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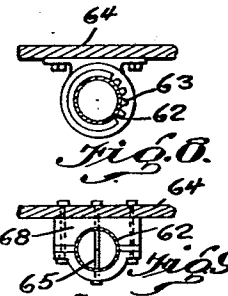
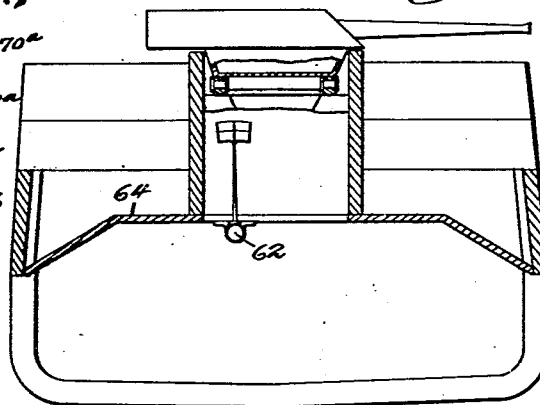
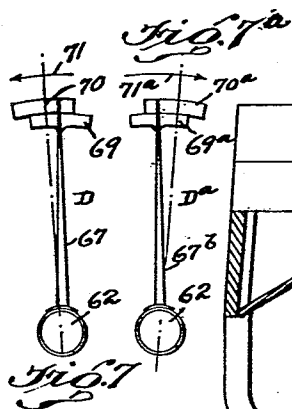
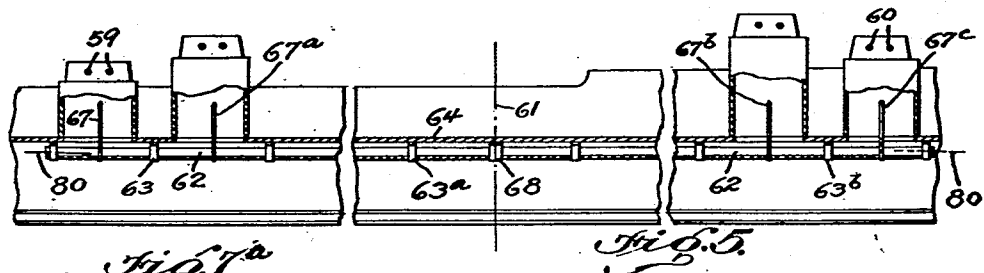
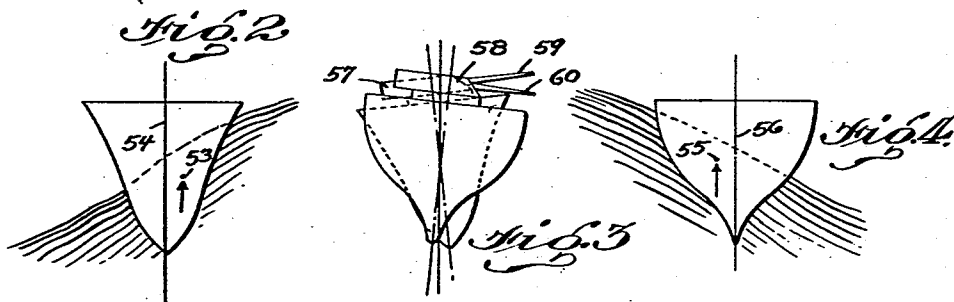
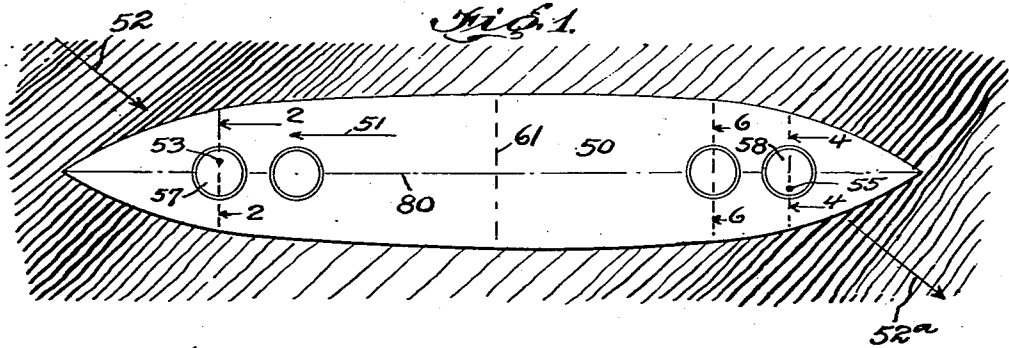
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J. B. WALKER ET AL

DIRECTOR FIRING SYSTEM

Original Filed Nov. 22, 1919

5 Sheets-Sheet 1



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By *Fig. 6.*

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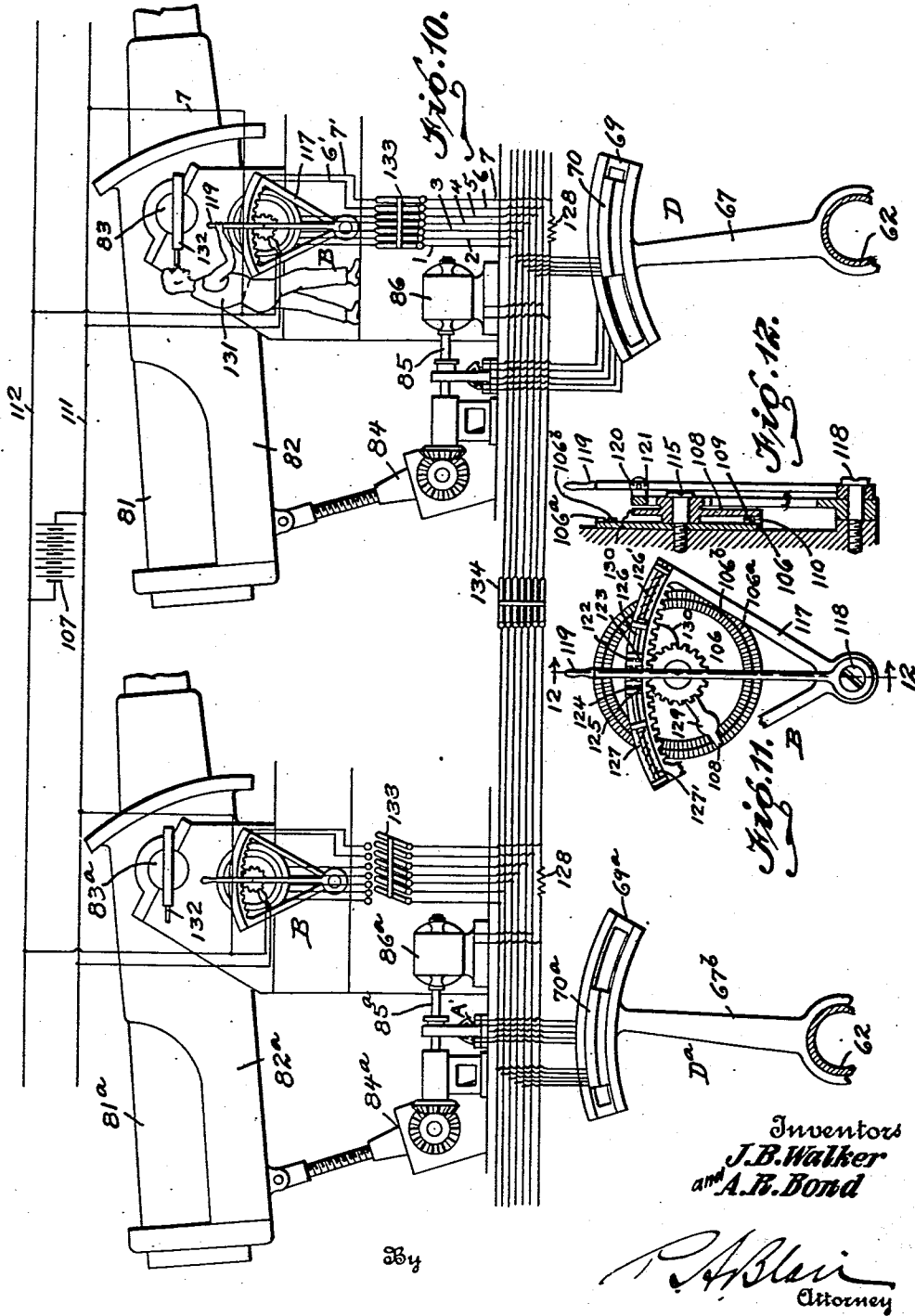
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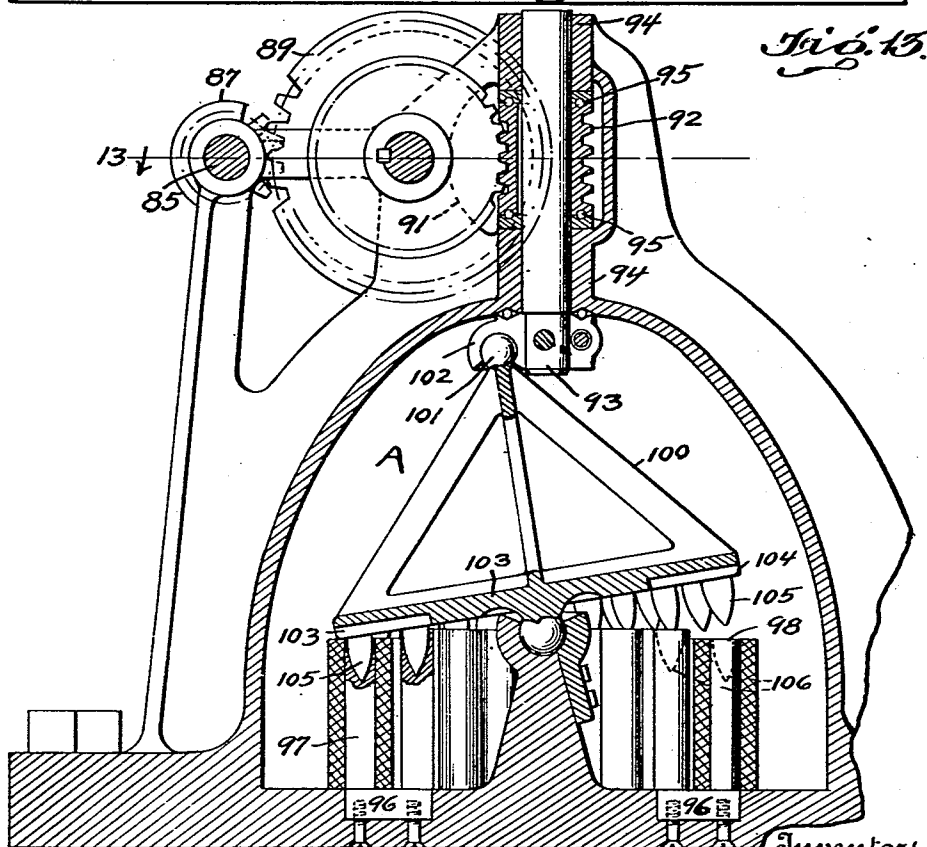
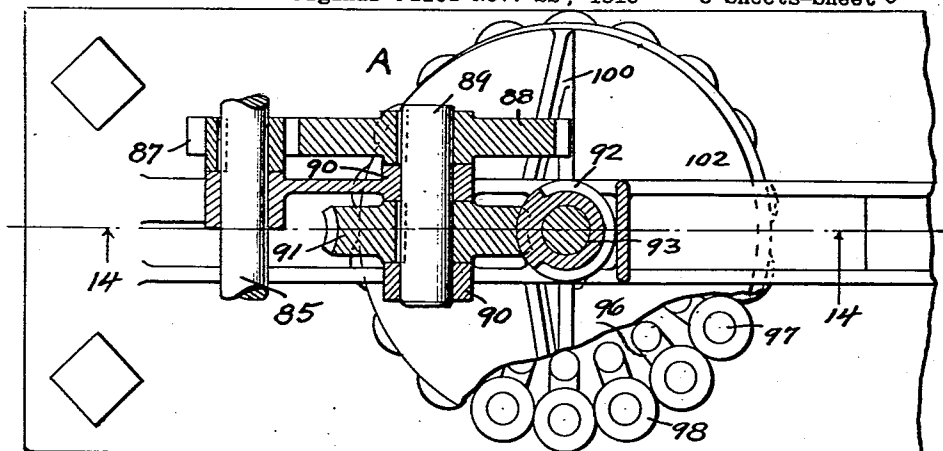


Fig. 14.

Fig. 13.

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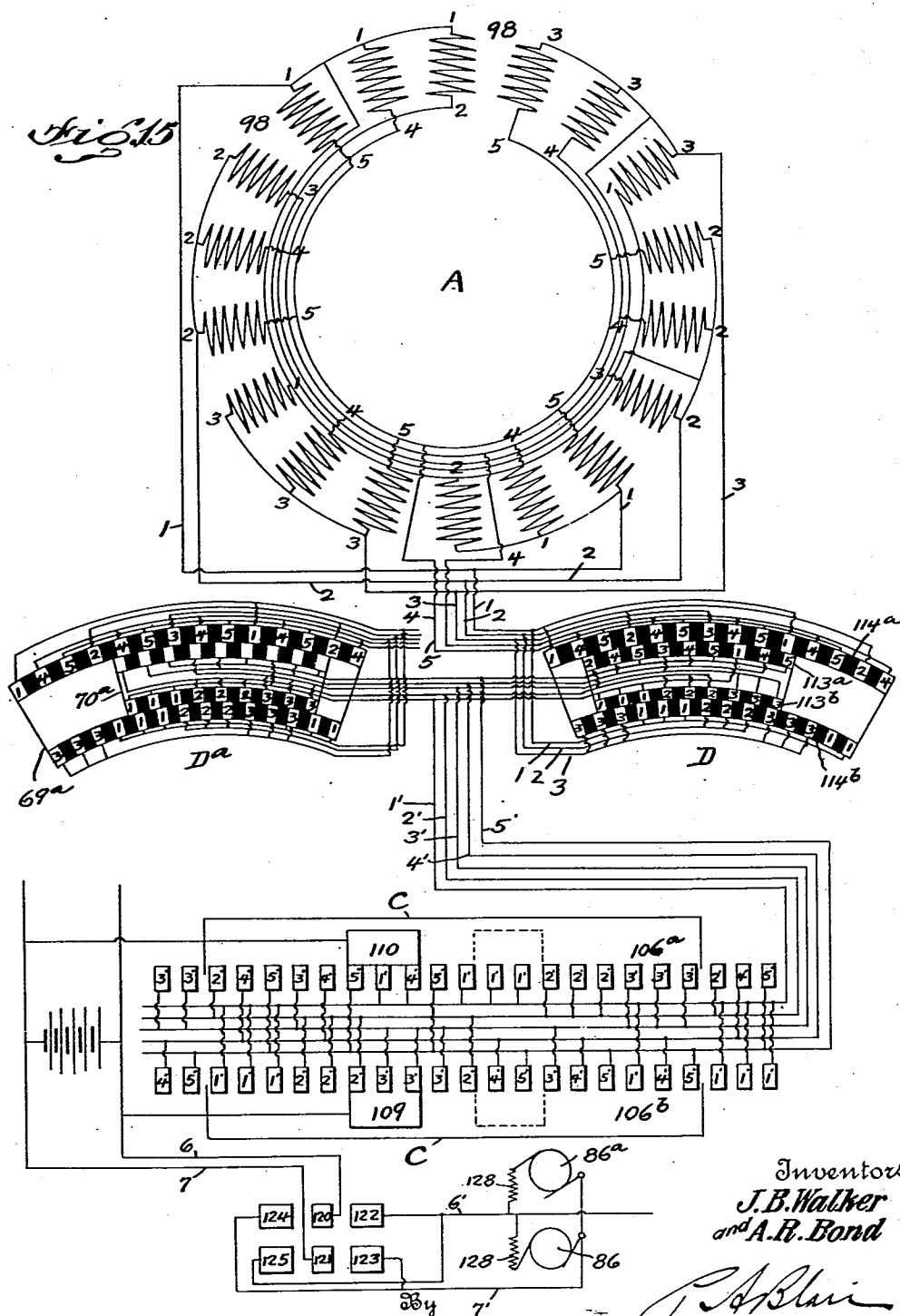
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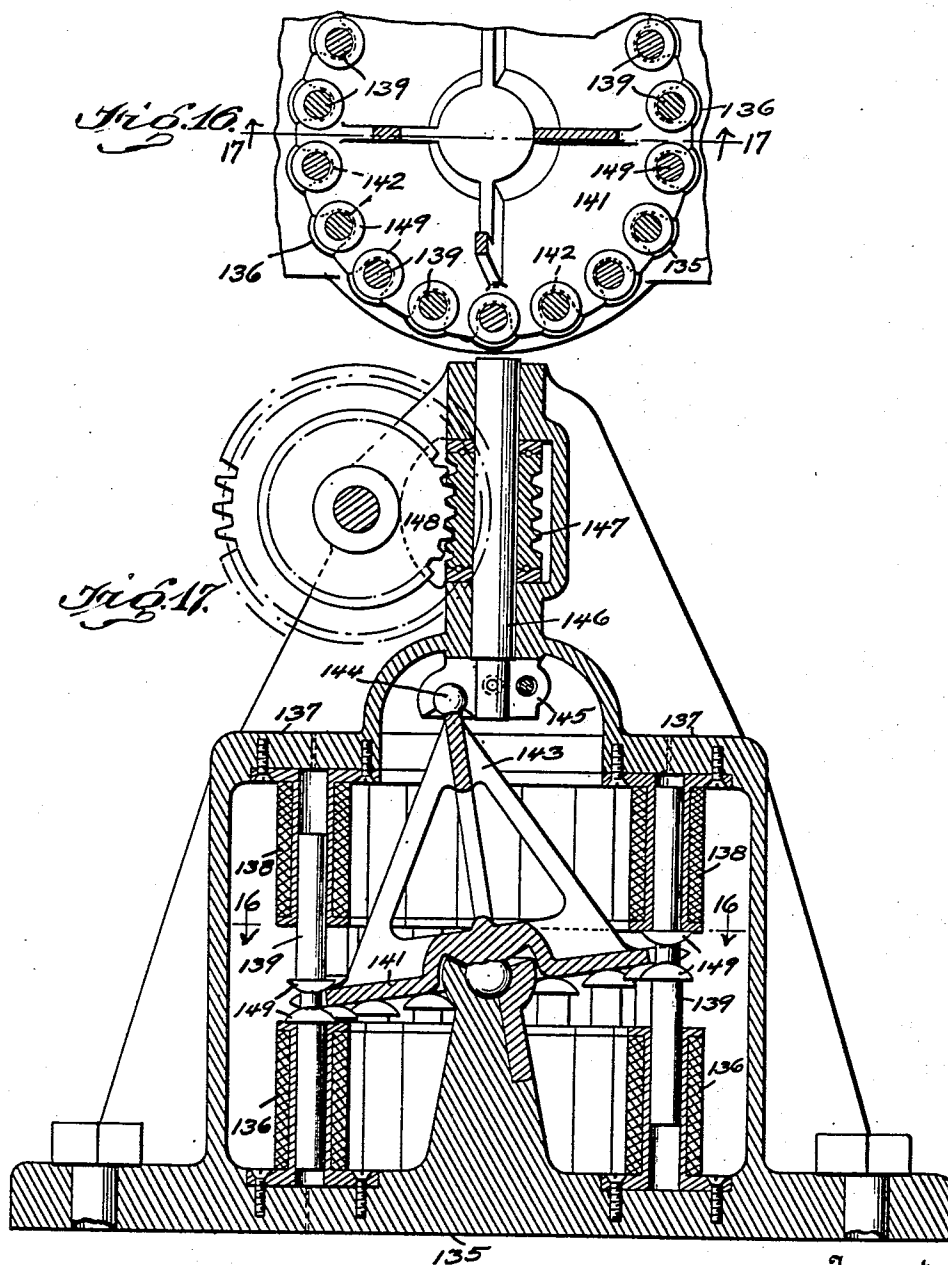
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J. B. WALKER ET AL

DIRECTOR FIRING SYSTEM

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE.

JOHN BERNARD WALKER, OF BROOKLYN, NEW YORK, AND ALEXANDER RUSSELL BOND, OF PLAINFIELD, NEW JERSEY.

DIRECTOR FIRING SYSTEM.

Application filed November 22, 1919, Serial No. 339,941. Renewed July 18, 1923.

To all whom it may concern:

Be it known that we, JOHN BERNARD WALKER and ALEXANDER RUSSELL BOND, citizens of the United States, residing at Brooklyn, New York, and Plainfield, New Jersey, respectively, have invented new and useful Improvements in Director Firing Systems, of which the following is a specification.

Our invention relates particularly to what is known as master or director firing of the batteries of warships, in which a whole battery of guns of the same caliber and ballistic properties, is elevated, trained and fired by one man; and it is the object of our invention to enable one man to simultaneously elevate and fire the battery, at any time during the roll of the ship and in any conditions of wind and sea in which an engagement is practicable.

In arranging a ship's battery for director firing, it is recognized that the fundamental adjustment is that of bringing the turntables of the guns into parallel planes, which preferably shall be parallel with the water, when the ship is floating in the vertical position. Not only should the machining of the lower roller path be done when the ship is afloat, but the ship should be loaded, as nearly as is practicable, as she will be when in fighting trim, with the ammunition, stores, coal, etc., or weights corresponding thereto, stowed as they will be in service conditions. The guns are then calibrated and the elevating and firing mechanisms are so adjusted that when one gun is on the target all are on, and the whole battery may be fired simultaneously by a single pointer. Such a result can be secured only if the parallelism of the turntables, as adjusted when the ship is afloat, in drydock, or in a sheltered basin, is maintained when the ship is at sea and being subjected to the complicated stresses which are set up within her elastic steel structure by the action of the sea.

It is our belief that in certain positions of the ship's course with regard to the direction of the waves, torsional stresses will occur which will be sufficient to throw the turn-

tables out of parallel adjustment, and produce more or less deviation from the common line of fire upon which the success of director firing depends.

It is the object of our invention to provide means for recording such distortions as occur in the ship and means for applying to each turret the necessary correction for maintaining its guns in parallel with the other guns of the battery.

One embodiment of the present invention is disclosed in the accompanying drawings forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the views, and in which,

Figure 1 is a plan view showing a ship steaming on a quartering course with regard to the waves.

Figure 2 is a transverse section of said ship taken near the bow on line 2—2 of Figure 1, looking in the direction of the arrow and showing a sea striking the starboard bow of the ship.

Figure 3 is a view showing distortion of the ship and change in elevation of the guns produced by said distortion.

Figure 4 is a transverse section of the ship on line 4—4 of Figure 1; taken near the stern looking toward the bow, showing a sea leaving the port quarter of the ship.

Figure 5 is a longitudinal section on the centerline of a portion of a warship, showing our torsion shaft for registering the distortions of a ship due to the stresses set up in a seaway.

Figure 6 is a transverse section taken on line 6—6 of Figure 1, showing our torsion shaft and means for registering transverse twist of the ship on graduated electrical contact plates.

Figures 7 and 7^a are diagrammatic views of the torsion shaft and the contact plates showing relative movements of the contact plates produced by twist of the ship at bow and stern, respectively.

Figure 8 is an enlarged view of a ball bearing for said torsion shaft.

Figure 9 is an enlarged view of a fixed center support for said torsion shaft.

Figure 10 is a diagrammatic view showing our improved means for simultaneously elevating and depressing a plurality of guns.

Figure 11 illustrates a control lever and accessory mechanism.

Figure 12 is a section taken on line 12—12 of Figure 11 but showing certain movable parts in a different position.

Figure 13 is a plan section taken on line 13—13 of Figure 14 showing an improved gyratory looking motor.

Figure 14 is a vertical section on line 14—14 of Figure 13.

Figure 15 is a diagram of electrical connections employed in our means for simultaneously elevating and depressing a plurality of guns and

Figures 16 and 17 show a modified form of our locking motor.

Referring to the drawings, 50 Figure 1 is a plan view of a battleship which is steaming in the direction indicated by arrow 51 against a quartering sea, the direction of whose waves, with respect to the ship, is indicated by arrows 52, 52^a. Under these conditions, the wave at the bow, indicated by arrow 52, will be higher on the starboard than on the port side, and the wave at the stern, as indicated by arrow 52^a, will be higher on the port than on the starboard side.

In Figure 2, which is a vertical transverse section on line 2—2, Figure 1, and in Figure 4, which is a similar section on line 4—4, Figure 1, these effects are more clearly shown. It will be seen that in Figure 2 the center of buoyancy 53 has moved to the right or starboard of the vertical axis 54 of the ship, and that in Figure 4 the center of buoyancy 55 has moved to the left or port of the vertical axis 56 of the ship at said section. The upward thrust of the displaced water at these respective sections being therefore to the right and left of the longitudinal axis 80 of the ship, as shown in Figure 1, produces a torsional stress within the structure of the ship, which, being elastic, must be subject to distortion such as shown in Figure 3. It will be seen that the bow of the ship with its turret 57 is sprung over to port, and the stern of the ship with its turret 58 is similarly sprung over to starboard. The effect of these movements, if all the guns are trained abeam on the starboard broadside, is to throw guns 59 in the bow turret above the intended common line of director fire, and to throw guns 60 of the stern turret below said line, thus defeating the object of director firing.

It will be evident, also, that the deviation of the several guns in the battery will bear a proportional relation to their distance from the transverse midship plane 61, Figure 1, of the ship, the deviation being least in the turret which is nearest to said mid-

ship plane, and increasing proportionately to the distance of any turret from said plane 61.

In order to maintain the several guns of a battery in true parallel in their elevation, we provide a stiff longitudinal member 62, Figure 5, preferably a steel pipe of large diameter, which is carried with its axis parallel to the neutral axis 80 of the ship, as shown in Figures 5 and 1. Preferably this member 62 is supported from the protective deck, 64, although for convenience it might be carried in some other position, provided care were taken to place it parallel throughout its length with the said neutral axis 80. The member 62 is carried preferably in ball or other bearings 63, 63^a, 63^b, etc., which are themselves bolted to the structure of the ship, as shown in Figures 5, 8 and 9. At some one point in its length, and preferably where it intersects the transverse midship plane 61 of the ship, the member 62 is bolted firmly to the structure of the ship by a bolt 65 which passes through the member 62 and through a block 68 which carries the said member 62 at said point of support. Now, since the pipe 62 is fixed firmly to the ship in the midship transverse plane 61, and the pipe is free to rotate in its ball-bearing supports 63, 63^a, 63^b, etc., it follows that any twist of the ship forward or aft of the support 68 will not be communicated to the member 62, the various bearings 63, 63^a, 63^b, etc., turning around said member.

In order to record the movement of the ship's structure at the several turrets, we attach firmly to the member 62 a series of levers, or other suitable members, 67, 67^a, 67^b, 67^c, (Figs. 7, 7^a and 10), one at each barrette, which are carefully adjusted when the turret turntables are trued up in the dockyard, so that they shall be exactly parallel to the vertical axes of the respective turrets.

At the top of each arm, 67, 67^a, etc. is carried a contact plate 69, 69^a, which contacts with another similarly graduated contact plate 70, 70^a fixed to the structure of the ship. Now it is evident that since the torsion-recording member is rigid, and is attached rigidly to the ship in the latter's transverse midship plane 61 is attached rigidly at no other point, the members 67, 67^a, 67^b, etc., will remain always in the same plane regardless of the twist of the ship, and the contact plates 70, 70^a, etc., which are fixed to the ship will be moved with relation to said members 69, 69^a, through angular distances corresponding to the twist of the ship at the points in its length at which said members are placed. Thus in the diagrammatic view, Figure 7, which indicates the twist of the bow to port at turret 57 (Fig. 1) the contact plate 70 on the ship will move past contact plate 69 on the torsion-record-

ing member 62, in the direction indicated by arrow 71. Similarly, in Figure 7^a which indicates the twist of the stern at turret 71, the contact plate 70^a on the ship will move to starboard, as indicated by arrow 71^a.

It thus becomes possible to record at each turret the angular distortion which takes place; and we provide means, as below described, by which the effects of said distortion tending to throw the guns of each turret out of their proper elevation with respect to the plane of members 67, 67^a, etc., can be automatically eliminated, and absolutely similar elevations can be maintained with respect to a fixed plane on all the guns of the battery.

In Figure 10 are shown two guns 81 and 81^a fitted in sleeves 82 and 82^a mounted in the customary manner on trunnions 83 and 83^a. The guns are respectively provided with elevating mechanism 84 and 84^a of well known design, connected to power shafts 85 and 85^a of motors 86 and 86^a. The purpose of said elevating mechanism is to keep the guns trained upon the target while the ship is rolled by the waves. To vary the speed of the power shafts 85, 85^a we provide the mechanism A and A^a, respectively, and of identical construction, illustrated more clearly in Figures 13 and 14. Keyed to the shaft 85 is a spur pinion 87 meshing with a spur gear 88 keyed to a shaft 89 mounted in suitable bearings 90. Said shaft 89 also carries a worm-wheel 91 keyed thereto which meshes with a worm 92 keyed to shaft 93 mounted in bearings 94. Said worm is provided with suitable thrust bearings 95. The gearing between the motor shaft 85 and the shaft 93 is such that the motor 86 will be unable to rotate shaft 93 or will be just barely able to rotate said shaft when the latter carries no load. It will be evident then, that the speed of shaft 85 may be controlled by a motor of relatively small horsepower operating to turn said shaft 93 at variable speeds. For this purpose we provide a gyrating auxiliary motor of special construction arranged to be moved step by step at variable speeds under control of a hand operated mechanism B.

As shown in Figures 13 and 14 our auxiliary motor comprises a series of preferably U-shaped electro-magnets 96 arranged in a circle with their axes parallel to the axis of said circle and their planes radially disposed. Preferably only the outer leg 97 of each magnet is wound with an energizing coil 98. Mounted on a ball bearing 99 at the center of said circle is a frame 100 of pyramidal form at the apex of which is a ball 101 fitting in a socket bearing formed in a crank 102 secured by a bolt 103 to shaft 93. The ball bearing 99 is concentric with axis of shaft 93 prolonged, and hence as the ball 101 is eccentric to said shaft the pyram-

idal frame 100 is tipped out of the vertical position. The base of said frame consists of a plate 103 of non-magnetic material fitted with armatures 104, each armature being formed with two bosses or conical plungers 105 adapted to enter sockets 106 formed in the legs of the respective electromagnets 96. It will be evident that if the magnets 96 are successively energized they will cause the plate 103 to pursue a gyratory or oscillatory motion about its bearing 99 without revolving, however, for the reason that the plungers 105 meshing with the electro-magnets 96 prevent revolution of said plate. But the apex of the frame will revolve about the axis of the shaft 93, carrying the crank 102 with it and thereby rotating the shaft 93.

The windings 98 of the electro-magnets are individually connected to contacts on a plate 106 of a controlling mechanism B, said contacts being adapted to be energized from a source of power 107 through contact arm 108. Instead of providing a separate wire for each magnet and a common return wire or ground, we prefer to use fewer wires arranged in combinations. For instance, in Figures 13, 14 and 15 we have shown eighteen electro-magnets connected with but five wires, but said wires are used in nine different combinations of two wires each. These wires are indicated by the numerals 1, 2, 3, 4 and 5, respectively. Diametrically opposite windings 98 are connected in series to the same pair of wires, but they are oppositely wound. The armatures 105 are preferably polarized so that as a magnet on one side is attracting its armature that on the diametrically opposite side is repelling its armature. This arrangement calls for but nine combinations of wires. The opposite pairs of windings are respectively connected to the following combinations of wires: 1-2, 1-4, 1-5, 2-3, 2-4, 2-5, 3-1, 3-4, and 3-5. After said combinations have been successively energized the current is reversed so that the magnets which were attracting their armatures before will be repelling them now, and vice versa. Thus, two diametrically opposed waves of energy of opposite polarity may be made to sweep around the circle of magnets.

While we use the member 98 to designate the windings of the magnets in general, we distinguish individual magnet coils by using the numbers of the wires connected to their terminals. Thus, magnet 3-5 is one whose terminals are connected to wires 3 and 5. The arrangement of contacts on the plate 106 is shown in the diagram, Figure 15. These contacts are directly connected to line wires 1', 2', 3', 4' and 5'. The contacts are individually designated with the same numbers as the wires with which they are normally connected. They are arranged in two

concentric circular rows 106^a and 106^b adapted to be connected to the positive and negative terminals, respectively, of the source of current supply 107. Reversal of the current is obtained by transposing the contacts in said circles. Thus, a complete group of contacts for eighteen magnets is embraced between the brackets C, C, but the first nine of said contacts in row 106^a are identical in arrangement with and connected to the same wires as the last nine of said contacts in the row 106^b; while the last nine of said contacts in row 106^a are identical with the first nine of said contacts in row 106^b. As shown in Figure 11, said rows of contacts 106^a and 106^b are arranged to form two complete circles, and said circles are made up of an aliquot number of groups C. Mounted on an arm 108 are two contact brushes 109 and 110 respectively connected with mains 111 and 112 leading from the current source 107. The brushes 109 and 110 are adapted to contact with the contacts in rows 106^b and 106^a, respectively.

Interposed between said contacts and the magnet windings 98 is our torsion-correcting device. The plate 70 which is secured to the ship is provided with two rows of contacts 113^a and 113^b adapted to contact respectively with the rows of contacts 114^a and 114^b carried by plate 69, said plate being secured to the torsion shaft 62. Contacts 113^a and 113^b are arranged in the same series of combinations as the contacts in rows 106^a and 106^b and are directly connected thereto by wires 1', 2', 3', 4' and 5', as shown in Figure 15, individual contacts being numbered with the same numbers as corresponding contacts on plate 106. Contacts 114^a and 114^b are also arranged in corresponding series of combinations with individual contacts bearing the same numbers as corresponding levers 1, 2, 3, 4 and 5. When there is no twist of the ship contacts 113^a and 113^b will contact with contacts 114^a and 114^b of similar number. In Figure 15 brushes 109 and 110 are shown as making contact with contacts 2'-5', 3'-1' and 3'-4' on plate 106, and were there no twist of the ship the corresponding magnet coils 2-5, 2-5; 3-1, 3-1 and 3-4, 3-4 would be energized. But plates 70 and 69 are represented (in Figure 15) as having shifted relatively one to the other so that instead magnets 2-3, 2-3, 2-4, 2-4 and 2-5, 2-5 are energized. In Figure 15 is also shown another torsion correcting device D^a located in a different part of a ship and consisting of plate 70^a secured to the ship and a plate 69^a secured to torsion shaft 62. Contacts on plate 70^a are respectively connected to corresponding contacts on plate 106, and contacts on plate 69^a are connected to motor A'. In Figure 15 plates 70^a and 69^a are represented as having shifted relatively one to the other by a different amount

from that of similar plates 70 and 69, so that magnet coils 3-1, 3-1; 3-4, 3-4 and 3-5, 3-5 will be energized in motor A' (not shown in Figure 15) although brushes 109 and 110 are contacting with contacts 2-5, 3-1 and 3-4. Thus the energizing wave through the magnets 98 of a set of motors may be retarded or advanced in proportion to the torsion of the ship in the vicinity of said motor.

To operate the contact arm 108 we provide the mechanism illustrated in Figures 11 and 12. The arm 108 is mounted to turn in a shaft 115. Affixed to said arm or integrally formed therewith is a pinion 116 meshing with a toothed sector 117 mounted to turn on a shaft 118. On said shaft is also mounted a hand lever 119 having contacts 120 and 121 adapted to contact with contacts 122 and 123 on one side of said lever or with contacts 124 and 125 on the other side of said lever. Contacts 122 and 123 are mounted on a spring-pressed plunger 126 while contacts 124 and 125 are mounted on a spring-pressed plunger 127. As indicated in Figure 15 the contacts 120 and 121 are respectively connected by wires 6 and 7 to the mains 111 and 112. Contacts 125 and 122 are connected to one terminal and contacts 124 and 123 to the other terminal of one or more motors 86, 86^a, etc. Said motors are preferably connected in parallel and are of series type with a fixed resistance 128 in the circuit of each motor to prevent said motor from absorbing an excessive amount of current when operating at speeds so reduced as to prevent it from generating an appreciable amount of back-electromotive force. It will be clear from diagram, Figure 15, that when contacts 120 and 121 engage contacts 122 and 123 power motors 86 and 86^a will turn in one direction and when contacts 120 and 121 engage contacts 124 and 125 said motors will turn in the opposite direction. In other words, the contacts on lever 119 and the coacting contacts on sector 117 constitute a pole changing switch for the power motors 86 and 86^a.

When the operator moves the lever 119 from a position of rest he first energizes the power motors 86 and 86^a, causing them to turn in one direction or the other, depending upon the direction in which he has thrown the lever 119. One or the other of the plunger springs 126', 127' will thereby be compressed until sufficient force is transmitted through said spring to the sector 117 to overcome friction and inertia of the various parts, whereupon the sector 117 will turn the pinion 116, causing arm 108 to sweep over the contacts on plate 106, thereby causing waves of energy to sweep around the circles of magnets 98 of the locking motors A, A', etc., at a rate that will be commensurate with the sweep of the arm

108 over said contacts, plus or minus the correction for torsion of the ship as explained above. As soon as the power motors 86, 86^a, etc., are energized they exert a torque on the shafts 85, 85^a, etc. However, said shafts cannot be rotated owing to their gear connection with the respective magnetic auxiliary motors A, A', etc., until said locking motors are actuated by the sweep of the arm 108 over the rows of contacts 106^a and 106^b. Furthermore, said motor shafts 85, 85^a, etc., actuated by the power motors 86, 86^a, etc., will move as fast as their respective auxiliary motors A, A', etc., permit them to. As long as the lever 119 is moved the elevating mechanism will operate and at a commensurate rate, and when the lever is stopped the elevating mechanism will also stop. In order to prevent said elevating mechanism from stopping too abruptly the arm 108 is provided with a weight 129 and counterweight 130. The inertia of said weights will cause said arm to lag behind the lever 119 in case said lever starts or stops very abruptly and thereby prevent excessively rapid starting and stopping of the motor A.

In operation then, a pointer 131 with his eye at the customary telescope 132 mounted on the gun 81 endeavors to keep the sights or hair lines of his telescope on the target by moving the lever 119 forward or backward and correspondingly moving the gun and his telescope up and down with respect to the ship. If a number of motors 86, 86^a, etc., are connected in parallel, said motors respectively operating guns 81, 81^a, etc., under control of auxiliary motors A, A', etc., said guns will be simultaneously elevated or depressed through equal arcs plus or minus the correction for twist of the ship provided by the mechanism D, D^a, etc., acting respectively on the circuits.

Each gun is provided with a controller mechanism B adapted to control the elevating apparatus of all the guns, but normally all but one of said controller mechanisms are rendered inactive by opening multiple switches 133 and thereby disconnecting said controller mechanisms from the lines 1', 2', 3', 4' and 5' of the locking motors and 6, 7 of the power motors. If it be desired to operate the guns separately said multiple switches 133 are all closed, but switches 134 are opened to electrically disconnect each gun from the other.

The accuracy of aim of each gun will depend upon the movement in elevation or depression permitted by the controlling motor in progressing from one magnet 98 to the next. As indicated in Figure 15, the brushes 109 and 110 are just large enough to contact with three pairs of contacts 106^a and 106^b at a time, but the spaces between said contacts are of such width that as the

brushes are moved, say to the right, they will break connection with a pair of contacts at the left before contacting with a new pair at the right, so that as the brushes sweep over the contacts they will alternately energize two and three pairs of magnets 98 at a time. When three pairs of magnets are energized the axis of maximum effort will be in the plane of the middle pair of the three, while when two pairs are energized the axis of maximum effort will be in a plane midway between said two pairs. Thus, twice as many steps of progression may be provided as there are magnets in the motor. If progression from one magnet to another represents an elevation or depression of the gun through two minutes of arc it is possible by energizing alternately two and three magnets at a time to elevate or depress said gun in steps of one minute of arc.

We show a modified form of auxiliary motor in Figures 16 and 17. Figure 16 is a sectional plan view of a part of said motor taken on the line 16—16 of Figure 17, while Figure 17 is a vertical section taken on the line 17—17 of Figure 16. Mounted on a base 135 is a series of solenoids 136 arranged in a ring. Secured to a support 137 overlying said base is another series of solenoids 138, coinciding in number and in axial alignment with the solenoids 136 but spaced apart from them. Plungers or movable cores 139 are provided which are common to mating solenoids 136 and 138; that is, a single core is furnished for a solenoid 136 and that immediately overhead. Mounted on a ball-and-socket joint 140 concentrically with said series of solenoids is a plate 141 formed with slots 142 along its periphery to receive the plungers 139. Said plate 141 carries a pyramidal frame 143 connected at its apex by a ball-and-socket joint 144 with crank arm 145 secured to shaft 146. Affixed to shaft 146 is a worm 147 engaging worm wheel 148. Formed on each plunger 139 is a pair of buttons 149 adapted to bear against opposite side of plate 141. The solenoids 136 are wound like magnets 98 in Figure 15 and are similarly connected to a controlling mechanism C by which they may be energized in pairs or groups of pairs, as explained above. Each solenoid 138 is electrically connected in series with the solenoid 136 directly below it but is oppositely wound. The plungers 139 are polarized so that when a solenoid 136 is attracting its plunger 139 its mate 138 is repelling said plunger and assisting in moving it downward. At the same time the diametrically opposite solenoids 136 and 138 will be operating to move their respective common plungers 139 upward. As the solenoids are successively energized by the movement of contact lever 108 plungers 139 will be successively actuated to gyrate said plate

141 on its bearing, communicating rotary motion to worm 147 and worm wheel 148. The function of said worm and worm wheel is the same as the function of worm 92 and worm wheel 91. The periphery of plate 141 and the adjacent faces of contact buttons 149 are so curved as to remain always in contact while said plate is gyrated by reciprocatory motion of said plungers 139.

10 While we have shown in the drawings only a few line wires (1—5 Figs. 10 and 15) connected with a much greater number of windings (98 Fig. 15), we do not limit ourselves to the form of electrical connection.

15 We wish it to be clearly understood that we may use other combinations of wiring or we may provide a line wire for each magnet or solenoid winding with a common return or ground wire, and we may energize any desired number of solenoids at a time.

20 We have shown the gun 81 and 81^a as elevated by means of electric motors 86 and 86^a. However, we do not limit ourselves to such elevating mechanism. Naval guns are often elevated by means of hydraulic plungers and it will be clearly evident that our auxiliary motors A and A' may be employed to curb said hydraulic plungers in exactly the same manner as the movement of the motors 86 and 86^a may be controlled.

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

35 1. In a vessel subject to torsional movements, a rigid member secured to said vessel at one point while the vessel may move rela-

tively thereto at other points, and means for indicating relative torsional movements of the said vessel with respect to said rigid member at the said points thereon.

2. In a structure subject to torsional movements, the combination of a gun mounted on said structure; a rigid member secured to said structure at one point while the structure may move relatively thereto at other points, and means for moving said gun with respect to said structure in proportion to the said torsional movements of said structure with respect to said rigid member.

3. In a vessel subject to torsional movement, a shaft rigidly secured to said vessel at one point, bearings secured to said vessel at other points in which bearings said shaft may freely turn, graduated arcs on said ship, and arms secured to said shaft and adapted to move with respect to said arcs.

4. A vessel subject to torsional movements, a plurality of guns mounted on said vessel, means for rocking said guns with respect to said vessel, mechanism for the control of the speed of operation of said means, a member mounted on said vessel but not partaking of said torsional movements, and apparatus for modifying said control of the speed of operation of said means in proportion to the torsional movement of said vessel with respect to said member.

Signed at New York, New York, this 11th day of November, 1919.

JOHN BERNARD WALKER.
ALEXANDER RUSSELL BOND.