Feb. 20, 1923. 1,446,280

M. M. TITTERINGTON

STABILIZED BOMB SIGHT

Filed Sept. 9, 1918 3 sheets-sheet 1

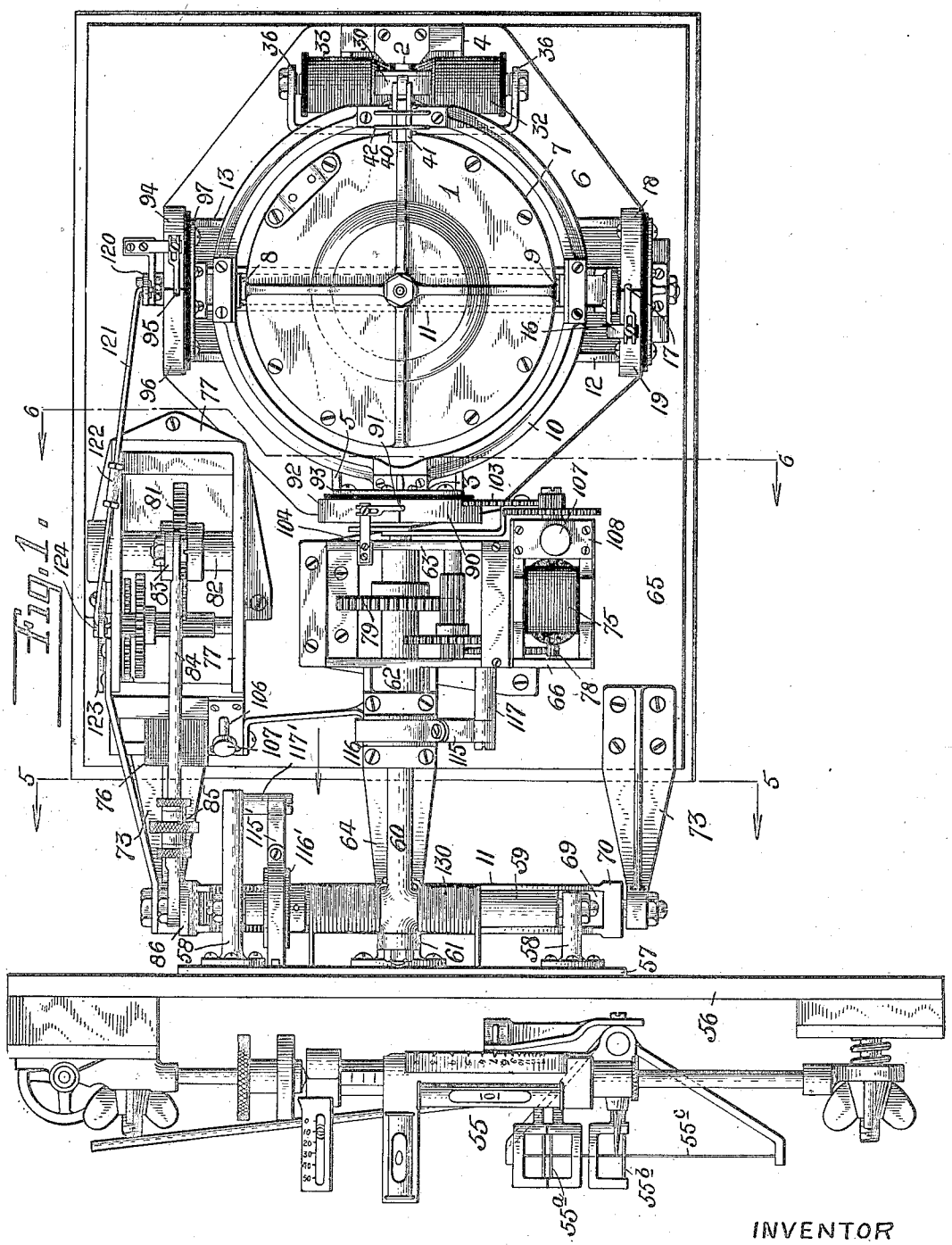


Fig. 1.

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Fig. 2.

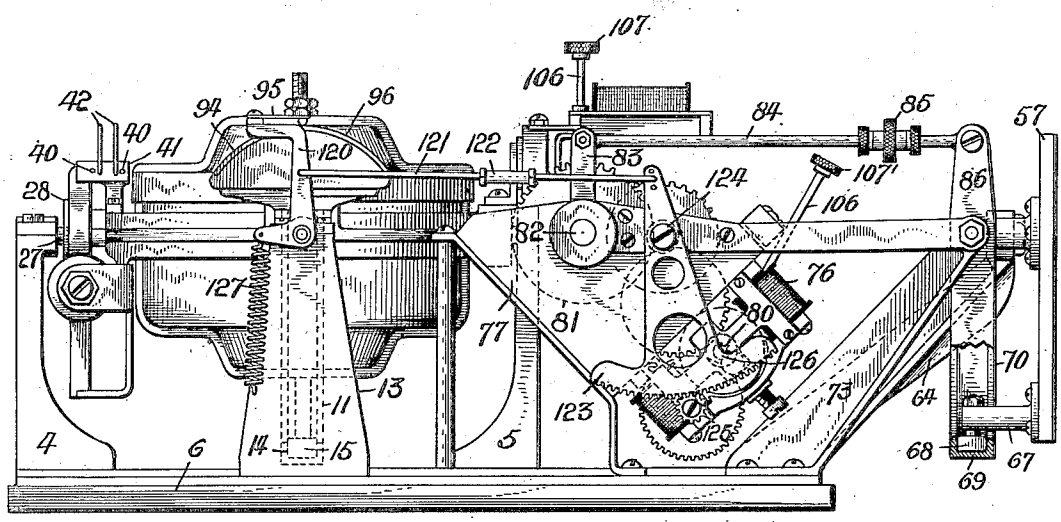


Fig. 3.

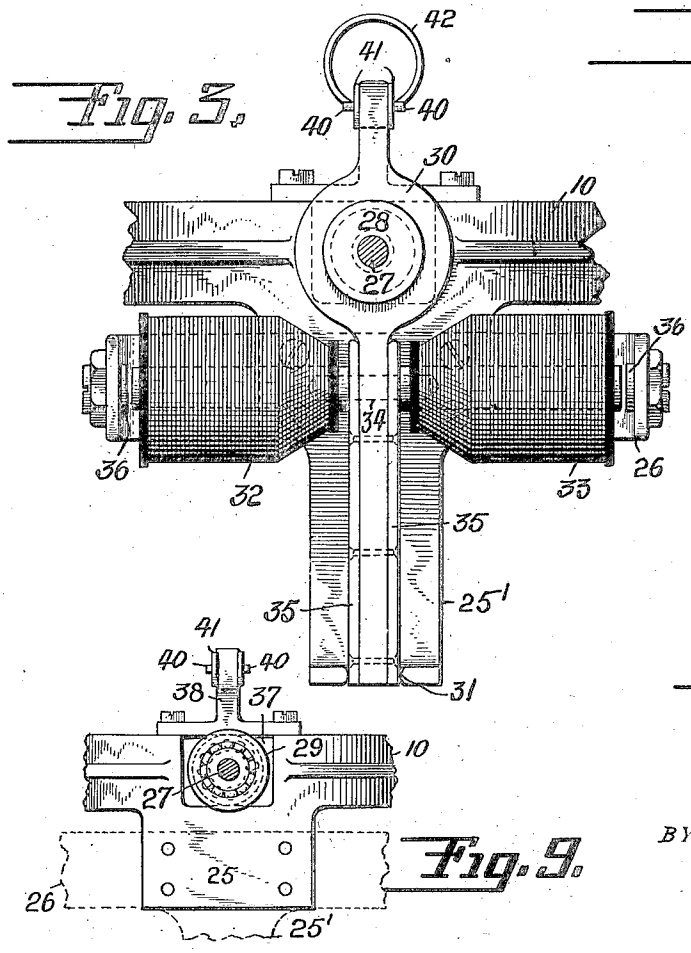


Fig. 4.

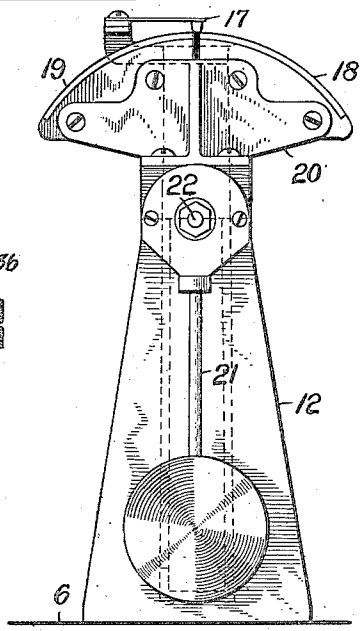


Fig. 9.

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Fig. 5.

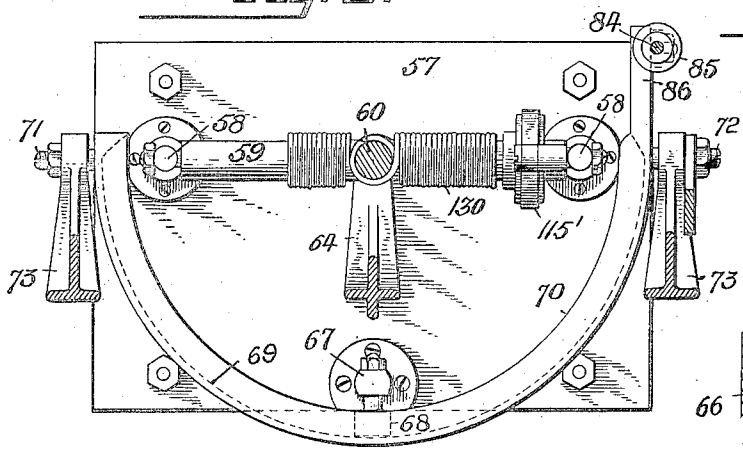


Fig. 8.

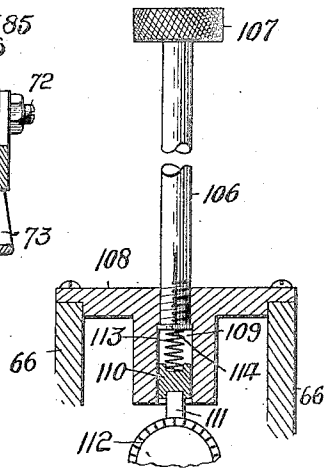


Fig. 6.

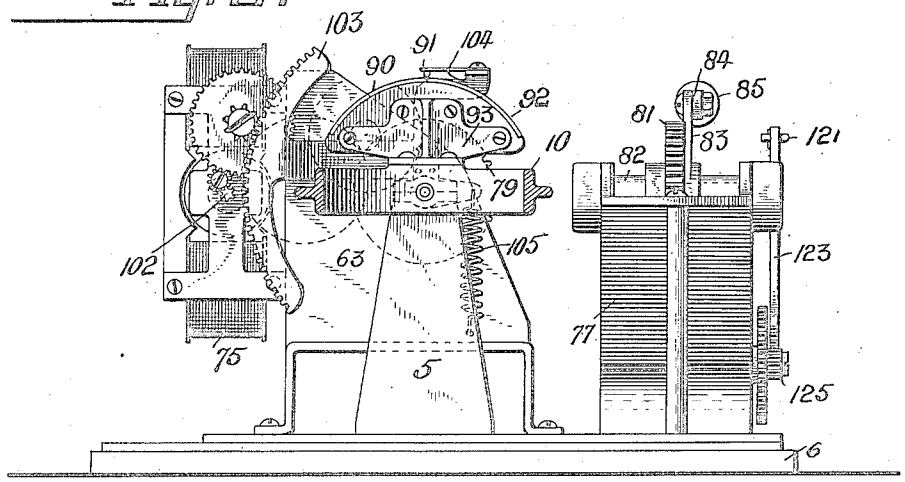
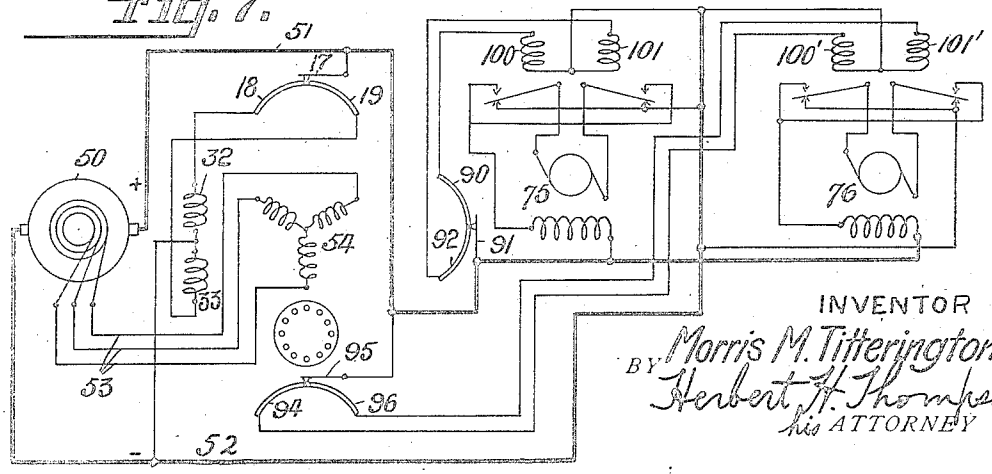


Fig. 7.



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Patented Feb. 20, 1923. 1,446,280

UNITED STATES PATENT OFFICE.

MORRIS M. TITTERINGTON, OF BROOKLYN, NEW YORK, ASSIGNOR TO THE SPERRY GYROSCOPE COMPANY, OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK.

STABILIZED BOMB SIGHT.

Application filed September 9, 1918. Serial No. 253,207.

To all whom it may concern:

Be it known that I, MORRIS M. TITTERINGTON, a citizen of the United States of America, residing at 39 Sidney Place, Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Stabilized Bomb Sights, of which the following is a specification.

This invention relates to stabilized bomb sights adapted to be employed on an aeroplane or other aircraft to enhance the accuracy in bombing targets on the ground.

For accurate bombing from an aeroplane it is practically necessary that the bomb sight employed be maintained level, or stable with respect to the horizontal plane, regardless of the position or change in position of the aircraft on which the sight is mounted. The principal object of the present invention is to provide means for maintaining the sight in such position. Other objects and advantages will appear as the invention is hereinafter developed.

Referring to the drawings which illustrate what I now consider the preferred form of my invention:

Fig. 1 is a plan view of one form of bomb sight and stabilizing means therefor.

Fig. 2 is a rear elevation of the stabilizing means shown in Fig. 1.

Fig. 3 is a detail elevation of one form of force applying or damping means for the gyro pendulum employed.

Fig. 4 is a detail front elevation of a part of the structure illustrated in Fig. 1.

Figs. 5 and 6 are sections taken on lines 5—5 and 6—6 respectively of Fig. 1.

Fig. 7 is one form of wiring diagram of the electrical apparatus.

Fig. 8 is a fragmentary sectional detail illustrating one form of means for reducing or preventing hunting of the bomb sight.

Fig. 9 is a detail of certain of the structure illustrated in Fig. 3.

I employ pendulous means, preferably gyroscopically controlled, for establishing a horizontal or other reference plane and while the bomb sight may be directly connected to this means, I prefer the system illustrated. This system comprises power means controlled by the gyroscopic pendulum which power means actuates the bomb sight to maintain the latter in a predetermined relationship with respect to the above mentioned reference plane.

A simple gyroscopic pendulum is open to the objection that it is deflected from the position it should maintain when acted on by persistent acceleration pressures. I therefore prefer to employ means for applying an external torque or torques to neutralize the effect of such acceleration pressures. Various types of means suitable for this purpose have been devised as for example the means illustrated in the U. S. patents to Elmer A. Sperry and Harry L. Tanner No. 1,236,993, August 14, 1917, or Harry L. Tanner No. 1,324,478, December 9, 1919. The pendulum and acceleration-pressure-neutralizing means illustrated in the present application is the same except for certain improvements as one of the forms of invention illustrated in said Patent 1,324,478 and may be constructed substantially as follows:

The gyroscope 1 comprises a rotor casing 7 within which the rotor is journaled for rotation about a normally vertical spinning axis and which casing is pivotally mounted on an axis 8, 9 within the gimbal ring 10, the ring being in turn supported on axis 2, 3 in brackets 4, 5 on base plate 6. The gyroscope is centralized by the yielding force of gravity about both horizontal axes, as the casing 7, together with the structure it supports, is made pendulous. A loop or bail 11 is pivoted in brackets 12, 13, secured to base 6, for oscillation about an axis coincident with the axis 8—9. This bail is provided with a groove or trackway 14 which serves as a guide for a roller 15 rotatably secured to the lower side of the gyroscope casing 7. An arm 16 carrying a contact 17 is secured to one end of said bail, said contact being adapted to engage one or the other of contacts 18, 19. The latter are carried by a bracket 20 secured to an auxiliary pendulum 21 pivoted at 22 in the bracket 12 for oscillation about an axis coincident with the axis 8—9. Contacts 18, 19 are insulated from each other and from the

supporting bracket 20. These contacts 17, 18, 19 are adapted to control the force applying means which is illustrated in Figs. 1, 2, 3 and 8, and which may be constructed substantially as follows:

The ring 10 has a downwardly projecting portion 25 to which a bracket or yoke 26 of magnetic material is rigidly secured. The bracket 4 has mounted thereon a shaft or spindle 27, which is coaxial with the axis 2, 3 and which extends through ball bearings 28, 29 carried respectively by the member 30 and ring 10. The member 30 is preferably of non-magnetic material and extends downwardly into a notch 31 provided in the lower end of the downwardly extending portion 25' of the yoke 26. A pair of electro-magnets 32, 33 are secured to the member 30 by a screw 34 extending through said member and tapped into the cores of said magnets. Strips 35 of magnetic material are secured to each of opposite sides of said member 30 and the ends of yoke 26 are each provided with an adjustable lug of magnetic material. The ring 10 is provided with a notch 37 closed by an inverted T shaped member 38 and thus forming a means whereby the bearing 29 may move to the right or left with respect to said ring 10 as viewed in Figs. 3 and 9. In order to bias the ring 10 to central position with respect to the shaft or spindle 27 the vertical or upstanding portion of the T shaped member 38 carries a plurality of pins 40 on each side thereof on which pin-plates 41 are slidably mounted. Springs 42 engage said plates and tend to hold the same inwardly in contact with the upper end of the member 30.

It will be obvious to those skilled in the art that when the magnet 32 is energized the ring 10 will be shifted to the right (Figs. 3 and 8) with respect to the spindle 27 while if magnet 33 is energized the ring will be shifted to the left. Either one of these movements will cause a gravitational torque in a corresponding direction to be exerted on the gyro pendulum.

Calling attention to Fig. 7, which illustrates one form of wiring diagram, it will be seen that I have shown a double current generator 50 capable of delivering D. C. to the mains 51, 52 and three phase A. C. to the mains 53. The rotor of the gyroscope 1 may be driven by the induction motor 54 of the same general type as that illustrated in the U. S. patent to Elmer E. Sperry, No. 1,186,856, granted June 13, 1916. Said induction motor is supplied with energy from the mains 53. The contact 17 is shown connected with the main 51, contacts 18, 19 to one side of each of magnets 32, 33 respectively and the other side of each of said magnets is connected to the opposite main 52.

By virtue of the above described structure the gyro pendulum 1 will be maintained in such a position that the line through its virtual point of support and center of gravity is always substantially vertical. Any tendency to oscillate, or oscillation will be quickly damped out. Thus suppose that the gyro is oscillating so that the top thereof moves in a circle in a counterclockwise direction, as viewed in Fig. 1. When the said top portion is to the right of the axis 8—9 the contact 17 engages contact 19 and energizes solenoid 33. The latter then shifts the ring 10 as previously described and causes the oscillation of the gyro to work against the gravitational torque so created. The magnet 32 acts in a similar manner when the said top portion is to the left of axis 8—9 so that the oscillation will be quickly damped out.

Referring to Fig. 1, the bomb sight is designated generally at 55 and is mounted on a normally vertical base 56. This sight comprises cross hairs or wires 55^a, 55^b, 55^c relatively adjustable in accordance with the altitude of the aircraft, speed of the aircraft, etc, so as to cause a bomb, released when the cross-hairs coincide, to hit the target. As the specific details of the bomb sight employed form no part of the present invention, the invention residing rather in the combination, I will omit further description of this device. Suffice it to say that the desideratum is to stabilize the sight about both horizontal axes. The base 56 is shown secured to a plate 57 to which standards 58 are secured. The latter rotatably receive the opposite ends of a rod 59 extending at right angles and connected to a shaft 60 journaled at 61, 62 and 63. The journal 61 is carried by a bracket 64 secured to the base 65 on which the base 6 is mounted and the journals 62 and 63 are a part of a frame 66 also secured to said base 65. The said journals are so arranged that the shaft 60 is parallel to the axis 2—3. The plate 57 has also secured thereto a standard 67 which rotatably supports a roller 68. The latter runs in a trackway or depression 69 provided in a loop or bail 70 pivotally mounted for oscillation about an axis 71—72 in brackets 73 secured to the base 65. The design is such that the axis 71—72 is parallel to the axis of oscillation of the bail 11. By properly actuating the shaft 60 and the bail 70 it will be clear that the plate 57 and consequently base 56, may be kept in a vertical plane, i. e., stable about both horizontal axes regardless of the movements of the base 65.

Any suitable form of power means may be utilized to actuate the members 60, 70 such as electric motors 75, 76 carried by the frames 66. 77 in turn secured to the base 65. The motor 75 is adapted to drive the shaft 60 through a suitable train of gearing 78—79 mounted in the frame 66. The other motor, 76, drives a shaft 82

through a train of gearing 80, 81 said shaft and train of gearing being mounted in the frame 77. The shaft 82 has secured thereto an arm 83 connected by a link 84 to an up-standing arm 86 on the bail 70, said link 84 being provided with a turnbuckle 85 for the purpose of adjustment.

For controlling the motors 75, 76 I provide two sets of electrical contacts. One, or more, of the contacts of one set is connected to the gyro pendulum 1 to be stabilized about the axis 2, 3, and one, or more of the contacts of the other set is connected to said gyro pendulum to be stabilized about the axis 8—9. These connections may be effected as illustrated in the drawings by mounting the contact segments 90, 92 on a bracket 93 secured to the ring 10 and the contact segments 94, 96 on a bracket 97 secured to the bail 11. The contacts 90, 92 and 94, 96 are each adapted to cooperate with a corresponding one of the contacts 91, 95 more specifically described hereinafter. It should also be noted that contacts 90, 92 are insulated from each other and from the supporting bracket 93 and contacts 94, 96 are insulated from each other and from supporting bracket 97.

The contact 91 is mounted on the base 65 and means are provided for causing the motor 75 to move said contact through the same angular distance as the relative angular displacement of the gyro pendulum 1 and base 65 but in a reverse direction. One portion of this means comprises electrical connections between contacts 90, 91, 92 and said motor 75 to cause actuation of said motor in one direction or the other depending on which of the contacts 90, 92 is engaged by the contact 91. While said motor may be directly controlled by said contacts I prefer to effect the control through relays as illustrated in Fig. 7. The winding of the relay 100 is connected at one end to the contact 90 and the winding of another relay 101 is connected to contact 92. The remaining ends of said windings are connected to the D. C. main 52 and the contact 91 is connected to the other D. C. main 51. The armature of the motor 75 is shown connected across the armature of the relays 100, 101, the back contacts of which are connected to each other and to the main 52 and the front contacts are connected to each other and to one terminal of the field of said motor. The opposite terminal of said field is connected to the main 51. Those skilled in the art will appreciate that when the contact 91 is central with respect to contacts 90, 92 the relays 100, 101 will both be energized or both deenergized depending on whether the contact 91 touches both contacts 90, 92 or touches neither. In either case the armature of the motor 75 will be short-circuited when the contacts are in the relative position stated and consequently the motor will not run at this time. If however the contact 91 engages only one of contacts 90, 92 the motor will run in either one direction or the other depending on which of the last mentioned contacts is engaged.

The structure of my invention is so designed that when there is a relative motion between the pendulum 1 and the support 65 about the axis 2, 3 the motor 75 will cause the plate 57 to move about the axis of shaft 60. To describe this action more specifically and clearly, assume that the supporting base 65 moves about the axis 2—3 in a clockwise direction, looking in the direction of arrow *a* in Fig. 1. Contacts 91 and 92 will then engage to cause the motor 75 to rotate the shaft 60 and base 57 about the axis of the shaft 60 in a counter-clockwise direction. If it is assumed further that the contact 91 is secured to the shaft 60 it will be clear that this movement of shaft 60 would continue until said contact 91 reached the neutral position with respect to contacts 90, 92. In short the base 57 and consequently the bomb sight 55 would be stabilized about the axis 60.

It has been found in practice that the above described arrangement while operative gives rise to considerable hunting of the bomb sight on both sides of the position at which it should be stabilized. This is probably due to various causes such as lost motion in the gear train 78, 79, inertia of the parts, etc. In view of the fact that the last mentioned gear train transmits considerable power in either of two directions it is extremely difficult, if not practically impossible, to take up this lost motion. For this reason I prefer to adopt the expedients hereinafter described which are found to minimize, if not entirely neutralize the hunting of the sight.

The contact 91 is positioned by the motor 75 through a train of gearing entirely distinct from the gear train 78—79 but of such design that said contact will receive substantially the same movement as though it were connected to the shaft 60. This gear train comprises a pinion 102 on the shaft of motor 75 and a gear sector 103 secured to one arm of a bell crank lever 104 pivoted on the bracket 5 for oscillation about the axis 2—3. (See Figs. 1 and 6). The contact 91 is shown adjustably secured to the arm of the bell crank 104 to which the sector 103 is connected. The remaining arm of the last mentioned bell crank may be connected to the bracket 5 by means of a spring 105 for the purpose of taking up lost motion in the gear train 102, 103, which transmits a comparatively small amount of power. By virtue of

the above described connections it will be seen that the brush and contact 91 will follow closely at all times the movement of motor 75.

Means are also provided for constraining the hunting of the motor 75 to an amount substantially equal to or slightly greater than that necessary to take up the lost motion of the gear train 78—79. One form of such means is shown in the drawings, particularly in Fig. 8. A rod 106 is threaded at one end to screw into a bracket 108, secured to the frame 66, and is provided at its other end with a thumb nut 107. The bracket 108 has a downwardly extending boss which is provided with a bore 109 into which the lower end of the rod 106 is adapted to extend. A plunger 110 is slidably mounted in said bore and carries at its lower end a plug of leather or other friction material 111 adapted to engage the commutator 112 of the motor 75. A spring 113 is also mounted in said bore and seats at opposite ends against the plunger 110 and a disc 114. By turning the nut 107 the pressure of the plug 111 on the commutator 112 may be adjusted.

The lower end of the rod 106 may be made slightly larger than the threaded opening in bracket 108 and split to hold the parts in adjusted position. As previously stated, the last described parts are preferably so adjusted that the hunting of the motor 75 will be equal to or slightly greater than the movement required to take up the lost motion in the gear train 78—79.

I also provide means for holding the bomb sight 55 against movement, about the axis 60, with respect to the base 65 except when actuated by the motor 75. This means is illustrated in the form of an adjustable friction band 115 secured to a standard or post 117, carried by the frame 66, and surrounding a drum 116 on the shaft 60.

The complete operation of the system for stabilizing the bomb sight 55 about the axis of the shaft 60 may be summarized as follows. Assuming that parts occupy the relative positions illustrated in Fig. 1 the motor 75 will hunt slightly causing the contact 91 to move from one to the other of contacts 90, 92. The degree of hunting is however limited by the brake 111 to such an amount that it is just sufficient or slightly more than that which will take up the lost motion in the gear train 78—79. The bomb sight 55 will accordingly either not hunt at all about the axis 60 or only slightly. The brake band 115 will hold the sight in position when it is not acted on by the motor 75. If the support 65 is tilted in either direction about the axis 2—3, or the axis of the shaft 60, the contact 91 will energize the motor 75 in such a manner as to cause said contact to assume neutral position with respect to contacts 90, 92. As the motor 75 imparts substantially the same movement to the shaft 60 as it does to the contact 91 it will be seen that the bomb sight will occupy the same position with respect to the base 65 that the gyro pendulum 1 does. In short the bomb sight will be stabilized with respect to the base 65 about the axis 60.

The operation of the apparatus for stabilizing the sight 55 about the axis 59, which is coincident with the axis of oscillation of the bail 70, is substantially the same as that for effecting the stabilization about the axis 60. Thus the contacts 94, 95, 96 control the motor 76 through relays 100′ and 101′ in all respects similar to the control motor 75 through relays 100, 101 by the contacts 90, 91, 92. An independent gear train is preferably provided for actuating the contact 95 to the same extent as though it were mounted on the shaft 82. The said contact 95 is shown adjustably connected to one arm of a bell crank lever 120, which arm is connected to one end of a segmental lever 123 by means of a link 121. The latter may be provided with a turnbuckle 122 for the purpose of adjustment. The segmental lever 123 is pivoted at 124 on frame 77 and is adapted to be driven by the motor 76 through a train of gearing 125, 126. A spring 127 may be connected to one arm of the lever 120 and to the bracket 13 for the purpose of taking up lost motion between said lever and its actuating motor 76.

The motor 76 may be provided with a rod 106 adapted to actuate mechanism similar in structure and function to that illustrated in Fig. 8. Furthermore the shaft may be provided with a drum 116′ adapted to be engaged by a friction band 115′ secured to a standard 117′ in turn secured to the plate 57. The last mentioned elements are for the primary purpose of holding the bomb sight 55 against movement about the axis 59 unless actuated by the motor 76. A spring 130 may be coiled about the rod or shaft 59 and may engage at its ends the plate 57 so as to oppose the pull of gravity on the bomb sight.

As the operation of the apparatus for stabilizing the sight 55 about the axis 59 is substantially the same as the operation of the means for stabilizing about the axis 60, it is thought that no further description is necessary. It will be apparent to those skilled in the art that the sight 55 will be effectively stabilized and that the hunting thereof will be practically inappreciable.

In accordance with the provisions of the patent statutes, I have herein described the principle of operation of my invention, together with the apparatus, which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative

and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In combination, a bomb sight and means including a gyroscopic pendulum for stabilizing said bomb sight.

2. In combination, a bomb sight, a support therefor, power means for moving said bomb sight with respect to its support and a pendulum for controlling said power means.

3. In combination, a bomb sight, a support therefor, means comprising a pendulum for controlling movement of said bomb sight with respect to its support and means for damping oscillations of said pendulum.

4. In combination, a bomb sight, a pendulum comprising a gyroscope, means controlled by said pendulum for controlling the position of said bomb sight and means controlled by said gyroscope for applying a torque on said pendulum.

5. A system for stabilizing a sighting device movably mounted with respect to its support, said system comprising power means, a pendulum, a set of contacts for reversibly controlling said power means, at least one of said contacts being connected to said pendulum and at least one other to said power means to be actuated thereby, connections between said power means and sighting device and means for restricting the hunting of said power means substantially to that necessary to take up lost motion in the last mentioned connections.

6. A system for stabilizing a sighting device movably mounted with respect to its support, said system comprising a motor, reversing contacts for controlling said motor, a gyroscopic pendulum for stabilizing at least one of said contacts, connections between said motor and another of said contacts for actuating the latter, separate connections between said motor and sighting device and means for taking up the lost motion in said first mentioned connections.

7. A system for stabilizing a sighting device movably mounted with respect to its support, said system comprising a motor, reversing contacts for controlling said motor, a gyroscopic pendulum for stabilizing at least one of said contacts, connections between said motor and another of said contacts for actuating the latter, separate connections between said motor and sighting device. and means for restricting the hunting of said motor substantially to that necessary to take up lost motion in the last mentioned connections.

8. In combination, a bomb sight, a support therefor, power means for moving said bomb sight with respect to its support, a set of contacts for reversibly controlling said power means, and a pendulum connected to at least one of said contacts for stabilizing the same.

9. In combination, a bomb sight, a support therefor, power means for moving said bomb sight with respect to said support, and gyroscopic means for controlling said power means.

10. In combination, a bomb sight, a support therefor, power means for moving said bomb sight with respect to its support, a set of contacts for reversibly controlling said power means, gyroscopic means connected to at least one of said contacts for stabilizing the same, and connections between said power means and another of said contacts for actuating the latter.

11. In combination, a bomb sight, a support therefor, power means for moving said bomb sight with respect to its support about two horizontal axes, and a single gyroscopic pendulum for controlling said power means.

12. In combination, a bomb sight, and means including a gyroscope normally free to change the direction of its axis of rotation with respect to said sight for stabilizing the latter.

13. In combination, a bomb sight, a gyroscope having three degrees of freedom with respect to said sight, and means controlled by said gyroscope for stabilizing said bomb sight.

14. A system for stabilizing a sighting device movably mounted with respect to its support, said system comprising a motor, reversing contacts for controlling said motor, a gyroscopic pendulum for stabilizing at least one of said contacts, connections between said motor and another of said contacts for actuating the latter, and separate connections between said motor and sighting device.

15. In combination, a bomb sight, a support therefor, means including a pendulous device for controlling movement of said bomb sight with respect to its support, and means for including a second pendulous device for damping oscillations of said first mentioned pendulous device.

16. In combination, a bomb sight, a gyroscope, means controlled by said gyroscope for controlling the position of said bomb sight, a pendulum, and means controlled by said pendulum for applying a torque on said gyroscope.

17. In combination, a bomb sight, a gyroscope, means controlled by said gyroscope for controlling the position of said bomb sight, a pendulum, and means controlled

jointly by said gyroscope and pendulum for exerting a torque on said gyroscope to damp oscillations thereof.

18. In combination, a bomb sight, a gyroscope, means controlled by said gyroscope for controlling the position of said bomb sight, and means including a pendulum responsive to movement of said gyroscope about an axis for applying torque to said gyroscope about another axis.

19. In combination, a support, a bomb sight, mounted thereon for movement about a plurality of axes, power means for moving said sight about said axes, and gyroscopic means for controlling said power means.

20. In combination, a support, a bomb sight movably mounted thereon, power means for moving said bomb sight with respect to its support, and gyroscopic means for controlling said power means.

21. In combination, a support, a bomb sight movably mounted thereon, power means for moving said bomb sight with respect to its support, gyroscopic means for controlling said power means and means for adjusting said bomb sight with respect to said support independently of said power means.

In testimony whereof I have affixed my signature.

MORRIS M. TITTERINGTON.