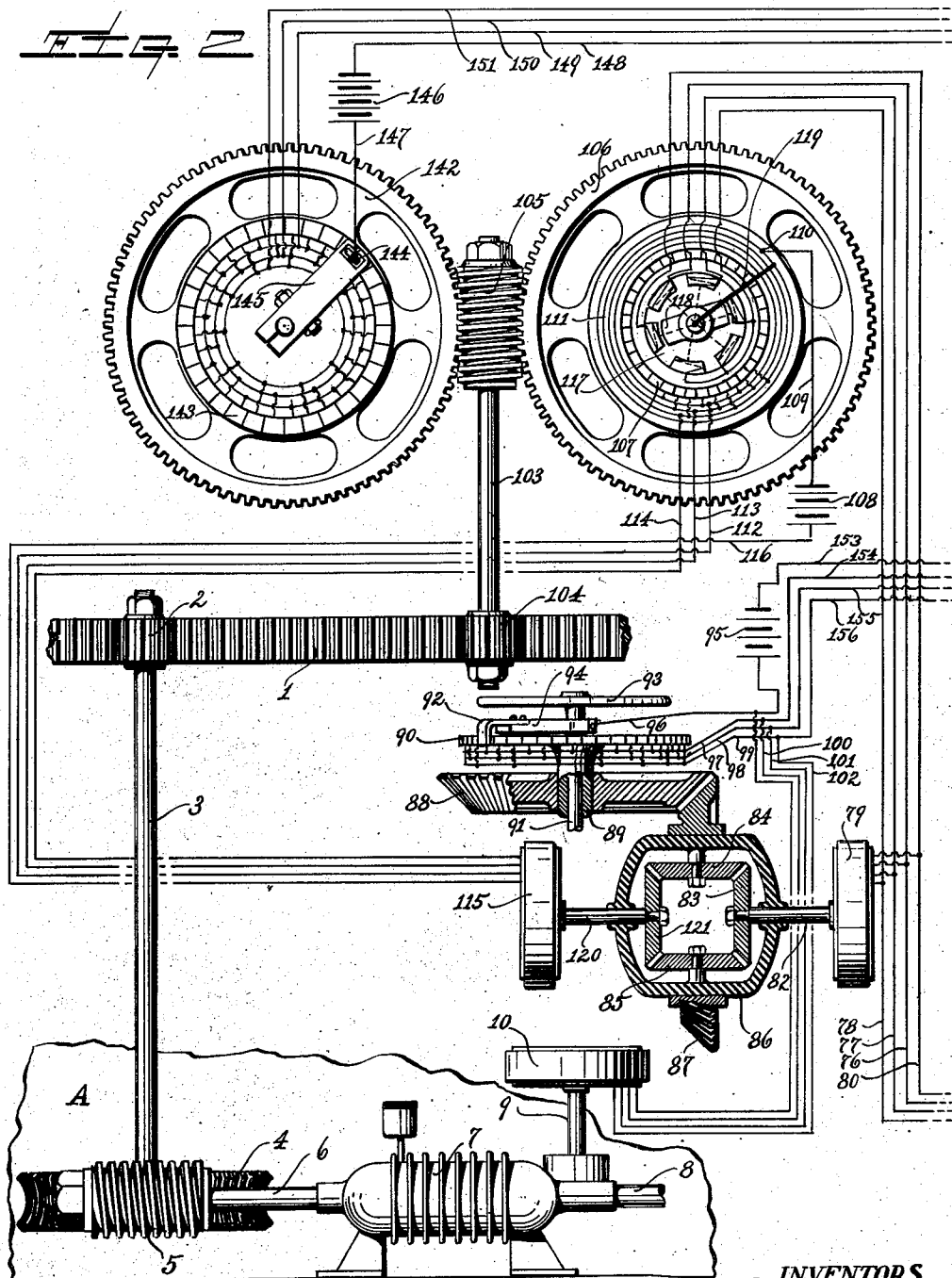




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**1,559,566**

25. **S. A. FARRELL ET AL**  
MEANS FOR CONTROLLING THE MOVEMENTS OF ORDNANCE MEMBERS,  
SIGHTING INSTRUMENTS, AND THE LIKE  
Filed Dec. 18, 1919 5 Sheets-Sheet 2



**INVENTORS**  
S.A. Tharrell & M.R. McNeill  
**BY**  
Charles H. Worley  
**ATTORNEY**

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FIG. 3

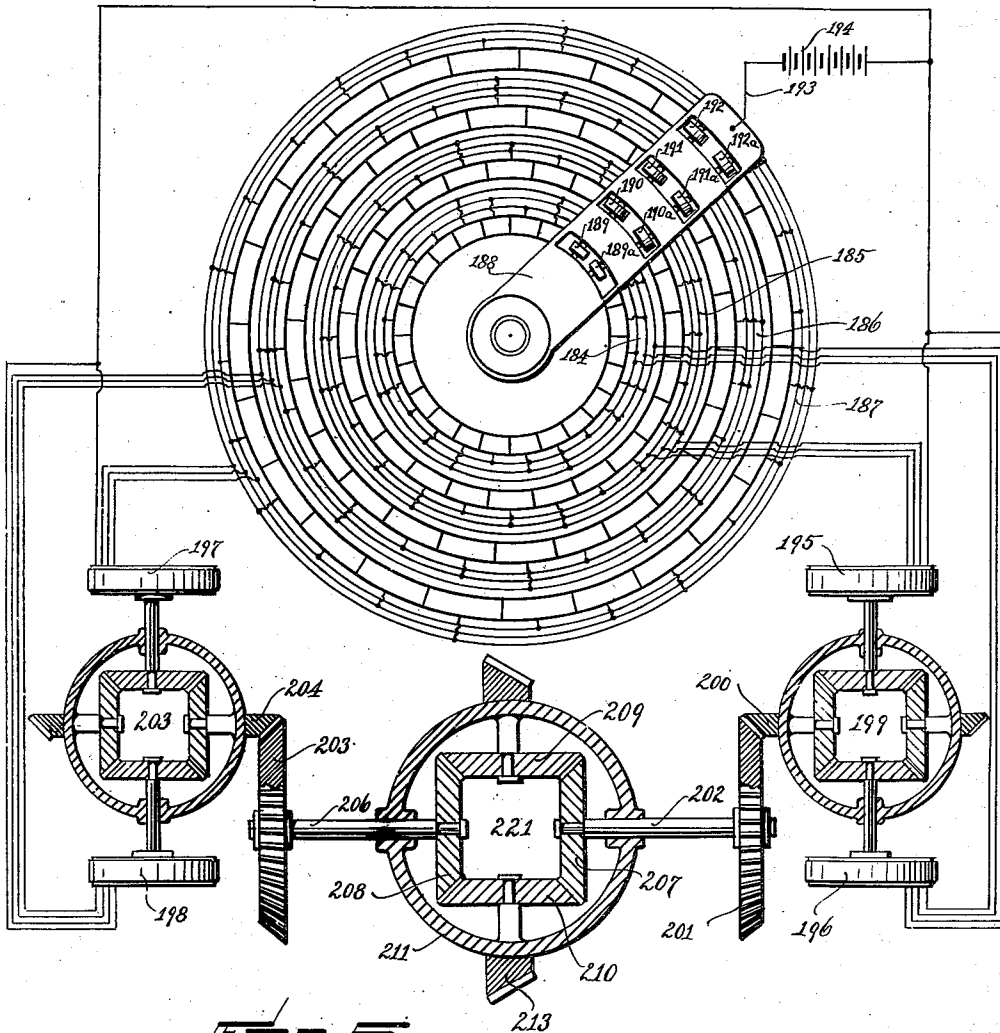
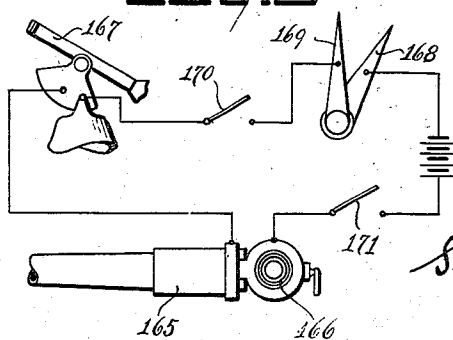


FIG. 5



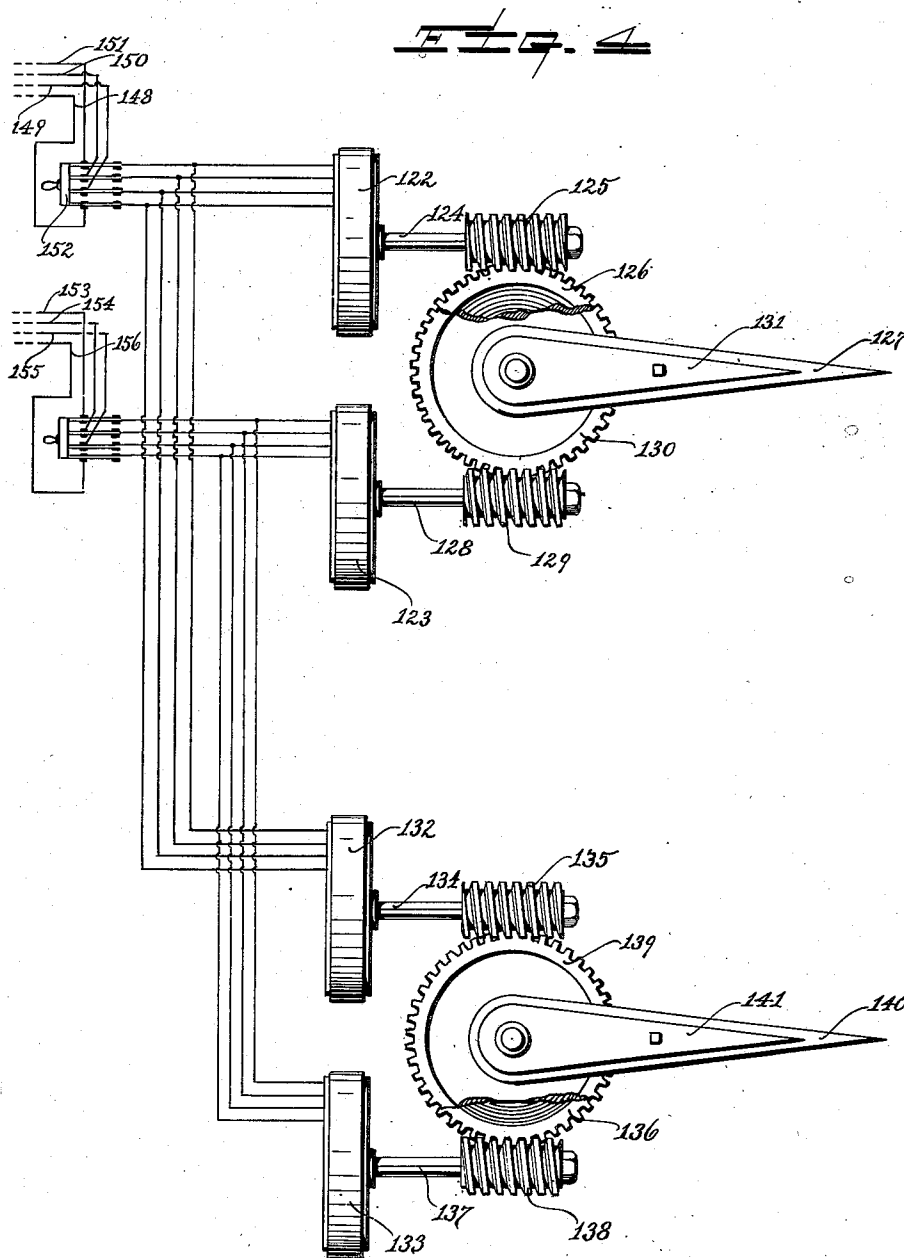
S. A. Farrell & M. R. McNeil INVENTORS  
BY  
Charles H. Wilson ATTORNEY

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5 Sheets-Sheet 4



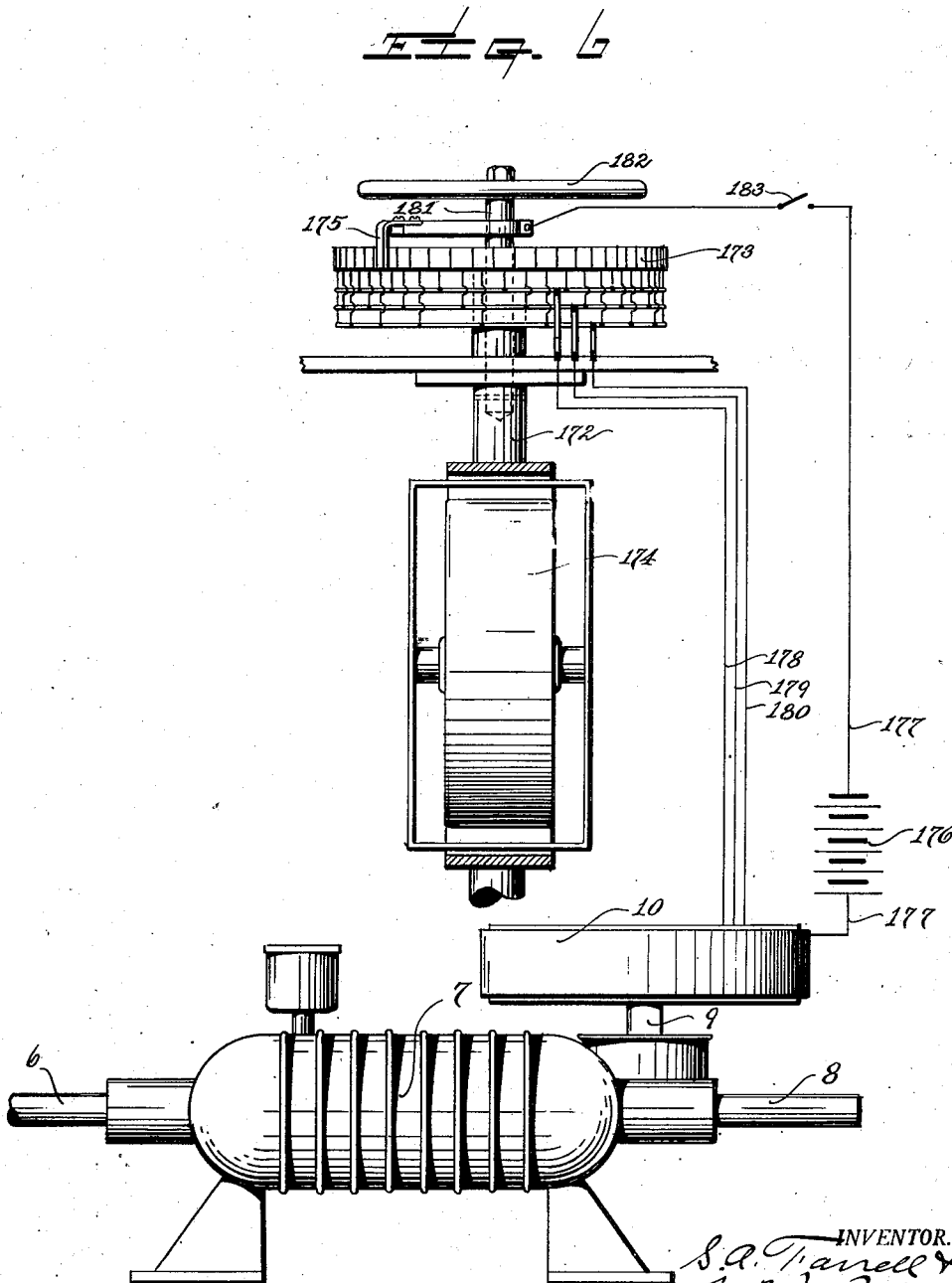
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BY  
Charles H. Wilson  
INVENTORS  
ATTORNEY

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5 Sheets-Sheet 5



INVENTOR. S  
S. A. Farrell  
BY M. R. McNeill  
Charles H. Wilson  
ATTORNEY.

# UNITED STATES PATENT OFFICE.

STEPHEN A. FARRELL, OF BROOKLYN, NEW YORK, AND MALCOM R. McNEILL, OF CHICAGO, ILLINOIS, ASSIGNORS TO AUTOMATIC GUN CONTROL COMPANY, INC., OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK.

MEANS FOR CONTROLLING THE MOVEMENTS OF ORDNANCE MEMBERS, SIGHTING INSTRUMENTS, AND THE LIKE.

Application filed December 18, 1919. Serial No. 345,909.

*To all whom it may concern:*

Be it known that we, STEPHEN A. FARRELL and MALCOM R. McNEILL, residing at Brooklyn and Chicago, in the counties of Kings and Cook, and State of New York and State of Illinois, respectively, have invented certain new and useful Improvements in Means for Controlling the Movements of Ordnance Members, Sighting Instruments, and the like, of which the following is a specification.

This invention relates to means for transmitting motion and the prime object thereof is to provide new and improved means for moving instrumentalities in synchronism or unison and while the invention is useful in many relations, we have adapted it to the art of pointing and training guns and sighting instruments mounted upon unstable supports, such for instance as on board a ship.

In carrying out the present embodiment of the invention we contemplate providing improved means which will automatically maintain a gun or sighting instrument aimed or directed towards a fixed object despite the undesirable movements of the ship, such as is produced by the uneven surface of the sea, or such as are caused by the travel of the vessel, the deviation of the vessel from a given course or variations in its speed.

The invention further contemplates the provision of means whereby lag and lost motion are taken care of during the operation of the mechanism caused by the undesirable movements of the vessel, and whereby the human element can be superimposed upon the automatically controlled parts to vary their operation, to meet emergencies or to change the position of the instruments under control, as where it is desirable to transfer the range or sight upon another object.

More specifically stated, our invention relates to the pointing of a gun in a turret, or sighting instrument, or moving or restraining the movement thereof in azimuth during the turning movement of turret or the travel of the vessel, such that the gun or sighting instrument will at all times be kept automatically in trained position, combined with means which will automatically fire

the gun or place it in a condition for firing at the proper instant.

A further object of the invention is to provide a system of semi-automatic control which can be employed when one or more parts of the main control becomes inoperative or destroyed by gun fire.

In carrying out the invention we have adapted the same to the standard equipment now installed upon the modern war vessels.

Other objects and aims of the invention, more or less specific than those referred to above, will be in part obvious and in part pointed out in the course of the following description of the elements, combinations, arrangements of parts and applications of principles, constituting the invention; and the scope of protection contemplated will be indicated in the appended claims.

In the accompanying drawings, wherein we have illustrated a preferred form of embodiment of our invention:

Figure 1 is a view, partly in elevation, and partly in section, and partly schematic, showing the standard or supporting base upon which is mounted a part of the apparatus, which is located remote from the turret of a warship, and a sighting instrument, and other mechanism which is located in a position remote from the turret.

Figure 2 is a view, partly in elevation, partly in section, and partly schematic, showing a part of the controlling means, which is also located within the turret of a warship.

Figure 3 is a view, partly in diagram, and partly in section, showing the preferred manner of constructing the commutators and the method of increasing the increment of motion of the step-by-step motors acting on differential mechanism.

Figure 4 is a view in elevation, showing certain indicators forming a part of our improved apparatus.

Figure 5 is a diagrammatic view, showing the manner of firing a piece of ordnance, in accordance with the apparatus which forms the subject matter of this invention; and

Figure 6 is an elevational view of a modified form of construction.

Referring now to the drawings, wherein similar reference characters refer to similar parts throughout the several views thereof, A denotes a portion of a turret and the reference numeral 1 denotes a portion of the barbette of a turret, said barbette comprising a stationary circular structure forming a fixture on the deck of a war vessel, having an inwardly extending toothed edge or rim, which extends entirely about the turret. This rim is engaged by a gear wheel 2, mounted on the drive shaft 3, upon the opposite end of which is provided a worm wheel 4, driven by a worm 5 upon the shaft 6. Shaft 6 extends within the casing 7, which encloses a system of variable speed control, and a follow-up gear, and leading into this system of variable speed control is a drive shaft 8, which derives its power from a motor or other driving apparatus not shown.

It will be understood that the mechanism so far described forms no part of our invention, but comprises a part of an old and well known mechanism employed for driving a turret. Likewise the variable speed control or gear comprised in the casing 7, forms no part of our invention, the latter being a well known apparatus employed for transmitting a variable speed to the turret from the power driven shaft 8.

It will be also understood that the mechanism thus far described, with the exception of the barbette 1, is all located within the turret and turns with it. At this point it may be explained that, in so far as this part of our invention is concerned, the controlling devices hereinafter to be described, operate upon the variable speed gear 7 to control the direction of movement, as well as the velocity of movement of the turret, said speed controlling means being transmitted to the variable speed gear 7 by means of a shaft 9, whose operation is in turn controlled by a motor 10, the latter being what is known as a step-by-step motor, the construction of which will be hereinafter more fully described.

Referring now to Figure 1 of the drawings, the reference numeral 11 denotes an upright standard or hollow post-like structure having the base portion 12, which post or standard is located in a position in the vessel remote from the turret. The upper end of the post 11 rotatively supports a hood 13, for instance as by means of the ball-bearing 14, and fixedly carried upon the hollow post 11, near its upper end, is a worm wheel 15, which is engaged by a worm 16. The worm 16 is provided with an interior chamber 17, in which is located a variable speed gear comprising the bevel gears 18 and 19, each of which is mounted upon bearings supported interiorly of the worm 16, so as to be independently rotatable.

Meshing with both the bevel gears 18 and 19 are bevel gear wheels 20 and 21. The bevel gear wheel 20 is carried upon the shaft 22, having the hand wheel 23, by means of which the shaft 22 may be rotated. The bevel gear 21 is carried by the shaft 24, which is driven as by means of a pulley 25, and in turn driven as by means of a belt 26, which receives its power from a pulley wheel 27, carried by the armature shaft 28 of a step-by-step motor 29.

It may here be noted that the power transmitting means extending between the step-by-step motor 29, and the shaft 24, as shown herein, is purely diagrammatic, and in actual practice such mechanism will be employed as will be suitable for performing this operation.

From the mechanism just described it will be seen that when the shafts 22 and 24 are rotated at uniform speeds in opposite directions, the bevel gear wheels 18 and 19 will merely be revolved upon their journals and no rotative movement of the worm 16 will be accomplished. When, however, the shafts 22 and 24 are rotated at different speeds the bevel gears 18 and 19 will be moved bodily in directions transverse to their axes, and inasmuch as these gears are carried by the worm 16, said worm will be rotated, and through its connection with the hood 13, effecting a rotative movement of the latter.

Suspended from a pivotal support 30, located centrally of the hood 13, is a rod 31, the pivotal connection of said rod with the bearing 30 being such that it can swing in but a single plane. The lower end of the rod 31 is provided with a bearing 32, from which hangs a cradle 33, the latter carrying a gyroscopic ring 34. The bearing 32 from which hangs the cradle 33, is so disposed that said cradle can swing in but a single plane, which plane is opposite to that, in which swings the rod 31. Thus it will be seen that the cradle 33 is permitted to swing in two planes, and that said planes are at right angles to each other. The gyroscopic ring 34 is provided with pintles 35, which carry a gyroscopic ring 36, and pivoted to the latter element, by means of the vertically disposed pivots 37, is a gyroscopic wheel 38. The gyroscopic wheel 38, in practice, will be driven by a suitable source of power at a very high speed of rotation, such construction being well known in the art and being quite similar to that now employed in connection with gyroscopic compasses, and said gyroscopic wheel being freely suspended, and when once set in rotation in a given plane will continue to rotate in said plane, despite the movements of its supporting means which would tend to carry it into a different plane. This gyroscopic apparatus stabilizes the pendulum 31.

The reference numeral 39 denotes a telescope or sighting instrument mounted upon a suitable pivotal support 40. This sighting instrument in practice will be supported upon hood 13 and rotatable therewith but located above said hood a predetermined distance, the mounting of the telescope 39, however, being such that it can swing only in a plane parallel to that in which swings the rod 31, which carries the gyroscopic element 38.

In practice the sighting instrument 39 may be located in a position commanding an unimpeded view of objects at which the ordnance member is to be pointed or trained, for instance, in the fighting top of a warship.

The sighting instrument 39 is provided with a sector-shaped gear 41, the teeth 42 of which are in mesh with a worm 43, in the interior of which is a differential mechanism 44, which is in all respects similar to that described in connection with the worm 16, and therefore need not be specifically described, it being understood that the shaft 45 carrying the hand wheel 46 operates upon one side of the differential, and that the shaft 47, driven by the armature 48 of the step-by-step motor 49 operates upon the other side of the differential 44.

Located within the post 11 is an arc-shaped commutator 50 mounted to rotate with hood 13, comprising a plurality of spaced commutator members which are engaged by a suitable contact member 51 carried by the swinging rod 31. This latter rod may be considered as a shaft of a pendulum, the weight being comprised by the gyroscopic apparatus, so that when the vessel moves in a direction other than a direction of travel, due to the uneven surface of the sea, the rod 31 remaining stationary, will cause the commutator 50 to be swung with respect to the contact point 51, thereby opening and closing various circuits which will now be described.

The reference numeral 52 indicates a suitable supply of electric energy, such for instance as a dynamo, although the same is herein, for convenience, illustrated as an electric battery, the negative pole of which is connected by a wire 53 with the contact member 51 mounted upon the shaft or rod 31. The opposite pole of the battery 52 is connected with the negative poles of the step-by-step motor 49.

The commutator 50, it will be noted, is divided into a plurality of units, each unit comprising three adjacent commutator members, each of these units is connected by the wires 54, 55 and 56 with the positive poles of the step-by-step motor. Therefore, it will be seen that a movement of the contact 51 over its commutator will successively

energize the pole pieces of the step-by-step motor 49, whereby the armature thereof, due to the successive changing of the poles of the field of the motor 49, will be rotated in a direction commensurate with and in proportion to the swing or movement of the commutator 50 with relation to contact member 51.

Inasmuch, therefore, as the sighting instrument 39 is connected with the armature 48 of the step-by-step motor 49, it will be swung upon its axis through an arc proportional to the arc over which swings the contact 51 of the pendulum. Thus it will be seen that when the sighting instrument is once trained upon an external object, such for instance as a target, it will remain in such trained position, despite any movement of the ship which will cause a relative movement between the contact 51 of the pendulum and the commutator 50.

The hand wheel 46 controlling the movement of the shaft 45 may be operated to cause the differential mechanism 44 to swing the sighting instrument 39 independent of its automatic control, when for instance it is desired to train the sighting instrument upon another external object or target.

The description of the mechanism thus far accomplished relates to what is known as gun pointing, that is to say, the vertical angle through which the sighting instrument would tend to move, due to the movement of the vessel, and which movement is corrected by said controlling mechanism.

Referring now to the means for controlling the turret, and thereby controlling the movement of the ordnance member in azimuth, it will, of course, be understood that the gun is mounted in the turret so as to swing with it, and the object of the part of the mechanism now to be described is directed to the problem of maintaining the gun through the turret in a trained position, despite a movement of the vessel, such as a movement of travel or the swinging of the vessel from its course. This mechanism, as before stated, operates through the variable speed gear or control contained in the casing 7.

Mounted upon horizontal axes upon a vertically disposed standard or post 57, rotatably supported upon the base 12, is a gyroscopic wheel or element 58, which is carried upon the gyroscopic rings 59 and 60. The gyroscopic member 58, as in the gyroscopic devices already described, is power driven at a high rate of speed, so that it will tend to remain in any plane in which it is set in motion, despite a swinging movement of the ship.

The post 57 carries an arm 61, the latter at its outer end being provided with a contact member, the latter comprising a wheel

62, which co-operates with a circular commutator 63, supported upon the posts 64 erected upon the base member 12.

Thus it will be seen when the vessel is turned upon its axis the gyroscopic element 58 remaining in its fixed plane, the commutator 63 will be moved underneath the contact member 62, whereby various circuits hereinafter described will be opened and closed.

The reference numeral 65 indicates a source of electric supply, such as dynamo, although for clearness it is herein illustrated as an electric battery. The negative pole of this battery is connected by means of the wire 66 with the contact member 62. The opposite pole of the battery is connected as by means of the wire 67 with the negative pieces of the step-by-step motor 29.

The commutator 63 is divided into a series of units, each in the present instance comprising three contact members, and the wires of each unit are connected by means of the wires 68, 69 and 70 with the pole pieces of the step-by-step motor 29, so that a movement of the commutator 63 relative to the contact member 62 will cause an equal or proportionate operation of the armature 27 of the step-by-step motor 29. This step-by-step motor 29 being connected with the worm 16, the rotative movements of the armature 27 thereof, will cause said worm 16, through its connection with the worm wheel 15 to move the hood 13 through an arc equal or proportionate to the arc in which the vessel has turned upon its axis, that is to say, an arc equal to that traversed by the commutator 63 under the contact point 62.

Mounted upon the post 11, adjacent the lower edge of the hood 13, is a commutator 71, and co-operating with this commutator is a contact member comprising a wheel 72, carried by the inner wall of the hood 13, so that when said hood is rotated, as above described, the movement of the contact member 72 over the commutator 71 will open and close various circuits hereinafter to be described.

The reference numeral 73 denotes a source of electric supply herein illustrated as a battery, although a dynamo would be employed in actual service, the negatives of said battery being connected by the wire 74 of the contact member 72, a manually operated switch 75 being provided to open and close the circuit through this wire. The commutator 71, as in the commutators above described, is divided into several units, each unit comprising three contact members, and the contact members of each of these units are connected as by means of the wires 76, 77 and 78 with the pole pieces of the step-by-step motor 79, the wire 80 leading from the

battery 73 being also connected with said contact members. A manually controlled switch 81 is provided in these last named wires, whereby the circuits may be opened or closed. The armature of the step-by-step motor 79 operates the shaft 82 and said shaft is connected with a bevel gear wheel 83, which co-operates with the bevel gear wheels 84 and 85, journaled upon pivots formed interiorly of the casing 86, which casing is provided exteriorly with a bevel gear wheel 87, which meshes with a bevel gear wheel 88 mounted upon a suitable shaft 89, bearings of which are not shown herein.

Carried upon the shaft 89 of the bevel gear wheel 88, is a commutator 90, said commutator partaking of the rotative movement of the bevel gear wheel 88. Carried near the upper end of a shaft 91, is a contacting member or brush 92, which is adapted, when the commutator 90 is rotated to pass over and make electrical contact with the various contact pieces of the commutator 90.

The commutator 90, as in the commutators already described, is divided into a plurality of units, each of the units in the present instance comprising three contact pieces.

Provided upon the upper end of the shaft 91 is a hand wheel 93, by means of which the shaft 91 and the arm 94 carrying the brush 92 may be operated. It will be understood, however, that normally the shaft 91, which carries the arm 94, is held against rotation and is only rotated when it is necessary to operate the hand wheel 93, as will be hereinafter pointed out.

The reference numeral 95 indicates a source of electric current supply herein indicated as a battery, the negative pole of which is connected through a sliding contact by the wire 96 with the arm 94. The various contact members of the commutator 90 are also connected by sliding contacts by means of the wires 97, 98 and 99, and the wires 100, 101 and 102 with the step-by-step motor 10.

Therefore, operation of the side of the differential located in the casing 86, comprised by the bevel gear 83, which operation, as above pointed out, is determined by the rotative movement of the hood 13, will cause the proper operation of the step-by-step motor 10. This step-by-step motor 10, as already described, controls the operation of the variable speed gear 7 through the control exercised by the bevel gear 88. Therefore, the shaft 6, which leads from the speed gear, will, through its connection with the barrette, cause a motion of the turret with respect to said barrette and likewise the ship, which is equal and opposite to the movement of the ship upon its vertical axis.

The last described mechanism is intended to compensate for the aforesaid turning

movement of the ship, that is to say, to move the turret relative to the ship, so that the ordnance member will remain in trained position. In practice, however, it is found  
 5 that due to lag, loss of movement, and allied inherent mechanical imperfections, also to the necessity of overcoming inertia, of the parts to be moved or retarded, it is desirable to provide means which will give impetus  
 10 to, or accelerate the initial movement or retardation of said parts to be moved. We have, therefore, provided means to overcome these obstacles, which means will now be described.

15 Suitably mounted and journaled within the turret is a shaft 103, which shaft is provided with a gear wheel 104, which meshes with the teeth of the barrette 1, so that when the turret is rotated, the shaft 103 will be rotated upon its axis. Shaft 103 is provided with a worm 105, and worm 105  
 20 meshes with a gear wheel 106 suitably supported by means not herein shown. Mounted upon and carried by the gear wheel 106 is a commutator 107, the contact pieces of which, as in the commutators already described, being divided into a plurality of  
 25 units, three adjacent commutator parts comprising each unit.

30 The reference numeral 108 indicates a source of electric current supply, shown herein as a battery, and the negative pole of this battery is connected as by means of the wire 109 at 110 with a circular bus-bar 111. The commutator members are connected by  
 35 means of the wires 112, 113 and 114 with the pole pieces of a step-by-step motor 115, and a circuit through the step-by-step motor, by means of the battery 108, is completed by a  
 40 wire 116 which connects said battery with the negative pole pieces of the step-by-step motor 115.

Suitably supported concentrically of the wheel 106, but independent of it, are the  
 45 pole pieces of a step-by-step motor 117, having an armature 118. The wires 76, 77 and 78 being connected with the positive pole pieces of said step-by-step motor 117 and the wire 80, which leads from the bat-  
 50 tery 73, are connected with the negative pole pieces thereof. Therefore, when the step-by-step motor 79 is operated through its connection with the battery 73, the step-by-step motor 117 will also be operated, that is to  
 55 say, the armature 118 will be rotated in exactly the same manner as will the armature of the step-by-step motor 79, the said armatures moving in unison.

60 Carried by the armature 118 is a contact arm 119, which contact arm in the present instance is merely shown diagrammatically by a black line. This contact arm co-operates with the commutator 107 and closes a  
 65 circuit through the various contact members from the bus-bar 111, so that during the

rotative movements of the armature 118 of the step-by-step motor 117, circuits will be opened and closed through the wires 112, 113, 114 and 116 and the step-by-step motor 115 operated thereby.

The armature of the step-by-step motor 115 operates the shaft 120, which carries a bevel gear wheel 121, the latter meshing with the bevel gear wheels 84 and 85 of the differential mechanism, and at this point it  
 75 may be noted that the step-by-step motor 115 and the step-by-step motor 79 are so related and connected with their associated differential mechanism that when they are  
 80 operated by the commutator 71 upon the standard or post 11, they impart an initial movement to the bevel gear wheel 87 which is twice as great as is the movement necessary to cause, through the connections above  
 85 described, a movement of the turret, such as will exactly compensate for the movement of the ship.

This initial acceleration or impulse we have found necessary in order to compensate for the mechanical imperfections, and to  
 90 overcome the inertia of parts, as above stated.

During this operation the movement of the turret will, through the shaft 103 and worm 105, impart a rotative movement of  
 95 the gear wheel 106, such that the armature of the motor 115 will be moved contrary to its initial movement, whereby the movement of the turret will be slowed down in a measure which is exactly proportionate for the  
 100 latter part of the interval of time in which the turret is moved to the acceleration given it in the first part of the interval of time of the movement of said turret, and the turret will come to rest when the commutator 107  
 105 bears the same relation to the contact arm 119, as it did before the starting of the movement.

Therefore, it will be seen that the lost motion, lag and inertia will be compensated  
 110 for by the mechanism just above described.

Referring now to Figure 4 of the drawings, the reference numeral 122 indicates one step-by-step motor and the reference  
 115 numeral 123 indicates another step-by-step motor. The shaft 124 of the armature of the step-by-step motor 122 carries a worm 125 which meshes with a gear wheel 126. The shaft of gear wheel 126 carries the indicator pointer 127. The shaft 128 of the armature of the step-by-step motor 123 carries the worm 129 which meshes with the gear wheel 130, the shaft of which carries the indicator pointer 131. The gear wheels 126  
 120 and 130 are mounted concentrically, and the indicator pointers 127 and 131 have a common axis of rotation.

The reference numerals 132 and 133 respectively denote other step-by-step motors,  
 125 and the shaft 134 of the armature of the

step-by-step motor 132 has a worm 135 mounted thereon, which worm meshes with a gear wheel 136. The shaft 137 of the armature of the step-by-step motor 133 is provided with a worm 138 which meshes with a gear wheel 139, said gear wheels 136 and 139, as in the construction first described in connection with this Figure 4, being mounted concentrically. The shaft of gear wheel 136 carries the indicator pointer 140 and the shaft of the gear wheel 139 carries the indicator pointer 141, said indicator pointers revolving upon a common axis.

Worm 105 meshes with a suitably supported gear wheel 142 having mounted thereon a commutator 143, which commutator, as in the commutators above described, is divided into a plurality of units, each comprising three adjacent contact pieces. Co-operating with the commutator is a contact member or brush 144, carried by a fixed contact arm 145, so that during the rotation of the gear wheel 142, the commutator 143 will move under the brush 144 and open and close the circuits now to be described.

The reference numeral 146 denotes a source of electric current supply, the same being shown herein as a battery, the negative pole of which is connected by the wire 147 with the brush 144, and from the battery leads a wires 148. Leading from each unit of the commutator parts 143 are wires 149, 150 and 151, which wires connected with the poles of the step-by-step motors 122 and 132, the wire 148 extending from battery being connected with the negative pole pieces of said step-by-step motors 122 and 132. Therefore, when the gear wheel 142 is rotated by the worm 105, the position of the step-by-step motors 122 and 132 will be effected, and the indicator pointers 127 and 140 swung upon their axis. A switch 152 is interposed in the last described circuit. Wires 153, 154, 155 and 156 are connected respectively with the wires 96, 97, 98 and 99, which lead from the commutator 90, and these wires are connected with the step-by-step motors 123 and 133, the wire 153 being connected with the negative poles of the battery and the wires 154, 155 and 156 leading from the commutator 90 are connected with the positive pole pieces of the step-by-step motors 123, 133.

Thus it will be seen that the operation of the step-by-step motors 123 and 133 is determined by the operation of the differential mechanism under the control of the step-by-step motors 79 and 115, and the associated hand wheel, and that likewise the indicator pointers 127 and 140 are moved in unison with each other and with the means which control the movements of the turret through the variable speed gear 7, and that the step-

by-step motors 122 and 132 are controlled by the movement of the turret itself through its connection with the commutator 143. In other words, the movements of the indicator pointers 127 and 140 are determined by the controlling mechanism of the turret and give a true indication of the operation of such mechanism, whereas the indicator pointers 131 and 141 are controlled by the turret itself, whereby each pair of indicator arms gives a true indication of the movement of the turret.

The indicator pointing devices under the control of the motors 122 and 123 are preferably located within the turret while the corresponding apparatus controlled by the step-by-step motor 132 and 133 are preferably located in the fighting top so that they may be observed by the man taking sights upon the targets upon which the ordnance is to be trained. It will be understood, of course, that similar apparatus may be connected in the circuit and similarly constructed apparatus located wherever desired upon board of the ship.

Referring now to Figure 1 of the drawings, the reference numeral 157 denotes a gyroscopic element similar to that located upon the base 12 of the post 11, and is of identical construction. This mechanism is preferably located in a protected position within the barbette and is normally disconnected from the other operating mechanism. The object of providing this mechanism is to provide automatic controlling means for the ordnance which could be utilized in case of emergency, such as would occur if the mechanism under the control of the gyroscopic member 58 were damaged by gun fire, or otherwise rendered inoperative. Leading from the commutator 158 which is of similar construction to those already described, are wires 159, 160 and 161, and from the brush 162 leads a wire 163, the wires 159, 160, 161 and 163 terminating in a position to be connected with the wires 76, 77, 78 and 80 by the throwing of the switch 81, whereby the control to be exercised by the gyroscopic member 157 will be effective through the differential mechanism controlled by the step-by-step motors 79 and 115. This last described circuit is supplied with current by means of a source of electrical supply, such as is illustrated by the battery 164.

Having thus described the construction of this embodiment of our invention, the operation thereof, which should be largely obvious from the description already given, may now be understood.

Briefly stated, the sighting instrument 39 is controlled by the relative movement which takes place between the brush or contact member 51, and the commutator 50, due to the undesirable movements of the ship, the sighting instrument 39 being kept in

trained position by mechanism controlled by the operation of the step-by-step motor 49, which automatic control can be varied or the sighting instrument moved to a new position by means of the manual control 46. This takes care of the elevational displacements of the sighting instrument.

The control exercised by the gyroscopic member 58 is transmitted through the mechanism described to act upon the variable speed gear 7, whereby the movement of the turret is taken care of, as described, the turret itself controlling the indicating mechanism which, in conjunction with the indicating mechanism under control of the turret moving mechanism, proves the accuracy of the movement of the turret to compensate for the axial movement of the ship.

Referring now to Figure 5 of the drawings, it will be noted that the indicator pointers may be connected in circuit with the ordnance member. In this figure the reference numeral 165 indicates the ordnance member; and the reference numeral 166 the breech block thereof, 167 the sighting instrument, and 168 and 169 the pointers. The circuit, it will be noted, is broken at the sighting instrument, at the indicator pointers, and at the breech block, making it necessary for each of these three instrumentalities to be in proper position before the ordnance member can be fired, which firing operation can be effected by closing the manually operated switches 170 and 171, one of the switches is intended to be located within the turret, and the other adjacent the director'scope in the fighting top.

Referring now to the embodiment of our invention shown in Figure 6, this arrangement is intended to be utilized when all the mechanism illustrated in Figure 1 of the drawings, and at the top of Figure 2 of the drawings, and of course the indicator mechanism as shown in Figure 4, has been rendered inoperative, for instance, as by gun fire, or other cause. In this embodiment of our invention the shaft 172 which carries the commutator 173, which commutator is in all respects similar to that shown at 90 in Figure 2 of the drawings, carries a gyroscopic member 174, which as in the heretofore described embodiment of our invention, is freely suspended in the usual gyroscopic rings, is power driven at a high rate of speed, and is located in any desired vertical plane. The brush 175 of the commutator is connected through the source of electric current supply, herein shown as a battery 176, by the wire 177 with the step-by-step motor 10, and the commutator pieces, comprising each unit of said commutator, are connected with the step-by-step motor 10 by the wires 178, 179 and 180.

The shaft 181 which carries the brush arm 175 is as in the first described embodiment,

normally held against rotation, but if desired, can be rotated as by means of the hand wheel 182. A switch 183 is provided in the circuit partly formed by the wire 177, which extends from the commutator 173 through the battery 176.

Thus it will be seen that should the unforeseen events above enumerated occur, the switch 183 can be operated to close its circuit, whereupon the gyroscopic member 174 will exercise its control of the commutator 173 which control will be impressed upon the step-by-step motor 10 and through said instrumentality to the variable speed gear 7, which at this point it may be noted, as in the first described embodiment, is a well known piece of mechanism now employed in turret turning, and is provided with what is known as the "follow-up" gear, such parts not being shown in detail herein, inasmuch as aforesaid, they are of old and well known construction.

The mechanism just described will be preferably located in the turret proper, and turns with it. Therefore, it will be seen that the mechanism takes up lag and lost motion in the same manner as does the mechanism of which the gear 106 plays a part in Figure 2. It also acts as its own follow-up gear, inasmuch as aforesaid, it is carried by and rotates with the turret.

Referring now to Figure 3 of the drawings, wherein we have illustrated schematically a form of commutator and step-by-step motor arrangement, which we prefer to employ in carrying out our invention as set forth in this application.

In this arrangement it is intended to effect a refinement upon the operation of each of the step-by-step motors illustrated herein. That is to say, it diminishes each increment of motion of the step-by-step motors, whereby the motion of the ultimate controlling member is rendered practically continuous, rather than divided into a plurality of independent rotative movements.

In this figure we have illustrated four concentrically disposed commutator rings 184, 185, 186 and 187, and a concentrically mounted arm 188 provided with four pairs of spaced brushes herein shown as rollers, the rollers of the several pairs being designated 189, and 189<sup>a</sup>, 190, 190<sup>a</sup>, 191, 191<sup>a</sup>, 192 and 192<sup>a</sup>. The arm 188 with which all the brushes are in electrical contact, leads, by means of a wire 193, through a source of power 194, to step-by-step motors 195 and 196, and also to step-by-step motors 197 and 198. The step-by-step motors 195 and 196 operate upon opposite sides of a differential mechanism, denoted generally at 199, said differential mechanism carrying a bevel gear 200 which meshes with the bevel gear 201 carried upon the shaft 202. Similarly step-by-step motors 195 and 196 operate

upon different sides of the differential mechanism, indicated at 203, which differential mechanism carries a bevel gear 204, which meshes with the bevel gear 205, carried by the shaft 206. Shafts 202 and 206 are provided with bevel gear wheels 207 and 208, which mesh with bevel wheels 209 and 210, mounted upon journals within the casing or ring 211 of the differential mechanism 212, which casing is provided with a bevel gear 213, said bevel gear being connected with the element to be controlled, for instance, the worm such as illustrated at 16, 43, or the bevel gear 87, or in fact any of the elements, the movements of which it is desired to control.

Referring now to the commutator illustrated in Figure 3, it will be understood that the segments of the commutator are staggered relative to each other, and that two roller brushes are utilized instead of one, because of a greater current carrying capacity, and to keep the source of current in contact with the two segments longer than a single brush would keep it, inasmuch as the brushes in passing from one segment to another will energize two adjacent segments. The reason for the provision of this form of commutator is on account of mechanical limitations of commutator construction.

The apparatus just described permits a splitting up or multiplication of a single segment of a commutator into a greater number of small steps or increments which advantage is further enhanced by the provision of the multiplicity of commutator rings. This insures a smooth and substantially continuous motion of the ultimate control member driving element, thus eliminating the jumping movement which would obtain were but a single member employed.

It will accordingly be seen that we have provided a construction well adapted to attain, among others, all the aims and objects above pointed out, in a simple yet efficient manner. By means of our combination of gun pointing and turret turning apparatus in a unitary system, the control of an ordnance member or sighting instrument is effected substantially automatically, means being employed, however, to correct any defect of operation, whereby the human element can always be superimposed upon the automatically operated mechanism to correct any such deficiency, or to move the part to be trained to another position.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:—

1. In apparatus of the class described, in combination, a member to be trained, turret operating means, gyroscopic means operating on said member to be trained to control the movements thereof to compensate for undesirable movements of a vessel, a turret, an

electric motor for controlling the operation of the turret operating means to compensate for other undesirable movements of the vessel, gyroscopically operated contacts for controlling the action of said motor, and manually controlled means operable jointly with at least one of said gyroscopically controlled means for controlling the movements of the respective movable element.

2. In apparatus of the class described, in combination, a member to be trained, mounted upon an unstable support, turret operating means also mounted upon said unstable support, gyroscopically controlled means adapted to maintain said member to be trained in a fixed elevational position despite undesirable movements of said support, an electric motor adapted to control the operation of said turret operating means to compensate for undesirable movements of said support in azimuth, gyroscopically operated contacts for controlling the action of said motor, and manually controlled means operable jointly with each of said gyroscopically controlled means for controlling the movements of said turret and said member.

3. In apparatus of the class described, in combination, a member to be trained adapted to be mounted upon shipboard so as to swing in a vertical plane relative to said ship, a freely suspended gyroscopic element, differential mechanism for operating said member to be trained, a step-by-step motor for operating said differential mechanism, a commutator, a brush carried by the swinging means upon which said gyroscopic element is supported, adapted to co-operate with said commutator so as to cause said step-by-step motor to operate said differential mechanism whereby said member to be trained will be held in a fixed vertical position relative to an exterior object, despite movements of said ship which would tend to move said member to be trained from the aforesaid fixed position.

4. In apparatus of the class described, in combination, a member to be trained, adapted to be mounted upon shipboard so as to swing in a vertical plane, differential mechanism associated with said member to be trained adapted to swing the latter in a vertical plane, step-by-step motor means for operating said differential mechanism, a commutator mounted upon said ship and adapted to partake of the movements thereof, a freely suspended power driven gyroscopic element having a brush adapted to traverse said commutator during the undesirable movements of said ship, and a plurality of electric circuits connecting said commutator with said brush, and said step-by-step motor adapted to be operated by the relative movement between said brush and said commutator during undesirable movements of the ship, whereby said step-by-step motor will

so operate said differential mechanism that said member to be trained will be maintained in a fixed position relative to an exterior object, despite the said undesirable movements of said ship.

5 5. In apparatus of the class described, in combination, a member to be trained adapted to be mounted upon shipboard so as to be swung in a vertical plane, differential  
10 mechanism adapted to operate said member to be trained and to swing the latter in a vertical plane, a step-by-step motor operating upon one side of said differential mechanism, a commutator fixedly mounted upon  
15 said ship so as to partake of the undesirable movements thereof, a pendulum, the weight of which consists of a power driven gyroscopic element, said pendulum being adapted to swing in a plane parallel with that in  
20 which lies said commutator, and said gyroscopic element being suspended upon the shaft of said pendulum so that it can swing in a plane at right angles to the plane in which swings said pendulum, a brush carried by the shaft of said pendulum adapted to  
25 traverse said commutator, and circuits including a source of current supply, associated with said commutator and said brush, and said step-by-step motor, whose operation is determined by the traverse of said  
30 brush over said commutator, whereby said step-by-step motor will so operate said differential mechanism, that the members to be trained will be maintained in a fixed vertical position relative to a target despite  
35 such undesirable movements of the vessel as would tend to untrain said member.

6. In apparatus of the class described, the combination, a member to be trained adapted to be mounted upon shipboard so as to be swung in a vertical plane, differential  
40 mechanism adapted to operate said member to be trained and to swing the latter in a vertical plane, a step-by-step motor operating upon one side of said differential mechanism, a commutator fixedly mounted upon  
45 said ship so as to partake of the undesirable movements thereof, a pendulum, the weight of which consists of a power driven gyroscopic element, said pendulum being adapted to swing in a plane parallel with that in  
50 which lies said commutator, said gyroscopic element being suspended upon the shaft of said pendulum so that it can swing in a plane at right angles to the plane in which  
55 swings said pendulum, a brush carried by the shaft of said pendulum, adapted to traverse said commutator, and circuits including a source of current supply, associated with said commutator and said brush, and  
60 said step-by-step motor, whose operation is determined by the traverse of said brush over said commutator, whereby said step-by-step motor will so operate said differential  
65 mechanism, that the members to be trained

will be maintained in a fixed vertical position relative to a target despite such undesirable movements of the vessel as would tend to untrain said member, and means operated by the other side of said differential mechanism, adapted to manually vary the automatic control impressed upon said differential mechanism.

7. In apparatus of the class described, in combination, a member to be trained mounted upon shipboard adapted to be swung in a vertical plane, and a differential mechanism operating upon said member to be trained adapted to swing the latter in a vertical plane, and a gyroscopically controlled step-by-step motor adapted to so operate said differential mechanism that the member to be trained will be held in a fixed position relative to an exterior object despite the undesirable movements of the ship, such as  
85 would tend to untrain said member.

8. In apparatus of the class described, in combination, a member to be trained mounted upon shipboard adapted to be swung in a vertical plane, and a differential mechanism  
90 operating upon said member to be trained adapted to swing the latter in a vertical plane, and a gyroscopically controlled step-by-step motor adapted to so operate said differential mechanism that the member to be trained will be held in a fixed position relative to an exterior object despite the undesirable movements of the ship, such as  
95 would tend to untrain said member, the operation of said gyroscopically controlled motor being determined by said undesirable movements.

9. In apparatus of the class described, in combination, a member to be trained mounted upon shipboard adapted to be swung in a vertical plane, and a differential mechanism operating upon said member to be trained adapted to swing the latter in a vertical plane, and a gyroscopically controlled step-by-step motor adapted to so operate said differential mechanism that the member to be trained will be held in a fixed position relative to an exterior object despite the undesirable movements of the ship, such as  
105 would tend to untrain said member, the operation of said gyroscopically controlled motor being determined by said undesirable movements, and manually controlled means adapted to vary the operation of said differential mechanism.

10. In apparatus of the class described, in combination, a barbette, a turret adapted to be revolved within said barbette, power driven variable speed gear adapted to rotate said turret, a step-by-step motor adapted to control the operation of said variable speed gear, and gyroscopically controlled differential mechanism adapted to determine the operation of said step-by-step motor, whereby said variable speed gear will move or retard  
130

the movement of said turret to compensate for undesirable movements of the ship.

11. In apparatus of the class described, in combination, a barbette, a turret mounted to revolve within said barbette, a power driven variable speed gear, power transmitting means extended between said variable speed gear and said barbette, adapted to revolve said turret, step-by-step motor means for controlling the operation of said variable speed gear, and gyroscopically controlled differential mechanism, including one or more units of step-by-step motor means adapted to control the operation of said first named step-by-step motor means.

12. In apparatus of the class described, in combination, a barbette, a turret mounted to revolve within said barbette, a system of variable speed gears adapted to be power driven, mechanical connections interposed between said variable speed gears and said barbette for revolving said turret, step-by-step motor means for controlling the operation of said variable speed gear, and gyroscopically controlled differential mechanism, including step-by-step motor means adapted to determine the operation of said first named step-by-step motor means whereby said variable speed gear will be caused to revolve said turret to compensate for undesirable movements of the ship.

13. In apparatus of the class described, in combination, a barbette, a turret mounted to revolve within said barbette, a system of variable speed gears adapted to be power driven, mechanical connections interposed between said variable speed gears and said barbette for revolving said turret, step-by-step motor means for controlling the operation of said variable speed gear, and gyroscopically controlled differential mechanism, including step-by-step motor means adapted to determine the operation of said first named step-by-step motor means whereby said variable speed gear will be caused to revolve said turret to compensate for undesirable movements of the ship, and manually controlled means for varying the operation of at least one of the instrumentalities included in the control of said first named step-by-step motor means.

14. In apparatus of the class described, in combination, a barbette, a turret mounted to revolve within said barbette, a system of variable speed gear, adapted to be power driven and having mechanical connections interposed between it and said barbette for revolving the turret, step-by-step motor means for controlling the operation of said variable speed gear, differential mechanism for controlling the operation of said step-by-step motor means, gyroscopically controlled step-by-step motor means working upon one side of said differential, whereby the latter is caused to operate said first named step-by-

step motor means, and step-by-step motor means whose operation is determined by a lag in the movement of the turret or associated parts, and operating on the other side of said differential adapted to so vary the operation of the latter as will compensate for said lag or lost motion whereby the movement of the turret will compensate for undesirable movements of the ship.

15. In apparatus of the class described, in combination, a barbette, a turret mounted to revolve within said barbette, consisting of power driven variable speed gearing mechanically connected to said turret and said barbette, so as to rotate the former, step-by-step motive means for controlling the operation of said variable speed gearing, gyroscopically controlled differential mechanism, including step-by-step motive means adapted to determine the operation of said first named step-by-step motive means, whereby said variable speed gear will be caused to revolve the turret to compensate for the undesirable movements of the ship, and a pair of indicator pointers having a common axis of rotation, the operation of one of which is controlled by the turret operating means, and the other by the turret itself.

16. In apparatus of the class described, in combination, a barbette, a turret mounted to revolve within said barbette, a system of power driven variable speed gearing, driving connections interposed between said variable speed gearing and the barbette, whereby said turret is revolved within the latter, step-by-step motive means for controlling the operation of said variable speed gearing, differential mechanism for controlling the operation of said step-by-step motive means, gyroscopically controlled step-by-step motive means working upon one side of said differential mechanism, whereby the latter is caused to operate said first named step-by-step motive means and step-by-step motive means whose operation is determined by a lag in the turret operating means, which operates upon the opposite side of said differential mechanism, adapted to so vary the operation of the latter as will compensate for said lag or lost motion, whereby the turret will compensate for the undesirable movements of the ship, two pairs of indicator pointers, the pointers of each pair of which are in registry when the turret operating mechanism has moved the latter to compensate for undesirable movements of the ship.

17. In apparatus of the class described, in combination, a barbette, a turret mounted to revolve within said barbette, a system of power driven variable speed gearing, driving connections interposed between said variable speed gearing and the barbette, whereby said turret is revolved within the latter, step-by-step motive means

for controlling the operation of said variable speed gearing, differential mechanism for controlling the operation of said step-by-step motive means, gyroscopically controlled step-by-step motive means working upon one side of said differential mechanism, whereby the latter is caused to operate said first named step-by-step motive means and step-by-step motive means whose operation is determined by a lag in the turret operating means, which operates upon the opposite side of said differential mechanism, adapted to so vary the operation of the latter as will compensate for said lag or lost motion, whereby the turret will compensate for the undesirable movements of the ship, two pairs of indicator pointers, the indicators of each pair being mounted upon a common axis of rotation, one of the indicator pointers of each pair being operated by the turret, and one indicator of each pair being operated by the turret operating mechanism, indicator pointers of each pair being in registry when the turret has been moved to compensate for undesirable movements of the ship.

18. In apparatus of the class described, in combination, a member to be trained adapted to be mounted upon shipboard; a revolvable turret also mounted upon shipboard, an electric motor adapted to control the operation of said member to be trained to compensate for undesirable movements of the ship, gyroscopic means working in one plane adapted to control the action of said motor, gyroscopic means operating in a different plane adapted to control the movement of the turret to compensate for undesirable movements of the ship, and manually controlled means for varying the operation of each of said gyroscopic means.

19. In apparatus of the class described, in combination, a turret suitably mounted to revolve upon shipboard, power driven means for rotating said turret to compensate for undesirable movements of the ship, means operating through said power driven means to compensate for lost motion or lag in the movement of the turret, two pairs of indicator pointers, and the pointers of each pair rotating upon a common axis, one indicator pointer of each set being controlled by the movements of the turret itself, and one indicator of each pair being controlled by said last named means, said indicator pointers when lying in registry determining the fact that the turret has been turned to compensate for undesirable movements of the ship, and a firing circuit adapted to be closed by each pair of said indicator pointers when they lie in registry.

20. In an apparatus of the class described, a movable support, a member to be trained adapted to be mounted on said support, means for operating said member including

a variable speed gear, a motor for controlling said gear, hand-operated means adapted to control said motor for setting the member in position, and means adapted to control said motor jointly with said last-named means for maintaining said member in set position regardless of movements of the support.

21. In an apparatus of the class described, a movable support, a member to be trained adapted to be mounted on said support, means for operating said member including a motor, a differential adapted to control said motor for setting the member in position and for maintaining said member in set position regardless of movements of the support, hand-operated means adapted to control one side of said differential for setting the member in position, and means adapted to control the other side of said differential for maintaining the member in set position.

22. In an apparatus of the class described, a movable support, a member to be trained adapted to be mounted on said support, means for operating said member including a motor, a differential adapted to control said motor for setting the member in position and for maintaining said member in set position regardless of movements of the support, hand operated means adapted to control one side of said differential for setting the member in position, and means including a gyroscope adapted to control the other side of said differential for maintaining the member in set position.

23. In an apparatus of the class described, a movable support, a member to be trained adapted to be mounted on said support, means for operating said member including a variable speed gear, a motor for controlling said gear, means adapted to control said motor for setting the member in position, and means adapted to control said motor jointly with said last-named means for maintaining said member in set position regardless of movement of the support.

24. In an apparatus of the class described, a movable support, a member to be trained adapted to be mounted on said support, means for operating said member including a motor, a differential adapted to control said motor for setting the member in position and for maintaining said member in set position regardless of movements of the support, means adapted to control one side of said differential for setting the member in position, and means including a gyroscope adapted to control the other side of said differential for maintaining the member in set position.

25. In an apparatus of the class described, a movable support, a turret adapted to be mounted on said support, means for

operating said turret including a variable speed gear and a motor for controlling said gear, means responsive to movements of the support for actuating said motor to  
 5 move said turret opposite to the movements of the support, and means for increasing the initial speed of said motor and for reducing said speed as the turret approaches the end of its movement.

10 26. In an apparatus of the class described, a movable support, a turret adapted to be mounted on said support, means for operating said turret including a variable speed gear and a motor for controlling said gear,  
 15 a differential operatively connected to said motor, means responsive to movements of the support, said last named means being connected to one side of the differential and means also responsive to movements of the  
 20 support and connected to the other side of the differential for increasing the initial speed of said motor.

27. In an apparatus of the class described, a movable support, a turret adapted to be  
 25 mounted on said support, means for operating said turret including a variable speed gear and a motor for controlling said gear, a differential operatively connected to said motor, a motor connected to one side of the  
 30 differential, means whereby said last named motor is responsive to movements of said support, a motor connected to the other side of the differential also responsive to movements of the support for increasing the initial  
 35 speed of said first named motor.

28. In an apparatus of the class described, a movable support, a turret adapted to be mounted on said support, means for operating said turret including a variable speed  
 40 gear and a motor for controlling said gear, a differential operatively connected to said motor, a motor connected to one side of the differential, means whereby said last named motor is responsive to movements of said  
 45 support, a motor connected to the other side of the differential also responsive to movements of the support for increasing the initial speed of said first named motor, and means whereby the movement of the turret  
 50 gradually slows down said last named motor.

29. In an apparatus of the class described, a movable support, a sighting instrument mounted on said support, gyroscopic means,  
 55 means including a differential controlled by said gyroscopic means for stabilizing said instrument in elevation, and manually operable means acting through said differential to control said instrument in elevation  
 60 jointly with said gyroscopic means.

30. In an apparatus of the class described, a movable support, a sighting instrument mounted on said support, means including  
 65 a differential for controlling the movements of said instrument in elevation, automatic means controlling said differential for stabilizing said instrument in elevation, and manually operable means acting through  
 70 said differential for controlling said instrument in elevation jointly with said automatic means.

31. In an apparatus of the class described, a turret, turret operating means including a motor, a remotely located sighting instrument, means including a differential where-  
 75 by the movements of said instrument in azimuth are transmitted to said motor, automatic means acting through said differential for stabilizing said instrument and said turret in azimuth, and manually oper-  
 80 able means acting through said differential for controlling said instrument and said turret in azimuth jointly with said automatic means.

32. In an apparatus of the class described, a turret, turret operating means including  
 85 a motor, a remotely located sighting instrument, means including a differential whereby the movements of said instrument in azimuth are transmitted to said motor, gyroscopic means acting through said dif-  
 90 ferential for stabilizing said instrument and said turret in azimuth, and manually operable means acting through said differential for controlling said instrument and said  
 95 turret in azimuth jointly with said gyroscopic means.

In testimony whereof, we affix our signatures.

S. A. FARRELL.  
 M. R. McNEILL.