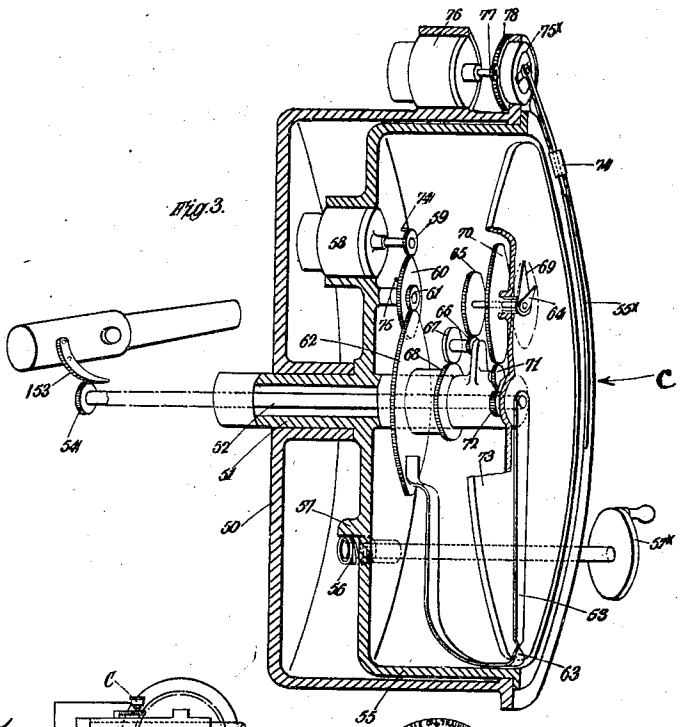
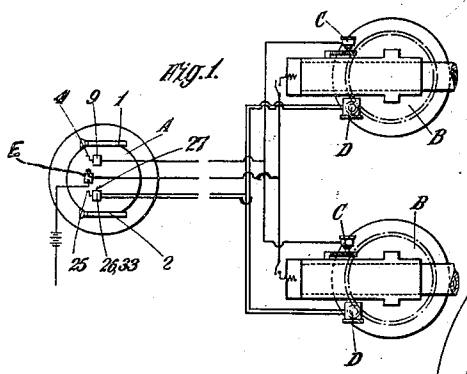
Dec. 18, 1928. **1,695,483**

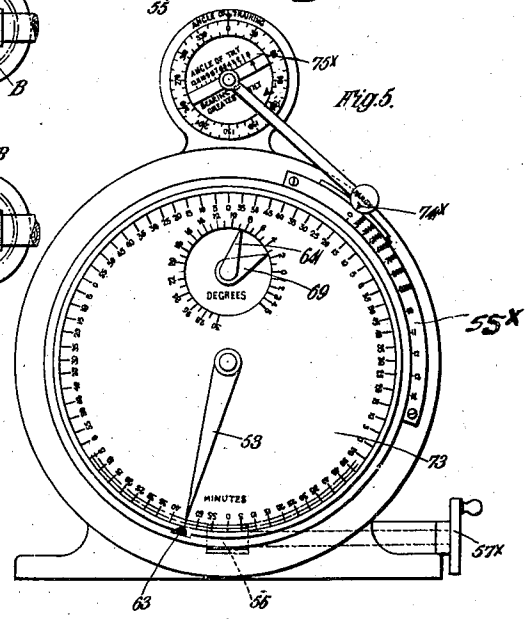
A. T. DAWSON ET AL

MEANS FOR USE IN THE LAYING OF ORDNANCE

Filed Aug. 13, 1920 2 Sheets-Sheet 1







Arthur Trevor Dawson,
George Edwin Watt,
Arthur Lamard Perham, Inventors.
Penne, Davis, Marvin & Edmonds,
Attorneys

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A. T. DAWSON ET AL

MEANS FOR USE IN THE LAYING OF ORDNANCE

Filed Aug. 13, 1920 2 Sheets-Sheet 2

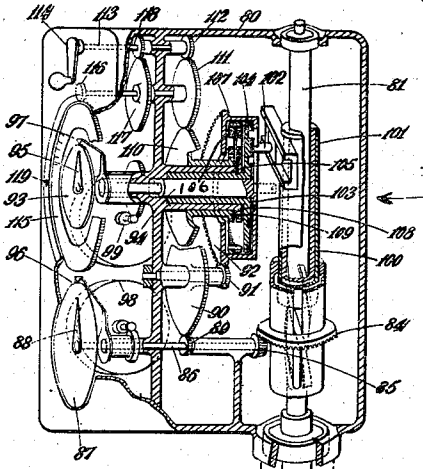


Fig. 4.

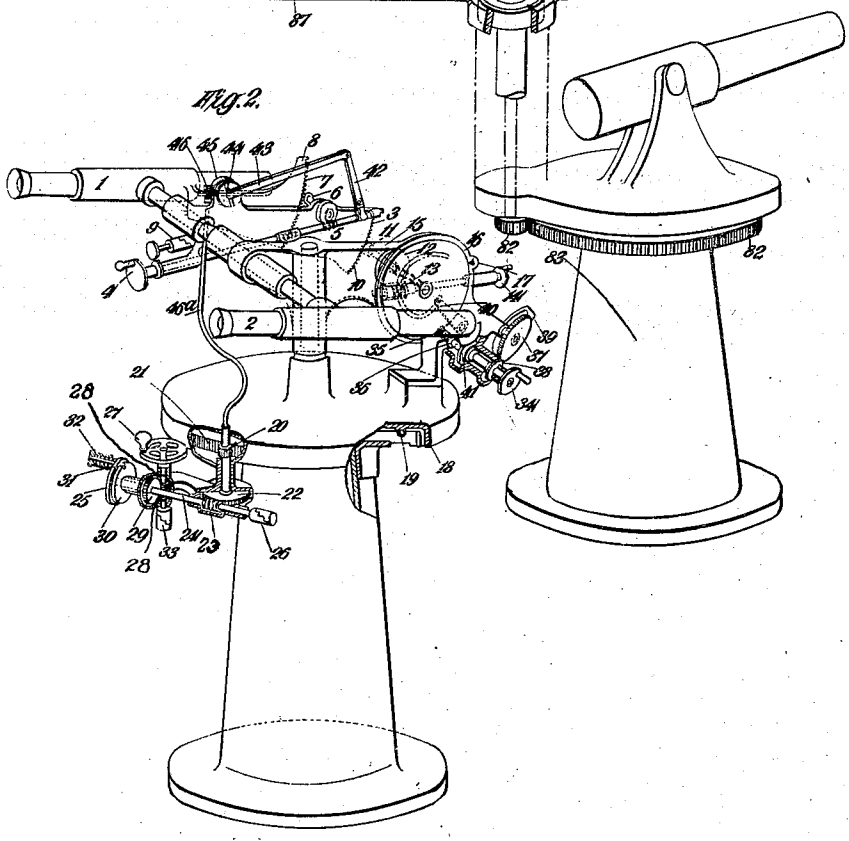


Fig. 2.

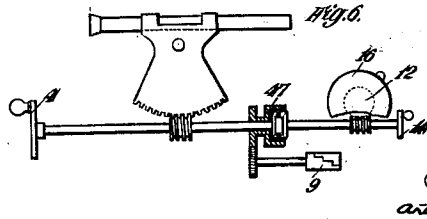


Fig. 6.

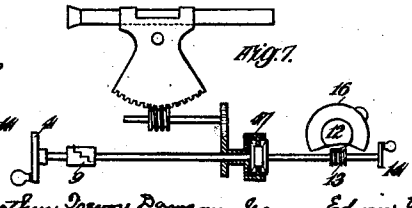


Fig. 7.

Arthur Trevor Dawson, George Edwin Watts, Arthur Leonard Pelham, Inventors.
Pennie, Davis, Marvin & Edmonds, Attorneys.

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UNITED STATES PATENT OFFICE.

ARTHUR TREVOR DAWSON, GEORGE EDWIN WATT, AND ARTHUR LEONARD PERHAM, OF WESTMINSTER, LONDON, ENGLAND, ASSIGNORS TO VICKERS LIMITED, OF WESTMINSTER, LONDON, ENGLAND.

MEANS FOR USE IN THE LAYING OF ORDNANCE.

Application filed August 13, 1920. Serial No. 403,432.

The primary object of this invention is to provide a practical system whereby the guns of a warship may be accurately trained and elevated and fired under control from a single sighting or controlling station situate some distance from the guns, preferably in a position above the level of the guns.

According to our invention we provide means for directing the guns in elevation or training, or both, in accurate agreement with the elevational and training movements of a sighting or controlling device at the controlling station, together with means for introducing alterations in the angular relationship between each gun and the sighting device, these alterations being for the purpose of correcting for the effect of differences in the relative location of the sighting device and the guns, vertically or horizontally or both, correcting for the effect of various factors affecting the path of the flight of the shells, and correcting for the relative alteration of position of the ship and the target during the time of flight of the shells. The angle in elevation or training to which a gun is laid when using this system is thus made up partly of an angle representing the position of the sighting or controlling device and partly of an angle representing the sum of all angular correctional adjustments that have been introduced.

The more important of the corrections required are as follows:—

(1) Tangent Elevation, to correct for the effect of the curvature of the trajectory of the shell in the vertical plane,

(2) Drift Correction, to correct for the horizontal deviation of the shell from the vertical plane containing the gun axis,

(3) Convergence to compensate for the difference in the angle of bearing of the target at the gun and at the sighting or controlling station due to the distance separating the gun and the sighting or controlling device,

(4) Dip Correction to compensate for the difference in height between the sighting or controlling device, and the gun,

(5) Tilt Correction, to compensate for irregularity in the level of the plane in which the sighting device and the respective guns rotate, and

(6) Deflection, a lateral correction of the gun to compensate for the relative movement of ship and target during the flight of the shell.

Other corrections may be introduced, but the above are the most important.

In general it is convenient to apply a common Tangent Elevation correction for all the guns and as the guns may differ in their respective muzzle velocities we introduce for each gun an individual correction based on muzzle velocity differences.

The correctional adjustments can be introduced either at the sighting or controlling station, at the guns, or at an intermediate station and, in the latter case, a break in the electrical connections between the sighting or controlling device and the guns becomes necessary.

A convenient method is to introduce at the sighting or controlling station corrections that are common to all guns and to apply at the guns corrections that are individual to each gun. Thus at the sighting or controlling station we might apply Tangent Elevation, Drift, Dip, Deflection, and the Tilt correction of the sighting device, and at the guns we might apply the Convergence correction in the training, and the Muzzle velocity Difference and the Tilt correction of the gun mounting in the elevation, and also an individual Dip difference correction should any gun not be in the common or average level of the guns taken as a basis for calculating the Dip correction imparted at the sighting or controlling station.

Special features of our invention are the means employed for automatically applying the Convergence and the Tilt corrections.

In carrying our invention into effect, we employ, as hereinbefore stated, means for directing the guns in elevation or training in agreement with the elevation and training movements of a distant sighting or controlling device. The means we preferably employ for this purpose comprise at the gun an indicating pointer electrically connected to the distant sighting device by a synchronous or step-by-step electric motor so that any movement of the sighting device is reproduced or mimicked by the pointer, and we prefer to make the angular movement of the

pointer a multiple of the angular movement of the sighting device so that small movements of the latter may be more readily observed at the pointer. About the same axis as this pointer we arrange a second or "follower" pointer geared to the gun so that angular movement of the gun in elevation or training, as the case may be, causes a proportionate movement of the pointer, this proportion being made the same as that adopted between the electrically operated or indicating pointer and the sighting device. Thus if, when the gun and the sighting device are parallel in training or elevation, their respective pointers are initially adjusted into alignment and if the gun is trained or elevated so that its follower pointer is kept in alignment with the indicating pointer, then changes of position of the sighting device may be accurately and easily reproduced by the gun-layer. Where one revolution of the pointers represents a smaller angle of movement than the total range of movement through which it is desired to control the gun, we may provide a second pair of indicating and follower pointers so arranged that one turn represents a number of degrees of angular movement equal to or greater than the maximum movement required of the gun. Thus by first bringing this latter pair of pointers into alignment, the gun is brought within the scope of the first pair of pointers and by bringing these into alignment the gun becomes accurately laid in a position corresponding to that of the sighting device and thus receives the primary component of its angular position. In order to introduce the secondary or correctional component of its angular position, we arrange means for imparting to the indicating pointer or to the follower pointer a movement additional to that given by the electric motor or the gun respectively. This movement we apply either by hand adjustment of by automatic means as will be hereinafter explained. As an alternative to the use of a moving indicating and follower pointer, we may substitute a single pointer of which the angular position relatively to a fixed setting mark represents the difference of angular positions between the gun and the sighting device, in which case correctional movements may be introduced by altering the position of the setting mark; an arrangement of this kind is described in our United States Patent No. 1,529,172, granted March 10, 1925. The guns are laid by the operators manipulating the training and elevating control gear of the gun mounting until the training and elevating follower pointers have been brought into alignment with their respective indicating pointers, or the said single pointers with their setting marks.

The synchronous or step-by-step motors that operate the indicating pointers at the guns are controlled by switches or transmitter elements connected to the sighting device these transmitter elements forming one portion of the synchronous means connecting this device and the pointers. The transmitter elements are geared to the sighting device so that movements of the latter in training or elevation are reproduced by the indicating pointers. In order that correctional adjustments may be introduced at the sighting device we arrange means for applying an angular movement to this device unaccompanied by operation of the transmitter elements to transmit impulses. This we do either by altering the position of the transmitter elements relatively to the sighting device or by altering the position of the device relatively to the transmitter elements, this latter method being generally the more easily arranged for and giving a simple construction of sighting apparatus when used, for example, for the introduction of the Tangent Elevation, Deflection and Drift corrections.

In applying the corrections in elevation for individual guns, for example the Muzzle Velocity difference and the Height or Dip difference corrections, a simple construction that we adopt is that of a hand adjustment of either the indicating or the follower pointer, a scale and reader being provided to indicate the amount of adjustment applied, and conveniently this scale may be marked in terms of Range and spaced to give the correct adjustment for any particular Muzzle Velocity difference and Height or Dip difference at each Range engraved thereon.

To provide an automatic correction for Tilt we employ a special device comprising a crank arranged to be rotated in unison with the gun in training. From the rotation of the crank we obtain a reciprocating or harmonic motion and we cause this to effect corrections in the indicating and follower pointer relationships. The throw of the crank is made adjustable so that it may be set by a scale to correct for any tilt error that tests of the gun level at different bearings may indicate. The angular relationship of the crank and the gun training angle are also made adjustable so that by means of a scale which is provided, the crank may be set to that bearing at which the error in the gun level has been found to be a maximum. At this particular bearing the crank will be on one of its dead centres. As the error in gun elevation due to the training axis not being vertical varies almost exactly in proportion to the sine of the angle of bearing measured from that bearing at which tilt of the training axis has no effect on the gun level, we obtain from the crank mechanism a correction almost exactly corresponding to the error in level at

different angles of bearing. Any mechanism equivalent to a crank (such as a swash-plate) from which a harmonic motion, adjustable in phase relatively to the gun turntable and also adjustable in amount, can be derived, may be used instead of the crank. To cause the crank or its equivalent to rotate in unison with the turn table of the gun mounting, any form of mechanical gearing may be employed, or the corrector may if desired be set by hand to the angle of training. Alternatively we may arrange that the corrector is rotated by an electric synchronous or step-by-step motor receiving current from a transmitter. This transmitter may be geared to the training gear of the gun mounting or the electric motor may be adapted to work off the electrical circuit appertaining to the aforesaid system of distant control of the gun training from the sighting device. A simple method of causing the tilt correction, derived from the aforesaid crank, to adjust the indicating and follower pointer relationship, is to make the reader of the Muzzle Velocity difference Range scale free to slide to and fro and to couple it by a connecting rod or through a crosshead to the crank pin of the tilt corrector.

The correction for Convergence of each individual gun mounting upon the line of sight of the sighting device may be applied by hand to the training indicating or follower pointers at the gun after the manner described for applying the Muzzle Velocity difference correction, but in the case of the convergence correction it is necessary to ascertain the amount of convergence to be applied and this amount varies with the range of the target, with the angle of bearing of the gun and relatively to a line joining the gun mounting and the sighting device, and with the distance separating gun and the sighting device. We prefer however to provide automatic means for applying the convergence correction, these means comprising an adjustable throw crank operating a crosshead which is arranged to cause relative displacement of the training indicating pointer and the training follower pointer in the usual case where the convergence correction is applied at the gun. The crank is caused to rotate equally with the gun turn table or the sighting device and the length of the throw or radius of the crank is adjusted by hand in inverse proportion to the range of the target, the ratio of this proportion varying with the separation of gun and sighting device. The amount of crank adjustment is indicated on a scale marked in terms of range. By these means when the crank has been set for the range of the target the convergence correction becomes automatically applied at any angle of bearing.

As hereinbefore described we may employ, for the purpose of angularly relating the sighting device and the guns, a step-by-step electric motor system, and such a system is limited according to its type to the transmission of only a certain maximum number of steps per minute if the receiver motor is not to lose synchronism with the transmitter. Particularly in the case of transmission of training this maximum speed is likely to prove too low for dealing with rapid changes of angle of bearing occurring, for example, when the sighting device changes from one target to another, or from broadside to broadside, or when it is required to train quickly upon a target. According to a feature of our invention we provide a special combination of two training transmission systems that enabled us to obtain a rate of training of upwards of 30 times as great as if only one system were employed. The method is most simply carried into practice by employing two pairs of indicating and follower pointers as hereinbefore described and by arranging that each indicating pointer has a separate motor to operate it. Normally both motors work together at their respective speeds, but when quick changes of bearing occur, then only the motor driving the pointer one turn of which represents the greater number of degrees of training is operated. At the sighting or controlling station, the two transmitter switches are geared to the sighting or controlling device in such a way that the transmitter switch operating the pointer of lesser value of degrees of training per turn may be disconnected from the said device. This disconnecting means is arranged so that the last mentioned transmitter switch can only be reconnected to the said device at angular training intervals equal to the degree value of one turn of the pointer which it controls. In order that the step-by-step motors at the guns may be initially put into synchronism with the transmitter switches at the sighting or controlling device at a certain definite position of training, e. g. fore and aft, we provide distinctive marks to which the motor operated indicating pointers can be set by hand.

Where a single step-by-step motor system only is used (as is the case in transmitting elevation angles) for transmitting the angle of the sighting device to the guns, the process of setting the indicating pointers by hand to a lining-up mark tends to be slow and tedious, and to simplify the process we employ a special means for bringing the motors and the sighting device into synchronous relation. The means consists of a stop gear at the said pointers limiting their movement to a certain definite number of degrees of elevation and we also provide for the transmitter switch at the sighting station a stop-gear limiting its movement so as to be proportional to the same amount of elevation

as the pointers are allowed. To line up the motors into synchronism with the transmitter switch it is thus only necessary to operate the latter as far as it will turn in both directions and if any motor is not already in synchronism with the transmitter switch it will be forced into synchronism by prematurely encountering the stop in one or other of its directions of movement. We also provide means whereby the guns may be fired from the sighting or controlling station.

In order that the invention may be readily understood and carried into effect we will describe the same with reference to the accompanying drawings which shew by way of example apparatus according to the invention for controlling two guns and mountings from a distant sighting station and in which:—

Figure 1 is a diagram shewing the sighting device and the circuits connecting it to the two guns,

Figure 2 is a diagrammatic perspective view, partly in section of the sighting device,

Figure 3 is a diagrammatic arrangement of the elevation receiver at the gun,

Figure 4 is a diagrammatic arrangement of the training receiver at the gun.

Figure 5 is a view in elevation shewing the tilt corrector and the elevation receiver scales, and

Figures 6 and 7 are diagrammatic views shewing alternative means for introducing corrections to the sight.

Referring to Figure 1, A represents the sighting device comprising the sighting telescopes 1 and 2 mounted on a turn table 18, the telescope 1 being for the use of the layer or man controlling the elevation and the telescope 2 being for the use of the trainer or man controlling the training. B, B represent the two gun mountings each fitted with an elevation receiver C and a training receiver D. The receivers C, C are controlled by an elevation transmitter switch 9 arranged on the sighting device contiguous to the telescope 1 and operated by a handwheel 4 and the receivers D, D are controlled by slewing and training transmitter switches 26, 33 arranged on the sighting device contiguous to the telescope 2 and operated by handwheels 25, 27, all in the manner hereinafter fully described. E is a firing key which is arranged on the sighting device and by means of which the guns can be fired simultaneously.

Referring to Figure 2, the sighting telescopes 1 and 2 are coupled rigidly together and can be adjusted in elevation relatively to an element 3 (termed the intermediate arm) by means of a handwheel 4, a worm 5, a worm-wheel 6, a pinion 7, and an elevating rack 8. Geared to the handwheel 4 is a transmitter switch 9, forming the transmitting element of the step-by-step electrical system connecting the sighting device with the elevation indicating pointers (hereinafter described) at the guns. Any movement of the handwheel 4 thus simultaneously adjusts the sighting telescopes in elevation and the gun elevation indicating pointers. The intermediate arm 3 is itself capable of adjustment in elevation by means of a rack 10, a pinion 11, a wormwheel 12, a worm 13 and a handwheel 14, the last four mentioned elements being mounted in a bracket 15, which is termed the main frame of the sight. The spindle carrying the pinion 11 and the worm wheel 12 also carries a dial 16 engraved in terms of range so spaced that on setting any range figure against a reader or index 17, the intermediate arm 3 receives an angle of depression equal to the Tangent Elevation of the guns at that range. As the handwheel 4 and the elevating gear of the telescopes are carried by the intermediate arm 3, movements of the range dial cause the arm and the telescopes to be adjusted together in elevation. In the spacing of the range graduations on the dial 16 an allowance may be included for the aforesaid Dip correction due to the height of the sighting telescopes above the common or average level of the guns.

The telescopes, the intermediate arm and the main frame of the sight are mounted on a turn table 18, which is supported on ball or roller bearings 19 so as to be capable of easily being rotated by means of a training pinion 20 engaging with a training rack 21 carried by the fixed pedestal supporting the whole sighting device. The training pinion 20 is operated by a wormwheel 22 and a worm 23 secured to spindle 24, which carries at one end a handwheel 25 and at the other end a transmitter switch 26 forming a transmitting element of the step-by-step electrical system connecting the sighting device with the gun training indicating pointers. A second handwheel 27 drives a worm 28 gearing with a worm wheel 29 mounted about the spindle 24. This worm wheel 29 drives a disc 30 behind the handwheel 25, and a sliding pin 31, in the handle of the handwheel 25 engages with a hole cut in the disc 30. Normally a spring 32 serves to keep the sliding pin in engagement with the hole in the said disc so that the wormwheel 29 is rigidly coupled to the spindle 24. The irreversibility of the worm gear 28 and 29, so long as the pin 31 engages the disc 30, prevents the handwheel 25 being directly rotated by hand and the turntable 18 can then only be trained by the use of the handwheel 27. The other end of the spindle carrying this handwheel 27 drives a transmitter switch 33 forming another transmitting element of the step-by-step electrical system connecting the sighting device with the gun training indicating pointers. This transmitter switch 33 transmits small angular in-

crements of training e. g. steps of four minutes whereas the transmitter 26 transmits larger increments, e. g., steps of two degrees. By pulling outwards the handle of the handwheel 25, the pin 31 becomes disengaged from the disc 30, and the handwheel now being free of the worm gear 28 and 29, may be directly turned by hand, thus training the turn table. In this case only the transmitter switch 26 functions, thus enabling the sight to be rapidly trained. One turn of the spindle 24 is arranged to be of the same angular training value e. g. six degrees, as one turn of the training indicating pointer at the gun, and as the coupling pin 31, can only engage at one point in the disc 30, it is thereby made impossible for it to re-engage except at intervals of six degrees of training, thus re-establishing correct relationship between the six degrees or training indicating pointer and the three hundred and sixty degrees or "slewing" indicating pointer. This arrangement of the transmitter switches 26, 33 is fully described in our co-pending application Serial No. 334,281.

To enable a deflection correction to be applied to the sighting telescope, the main frame of the sighting apparatus is mounted on a vertical pivot carried from the turn table. By means of a handwheel 34 and worm 35 supported in bearings in the main frame and engaging with a toothed segment or section of wormwheel 36 secured rigidly to the turntable 18, an adjustment of the sighting device in training relatively to the turn table may be applied. The amount of such adjustment is indicated by a dial 37 geared to a toothed wheel 38 carried by the worm spindle. This dial is set to a fixed index 39 and may be engraved in terms of angular measurement or of ship speed or both as preferred.

In Fig. 2 an automatic application of the drift correction is shewn, this being effected by a cam slot on the back of the range dial 16 controlling the position of a lever and roller 40. A toothed quadrant formed on this lever gears with a toothed wheel 41 and the hub of this wheel is screw-threaded to engage with a screw thread cut in the main frame casting. Rotation of the wheel 41 therefore is accompanied by an endwise movement. The hub of the wheel 41 is bored out to form a bearing for the spindle of the deflection worm 35 and collars on the spindle cause any endwise movement of the wheel 41 to be imparted to the worm spindle, thus causing a deflection of the sight main frame relatively to the turntable. Alternatively the drift correction may be applied by arranging for a displacement of the index 39, or the drift correction may be included in a setting given to the deflection dial and other drift correcting devices omitted.

A somewhat similar device is shewn for applying the tilt correction by causing the sight elevating worm 5 to receive an endwise movement through the lever 42, pivoted on the intermediate arm 3, said lever receiving movement through a connecting rod 43 from the crank 44 of the tilt corrector. This crank receives a rotation equal to that of the turn table from a worm wheel 45 and a worm 46 coupled by a flexible shaft 46a to the spindle of the training pinion 20. As hereinbefore explained the crank pin radius and its phase adjustment in training relatively to the turn table are adjustable, the amount of adjustment being indicated by scales as is illustrated in and more fully described hereinafter with reference to Figure 5.

The construction of the sighting device above described provides for the requirements hereinbefore described for transmitting the angular movements of the telescopes in elevation and training to the guns and also provides for adjustments of the telescopes in elevation and training to be made for correctional purposes. It is to be understood that other means than those described may be employed for this relative adjustment between the telescopes and the transmitter switches, the most important alternative construction being to interpose a differential gear in the drive from the handwheel to the switch and to arrange for the corrections to be made by adjusting the abutment member of the differential gear. Such an alternative construction is illustrated diagrammatically in Figure 6 as applied to the introduction of the Tangent Elevation correction. As shewn the transmitter switch 9 receives the sum of the movements of the elevating handwheel 4 controlling the telescope in elevation and the movements of the handwheel 14 controlling the position of the range dial 16 through worm gear 13 and 12, a differential gearing 47 of known type forming the means for adding the two movements together. In contra-distinction to the arrangement in Figure 1, the transmitter switch 9 receives the resultant effect of the movements of the handwheels 4 and 14, and corrections for Tangent Elevation are thus introduced without disturbing the elevation of the telescope. If desired however the differential gear may be arranged to give the telescope the sum of the switch movements and the range setting handwheel movements. The latter construction which is shewn in Figure 7, gives the same effect as the arrangement in Figure 1 and has the advantage that correctional movements for Tangent Elevation are not directly transmitted to the indicating pointers at the guns, as the handwheel 4 need only be operated by the observer when the elevation of the telescope resulting from the application of Tangent Elevation corrections, become unsuitable for sighting purposes. The task of the layers

of the guns is accordingly rendered lighter as the indicating pointers are not continually changing their position.

Stop gear of any suitable type is preferably provided to limit the turns of the elevation transmitter switch 9 to a certain number for the purpose hereinbefore described of facilitating the process of lining-up the elevation pointers at the guns with the transmitter switch at the sighting station, and preferably indicating or counting means are fitted to indicate the position in elevation or training of the respective transmitter switches, which means enable the synchronism between the gun indicating pointers and the transmitter switches to be easily verified at any time, by comparison of pointer and transmitter switch readings.

Referring to Figure 3 which shews a form of the elevation receiver, the receiver consists of a circular casing 50 carrying an inner casing 55 at the centre of which is a bearing 51 supporting a spindle 52. At one end of this spindle is mounted the follower pointer 53 and the other end of the said spindle is adapted to be driven by any convenient form of gearing from the gun cradle so that movements of the latter in elevation cause proportionate multiplied movements of the pointer 53. For example the pointer might be geared up 60 times, thus resulting in one turn of the pointer representing 6 degrees of gun elevation, or it might be geared up 36 times with a corresponding value of 10 degrees of elevation per turn. Such operating gearing is represented diagrammatically by a rack 153 secured to the gun cradle and a pinion 54 secured to the spindle 52. In this figure the gun is shewn at a very much reduced scale in comparison with the receiver. The inner circular casing 55 is free to be rotated within the outer casing 50 for giving the aforesaid Dip difference and Muzzle Velocity difference corrections, by means of a worm 56 engaging a toothed segment 57 carried by the inner casing, the spindle of the worm 56 having a handwheel 57× secured to it and being supported in a bearing formed in the outer casing. To the inner casing is secured an electric step-by-step motor 58 arranged to drive through gear wheels 59, 60, 61 and 62, the indicating pointer 63 mounted coaxially with the spindle 52, the two pointers 53 and 63 forming a "follow-the-pointer" combination as hereinbefore described. Each pointer drives through reducing gearing a second pointer, thus forming a pair of indicating and following pointers limited to one or less than one revolution for the purpose hereinbefore explained of allowing the pointers 53 and 63 to rotate more than one turn. The second pair of pointers will be referred to as "counter" pointers, the indicating one being figured 64 and driven through wheels 65, 66, 67 and 68 from the main indicating pointer 63, and the follower pointer being figured 69 and driven by wheels 70, 71 and 72 from the spindle 52 of the main follower pointer 53. This arrangement of pointers is described in our Patent Number 1,529,172, above referred to. Preferably both main and counter pointers are provided with scales of minutes and degrees of elevation so that their positions at any time may be read. These scales are shewn in Figure 5, and according to the construction illustrated in Figure 3, they are marked on a disc 73 supported from the end of the bearing 51. This disc 73 also carries the bearings for the counter pointers. On the wheels 59 and 60 driving the indicating pointer 63 are secured stops 74 and 75 which after a number of turns of the wheels 59 and 60 intercept or obstruct one another and prevent further rotation of the wheels, thus acting as a simple form of stop gear. The number of turns possible depends on a cyclic value varying according to the number of teeth on the wheels, and the teeth numbers must be selected so that the cyclic period is at least equal to the number of turns required of the wheels. Where the cyclic period is in excess of the required number of turns a second stop is required on the wheel 60 so as to engage the stop on the wheel 59 before the natural cyclic period of the gearing has been completed. Alternatively both wheels 59 and 60 may each carry two stops positioned so that their cyclic period overlap, the amount of overlap thus determining the free movement possible to the gear wheels. Each pair of stops in this case will operate in separate planes, e. g. the stops may be on opposite sides of the wheels 59 and 60. Other forms of stop gear may be employed for the purpose of limiting the permissible movement of the indicating pointer to the desired number of degrees of elevation.

To indicate the amount of adjustment of the inner casing 55 relatively to the outer casing 50, a scale 55× (Figure 5) is attached to the inner casing and is arranged to read against an arrow or index 74×, carried by the outer casing 50. This scale is as hereinbefore described engraved in terms of range and is made readily detachable so as to be exchanged when desired for a scale graduated for some other Muzzle Velocity difference.

The position of the index 74× is arranged to be varied under the influence of the tilt corrector crank 75× rotating in bearings carried by the outer casing. A step-by-step motor 76 is shewn for rotating the crank 75× through a pinion 77 and a gear wheel 78. The transmitter switch controlling this motor is geared either to the sighting device or to the gun turntable and causes the crank to rotate in accordance with the angle of training of the sighting device or the gun, which angle, except for the effect of con-

vergence, drift and deflection corrections is the same, the more strictly accurate method of rotating the crank being from a transmitter switch geared to the gun turntable. Alternatively mechanical gearing may be employed to connect the crank with the turntable training gear or the crank may be rotated by hand to the angle of gun training by the use of the scale of training engraved on the crank disc as shewn in Figure 5. This tilt corrector is fully described in the specification of our United States Patent Number 1,479,587, granted January 1, 1924.

In Figure 4 which shews a form of the training receiver and in which the latter is shewn to a much greater scale than the gun mounting to which it is applied, 80 is the casing of the receiver carried by the revolving portion or turntable of the gun mounting. Mounted in bearings in the casing 80 is a shaft 81 carrying at its lower end a pinion 82 engaging with a circular rack attached to the stationary supporting pedestal 83 of the gun mounting. The shaft 81 carries a bevel gear wheel 84 driving a bevel gear pinion 85 mounted on a spindle 86. The other end of this spindle carries a dial 87 on which is marked clearly a pointer 88. A second dial 93 carried on a spindle 94 is driven at a reduced speed by a gear wheel 89, countershaft gear wheels 90 and 91 and a gear wheel 92. The dial 93 is also clearly marked with a pointer 95. These two dials form the pair of follower pointers hereinbefore described. The second or slow speed dial 93 is geared so that it rotates 360° for one complete revolution of the gun mounting and the first dial 87 would conveniently be arranged to rotate once for every 6° or 10° for example of the gun mounting. Mounted co-axially about the dial spindles 86 and 94 are the indicating pointers 96 and 97 which are rotated through worm gearing by electric step-by-step motors 98 and 99 in electrical connection with the transmitter switches 33 and 26 respectively of Figure 2. By training the gun so that coincidence of indicating and follower pointers is maintained, the gun is made to train synchronously with the sighting device of Figure 2. This arrangement of the pointers is described in our Patent Number 1,529,172, above referred to.

In order to introduce the convergence correction individual to a particular gun, the bevel wheel 84 is driven from shaft 81 through a sleeve 100. On the shaft 81 are formed helical keys engaging in corresponding key slots cut internally in the sleeve 100. In the hub of the bevel wheel 84 are cut straight keyways to engage with keys projecting from the sleeve 100. The bevel wheel 84 is free to rotate on the shaft 81 but is restrained by collars from moving endwise along it. The sleeve 100 is free to move endwise along the shaft 81 and this endwise movement, owing to the spiral keys on the shaft, causes a rotational movement of the sleeve which is imparted to the bevel wheel 84 by means of the straight keyways in its hub. Endwise movement is imparted to the sleeve 100 by an outer sleeve 101 surrounding it, the sleeve 100 being free to rotate within it, but relative endwise movements of the sleeves is prevented by collars carried at the ends of the inner sleeve. On the outer sleeve is formed at right angles to its axis a cross-head or slot in which engages a crank pin and a sliding block 102 carried by the spindle 94 of the slow moving follower pointer 95. Thus rotation of the crank causes a to and fro movement of the crosshead, which movement is converted by the helical keyways described into a corresponding angular advance or retard of the bevel wheel 84 relatively to the shaft 81. The throw or radius of the crank pin 102 is made adjustable by mounting it on a block free to traverse along a radial groove cut in the crank disc 103. A projection from the block engages in a spiral groove cut in a disc 104 mounted behind the crank disc 103. Relative movement of the crank disc 103 and the disc 104 accordingly causes the crank pin block to travel radially in its groove and thus adjust its radius. The discs 103 and 104 carry the axis pins of planet pinions 105 and 106 forming parts of two similar sets of sun and planet or epicyclic gears mounted side by side. An internally toothed annulus 107 surrounds the two sun and planet gears and is wide enough to engage the planet pinions of both gear sets. The sun pinion 108 of one of the gear sets is anchored to the casing 80 by being secured to the end of the bearing supporting the spindle 94 and the crank disc. The sun pinion 109 of the other gear set carries a gear wheel 110 meshing with an idle wheel 111 which meshes with a pinion 112 on a spindle 113 to the other end of which is attached a handle 114. Rotation of this handle causes a relative displacement of the sun pinions 108 and 109 and as the annulus 107 is common to both gear sets a proportional displacement of the discs 103 and 104 carrying the planet pinions must take place. The rotation of the crank on the other hand does not cause a relative displacement of the two sun pinions and thus the crank pin radius adjustment is unaffected by such crank rotation. This arrangement of convergence corrector is described in our United States Patent Number 1,446,336, granted February 20, 1923. To enable the amount of radial adjustment of the crank pin 102 to be indicated, a scale ring 115 is mounted free to rotate co-axially about the spindle 94. Teeth are cut on the rim of the scale ring to engage with a pinion 116 driven by gear

wheels 117 and 118 from the crank adjustment handle 114. An index mark 119 is provided to read against the graduations of this scale ring. These graduations, assuming that the spiral groove of the disc 104 is of uniform pitch, are angularly spaced proportionately to the reciprocal of the range figures marked on the scale. Alternatively the spacing of the graduations might to made uniform, but in this case the spiral groove of the disc 104 could not be of uniform pitch but would vary in pitch so that the radial adjustment of the crank pin 102 is inversely proportional to the range indicated by the index 119.

Instead of using a crank of adjustable throw for applying the Tilt and the Convergence corrections, any mechanical equivalent of the crank, may be substituted.

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

1. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station movable in acordance with the relative movement of a target, means at the station for transmitting the movement of the controlling mechanism, means jointly responsive to said transmitting means and the movement of the apparatus for indicating the relative positions of the controlling mechanism and the apparatus in elevation and means for modifying the indications of said indicating means in accordance with correctional alterations in the vertical angular relationship between the controlling mechanism and the apparatus.

2. Means for laying a gun under the control of a distant station comprising in combination with the gun, controlling mechanism at the station movable in accordance with the relative movement of a target, means at the station for transmitting the movement of the controlling mechanism, means jointly responsive to said transmitting means and the movement of the gun for indicating the relative positions of the controlling mechanism and the gun in elevation and means for modifying the indications of said indicating means in accordance with the tangent elevation required to be given to the gun for the range of the target.

3. Means for laying a gun under the control of a distant station comprising in combination with the gun, controlling mechanism at the station movable in accordance with the relative movement of a target, means at the station for transmitting the movement of the controlling mechanism, means jointly responsive to said transmitting means and the movement of the gun for indicating the relative positions of the controlling mechanism and the gun in elevation and means for modifying the indications of said indicating means in accordance with the difference in height between the station and the gun.

4. Means for laying a gun under the control of a distant station comprising in combination with the gun, controlling mechanism at the station movable in accordance with the relative movement of a target, means at the station for transmitting the movement of the controlling mechanism, means jointly responsive to said transmitting means and the movement of the gun for indicating the relative positions of the controlling mechanism and the gun in elevation and means for modifying the indications of said indicating means in accordance with any departure of the path of movement of the controlling mechanism from the true horizontal plane during its training.

5. Means for laying a gun under the control of a distant station comprising in combination with the gun, controlling mechanism at the station movable in accordance with the relative movement of a target, means at the station for transmitting the movement of the controlling mechanism, means jointly responsive to said transmitting means and the movement of the gun for indicating the relative positions of the controlling mechanism and the gun in elevation and means for modifying the indications of said indicating means in accordance with any departure of the path of movement of the gun mounting from the true horizontal plane during training.

6. Means for laying a plurality of guns under the control of a distant station, comprising in combination with the guns, a controlling device at said station movable in accordance with the relative movement of the target, means including a transmitting element at said station for directing the movement of the guns in accordance with the movement of said device, means at said station for controlling alterations in the angular relationship between the guns and said device by effecting movement of one unaccompanied by corresponding movement of the other for factors which require a correction common to all the gums and means at each gun for controlling further alterations in the said angular relationship by effecting movement of the gun unaccompanied by corresponding movement of the controlling device for factors which require a correction individual to each gun.

7. Means for laying a plurality of guns in elevation under the control of a distant station, comprising in combination with the guns, a controlling device at said station movable in accordance with the relative movement of the target, means including a transmitting element at said station for directing the movement of the guns in elevation in accordance with the movement of

said device, operating mechanism at said station for controlling alterations in the vertical angular relationship between the guns and said device by movement of one unaccompanied by corresponding movement of the other for factors which require a correction common to all the guns and operating mechanism at each gun for controlling further alterations in the said angular relationship for factors which require a correction individual to each gun.

8. Means for laying a plurality of guns in elevation under the control of a distant station, comprising in combination with the guns, a controlling device at said station movable in accordance with the relative movement of the target, means including a transmitting element at said station for directing the movement of the guns in accordance with the movement of said device, means at said station for controlling alterations in the vertical angular relationship between the guns and said device by movement of one unaccompained by corresponding movement of the other in accordance with the difference in height existing between said station and the average level of the guns and means at any of the guns that are not in said average level for effecting further alternations in said angular relationship in accordance with the amount by which any particular gun is out of said average level.

9. Means for laying a plurality of guns in elevation under the control of a distant station, comprising in combination with the guns, a controlling device at said station movable in accordance with the relative movement of the target, means including a transmitting element at said station for directing the movement of the guns in accordance with the movement of said device, means at said station for controlling alterations in the vertical angular relationship between the guns and said device by movement of one unaccompanied by corresponding movement of the other in accordance with the tangent elevation required to be given to the guns for the range of the target and means at each of the guns for effecting further alterations in said angular relationship in accordance with the individual muzzle velocity of each gun.

10. Means for laying a plurality of guns in training under the control of a distant station, comprising in combination with the guns, a controlling device at said station movable in accordance with the relative lateral movement of the target, means including a transmitting element at said station for directing the movement of the guns in train in accordance with the movement of said device, means at said station for controlling alterations in the lateral angular relationship between the guns and said device by movement of one unaccompanied by corresponding movement of the other for factors which require a correction common to all the guns and means at each gun for controlling further alterations in the said angular relationship for factors which require a correction individual to each gun.

11. Means for laying a plurality of guns in training under the control of a distant station, comprising in combination with the guns, a controlling device at said station movable in accordance with the relative lateral movement of the target, means including a transmitting element at said station for directing the movement of the guns in train in accordance with the movement of said device, means at said station for controlling alterations in the lateral angular relationship between the guns and said device by movement of one unaccompanied by corresponding movement of the other to compensate for drift and means at each gun for controlling a further alteration in said angular relationship to compensate for the difference in the angle of bearing of the target at the gun and the angle of bearing of the target at said station.

12. Means for laying a plurality of guns in training under the control of a distant station, comprising in combination with the guns, a controlling device at said station movable in accordance with the relative lateral movement of the target, means including a transmitting element at said station for directing movement of the guns in train in accordance with the movement of said device, means at said station for controlling alterations in the lateral angular relationship between the guns and said device by movement of one unaccompanied by corresponding movement of the other to compensate for deflection and means at each gun for controlling a further alteration in said angular relationship to compensate for the difference in the angle of bearing of the target at the gun and the angle of bearing of the target at said station.

13. Means for laying a gun under the control of a distant station, comprising the combination of a controlling device at the distant station movable in accordance with the relative movement of the target, a transmitter actuated in accordance with the movement of said device, a member at the gun connected to the transmitter and actuated in correspondence with the actuation of the transmitter as the said controlling device is moved, and operating mechanism for angularly moving the said controlling device with respect to the transmitter without actuating the transmitter and therefore without actuating the said member at the gun.

14. Means for laying a gun under the control of a distant station, comprising the combination of a controlling device at the dis-

tant station movable about vertical and horizontal axes in accordance with the relative movement of the target, transmitters actuated by the movement of the controlling device about the horizontal and vertical axes, members at the gun connected to said transmitters and actuated in correspondence with the movement of the transmitters and means actuated by turning movement of the controlling device about a vertical axis for turning the controlling device about a horizontal axis an amount bearing a predetermined relation to the magnitude of the turning movement about the vertical axis.

15. Means for laying a gun under the control of a distant station, comprising a controlling device at the distant station movable in elevation and in training in accordance with the relative movement of the target, two transmitters actuated in accordance with the elevation and training movements of the controlling device, two members at the gun, connections from each of said members to one of the transmitters at the distant station for effecting movement of the said members in accordance with the movement of the transmitters, two members at the gun in cooperative relation to the said members and connected to the gun so as to be moved in accordance with elevation and training movements of the gun and operating mechanism for angularly moving the controlling device without actuating the transmitters.

16. Means for laying a gun under the control of a distant station, comprising a controlling device movable in elevation and in training in accordance with the relative movement of the target, a transmitter connected to the controlling device and actuated in accordance with elevational movements thereof, two means for turning the said controlling device in training, two transmitters each connected to one of said means so as to be actuated in accordance with the actuation of that means, three members at the gun each connected to one of the said transmitters so as to be actuated in correspondence with the movement of the transmitter to which it is connected, and three members at the gun mounted in cooperative relation to said members, one connected to the gun so as to be moved in correspondence with the elevational movements of the gun and the other two connected to the gun so as to be moved as the gun is trained.

17. Means for laying a gun under the control of a distant station, comprising the combination of a controlling device at the distant station movable in training and in elevation in accordance with the relative movement of the target, two transmitters connected to the controlling device, one actuated in accordance with training movements and the other in accordance with elevational movements of the controlling device, two members at the gun each connected to one of said transmitters so as to be actuated in accordance with the movement of the transmitter, two cooperating members at the gun, one mounted in cooperative relation to each of said members and connected to the gun so that one will be moved in accordance with training movements and the other in accordance with elevational movements of the gun and means located at the gun for effecting displacement of one of the members of each of the said pairs independently of its actuating mechanism.

18. Means for laying a gun under the control of a distant station, comprising the combination of a controlling device at the distant station movable about vertical and horizontal axes in accordance with the relative movement of the target, transmitters actuated in accordance with the movement of the controlling device about the horizontal and vertical axes, members at the gun connected to said transmitters and actuated in accordance with the movement of the transmitters and means actuated by turning movement of the controlling device about a horizontal axis for turning the controlling device about a vertical axis an amount bearing a predetermined relation to the magnitude of the turning movement about the horizontal axis.

19. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting movement of the devices in elevation and train respectively and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating respectively the relative elevation and the relative train of the sighting devices and the apparatus.

20. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating respectively the relative elevation and the relative train of the sighting devices and the apparatus and means for modifying the indications of each of said last named means in accordance with correctional alterations in the relation between the devices and the apparatus.

21. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly mov-

able in elevation and train, transmitters at the station actuated in accordance with the movement of the devices in elevation and train respectively, means for adjusting each of the devices independently of its transmitter and separate means each jointly responsive to one of said transmitters and the corresponding movement of the apparatus for indicating respectively the relative elevation and the relative train of the sighting devices and the apparatus.

22. In a fire control system, a plurality of devices to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the sighting devices in elevation and train respectively, separate means associated with each of the controlled devices and each jointly responsive to one of said transmitting means and the corresponding movement of the controlled device for indicating respectively the relative elevation and the relative train of the sighting devices and the controlled device and means associated with each of the elevation indicating means for modifying the indications thereof in accordance with the correctional alterations in the vertical relation between the sighting devices and the corresponding controlled device.

23. In a fire control system, a plurality of devices to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the sighting devices in elevation and train respectively, separate means associated with each of the controlled devices and each jointly responsive to one of said transmitting means and the corresponding movement of the controlled device for indicating respectively the relative elevation and the relative train of the sighting devices and the controlled device and means associated with each of the train indicating means for modifying the indications thereof in accordance with correctional alterations in the horizontal relation between the sighting devices and the corresponding controlled device.

24. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, means for adjusting the devices in elevation independently of the elevation transmitting means and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively of the sighting devices and the apparatus.

25. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, means for adjusting the devices independently of the elevation transmitting means to compensate for the tangent elevation required to be given to the apparatus for the range of the target and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively of the sighting devices and the apparatus.

26. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, means for adjusting the devices independently of the elevation transmitting means to compensate for the difference in height existing between the station and the apparatus and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively between the sighting devices and the apparatus.

27. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, means for adjusting the devices independently of the elevation transmitting means to compensate for any departure of the path of movement of the devices from a true horizontal plane during their training and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively of the sighting devices and the apparatus.

28. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and

train respectively, means for adjusting the devices in train independently of the train transmitting means and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively of the sighting devices and the apparatus.

29. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, means for adjusting the devices independently of the train transmitting means to compensate for the difference in the angle of bearing of a target at the apparatus and the angle of bearing of the target at the said station and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively between the sighting devices and the apparatus.

30. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, means for adjusting the devices independently of the train transmitting means to compensate for drift and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively between the sighting devices and the apparatus.

31. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, means for adjusting the devices independently of the train transmitting means to compensate for deflection and separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train respectively between the sighting devices and the apparatus.

32. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating the relative elevation and the relative train of the sighting devices and the apparatus and means associated with the elevation indicating means for modifying the indications thereof in accordance with any departure of the path of movement of the apparatus from the true horizontal plane during training.

33. In a fire control system, a plurality of devices to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the sighting devices in elevation and train respectively, means for adjusting the sighting devices in elevation independently of the elevation transmitting means in accordance with correctional alterations in the vertical relation between the sighting devices and the average level of the controlled devices, separate means associated with each of the controlled devices and each jointly responsive to one of said transmitting means and the corresponding movement of the controlled device for indicating respectively the relative elevation and the relative train of the sighting devices and the controlled device and means associated with the elevation indicating means of each of the controlled devices which are not in the average level for modifying the indications thereof in accordance with the amount by which the device differs from said level.

34. In a system for controlling a gun from a distant station, controlling mechanism at the station compressing a pair of sighting devices jointly movable in elevation and train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, separate means each jointly responsive to one of said transmitting means and the corresponding movement of the gun for indicating the relative elevation and the relative train of the sighting devices and the gun and means associated with the elevation indicating means for modifying the indications thereof in accordance with muzzle velocity corrections of the gun.

35. In a fire control instrument, the combination of a support, a member mounted on the support for rotation about a vertical axis, a second member mounted on the first named member for rotation about a horizontal axis, a pair of sighting devices mounted on the second member and means associated with each of the members for transmitting the angular movements thereof.

36. Means for laying a gun under the control of a distant station, comprising the combination of a controlling device at the distant station movable about vertical and horizontal axes in accordance with the relative movement of a target, transmitters actuated by the movement of the controlling device about the horizontal and vertical axes, members at the gun connected to said transmitters and actuated in correspondence with the movement of the transmitters and means actuated by turning movement of the controlling device about one axis for turning the controlling device about the other axis an amount bearing a predetermined relation to the magnitude of the turning movement about the first named axis.

37. In a fire control system, an apparatus to be controlled from a distant station, and controlling mechanism at the station comprising a pair of sighting devices movable in elevation and jointly movable in train, separate means at the station for transmitting movement of the devices in elevation and train respectively and separate means each jointly responsive to one of said transmitting means and corresponding movement of the apparatus for indicating respectively the relative elevation and the relative train of the sighting devices and the apparatus.

38. In a fire control system, an apparatus to be controlled from a distant station, and controlling mechanism at the station comprising a pair of sighting devices movable in elevation and jointly movable in train, separate means at the station for transmitting the angular movement of the devices in elevation and train respectively, separate means each jointly responsive to one of said transmitting means and the corresponding movement of the apparatus for indicating respectively the relative elevation and the relative train of the sighting devices and the apparatus and means for modifying the indications of each of said last named means in accordance with correctional alterations in the relation between the devices and the apparatus.

39. In a fire control system, a plurality of devices to be controlled from a distant station, controlling mechanism at the station comprising a pair of sighting devices movable in elevation and jointly movable in train, separate means at the station for transmitting the angular movement of the sighting devices in elevation and train respectively, means for adjusting the sighting devices independently of their transmitting means in accordance with correctional alterations in the relation between the sighting devices and all of the controlled devices, separate means associated with each of the controlled devices and each jointly responsive to one of said transmitting means and the corresponding movement of the controlled device for indicating respectively the relative elevation and the relative train of the sighting devices and the controlled device and means associated with one of the last named means for modifying the indications there of in accordance with correctional alterations in the relation between its sighting device and the corresponding controlled device.

40. In a fire control instrument, the combination of a support, a member mounted on the support for rotation about a vertical axis, a second member mounted on the first named member for rotation about a vertical axis, a pair of sighting devices mounted on the second member and means associated with one of the members for transmitting the angular movements thereof.

41. In a fire control instrument, the combination of a support, a member mounted on the support for rotation about a vertical axis, a frame mounted on the member for rotation about a vertical axis, a second member mounted on the frame for rotation about a horizontal axis, a sighting device mounted on the second member, a sighting device movable with the frame and means associated with each of the members for transmitting the angular movements thereof.

42. A director comprising two sighting devices movable in planes of reference at right angles to each other, motion transmitting means responsive to the movements of said sighting devices in said planes of reference, and a common support for said sighting devices movable in one of said planes of reference.

43. In a fire control system, an apparatus to be controlled from a distant station and controlling mechanism at the station comprising a base, a member movably mounted on the base, a transmitter associated with the member to be actuated by angular movement thereof, a second member mounted on the first member, means for producing relative angular adjustment between the members without actuating the transmitter, a pair of sighting devices mounted on the second member and movable in elevation, a transmitter connected to one of the sighting devices to be actuated by angular movement thereof in elevation and means for effecting angular movement of the said sighting device in elevation without actuating the transmitter.

44. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station including a pair of sighting devices adapted to be cooperatively actuated in train and elevation, transmitting means at the station operable from the actuation of the devices in train and elevation and means jointly responsive to the transmitting means and the corre-

sponding movement of the apparatus for indicating the relative train and the relative elevation of the sighting devices and the apparatus.

45. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station including a pair of sighting devices adapted to be cooperatively actuated in train and elevation, transmitting means at the station operable from the actuation of the devices in train and elevation, means jointly responsive to the transmitting means and the corresponding movement of the apparatus for indicating the relative train and the relative elevation of the sighting devices and the apparatus and means for modifying the indications of the indicating means in accordance with the correctional alterations in the relation between the devices and the apparatus.

46. In a fire control instrument the combination of a support, a member mounted on the support for rotation about a vertical axis, a second member mounted on the first named member for rotation about an axis bearing a predetermined relation to the axis of the first named member, a pair of sighting devices operatively related to the members and means associated with the members for transmitting the angular movements thereof.

47. In a fire control instrument, the combination of a support, a member mounted on the support for rotation about a vertical axis, a frame mounted on the member for rotation about an axis having a predetermined relation to the axis of the first named member, a second member mounted on the frame for rotation about an axis having a predetermined relation to the other axes, a sighting device operatively related to the second member, a second sighting device operatively related to the frame and means associated with each of the members for transmitting the angular movements thereof.

48. In a fire control instrument, the combination of a support, a member mounted on the support for rotation about a vertical axis, a frame mounted on the member for rotation about an axis having a predetermined relation to the first named axis, a second member mounted on the frame for rotation about an axis having a predetermined relation to the other axes, means operatively related to the second member for viewing a target and means responsive to the movements of the members for transmitting such movements.

49. In a fire control instrument, the combination of a support, a member mounted on the support for rotation about a vertical axis, a frame mounted on the member for rotation about an axis bearing a predetermined relation to the first named axis, a second member mounted on the frame for rotation about an axis having a predetermined relation to the other axes, a pair of sighting devices operatively related to the second member and means responsive to the movements of the members for transmitting such movements.

50. In a fire control system an apparatus to be controlled from a distant station, controlling mechanism at the station comprising a base, a member movably mounted on the base, a transmitter responsive to the movement of the member, a second member movably mounted on the first member, means for producing relative displacement between the members without actuating the transmitter, sighting means mounted on the second member and movable in elevation, a transmitter for transmitting movements in elevation, means for jointly actuating the sighting means and the second transmitter and means for actuating the sighting means without actuating the second transmitter.

51. In a fire control system, a gun, controlling mechanism including a part adapted to bear a predetermined relation to the line of sight to a target and elements adjustable with respect to said part in accordance with required correctional displacements of the gun from the part in predetermined planes of reference, means associated with the elements for transmitting to the gun the data for aiming it and means for maintaining the part in the predetermined relation to the line of sight.

52. In a fire control system, a gun, controlling mechanism including a part adapted to bear a predetermined relation to the line of sight to a target and elements adjustable with respect to said part in accordance with required correctional displacements of the gun from the part in predetermined planes of reference, transmitters associated with said elements, means operable to maintain the part in such predetermined relation and means jointly responsive to the transmitters and the corresponding movement of the gun for indicating the relation between the elements and the gun.

53. In a fire control system, a gun, controlling mechanism including a part adapted to bear a predetermined relation to the line of sight to a target and elements adjustable with respect to said part in accordance with required correctional displacement of the gun from the part in predetermined planes of reference, transmitters associated with said elements, means operable to maintain the part in such predetermined relation, means jointly responsive to the transmitters and the corresponding movement of the gun for indicating the relation between the elements and the gun and means for modifying the indications of the indicating means in accordance with corrections individual to the gun.

54. In a fire control system, a plurality of guns, controlling mechanism including a part adapted to bear a predetermined relation to the line of sight to a target and means for producing alterations in the angular relationship between the part and the guns for factors which require a correction common to all the guns, means including transmitting elements for directing the movement of the guns in response to the actuation of the mechanism and means at the guns for producing alterations in the angular relationship between the part and the guns for factors which require a correction individual to each gun.

55. In a fire control system, a gun, a gun director having a plurality of controls operable to position parts of the director representing a line in a plane containing a target, a transmission system from the director for controlling the aim of the gun in train and elevation, and means for adjusting, relative to the parts representing the line, the train and elevation transmitted to the gun.

56. In a fire control system, a gun, a director therefor having a member adapted to be maintained in a predetermined relation to the line of sight to a target, elements adjustable in accordance with the required angular displacements of the gun in train and elevation from the member and means for transmitting angular positions for controlling the aim of the gun.

57. In a fire control system, a gun, controlling mechanism for the gun including a pair of sighting devices adapted to be cooperatively actuated in train and elevation and means jointly operable with the devices for directing the aim of the gun.

58. In a fire control system, a gun, controlling mechanism for the gun including a pair of sighting devices adapted to be cooperatively actuated in train and elevation, means jointly operable with the devices for directing the aim of the gun, and means associated with the last named means for modifying the directing effect thereof in accordance with correction factors for the gun.

59. In a fire control system, a gun, a gun director having a plurality of controls operable to position parts representing a line in a plane containing a target, means operable from the director for directing the aim of the gun in train and elevation, and means for adjusting relative to the parts, the effect of the directing means.

60. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station including a pair of sighting devices adapted to be cooperatively actuated in train and elevation, transmitting means at the station operable from the actuation of the devices in train and means jointly responsive to the transmitting means and the corresponding movement of the apparatus for indicating the relative train of the sighting devices and the apparaus.

61. In a fire control system, an apparatus to be controlled from a distant station, controlling mechanism at the station including a pair of sighting devices adapted to be cooperatively actuated in train and elevation, transmitting means at the station operable from the actuation of the devices in train, means jointly responsive to the transmitting means and the corresponding movement of the apparatus for indicating the relative train of the sighting devices and the apparatus, and means for modifying the indications of the indicating means in accordance with correctional alterations in the relation between the devices and the apparatus.

62. A director comprising two sighting devices movable in planes of reference at right angles to each other, motion transmitting means actuated in accordance with the movements of said sighting devices in said planes of reference, and a common support for said sighting devices movable in one of said planes of reference.

63. In a fire control system, a gun, controlling mechanism for the gun having parts adjustable for components of the position of a target and means for adjusting the parts for the components, and means for directing the aim of the gun in accordnace with the position of the parts and adjustable correctional factors.

64. In a fire control system, a gun director having traget reference elements adjustable in train and elevation, a gun and means for controlling the aim of the gun in train and elevation at adjustable relation to the reference elements of the director.

65. In a fire control system, a gun director having elements representing the position of a target, means for adjusting the elements, a gun, means for controlling the aim of the gun in train and elevation from the adjustment of the elements and means for introducing correctional factors between the elements and the gun.

66. In a fire control system, a plurality of guns, controlling mechanism including a part adapted to bear a predetermined relation to a line of sight to a target and means for producing alterations in the lateral angular relationship between the part and the gun in accordance with the required correction including drift and/or deflection, means including transmitting elements for directing the movements of the gun in response to the actuation of the mechanism and means at the guns for producing alterations in the angular relationship between the part and the gun in accordance with required corrections for the differences between the angle

of bearing of the target at the controlling mechanism and the angles of bearing of the target at the gun.

67. In a fire control system a plurality of guns, controlling mechanism including a part adapted to bear a predetermined relation to the line of sight to a target and means for producing alterations in the vertical angular relationship between the part and the guns in accordance with the tangent elevation required to be given to the guns for the range of the target, means including transmitting elements for directing the movement of the guns in response to the actuation of the mechanism, and means at the guns for producing alterations in the angular relationship between the part and the guns in accordance with required corrections including muzzle velocity and/or tilt corrections for the guns.

68. In a fire control system, a plurality of guns, controlling mechanism including a part adapted to bear a predetermined relation to the line of sight to a target, means for producing alterations in the lateral angular relationship between the part and the guns in accordnace with lateral corrections including drift and/or deflection and means for producing alterations in the vertical angular relationship between the part and the guns in accordance with the tangent elevation required to be given to the guns for the range of the target, means including transmitting elements for directing the movements of the guns in response to the actuation of the mechanism, means at the guns for producing alterations in the angular relationship between the part and the guns in accordance with required corrections for the differences between the angle of bearing of the target at the controlling mechanism and the angles of bearing of the target at the guns and means at the guns for producing alterations in the angular relationship between the part and the guns in accordance with required corrections including muzzle velocity and/or tilt corrections for the guns.

In testimony whereof, we hereby affix our signatures.

ARTHUR TREVOR DAWSON.
GEORGE EDWIN WATT.
ARTHUR LEONARD PERHAM.