The driving shaft 48 of the reproducer 35 is mechanically connected with the shaft 41*a* through an intermediate shaft 50, and is connected with this latter shaft by means of a yield-

able coupling comprising a spring-pressed arm 51 carrying a roller 52 and a heart-shaped cam 53 on which the roller bears. The spring-pressed arm and roller are mounted on the end of the shaft 48, while the heart-shaped cam is carried on the shaft 50. The shaft 50, as shown, is connected with the shaft 41*a* by intermeshing gears 54. The gearing 54 is arranged to interpose a speed ratio of 4:1 between the shafts 50 and 41*a*. In other words, the shaft 50 is a four-speed shaft relative to the shaft 41*a*.

By means of above-described heart cam connection, the shaft 50 and hence the shaft 41*a* are biased to a predetermined angular relation with the reproducer 35 since the spring-pressed roller seeks a position in the depression at the base of its heart cam, although the reproducer can follow its transmitter instantly moving against the slight bias of the heart cam coupling. This heart cam coupling interposed between the reproducer 35 and the contact controlling shaft 41*a* is described and claimed in U. S. Patent No. 1,559,525 granted to Edward J. Murphy and Leonard P. Hutt, dated October 27, 1925.

The reproducer 36, as pointed out above, operates in a high speed driving ratio such as 72:1 with the mirror shaft.

A releasable driving connection is provided between this reproducer and the mirror, which connection is released or broken when the low speed reproducer 35 is adjusting the mirror and is established upon the completion of the adjustment by the low speed reproducer.

A magnetic driving connection controlled by the low speed reproducer 35 is provided between the high speed reproducer 36 and the mirror.

The driving shaft 56 of the reproducer 36 is made of soft iron and is provided with a soft iron worm 57 secured to rotate with the shaft. Carried by the shaft 41 and cooperating with the worm 57 is a soft iron worm gear 58. The lead of the worm 57 is equal to the pitch of the worm wheel or gear 58. The worm and gear are not meshed but are slightly spaced from one another. In the particular form of my invention shown in the drawings, the worm and gear are set so that there is a space of approximately .002" or .003" between the tip of the worm and the tip of the corresponding tooth.

Mounted on the shaft 56 on opposite ends of the worm 57 are a pair of stationary magnet coils 60 and 61. Also mounted on the shaft 56 on opposite ends of the worm 57 and closely encircling the shaft are a pair of stationary members 62 and 63. These members are provided with pole faces 64 and 65 which are placed near the periphery of the worm gear 58. These members 62 and 63 complete a magnetic circuit for the coils 60 and 61 through the shaft 56 and the worm and worm gear.

The coils 60 and 61 are oppositely connected to a suitable source of direct current supply 66 (Fig. 1). As thus connected, the magnetic fluxes set up by the coils will be in opposite directions along the shaft 56 and through the thread of the worm across the air gap to the teeth of the worm gear where the fluxes divide and return on each side through the worm gear and the members 62 and 63. The thread of the worm and the teeth of the adjacent portion of the worm gear thus form magnetic poles of opposite polarity when the coils are energized and, therefore, attract each other. This causes a gear tooth to be drawn exactly opposite the worm thread, and so upon rotation of the worm 57 by the reproducer 36, the teeth of the worm gear will follow the threads of the worm.

The coils are controlled by means of the contact arm 43 and the contacts 44 and 45, which in turn are controlled by the reproducer 35. The coils are controlled by establishing a short circuit around them so as to deenergize them when the contact arm 43 is in engagement with either of the contacts 44 and 45.

As shown in Fig. 1, the contact arm 43 is electrically connected to one side of the coils 60 and 61, while the contacts 44 and 45 are connected to the other side of the coils so that the coils are short circuited when the contact arm is in engagement with either one of the contacts.

A resistor 67 is connected to the supply source 66 in series with the coils 60 and 61 so as to prevent a short circuit of the supply source when the contact arm engages either one of the contacts.

It will be observed that when the contact arm 43 is in engagement with either one of the contacts 44 and 45, the driving connection for the reproducer 36 is broken to permit the mirror 32 to be adjusted by the low speed reproducer 35. When the latter reproducer has completed its adjustment, the contact will be broken due to the inertia of the mirror and its driving shafts 33 and 41, and the magnetic driving connection between the shaft 41 and the reproducer 36 will be established by the energization of the coils 60 and 61 whereupon the adjacent teeth of the worm gear will move to the positions opposite to the threads of the worm to complete the accurate adjustment.

The stators of the reproducers 35 and 36 are geared together by gearing 68*a*, 68*b*, 68*c* and 68*d* which connect the stator of the device 35 with the shaft 69 which in turn is connected with the stator of the reproducer 36 through bevel gears 69*a*. The gear ratio between these stators is the same as the speed ratio between the rotors of the reproducers.

Suitable means are provided for limiting the motion of the mirror 32 to approximately 15° on each side of its neutral position. This means comprises a pin 69*c* carried by the worm gear 58 and cooperating with spaced stops 69*d* and 69*e*.

As in the system of elevation control set forth in the above-mentioned Hewlett and Willard Patent No. 1,650,626, I introduce at the director the angular adjustment to be applied to the gun in elevation above the deck of the ship. This angular adjustment will be called "gun elevation order angle". It is applied by turning the handwheel 40 and it is transmitted directly to the gun 10 and also to the auxiliary control means 12. The control means 12 functions to apply a correction for range, which I will call "sight angle". This angle is subtracted in the mechanism 12 from the gun elevation order angle, and the resultant or "director correction angle" is applied to the mirror 32.

The "sight angle" is the angle of elevation of the gun with respect to a horizontal plane. When the ship's deck or other support for the gun is inclined at the instant of fire, and it generally is, it is obvious that the total gun elevation above the deck, i. e., gun elevation order angle will not be equal to the sight angle but will have a value equal to the sight angle corrected by the application of the angle between the ship's deck and the horizontal plane at the instant the gun is fired. This angle between the ship's deck and the horizontal plane is known as the "director correction angle" referred to above.

As pointed out above, the gun elevation order

angle is received by the auxiliary control means 12 where it is modified by sight angle. The corrected angle, i. e., director correction angle, which preferably will be compensated for tilt of the gun trunnions, is transmitted to the director where it is further compensated for vertical parallax between the director and the gun and then utilized to control the line of sight.

The gun elevation order angle is issued from the director by means of a pair of high and low speed transmitters of angular motion 70 and 71 which are controlled by means of the gun directing member or handwheel 40. This handwheel 40 may be connected in a 2:1 ratio with the shaft 72 of the high speed transmitter 70 through a shaft 73 and reducing gearing 74, 74*a* and 74*b*, and with the shaft 75 of the low speed transmitter 71 in a 24:1 ratio through a further reducing gear train 76, 76*a*, 76*b* and 76*c*. The ratios between the high and low speed transmitter 70 and 71 is 72:6.

As shown, suitable high and low speed indicating dials 77 and 78 are driven by the shafts 72 and 75 of the transmitters 70 and 71 respectively. These dials read gun elevation order that is transmitted.

The transmitters 70 and 71 are electrically connected to high and low speed reproducing or receiving devices 80 and 81 located adjacent the gun 10 through sets of conductors 82 and 83, shown as single lines for the sake of simplicity.

While any suitable system may be used for the transmission of this angular motion, preferably an alternating current system of the same type used to transmit motion between the auxiliary correction control means 12 and the sighting device and comprising the transmitters 37 and 38 and the reproducers 35 and 36 will be used. This system has been described previously. In this system it will be understood that like points of the armatures of the transmitters 70 and 71 are connected with like points of those of the reproducers 80 and 81 respectively by the conductors 82 and 83, and that the fields of these devices are connected with a common source of excitation (not shown).

The reproducers 80 and 81 are located in a suitable pointer station and, as shown, their shafts 86 and 87 are connected to drive indicating dials 90 and 91 respectively. These dials indicate gun elevation order angle.

Adjacent these dials in the gun pointer station are a second set of dials 92 and 93. The dial 92 is mechanically connected through gearing 94, 94*a*, 95, 95*a*, 96 and 96*a* with a shaft 97, this gearing interposing a 72:1 speed ratio between the movement of the shaft 97 and that of the dial 92. The shaft 97 in turn is mechanically connected through gearing 98 with a shaft 100 which is used to operate the gun in elevation through a worm and gear segment drive 101. The shaft 100 is operated by any suitable means (not shown). The dial 93 is directly connected with the shaft 97 and hence is operated in a 1:1 speed ratio with this shaft. The dial 92 is further connected with the stator of the receiver 80 in a 1:1 ratio through a gear 102 attached to the stator and meshing with the gearing 94, while the dial 93 is mechanically connected with the stator of the reproducer 81 in a 1:1 ratio by means of a gear 103 attached to the stator and meshing with the gearing 96.

It will be understood that the dials 90 and 91 will be turned from their zero positions by the receivers 80 and 81 to indicate gun elevation order angle. When the gun is elevated by its power shaft 100 in accordance with this order, the dials 90 and 91 will be returned to their initial positions by the drives between the stators of the devices 80 and 81 and the shaft 97, and the dials 92 and 93 will be operated to show the actual elevation of the gun.

Gun elevation order angle generated in the director 11 is also transmitted to the auxiliary correction control means 12. As shown, the gun elevation order angle transmitters 70 and 71 are electrically connected with high and low speed reproducers or receivers 105 and 106 of the control means 12 through the sets of conductors 82 and 83 and sets of conductors 107 and 108.

The reproducers 105 and 106 have substantially the same construction as have the transmitters 70 and 71. Like points of the armatures of these transmitters and reproducers are interconnected by the sets of conductors 82 and 83 and 107 and 108. The field windings of these devices are connected to a common source of alternating current supply (not shown).

The reproducers 105 and 106 operate the transmitters 37 and 38 through a servo-motor 110, which reproduces the motion of the handwheel 40. These reproducers 105 and 106 control the servo-motor in accordance with the disclosure of the above-mentioned United States Murphy and Hutt Patent No. 1,559,525.

The motor 110 which is of the direct current shunt type is energized from a suitable direct current source of electrical supply 111. The field 112 of this motor has a permanent connection to the supply source. The armature 112*a* of the motor is supplied by the source 111 through a control relay 112*b* which functions through the operation and guidance of contact devices 113 and 114 to control the starting, stopping and direction of rotation of the motor 110 in accordance with the movements of the reproducers 105 and 106 so that the motor will reproduce the gun elevation order angle transmitted from the director 11. A resistance 114*a* is included in the armature circuit of the servo-motor 110. This resistance is controlled by a relay 114*b* which in turn is controlled by the contact devices 113 and 114. The function of the resistance 114*a* is to control the speed of the servo-motor.

The contact device 113 comprises a contact arm 115 mounted on a shaft 116 to move between a pair of fixed contacts 117 and 118. The contact arm 115 is connected to the shaft 119 of the reproducer 105 through a yieldable coupling comprising a spring pressed arm 120 carrying a roller 121 that bears on a heart-shaped cam 122. The arm 120 and its roller are carried by the reproducer shaft 119, while the cam 122 is carried by the contact arm shaft 116. The contact device 114 comprises a similar arrangement, this device being provided with a contact arm 125 movable between fixed contacts 126 and 127 and connected with the receiver shaft 130 of the reproducer 106 through a flexible coupling. This coupling includes a spring pressed roller 131 bearing on a heart-shaped cam 132.

The motor 110, as shown, is geared to the stator of the reproducer 105 by a spur gear 133 on the motor shaft meshing with a spur gear 134 on the stator, and is geared to the stator of the reproducer 106 by a gear train 135, 136, 137, 138 and 140. The gear ratio between the stators is the same as the speed ratio between their rotors.

The reproducers 105 and 106 control the servo-motor 110 to reproduce the motion of the handwheel 40 in identically the same manner as is the servo-motor 10, shown in Fig. 2 of the above-mentioned Murphy and Hutt Patent No. 1,559,525, controlled by the reproducers 12 and 12' of this patent. It is believed to be unnecessary, therefore, to describe this operation in detail in this application.

Briefly, when the transmitters 70 and 71 are moved, the rotors of the reproducers 105 and 106 move into angular positions with relation to their stators which correspond with the angular positions of the transmitter rotors with relation to their stators moving the arms 115 and 125 into engagement with one or the other of their cooperating contacts. The heart cam couplings yield so as to permit movement of the receiving rotors independently of the contact arms. The contact arms 115 and 125 are thus moved to control energizing circuits for the operating coils of the relay 112*b*, which in turn controls the energization of the servo-motor to operate in one direction or the other depending upon which pairs of contacts of the devices 113, 114 are closed to move its shaft into angular agreement with the handwheel 40.

The motor 110 operates the transmitters 37 and 38 through a differential device 142. As shown, the motor is connected with a bevel gear 143 of the differential, whereas the transmitter 38 is connected by a shaft 144 with the output bevel gear 145 of the differential so as to be driven from the motor through the differential. The rotor of the transmitter 38 is geared to the rotor of the transmitter 37 to have a 4:72 speed ratio with it by gearing 146, 146*a*, 146*b* and 146*c*.

The differential 142 further comprises planetary bevel gears 147 and 148 cooperating with the bevel gears 143 and 145 and carried by a worm gear 150 which meshes with a worm 151 driven by suitable mechanism indicated diagrammatically by a handwheel 152.

It is contemplated that by means of the foregoing arrangement, the gun elevation order angle issued by the transmitters 70 and 71 will be received in the control means 12, reproduced by the servo-motor 110, and then modified by the correction for sight angle, preferably compensated for elevation component of trunnion tilt, which correction is introduced by the mechanism 152, and the resultant then transmitted to the director by the devices 37 and 38.

As pointed out above, this resultant is the "director correction angle" and is a measure of the algebraic difference between gun elevation order angle and sight angle.

It is obvious that the director correction angle thus determined must be corrected for vertical parallax between the director and the gun before the line of sight can be brought into proper relation to the elevation of the gun.

The director correction angle which is transmitted to the director is there compensated for vertical parallax which correction is introduced into the motions of the reproducers 35 and 36. Vertical parallax is introduced into the director by means of a handwheel 155 (Fig. 4) which is connected by gearing to a suitable scale dial 156 calibrated in yards range, whereby the parallax correction for any given range is introduced by turning the scale to the yards range. As shown, the hand-wheel operates a shaft 157 which is connected through gears 158 with a shaft 160. This shaft in turn is connected with a shaft 161 through a worm and worm wheel drive 162. The shaft 161 as shown carries the dial 156.

The shaft 161 is geared to a shaft 163 through a gear connection 164 and the latter shaft is connected with a shaft 165 through a worm and worm gear connection 166. The shaft 165 is connected with the gearing 68*a*—68*d* interposed between the stators of the reproducers 35 and 36 and hence, with these members, by means of bevel gears 167.

The gear connections 158, 162, 164, 166, and 167 are arranged to give an appreciable speed reduction between the handwheel 155 and the stators of the reproducers.

It will be understood that if the stators of the reproducers 35 and 36 are held stationary when the transmitters 37 and 38 are operated, the shafts 48 and 56 of the members 35 and 36 respectively will be rotated in space through the angles that the rotors of these members turn relative to their stators. However, if the stators are rotated by the handwheel 155, the shafts 48 and 56 will no longer be rotated in space through the angles that the rotors move relative to their stators, but will be moved through angles which will be the algebraic sum of the angles through which the rotors are turned relative to their stators and the angles through which the stators themselves are turned.

Hence, the motion imparted to the mirror 32, i. e., the line of sight, depends upon the angles transmitted by the devices 37 and 38 in the control means 12 and upon the setting of the vertical parallax handwheel 155. In other words, the line of sight is adjusted in accordance with the director correction issued by the control means modified to correct for vertical parallax between the director and the gun.

The parallax mechanism is provided with suitable stops preventing over-travel of the adjusting mechanism; this stop means comprises a member 168 threaded to travel on the shaft 157 and arranged to engage stops 169 and 169*a* to limit the movement of the handwheel 155 for both of its directions of motion.

The "target bearing" is generated in the director by the director trainer as he follows the target with his sight and is transmitted by the director to the auxiliary correction control means 12 where it is combined with "deflection", preferably duly modified by the required correction in train for trunnion tilt of the gun, as computed by the control means. The resultant, i. e., the adjustment to be applied to the gun in train is issued by the control means 12 and transmitted to indicators at gun 10. This train adjustment, I will call "gun train order angle".

"Deflection" correction is a function of the velocity and direction of the wind, drift, speed and direction of the ship and target, etc. and must be applied to the target bearing generated in the director for the purpose of determining the adjustment to be applied to the gun in train.

As previously pointed out, the controlling mechanism of the director is carried on the frame 20 (Fig. 2), which in turn is mounted for movement in train on the pedestal 13. The turntable or frame 20 is rotated about the pedestal by means of the training spur gear 23 which meshes with the relatively large fixed spur gear 22 supported at the base of the pedestal. The gear 23 is operated by the training handwheel 23*a* to keep the training sight 24 on the target.

Supported at the upper end of the pedestal 13 is a second relatively large fixed spur gear 175

(Figs. 2 and 4) which is used to operate the target bearing generating mechanism. This mechanism comprises a spur gear 176 mounted on a shaft 177 and meshing with the gear 175 so that motion will be imparted to the shaft 177 when the director is turned in train.

The shaft 177 is used to drive low and high speed target bearing transmitters 180 and 181 located in the director and which function to generate "target bearing" and to transmit the bearing thus generated for utilization at the gun where suitable gun train indicators are mounted.

The shaft 177 is connected with the rotors of the transmitters through suitable gearing introducing predetermined speed ratios between the motion of the director in train and the motion of the rotors.

As shown, the shaft 177 meshes with a shaft 182 through a bevel gear connection 183. The shaft 182 is mechanically connected with a shaft 184 through a differential 185. The shaft 182 is connected through spur gears 186 and 187 with a bevel gear 188 of the differential, while the shaft 184 is connected with the output bevel gear 190 of the differential through spur gears 191 and 192.

The differential also comprises planetary bevel gears 193 and 194 meshing with the bevel gears 188 and 190. The gears 193 and 194 are mounted on a shaft 195, the motion of which is controlled by suitable mechanism to be described in detail hereinafter.

The shaft 184 is mechanically connected with a shaft 196 by means of spur gears 197 and 198 and a differential 200 similar to the differential 185. The gear 198 is connected with a bevel gear 201 of the differential, while the shaft 196 is connected with the output bevel gear 202 of the differential. The planetary bevel gears 203 and 204 of the differential mesh with the gears 201 and 202 and are mounted on a shaft 205, the motion of which is controlled by a suitable mechanism which will be described in detail hereinafter.

The shaft 196 is connected to the rotor of the low speed transmitter 180 through gearing 206, 207, 208 and 210 and is connected with the rotor of the high speed transmitter 181 through spur gears 211 and 212.

The gearing 176, 183, 186, 187, 191, 192, 197 and 198 interposed between the pedestal gear 175 and the shaft 196 introduces between these members a speed ratio of 1:36. The gearing 206, 207, 208 and 210 interposed between the shaft 196 and the rotor of the device 180 introduce a speed ratio between these members of 36:1, while the gearing 211 and 212 introduce a speed ratio of 1:1 between the shaft 196 and the rotor of the transmitting device 181. Hence, the transmitter 180 is driven in a 1:1 speed ratio with the motion of the director in train, while the transmitter 181 is driven in a 36:1 speed ratio with this motion of the director.

The shaft 184 is driven at the same speed as the shaft 196 and is geared to a shaft 213 in a 1:1 speed ratio by the spur gear 192 and a meshing spur gear 214. The shaft 213 drives a high speed indicator dial 215. The shaft also drives a low speed indicator dial 216 at a reduced speed through gearing 217, 218, 219, 220, 221 and 222. The speed ratio introduced between the shaft 213 and the dial 216 is 36:1.

Parallax in train between the gun 10 and director 11 is compensated for by referring bearing to a suitable common reference point. The director itself may be the reference point, or if a number of directors are used in the system, this point may be located at the vertical axis of the after gun director. It will be understood, however, that any suitable point may be chosen as the reference point.

The parallax compensation is effected by suitable mechanism at the director arranged to modify the angles through which the transmitting devices 180 and 181 are moved, as the director is turned in train, so that the angle transmitted is the target bearing from the chosen reference point. Similar parallax mechanism is located at the gun arranged to modify the angles through which the gun train indicators are turned so that the indicated angle is referred to the reference point.

The operation of the parallax correction mechanism may be understood by reference to Fig. 6 which is a diagrammatic representation of the field of action; the position of the director is indicated by the point A, that of the reference point by the point B and that of the target by the point C. The distance AB from the director to the reference point, i. e. β, is fixed for any particular control system, while the distance BC which is the range R, of course, is variable.

If in this diagram, a perpendicular be dropped from the point B to the line AC as at E, it will be seen that:

$$AE=\beta \sin \alpha=R \sin P$$

i. e. R sin of the parallax angle

$$\therefore \sin P=\frac{\beta \sin \alpha}{R}$$

For small angles the sin is substantially equal to the arc, so that for small values of P

$$P=\frac{\beta}{R} \cdot \sin \alpha$$

From this it will be observed that the parallax angle P can be introduced by applying an angular movement to the rotors of the transmitters 180 and 181 proportional to

$$\frac{\beta}{R} \cdot \sin \alpha,$$

this angular movement being superposed upon the angle transmitted from the training gear 175.

This correction angle is introduced into the driving connection between the gear 175 and the transmitters 180 and 181 through the differential device 185.

The parallax mechanism is shown in detail in Fig. 4. This mechanism has been omitted from the diagrammatic representation of the system shown in Fig. 1 for the sake of simplicity. As shown (Fig. 4) the shaft 195 which operates the planetary gears 193 and 194 of the differential 185 is provided with a spur gear 225. This gear meshes with a rack 226 which, as shown, is rigidly secured to a carriage 227. This carriage is movably mounted on rollers 228 for reciprocatory motion in guideway 230.

The carriage 227 has a mechanical connection with a lever 231, this connection as shown comprising a roller 232 carried by a pin 233 projecting from the carriage and received in guides 234 provided for it on the lever.

The lever 231 connects the carriage 227 with a similar carriage 235 that reciprocates in guides 236 arranged in parallel relation with the guides 230. The lower end of the lever 231, as viewed

in Fig. 4, is connected with the carriage 235 by means of a pin 235a.

The carriage 235 is connected mechanically with a gear 237 through a crank 238. This crank, as shown, is rigidly secured to rotate with and on the axis of the gear 237 by means of a shaft 240 and is connected with the carriage 235 by means of a pin 241 mounted on the crank and carrying a roller 242 that moves between vertical guides 243 on the carriage. These guides, as shown, are arranged at right angles to the line of movement of the carriage in its guide ways.

The gear 237 is connected through gearing 244, 245 and 246 with the shaft 182 whereby the shaft 240 has a 1:1 speed ratio with the movement of the director in train.

The lever 231 is mounted upon a pivot or fulcrum 248 that is adjustable in the guides 234 and in a direction at right angles to the line of movement of the carriage 227 in its guides 230. The fulcrum 248, as shown, is mounted upon a carriage 250 which in turn is mounted for reciprocatory motion in guideways 251 arranged at right angles to the guideways 230 and 236.

The motion of this carriage 250 is controlled by a handwheel 252 which is connected through gearing 253, 254 and 255 with a vertically arranged adjusting screw 256. Threaded upon this screw is a fulcrum operating arm 257 which as shown is mechanically connected with the fulcrum carriage 250 to impart motion to it when the screw is turned. Suitable stops 258 are provided to limit the extent of movement of the arm 257 and hence of the carriage 250 in either direction. As shown, the arm 257 is provided with a stop 259 arranged to engage with the stops 258.

The adjustment of the fulcrum is made in accordance with the range. A suitably calibrated range scale 260 is provided whereby this adjustment can be made accurately. This scale is connected to the screw 256 through suitable reducing gearing 260a, 260b, 260c and 260d.

It will be observed that the gear 237 has the same angular movement as has the director in train and hence generates the angle α, and that the carriage 235 therefore has a movement proportional to sin α. And further, that the carriage 227 controlling the differential 185 has the motion of the carriage 235 modified by adjustment of the range fulcrum 248. The distance AB (Fig. 6) is fixed for any particular system and the only variable to be introduced is the range R, which, as previously pointed out, is introduced by the handwheel 252. It will be understood that the scale 260 is calibrated for the range adjustment and also to take into consideration the particular distance β the director is from the reference point. The resulting angular movement applied to the transmitters through the differential 185 is proportional to the parallax angle P so that the target bearing transmitted by the director is corrected for parallax and is the same as it would be if the director were located in the same position as the reference point.

As previously pointed out, the parallax mechanism has not been shown in Fig. 1. It is also to be noted that the operating mechanism for the transmitters 180 and 181 whereby they are driven by the shaft 177 is shown quite diagrammatically in this figure.

As pointed out above, the transmitters 180 and 181 generate target bearing and transmit the generated bearing to the auxiliary control means 12 where it is compensated for deflection and transmitted to the gun train station. As shown (Fig. 1) the device 180 is connected with an electrical differential device 261 in the auxiliary control means 12 through a set of conductors 262, a switch 263 and a set of conductors 264. The transmitting device 181 is connected with a similar differential device 265 of the control means 12 through a set of conductors 266, a switch 266a, and a set of conductors 267.

The differential device 261 is connected with an electrical differential device 268 in the trainer station by means of a set of conductors 270, a switch 271 and a set of conductors 272, while the differential device 265 in the control means 12 is connected with a reproducer 273 in the gun trainer station through a set of conductors 274, a switch 275 and a set of conductors 276.

The differential device 268 in the trainer station is connected through a set of conductors 277 with a transmitting device 278 that is operated by the gun as it is turned in train.

The deflection correction, preferably modified by the required correction in train for the tilt of the gun trunnions, is introduced into the differential devices 261 and 265 by means of suitable mechanism, shown diagrammatically as a handwheel 280 which, as shown, is connected in a 1:1 ratio with the rotor of the differential device 261, and in a 1:36 ratio with the rotor of the differential device 265 through gearing 281, 282, 283 and 284.

As previously pointed out, the transmitter 278 is driven by the gun as it moves in train. As shown, the gun mount is provided with a relatively large spur gear 285 mechanically connected with a shaft 286 through a relatively small spur gear 287. The shaft 286 is mechanically connected with the rotor of the transmitting device 278 through gearing 290, 291, 292, 293, 294, 295, 296 and 297 whereby the rotor is driven in a 1:36 speed ratio with the motion of the gun in train.

The trainer station is provided with five indicating dials 300, 301, 302, 303 and 304. The dial 300 is driven by the rotor of the reproducing device 273; the dial 301 is driven through gears 305 and 306 by the shaft 286 driven by the gun as it moves in train; the dial 302 is driven directly by the shaft 286; the dial 303 is driven directly by the rotor of the transmitting device 278; and the dial 304 is driven by the rotor of the differential device 268.

The transmitting devices 180, 181 and 278 and the receiver 273 are electrical devices having substantially the same construction and operation as have the devices 35, 36, 37 and 38 previously described in detail. Like points of the armatures of the transmitter 180 and the receiver 278 are arranged to be connected together. Likewise, like points of the armatures of the devices 181 and 273 are arranged to be connected together. The field windings of these devices will be connected with a common source of excitation (not shown).

The electrical differential devices 261, 265 and 268 interposed between the transmitters 180 and 181 and the receivers 278 and 273 are similar in construction. As shown diagrammatically in Fig. 7, each comprises two three-circuit cooperating windings 306 and 307 that are physically similar to a three-phase Y-connected armature winding. One of these two windings is rotatably mounted.

When the two windings are in corresponding

angular positions, the electromotive forces impressed on one of the windings by the transmitter connected with the device will be induced without change in the other winding so that the angular movement being transmitted through the windings will not be affected, but when the two windings are angularly displaced, the displacement causes the electromotive force output of the differential device to be different from the impressed electromotive force so that the angular displacement is added to or subtracted from the movement of the transmitter depending on the direction of the displacement. This differential device is described and claimed in U. S. Patent No. 1,612,117 granted to Edward M. Hewlett and Waldo W. Willard, dated December 23, 1926.

The transmitting devices 180 and 181 in the director transmit target bearing to the differential devices 261 and 265 of the auxiliary control means 12 where the bearing angle is compensated for deflection which in turn is preferably compensated for tilt of the gun trunnions. The deflection correction preferably compensated for trunnion tilt is generated by suitable mechanism (not shown in detail), but which is indicated diagrammatically by the handwheel 280, which controls the devices 261 and 265. It will be understood that when the rotors of the differential devices 261 and 265 are displaced relative to their stators by operation of the deflection compensating mechanism, the angle which is transmitted through these devices from the transmitters 180 and 181 will be modified accordingly. The angle transmitted through the differential device 261 is received in the gun train order station by the differential device 268, which operates to reproduce this angle, the magnitude of the angle being shown on the dial 304. The angle transmitted through the differential device 265 is reproduced by the receiver 273 in the gun train order station and is read on the dial 300.

When the gun is adjusted in train in accordance with the amount and direction of displacement of the indicators in the gun train order station, it rotates the dial 301 so as to bring this dial to its previous positional agreement with the dial 300. As the gun is thus turned in train, it will also operate the transmitting device 278 which feeds into the electrical differential device 268 in such manner as to return the dial 304 to its original position. The dials 302 and 303, however, will be operated to indicate directly the angle through which the gun is turned in train.

As previously pointed out, train parallax mechanism similar to the train parallax mechanism in the director, described in detail above, is provided at the trainer's station so as to refer the indicated bearings to the common reference point. This parallax mechanism is driven by the shaft 286. It is believed to be unnecessary to describe this mechanism in detail since it is substantially the same as that provided in the director.

In the operation of my invention thus far described, the trainer brings the director to bear on the target in train by turning his handwheel 23*a*. This operation, as has been described in detail, causes the generators 180 and 181 to generate target bearing referred to the chosen reference point. It will be understood that parallax correction will have been introduced at some suitable time by means of the handwheel 252. The bearing of the target referred to the reference point is indicated on the dials 215 and 216 at the director station.

The target bearing thus generated is transmitted through the differential devices 261 and 265 of the auxiliary control means 12 to the trainer station. The deflection correction, preferably compensated for tilt of the gun trunnions, is introduced by these differential devices and the resultant, i. e., gun train order angle, is transmitted to the trainer station where it is reproduced by the differential device 268 and the reproducer 273 and indicated on dials 300 and 304.

The gun trainer may then train the gun on the target, as instructed by the gun train indicators. As he does so, the dial 301 is rotated by the gun so as to be brought to agree with the dial 300 and the dial 304 is returned to its zero position by the operation of the transmitter 278. The dials 302 and 303, however, will be driven by the gun to indicate the angle that the gun is turned in train.

The desired gun elevation order angle is generated and transmitted by operating the elevation directing handwheel 40. The sight pointer operates the handwheel 40 in accordance with his observations as to whether the target appears too high or too low in this field of view so as to generate an arbitrary gun elevation order.

The movement of the handwheel 40 is applied to the transmitting devices 70 and 71 and is reproduced in the pointer station on the dials 90 and 91 which are operated by the reproducers 80 and 81.

The gun elevation order angle is received in the auxiliary control means 12 by the reproducers 105 and 106 which control the servo-motor 110 to reproduce the angle of gun elevation order. This movement of the motor 110 is applied to the transmitting devices 37 and 38 through the differential device 142 which operate to cause the movement to be repeated by the reproducers 35 and 36 in the director. These reproducers, as has been pointed out in detail, apply the movement to the mirror 32, whereby the line of sight is adjusted in accordance with the movement given to the gun elevation order handwheel 40.

Therefore, the adjustment of the line of sight can be effected by rotating the handwheel 40, which can be operated to bring the target within the desired limits in the field of view.

The correction for sight angle, preferably compensated for elevation component of trunnion tilt correction, is introduced into the differential device 142 by mechanism of the auxiliary control means 12 indicated diagrammatically by the handwheel 152. This correction is applied to the transmitting devices 37 and 38 and then is issued as director correction angle and applied to the mirror 32 and by the reproducers 35 and 36.

This, of course, changes the direction of the line of sight, and the sight pointer, upon observing this movement, may, if he so desires, turn the handwheel 40 to return the line of sight to its original direction or to any other direction that he feels to be more satisfactory. This automatically introduces director correction. The resulting movement applied to the transmitters 70 and 71 is, as before, indicated on the dials 90 and 91 in gun pointer station.

It will be observed, therefore, that the angular relation between the line of sight and the gun is controlled jointly by the director 11 and the control means 12. The director generates and transmits an arbitrary gun elevation order angle. This order is corrected for sight angle, preferably compensated for tilt of the gun trunnions by the

control means 12, and the resultant director correction angle is issued and applied to the line of sight. This changes the direction of the line of sight and in returning it to its original direction or to a new direction, the director generates a new gun elevation order angle which again is corrected for sight angle by the control means 12 and applied to the mirror. In other words, the director elevation operator or sight pointer changes director correction angle indirectly by changing gun elevation order angle.

This operation is repeated until the sight pointer feels that the target is brought onto his sight cross-hairs at the proper point in the roll of the ship for fire.

This method of control in elevation possesses the advantage that the line of sight is weaved up and down rather than the guns themselves, as the correction for trunnion tilt is continually changed to compensate for roll and pitch of the ship.

The gun pointer adjusts the gun in elevation in accordance with the amount and direction of the displacement of the dials 90 and 91 which indicate gun elevation order.

In doing so, the movement of the gun returns these dials to their zero positions and at the same time operates the dials 92 and 93 to indicate the angle of elevation through which the gun is adjusted.

It will be understood, of course, that at some suitable time the handwheel 155 will have been adjusted to introduce the proper correction for vertical parallax between the director and gun trunnions.

An important feature of my invention is the provision of suitable means whereby the corrections heretofore described as introduced by the auxiliary correction control means 12 may be applied directly at the sighting device 11.

In this type of control, the auxiliary correction control means 12 in the plotting room is not used and there is no provision made for trunnion tilt correction. The entire control of the gun is effected at the director. Sight angle, i. e. correction for range, and deflection are introduced into the director as well as corrections for horizontal and vertical parallax. The director issues directly gun elevation order angle and gun train order angle. The mirror 32 is controlled directly by means of the handwheel 40 and not through the auxiliary control means 12.

The controlling action of the control means 12 on the operation of the mirror 32 is eliminated by cutting out the mirror operating reproducers 35 and 36 electrically from the system.

These members are cut out of the system and the mirror 32 is connected with the handwheel 40 by the operation of a single control member 310. This control member, as shown, (Fig. 4), is mechanically connected with a shaft 311 by means of gears 312 and 313 and through these gears and a gear 314 with a multiple switch 315. This switch, as shown (Fig. 1), is provided with a pair of contacts 315*a* and 315*b* which control the connections between the supply source 66 and the coils 60 and 61 that control the magnetic connection between the reproducer 36 and the shaft 41, and with two sets of contacts 315*c* and 315*d* that control the sets of conductors 38*a* and 37*a*. While each of these latter sets is indicated as a single contact, it will be understood that it will include a plurality of contacts, one for each conductor of the sets 38*a* and 37*a*.

The shaft 311 is connected with a shaft 316 through gears 317 and 318. This shaft operates a clutch interposed in the driving mechanism between the handwheel 40 and the mirror 32.

The driving connection between the handwheel and the mirror comprises the handwheel shaft 73 and a shaft 319. These shafts are mechanically connected through suitable gearing and a differential device 320. As shown, the shaft 73 is connected with a spur gear 321 through a gear 322 attached to the shaft and an idler gear 323. The gear 321 is connected to rotate with a bevel gear 324 of the differential 320. The gearing between the shaft 73 and the gear 324 preferably will be such as to introduce a 3:1 speed ratio between these members. The gear 325 of the differential 320 is connected with a handwheel 326 through gears 327, 328 and 329 and a shaft 329*a* arranged to introduce a 1:3 speed ratio between these members. The function of this handwheel will be described in greater detail hereinafter. The planetary gears 330 and 331 of the differential are secured to the differential output shaft 332 which rotates within and separately from the gears 321 and 324. This shaft 332 is connected through gearing 333 and 334 with a shaft 335 which in turn is connected through bevel gears 336 with the shaft 319. The speed ratio interposed between the shafts 332 and 319 preferably will be 6:1.

The shaft 319 has a driving connection with a driving member of the clutch referred to above, while the driven member of this clutch is connected with the shaft 41.

The clutch, as shown (Figs. 1 and 4), comprises a driving member 337 and a driven member 338. The driving member comprises a sleeve 339 slidably mounted for reciprocatory motion on the shaft 41. The sleeve 339, as shown, is mechanically connected with the shaft 319 by bevel gears 340, which introduce a 4:1 speed ratio between the shaft and the sleeve. The sleeve carries a pair of driving pins 341 projecting from the sleeve parallel with the shaft 41 toward the driven member 338. The pins, as shown, are arranged on opposite sides of the shaft 41 substantially 180° apart.

The driven member comprises a plate 342 keyed or otherwise secured to rotate with the shaft 41 and a second plate 343 arranged to have limited relative movement to and from the plate 342 and secured to rotate with it by means of dowel pins 344. A spring 345 positioned between these plates tends to separate them. The plate 343 is provided with a pair of apertures 346 positioned so that they may receive the pins 341 to effect a driving connection between the driving and driven members of the clutch.

It will be observed that this connection may be effected by moving the sleeve 339 toward the cooperating plate 343. It can be effected, however, in only one relative angular position between the members 339 and 343. If these members occupy any other relative angular position, the pins cannot fall within their apertures 346.

If when the plates occupy any of these other relative positions, the sleeve 339 be moved toward the plate 343, the pins 341 will engage the face of the plate 343, and can only be caused to enter their apertures by imparting rotary motion to the sleeve 339 by its driving shaft 319 so as to bring the pins and apertures into alignment. Suitable means are provided for preventing rotation of the plate 343 and its connected clutch member 342 when the sleeve 339 is thus rotated. As

shown, the plate 343 is provided with a knurled edge 347 arranged at an angle to the vertical axis of the plate and with which a member 348 is arranged to engage. This member, as shown, is provided with a knurled edge 350 arranged at an angle to engage the edge 347 to lock the plate 343 against rotation when it is moved a predetermined distance toward the member 342 by the pins after they have engaged the face of the plate. This allows the sleeve 339 to be rotated until the pins are aligned with their apertures 346 without it imparting any rotary motion to the plate 343. When these members are aligned, the pins will be received within their apertures, whereupon the plate 343 will be moved away from the stop plate 348 to disengage the stop plate by means of the spring 345.

The clutch driving member 339 is moved into engagement with the driven member 342 by the operation of the operating member 310 through the shafts 311 and 316. As shown, the latter shaft is mechanically connected with the clutch member 339 by means of a link 350 which is connected at its lower end to a crank 351 rotated by the shaft 316 and at its upper end to one arm of a substantially right angle bell crank 352 pivoted to a fixed shaft 353. The other arm of this crank, as shown, is connected to the member 339 by means of a second bell crank 354 also arranged to rotate on the fixed shaft 353. One arm 355 of this crank, the lower, as shown in Fig. 4, is provided with a fork that is received in a recess provided for it in the sleeve 339. The other arm 357 of the crank, as shown, projects vertically upwardly and is arranged substantially opposite an ear or projection 360 provided on the bell crank 352, as clearly shown in Fig. 4. Interposed between the members 357 and 360 is a spring 361.

It will be observed that when the shaft 316 is rotated in a clockwise direction by a similar rotary motion imparted to the handle 310, the bell crank 352 likewise will be rotated in a clockwise direction. This motion compresses the spring 361 and hence, exerts a force on the member 357 of the bell crank 354 tending to move the driving clutch member 339 into engagement with the driven clutch member. If when the handwheel 310 is thus operated the pins 341 in the driving member are aligned with their apertures 346 in the driven member, the clutch will engage and as a result the mirror 32 will be directly connected with its operating handwheel 40. If, however, the pins are not aligned with their apertures, the plate 343 will be moved to engage its stop member 348 so that the plate 343 will be secured against rotation while the member 339 is turned by the handwheel 40 to align the pins with their apertures, whereupon the clutch member 339 will be moved by the spring 361 to engage the clutch.

It will be observed, therefore, that on deciding to effect complete control of the guns from the sighting device, the handle 310 will be turned in a clockwise direction. This operation of the handle operates the switch 315 to disconnect the reproducers 35 and 36 and to operate the clutch to effect a driving connection between the handwheel 40 and the mirror 32.

Sight angle or correction for range is introduced into the driving connection between the handwheel 40 and the mirror 32. This correction is introduced by the handwheel 326. This wheel operates through the differential 320 by imparting a rotary motion to the bevel gear 325 which modifies the angle through which the shaft 332 is rotated by the differential gear 320 in response to the operation of the handwheel 40.

The correction for vertical parallax which is a function of range is also introduced by the handwheel 326 through the differential device 320 at the same time that the sight angle correction is introduced. It will be understood that the handwheel 326 will be turned an amount proportional to the values of the corrections to be introduced. A suitably calibrated parallax-range scale 364 is provided whereby the handwheel 326 can be accurately adjusted. It will be understood that this scale will be properly graduated to take into account vertical parallax correction as well as range. The scale 364, as shown, is arranged upon a pair of supporting drums 365 and 366. These drums are driven together in the same direction of rotation by the shaft 367 through gearing 368, 370, 371 and 372. The shaft 367 is connected in a 1:1 speed ratio with the shaft 329*a* of the handwheel 326 by bevel gears 373. A suitable stop member 374 is threaded on the shaft 367 to travel thereon when the shaft is turned. This member cooperates with suitable stops 375 and 376 which limit the motion of the handwheel in both directions.

It will be understood in view of the foregoing that gun elevation order angle is introduced into the differential device 320 by means of the handwheel 40. This angle is corrected for sight angle and vertical parallax by means of the handwheel 326. It will also be understood that the differential device serves to subtract algebraically the value of sight angle from gun elevation order angle and to issue the resultant, namely, director correction angle. This resultant is transmitted through the shaft 319 to the mirror 32.

Suitable low and high speed director correction scales 377 and 377*a* are operably associated with the output shaft 332 of the differential 320. As shown, the dial 377 is mounted on a shaft 378 which is connected with the shaft 332 by means of gearing 378*a* and 378*b* introducing a 1:6 speed ratio between these members, that is, a 6:1 speed ratio between the output shaft 332 and the dial 377 which it drives. The dial 377*a* is driven by a shaft 379 which is connected with the shaft 332 by means of gearing 379*a*, 379*b* and 379*c*. This gearing introduces a 1:3 speed ratio between the shaft 332 and the dial 377*a* which it drives.

The clutch mechanism between the handwheel 40 and the mirror 32 is so arranged that if the director has been in control using the auxiliary control means 12 to introduce corrections, and giving out a certain gun elevation order angle and receiving from the control means 12 a corresponding director correction angle based on a certain sight angle, and further, if the range corresponding to that sight angle be set on the handwheel 326, the clutch pins will enter their apertures and the shift to complete local control at the sighting device can be effected without disturbing either gun elevation order angle or director correction angle. When shifting, the fact that the clutch pins have entered their apertures may be announced by means of a suitable visual signal or tell-tale device, such as a flag 380. This flag is mounted upon a shaft 380*a* which is mechanically connected with the shaft 316. As shown, the shaft 380*a* is provided with a crank arm 381 which is connected with a similar crank arm 381*a* connected with the bell-crank 354 of the clutch operating mechanism by

means of a link 382. The flag is arranged to move behind a screen 383 in which a window 384 is provided, and on the flag the words "Engaged" and "Not engaged" are lettered in such positions as to appear at the window in certain positions of the flag. Thus, when the clutch members are engaged the tell-tale device 380 will be moved to such a position that the word "Engaged" will appear behind the window, whereas when the clutch members are not engaged the tell-tale device will be in such a position that the words "Not engaged" will appear at the window.

At times, a relatively small discrepancy may exist between sight angle set by the auxiliary control means 12 when it is in control and the sight angle required for the same range for complete control at the sighting device due to the fact that the former is compensated for tilt of the gun trunnions, whereas the latter is not. A similar discrepancy may exist by reason of improper setting of the handwheel 326, or because the mirror 32 has been moved in some manner, as for example, by the director correction transmitters 37 and 38 of the auxiliary control means 12 which may have been out of control a second or so before the shift was effected. Such discrepancies will prevent engagement of the clutch immediately upon operation of the member 310. This fact will be known by the failure of the clutch-engaged flag to appear at the window 384. In this case the director pointer must feel out the point at which the clutch will engage by running the gun elevation order angle up or down by the handwheel 40 until the clutch does engage and the clutch-engaged flag appears, whereupon he may reset the gun elevation order angle to the value it had, or to any new setting that will give a satisfactory director correction angle.

Suitable interlocking means are provided to prevent the handle 310 from being thrown to effect complete local control at the director in the event the range set on the range scale 364, together with the gun elevation order angle set on the handwheel 40, is such as to yield an impossible director correction angle, i. e. out of bounds of the limits of motion of the mirror 32, which as previously pointed out, are 15° on each side of its neutral position. This interlocking means comprises a cam-like member 385 with which a latch 386 cooperates. This latch is secured to a shaft 387 which is mechanically connected with the shaft 316 through a crank arm 388 secured to the shaft 387, a crank arm 389 secured to the shaft 316 and a link 390 connecting the two crank arms. It will be observed that this mechanical connection between the shafts 316 and 319 is so arranged that when the shaft 319 is in a position such that if the latch 386 engages any portion of the cam 385, it will be impossible to turn the handle 310 to engage the clutch to connect the handwheel 40 with the mirror. In other words, when the shaft 319 is in any position beyond limits determined by the effective length of the member 385, it will be impossible to effect a driving connection between the handwheel 40 and the mirror.

Signal means are provided to indicate such a condition to the sight pointer. This means comprises two flags 400 and 401 which read respectively "Too low" and "Too high". These flags are mounted upon shafts 402 and 403 respectively and are arranged to move from positions shown in Fig. 4 to positions over and partially covering the director correction scales 377 and 377*a*.

The shafts 402 and 403 are operated by cams 404 and 405 mounted on the shaft 378 and arranged to engage followers 406 and 407 secured to the shafts 402 and 403. These cams are arranged so that when the director correction angle is too high, the flag 401 will be moved to partially cover the dials 377 and 377*a*, whereas when the director correction angle is too low the flag 400 will be moved to partially cover the dials 377 and 377*a*.

These flags instruct the pointer to reduce or increase the gun elevation order angle until a possible combination of gun elevation order angle and sight angle is reached, whereupon the flag will disappear. The pointer can then operate the clutch handle 310.

An impossible combination of gun elevation order angle and range setting may have arisen from failure to set gun elevation order properly or from failure to set the proper sight angle. If it is from the latter cause, the pointer, instead of attempting to remedy the difficulty by changing the gun elevation order angle, will prefer to instruct the sight setter to set the correct range. After correcting the improper setting and operating the clutch handle, it may still be necessary for the pointer to run his gun elevation order angle up or down and feel out the point where the clutch pins will engage and the "Clutch-engaged" flag will appear.

It is to be noted that the handwheel shaft 73 is provided with suitable stop means for limiting the movement of the handwheel 40 in both directions. For this purpose, a Geneva stop 409 has been provided.

In complete control at the director, deflection correction is introduced into the director, and the transmitters 180 and 181 generate and transmit gun train order angle rather than target bearing. Deflection correction is introduced into the driving connection between the gear 175 and the transmitters 180 and 181 by means of a handwheel 410. This handwheel is mechanically connected to operate the shaft 205 of the differential 200, referred to in a previous portion of this specification.

As shown, the hand wheel 410 is connected to rotate a shaft 411 which is connected with a shaft 412 by means of a worm 413 secured to the shaft 411 and a cooperating worm wheel 414 secured to the shaft 412. The shaft 412 in turn is connected with another shaft 415 by bevel gears 416, and the shaft 415 in turn is connected through bevel gears 417 with a shaft 418. This shaft 418 is connected mechanically with a shaft 420 through spur gears 421, while the shaft 420 is mechanically connected with the shaft 205 of the differential 200 by means of bevel gears 421. Mounted on the shaft 412 is a suitable scale 422 to assist in setting the deflection correction.

It will be observed, in view of the foregoing arrangement, that when the handwheel 410 is rotated, the shaft 205, and hence, the planetary gears 203 and 204 of the differential 200 will be moved so as to introduce the correction directly into the motion imparted to the transmitters 180 and 181 by the gear 175, whereby these transmitters issue gun train order angle, i. e., target bearing properly compensated for deflection, rather than target bearing, as is the case when the auxiliary control 12 is being used. It will be observed, however, that this correction is not introduced into the drive for the indicators 215 and 216, and that these members indicate target bearing.

Suitable stop means 422*a*, shown as a Geneva stop, is provided to limit the movement of the handwheel 410 in both directions.

Suitable interlocking means are provided for preventing the motion of the handwheel 410 to effect a deflection correction when the auxiliary control means 12 are being used, and when the director is in complete control to prevent the operation of the control member 310 to throw the system into control using the auxiliary means 12 if any deflection is set by the handwheel 410, thereby insuring that the target bearing transmitters 180 and 181 will issue target bearing when the auxiliary means 12 is in control, rather than target bearing compensated for the deflection set by the handwheel 410.

This interlocking means comprises a locking cam or member 423, the position of which is controlled by a shaft 424, which in turn is controlled by the operation of the handwheel 410. For this purpose, the shaft 424 is mechanically connected with the shaft 411 by means of a worm gear 425 secured to the shaft 424 and meshing with a worm 426 secured to the shaft 411. Cooperating with the locking member 423 is a bell crank 427 pivotally mounted on fixed pivots 428. As shown, one arm of this bell crank lever is mechanically connected with the shaft 316 and hence, with the operating member 310, by means of a link 430 that is mechanically connected at one end to the bell crank and at its other to a crank arm 431 secured to the shaft 316. The other arm of this bell crank 427 cooperates with the lock 423 which is provided with a recess 432 arranged to receive this arm in one position of the member 423, whereby freedom of motion of the bell crank and of the connected shaft 316 and handle 310 is permitted, but movement of the wheel 410 is prevented. In any other position of the cam 423 the bell crank 427 will be locked so that the operating member 310 cannot be operated, but the wheel 410 is free to be turned.

The locking mechanism is shown in its operative condition when the auxiliary correction means 12 is in control. It will be observed that when in this condition, the operating member 310 may be operated to disconnect the correction means 12, but that the member 423 and hence, the handwheel 410, are locked against rotation so that it is impossible to set any deflection on the scale 422, that is, it is impossible to introduce any deflection correction into the system by operation of the wheel 410.

However, when the member 310 is operated to disconnect the auxiliary correction means 12, the bell crank 427 will be operated to disengage the locking disc 423 so as to free or release the deflection handwheel 410. Hence, when the director 11 has complete local control the handwheel 410 may be operated to introduce a deflection correction. However, it will be observed that when the handwheel 410 is rotated so as to introduce a deflection correction, the disc 423 will be moved to carry the slot 432 out of the path of movement of the bell crank 427. Hence, as long as there is any deflection set when the director alone is in control, it will be impossible to throw the member 310 to connect the auxiliary means 12 into the system because any such attempt will be thwarted by the bell crank engaging the disc 423.

In the operation of the system, assuming that the director is in control, using the auxiliary means 12 to introduce corrections, and that it is decided to go into complete local control at the director, the handle 310 will be operated to throw the switch 315 to its open position to disconnect the reproducing devices 35 and 36 in the director and at the same time to operate the clutch 337 to its engaging position. If when the auxiliary control means 12 was in control, the director gave out a certain gun elevation order angle and received from the control means 12 a corresponding director correction angle based upon a certain sight angle, and further, if the range corresponding to this sight angle be set by the handwheel 326 before the member 310 is operated, the clutch pins 341 will enter their apertures 346, whereby the shift in control can be effected instantly without disturbing either the gun elevation order angle or director correction angle. The fact that the clutch has been engaged will be announced by the flag 380 which will indicate "clutch engaged".

As pointed out previously, if a small discrepancy should exist between the sight angle used by the correction means 12 and the sight angle required for the same range when the director alone is in control due to the fact that one is compensated for trunnion tilt while the other is not, or if a discrepancy exists by reason of improper setting of the range on the director, or for some other reason, this discrepancy will prevent the engagement of the clutch, which fact will be made known by the failure of the "clutch engaged" flag to appear in place of the "clutch not engaged" flag which will remain in its indicating position. In this case the director pointer will operate the handwheel 40 to feel out the point at which the clutch will engage by running the gun elevation order angle up or down, whereupon the "clutch engaged" flag will appear. Then he may reset the gun elevation order angle to the value that it had, or he may set it to a new value that gives him a satisfactory director correction, and then proceed with the battle action.

As pointed out previously, if the range set on the range scale 364, together with the gun elevation order angle set by the handwheel 40, is such as to yield an impossible director correction angle, the locking mechanism 385, 386 will not permit the handle 310 to be thrown to disconnect the auxiliary means 12, which condition will be explained by the flags 400, 401 reading "Too low" or "Too high", which will appear directly over the director correction scales 377 and 377*a*. This indication informs the sight pointer that he must either reduce or increase the gun elevation order angle until a possible combination is reached, whereupon the indicating flags 400, 401 will disappear. Then he may operate the handle 310 to throw the system into complete control at the director.

Also when it is decided to go into this control, the switches 263, 266*a*, 271 and 275 will be thrown from their right-hand controlling position, as viewed in Fig. 1, to their left-hand controlling positions, so as to disconnect the devices 261 and 265 in the auxiliary control means 12 and to electrically connect the transmitters 180 and 181 directly with the reproducing devices 268 and 273 respectively located in the gun trainer station. If desired, these switches may be provided with an interlock whereby they are operated simultaneously between their controlling positions.

After the handle 310 has been operated to disconnect the auxiliary control means 12 and to throw the system into complete local control at the director, the handwheel 410 may be oper-

ated to introduce proper deflection correction to the driving mechanism between the gear 175 and the transmitters 180 and 181. By reason of this, when the director is in complete control and the proper deflection is set, the transmitters 180 and 181 will transmit gun train order angle directly to the guns.

It will be observed that when the director is in complete control, the director pointer controls the gun elevation order angle in the same fashion that he does when the auxiliary correction means 12 is used, but that any change that he makes in gun elevation order angle is communicated directly to the mirror 32 so that the gun elevation order angle and director correction angle change together as a rigid system except as their relation is fixed or changed by the introduction of sight angle or vertical parallax by the operation of the handwheel 326.

When in complete local control at the director, the gun elevation order angle transmitted by the transmitters 70 and 71 is reproduced in the gun pointer station by the receivers 80 and 81, the indicating mechanism in this station functioning in identically the same fashion as it does when the auxiliary correction means 12 is in control.

Gun trail order angle, as previously pointed out, is issued by the transmitters 180 and 181. This order is reproduced in the gun trainer station by means of the reproducer 273 and the differential device 268. The indicating mechanism in the gun trainer station operates in identically the same manner as it does when the auxiliary means 12 is in control.

On deciding to reconnect the auxiliary correction means 12 to the system, it is merely necessary to set the deflection scale 422 to its zero position, operate the switches 263, 266*a*, 271, and 275 to their right-hand controlling positions, and properly operate the handle 310 to disengage the clutch between the handwheel 40 and the mirror 32, and to close the switch 315 to reconnect the reproducers 35 and 36 to the auxiliary means 12.

It will be observed in view of the foregoing description that my system is quite flexible in its control. It may be used so as to control the gun 10 by means of the director 11 assisted by the auxiliary correction means 12, or it may be used to effect direct and complete control of the gun from the director, with no assistance whatsoever from the auxiliary control means. Moreover, it will be observed that my system includes a simple and reliable means controlling the system whereby it can be quickly and easily shifted from one system of control to the other.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made, and I, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. A system of gun fire control comprising a sighting device, means for directing said sighting device on a target, means remote from said sighting device arranged to modify the motion imparted to said sighting device by said directing means for applying corrections to the movement thereof so as to determine adjustments to be applied to a gun and means adjacent said sighting device for modifying the motion imparted to said sighting device by said directing means so as to apply similar corrections to said movement of said sighting device.

2. A system of gun fire control comprising a sighting device, directing means for moving said sighting device to direct it on a target, means located locally at said sighting device arranged to modify the motion imparted to said sighting device by said directing means for applying corrections to the movement of said sighting device so as to generate adjustments to be applied to a gun, auxiliary correction means remote from said sighting device arranged to modify the motion imparted to said sighting device by said directing means so as to apply similar corrections to the movement of said sighting device and control means arranged to selectively render said local and said remote correction means effective.

3. A system of gun fire control comprising a gun, a sighting device remote from said gun, directing means for moving said sighting device to keep it on a target, and separate means adjacent said sighting device and remote both from said sighting device and said gun arranged to modify the motion imparted to said sighting device by said directing means so as to apply corrections to the movement of said sighting device to determine adjustments to be applied to said gun.

4. A system of gun fire control comprising a gun, a sighting device remote from said gun, directing means for moving said sighting device to keep it on a target, means in a remote station responsive to the movement of said sighting device arranged to modify the motion imparted to said sighting device by said directing means for applying corrections to said movement so as to generate adjustments to be applied to said gun, and means adjacent said sighting device arranged to modify the motion imparted to said sighting device by said directing means for applying similar corrections so as to generate the adjustments to be applied to said gun.

5. A system of gun fire control comprising a sighting device, gun directing means adjacent said sighting device, means remote from said sighting device and responsive to said gun directing means controlling said sighting device and means for rendering said remote controlling means ineffective and said gun directing means effective to control said sighting device directly.

6. A system of gun fire control comprising a sighting device, a gun directing member, control means remote from said sighting device responsive to said gun directing member for applying a movement thereof to said sighting device and means adjacent said sighting device for rendering said remote control means ineffective and for applying a movement of said gun directing member directly to said sighting device.

7. A gun fire control system comprising a sighting device, gun directing means adjacent said sighting device, and separate means remote from and adjacent said sighting device selectively responsive to said gun directing means for applying the movement thereof to said sighting device and arranged to modify the motion imparted to said sighting device by said gun directing means.

8. In a system of gun fire control, a sighting device, gun directing means adjacent said sighting device, means adjacent said sighting device and responsive to said gun directing means for applying movement thereof to said sighting device, means remote from said sighting device and responsive to said gun directing means for applying movement thereof to said sighting device

and means for selectively rendering said control means effective.

9. A system of gun fire control comprising a sighting device, gun directing means adjacent said sighting device, means remote from said sighting device and responsive to said gun directing means controlling said sighting device and means adjacent said sighting device arranged to control said sighting device responsively to said gun directing means.

10. A system of gun fire control comprising a sighting device, a control member, control means for said sighting device remote therefrom and responsive to the operation of said control member and control means for said sighting device adjacent said sighting device and responsive to the operation of said control member.

11. In a gun fire control system, a sighting device, gun directing means, control means remote from said sighting device responsive to movements generated by said gun directing means controlling said sighting device and for adjusting said sighting device to introduce a correction, second control means adjacent said sighting device responsive to the movements of said gun directing means controlling said sighting device and for adjusting said sighting device to introduce a similar correction, control means arranged to selectively render said sighting device control means effective and means controlling said selective control means in accordance with the movements of said gun directing member and with the operation of said second sighting device control means to introduce its correction.

12. A gun fire control system comprising a sighting device, a gun directing member, control means remote from said sighting device operably associated therewith and with said gun directing member for applying a movement of said member to said sighting device, control means adjacent said sighting device operably associated therewith and with said gun directing member for applying a movement of said member to said sighting device, means adjacent said sighting device operably associated therewith arranged to introduce a correction in the movement of said gun directing member applied to said sighting device, means selectively controlling said remote and adjacent control means to render them effective and means dependent upon the movement of said gun directing member and the operation of said correction means controlling said selective control means.

13. In a system of gun fire control, a sighting device, gun directing means, control means remote from said sighting device and operably associated therewith and with said gun directing means for applying movements of said gun directing means to said sighting device and for adjusting said sighting device to introduce a correction, a second control means adjacent said sighting device and operably associated therewith and with said gun directing means for applying movement of said gun directing means to said sighting device and for adjusting said sighting device so as to introduce a correction and means operably associated with both of said control means for selectively rendering them effective to control said sighting device.

14. A system of gun fire control comprising a sighting device, means for moving said sighting device to direct it on a target, means located locally at said sighting device arranged to apply corrections to the movement of said sighting device so as to generate adjustments to be applied to a gun, auxiliary correction means remote from said sighting device arranged to apply similar corrections to the movement of said sighting device, and control means including a single manually operable control member arranged to render said local correction means ineffective and said auxiliary control means effective.

15. In a gun fire control system, a sighting device, a gun directing member adjacent said sighting device, control means remote from said sighting device arranged to apply a movement of said gun directing member to said sighting device, second control means adjacent said sighting device arranged to apply a movement of said gun directing member to said sighting device and means including a single manually operable control member selectively controlling said control means to render them effective.

16. In a system of gun fire control, a sighting device, a gun directing member adjacent said sighting device, motion transmitting means remotely situated with respect to said sighting device and responsive to the movements of said gun directing member, means adjacent said sighting device for reproducing the movements of said transmitting means and for applying them to said sighting device, means adjacent said sighting device arranged to effect a driving connection between said sighting device and said gun directing member and means for simultaneously disconnecting said motion reproducing means and for establishing said driving connection.

17. In a system of gun fire control, a sighting device, a gun directing member adjacent said sighting device, motion transmitting means remotely situated with respect to said sighting device and responsive to the motion of said gun directing member, motion reproducing means adjacent said sighting device electrically responsive to said motion transmitting means and arranged to apply the reproduced motion to said sighting device, a switch arranged to disconnect said motion reproducing means, means adjacent said sighting device including a clutch arranged to mechanically connect said sighting device with said gun directing member and a common operating member for said switch and said clutch.

18. In a system of gun fire control, a sighting device, a gun directing member adjacent said sighting device, motion transmitting means responsive to the movement of said member, motion reproducing means in a station remote with respect to said sighting device responsive to said motion transmitting means so as to reproduce the movement of said gun directing member, motion transmitting means responsive to said reproducing means so as to transmit the movement of said reproducing means, a second motion reproducing means adjacent said sighting device electrically responsive to said motion transmitting means and arranged to apply the reproduced movements to said sighting device, a switch controlling the connections between said second mentioned motion reproducing means, a driving connection between said sighting device and said gun directing member including a clutch and a common control member for said clutch and said switch.

19. In a system of gun fire control, a sighting device, a gun directing member adjacent said sighting device, motion transmitting means responsive to the movement of said member, motion reproducing means in a station remote with respect to said sighting device responsive to said motion transmitting means so as to reproduce the movement of said gun directing member, motion

transmitting means responsive to said reproducing means so as to transmit movement of said reproducing means, means in said remote station for correcting the movement received by said reproducing means and generated by said transmitting means, second motion reproducing means adjacent said sighting device responsive to said remote transmitting means and arranged to apply the reproduced movements to said sighting device, a switch controlling the connections between said second mentioned motion transmitting and reproducing means, a mechanical driving connection between said sighting device and said gun directing members including a clutch, means for introducing corrections in the movement generated by said gun directing member and applied to said sighting device, a common control member for said clutch and said switch arranged by operation thereof to open said switch and engage said clutch and means operably associated with said control member and said means for introducing corrections in the movement generated by said gun directing member preventing the operation of said control member except when corrections having magnitudes falling within a predetermined range are applied.

20. A system of gun fire control comprising in combination with a gun, a sighting device remote therefrom, a gun directing means adjacent said sighting device for determining the adjustment to be applied to said gun in a predetermined plane, an indicator adjacent the gun responsive to the movements of said gun directing means arranged to show the adjustment to be applied to said gun, means in a station remote with respect to said gun and said sighting device responsive to the movement of said gun directing means controlling said sighting device and means adjacent said sighting device for rendering said control means ineffective and for applying the movement of said gun directing means directly to said sighting device.

21. A system of gun fire control comprising in combination with a gun, a sighting device remote therefrom, a gun directing member adjacent said sighting device for generating an adjustment for said gun in a predetermined plane, means in a station remote from said sighting device and said gun responsive to said gun directing member arranged to apply a movement thereof to said sighting device, indicating means adjacent said gun responsive to said gun directing member arranged to reproduce and show said adjustment, means adjacent said sighting device adapted to transmit a movement of said gun directing member and apply it to said sighting device and means for rendering said last mentioned means effective and for disconnecting said sighting device from said remote station.

22. A system of gun fire control comprising a gun, a sighting device remote therefrom, a gun directing member adjacent said sighting device, means for reproducing the movement of said gun directing member in a remote control station, motion transmitting means in said control station, operating means for correcting and applying the reproduced movement of said gun directing member to said motion transmitting means, motion reproducing means adjacent said sighting device connected to said transmitting means, a driving connection between said last mentioned reproducing means and said sighting device whereby said sighting device is adjusted in accordance with the movement of said motion transmitting means, means adjacent said sighting device for establishing a driving connection between said sighting device and said gun directing member, means controlling said last means to establish said driving connection and for disconnecting said sighting device from said remote control station, means adjacent said gun for reproducing the movement of said gun directing member and an indicating device responsive to said reproducing means to show the adjustments to be given said gun.

23. A system of gun fire control comprising a sighting device, a control member, control means for said sighting device remote therefrom and responsive to the operation of said control member, control means for said sighting device adjacent said sighting device and responsive to the operation of said control member and means preventing simultaneous operation of said control means.

24. In a system of gun fire control, a sighting device, gun directing means, control means for said sighting device remote therefrom and responsive to said gun directing means, control means for said sighting device adjacent said sighting device and responsive to said gun directing means and means for selectively rendering said control means effective to control said sighting device and for preventing simultaneous operation of said control means.

25. In a system of gun fire control, a sighting device, gun directing means adjacent said sighting device, control means in a station remote from said sighting device responsive to said gun directing means for applying a movement of said gun directing means to said sighting device, control means adjacent said sighting device responsive to said gun directing means for applying a movement of said gun directing means to said sighting device, means operably associated with said latter means for adjusting said sighting device to introduce a correction, means for selectively rendering said control means effective to apply the movement of said gun directing means to said sighting device and means preventing the operation of said selective control means to render said adjacent control means effective when corrections falling within a predetermined range are introduced by said sighting device adjusting means.

26. In combination, a sighting device, a plurality of control members for said sighting device, a driving connection between said members and said sighting device so that movements of said members are applied to said sighting device, a clutch in said driving connection, operating means for said clutch and means controlling said operating means in accordance with the positions of said control members.

27. In combination, a sighting device, gun directing means, a driving connection between said gun directing means and said sighting device including means for introducing a correction in the motion imparted to said sighting device by said gun directing means, a coupling between said gun directing means and said sighting device and means responsive to said gun directing means and said means for introducing a correction controlling said coupling.

28. Ordnance control comprising a sighting device, directing means, a driving connection between said directing means and said sighting device including a driving shaft and a clutch in said shaft and means for operating said clutch between its engaged and disengaged positions.

29. In combination, a sighting device, a mem-

ber for operating said sighting device, a driving connection between said member and said sighting device including a driving shaft, a coupling in said driving shaft, means for operating said coupling to connect and disconnect said operating member and signal means for indicating the controlling operation of said coupling.

30. In combination, a sighting device, a gun directing member, a driving connection between said gun directing member and said sighting device, a clutch for said driving connection, an operating member for said clutch to operate it between its engaged and disengaged positions, means for introducing a correction in the driving connection between said gun directing member and said sighting device and means controlling said clutch operating member in accordance with the corrected movement applied to said sighting device.

31. In combination, a sighting device, a control member for said sighting device, a shaft, an operable connection between said shaft and said sighting device including a clutch, an operable connection between said shaft and said control member including a differential device, means for operating said differential device to modify the motion of said control member as applied to said shaft and means dependent upon the position of said shaft controlling said clutch.

32. In combination, a sighting device, a control member for said sighting device, a shaft, means including a clutch operably connecting said shaft to said sighting device, means including a differential device operably connecting said control member with said shaft, means controlling the operation of said differential device, means including a second control member controlling said clutch, and means responsive to the position of said shaft controlling the actuation of said second control means to prevent the engagement of said clutch when said shaft is in predetermined positions.

33. In combination, a sighting device, a control member for said sighting device, a shaft, means including a clutch operably connecting said shaft with said sighting device, a differential device, means connecting said control member with one side of said differental device, a control member for the other side of said differential device means connecting the output of said differential device with said shaft, means including a second control member controlling said clutch, means responsive to the position of said shaft controlling the actuation of said second control member to prevent the engagement of said clutch when said shaft is in predetermined positions and means responsive to the position of the output of said differential for indicating the positions of said shaft.

34. In ordnance control, a sighting device, a shaft connected to operate said sighting device, a second shaft, a clutch connecting said shafts, a third shaft, a fourth shaft, a control member for said fourth shaft, a differential device, means connecting said fourth shaft with one side of said differential, a control member for the other side of said differential, means connecting the output of said differential with said third shaft, a control member operably connected to actuate said clutch, an operable connection between said control member and said third shaft arranged so that when said shaft is in any position within a predetermined range the operation of said member to engage said clutch is prevented and means responsive to the position of said third shaft for indicating the limits of said range of position.

35. A system of gun fire control comprising in combination with a gun, a sighting device, means for directing said sighting device on a target, indicating means adjacent said gun responsive to the movement of said sighting device directly, means at said sighting device for applying a correction to the movement of said sighting device and auxiliary correction means remote from said sighting device for applying a similar correction to the movement of said sighting device and for applying said corrected movement to said indicating means.

36. A system of gun fire control comprising in combination with a gun, gun directing means remote from said gun, indicating means adjacent said gun, means remote from said gun directing means and said gun responsive to said gun directing means and operably associated with said indicating means and means for controlling said indicating means and means for rendering said remote controlling means ineffective and said gun directing means effective to control said indicating means directly.

37. A system of gun fire control comprising in combination with a gun, gun directing means remote from said gun, indicating means adjacent said gun, means responsive to said gun directing means and operably associated with said indicating means controlling said indicating means in accordance with the movement of said gun directing means and for introducing a correction to the movement applied to said indicating means and means for rendering said means for controlling said indicating means ineffective and for effecting direct control of said indicating means by said gun directing means.

38. A system of gun fire control comprising in combination with a gun, gun directing means remote from said gun, indicating means adjacent said gun, means remote from said gun directing means and said gun responsive to said gun directing means and operably associated with said indicating means for controlling said indicating means, means for controlling said remote control means for introducing a correction in the movement applied to said indicating means, control means for rendering said remote control means ineffective and for effecting direct control of said indicating means by said gun directing means and means controlling said gun directing means for introducing a correction.

39. A system of gun fire control comprising in combination with a gun, gun directing means remote from said gun, indicating means adjacent said gun, means remote from said gun directing means and said gun responsive to said gun directing means and operably associated with said indicating means for controlling said indicating means, means for controlling said remote control means for introducing a correction in the movement applied to said indicating means, control means for rendering said remote control means ineffective and for effecting direct control of said indicating means by said gun directing means, means controlling said gun directing means for introducing a correction and means preventing the operation of said latter means to introduce a correction when said remote control means is effective.

40. A system of gun fire control comprising in combination with a gun, gun directing means remote from said gun for determining a movement to be applied to said gun in a predeter-

mined plane, means adjacent said gun directing means for introducing a correction in the movement generated by said gun directing means to be applied to said gun in said predetermined plane, an indicator adjacent said gun for showing the movement to be applied to said gun in said predetermined plane, means for rendering said indicator responsive to said gun directing means so that said corrected movement is applied to said indicator, means for rendering said correction introducing means ineffective, means remote from said gun directing means and said gun responsive to said gun directing means for applying the movement thereof to said indicator and means controlling said remote control means to introduce a correction in the movement generated by said gun directing means and applied to said indicator.

41. A system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, means for directing said sighting device on a target, means responsive to the operation of said directing means for generating the bearing of said target, an indicator adjacent said gun arranged to show the adjustment to be applied to said gun in train, means remote from said sighting device responsive to said bearing generating means arranged to control said indicator and to introduce a correction in the movement applied to said indicator, means for rendering said last mentioned means ineffective and operably associating said bearing generating means with said indicator whereby the latter is caused to respond directly to said generating means and means adjacent said sighting device operably associated with said generating means for introducing a correction.

42. A system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, indicating means adjacent said gun, means adjacent said sighting device for transmitting the movement of said sighting device to said indicating means, means in a station remote from said sighting device and said gun and operably associated with said transmitting means and said indicating means for introducing a correction in the movement applied to said indicating means, means arranged to render said last mentioned means ineffective and means adjacent said sighting device arranged to introduce corrections in the movement of said sighting device transmitted by said transmitting means.

43. In a system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, means for training said sighting device on a target, means responsive to said means for generating the bearing of said target, motion transmitting means operably associated with said bearing generating means, indicating means adjacent said gun, motion reproducing means connected with said motion transmitting means adjacent said gun for driving said indicating means, means remote from said sighting device and said gun arranged to be connected to said motion transmitting and reproducing means so as to introduce a correction in the movement transmitted by said motion transmitting means, means for connecting said last mentioned means to said transmitting and reproducing means and for disconnecting said means therefrom and means adjacent said sighting device operably associated with said bearing generating means for introducing a correction in the movement to be transmitted by said transmitting means.

44. A system of gun fire control comprising a gun, a sighting device remote from said gun, means for directing said sighting device on a target to generate its bearing, means located at said sighting device arranged to apply corrections to the movement thereof so as to generate the adjustment to be applied to said gun in train, auxiliary correction means remote from said sighting device arranged to apply similar corrections and indicating means adjacent said gun responsive to the movement of said sighting device and the operation of said correction means for showing the corrections to be applied to said gun.

45. A system of gun fire control comprising a sighting device, means for moving said sighting device in train and elevation planes to keep it on a target, means remote from said sighting device for applying corrections to the movements of said sighting device in said planes so as to generate the adjustments to be applied to a gun in train and elevation planes and means adjacent said sighting device for applying similar corrections to said movements of said sighting device.

46. A system of gun fire control comprising a sighting device, means for training said sighting device on a target so as to generate its bearing, means remote from said sighting device for applying corrections to the movement of said sighting device so as to determine the adjustment to be applied to a gun in train, means for moving said sighting device in elevation, means remote from said sighting device for applying corrections to its elevation movement so as to determine the adjustment to be applied to said gun in elevation and means adjacent said sighting device for applying similar corrections to its train and elevation movements so as to determine the adjustments to be applied to said gun in train and elevation.

47. A system of gun fire control comprising a gun, a sighting device remote from said gun, means for moving said sighting device in train to bring it to bear on a target so as to generate its bearing, means remote from said sighting device and said gun for applying corrections to the movement of said sighting device in train so as to generate the adjustment to be applied to said gun in train, means for moving said sighting device in elevation to generate the adjustment to be applied to said gun in elevation, means remote from said sighting device for applying corrections to its movement in elevation and means adjacent said sighting device for introducing corrections to its train and elevation movements to generate the adjustments to be applied to said gun in train and elevation.

48. A system of gun fire comprising a gun, a sighting device remote from said gun, means for moving said sighting device in train and elevation planes to keep it on a target, means located locally with respect to said sighting device arranged to apply corrections to the movements of said sighting device so as to generate the adjustments to be applied to said gun in train and elevation planes, auxiliary correction means remote from said sighting device for applying similar corrections to the movements of said sighting device and indicating means adjacent said gun responsive to the movements of said sighting device and the operation of said correction means for showing the adjustments to be applied to said gun.

49. A system of gun fire comprising a gun, a

sighting device remote from said gun, means for moving said sighting device in train and elevation planes to keep it on a target, means located locally with respect to said sighting device arranged to apply corrections to the movements of said sighting device so as to generate the adjustments to be applied to said gun in train and elevation planes, auxiliary correction means remote from said sighting device for applying similar corrections to the movements of said sighting device and control means arranged to selectively render said local and remote correction means effective.

50. A system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, means for moving said sighting device in train to bring it to bear on a target, means for transmitting the movement of said sighting device in train to said gun, means for introducing a correction in the movement transmitted, a gun directing member adjacent said sighting device, means remote from said sighting device responsive to said gun directing member controlling said sighting device to move it in elevation, means for rendering said remote controlling means ineffective and for establishing a direct response of said sighting device to said gun directing means and means controlling said last mentioned means in accordance with the operation of said means for introducing said correction.

51. A system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, means for moving said sighting device in train to bring it to bear on a target, means for transmitting the movement of said sighting device in train to said gun, means for introducing a correction in the movement transmitted, means at said gun for indicating said corrected movement to show the adjustment to be applied to said gun in train, a gun directing member adjacent said sighting device for generating the adjustment to be applied to said gun in elevation, means remote from said sighting device arranged to respond to said gun directing means to control said sighting device to move it in elevation, means adjacent said sighting device arranged to respond to said gun directing member to control said sighting device to move it in elevation, means selectively controlling said remote and adjacent control means to render them effective to control said sighting device and means preventing the operation of said selective control means to render said remote control means effective except when a correction of predetermined magnitude is introduced by said correction means.

52. A system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, means for moving said sighting device in train to bring it to bear on a target, means for transmitting the movement of said sighting device in train to said gun, means for introducing a correction in the movement transmitted, means at said gun for indicating said corrected movement to show the adjustment to be applied to said gun in train, a gun directing member adjacent said sighting device for generating the adjustment to be applied to said gun in elevation, means adjacent said gun for indicating the movement of said gun directing member, means in a station remote from said sighting device and said gun arranged to respond to said gun directing member for controlling said sighting device to move it in elevation, means in said remote station for introducing a correction in the movement applied to said sighting device, means adjacent said sighting device arranged to respond to said gun directing member to control said sighting device to move it in elevation, means operably associated with said gun directing member and said sighting device for introducing corrections in the movement between said members, means selectively controlling said sighting device control means adjacent said sighting device and in said remote stations to render them effective and means jointly responsive to the operation of said correction introducing means controlling the operation of said selective controlling means.

53. A system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, a gun directing member adjacent said sighting device for generating the adjustment to be applied to said gun in elevation, means remote from said sighting device and said gun responsive to said gun directing member for applying a movement thereof to said sighting device in elevation, means adjacent said sighting device responsive to said gun directing member for applying a movement thereof to said sighting device in elevation, control means including a manually operable control member for shifting the control of said sighting device from one to the other of said adjacent and remote control means, means for moving said sighting device in train to generate the bearing of a target, means adjacent said sighting device operably associated with said bearing generating means for introducing a correction and means dependent upon the operation of said last mentioned means controlling the operation of said manually operable control member.

54. In a system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, means for moving said sighting device in train for generating the bearing of a target, means adjacent said gun responsive to the operation of said bearing generating means for indicating the adjustment to be applied to said gun in train, control means in a station remote from said sighting device and said gun for introducing a correction in the movement of said sighting device in train and for applying said corrected movement to said indicating means, means for disconnecting said remote control means and means adjacent said sighting device for introducing a similar correction in the train movement applied to said indicating means, a gun directing member adjacent said sighting device for generating the adjustment to be applied to said gun in elevation, indicating means adjacent said gun responsive to said gun directing member so as to show the adjustment to be applied to said gun in elevation, control means in said remote station responsive to said gun directing member and operably associated with said sighting device to move it in elevation and for introducing a correction in the movement applied to said sighting device in elevation, means adjacent said sighting device responsive to said gun directing member and operably associated with said sighting device to move it in elevation and for introducing a correction in the movement applied to said sighting device in elevation, control means arranged to selectively render said adjacent and said remote sighting device control means effective and means controlling said selective control means responsively to the operation of said means adjacent said sighting device for introducing corrections in the elevation

movement applied to said sighting device and in the movement applied to said sighting device in train.

55. A system of gun fire control comprising in combination with a gun, a sighting device remote from said gun, means for moving said sighting device in train to bring it to bear on a target, means responsive to the movement of said sighting device in train for generating the bearing of said target, motion transmitting means driven by said last mentioned means, means adjacent said sighting device operably associated with said bearing generating means and said motion transmitting means for introducing a correction so as to determine the adjustment to be applied to said gun in train, an indicating device adjacent said gun, motion reproducing means responsive to said motion transmitting means arranged to drive said indicating means to show the adjustment to be applied to said gun in train, means in a station remote from said sighting device and said gun operably associated with said motion transmitting and reproducing means for introducing a correction to determine the adjustment to be applied to said gun in train, means for rendering said adjacent and remote control means for introducing said correction effective and ineffective at will, a gun directing member adjacent said sighting device for determining the adjustment to be applied to said gun in elevation, motion transmitting means driven by said gun directing member, indicating means adjacent said gun, motion reproducing means responsive to said transmitting means arranged to drive said indicating means to show the adjustment to be applied to said gun in elevation, transmitting means in said remote station, means in said remote station, responsive to said gun directing motion transmitting means controlling said last mentioned motion transmitting means so as to apply a movement of said gun directing member to said last mentioned motion transmitting means, motion reproducing means adjacent said sighting device responsive to said transmitting means in said remote station arranged to apply the movement thereof to said sighting device in elevation, means in said remote station for introducing a correction in the movement applied to said sighting device in elevation, control means adjacent said sighting device arranged to render said remote elevation control means ineffective and for establishing a driving connection between said gun directing means and said sighting device including an adjustable member for introducing a correction to be applied to said sighting device and means controlling said last mentioned control means responsively to the operation of said adjustable member and said means adjacent said sighting device for introducing a correction in the said generated bearing of said target.

56. In combination, a sighting device, means for moving said sighting device in a predetermined plane, means for measuring the movement of said sighting device in said plane, controlling means for introducing a correction in the measured movement of said sighting device in said plane, means for moving said sighting device in a second predetermined plane, and means responsive to the operation of said correction control means for controlling the operation of said last mentioned means.

57. In combination, a sighting device, a gun directing member, a driving connection between said sighting device and said gun directing member including a clutch, means for generating the bearing of a target, means for applying a correction to the measured value of said target bearing and means responsive to the operation of said last mentioned means controlling said clutch.

58. In combination, a sighting device, gun directing means, a driving connection between said gun directing means and said sighting device including means for introducing a correction in the motion imparted to said sighting device by said gun directing means, a coupling between said gun directing means and said sighting device, means for moving said sighting device to generate the bearing of a target, means for applying a correction to the generated value of said target bearing and means jointly responsive to the operation of said last mentioned means and said first mentioned means for introducing said correction controlling said coupling.

59. In combination, a sighting device, a gun directing member, a driving connection between said gun directing member and said sighting device, a clutch in said driving connection, an operating member for said clutch to operate it between its engaged and disengaged positions, means for introducing a correction in the driving connection between said gun directing member and said sighting device, means for moving said sighting device to generate the bearing of a target, means for correcting the measured value of said bearing and means controlling said clutch operating member in accordance with the corrected movements applied to said sighting device by said gun directing member and said means for moving it to generate the target bearing.

60. In a system of gun fire control, a sighting device, a gun directing member adjacent said sighting device for determining the adjustment to be applied to a gun in elevation, a driving connection between said gun directing member and said sighting device arranged so that movement of said gun directing member is applied to move said sighting device in elevation, a clutch in said driving connection, means for introducing a correction in the movement applied to said sighting device in elevation, means for moving said sighting device in train to generate the bearing of a target, means for measuring the generated bearing, means for applying a correction to said generated bearing for determining the adjustment to be applied to said gun in train and means operably associated with said gun directing member and said correction means for operating said clutch in accordance with the movement of said gun directing member and with the magnitude of the correction applied.

61. In combination, sighting mechanism, means for driving said sighting mechanism in an elevation plane, mechanism for connecting and disconnecting said sighting mechanism from its driving means, means for driving said sighting mechanism in a train plane, means for applying corrections to the movement of said sighting mechanism in each of said planes by its driving means, and means responsive to the magnitudes of the corrections introduced controlling the operation of said connecting and disconnecting mechanism.

62. In a system of gun fire control, a sighting device, a gun directing member for determining the adjustments to be applied to a gun in elevation, an operable connection between said gun directing member and said sighting device including a clutch, means correcting the adjustment of said sighting device by said gun directing means, means for moving said sighting de-

vice in train to generate the bearing of a target, means for correcting the generated value of said bearing for determining the adjustment to be applied to said gun in train, an operating member for said clutch, and means operably associating said operating member with both of said means for introducing corrections so as to prevent the operation of said member to engage said clutch except when said first mentioned correction means is operated to produce corrections having magnitudes falling within predetermined limits and to allow the disengagement of said clutch only when said second mentioned correction means is operated to introduce a correction having a predetermined magnitude.

63. In a system of gun fire control, a sighting device, means for moving said sighting device in train to bring it to bear on a target, means responsive to the movement of said sighting device in train to measure the bearing of said target, means operably associated with said last mentioned means for correcting the bearing thus measured so as to determine the adjustment to be applied to a gun in train, a gun directing member adjacent said sighting device for determining the adjustment to be applied to said gun in elevation, a shaft, a driving connection between said shaft and said sighting device including a clutch, an operable connection between said shaft and said gun directing member including a differential device, means for operating said differential device to modify the motion of said gun directing member applied to said shaft, a control member for said clutch, interlocking means between said control member and said shaft and said bearing correcting means including means preventing the operation of said correcting means when said clutch is disengaged and the operation of said control member to disengage said clutch when said correction means is operated to introduce corrections of predetermined magnitude and means preventing the operation of said member to engage said clutch when said shaft is in predetermined angular position.

64. In a system of gun fire control, a sighting device, means for moving said sighting device in train to bring it to bear on a target, means responsive to the movement of said sighting device in train to measure the bearing of said target, means operably associated with said last mentioned means for correcting the bearing thus measured so as to determine the adjustment to be applied to a gun in train, a gun directing member adjacent said sighting device for determining the adjustment to be applied to said gun in elevation, a shaft, a driving connection between said shaft and said sighting device including a clutch, an operable connection between said shaft and said gun directing member including a differential device, means for operating said differential device to modify the motion of said gun directing member applied to said shaft, a control member for said clutch, a shaft driven by said control member, means operably connecting said shaft with said clutch arranged so that the movement of said shaft controls the engagement and disengagement of said clutch, an interlock between said first and second mentioned shafts preventing the operation of said control member to engage said clutch when said first shaft is in predetermined positions and an interlock between said second mentioned shaft and said means for correcting the generated bearing preventing the operation of said correction means to introduce a correction when said clutch is disengaged and when said clutch is engaged to prevent the disengagement thereof except when a correction of predetermined magnitude has been introduced by said correcting means.

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