

Aug. 7, 1945.

L. F. CARTER

2,380,941

ERECTION DEVICE FOR GYRO VERTICALS

Filed Dec. 7, 1940

3 Sheets-Sheet 1

Fig. 1.

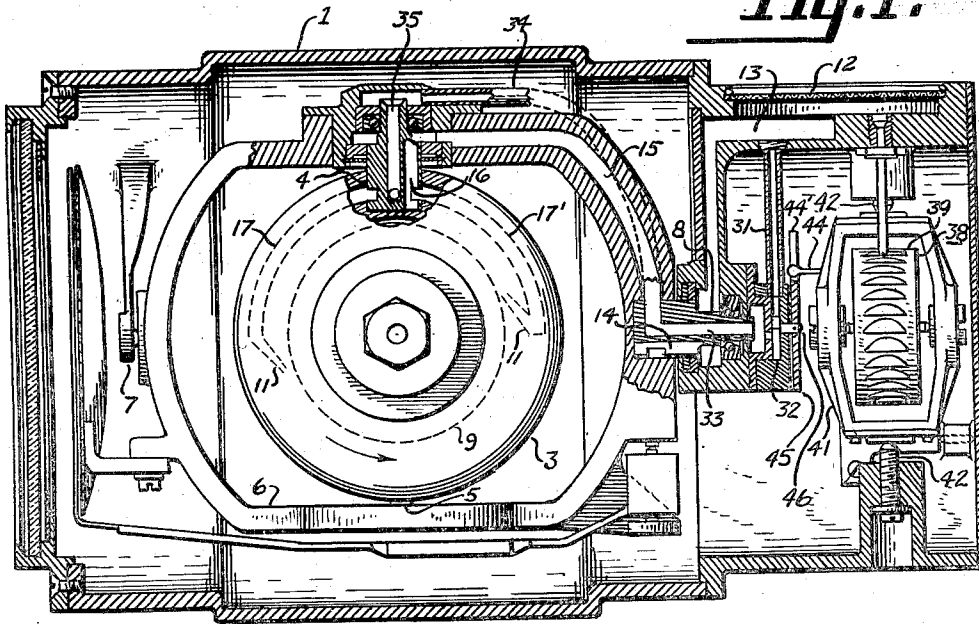
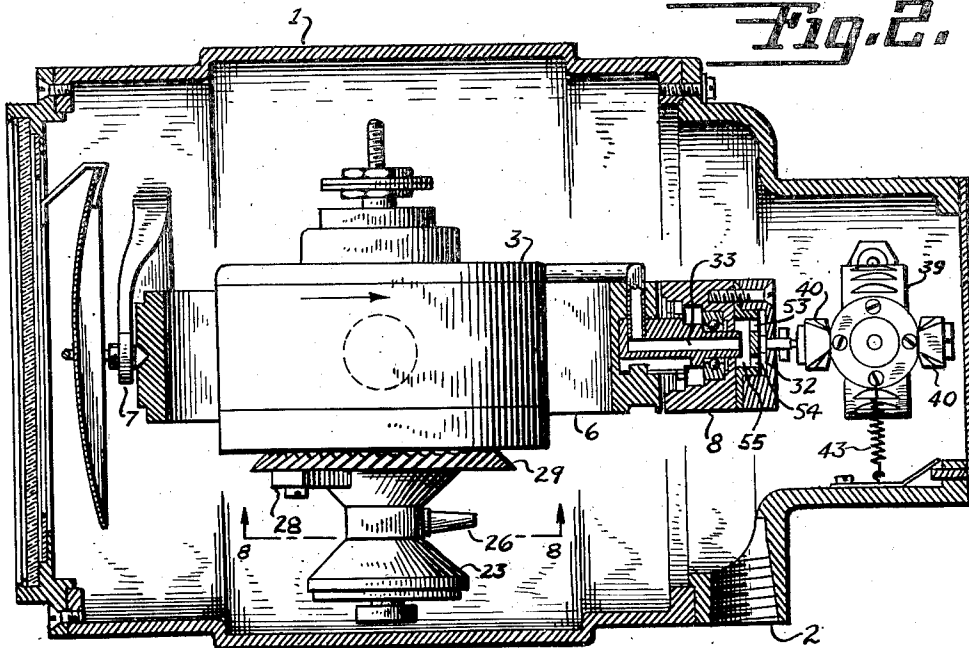


Fig. 2.



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Fig. 3.

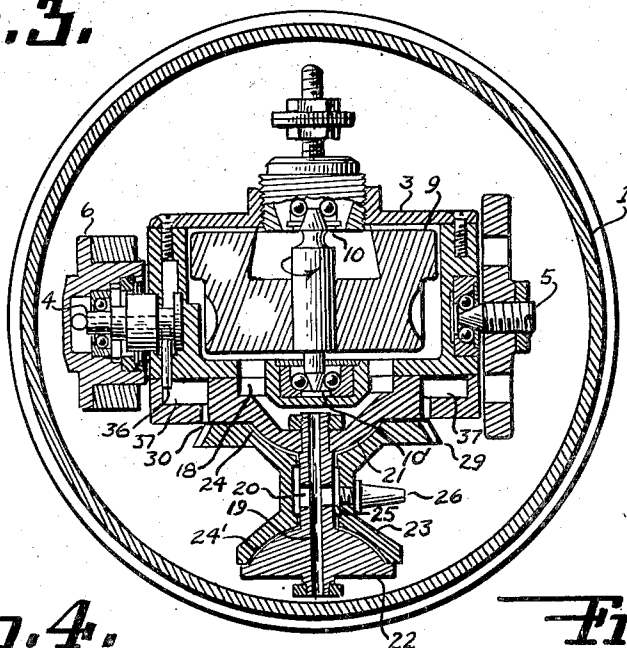


Fig. 4.

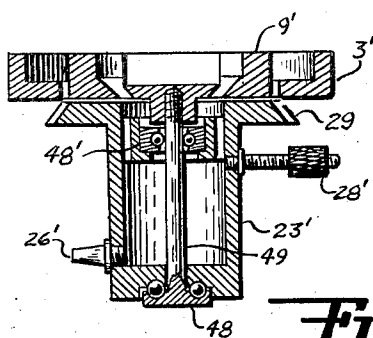
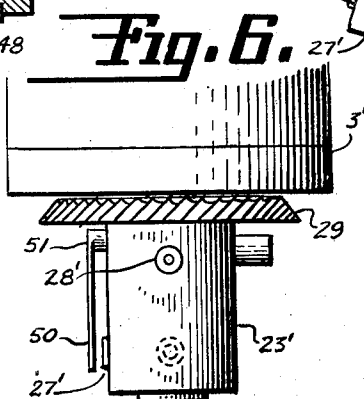
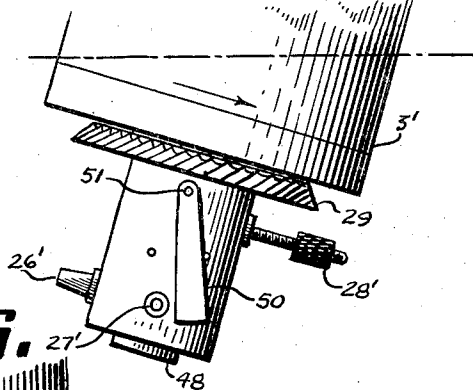


Fig. 5.



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Fig. 7.

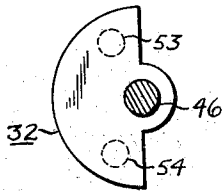
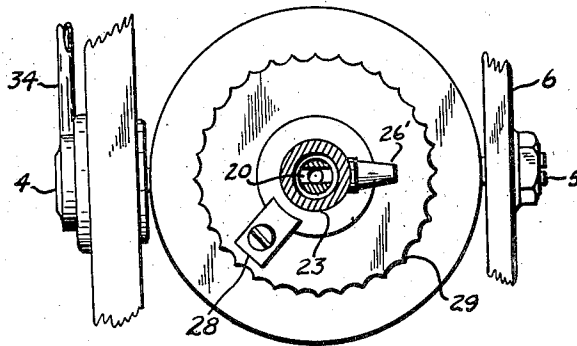


Fig. 8.



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2,380,941

ERECTION DEVICE FOR GYRO VERTICALS

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Application December 7, 1940, Serial No. 369,016

12 Claims. (Cl. 74-5)

This invention relates to erection devices for gyro-verticals or gyroscopic artificial horizons wherein the source of power is controlled by a gravitationally responsive element to maintain the gyroscope erect with a minimum of oscillation. More particularly, this invention constitutes an improvement on the invention described and claimed in my prior Patent No. 2,314,343, dated March 23, 1943, for Erecting device for gyro verticals.

One of the objects of the present invention is to render the gyroscope of my prior invention more stable in its vertical position so that small amplitude hunting around the vertical is avoided.

Another object of my invention is to prevent inclination of the gyroscope during turning of the craft.

Still another object is to simplify the construction of this type of erection device.

The present invention also has application to other types of gyro erectors, as will be evident from the following description.

Referring to the drawings showing several forms my invention may assume,

Fig. 1 is a plan view, parts being in section, of one of my improved gyro-verticals.

Fig. 2 is a side elevation of the same, also partly in section.

Fig. 3 is a transverse section through the gyro and its casing.

Fig. 4 is a sectional detail of a modified form of erection device adapted to be used in connection with a gyroscope of the type shown in Figs. 1, 2 and 3, in lieu of the erection device there shown.

Fig. 5 is a side elevation of the same.

Fig. 6 is a front elevation of the same.

Fig. 7 is a detail of the turn controlled valve shown in Figs. 1 and 2.

Fig. 8 is a transverse section looking upwardly taken on line 8-8 of Fig. 2.

Referring first to Figs. 1, 2 and 3, there is therein shown a gyro-vertical or artificial horizon for aircraft enclosed within a casing 1, from which air may be continuously exhausted through outlet 2. Within said casing is universally mounted the rotor bearing frame or casing 3 of the gyroscope, which is shown as pivoted on minor transverse trunnions 4 and 5 within the gimbal ring 6, which in turn is pivoted on fore and aft major trunnions 7 and 8 within the casing 1. The rotor proper 9 is journaled within the casing 3 on normally vertical pivots 10 and 10', the rotor being preferably spun in the usual manner from air jets 11 within the

case. Air at atmospheric pressure is shown as supplied to said jets from a screened opening 12 in the side of the casing and communicating with a channel 13, which in turn leads air through passages 14 in the hollow trunnion 8, thence to channel 15 in the gimbal ring, thence through passages 16 in the hollow trunnion 4, thence through passages 17 and 17' to the aforesaid jets 11.

The used air is shown as discharged downwardly through channels 18 in the bottom of the casing 3, whence it passes downwardly through hollow stem 19 and a goodly part passes out through cross bores 20. Said stem is shown as secured in the central aperture of a spherical button 21 formed on the bottom of the gyro casing, and it supports at its lower end a similar spherical button 22. Between said buttons is loosely mounted a freely rotatable spool or member 23 formed with upwardly and downwardly spherical cavities 24 and 24' which conform to but are slightly spaced from the aforesaid buttons. The used air from the rotor passes upwardly and downwardly from the annular space 25 communicating with the passages 20 and thence the air flows outwardly between the complementary buttons and cups to form air bearings for the member 23, supporting it for freedom about the vertical axis. Member 23 is preferably unbalanced about said axis as by securing thereto an eccentric mass 26 which exerts a torque on the gyroscope about a horizontal axis normal to the horizontal radius connecting said mass and said vertical axis. A portion of the air is also discharged from one or more jets so placed as to perform two functions, one to exert a torque on the gyroscope which is kept upon tilt, at right angles to the tilt, and two, to balance or nullify the gravitational pull on an unbalanced or eccentric mass 26 represented as secured to the member 23. In case of inclination of the gyroscope, the moments of the mass and jet become unequal and the member 23 is rotated so that the mass 26 is on the low side of the gyroscope, as explained in my aforesaid prior application. The result is that there is always exerted an unbalanced torque on the gyroscope, the position of which is in a direction to erect the gyroscope by the shortest path but a slight conical precession of the gyroscope may result of small and almost inconsequential magnitude, because this torque continues to be exerted in one form of my invention even though the gyroscope be level.

In my aforesaid prior application and in the form of the present invention shown in Figs. 4

to 6, these two functions of the present invention are effected by separate air jets 26' and 27' directed at right angles to each other. In the form shown in Figs. 1, 2, 3, and 8, however, I accomplish both functions by a single jet 26 (see Fig. 8) placed at an angle to the position of the eccentric mass 28. An analysis of the forces involved will show that the same result is secured as with two jets since the torque exerted by the jet 26 may be resolved into a component in the vertical plane through the mass 28 and the vertical center line of the gyroscope and a second component at right angles thereto, so that the first named component balances the gravitational pull on the mass 28 when the gyro is vertical and the second named component applies the erecting torque. As with the two jets, as soon as the gyro becomes inclined, the gravitational pull predominates and swings the entire spool 23 so that the mass 28 remains at the low side of the gyroscope.

Such devices, however, being also effected by centrifugal force, give rise to errors during turns. In order to avoid such errors, I propose a novel means for rendering the erecting torque ineffective during turns, i. e., by spinning the entire member 23 on its air bearings whenever turning occurs. By this means the slight unbalanced torque exerted by the jet 26 is distributed, so that there is no continuously effective torque about any axis. For this purpose I have shown the top of the member 23 provided with inclined blades 29 against which equal jets of air from symmetrically placed ports 30 in the bottom of the case may be directed. No reactive torque is thereby exerted on the gyro-casing 3 about any horizontal axis. Said ports are shown as connected to a separate source of air supply from the previously described jets so that the jets from said ports may be rendered effective during turns and ineffective during ordinary operation. For this purpose I have shown a separate pipe 31 (Fig. 1) for leading air in through a valve 32 and thence in through a separate axial channel 33 in trunnion 8, connected with a pipe 34 leading into an axial channel 35 in trunnion 4. Thence the air is led downwardly through pipe 36 into an annular channel 37 in the bottom of the gyro case, in which the above described ports 30 are placed.

The valve 32 is shown as in the form of a semi-circular cut-off plate (see Fig. 7) secured to a stub shaft 46 and normally closing both outlet ports 53 and 54 which connect with the channel 55 connected in turn with the central bore 33 of trunnion 8. When, however, the plate is rotated through a substantial angle in either direction one of the ports 51 or 52 will be uncovered, thus admitting air to the jets 26.

The valve 32 may be controlled by any suitable means for closing the same during turns. Preferably such means is automatic and comprises a rate of turn or turn responsive gyroscope 38, shown as comprising a rotor 39 journaled on horizontal trunnions 40 in rotor bearing frame 41, which in turn is journaled for precession about horizontal trunnions 42 in casing 1, the gyroscope being normally centralized by springs 43. The gyroscope is shown as having a loose pin and slot connection 44 and 44' with the disc 45 secured to the stem or shaft 46 of the aforesaid valve 32. As shown in Fig. 7, the valve is so arranged as to be opened on precession of the gyroscope in either direction from the central position, thereby admitting air to the spinning

jets 26 to spin the erection device and render the same temporarily inoperative.

In the form of the invention shown in Figs. 4, 5 and 6, the above mentioned purpose is accomplished and, in addition, the erecting action of the jet or jets is rendered ineffective when the gyroscope is vertical thereby reducing the above described hunting action or slight conical precession otherwise caused thereby. In this form, the rotatable member or sleeve 23' is shown as supported on ordinary anti-friction bearings 48 and 48' on the stem 49 projecting downwardly from the gyro case 9'. The sleeve is again provided at its top with teeth 29 so as to be rotated in case of turns. In this form the sleeve is shown as provided with a balancing jet 26', unbalanced mass 28' or the equivalent, and a separate precessing jet 27' normal to the jet 26'. In this case, also, I have shown a pendulous shutter 50 pivoted at 51 on the sleeve above the port 27', so that when the gyroscope is vertical, the shutter 50 overlies the port 27' and spoils the air reaction therefrom so that little or no torque is exerted on the gyroscope from this port. In case, however, the gyroscope becomes inclined, as shown in Fig. 5, the pendulum swings to one side and the port is opened so as to exert the desired air reaction and erective torque on the gyroscope.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

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

1. In a gyro vertical for moving craft, including a rotor mounted for freedom about normally perpendicular horizontal axes and a normally vertical axis and a rotor bearing frame, an unbalanced mass rotatably mounted on said frame about said vertical axis, whereby the mass remains on the low side of the frame, means rotatable with said mass for exerting an erecting torque about a horizontal axis of said frame substantially normal to the horizontal axis about which said mass acts and means responsive to turn of the craft for spinning said mass and torque means at sufficient speed to temporarily eliminate the effect of said torque on said gyro vertical.

2. A gyro vertical as claimed in claim 1, having a gravitationally responsive means mounted on said mass and operating to render said torque means ineffective except on relative inclination of the gyro vertical and gravitational means.

3. In a gyro vertical for moving craft, including a rotor mounted for freedom about normally perpendicular horizontal axes and a normally vertical axis, an unbalanced mass rotatably mounted on said gyro vertical on an axis in line with said vertical axis, and a single torque applying device for exerting a continuous torque about a horizontal axis of the gyro vertical at a single point and in a direction to normally both balance the gravitational pull on said unbalanced mass and to exert an erecting torque on the gyro vertical at an angle to said pull.

4. A gyro vertical as claimed in claim 3 having means responsive to turn of the craft for spinning said mass and torque means during turns.

5. In a gyro vertical for moving craft, including a rotor mounted for freedom about normally

perpendicular horizontal axes and a normally vertical axis, an unbalanced mass rotatably mounted on said gyro vertical on an axis in line with said vertical axis, and a single air jet rotatable with said mass and directed at an angle to the vertical plane containing said mass and vertical axis, said jet being so constructed and arranged as to both balance the normal gravitational pull on said mass and to exert an erecting torque on the gyro vertical at an angle to said pull.

6. An erection device for neutrally mounted gyro verticals comprising an unbalanced mass rotatably mounted about a vertical axis on the rotor casing of said gyro vertical, an air jet on said mass so located and directed that its reaction on the gyro vertical balances the gravitational torque on the gyro vertical from said unbalanced portion of said mass, but leaving said mass subject to gravity upon inclination of the gyro vertical, a second air jet on said mass so located and directed that its mean reaction on the gyro vertical during inclination is such as to erect the same, and a pendulous baffle rendering said last named jet ineffective except upon relative inclination of the gyro vertical and baffle.

7. A gyro vertical as claimed in claim 9, in which both the gyro rotor and said mass are spun by air jets, an air channel through the gyro axes for leading air to the rotor jets, a separate channel through the gyro axes for leading air to the said mass spinning jets, and a valve in the air supply for the latter jets adapted to be opened only on turning of the craft.

8. A gyro vertical as claimed in claim 9, in which both the gyro rotor and said mass are spun by air jets, an air channel through the gyro axes for leading air to the rotor jets, a separate channel through the gyro axes for leading air to the said mass spinning jets, a valve in the air supply for the latter jets, and a rate of turn gyroscope connected to said valve to open said valve on precession in either direction.

9. A gyro vertical for moving craft mounted for freedom about mutually perpendicular normally horizontal axes and a normally vertical axis and including a rotor bearing frame, a rotatable mass mounted on the frame about the vertical axis thereof, said mass having an unbalanced portion adapted to move to the lower side of the gyro vertical upon inclination of its vertical axis, means for exerting an erecting torque on said frame, and counterbalancing the torque caused by the weight of the unbalanced portion of said mass, and means for rapidly spin-

ning said rotatable mass to render the torque exerting means ineffective only during turning movements of the craft.

10. In a gyro vertical for moving craft mounted for freedom about mutually perpendicular normally horizontal axes and a normally vertical axis and including a rotor bearing frame, a rotatable mass mounted on the frame about the vertical axis thereof, said mass having an unbalanced portion adapted to move to the lower side of said frame upon inclination of its vertical axis, air jet means carried by said mass for both exerting an erecting torque on the gyro vertical and counterbalancing the torque caused by the weight of the unbalanced portion of said mass, and means for spinning said rotatable mass sufficiently rapidly to render the air jet torque exerting means thereon ineffective only during turning movements of the craft.

11. An erection device for neutrally mounted gyro verticals comprising an unbalanced mass rotatably mounted on said gyro vertical on a normally vertical axis, an air jet on said mass so located and directed that its reaction on the gyro vertical balances the reaction on the gyro vertical from said unbalanced portion of said mass, but leaving said mass subject to gravity upon inclination of the gyro vertical, a second air jet on said mass so located and directed that its mean reaction on the gyro vertical during inclination is such as to erect the same, and a pendulous baffle pivoted adjacent said second jet to render the same ineffective when both said gyro vertical and baffle are vertical.

12. In combination, a gyro vertical having a gyro rotor bearing frame mounted for freedom about mutually perpendicular normally horizontal axes, a gyro rotor in said frame mounted to spin about a normally vertical axis, a rotatable member mounted on said frame situated in coaxial relation to the spin axis of the gyro rotor and including an unbalancing mass thereon, air jet directing means situated in said member by which the gravitational reaction on said frame caused by the unbalanced mass is normally balanced and a reactive erecting force is exerted about a horizontal axis of the frame, which is effective when the frame is inclined from a normal position, to restore the spin axis of the gyro rotor to a normal position, and a gravitationally responsive shutter rendering said last named jet ineffective except upon inclination of the gyro vertical.

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