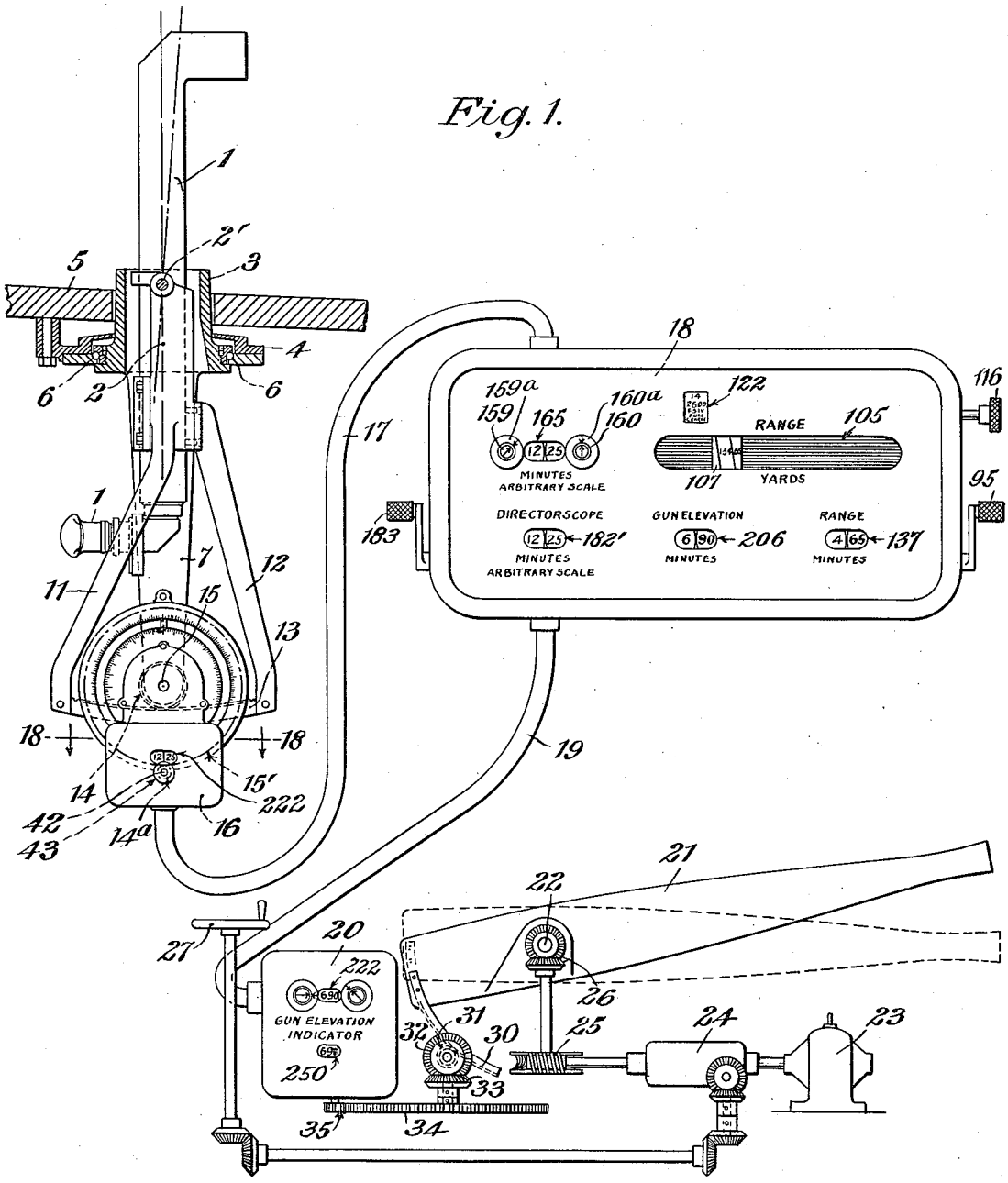
Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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Fig. 1.



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Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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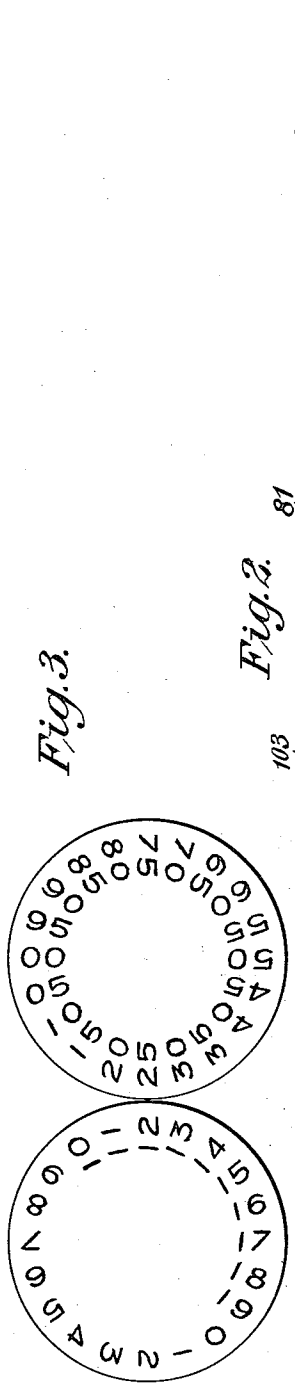


Fig. 3.

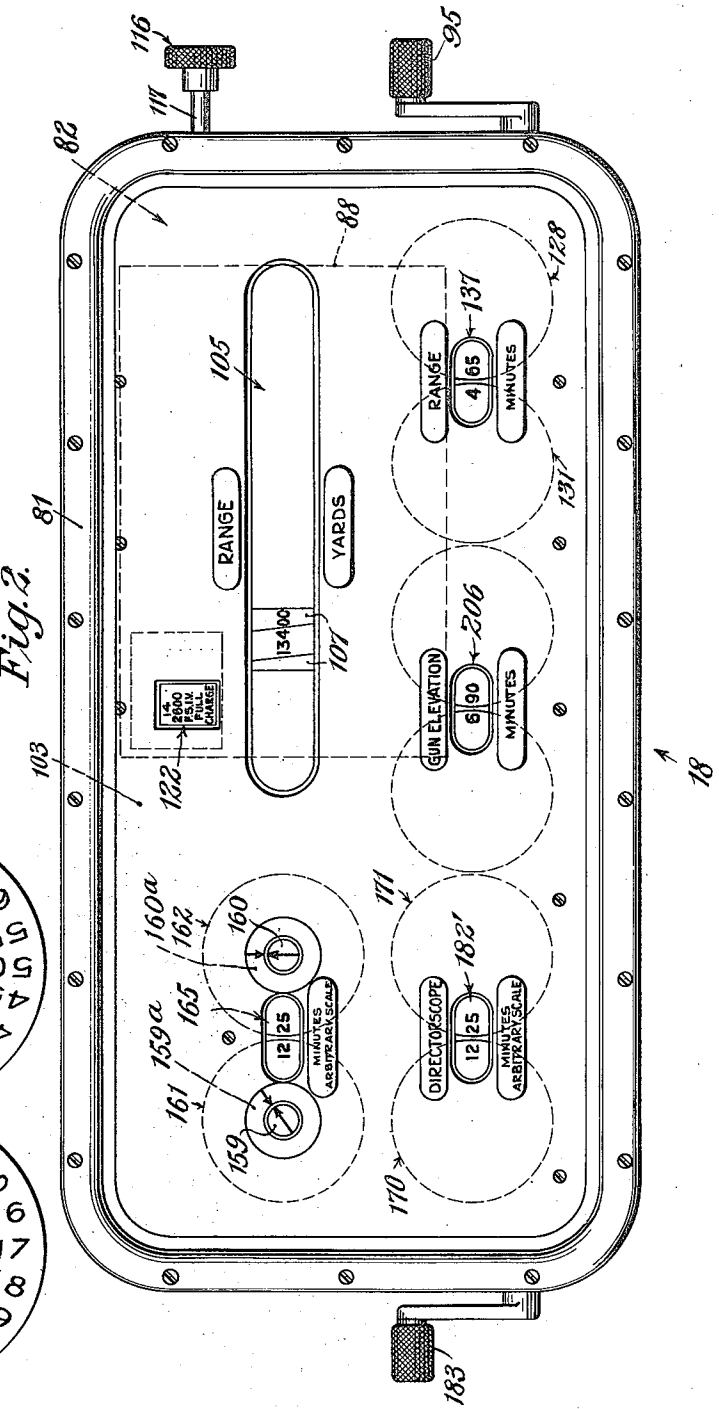


Fig. 2.

INVENTOR
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Henry Woodbury
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Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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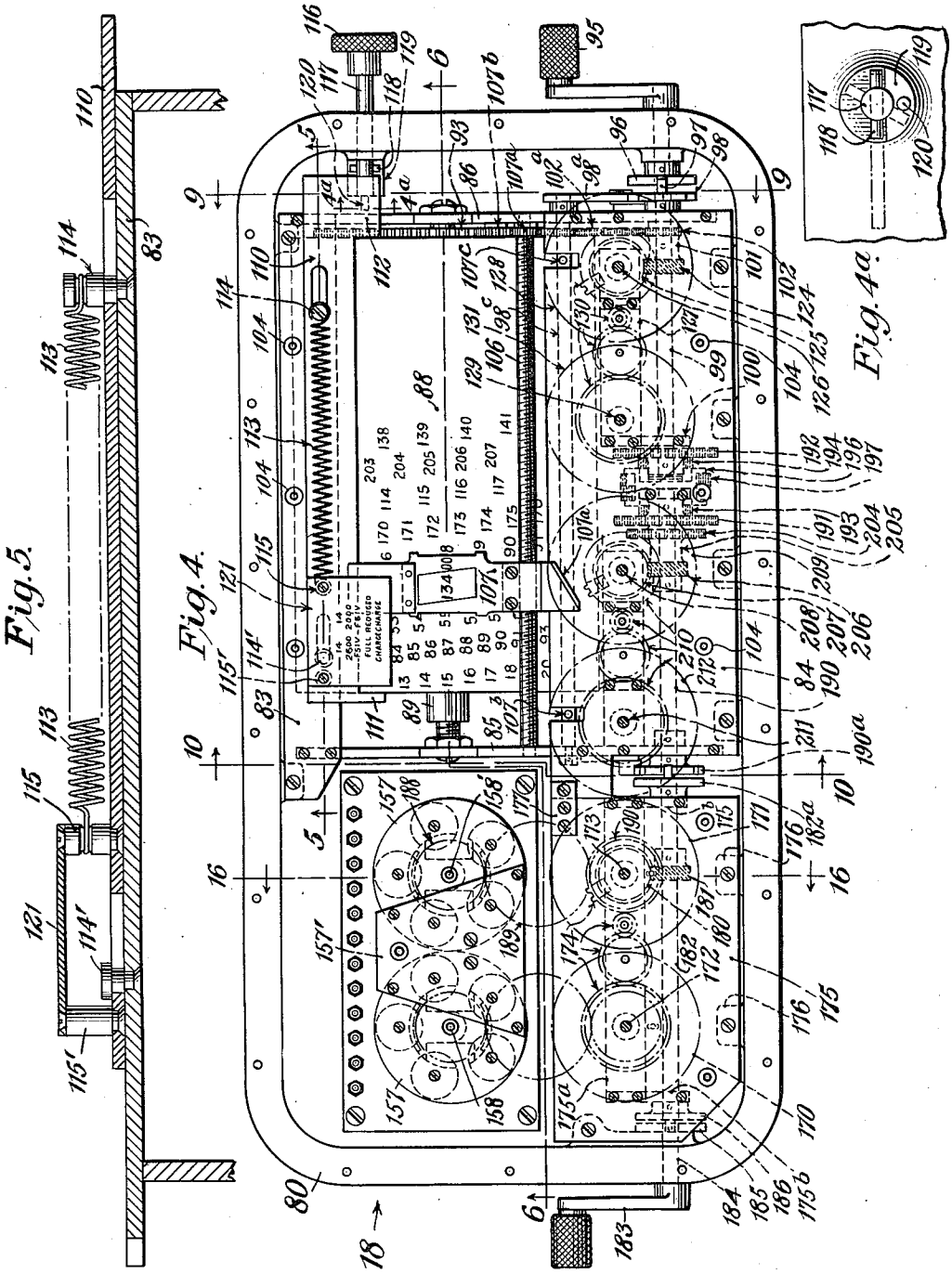


Fig. 5.

Fig. 4.

Fig. 4a.

INVENTOR
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Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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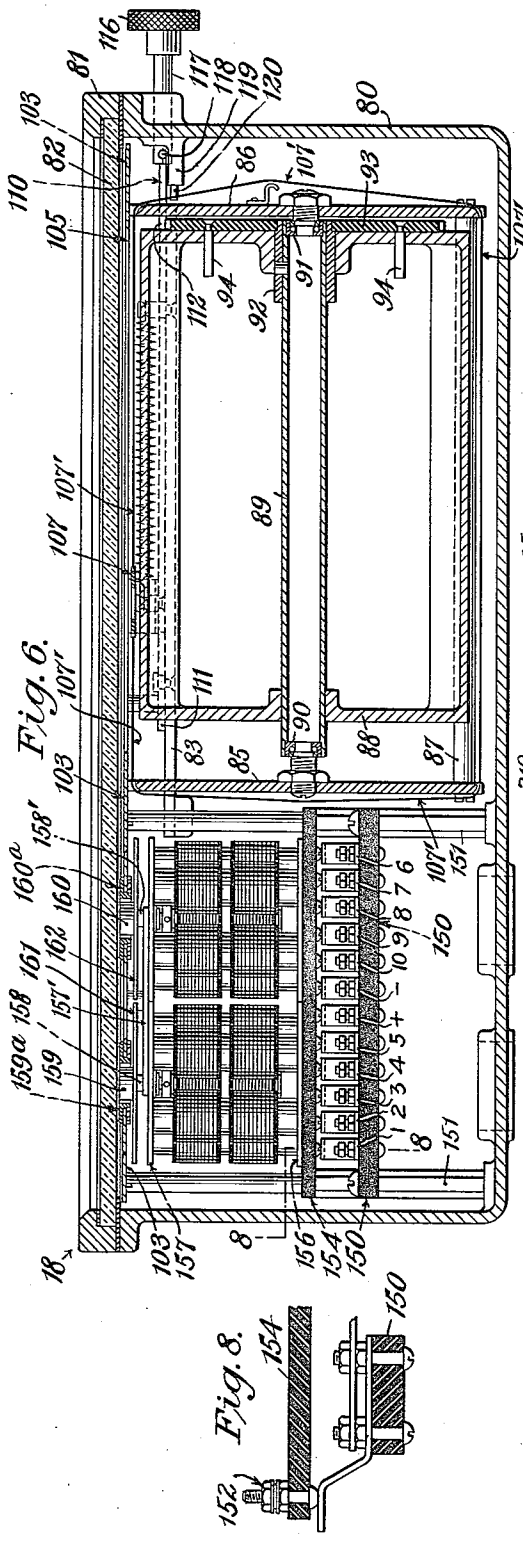


Fig. 6.

Fig. 8.

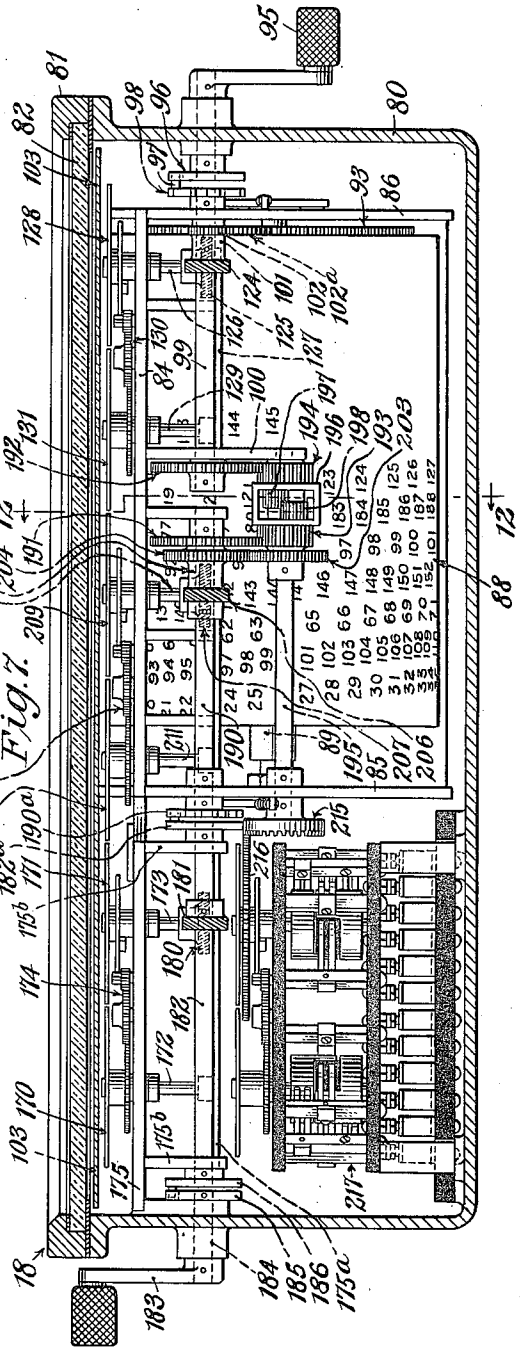


Fig. 7.

INVENTOR
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Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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Fig. 9.

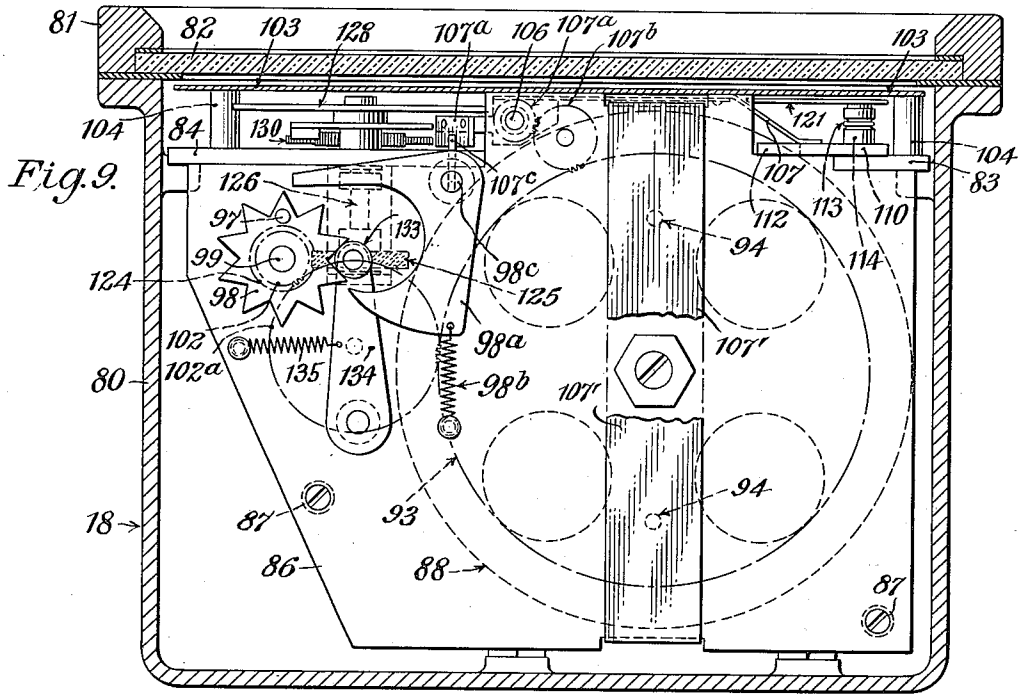


Fig. 10.

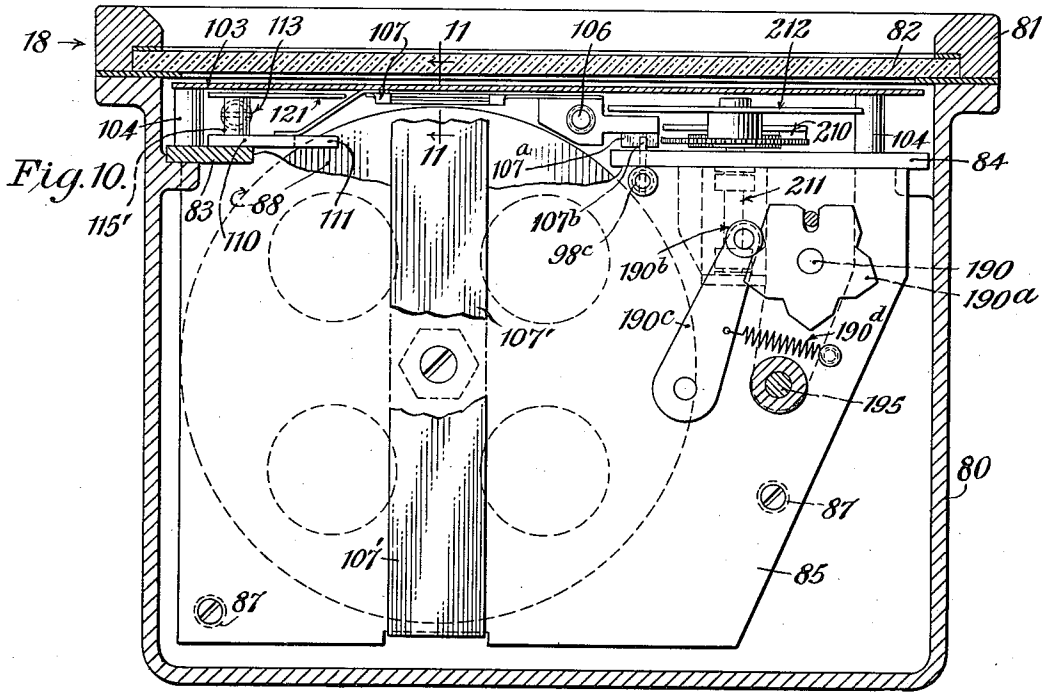
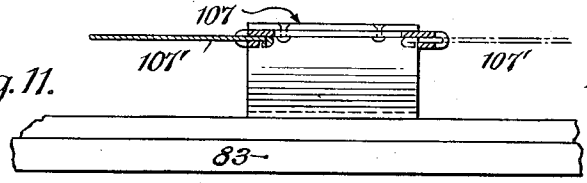


Fig. 11.



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Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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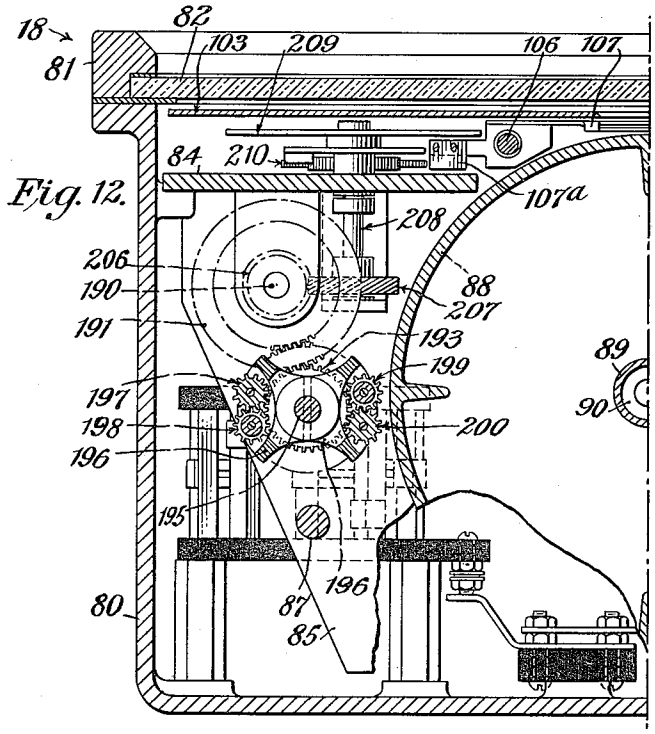


Fig. 12.

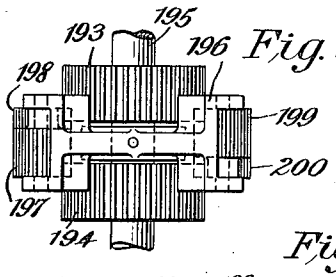


Fig. 13.

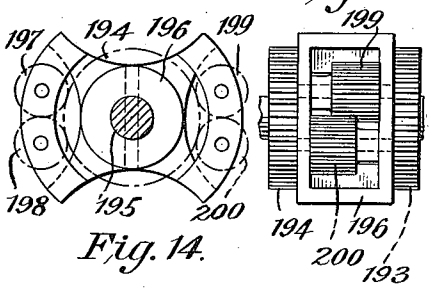


Fig. 14.

Fig. 15.

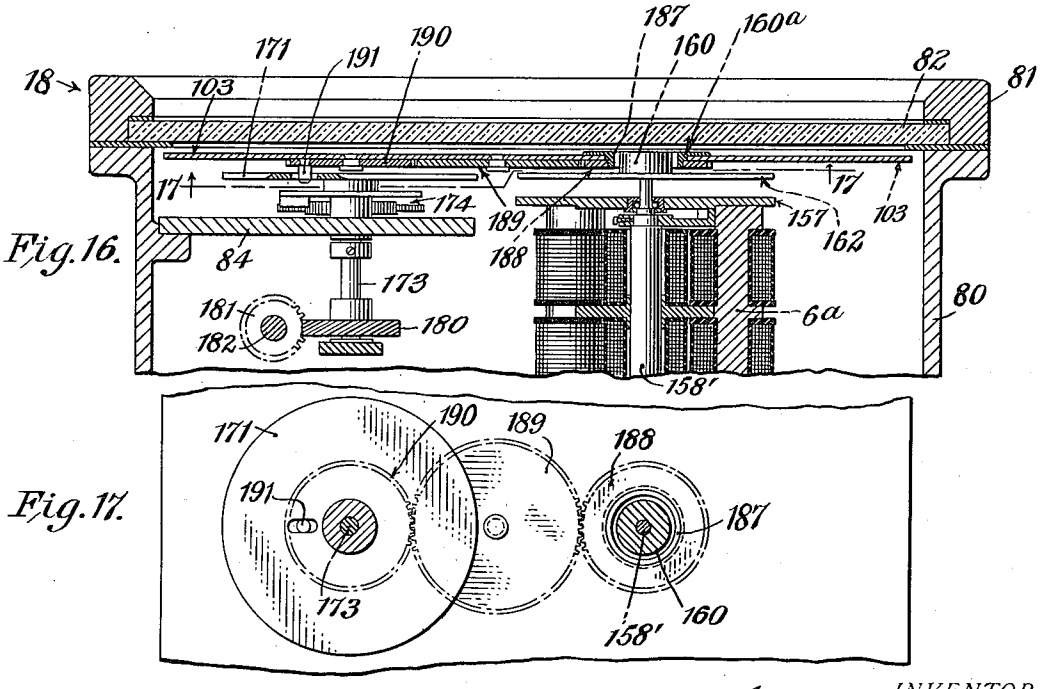


Fig. 16.

Fig. 17.

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DIRECTOR FIRING SYSTEM

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Fig. 18

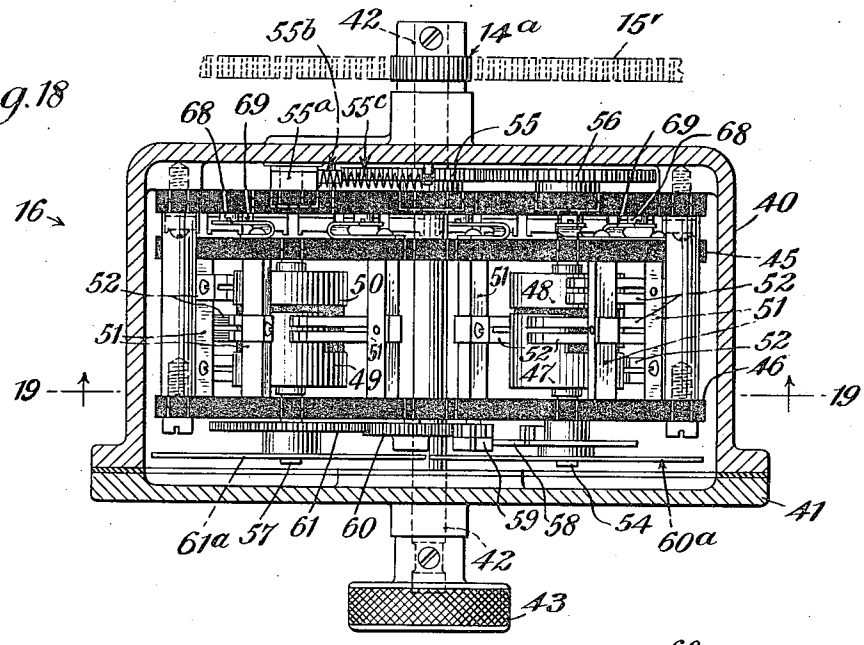


Fig. 19.

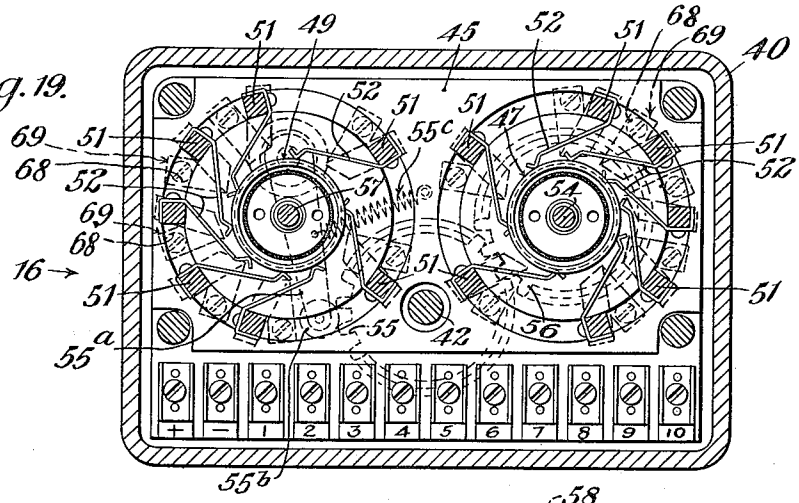
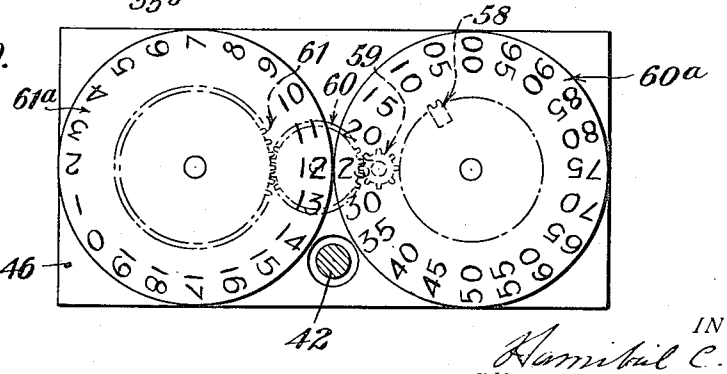


Fig. 20.



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DIRECTOR FIRING SYSTEM

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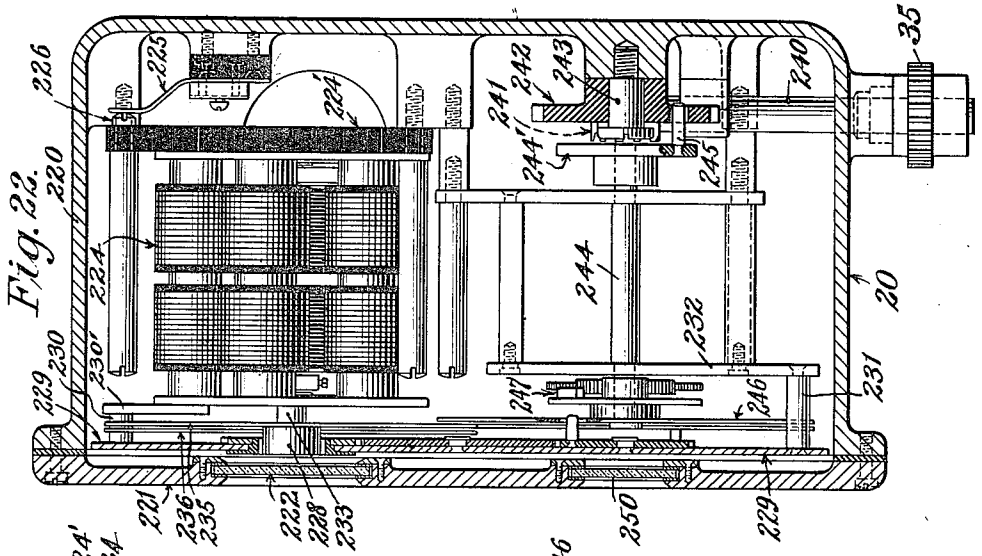


Fig. 22.

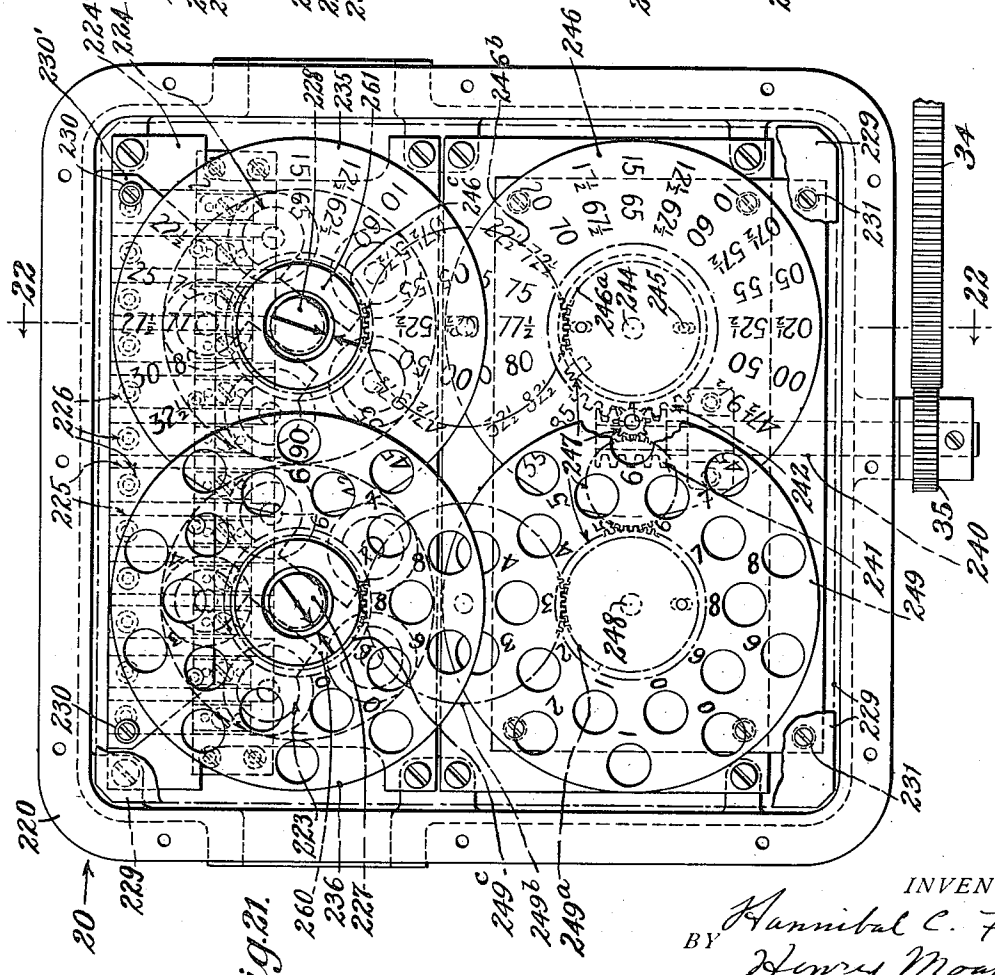


Fig. 21.

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Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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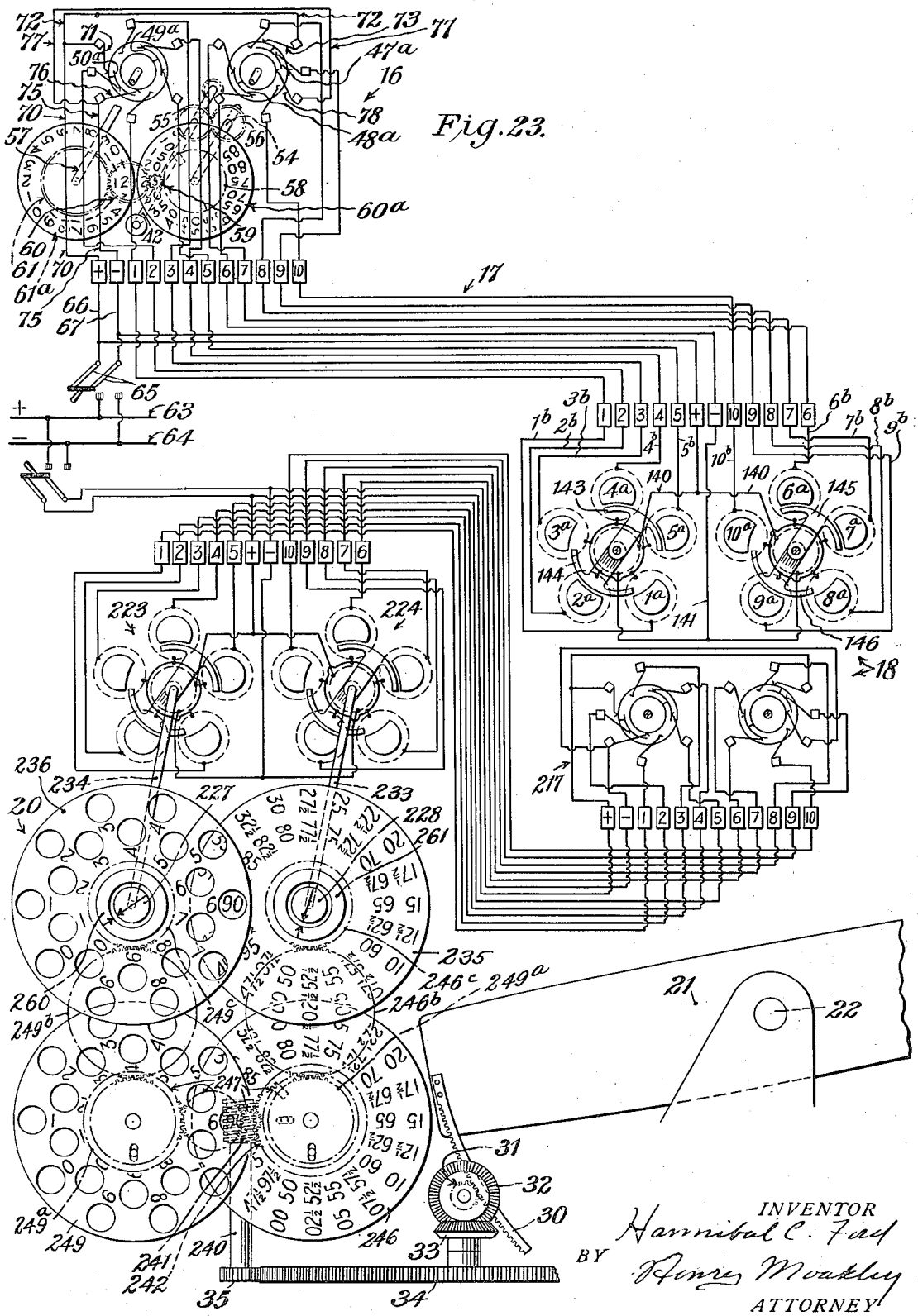


Fig. 23.

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BY Henry Woakley
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Jan. 12, 1932. H. C. FORD 1,840,497

DIRECTOR FIRING SYSTEM

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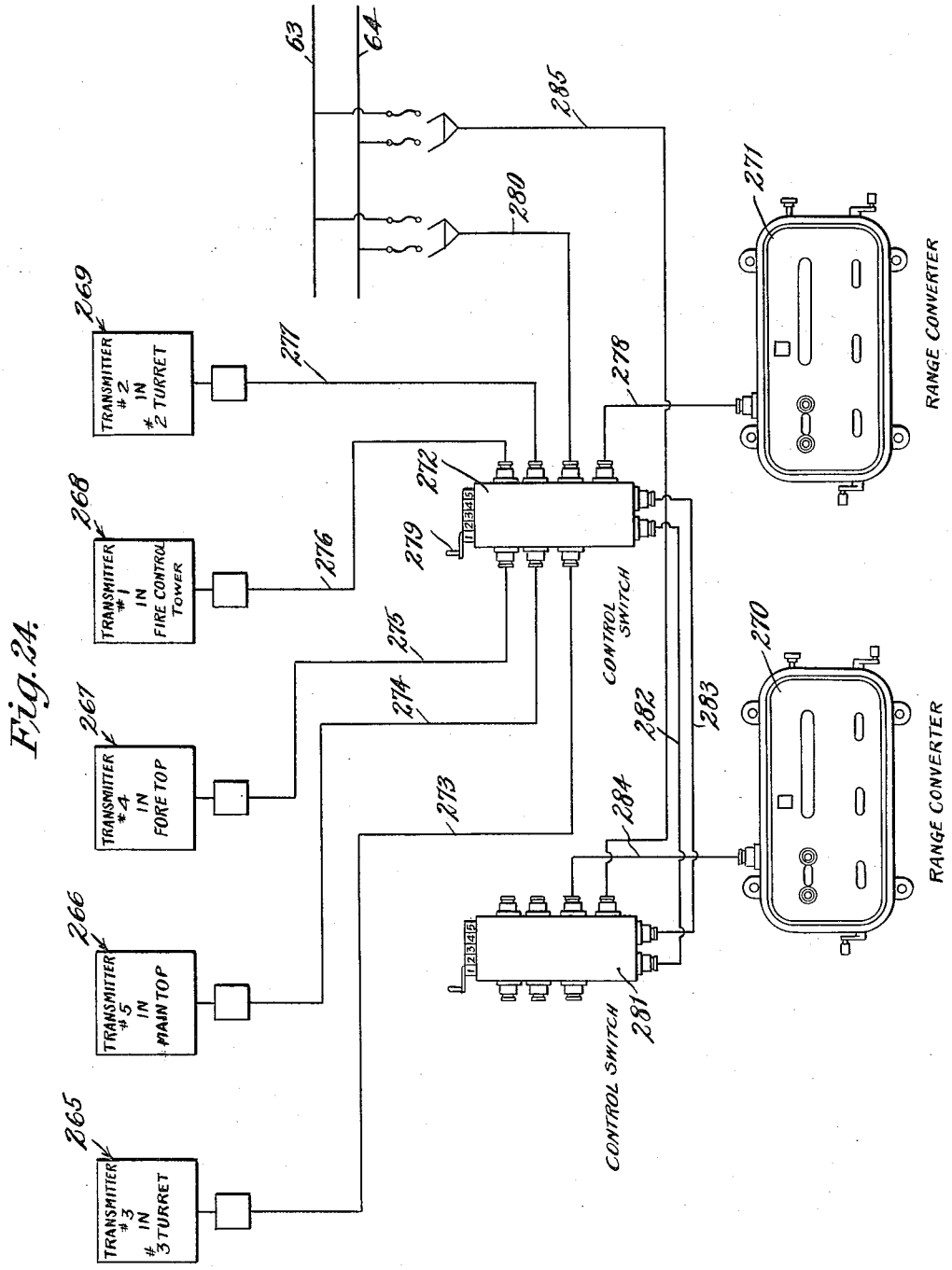


Fig. 24.

INVENTOR
Hannibal C. Ford
BY Henry Mosley
ATTORNEY

Patented Jan. 12, 1932

1,840,497

UNITED STATES PATENT OFFICE

HANNIBAL C. FORD, OF JAMAICA, NEW YORK, ASSIGNOR TO FORD INSTRUMENT CO., INC., OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

DIRECTOR FIRING SYSTEM

Application filed August 16, 1918. Serial No. 250,226.

This invention relates to fire control systems or more particularly to a system for controlling the sighting of a gun or guns of a battle-ship or other armored craft. The invention is particularly applicable to indirect fire.

As is well known, two of the main factors which control the sighting of a gun are the range and the directorscope angle. The angle of gun elevation corresponding to a given range does not vary directly proportional to the range but increases for equal increments of range as the range increases. The gun elevation is ordinarily computed from a horizontal plane and it frequently occurs that it is desirable or necessary to fire the gun or guns when the ship is inclined to the horizontal. For this reason a directorscope is used which measures the angle which the deck of the vessel makes with the horizontal plane when the shot is fired.

It is the purpose of the present invention to provide a system in which the directorscope angle and the range converted into an angle of gun elevation may be combined and the corrected angle transmitted to the gun so that the gun will throw a projectile the required range when it is fired with the vessel inclined to the horizontal.

Additional objects of the invention are to provide a system of this character which is flexible and which is not likely to be put out of action during a naval engagement.

Still further objects and advantages of the system will be apparent from the detailed description hereinafter to follow when taken in conjunction with the accompanying drawings and which will be particularly pointed out in the appended claims.

In the drawings:

Fig. 1 shows somewhat diagrammatically one embodiment of the invention;

Fig. 2 is a plan of the range converter;

Fig. 3 is a plan of the dials for indicating the gun elevation or the directorscope angle in minutes of arc;

Fig. 4 is a view similar to Fig. 2 with the top plate removed to show the interior mechanism of the range converter;

Fig. 4a is a detail of the stop for the drum-shifting plunger;

Fig. 5 is a section on the line 5—5 of Fig. 4, looking in the direction of the arrows;

Fig. 6 is a section on the line 6—6 of Fig. 4;

Fig. 7 shows the side elevation of the instrument, a portion of the casing being removed to more clearly show the parts;

Fig. 8 is a section on the line 8—8 of Fig. 6;

Fig. 9 is a section in the line 9—9 of Fig. 4;

Fig. 10 is a section on the line 10—10 of Fig. 4;

Fig. 11 is a detail showing a section on the line 11—11 of Fig. 10;

Fig. 12 is a section on the line 12—12 of Fig. 7;

Fig. 13 is a plan of one of the differential gears;

Fig. 14 is an end figure of the differential;

Fig. 15 is a front view of the differential;

Fig. 16 is a section on the line 16—16 of Fig. 4 looking in the direction of the arrows;

Fig. 17 is a section on the line 17—17 of Fig. 16 looking in the direction of the arrows;

Fig. 18 is a section of the directorscope transmitter on the line 18—18 of Fig. 1;

Fig. 19 is a section on the line 19—19 of Fig. 18 looking in the direction of the arrows;

Fig. 20 is a detail showing the dails and transfer mechanism therebetween;

Fig. 21 is a front view of the gun elevation indicator with the top plate removed to more clearly show the parts;

Fig. 22 is a section on the line 22—22 of Fig. 21;

Fig. 23 is a diagram of the electrical connections of the system, part of the mechanical instrumentalities being shown to fully identify the parts; and

Fig. 24 is a diagram showing the manner in which a plurality of transmitters and range converters are connected together.

Referring to Fig. 1, here a simplified form of one embodiment of the system is shown somewhat diagrammatically for the purpose of illustration, it being understood that the directorscope per se and gun elevating mechanism per se shown form no part of the invention. The directorscope shown is of

a well known type and comprises a periscope 1 which is mounted in a support 2, the latter in turn, being mounted upon trunnions 2′ carried by a sleeve 3 which is mounted upon a ring 4 secured to the conning-tower or other part of the vessel which is indicated at 5. The sleeve 3 is free to rotate in the ring 4 upon ball bearings 6 so that the periscope may be swung on its vertical axis to bear upon the target.

The sleeve 3 carries a rigid arm 7 and the support 2 which surrounds the periscope carries downwardly diverging arms 11 and 12 which are secured together at their ends by a rack 13, it being understood that the rack and periscope 1 swing together through the same angle. Mounted upon the arm 7 is a small gear 14 which meshes with the rack 13. This gear is secured upon a shaft 15 which shaft carries a larger gear 15′, also secured thereto. The gear 14 is driven by a directorscope angle transmitter 16 which is electrically connected by an electric cable 17 to a range converter 18. The rang converter is connected to an electric cable 19 to a gun elevation indicator 20 which is connected to the gun. In the illustration shown, the gun is designated 21 and is mounted upon trunnions 22. The gun may be elevated in any approved manner and in the construction shown, a motor 23 actuates the variable speed hydraulic gear 24 which is connected by worm gear 25 and gears 26 to the gun. The hydraulic gear is controlled by a hand wheel 27 in the usual manner, it being understood that this method of operating the gun is shown only for the purposes of illustration and forms no part of the present invention.

The gun elevation indicator is connected to the gun by means of a rack 30 which, through gear 31 and bevel gears 32 and 33 and spur gear 34, actuates a gear 35 which forms a part of the gun elevation indicator that will be hereinafter described in detail.

Referring now to the directorscope transmitter, the gear 14 which meshes with the rack 13, is mounted upon the support 7 for the periscope 1. To change the angle of the periscope 1, the gear 14 is rotated which will shift the movable rack 13 until the directorscope makes the desired angle with the deck of the vessel, and the amount which the periscope is shifted from the vertical, will give the directorscope angle, since this angle is equal to the angle which the deck of the vessel will make with the horizontal. The shifting of the periscope is accomplished through the gear 14 by the construction shown in Figs. 18, 19 and 20 of the drawings. Here the directorscope transmitter is shown in detail and comprises a casing 40 having a top plate 41. Passing through this closed casing is a shaft 42 which carries a gear 14*a*. The other end of the shaft also extends beyond the casing and carries a knurled head 43 by means of which the gear 14*a* is rotated. When rotated, gear 14*a* drives gear 15′ indicated in Fig. 1, thus turning the shaft 15 and the gear 14 mounted thereon, which in turn, acts on rack 13 to actuate the periscope. Mounted within the casing 40 is an electrical transmitter for transmitting the angle of the directorscope. This transmitter is of a similar construction to that shown in my United States Letters Patent for an electrical transmitter, granted May 3, 1927, and numbered 1,627,168.

The transmitter comprises a frame consisting of two plates of insulating material 45 and 46 which support between them two rotary contact switches, each consisting of two combined slip rings and contact segments designated 47, 48 and 49, 50, the segments of each pair being insulated from each other. Surrounding each of the rotary switches are a plurality of posts 51, each of which carries a contact brush 52. The rotary switch having segments 47 and 48 is mounted upon a shaft 54 which is driven from the shaft 42 by means of gears 55 and 56. As best shown in dotted lines in Fig. 19, a lever 55^a is pivoted to the wall of the casing and carries at its lower end a roller 55^b which is maintained in engagement with gear 55 by a spring 55^c attached at one end to the removable lever and at the other to a pin extending from the casing. Thus, as the rotary contact switches are turned, the roller 55^b snaps between the teeth of gear 55, and imparts a step-by-step rotation thereto. The rotary switch comprising contact segments 49 and 50 is mounted upon a shaft 57 which is driven through a transfer mechanism consisting of Geneva gears 58 and 59 and gears 60 and 61, the ratios between the gears being such that for a complete revolution of the shaft 54 the shaft 57 is driven a one-twentieth of a revolution. The shafts 54 and 57 carry dials 60^a and 61^a respectively. The dial 60^a is divided into twenty parts, the graduation being indicated by the numerals 00 to 95 and the dial 61^a is divided into a similar number of divisions and designated by numerals 0 to 19 inclusive.

These dials are utilized to give the directorscope angle in minutes of arc and for convenience one thousand minutes has been arbitrarily selected to correspond to the periscope when the periscope is directly perpendicular to the deck of the vessel, and readings below a thousand indicate that the directorscope is set to fire the guns when the deck of the vessel is inclined upwardly, with respect to the target, so that the directorscope angle must be subtracted from the angle of gun elevation.

Readings above one thousand indicate that the directorscope is set at an angle at which the deck of the vessel is inclined downwardly, with respect to the target, so that the directorscope angle must be added to the angle

of the gun elevation in order to correct the gun elevation for the directorscope angle. For example: in the present construction a reading of 1225 minutes is indicated by the directorscope, which corresponds to the position of the dot and dash line and which indicates that the deck of the vessel at the moment that the shell is to be fired from the gun will be tilted downwardly an angle of 225′ from the horizontal, which angle must be added to the gun elevation in minutes (which in Fig. 1 is shown to be 465′) to give the corrected gun elevation of 690′. By this construction directorscope angles of 1,000 minutes from from the horizontal in either direction may be obtained.

Referring now to the transmission system which is utilized to transmit the directorscope angle to the range converter 18, this system comprises a step-by-step transmission system, the transmitter of which has been described as consisting of rotary switches having contacts 47, 48, 49 and 50 which are surrounded by brushes 52 carried by posts 51. In Fig. 23 the electrical system of transmission used is clearly shown. Here the rotary contacts 47 and 48 are each shown as consisting of a slip ring and contact segments numbered 47*a* and 48*a*, respectively, the rotary contacts 49 and 50 of a similar construction, having contact segments 49*a* and 50*a*. The current for the transmission system is supplied by line wires 63 and 64 which connect to a cut-out switch 65 and are connected by wires 66 and 67 to the plus and minus terminal bars which are also disclosed in Fig. 19. These terminal bars are connected by wires (not shown) to posts or screws 68 which are each electrically connected by spring clips 69 to one of the posts 51, it being understood that similar posts and spring clips are utilized to electrically connect each of the terminal bars of the set shown in Fig. 19 and designated +, −, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10. These spring clips are shown in Fig. 18 and in dotted lines in Fig. 19.

Referring again to Fig. 23 it will be seen that the + terminal bar is connected by a wire 70 to a brush 71 which engages the slip ring connected to the contact segment 50*a* and by a wire 72 to a brush 73 which engages the slip ring electrically connected at segment 47*a* so that contact segments 50*a* and 47*a* are permanently energized with a current of positive polarity when the system is in operation. In the same manner the − terminal bar is connected by a wire 75 to a brush 76 which connects with the slip ring carrying the contact 49*a*. A wire 77 also connects the negative terminal to the brush 78 which engages the slip ring connected to the contact segment 48*a* so that the contact segments of each switch are normally engaged with opposite polarity. The terminal bars designated 1 to 5 inclusive are connected by wires to five brushes spaced equal distances around the contact segments 49*a* and 50*a* and the terminal bars designated 6 to 10 inclusive are electrically connected by wires to five similar brushes surrounding the contact segments 47*a* and 48*a*, the arrangement of the brushes being the same as in my Patent No. 1,627,168 referred to above. The terminal bars + and − and 1 to 10 inclusive are connected by wires in the cable 17 to the converter, the wires from each of the brushes passing to the poles of a step-by-step motor, which will be later described.

This range converter is clearly disclosed in Figs. 2 to 17 inclusive of the drawings and consists of a casing 80 having a bezel 81 and a glass cover plate 82 which forms a closed casing for the mechanism of the converter. As before stated, the function of the range converter is to convert the readings of range into angles of gun elevation and to correct the angle of gun elevation for the directorscope angle, and the mechanism for performing this function will now be described.

Secured to lugs extending from the inner walls of the casing are two supporting plates 83 and 84 which plates have secured to them side plates 85 and 86 which are held in spaced relation by tie rods 87. Mounted between the side plates 85 and 86 is a range drum 88 consisting of a hollow cylindrical body mounted upon a hollow shaft 89 which is supported at its ends upon ball bearings 90 and 91. The drum is loosely mounted upon this hollow shaft and has a longitudinal movement therealong, as will be later referred to. Secured to one end of the hollow shaft 89 (see Fig. 6) is a bushing 92 to which is fastened a gear 93 which gear is fixed against longitudinal movement but is secured to the range drum by dowel pins 94 which slide in openings in one of the side walls of the range drum whereby the drum is free to move longitudinally with respect to the gear but is constrained to rotate with it. The range drum is driven by a crank 95 which is permanently mounted in a bearing in the side wall of the casing. The shaft of this crank carries a disk 96 provided with a slot into which fits a pin 97 carried by a disk 98 mounted upon a shaft 99 to form a simple form of clutch between these parts. The shaft 99 is supported by the side plate 86 and an auxiliary side plate 100. The shaft 99 also carries a sleeve 101 upon which is formed a gear wheel 102 which meshes with a gear 102*a* that is also in mesh with the gear wheel 93 to drive the range drum when the crank 95 is turned.

The range drum carries two helically arranged rows of numerals which are spaced angular distances apart, proportionally to the gun elevations which they represent. To explain more fully, the angle to which a gun should be elevated in order to throw a pro-

jectile a required distance or range, is not directly proportional to the range, but requires greater changes in angular elevation at long ranges than at short ranges. In the present construction, one of these range scales is spaced angularly around the drum between each two ranges so that the angle is proportional to the required change in gun elevation for a corresponding range of a 14" gun having 2600 ft. seconds initial velocity. The other scale is spaced in accordance with the gun elevation required when firing under reduced charges or having 2000 ft.-seconds initial velocity. It is to be understood that by slightly varying the spacing of the range readings on the drum it may be used to indicate the angle required for any other type of gun.

The range drum is normally concealed by a top plate 103 which is supported from the plates 83 and 84 by posts 104. This top plate is provided with an elongated slot 105 (see Fig. 2) and supported upon a feed screw 106 is a shutter 107 which is provided with an opening therein through which one of the numerals on the drum is visible, this shutter being arranged behind the elongated slot 105. A ribbon 107' is connected at its ends to the shutter and conceals the portion of the drum which would otherwise be visible through the slot 105. The feed screw 106 is driven by a gear 107*a* which meshes with a gear 107*b* that is in mesh with the gear 93 carried by the range drum, so that as the range drum is rotated the shutter is moved longitudinally across the face of the drum to put the opening therein over the convolution of the helically arranged numerals upon the drum, so that range readings will appear behind the opening in the shutter.

For convenience two ciphers are placed upon the shutter to co-operate with the numerals upon the drum in order to avoid repeating the ciphers for each range reading; as for example, the shutter is shown co-operating with the numeral 134 which designates a range of 13400 yards. In the normal position of the drum the shutter co-operates with the ranges designating full charges and to indicate the reduced charges, the drum which is longitudinally movable upon the shaft 89, is displaced to bring the numerals of the convolutions of the other helical row of range readings beneath the opening in the shutter. This movement of the drum is accomplished by means of a sliding plate 110 which, as is clear from Fig. 4 and Fig. 6 is provided with flanges 111 and 112 engaging the ends of the drum to cause the drum to be displaced with the plate. The plate is held in its normal position by a spring 113, one end of which is carried by a post 114 secured to the plate 83 and the other end of which is secured to the post 115 carried by the sliding plate 110, the post 114 passing through a slot in the plate 110. A pin 114' secured to plate 83 and passing through another slot in plate 110, cooperates with pin 114 in guiding plate 110 when the latter is caused to slide (see Fig. 4*a*). When it is desired to use reduced charges, a knob 116 carried by a plunger 117 that is mounted in and passes through the casing, is pressed inwardly, whereupon the plunger 117 engages the end of the sliding plate 110 to move it and the range drum to the left, as shown in Fig. 4 and Fig. 6, in which position the sliding plate may be locked against the tension of the spring 113 by means of a pin 118 on the plunger 117 which engages the end wall of a shelf 119 carried by the casing wall. A stop pin 120 may also be provided to prevent the pin 118 being inadvertently rotated out of engagement with the shelf 119.

Mounted upon the posts 115 and 115' (see Fig. 5) is a plate 121 which carries the legends "14—2600 F. S. I. V., Full charge" and "14—2000 F. S. I. V., Reduced charge," which legends indicate that the two scales upon the drum are for 14" guns having 2600 and 2000 ft.-seconds initial velocity at full and reduced charges, respectively, (see Fig. 4). The top plate 103 is provided with an opening 122 behind which one of these legends appears, as will be clear from Figs 1 and 2, to indicate which range scale on the drum is co-operating with the shutter.

As before stated, the purpose of the unequal spacing of the range scale upon the range drum is for the purpose of converting the range into the angle of gun elevation. In the embodiment of the invention shown, the converted range is indicated in minutes of arc, as for example, from Fig. 1 it is evident that a range of 13,400 yards represents a gun elevation of 465 minutes for the particular gun for which the range scales upon the drum have been laid out. The manner in which the reading of gun elevation is obtained will now be described. Mounted upon the sleeve 101 which carries the gear 102 which drives the range drum, is a spiral gear 124 which spiral gear meshes with a corresponding gear 125 mounted upon a shaft 126. The shaft 126 is mounted between the supporting plate 84 and an auxiliary supporting plate 127. The shaft 126 also carries a dial 128 which is connected to a shaft 129 by a transfer mechanism 130, the shaft 129 carrying a second dial 131. The construction of this transfer mechanism is similar to that previously described, being such that for one revolution of the shaft 126, the shaft 129 makes a one-twentieth of a revolution. The dials 128 and 131 are numbered similarly to the dials shown in Fig. 3, that is, the dial 128 is provided with a scale running from 00 to 95 and the dial 131 is provided with a scale running from 0 to 19, so that readings of minutes of arc from 0 to 1995 may be obtained in steps of

five minutes. To insure a step-by-step movement of the dials 128 and 131 the shaft 99 which carries the gears 124 and 102, is provided with a detent wheel, which detent wheel, as clearly shown in Fig. 9 of the drawings, is formed by cutting teeth on the disk 98. A roller 133 co-operates with this detent and is mounted upon an arm 134, the roller being pressed against the detent wheel by a spring 135.

The operation of the converter so far described will be clear from the previous description but will be briefly referred to at this point to make the remaining description clear. When the full charge scale is being utilized the knob 116 is left in its normal position and the crank 95 is turned until the range corresponding to the range to which the gun is to be sighted, appears behind the opening in the shutter 107, it being evident that upon rotation of the crank and range drum the shutter 107 is fed by the screw 106 to maintain it in alinement with the numerals of the helical range scale. When the range corresponding to the range for which the gun is to be elevated appears behind the shutter, the corresponding gun elevation in minutes of arc is read from the dials 128 and 131 behind an opening 137 in the top plate 103, as will be clear from Figs. 1 and 2.

It is evident that by converting the range into minutes of arc for a corresponding gun elevation, the angle of the directorscope may be added or subtracted from the gun elevation to obtain the corrected gun elevation at which the gun should be sighted for a known range to correct for firing the gun when the vessel is inclined to the horizontal.

The construction for performing this addition or subtraction will now be described. As before stated, the directorscope angle is transmitted by means of the transmitter shown in Figs. 18, 19 and 20 of the drawings, to the range converter, the diagram of the electrical transmitter and its wiring connection to the range converter being shown in Fig. 23 of the drawings. This transmitter, as has been described, consists of two rotary switches, each of which is surrounded by five independent brushes which lead to the terminals designated 1 to 5 and 6 to 10 of the range converter, (see Fig. 23). This transmitter and wiring form a part of an electrical step-by-step transmission in which two step-by-step motors are utilized, of a similar construction to that shown in my United States Letters Patent for a signal system granted June 20, 1922, and numbered 1,420,030.

Briefly stated, one of the step-by-step motors consists of five poles designated 1*a*, 2*a*, 3*a*, 4*a* and 5*a* and the other one of five poles designated 6*a*, 7*a*, 8*a*, 9*a* and 10*a*, each of which poles is surrounded by two coils connected in series, which are connected by wires 1*b*, 2*b*, etc., to the corresponding terminals, as shown in Fig. 23 of the drawings. Each of the five pole motors is provided with a polarized armature also having two coils connected in series, which coils are connected to the plus and minus terminals by wires 140 and 141, the coils of the two armatures being in parallel. The armature itself which is surrounded by these coils is provided with two segmental-shaped pole pieces, these segmental-shaped pieces of one motor being designated 143 and 144 and the segmental-shaped pieces of the other motor being designated 145 and 146. These motors are of the same construction as that disclosed in my co-pending application for signal system before referred to, and provides a step-by-step signal system which is self-synchronizing and which gives twenty steps for a five pole motor. The self-synchronizing feature of the system will be clear, if it is considered that the brushes of the transmitter are connected to individual poles of the step-by-step motor and the armatures 143, 144, 145 and 146 of the motors are polarized which will insure that the armature will always be rotated in accordance with the energizations of the poles.

The mechanical construction of the terminals designated 1, 2, 3, 4, 5, +, and −, 10, 9, 8, 7 and 6 of the range converter, is clearly shown in Figs. 6 and 8. Each of the terminals, as for example the terminal 1, consists of a spring clip fastened to an insulated plate 150 which is mounted in the casing of the range converter upon posts 151. These spring clips engage terminals 152 mounted upon an insulated plate 154 which supports the step-by-step motors, the terminals 152 being connected to the coils of the poles of the motor, as indicated in Fig. 23. It will also be clear from Fig. 6 that the poles of the motors are rigidly united by plates 156 and 157 and the two motors connected together by a tie plate 157′. The armature shaft which carries the armatures 143 and 144 is designated 158 and carries a small head 159. The armature shaft 158′ which carries the armatures 145 and 146 is provided with a similar head designated 160. These heads extend to the openings in the top plate 103 and are provided with arrows, as is indicated in Figs. 1 and 2 of the drawings. The shafts 158 and 158′ also carry dials 161 and 162 which dials are of the same construction as the dials shown in Fig. 3 of the drawing. The numerals on these dials appear behind an opening 165 in the top plate 103 (see Figs. 1 and 2), and the electrical transmission system described is such that the angle of the directorscope will be repeated in the converter, in intervals of five minutes from 1000 up to 1995 and from 1000 down to 0, corresponding to the directorscope angle of the transmitter 16. As for example, in the present construc-

tion, each set of dials reads 1225′ which indicates that the guns are to be fired when the vessel is inclined downwardly toward the target at an angle of 225 minutes of arc.

Referring now to Fig. 2, it will be seen that in addition to the dials of the receiver motors which are electrically connected to the directorscope transmitter, is a second set of dials designated 170 and 171, which dials are of the same construction as those shown in Fig. 3, the dials being mounted upon shafts 172 and 173 respectively. These shafts are mounted between upper and lower plates 175 and 175*a* respectively, which are joined by vertically disposed plates 175*b*. Shafts 172 and 173 are also connected by a transfer mechanism 174 which is such that each time the dial 171 makes a complete revolution, the dial 170 makes a one-twentieth of a revolution. Upper and lower plates 175 and 175*a* respectively, together with the upright plates or posts 175*b*, form a frame that not only supports vertical shafts 172 and 173 and their interconnecting transfer mechanism 174, but also affords a support for a shaft 182, the vertical plates 175*b* serving as bearings therefor. The frame formed by plate 175 and associated parts is removable independently of plate 84 but normally is secured thereto by a small plate 177 (see Fig. 4) and is mounted upon lugs 176 in the casing. The shaft 173 carries a spiral gear 180 which meshes with a second spiral gear 181 mounted upon a shaft 182. The shaft 182 is rotated by means of a crank 183 mounted upon the shaft 184 which is connected to the shaft 182 by means of a clutch consisting of two disks 185 and 186 which are united by a pin and slot connection, similar to the disks 96 and 98 so that the plate 175 and dials 170 and 171, etc., may be removed without disturbing the handle 183. The dials 170 and 171 in the operation of the device, are turned until the same numerals on the dials 170 and 171 appear behind the opening 182′, as appear on the dials 161 and 162 behind the opening 165, which latter dials, as described, are actuated by the step-by-step receiver motors.

To aid in synchronizing the readings of the two dials, a "follow-the-pointer" indicator is preferably used. This indicator consists of the heads 159 and 160 carried by the armature shafts of the receiver motors and rings 159*a* and 160*a* surrounding these heads. As shown in Figs. 16 and 17 of the drawings, the ring 160*a* is formed with a bushing 187 that is rotatable in an opening in the top plate 103. The bushing 187 is secured to a gear 188 which meshes with an intermediate gear 189 which, in turn, meshes with a gear 190 having a pin 191 fitting into a slot in the dial 171. The heads 159 and 160 are displaced angularly a similar amount to the dials 161 and 162 and when the crank 183 is turned to cause the reading before the opening 182′ to correspond with the reading before the opening 165, the rings 159*a* and 160*a* will also be rotated and when the same reading appears before both openings, the arrows carried by the heads 159 and 160 will appear opposite the arrows carried by the rings 159*a* and 160*a* which will indicate that the readings of both dials are identical. In practice it has been found more convenient to follow two pointers of this character than to compare the two separate readings, although it is evident that this "follow-the-pointer" indicator is not essential to the operation of the system.

As before stated, the dials 170 and 171 are rotated by means of the shaft 182 through spiral gears 180 and 181. It is therefore evident that the angular displacement of the shaft is proportional to the directorscope angle and as has already been described, the angular displacement of the shaft 99 is proportional to the angle of gun elevation. If therefore, the angular displacement of these two shafts is added or subtracted, a resultant angular displacement will be obtained which is proportional to the corrected gun elevation. This is accomplished by means of the construction shown in Fig. 7 of the drawings. The shaft 182 is connected by means of two disks 182*a* and 190*a* having a pin and slot connection between them, to a shaft 190. This shaft carries a gear 191 and the shaft 99 carries a similar gear 192. The gears 191 and 192 mesh with gears 193 and 194, respectively. The gears 193 and 194 are loosely mounted upon a shaft 195 and form a part of a differential gear which is shown clearly in Figs. 13, 14 and 15. The center of the differential comprises a spider 196 which is fastened to the shaft 195. This spider carries two sets of pinions, one set being indicated 197 and 198 and the other set being indicated 199 and 200. The pinion 199 meshes with the gear 193, the pinion 200 with the gear 194; the pinions 199 and 200 are in mesh with each other. Similarly, pinions 197 and 198 are in mesh with each other, pinion 197 also meshing with gear 194 and pinion 198 with gear 193. These gears form a spur differential of a well known type so that the center of the differential will be displaced an amount which is proportional to the sum or difference of the angular displacements of the gears 193 and 194, depending upon whether the angular displacements of the gears 193 and 194 are in the opposite or in the same direction. The differential gear, will, therefore, add or subtract the angular displacements of shafts 182 and 99, or in other words will add or subtract the directorscope angle and the angle of gun elevation and the center of the differential may therefore be utilized to drive a set of dials for indicating the corrected gun elevation. In Fig. 7 the center of the differential which is

mounted upon the shaft 195, drives a gear 203 which is fastened to the shaft. This gear meshes with a gear 204 upon a sleeve 205 which is loosely mounted upon the shaft 190. The sleeve 205 also carries a spiral gear 206 which meshes with a spiral gear 207 upon a shaft 208, which shaft carries a dial 209 and is connected by a transfer mechanism 210 to a shaft 211 which carries a dial 212, the dials 209 and 212 being similar to the dials shown in Fig. 3 of the drawings, and since they are driven from the center of the differential, it is evident that numerals appearing before the opening 206*a* in the top plate (shown in Figs. 1 and 2), will indicate the corrected gun elevation in minutes of arc, which should be transmitted to the gun.

The system thus far described is capable of being utilized as a unit without the other features of construction to be hereinafter described, it being evident that the corrected gun elevation in minutes of arc appearing before the opening 206*a*, may be transmitted to the gun in order to set the same in any desired manner, as for example, by telephone or any other type of signal transmission system.

In practice, however, it is desirable to connect the range converter by a step-by-step electrical transmission system, to the gun and in Fig. 7 the shaft 195 is shown provided with a crown gear 215 which drives a gear 216 of a transmitter 217, which is of the same construction as the transmitter shown in Fig. 18 which has already been described. This transmitter is electrically connected, as shown in the wiring diagram in Fig. 23, to the gun elevation indicator.

The gun elevation indicator is shown in Figs. 21 and 22 and consists of a casing 220 provided with a cover plate 221 having a sight opening 222 therein. Mounted within the casing is a pair of receiver motors 223 and 224, which are of the same construction as the receiver motors in the range converter and in my co-pending application for signal system No. 1,420,030, before referred to.

These receiver motors, 223 and 224 are mounted on a plate 224′ of insulating material which is secured to lugs in the casing. The electrical connections to the coils of the receiver motors are made through spring clips 225 which engage terminal posts 226 so that the motor may be readily removed from the casing. The armature shafts of the receiver motors are provided with heads 227 and 228 which form a part of a "follow-the-pointer" indicator, similar to the one previously described. These heads project through openings in a top plate 229 and the top plate 229 is supported at one end by posts 230 secured to a tie plate 230′ that connects the frames of the receiver motors and at the other end by posts 231 mounted upon a frame 232 which also is secured to lugs in the casing. The armature shaft which carries the head 228 is designated 233 and the shaft which carries the head 227 is identified by numeral 234 (see also Fig. 23). These shafts carry dials 235 and 236 respectively, which are arranged in over-lapping relation, as shown in Fig. 21. The dial 235 is provided with two annular scales, one running from 00 to 47½ in 2½ minute steps and the inner row running from 50 to 97½ in half minute steps. The other dial, namely 236, is provided with two annular rows of openings and the dials are disposed in such a relation that the opening of the outer row of holes will be brought over the indications of the inner scale upon the dial 235, while the inner row of holes will come into alinement with the outer scale on the dial 235. Each annular row of holes is also supplied with a scale running from 0 to 9. When, therefore, the dial 235 is rotated for the first rotation of the dial, the outer scale will co-operate with one of the holes in dial 236 to give readings from 0 to 47½ and then the dial 236 will make a one-twentieth of a revolution to bring the hole of the outer row into position where the numerals 50 to 97½ will appear successively behind the hole. In this manner readings of 2½ minute steps each may be obtained from 0 to 997½ which will designate in minutes of arc the gun elevation as for example, in the embodiment of the invention shown, it will be seen that the gun elevation of 690′ in the converter will be repeated by the electrical transmission shown and a corresponding reading will appear before the opening 222 in the gun elevation indicator.

Referring now to the system whereby the elevation of the gun is indicated, by a second set of dials to enable the gun pointer to determine when the gun has been properly set: As before stated, the gun is provided with a rack 30 which drives, through intermediate gears, the pinion 35 of the gun elevation indicator. This pinion is shown in Fig. 22 of the drawings as being mounted upon a shaft 240, which shaft carries a worm 241 which meshes with a worm wheel 242 mounted upon a stud shaft 243. Mounted in the frame 232 is a shaft 244 having affixed thereto a disk 244′ which is connected by a pin 245 to the gear 242. The shaft 244 carries a dial 246 which is similar to the dial 235 and is connected by a transfer mechanism 247 to a shaft 248 which carries a dial 249, similar to the dial 236. When the gun is elevated by the control mechanism shown, the amount of angular elevation of the gun will be indicated by the two dials 246 and 249, which are read behind an opening 250, it being evident that when the reading appearing before the opening 250 corresponds to the reading appearing before the opening 222, the gun has been properly sighted.

In order to expedite the pointing of the gun, a "follow-the-pointer" system is preferably utilized which is in all respects similar to the "follow-the-pointer" system utilized in the range converter consisting of the heads 227 and 228 carried by the armature shafts of the repeater motors, which heads are surrounded by rings 260 and 261 which are geared to the dials 246 and 249. When the dials are rotated the rings will therefore be displaced a similar amount, or in other words, when the arrows on the heads and rings appear opposite each other, as shown in these views, the gun pointer will be informed that the gun has been properly pointed without necessitating the comparing of the readings upon the dials.

Referring again to the range converter, it will be noted that, when crank 183 is rotated, the consequent turning of shaft 182 and disk 182*a* results in the rotation of disk 190*a* that has a pin and slot connection with the disk 182*a*. As shown in Fig. 10, the pentagonal disk 190*a* constitutes, in effect, a five-tooth ratchet wheel, which co-acts with roller 190*b* carried by lever 190*c* that is pivoted to side plate 85. A spring 190*d* attached at one end to a pin projecting from plate 85 and at the other end to lever 190*c*, keeps the roller 190*b* carried by that lever in engagement with disk 190*a*.

As this disk is rotated, it in turn rotates shaft 190 in steps of $\frac{1}{5}$ of a revolution, which, as will be explained, causes the transmitter 217 to transmit to the gun elevation instrument 20, shown in Figs. 21 and 22, in such manner that this instrument will give gun elevation readings varying by five minutes of arc. This is evident, since, as each step of disk 190*a* represents a five-minute of arc step, the 2:1 ratio of gear 191 on shaft 190 to gear 193 of the differential raises the rate of transmission to 10 minutes, the center of the differential comprising pinions 197 to 200, inclusive and spider 196 rotating at half the speed of gear 193, then restoring the transmission rate to 5 minutes. This is carried to transmitter 217 by shaft 195 to which spider 196 is screwed and by crown gear 215 meshing with the transmitter gear 216.

Reference to the disks of the gun elevation instrument, as illustrated in Fig. 21, shows that the dials are angularly divided into twenty sub-divisions and that dials 235 and 246 give gun elevation readings from 00 to 97½, i. e., a total of 100 minutes. This number of minutes divided by the twenty sub-divisions referred to, gives the five minute steps which the just described transmission from crank 183 of the range converter has been shown to be arranged to give.

But it will also be observed that dials 235 and 246 are arranged to give readings in steps of 2½ minutes and reference to dial 246 may be dispensed with, since it is controlled by the gun pointer and not from the range converter. Dial 235 gives changes in gun elevation in steps of 2½ degrees when handle 95 of the range converter is operated. As disk 98, which is a ten-tooth ratchet wheel, is turned, the shaft 99 is rotated $\frac{1}{10}$ of a revolution, which corresponds to a change of gun elevation reading amounting to 2½ minutes. The gear 192 drives gear 194 of the differential and as the gear ratio is 2:1 the rate of transmission is raised to 5 minutes. This rate is again reduced to 2½ minutes, since the center of the differential, as previously set forth, rotates at half the speed of gear 194 under these conditions. As before stated, the transmission drive to transmitter 217, is, by shaft 195, crown gear 215 and transmitter gear 216, but as shown, in steps giving 2½ minutes of arc, changes in gun elevation reading.

The operation of the system will be clear from the previous description but will now be briefly referred to. The handle 43 of the directorscope transmitter 16 is first turned to set the periscope 1 at the desired angle to the deck of the ship corresponding to the angle to the horizontal at which it is desired to fire the gun. The actuation of the handle 43 not only actuates the periscope 1 but also actuates the electrical transmitter which has been described in detail and which energizes the step-by-step repeater motor in the range converter so that a corresponding reading appears behind the opening 165 in the range converter. The range converter which is preferably disposed in the plotting room or at a point remote from the directorscope, is then operated by turning the handle 95 until the range reading appearing behind the shutter 107 corresponds to the range for which the guns are to be sighted, which will convert the range reading into a corresponding angle of gun elevation readable in minutes of arc, which may be read behind the opening 137 in the converter. The handle or crank 183 is also actuated to synchronize the readings of the dials behind the openings 165 and 182′. In this operation the "follow-the-pointer" system consisting of heads 159 and 160 and rings 159*a* and 160*a* with the arrows carried by these parts may be utilized instead of comparing the readings upon the dials as has been described. The rings 159*a* and 160*a* should be rotated until the arrows are again opposite each other. The differential gearing within the converter will then add or subtract these two readings and give the corrected gun elevation to send to the gun. The corrected gun elevation is electrically transmitted to the gun elevation indicator by means of the step-by-step transmission system described. The gun pointer then actuates the variable speed hydraulic gearing and sets the gun so that the two readings of gun elevation appearing

before the openings in the gun elevation indicator are the same. In this construction the "follow-the-pointer" head and ring are preferably utilized to expedite the setting of the gun.

Referring now to Fig. 24 of the drawings, a schematic arrangement for a battleship is shown which may be utilized in practice. Here a plurality of transmitters is shown which are indicated 265, 266, 267, 268 and 269. These transmitters are designated by proper legends indicating the positions of the indepedent directorscopes on the battleship. A plurality of range converters are also shown, which are indicated 270 and 271. The cables running from the respective transmitters instead of being directly connected to the range converter as shown in Fig. 1, pass to a control switch 272, the transmitter 265 being connected to this control switch by a cable 273; the transmitter 266 by a cable 274; the transmitter 267 by a cable 275; the transmitter 268 by a cable 276 and the transmitter 269 by a cable 277. The control switch 272 is connected to the range converter 271 by a cable 278, it being understood that by operating the handle 279 of the control switch any one of the transmitters may be directly connected to the range converter the type of control switch suitable for this purpose being disclosed in my United States Letters Patent granted June 12, 1923 and numbered 1,458,284. The circuit controller or control switch 272 is connected to the line wires 63 and 64 by a cable 280. A second control switch 281 may also be utilized and cables 282 and 283 connect corresponding contacts within these control switches in parallel. This circuit controller 281 is connected by a cable 284 to the range converter 270. The control switch 281 is also connected to the line wires 63 and 64 by a cable 285.

Since the contacts in the control switches are connected in parallel, it is evident that if desired, any one of the transmitters may be connected to one of the control switches and the other control switch thrown to its off or disconnected position. If desired, however, one of the transmitters may be connected to one control switch and its respective range converter and any one of the other transmitters connected to the other control switch and its converter. In this manner a flexible system of fire control is obtained which will permit of divided firing, that is, permit the fire of the guns to be directed at two different targets, or one of the control switches and corresponding range converter may be thrown out of action by disconnecting and connecting the control switch and the single converter used with any one of the directorscopes.

It is obvious that the invention as defined in the appended claims may be otherwise embodied than in the specific form disclosed herein. For instance, while the quantities which are referred to are shown as elevation factors measured in a vertical plane of reference the invention is of course equally applicable to quantities in other than a vertical plane and it is equally obvious that other changes may be made in the specific construction within the principles and scope of the invention as defined in the appended claims.

I claim:

1. In a fire control system, mechanical means for converting range into an angle of gun elevation, means for determining the directorscope angle and means for adding or subtracting the directorscope angle to or from the angle of gun elevation and means for transmitting the corrected gun elevation to the gun.

2. In a fire control system, means for transmitting the directorscope angle to a station remote from the directorscope, means at said station for converting range into an angle of gun elevation, and means for adding the directorscope angle to the angle of gun elevation or for subtracting it therefrom, and means for transmitting the sum or difference of said angles to a distant gun.

3. In a fire control system, means for transmitting the directorscope angle to a remote station, a device at said station for measuring the directorscope angle having a part whose displacement is proportional to the directorscope angle, a device at said station for converting range into gun elevation, having a part whose displacement is proportional to the angle of gun elevation for a given range and connections between said parts for adding the displacement of said first named part to said second named part, or for subtracting it therefrom.

4. In a fire control system, means for transmitting the directorscope angle to a remote station, a device at said station for measuring the directorscope angle, having a part whose displacement is proportional to the directorscope angle, a device at said station for converting range into gun elevation, having a part whose displacement is proportional to the angle of gun elevation for a given range, and differential gearing between said parts for adding the displacement of said first named part to said second named part or for subtracting it therefrom.

5. In a fire control system, means for transmitting the directorscope angle to a remote station, a device at said station for measuring the directorscope angle, having a part whose displacement is proportional to the directorscope angle, a device at said station for converting range into gun elevation, having a part whose displacement is proportional to the angle of gun elevation for a given range, and differential gearing between said parts for adding the displacement of said first named part to said second named part,

or for subtracting it therefrom, and means for indicating the sum or difference of said angular displacements in terms of gun elevation.

6. In a fire control system, means for transmitting the directorscope angle to a remote station, a device at said station for measuring the directorscope angle, having a part whose displacement is proportional to the directorscope angle, a device at said station for converting range into gun elevation, having a part whose displacement is proportional to the angle of gun elevation for a given range, and differential gearing between said parts for adding the displacement of said first named part to said second named part, or for subtracting it therefrom, and means for indicating the sum or difference of said angular displacements in terms of gun elevation, and means for transmitting said last named gun elevation to a gun.

7. In a fire control system, an instrument for determining the sum or difference of the gun elevation and the directorscope angle, a plurality of directorscopes and an electrical transmission connecting any one of said directorscopes to said instrument.

8. In a fire control system, an instrument for determining the sum or difference of the angle of gun elevation corresponding to a given range and the directorscope angle, a plurality of directorscopes, and electrical means for connecting any one of said directorscopes to said instrument.

9. In a fire control system, an instrument for determining the sum or difference of the angle of gun elevation corresponding to a given range and the directorscope angle, a plurality of directorscopes and means for electrically connecting any one of said directorscopes to said instrument.

10. In a fire control system, a plurality of independent directorscopes, a pair of electrical transmitters having transfer mechanism therebetween and operatively connected to each directorscope for transmitting the angle of the directorscope, a pair of self-synchronizing receiver motors at a station remote from the directorscope, means for selectively connecting the receiver motors to the transmitters and the directorscopes connected thereto and indicating devices associated with the motors for showing the angle of the directorscope to which the motors are connected.

11. In a fire control system, a plurality of instruments for combining the gun elevation corresponding to a given range and the directorscope angle, a plurality of directorscopes and means for electrically connecting any one of said directorscopes to any one of said instruments.

12. In a fire control system, a plurality of instruments for combining the gun elevation corresponding to a given range and the directorscope angle, a plurality of directorscopes and an electrical transmission system for connecting any one of said directorscopes to any one of said instruments.

13. In a fire control system, a plurality of independent directorscopes, operating mechanism for each directorscope, mechanism associated with each directorscope for indicating the angle thereof comprising a pair of dials having transfer mechanism therebetween, an electrical transmitter operatively associated with each of the dials, a pair of self-synchronizing receiver motors, means for selectively connecting the receiver motors to the pairs of transmitters of the several directorscopes and dials actuated by the receiver motor for repeating the reading of the dials at the directorscope to which the motors are connected.

14. In a fire control system, means for converting range into an angle of gun elevation having a part movable proportional to the angle of gun elevation, means for displacing a second part proportional to the angle of the directorscope and means for determining the sum or difference of said displacements, and means for indicating the sum or difference in terms of an angle of gun elevation.

15. In a fire control system, an instrument comprising a movable range scale graduated variably in proportion to the angles of gun elevation, means for displacing said scale having a part whose displacement is proportional to the angle of gun elevation, a second part having a displacement proportional to a directorscope angle and means for determining the sum or difference of the displacements of said parts.

16. In a fire control system, a range drum having a spirally arranged scale thereon graduated proportional to corresponding angles of gun elevation, means for rotating said drum, means for indicating successive range readings of said range scale when said drum is rotated, a part connected to said drum having a displacement proportional to the displacement of said drum, a second part adapted to be connected to a directorscope having a displacement proportional to the directorscope angle and means for determining the sum or difference of the displacement of said parts.

17. In a fire control system, a range drum having a spirally arranged range scale thereon graduated proportionally to corresponding angles of gun elevation, means for rotating said drum, means for indicating successive range readings on said drum when rotated, a part connected to said drum having a displacement proportional to the displacement of said drum, a second part, means for displacing said second part proportional to a factor affecting the angle of gun elevation and means for determining the sum or difference of said angular displacements.

18. In a system for controlling a gun from a distance, an angularly displaceable part, means for angularly displacing said part proportionally to the range for which the gun is to be laid, a second angularly displaceable part, means for displacing said second part proportionally to a factor affecting the angle of gun elevation, differential gearing connecting said parts for determining the sum or difference of said angular displacements and an indicator having an element actuated by the gearing and an element actuated by the movement of the gun.

19. In a fire control system, a range drum having a spirally arranged range scale thereon graduated proportionally to corresponding angles of gun elevation, means for rotating said drum, means for indicating successive range readings of said scale when said drum is rotated, a part connected to said drum having a displacement proportional to its angular displacement, a second part, means for angularly displacing said second part proportional to a factor affecting the angle of gun elevation and mechanism for indicating the sum or difference of said angular displacements in terms of an angle of gun elevation.

20. In a fire control system, means for converting range into a corresponding angle of gun elevation having an angularly displaceable part, means for angularly displacing a second part proportionally to an angle which affects the gun elevation and differential gearing connecting said parts for determining the sum or difference of their displacements.

21. In a fire control system, a gun elevation indicator comprising a pair of step-by-step receiver motors, means for electrically connecting said receiver motors to a remote station, a pair of co-operating dials for indicating the angle of gun elevation, a gun, a second pair of co-operating dials for indicating the angle of gun elevation and a pair of rotary heads, a pair of rotary rings surrounding said heads, connections between one of said pairs and said receiver motors and connections between said pairs and a member adapted to be set in accordance with the angular displacement of said motors and said heads, and rings carrying co-operating parts for indicating when they have been angularly displaced equal amounts.

22. In a fire control system, a gun elevation indicator including a receiver motor adapted to be actuated from a remote point, a dial operatively connected to the motor for indicating the desired gun elevation, a member associated with the dial and bearing an index, a gun, an element provided with a dial for showing the existing elevation of the gun, connections between the gun and the element, and a member associated with the element and bearing an index, said index bearing members being so related as to permit one index to be brought into registry with the other index to show when the existing elevation of the gun agrees with the desired elevation.

23. In a director firing system, a plurality of independent gun controlling directors located at different stations, an electrical transmitter operatively associated with each director, an indicating instrument remote from the director stations and having a receiver motor, circuits for connecting the motor to the transmitters, said motor being self-synchronizing when electrically connected to any one of said transmitters, and a circuit controller for selectively connecting the motor to the transmitters and associated directors.

24. In a director firing system, a plurality of independent gun controlling directors at different stations, an electrical transmitter operatively associated with each director, a receiver motor located at a point remote from the stations and which is self-synchronizing when electrically connected to any one of the transmitters, a circuit controller for selectively connecting the motor to the transmitters and associated directors, an instrument having a part mechanically connected to the gun to be controlled, and a part adapted to be actuated in accordance with a function of the movement of the receiver motor and means associated with each of the parts and adapted to cooperate with each other to give continuous indications of the relation between the transmitter and the gun.

25. In a director firing system, an apparatus to be controlled from a distant station, a controlling director at the station, a transmitter associated with the director, an instrument having an element responsive to a factor of the desired adjustment of the apparatus as determined by the director and an element responsive to another independent factor of the desired adjustment of the apparatus and means responsive to the joint effect of said elements and the existing adjustment of the apparatus for indicating differences between the desired and existing adjustments.

26. In a director firing system, a plurality of gun controlling directors, an independent gun to be selectively controlled thereby, an element responsive to the desired adjustment of the gun as determined by the controlling director, an element responsive to the existing adjustment of the gun, a pair of co-operating members each bearing an index mark and adapted to be controlled by the elements to indicate by the relative positions of the marks the direction and amount by which the adjustments differ and means for selectively connecting the first named element in operative relation to any one of the directors.

27. In a director firing system, a plurality

of controlling directors, a plurality of devices to be selectively controlled thereby, a transmitter associated with each director and operable in accordance with the desired adjustment of the device, a pair of elements responsive to the transmitter, a pair of elements responsive to the existing adjustment of the device, pairs of co-operating indicators adapted to be controlled by one of the elements of the first pair and one of the elements of the second pair in pairs to indicate by their relative position the divergence between the desired and existing adjustments and means for selectively connecting the first named pair of elements to the transmitter of any one of the directors.

28. In a fire control system, an apparatus to be controlled from a distant station, an instrument having a part adapted to be displaced angularly in accordance with one factor of the required adjustment of the apparatus and a second part adapted to be displaced angularly in accordance with a second independent factor of the required adjustment of the apparatus, means connecting said parts for determining the sum or difference of their displacements and an indicator having an element actuated by said means and an element actuated by the movement of the apparatus.

29. In a fire control system, a plurality of independent controlling devices, an apparatus to be controlled by said devices, an instrument for determining the sum or difference of a factor of the desired adjustment of the apparatus as determined by a controlling device and another independent factor affecting the adjustment of the apparatus and means for selectively connecting the instrument in operative relation to any one of the controlling devices.

30. In a fire control system, a plurality of independent controlling devices, a plurality of devices to be controlled therefrom, an instrument for determining the sum or difference of a factor of the desired adjustment of a controlled device as determined by a controlling device and another independent factor affecting the desired adjustment of the controlled device and means for selectively connecting the instruments singly or collectively to any of the controlling devices.

31. In a director firing system, a plurality of controlling directors located at different stations, a transmitter associated with each director, an apparatus to be selectively controlled by the directors, an instrument having an element responsive to a factor of the desired adjustment of the apparatus as determined by a director and an element responsive to another factor of the desired adjustment of the apparatus, means responsive to the joint effect of said elements and the existing adjustment of the apparatus for indicating differences between the desired and existing adjustments and means for selectively connecting the first named element of the instrument to any one of the transmitters.

32. A system of gun fire control comprising a plurality of directors, a plurality of guns, and means whereby said guns may be operated under the control of any one of said directors and the control transferred without delay from one director to another regardless of the angular relation of said directors.

HANNIBAL C. FORD.

CERTIFICATE OF CORRECTION.

Patent No. 1,840,497. January 12, 1932.

HANNIBAL C. FORD.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 7, line 46, for the words "co-pending application" read Patent; page 9, line 32, after "Patent" insert the words for Circuit Controller; page 11, line 117, claim 26, before "gun" insert the word independent and in same line for the words "an independent" read a; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of November, A. D. 1932.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.