April 1, 1958 T. O. SUMMERS, JR 2,828,629

PRECISION ERECTING MECHANISM

Filed Aug. 6, 1953 2 Sheets-Sheet 1

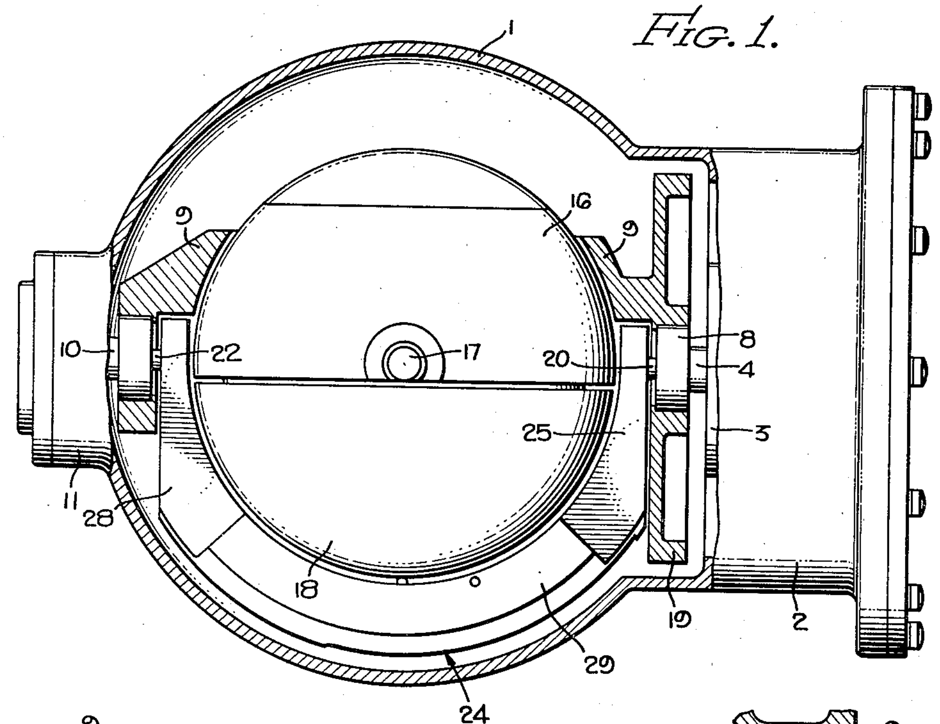

FIG. 1.

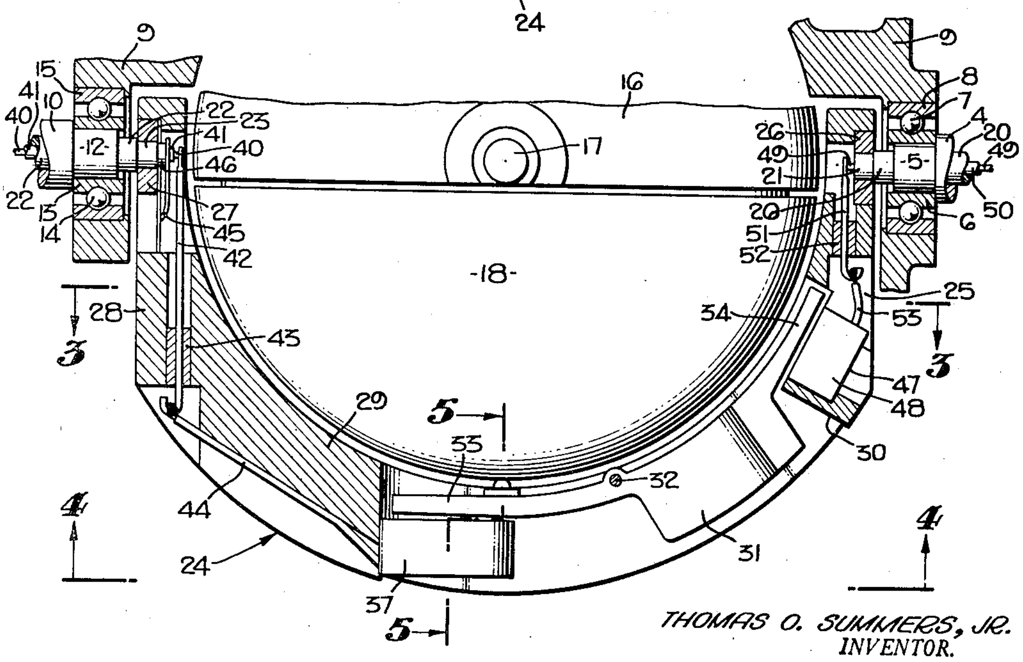

FIG. 2.

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PRECISION ERECTING MECHANISM

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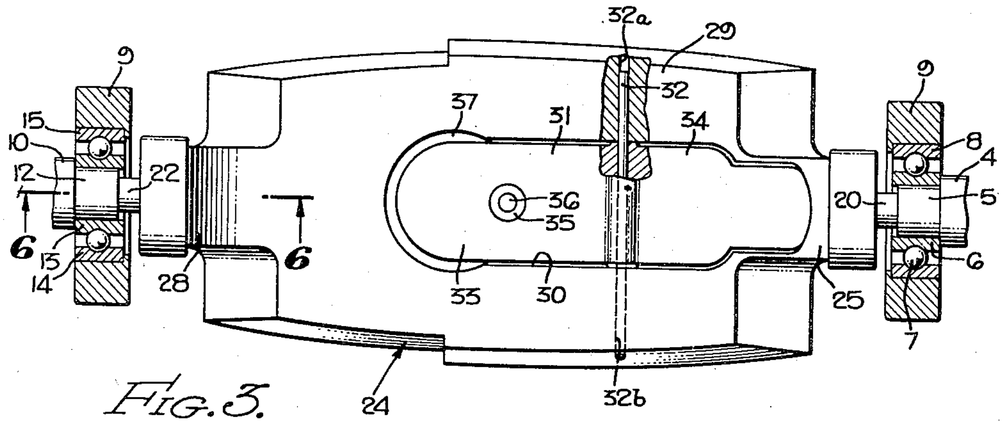


FIG. 3.

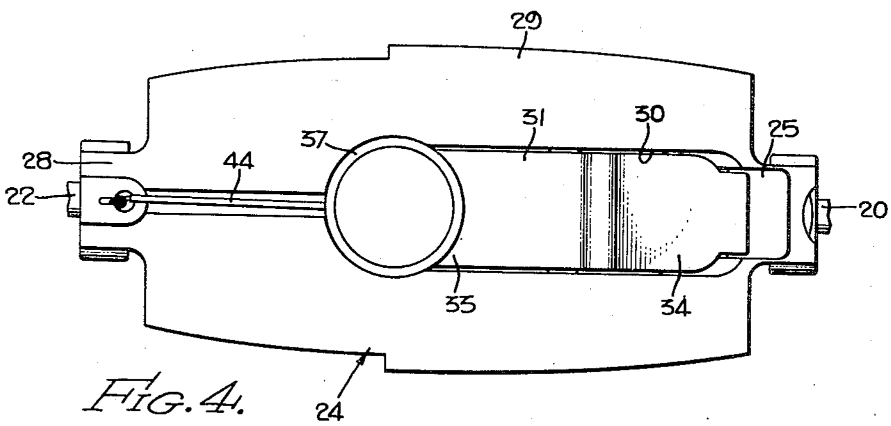
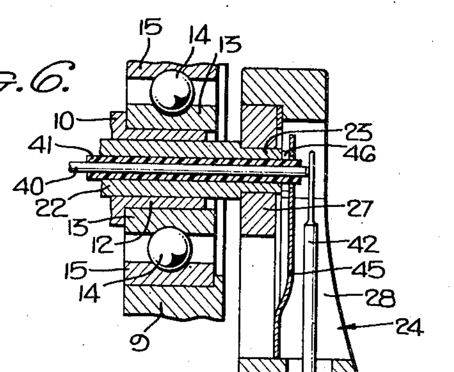


FIG. 4.

FIG. 6.



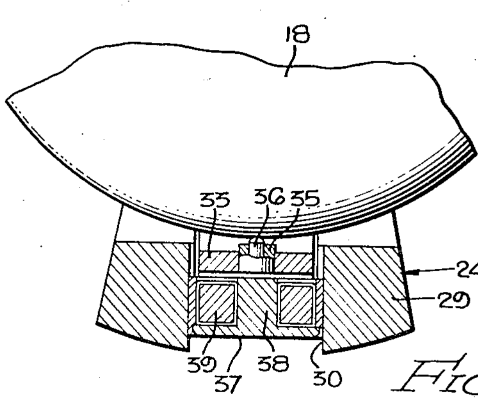


FIG. 5.

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PRECISION ERECTING MECHANISM

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Application August 6, 1953, Serial No. 372,721

17 Claims. (Cl. 74—5.45)

This invention relates to gyroverticals of the type employing a friction-actuated erecting mechanism and, more particularly, to an erecting device capable of exerting a constant friction erecting force over an extended period of time.

The erecting device in such mechanisms frequently comprises a friction member adapted to exert a pressure against a rotating surface fixed to the rotor. Heretofore, spring means have been utilized to assure positive pressure between the erecting friction element and the spinning spherical surface. In such apparatus, the inevitable wear of the friction element causes lessening of the spring pressure exerted against the friction member, with the result that the erecting rate is proportionately reduced. The falling-off in erecting precession rate can be minimized by the selection of a spring having an extremely low constant of proportionality, but invariably design limitations preclude the incorporation of a spring having a sufficiently low constant. Also, in such devices it is extremely difficult to control or adjust the spring pressure exerted by the erecting element or button against the spherical erecting dome because the erecting rate must be measured after each adjustment in order to ascertain the effect of the adjustment.

By the present invention, an erecting device is proposed which assures a constant pressure between the friction button and the dome, which force is determined by the constant force of gravity, with the result that wear of the button has no effect upon the precession rate. Also, by the present invention the need for adjustment is eliminated since the pressure to be exerted can be predetermined before assembly of the erecting mechanism. Therefore, if the gyro does not erect at a predetermined rate after assembly, the gyro assembler may look to the gyro element proper rather than the erecting mechanism for the trouble. An erecting mechanism capable of exerting a constant force against the dome has another advantage over the spring-loaded type erecting mechanism, in that the spring-loaded friction button must be adjusted to exert a force considerably above the force necessary to produce the desired erection rate, for the reason that if the erecting rate were adjusted to the minimum requirement, the gyro would not erect at an acceptable precession rate after slight wear of the erecting button.

By utilizing the erecting device of the present invention, however, the erecting rate may be set much lower initially for the reason that erecting button wear will produce no appreciable change in the erecting rate even after hundreds of hours of operation. This minimum erection rate is desirable at all times since temporary displacements of the friction erector by acceleration forces will cause minimum displacement of the gyroscope. The present invention lends itself readily to the incorporation of an electrically operated erecting cutout device to paralyze the erecting means during long periods of acceleration, such as when an aircraft is executing a turn. Also, an electrically operated device can be easily incorporated in the present invention to provide rapid erection or caging of the gyro element when this is desirable. For purposes of illustration, the present invention is disclosed in conjunction with a gyroscope of the type described in U. S. Patent No. 2,635,469, entitled, "Gyroscopic Navigational Instrument," dated April 21, 1953, but its use is not limited to that type of device since it may be readily employed as an erecting means for various other types of gyroscopes.

It is, therefore, an object of the invention to provide a precision erecting mechanism which is capable of continually erecting a gyroscope with a constant friction erecting force which is independent of wear of the friction element.

Another object of the present invention is to provide an erecting mechanism in which the friction erection force is controlled by the constant force of gravity instead of by a variable spring pressure, so that wear of the friction element will have no effect on the resulting erecting force.

A further object of the invention is the provision of a precision erecting mechanism in which the friction erecting force can be originally set at the minimum requirement in order to minimize unwanted erection of the gyroscope when the erecting mechanism experiences acceleration forces.

A still further object of the invention is to provide an erecting mechanism which lends itself readily to the incorporation of erecting cutout means and rapid erection means.

These, and other objects of the invention not specifically enumerated above, will become readily apparent from the accompanying description and drawings, in which:

Figure 1 is an elevational view, partly in cross-section, of a gyroscope equipped with the erecting mechanism of this invention.

Figure 2 is a vertical sectional view showing the erecting mechanism carried by a gravity-sensitive bail pivotally mounted about the pitch axis of the gyroscope.

Figure 3 is a top plan view along line 3—3 of Figure 2, showing the bail partly in cross-section and illustrating the manner in which the erecting button is carried by a pivotally mounted, gravity-sensitive mass.

Figure 4 is a bottom plan view of the bail along line 4—4 of Figure 2, illustrating the electromagnet for erection cutout and the electromagnet for rapid erection.

Figure 5 is a vertical sectional view along line 5—5 of Figure 2, illustrating the relationship between the erection button and the electromagnet for erection cutout.

Figure 6 is a vertical sectional view along line 6—6 of Figure 3, showing the manner in which electrical energy is supplied to the electromagnets carried by the bail.

The invention is disclosed herein as applied to a gyroscope which is gravity erected about its pitch axis and case erected about its roll axis in the manner shown in the United States Patent No. 2,635,469 previously referred to, and it is understood that the invention is not limited to the erection of such a gyroscope.

The gyroscope is mounted within an aircraft and has a casing 1 with an extension 2 for housing the elements controlled by the position of the gyroscope. A member 3 is centrally supported by the extension 2 in position to receive one end of an outer shaft 4. A reduced end portion 5 at the other end of shaft 4 supports the inner race 6 of ball bearings 7 and the outer race 8 for the ball bearings is secured within an opening at at one side of the outer gimbal ring 9. The opposite side of the outer gimbal ring is supported by an outer shaft 10 having one end rigidly secured to casing 1 within extension 11, while the other end of the shaft has a reduced portion 12 for supporting the inner race 13 of bearings 14. The outer race 15 for ball bearings 14 is secured within an opening in the outer gimbal ring 9 and it is, therefore, apparent that the outer gimbal is free to rotate on bearings 7 and 14 about the axis of shafts 4 and 10.

The inner gimbal 16 of the gyroscope is pivotally supported by the outer gimbal ring about an axis at right angles to the pivotal axis of the outer gimbal ring. While only one of the pivotal shafts 17 is illustrated, it is understood that there are two such shafts on opposite sides of the inner gimbal ring for pivotal support. The gyro motor and rotor (not shown) are mounted within the inner gimbal ring 16 and the rotor is rigidly connected to a dome 18 positioned below the rotor so that the dome is continually rotated when the rotor of the gyroscope is driven by the gyroscope motor. A brake shoe 19 is shown integral with the outer gimbal ring for the purpose of locking the outer gimbal ring during the starting period of the gyroscope, but the brake shoe forms no part of the present invention.

An inner shaft 20 projects through the outer shaft 4 and is threaded thereto so that the position of the end portion 21 of shaft 20 can be adjusted and locked in adjusted position. In a similar manner, an inner shaft 22 is positioned within outer shaft 16 and is threaded thereto so that the position of the reduced portion 23 thereof can be made adjustable and can be locked in any adjusted position. A gravity-sensitive bail 24 is shown positioned around the rotating dome 18 of the gyroscope for the purpose of gravity erecting the gyroscope about the pitch axis of the aircraft, and for case erecting the gyroscope about the roll axis of the aircraft. The upright leg 25 of the bail 24 has an opening for receiving an oilite bearing 26, which is press-fitted or otherwise secured within the opening. In a similar manner, an oilite bearing 27 is secured within an opening in the upright leg 28 of bail 24 and both the bearings 26 and 27 have center openings for respectively receiving the reduced portions 21 and 23, so that the bail 24 is free to pivot, under the influence of gravitational force, about these reduced portions. Since the axis of reduced portions 21 and 23 corresponds to the pitch axis of the aircraft, the bail will be gravity-sensitive about the pitch axis of the aircraft, and since the bail will move with the casing of the gyroscope during movements of the aircraft about the roll axis of the gyroscope, the bail will cause the gyroscope to be case erected about the roll axis in the manner described in the previously mentioned United States patent.

The contour of the bail 24 follows very closely the contour of the rotating dome 18, and the lower body portion 29 of the bail has an opening 30 for receiving an erection mechanism of the friction type. A mass 31 of the erection mechanism is positioned within opening 30 and is pivotally mounted by pin 32 which extends through the opening and is secured in openings 32*a* and 32*b* at opposite sides of the bail. It is pointed out that the pivot 32 is placed to one side of the normally vertical plane of the gyroscope passing through the axis of shafts 17 and perpendicular to the axis of shafts 4 and 10 of the gyroscope and that the center of gravity of the mass 31 is further displaced from this same plane of the gyroscope. Arms 33 and 34 project from opposite sides of the mass 31 and the arm 33 extends a sufficient distance so that it passes underneath and beyond the spin axis of the rotating dome 18. A plug 35 is positioned in an opening in arm 33 and carries a friction erecting button 36 in position to be intersected by said normally vertical plane of the gyroscope passing through shafts 17. Since the center of gravity of mass 31 is on the opposite side of pivot 32 from the erecting button 36, it is clear that the force of gravity acting on mass 31 will continually push the erecting button 36 into contact with the rotating dome 18, and that the force exerted on the erecting button will be a constant force proportional to the constant force of gravity. The contact between the erection button 36 and the dome 18 will cause erection of the gyroscope toward the button 36 when the button is displaced from the spin axis of the gyroscope since the frictional force exerted on the rotating dome will be at right angles to a line between the button and the spin axis. This erecting function is the same as described in the previously mentioned U. S. Patent No. 2,654,369 and is also the same as utilized in connection with the caging pin shown and described in U. S. Patent No. 2,412,481 to T. O. Summers, Jr., dated December 10, 1946.

With this type of friction erection, the rate at which the gyroscope is erected will be determined by thte frictional force exerted by the erecting button 36 upon the rotating dome 18, and since the erecting button 36 will continually exert a constant friction force against dome 18 resulting from the constant force of gravity acting on the mass 31, it is apparent that the wear of button 36 over a long period of operation will have no effect whatever on the erecting force exerted by the button against the rotating dome. Consequently, the erecting force can be determined at the time of the assembly of the gyroscope unit by selecting a mass 31 to give the desired minimum erection rate, and this rate will be maintained constant through many hours of operation and unaffected by wear of the erecting button. The minimum erection rate is desirable at all times so that temporary displacements of the erecting button from the spin axis of the dome will not have an appreciable effect upon the position of the spin axis.

It is pointed out that the pivot pin 32 in positioned in a plane tangent to the dome 18 at the point of contact with the erecting button 36. By so positioning the pivot 32, it is possible to eliminate any erecting torques about the pivot due to the direction of the erecting force between the button and the dome. When the erecting button is displaced from the spin axis about the pitch axis of the gyroscope, such displacement will cause reaction from the erecting force to pass directly through the pivot 32 and, thereby, eliminate any torques on the button itself. Also, any displacement of the erecting button from the spin axis resulting from movement about the roll axis of the gyroscope will cause a twisting torque on the pivot 32 but this torque will have no effect on the force between the button and the dome.

In order to provide for cutting out the erecting force of the button during turning of the aircraft at which time the bail 24 will experience a movement about the roll axis relative to the gyro dome, an electromagnet 37 is positioned at one end of opening 30 directly underneath the arm 33 of the mass 31. The core member 38 of the electromagnet is press-fitted into a circular section of opening 30 and retains a winding 39. The arm 33 serves as the armature for electromagnet 37, and it is obvious that when the electromagnet is energized, the arm 33 will be pulled against the electromagnet to move the friction erecting button 36 out of contact with dome 18. Electrical energy is supplied to electromagnet 37 through a silver pin 40 which passes through inner shaft 22 and is separated therefrom by an insulation ring 41. The pin 40 and the insulation ring 41 project completely through the bearing 27 and the end of the pin continually bears against the contact arm 42 which is secured to the bail 24 by an insulation section 43 pressed into an opening in the bail. The contact arm 42 connects with lead 44 leading directly to the electromagnet 37, and the electromagnet is grounded to the bail which, in turn, is grounded to the aircraft by a spring 45 which continually bears against a washer 46 in contact with the reduced portion 23 of shaft 22. The electromagnet 37 is placed in a circuit which is energized in response to a turn signal given to the aircraft so that automatic cut-out during turning is accomplished. Thus, when the friction button is displaced from the spin axis of the dome during turning of the aircraft. the erecting force is disengaged so that there will be no tendency for the erecting button to move the spin axis of the gyroscope away from its present position. It is understood, also, that the energization of electromagnet 37 could be made responsive to an altitude change signal, so that erection would be cut out during changes in pitch at which time acceleration forces would tend to move the bail away from gravity vertical about the pitch axis.

A second electromagnet 47 is positioned at the opposite end of opening 30 in a circular cut-out portion, and has a core member 48 for retaining a winding (not shown) in the same manner as winding 39 is retained within core 38. The arm 34 of the mass 31 serves as the armature for electromagnet 47 and when the electromagnet is energized, the pull on arm 34 will cause the force exerted by the erecting button 36 on the dome to substantially increase. Thus, the rate of erection will be increased so that the gyroscope can be quickly erected to caged position upon starting of the gyroscope. The supply of electrical current to the electromagnet 47 is through silver pin 49 which passes through inner shaft 20 and is separated therefrom by an insulated ring 50. Pin 49 projects through the bearing 26 and continually bears against the contact arm 51, which is retained in an insulated section 52 press-fitted in an opening in the upright leg portion 25. The contact arm 51 connects with lead 53 for the electromagnet 47 and the electromagnet is grounded to the bail in the same manner as electromagnet 37. The circuit for the electromagnet 47 is operated by the starting circuit for the gyroscope so that the electromagnet will be energized upon starting to rapidly erect the gyroscope spin axis to its caged position directly in line with the erecting button.

From the above description, it will be seen that upon starting of the gyroscope, the gyroscope spin axis will be rapidly erected to caged position and then the electromagnet 47 will be de-energized. During normal operation, the mass 31 will exert a constant erecting force on the erecting button 36 so that a constant erecting force will be applied to the rotating dome 18. This erecting force will be just sufficient to meet the erection rate required for normal operation. During the time that the aircraft is positioned for straight flight, the erecting button will cause the spin axis to assume a reference position about the roll axis which will control the aircraft and maintain straight flight. Also, since the bail is gravity-sensitive about the pitch axis, the erecting button will continuously erect the spin axis to gravity vertical about this axis. In the event that it is desired to turn the aircraft, a turn switch can be manually closed or a turn signal transmitted to the aircraft, at which time the electromagnet 37 will be energized to cut out the erecting force by moving the erecting button 36 away from the dome. Thus, during turns, the spin axis will not be erected away from its straight flight reference position to which it has been moved during straight flight of the aircraft. In the event that no erection cut-out is provided for the erecting mechanism, it is obvious that only a minimum amount of movement of spin axis of the gyroscope will result during turning of the aircraft, since the erection rate can be set to the minimum requirement by providing that mass 31 be of desired size to transmit the minimum force required for this erection rate.

By the present invention, a precision erecting mechanism is provided for obtaining a friction erection force which is constant throughout many hours of operation and is not affected by the wear of the friction button. It is apparent that the friction erecting force can be modified by changing the size or shape of the gravity-sensitive mass which exerts this constant force. Also, the use of the invention is not limited to a gyroscope of the type disclosed, which is case erected in roll and gravity erected in pitch, but can be utilized to frictionally erect any gyroscope in any desired manner. For instance, the erection button can be placed in any position relative to the gyroscope and can serve to erect about any axis. While the

description relates to the control instrument for an aircraft, it is understood that the invention is equally applicable to a control instrument for any moving craft. Various modifications will become readily apparent to those skilled in the art, without departing from the spirit and scope of the invention as hereinafter defined in the appended claims.

What is claimed is:

1. A friction erecting mechanism for exerting a constant friction erecting force, comprising a gravity-sensitive mass pivotally mounted at a point displaced from its center of gravity and a friction erecting button carried by said mass in position to receive only the constant force resulting from the force of gravity acting on said mass.

2. A friction erecting mechanism for exerting a constant friction erecting force, comprising a gravity-sensitive mass, a pivot for said mass displaced from its center of gravity so that said mass can develop a constant force about said pivot in response to the force of gravity on said mass, and a friction erecting button displaced from said pivot in the opposite direction from said center of gravity in order to continually receive said constant force.

3. A friction erecting mechanism as defined in claim 2, having means for selectively increasing the force received by said button and means for selectively overcoming the force received by said button.

4. A friction erecting mechanism for exerting a constant friction erecting force against a rotating dome of a gyroscope, comprising a gravity-sensitive bail pivotally mounted about an axis of said gyroscope, a gravity-sensitive mass pivotally mounted on said bail with its center of gravity displaced from the pivot point, a friction erecting button carried by said mass and displaced from said pivot point in the opposite direction from said center of gravity, said erecting button being positioned to contact and exert against said dome a constant erecting force derived from the force of gravity acting on said mass.

5. A friction erecting mechanism as defined in claim 4, wherein said pivot point is located in said bail at a position intersected by a plane tangent to said dome at the point of contact with said button.

6. A friction erecting mechanism as defined in claim 4, having first means for selectively increasing the force exerted by said button and second means for selectively overcoming the force erected by said button.

7. A friction erecting mechanism as defined in claim 6, wherein said first and second means each comprise an electromagnet, said electromagnets being positioned on opposite sides of said pivot point adjacent the same side of said mass to exert a force on said mass when selectively energized.

8. A friction erecting mechanism for exerting an erecting force against a rotating dome of a gyroscope mounted in a movable craft, comprising a gravity-sensitive bail pivotally mounted about the pitch axis of said gyroscope, a friction erecting button carried by said bail in position to contact said dome at a point located in the plane passing through the roll axis and perpendicular to the pitch axis of said gyroscope, a gravity-sensitive mass pivotally mounted upon said bail with the pivot point positioned between the said plane and the center of gravity of said mass, said button being mounted on said mass so that the force of gravity acting on said mass causes said button to exert a constant erecting force upon said dome which force is not affected by wear of the button.

9. A friction erecting mechanism as defined in claim 8, wherein said pivot point is located in said bail at a position intersected by a plane tangent to said dome at the point of contact of said button with said dome.

10. A friction erecting mechanism as defined in claim 8, wherein said gravity-sensitive mass comprises a body portion and first and second arms extending from opposite sides of said mass along said bail, said erecting button being positioned on the side of said first arm adjacent said

dome, a first electromagnet positioned opposite the side of said first arm away from said dome, a second electromagnet positioned opposite the side of said second arm away from said dome, said first electromagnet being energized during turning of said craft to overcome the force on said button and move said button away from said dome, and said second electromagnet being energized during starting of said gyroscope to increase the force of said button against said dome and provide for rapid caging of the gyroscope.

11. A friction erecting mechanism for exerting a constant friction erecting force, comprising a gravity-sensitive mass mounting a friction erecting button in position to exert an erecting force which is a function of the constant force of gravity on said mass, and which is exerted in opposite direction to said force of gravity, said erecting force remaining constant and unaffected by wear of the erecting button.

12. A friction erecting mechanism for exerting a constant friction erecting force comprising a pivotally mounted gravity-sensitive mass, a friction erection button connected to said gravity-sensitive mass in order to receive a force therefrom proportional to the force of gravity acting on said mass, said erecting button exerting a constant erecting force in the opposite direction to said force of gravity, said erection force being unaffected by wear of the button and can be preselected to the desired minimum prior to assembly of the mechanism.

13. A friction erecting mechanism for exerting a constant force against a rotating dome of a gyroscope, comprising a gravity-sensitive mass, a pivot for said mass displaced from its center of gravity so that said mass can

develop a constant force about said pivot in response to the force of gravity on said mass, and a friction erection button carried by said mass and displaced from said pivot in the opposite direction from said center of gravity in order to exert a constant erecting force upon said dome.

14. A friction erecting mechanism as defined in claim 13 wherein said pivot is located at a position intersected by a plane tangent to said dome at the point of contact with said button.

15. A friction erecting mechanism for exerting a constant friction erecting force, comprising a gravity-sensitive mass, a pivot for said mass displaced from its center of gravity, a friction erecting button carried by said mass and displaced from said pivot in the opposite direction from said center of gravity so that said button can exert an erection force proportional to the force of gravity and in the opposite direction.

16. A friction erecting mechanism as defined in claim 15 having means operative upon said mass for selectively increasing the force exerted by said button.

17. A friction erecting mechanism as defined in claim 15 having means operative upon said mass for selectively overcoming the force exerted by said button.

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