

Oct. 29, 1929.

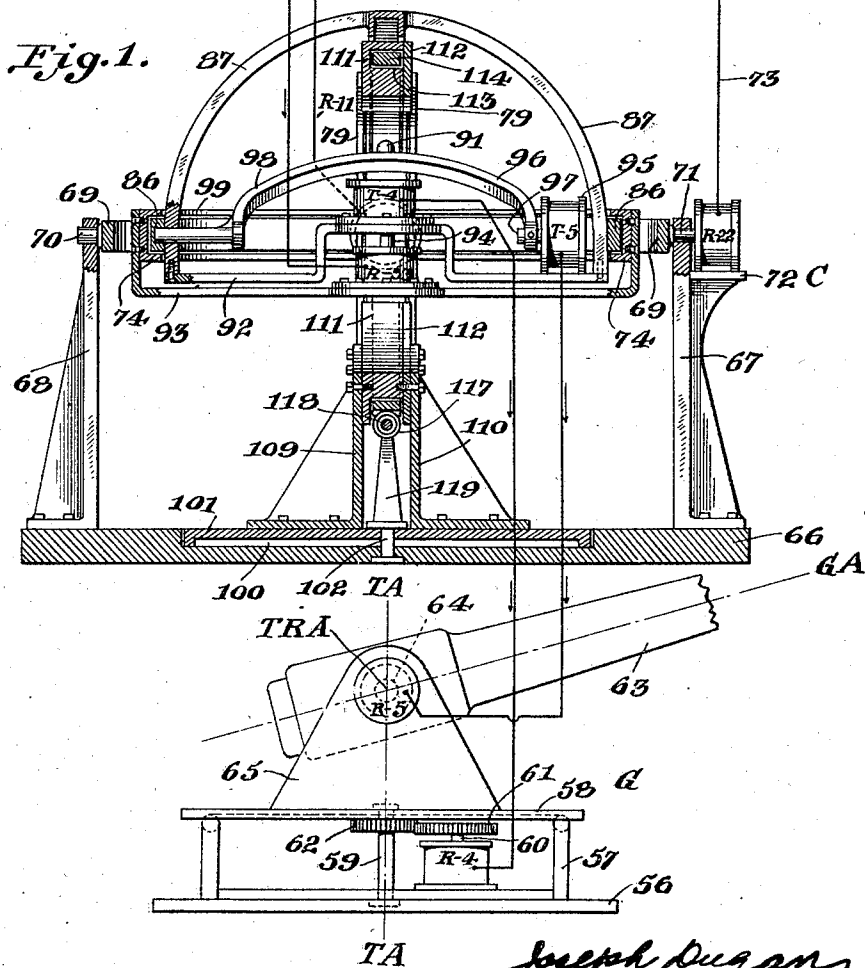
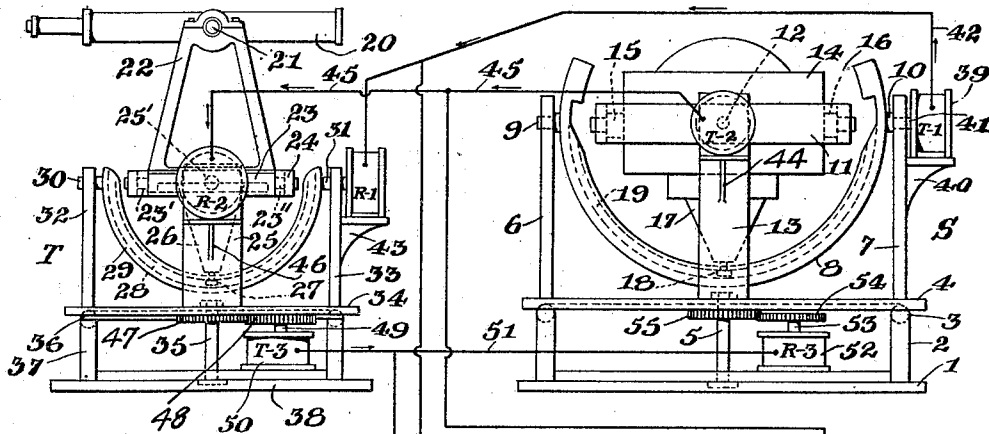
J. DUGAN

1,733,531

SIGHT CONTROLLED GUNNERY SYSTEM

Filed Feb. 7, 1927.

3 Sheets-Sheet 1



Oct. 29, 1929.

J. DUGAN

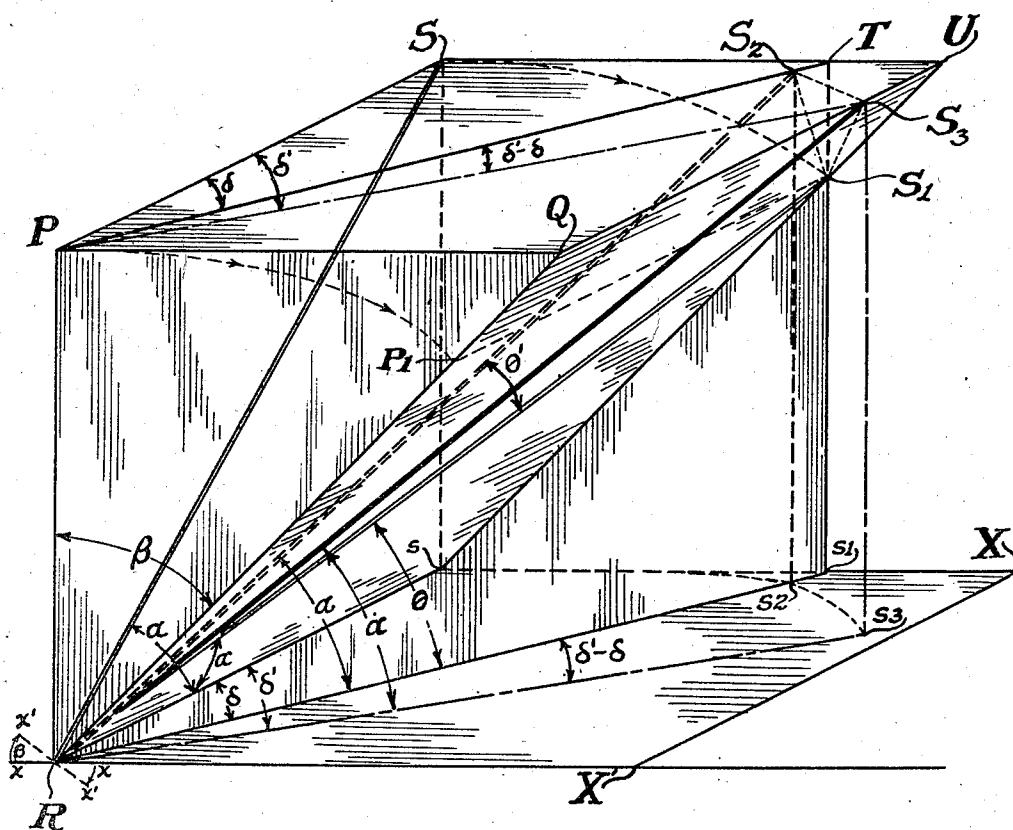
1,733,531

SIGHT CONTROLLED GUNNERY SYSTEM

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3 Sheets-Sheet 2

Fig. 1^a.



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SIGHT CONTROLLED GUNNERY SYSTEM

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3 Sheets-Sheet 3

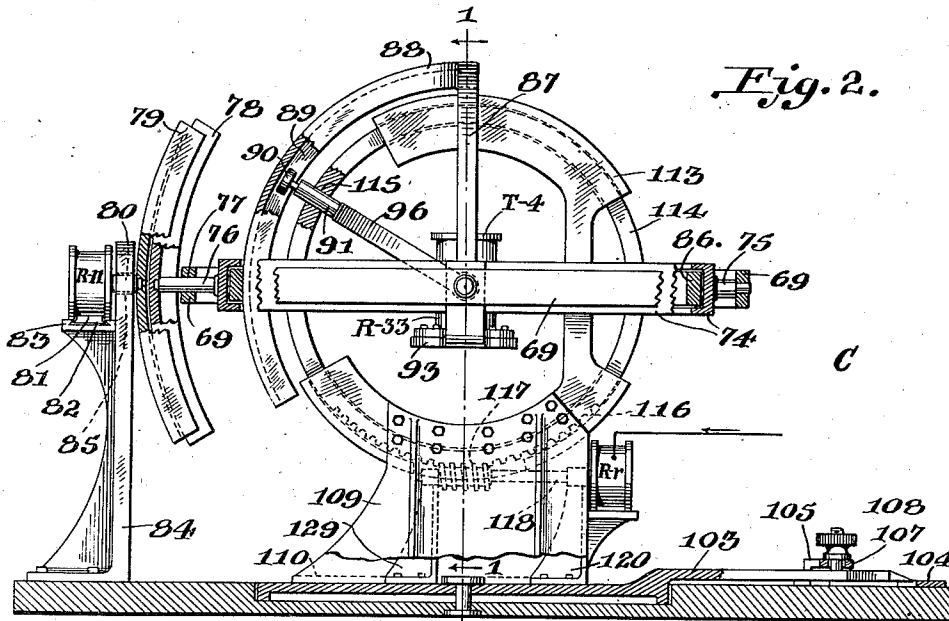


Fig. 2.

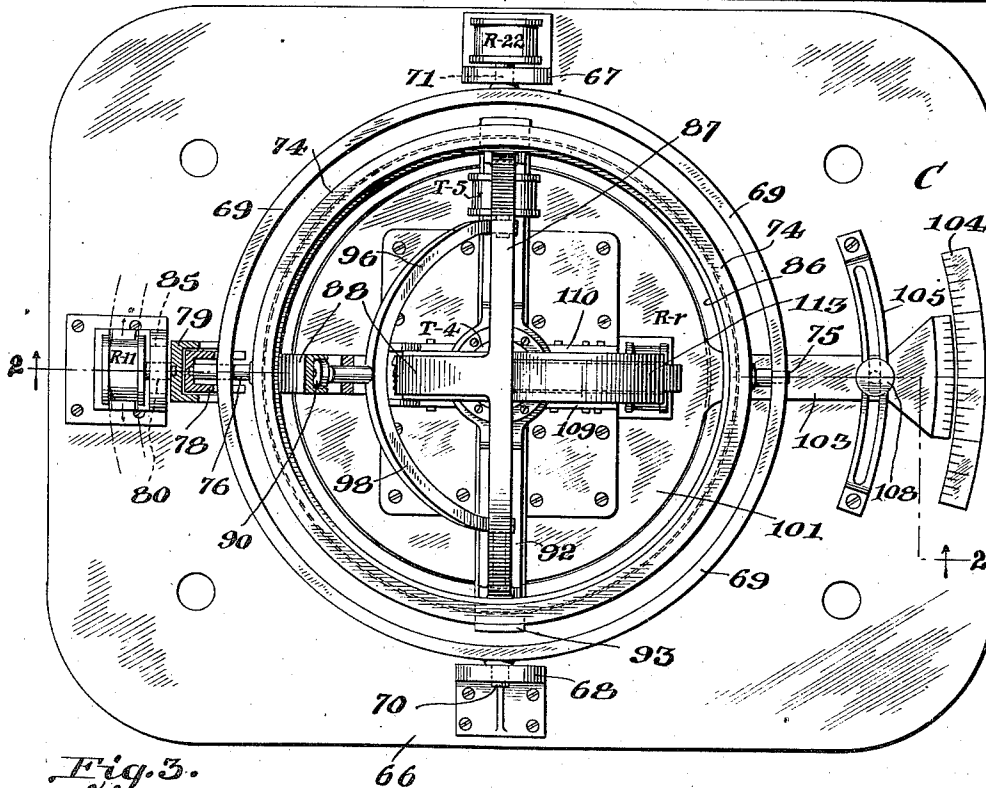


Fig. 3.

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SIGHT-CONTROLLED GUNNERY SYSTEM

Application filed February 7, 1927. Serial No. 166,361.

This application is a continuation in part of my copending application, Serial Number 29,843, filed May 12, 1925, which is, in turn, a continuation of my abandoned application Serial Number 746,238, filed October 27, 1924. The subject matter of these related applications, and common to all three, involves the stabilization of a sighting instrument by a pendulum suspended on a support to pivot about mutually perpendicular axes; and also involves the azimuthal rotation of the support by and in synchronism with the azimuthal rotations of the sighting instrument to maintain the trunnion axis of the sight and one of the pendulum support axes constantly in parallel planes; whereby rotation of the pendulum about its said axes may be utilized in determining the inclinations of an unstable platform, mounting said instrument and support, about either or both of said mutually perpendicular axes.

The invention forming the subject matter of this application embodies a radically new system for the automatic control of guns mounted on unstable platforms, such as the decks of battleships or the chassis of railroad guns, etc.

The object of the invention is to eliminate completely the inaccurate and costly directorscopes heretofore used in attempts to correct errors in gun training and elevating caused by the rolling and pitching of the gun supporting deck or platform; and to substitute for these directorscopes an extremely simple and mathematically accurate means for directing and holding the gun or guns with the gun axis or axes fixed in space in a predetermined vertical plane and at any desired angle of elevation regardless of the rolling or pitching of the deck or platform.

Before describing the invention itself in detail, it is deemed necessary to discuss, in geometric terms, the errors, and corrections therefor, which result from the rolling and pitching of the platform in the training and elevating of the gun. In this connection, it is to be understood that "pitch" refers to the angle of inclination of the deck or platform to the horizontal in the vertical plane of sight; and, that "roll" refers to the inclina-

tion of the gun trunnion axis (parallel to the deck or platform) to the horizontal in a vertical plane either perpendicular to the vertical plane of sight; or, to the inclination of the trunnion axis in a vertical plane inclined to the vertical sight plane at a horizontal deflection angle imposed on the gun (not on the sight) to correct for parallax, lateral drift of the projectile, lateral displacement of the target, etc.

While the apparatus embodying this invention is designed to be set to correct for all errors in train and elevation, it is primarily concerned only with the automatic correction, with mathematical accuracy, of all errors, whether in train or elevation, caused by tilt of the gun trunnions due to roll and/or pitch of the platform or deck. As will be shown presently, there are two errors in train and one in elevation to be compensated for in setting the inclined gun at its proper range angle in the plane of the target.

To illustrate the errors involved in trunnion tilt, and the necessary corrections therefor, reference is made to the perspective diagram of Fig. 1^a. In this diagram, the plane RPS_s represents the vertical plane through the target; $x-x$, represents the horizontal gun trunnions; R represents the intersection of the train and trunnion (elevation) axes; and S represents the muzzle end of the gun. The plane R_sXX' represents the horizontal plane passing through the pivot intersection R of the train and elevation axes of the gun; and the plane $PSUQ$ represents the horizontal plane passing through the muzzle end S of the gun elevated at the range angle α in the vertical plane RPS_s , with the trunnion axis $x-x$ horizontal.

If, now, the platform supporting the gun be assumed to roll through the angle β , and the trunnion axis assumes the position $x'-x'$ inclined at the same angle β to the horizontal, it is clear that the plane of the inclined gun bore tilts through the angle β until it assumes the position of the plane RP_1S_1 with the end of the gun at the point S_1 in the plane RQU_s . In its new position, the gun axis RS_1 also lies in the vertical plane R_sTP and is inclined at the angle θ to the horizontal plane R_sXX' .

If the gun axis could be elevated in this vertical plane RS_1TP until its end S_1 touched the horizontal plane $PSUQ$ in the point S_2 , it would move through the angle θ' , which is evidently the error in elevation when the gun is merely moved into the plane of the target without change in its range angle setting.

However, since the gun now lies in the inclined plane RQU_s and can only rotate in that plane about its axis $w'-w'$, it is evident that elevation of the gun, in that inclined plane, until it reaches the upper horizontal plane $PSUQ$ in the point S_2 , causes still another error $\xi'-\xi$ in train, which must be corrected in the setting of the gun. The total error in train is ξ' which is the sum of the deflection angle ξ , resulting from merely moving the gun from the vertical plane to the inclined plane, and the angle $\xi'-\xi$ resulting from elevating the gun in the inclined plane until its axis is inclined at the angle α to the horizontal.

It is evident from Fig. 1^a that if the inclined gun be swung from the position RS_s at the fixed range angle α or S_sRS_s , about R as a pivot until its plane RPS_sS_s coincides with the plane RPS_s , the gun axis RS_s will coincide with the axis RS in the plane of the target. Conversely, if the gun axis be held vertical during the inclination of the deck or platform, the deflection corrections ξ and $\xi'-\xi$ must be applied in the plane of the deck; that is, about the train axis of the gun. This is precisely what the present invention does automatically and with mathematical accuracy.

The angle θ is obviously less than the angle S_1RS_s , since it is merely the projection on the vertical plane RPT_s , of the angle S_1RS_s . As a matter of fact it is not practically possible to measure either of these constantly varying angles $\xi'-\xi$ and S_1RS_s . Therefore any instruments which purport to correct for trunnion tilt by the use of calculators for mechanically solving trigonometric equations, more or less approximately, can only effect correction of trunnion tilt with very crude approximation.

The present invention does not measure angles and does not include a calculator of any kind; it does, however, effect all three corrections, in train and in elevation, for trunnion tilt automatically and with mathematical accuracy.

In the prior art, the U. S. patent to Hewlett et al. 1,626,824 discloses apparatus approaching nearest to the present invention in mathematical accuracy; but the Hewlett corrector is incapable of being automatically operated, and requires no less than three operators, each exercising independent control, to make any corrections in the movements of the gun for trunnion tilt. Moreover, since the target sight of this patented apparatus is not sta-

bilized to rotate about a constantly horizontal axis, the trunnion tilt of the target sight itself actually introduces a trunnion tilt error into the corrector itself.

The U. S. patent to Henderson 1,683,073 discloses a trunnion tilt corrector apparatus which is capable only of deflecting the inclined gun into the vertical plane of the target; but is absolutely incapable of correcting the elevation error due to trunnion tilt, and consequently omits altogether the additional train correction which is coupled with the elevation correction. As is the case with the Hewlett apparatus, the Henderson target sight also introduces its own trunnion tilt error into the corrector mechanism.

The patents to Hewlett and Henderson have been discussed here because they disclose apparatus in the prior art most nearly approaching the present invention in correction for trunnion tilt; and because they most clearly illustrate the defects in prior art constructions which it is the object of the present invention to overcome. The automatic operation of the present invention eliminates at least three operators, and all the errors involved in their personal equations, required to operate the Hewlett corrector; and the operation of the present invention with mathematical accuracy to correct for all errors induced by trunnion tilt presents very decided advantages over the Henderson corrector which can only correct for one of the three errors arising from trunnion tilt of the gun.

In the drawings:

Fig. 1^a is a perspective diagram illustrating the errors arising in the elevation and train settings of a gun caused by trunnion tilt, and the necessary corrections required to eliminate these errors;

Figure 1 is a diagrammatic layout of the apparatus comprising this invention, with parts of the correcting mechanism shown in greater detail;

Figure 2 is an elevation of the corrector, with parts thereof broken away and sectioned to disclose the relative arrangement of several parts more clearly, the plane of section being indicated by line 2—2, of Fig. 3; and

Figure 3 is a plan of the corrector shown in Figure 2.

The apparatus comprises four main parts: (1) the telescope or sight T ; (2) the stabilizing pendulum S ; (3) the corrector C ; and (4) the gun G .

The stabilizer S comprises a platform 1 having a supporting ring 2 extending perpendicularly therefrom and having its upper edge provided with anti-friction rollers 3 on which is rotatably mounted the pendulum supporting platform 4, a bolt 5 serving as a central securing pivot for the platform 4. Standards 6 and 7, fixed on the platform 4, have the channeled bail 8 pivoted to swing between them on the trunnions 9 and 10.

A gimbal ring 11 has a trunnion 12 fixed thereto and pivoted in the standard 13, and a second trunnion fixed to said ring diametrically opposite trunnion 12 is similarly pivoted in a standard diametrically opposite standard 13 (the second trunnion and standard are not shown herein as the construction is well known in the art). A gyroscope 14 is pivoted by trunnions 15 and 16 in the gimbal ring 11 and has an arm 17 fixed to the bottom of the casing thereof, the arm 17 having a roller 18 fixed to its end and seated slidably in the channel 19 of the bail member 8. The structural details of the gyroscopic pendulum are not set forth in detail here because they are old and well known in the art. The novelty in the gyroscopic part of this invention lies in mounting the pendulum to rotate as a whole on the supporting ring 2 in synchronism with the sight.

The telescope or directing device 20 is pivoted by trunnions 21 in standards 22 (only one of each being shown herein) which are rigidly fixed to the standard supporting plate 23 having diametrically opposite trunnions pivoted in gimbal ring 24 which is, in turn, pivoted in standards 25 (only one of which is shown) in the usual gimbal ring arrangement. An arm 26, fixed rigidly to the bottom of plate 23, has a roller 27 at the end thereof slidable in the channel 28 of the channeled bail 29, which is pivoted by its trunnions 30 and 31 in the standards 32 and 33, respectively. The standards 32 and 33 are fixed to the sight platform 34 mounted to rotate about pivot bolt 35 on the anti-friction bearings 36 carried by the upper edge of the supporting ring 37 which is fixed to the supporting platform 38.

The gimbal ring supports of the gyroscope 14 and the sight 20 are identical structurally, and the gyro support 4 is connected to the sight support 34 to rotate therewith so that the axis of the trunnions 9 and 10 is always parallel to the axis of the trunnions 30 and 31, and the transverse axes of the sight and gyroscope are also parallel.

To maintain the sight 20 with its line of sight constantly in a vertical plane, the transmitter T—1 has its stator 39 fixed to a bracket 40 on the standard 7 and has its rotor 41 connected to the trunnion 10 to be rotated thereby. Through the wiring 42, the transmitter T—1 operates the repeater R—1 to rotate the trunnion 31 in exact synchronism with the rotation of the trunnion 10, the repeater R—1 being fixedly secured to the bracket 43 of the standard 33.

Similarly, the transmitter T—2, fixed on the bracket 44, transmits the rotations of the trunnion 12, through wiring 45 to the trunnion 25' through repeater R—2, which is fixed to bracket 46 on standard 25.

In order to maintain the telescope with its line of sight rotatable in a vertical plane, it

will obviously be necessary to rotate the gyroscope apparatus as a whole in synchronism with the rotation of the sighting apparatus as a whole in azimuth. To effect this rotation, a ring gear 47 is fixed to the bottom of the plate 34 to mesh with a gear 48 fixed to the rotor 49 of the transmitter T—3, the stator 50 of which is fixed to the platform 38. The transmitter T—3, through the wiring 51, operates the repeater R—3 having its stator fixed to the platform 1 and its rotor 53 operatively connected by the gears 54 and 55 to the platform 4 to rotate the latter in exact step with the rotations of the platform 34.

The arrangement just described keeps the axes of the gyroscope support in exact parallelism with the corresponding axes of the sight support, and maintains the plate 23 and trunnion arms 21 constantly horizontal.

The platform 56 of the gun G has fixed thereto the supporting ring 57 on which the gun turret 58 is mounted to rotate about the central pivot bolt 59. A repeater R—4, fixed to the platform 56, has its rotor 60 connected by gears 61 and 62 to the gun turret 58 to rotate the latter in synchronism with the rotations of the sight 20 in azimuth, plus or minus the additional rotations necessary to correct the azimuth settings of the gun when the gun trunnion axis is inclined to the horizontal.

If the gun trunnions were constantly horizontal, the setting of the gun about its train axis TA could be effected by connecting the repeater R—4 for direct operation by the sight transmitter T—3. All that would be necessary, then, would be to add or subtract the roll of the ship about the trunnion axis TA from the range setting of the gun. However, since the ship pitches and rolls in all directions, it will obviously be necessary to correct for the inclination of the gun trunnion axis to the horizontal as well as for the inclination of the gun supporting platform and of the gun direction pointing axis in the vertical plane containing the gun direction pointing axis GA and the target. It is to impose these necessary corrections simultaneously on the gun about its train and trunnion axes that the corrector shown in the drawing has been devised. The gun 63 is mounted to rotate on its trunnions 64 in the standards 65 fixed to the turret platform 58.

No attempt is made here to illustrate the wiring details of the gyroscope, repeater and transmitter circuits, since these details are old and well known in the art. The lines connecting the several repeaters to their controlling transmitters are merely intended to indicate that certain repeaters are controlled by certain transmitters. For example, transmitter T—3 controls repeaters R—3 and R—33, and the lines drawn from transmitter T—3 to the said repeaters indicate this and nothing more. The wiring details for devices of this nature are set out in prior pat-

ents such as that of Hewlett et al. 1,612,117. The gearing and hydraulic motors commonly used to operate the guns, are neither shown or described herein, as the details thereof form no part of the present invention. The various gears and motors are all controlled by transmitters and repeaters, and it is only the mechanism for operating the transmitters and repeaters that the present invention is concerned with. The repeaters and transmitters really act as relays to set in operation the brute force mechanism for moving the guns about their several axes. The apparatus is nothing more than a mechanical means for solving geometrical problems involved in setting guns on unstable platforms to compensate for the rolling and pitching of the platforms in all directions.

The gist of the invention lies in the "corrector" C. In the general setting up of the apparatus, it is necessary that the platforms 1, 38, and 56 be fixed in the same normally horizontal plane or in normally horizontal parallel planes. The supporting platform 66 of the corrector may be placed in any position found desirable or convenient.

The corrector comprises the base plate 66, having standards 67 and 68 fixed thereon. A gimbal ring 69 has its trunnions 70 and 71 rotatable in said standards, and the repeater R—22 is fixed on bracket 72 with its rotor operatively connected to the pivot 71, the repeater R—22 being tapped by the wiring 73 to wire 45 for control by the gyroscope transmitter T—2.

In the gimbal ring 69, there is pivoted the inner gimbal ring 74 by means of the diametrically opposite trunnions 75 and 76. The trunnion 76 passes pivotally through the aperture 77 (Fig. 2) in the ring 69 and has its end fixed to the arcuate slide 78 which is slidably mounted in the arcuate channel member 79 fixed at its center to the rotor shaft 80 of the repeater R—11. The repeater R—11 is fixed on an arcuate dovetailed slide 81 mounted to slide in a correspondingly shaped arcuate groove 82 formed in the supporting bracket 83 of the standard 84; and the standard 84 is provided with a slot 85 to permit the rotor shaft 80 to slide laterally therein.

The inner gimbal ring 74 is channeled and a ring 86 is slidably mounted therein. At diametrically opposite parts of the ring 86 and perpendicular to the plane thereof there is fixed a semicircular member 87; and extending laterally from said member at the center thereof, there is a quadrant arm 88 having a channel 89 in which slides a roller 90 mounted on the end of a range rod 91.

The member 87 has a diametral plate 92 fixed to its ends and has a transmitter T—4 secured to the center of said plate. The ring 74 likewise has a diametral plate 93 fixed thereto and below the plate 92; and at the

center thereof has a repeater R—33 fixed thereto, with the rotor shaft 94 thereof forming the rotor shaft of the transmitter T—4.

A transmitter T—5 has its stator casing 95 fixed to the member 87 and plate 92, and the range rod 91 has a branch 96 fixed to the rotor 97 of the transmitter T—5. The other branch 98 of the rod 91 has a trunnion 97 pivoted in the member 87 and ring 86.

In a circular recess in the base plate 66, a deflection plate 101 is mounted to rotate about the pivot bolt 102, and has a vernier indicator arm 103 extending radially therefrom to travel over a deflection and parallax scale 104. A guide plate 105 is fixed to the base plate 66 and has an arcuate slot formed therein to receive the shank of a pin 107 fixed to the arm 103; and a lock nut 108 screw-threaded onto said pin 107 serves to lock the arm in adjusted position.

Standards 109 and 110 are fixed to the plate 101 and serve as supports for a range gear casing 111 and a closure plate 112, respectively. The casing 112 is provided with a circular groove 113, in which is slidably mounted the range gear ring 114 having an aperture 115 therethrough to pivot the range rod 91.

The lower part of the range gear 114 is provided with worm teeth 116 in mesh with a worm 117 fixed to the range shaft 118 supported in the small standards 119 and 120. A range repeater R—r, controlled by a range finder or clock or other instrument (not shown), rotates the shaft 118 to set the range gear 114 and rod 91 for the range of the gun.

All the ring and arcuate members heretofore described, except those on the base plate, are really segments of a sphere having its center at the intersection of the trunnion axes of the gimbal rings 69 and 74. The pivot axis of the deflection plate 101 likewise passes through the center of this sphere.

In the operation of this invention, it is essential that the platforms 1 and 38 of the pendulum and sight, respectively, be placed in the same normally horizontal plane as that of the gun turret 58, or in planes parallel thereto. The sight may be located in a conning tower, while the gyroscope or pendulum might be placed at the metacenter of the ship where it would be least subjected to acceleration forces. The corrector can be placed wherever desired and preferably in the plotting room of the ship.

It will be understood that the trunnion axis of the sight pendulum and gun must be set up initially in parallelism, and with the controlling transmitters and repeaters correspondingly adjusted and mounted.

In operation, it is most convenient to consider the platform 66 as representing the horizontal plane and the gimbal ring 74 as representing a plane parallel to the plane of the deck or gun turret. Since all we are concerned with is the relative movements of the

deck and horizontal plane, and the corrector is controlled by repeaters and transmitters from the gyroscope and sight, it is obvious that the corrector can be placed in any position desired.

Assuming the parts properly set up, it will be apparent that when the sight 20 is rotated in azimuth from its initial position onto a target, it will operate the transmitter T—3 and thereby operate the repeater R—3 of the pendulum to rotate the support of the latter and maintain the trunnion axes of the pendulum parallel to those of the sight. Assuming, further, that the deck of the ship remains constantly horizontal, the transmitter T—3 also operates the repeater R—33 to turn the rotor 94 of the transmitter T—4, which, in turn, transmits the rotation of the transmitter T—3 to the repeater R—4 and thereby turns and holds the gun in azimuth onto the target sighted.

Assuming again that the range arm has been set for the range of the target and that the ship rolls about the trunnion axis of the gun while this axis remains horizontal, the operation is somewhat as follows: In setting the range rod 91, the rotor 97 of the transmitter T—5 is moved relative to its stator; and if member 87, to which the said stator is fixed, be perpendicular during the range setting, the transmitter T—5 will operate repeater R—5 to elevate the gun through the range angle for range. If the ship then rolls or pitches about the horizontal trunnion axis of the gun, the member 87 will be rotated by its gimbal ring connections with the repeater R—22 and this rotation of the member 87 naturally rotates the stator of the transmitter T—5 relative to its rotor and therefore operates the repeater R—5 to keep the gun at a fixed elevation in space irrespective of the rolling of the ship about the gun trunnion axis. Obviously, while the trunnion axis is horizontal, the channel member 88 will swing about its trunnions 70 and 71 without exerting any lateral pressure on the roller 90.

If the ship also pitches as it rolls about the gun trunnion axis, the transmitter T—1 will operate the repeater R—11 to incline the channel guide laterally and thereby tilt the ring 74 out of the plane of ring 69 which will also be tilted by the repeater R—22. Under these conditions, the rolling and pitching of the ship will cause the roller 90 to impinge against one side or the other of the channel 89 as the quadrant 88 swings angularly up and down over the roller 90, and, consequently, will rotate the ring 86 in the gimbal ring 74, thereby rotating, through plate 92, the stator of transmitter T—4 relative to its rotor 94, which, it will be remembered, is also the rotor of the repeater R—33. This rotation of ring 86 in the ring 74 adds to or subtracts from the movements already imparted by the sight transmitter T—3, through the repeater

R—3 and transmitter T—4, to the repeater R—4. In other words, the rotation imparted to the gun about its train axis TA is the algebraic sum of the rotation of the sight about the axis of its pivot 35 and the rotation of the gun about its train axis, in either direction, necessary to correct for the inclination of the gun trunnion axis TrA to the horizontal.

At the same time, the relative movements of the members 87 and 96 operates the transmitter T—5 so as to rotate the gun about its trunnion axis to compensate for the roll of the ship about that axis. The two operations are carried out automatically and simultaneously, so that the resultant effect is that the gun is held with its gun axis GA at a fixed elevation to the horizontal in a vertical plane passing through the target, while the ship rolls and pitches relative to this axis.

The platform 101 is evidently rotatable to carry the range gear with it, whenever it becomes necessary to compensate the apparatus for parallax or for deflection caused by relative azimuth movements of the target and gun during the flight of the shell.

In this application, every word, whether in the specification proper or in the claims, is to be taken in its every day, common sense meaning. For example, the word "by", wherever used, means actually, physically and mechanically by, in its simple two-letter meaning; it does not mean in accordance with.

The claims of this application do not cover, and are not intended to cover, apparatus of the type disclosed in the U. S. patent to Hewlett et al., 1,626,824, May 3, 1927, and Akeman 1,445,192, Feb. 13, 1923, in which the several elements of the corrector mechanism must be operated by human beings in accordance with the readings of indicators operated by rotations of the target sight, or/and in accordance with the indications of levels. The invention disclosed in this application is entirely automatic so far as the operation of its corrector mechanism is concerned; it has an inherent law of operation which never varies, since its operation is not dependent upon the use of human beings as elements of its corrector mechanism.

The device disclosed herein is mathematically accurate and is obviously much simpler than the vastly complicated directors of the prior art. While only one gun is shown in the drawing, it will be obvious that the corrector apparatus disclosed herein will control any number of guns, unless the locations of the guns relative to the control sight require correction for parallax.

The repeater R—11, instead of being slidably mounted on bracket 83, may be fixed thereto and have its rotor connected by a flexible shaft or universal coupling to the arcuate slide 79 to provide for lateral movement of the pivot-support for slide 79.

While the apparatus described in this ap-

plication is particularly designed for the control of guns on unstable platforms, it must not be considered as limited to such use; since it is also intended to control any member, such as a torpedo tube, search light, or anything else having a direction pointing axis and rotatable about train and elevation axes similar to those of a gun mounted on an unstable platform.

It will be apparent that whatever the range or deflection setting of the corrector may be, the apparatus disclosed herein will automatically maintain the gun, or similar direction pointing member, on an unstable platform with its direction pointing axis at the same angle to the horizontal as the member 91 is set relative to the base plate 66, and in a vertical plane either parallel to the vertical plane containing the optical axis of the sight or at a horizontal angle thereto equal to the deflection setting of the deflection plate 101.

This apparatus, too, completely eliminates the personal equation in its operation, since this involves nothing more than keeping a sight trained upon a target. The great advantage of this will be obvious when it is considered that in the operation of the directorscopes of the prior art, such as are disclosed in the patents to Radford 1,531,132, 1,583,308, to Akeman 1,445,192 and the patent to Hewlett et al., 1,626,824, not less than three operators are required to operate the apparatus during the controlling movements thereof; and every one of these men must be highly skilled and work with the minutest degree of care in order to maintain the several parts controlled by them in exact horizontal and vertical positions. With the present invention, anyone who can point a sighting device at a target can operate the apparatus, in which the necessary corrections are effected automatically by the movements of the platform itself.

The term "sight" must be considered, whenever used in this application, as a broad comprehensive term intended to include any suitable direction finder or pointing device.

The rod 91 of the corrector may be provided with a contact tongue located in a firing circuit, and a second contact tongue, adjustable on the member 88, may be set to make contact with the first named contact to cause firing of the gun at any desired point in the roll of the platform about the trunnion axis of the gun. Since the rod 91 represents the gun axis and ring 74 represents the deck, the adjustable contact should always be located above the ring 74 in order to avoid all possibility of the gun firing through the deck or platform carrying it.

I claim:—

1. In combination with an unstable platform, a directing device movably mounted on said platform, a directing device movably mounted on said platform, a gun rotatably

mounted on said platform, and mathematically accurate means on said platform mechanically controlled by said device and operable automatically by the movements of said platform to hold the gun with its gun pointing axis fixed in a given vertical plane during the rolling and pitching movements of the platform.

2. The combination with an unstable platform, of a gun mounted thereon to rotate about a plurality of axes, a directing device rotatable on said platform, and mathematically accurate means controlled mechanically by said device and operated by the movements of said platform to rotate the gun simultaneously about said axes to hold the gun with its gun axis fixed in a vertical plane determined by said device during the rolling and/or pitching movements of the platform.

3. The combination with an unstable platform, of a sight mounted thereon to rotate about an axis perpendicular thereto, a gun rotatable on said platform about mutually perpendicular axes one of which is also perpendicular to said platform, and mathematically accurate means interposed between said sight and sight and gun and controlled by said operable automatically by the movements of said platform to hold the gun with its gun axis fixed at a given range angle in a vertical plane passing through the target on which the sight is trained during the rolling and pitching of said platform.

4. An unstable platform, a sight rotatable about a fixed axis thereon, a gun rotatable about its train and trunnion axes on said platform, and mathematically accurate means connected to said sight and gun and operable automatically by the movements of said platform to rotate the gun about its said axes simultaneously and to hold the gun with its gun axis at a fixed range angle in a vertical plane passing through the target on which the sight is held trained.

5. An unstable platform, a sight, a stabilizing pendulum and a gun, each mounted to rotate about a separate axis perpendicular to said platform and about a second axis perpendicular to the first named axis; and automatic means connecting said sight, pendulum and gun to rotate the said pendulum and gun, each about its own axis perpendicular to the platform, in synchronism with the rotation of the sight about its axis perpendicular to said platform.

6. An unstable platform, a gun rotatable thereon, a sight, and mathematically accurate means connecting the sight to the gun and operable automatically by the movements of the platform to hold the gun with its gun axis fixed at a fixed angle in a vertical plane having a predetermined location relative to the vertical plane containing the line of sight and the target.

7. An unstable platform, a directing device rotatably mounted thereon, a member mounted to rotate on said platform about mutually perpendicular axes one of which is perpendicular to said platform and having a direction pointing axis, and mathematically accurate automatic operable means connecting said member to said device to rotate the member about said axes and maintain it with its pointing axis in a vertical plane determined by said finder throughout all movements of the unstable platform.

8. An unstable platform, a directing device rotatably mounted thereon, a member mounted to rotate on said platform about mutually perpendicular axes one of which is perpendicular to said platform, said member having a pointing axis concurrent with said axes, and mathematically accurate automatic operable means connecting said member to said device to rotate the member about said axes and maintain the member with its pointing axis fixed at a predetermined angle to the horizontal in a vertical plane determined by said device throughout all movements of the unstable platform.

9. An unstable platform, a member having a direction pointing axis mounted to rotate on said platform, about mutually perpendicular axes one of which is perpendicular to said platform, a directing device rotatable on said platform, and mathematically accurate automatic operable means connecting said device and member and controlled by the movements of said device and platform to maintain said member with its pointing axis in a vertical plane determined by said device.

10. An unstable platform, a directing device, a stabilizing pendulum and a pointing member, each mounted to rotate on said platform about parallel axes perpendicular to said platform and about parallel axes parallel to said platform and mathematically accurate automatically operable means connecting said device, pendulum and member to move the latter by and in accordance with the movements of the device and pendulum and maintain the member pointing in a vertical plane determined by said device throughout all movements of said platform.

11. In fire control apparatus, an unstable platform, a sight rotatable about an axis perpendicular to said platform, a stabilizing pendulum mounted to rotate about an axis perpendicular to said platform and about mutually perpendicular axes parallel thereto, a gun mounted to rotate about a train axis perpendicular to said platform and about a trunnion axis parallel to the platform, means connecting the sight to the pendulum to rotate the pendulum about its axis perpendicular to said platform in synchronism with the rotations of said sight about its axis, means connecting the sight to the pendulum and gun and operable

automatically and with mathematical accuracy by the rotations in azimuth of the sight and the movements of the said pendulum about its several axes to rotate the gun about its said axes and maintain it with its pointing axis in a vertical plane determined by the movements of the sight throughout all movements of the platform.

12. In fire control apparatus, an unstable platform, a sight rotatable on said platform about an axis perpendicular thereto, a gun rotatable on said platform about mutually perpendicular axes, and means mathematically accurate automatically operable connecting the sight to the gun and operable by azimuth rotation of the sight and movements of said platform to rotate the gun about said axes and maintain it with its pointing axis in a vertical plane determined by the sight.

13. The combination with a gun, of an unstable platform on which the gun is rotatable about a set of axes varying in angular position with the angular position of said platform, a directing device rotatably mounted on said platform, and mathematically operable means controlled by the rotation of said device and operable automatically by the movements of said platform with reference to a fixed set of planes to rotate the gun about its said axes and maintain it fixed relative to said planes.

14. The combination with a gun, of an unstable mount on which the gun is mounted to rotate about relatively fixed train and elevation axes varying in angular position with the angular position of said mount, a directing device rotatable on said mount, and mathematically operable means controlled by said device and operable automatically by the movements of said mount with reference to vertical and horizontal planes to rotate the gun about its said axes and maintain it fixed relative to said planes.

15. A system of gunfire control comprising a sighting device and a gun mounted on a common moving support and each adjustable about train and elevation axes, mathematically accurate means for transmitting the movements of said device about its train axis to said gun, and mathematically accurate automatic operable means for varying said movements during the transmission thereof, in accordance with the movements of said support, to rotate the gun simultaneously about its said axes to hold it with its pointing axis at a predetermined angle to the horizontal in a vertical plane inclined at a predetermined horizontal angle to the vertical plane of the line of sight of said device.

16. A gunfire control system including two members relatively rotatable about a common axis, means for rotating each member independently of the other about said axis, a receiver having one of its relatively rotatable elements fixed to one of said members, a transmitter having one of its relatively rotatable

elements fixed to the other member, the rotors of said receiver and transmitter being fixed to each other and rotatable about said common axis, two devices rotatable about separate axes, and means connecting said devices to said receiver and transmitter to transmit the rotations of one of said devices through said receiver and transmitter to the other device.

17. The combination with the apparatus set forth in claim 16, of means to rotate said members relatively to one another to modify the rotations of one device during the transmission thereto of the rotations of the other device.

18. An unstable platform, a sight rotatable on said platform about an axis perpendicular thereto, a support rotatable on said platform about another axis perpendicular thereto, a stabilizing pendulum rotatable on said support about mutually perpendicular axes one of which is parallel to said platform, and means connecting the sight to said support to rotate the support in synchronism with the sight and maintain the pendulum with one of its said axes parallel to a vertical plane containing the line of sight of the sight.

19. An unstable platform, a base plate mounted on said platform, a pair of supports extending upwardly from said base plate, a gimbal ring having diametrically opposite trunnions pivoted about an axis parallel to said base plate in said supports, a standard pivoted to said ring to swing about an axis perpendicular to the axis of said trunnions, a second pair of supports extending up from said plate, an arcuate channeled bail pivoted on said second pair of supports to swing about an axis parallel to said plate and perpendicular to the axis of said trunnions, an arm fixed to said standard and having its free end slidable in the channel of said bail, a sight pivoted on said standard about an axis parallel to one of the two axes first named, and means responsive to the movements of said platform to rotate said bail and trunnions and maintain the said standard stabilized horizontally.

20. An unstable platform, a base plate rotatable about an axis perpendicular to said platform, a pair of supports extending from said plate, a gimbal ring having diametrically opposite trunnions pivoted in said supports about an axis parallel to said plate, a pendulum pivoted to said ring to swing about an axis perpendicular to the axis of said trunnions, a second pair of supports on said plate, an arcuate channeled bail pivoted on said second pair of supports to swing about an axis parallel to said plate and perpendicular to the axis of said trunnions, an arm fixed to said pendulum and having one end thereof slidable in the channel of said bail, a sight rotatable on said platform about a plurality of axes, and means connecting the

pendulum to the sight to transmit movements of said pendulum to the sight and maintain the sight with its line of sight rotatable about a horizontal axis.

21. An unstable platform, a pair of gimbal ring supporting structures rotatable about parallel axes perpendicular to said platform; gimbal rings supported pivotally on each of said structures; a standard fixed to the inner gimbal ring of one of said structures, a sight pivoted on said standard about an axis parallel to one of the axes of its supporting gimbal rings; a pendulum fixed to the inner gimbal ring of the other supporting structure; means for rotating the pendulum supporting structure in synchronism with the sight supporting structure to maintain the gimbal axes of said pendulum constantly parallel to the gimbal axes of the sight structure; and means, including said gimbal rings, for transmitting the movements of said platform to said standard to maintain the standard with the pivot axis of the sight thereon horizontal.

22. An unstable platform, a sight, means for mounting said sight to pivot universally relative to said platform, a stabilizing pendulum, a second means for mounting said pendulum to pivot universally relative to said platform, and means connecting the pendulum and sight to maintain the sight rotatable about a horizontal, an axis rotatable in a horizontal plane.

23. In gunfire control apparatus, an unstable platform, a corrector comprising a base plate, a pair of standards on said plate, a pair of gimbal rings pivoted in said standards, means connected to said rings to maintain the inner gimbal ring in the same angular position relative to said base plate as the platform makes with the horizontal plane, said inner ring being grooved, an arcuate channeled bar, means slidably mounted in the groove of said inner ring to support said bar perpendicular to said ring, a member pivoted to said supporting means and having a part thereof slidable in the channel of said bar, and means fixed to said plate to adjust said member angularly relative to said plate; said rings, channeled bar, supporting and adjusting means forming skeleton parts of concentric spheres.

24. The combination with the apparatus set forth in claim 23, of means for angularly adjusting said adjusting means about an axis perpendicular to said plate and passing through the center of said spheres.

25. A gun, a mount on which the gun is adjustable about a set of axes varying in angular position with variations in the angular position of said mount; and means, settable with reference to a fixed set of planes to control the adjustments of the gun about said axes, for automatically generating cor-

rections in the movements of the gun about said axes in their various positions.

26. A gun, a mount therefor on which the gun is adjustable about elevation and train axes which vary in angular position with variations in the angular position of said mount; and means, settable with reference to a vertical and a horizontal plane to control the movements of the gun about said axes, for automatically generating corrections in the movements of the gun about said axes in their various positions.

27. A gun, an angularly movable mount on which the gun is adjustable about a set of relatively fixed mutually perpendicular axes which vary in angular position with variations in the angular position of said mount; and means, adapted to have corrections applied thereto with reference to horizontal and vertical planes, for automatically generating, from said applied corrections, corrections in the movements of the gun about said axes, and for subsequently varying said generated corrections to compensate the movements of the gun about said axes for changes in the angular positions of the axes due to angular movements of said mount.

28. A movable support, a sighting device and a gun, each rotatable on said support about elevation and train axes; and means adapted to have corrections applied thereto with reference to vertical and horizontal planes and operated by and in accordance with the movements of said sighting device, for automatically generating corrections in the movements of the gun about said axes and subsequently varying said generated corrections upon changes in the angular position of said axes due to movement of the support.

29. A movable support, a gun adjustable on said support about elevation and train axes varying in angular position with variations in the angular position of said support; and means, settable with reference to vertical and horizontal planes, to correct the movements of the gun about said axes, and for automatically generating the set corrections in terms of movements of the gun about said axes in their various positions, and for subsequently varying said generated corrections in response to and in proportion to changes in the angular position of said axes due to movement of said support.

In testimony whereof I have signed my name to this specification.

JOSEPH DUGAN.

CERTIFICATE OF CORRECTION.

Patent No. 1,733,531.

Granted October 29, 1929, to

JOSEPH DUGAN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, lines 15, 17, 18, 20, 32, 33 and 43, the large epsilons should be small deltas; page 6, line 93, claim 3, strike out the words "sight and" and insert the same before the word "operable" in line 94; page 7, lines 7, 19 and 33, claims 7, 8 and 9, and line 115, claim 15, for the word "automatic" read "automatically"; same page, line 79, claim 12, after the word "operable" insert the word "means"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 27th day of May, A. D. 1930.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.

DISCLAIMER

1,733,531.—*Joseph Dugan*, Los Angeles, Calif. SIGHT-CONTROLLED GUNNERY SYSTEM. Patent dated October 29, 1929. Disclaimer filed March 8, 1932, by the patentee.

Hereby enters this disclaimer to that claim in said specification which is in the following words, to wit:

"18. An unstable platform, a sight rotatable on said platform about an axis perpendicular thereto, a support rotatable on said platform about another axis perpendicular thereto, a stabilizing pendulum rotatable on said support about mutually perpendicular axes one of which is parallel to said platform, and means connecting the sight to said support to rotate the support in synchronism with the sight and maintain the pendulum with one of its said axes parallel to a vertical plane containing the line of sight of the sight."

[Official Gazette April 5, 1932.]