

July 27, 1937.

W. ANSCOTT

2,087,961

BALL GYRO VERTICAL

Filed Sept. 14, 1935

2 Sheets-Sheet 1

Fig. 1.

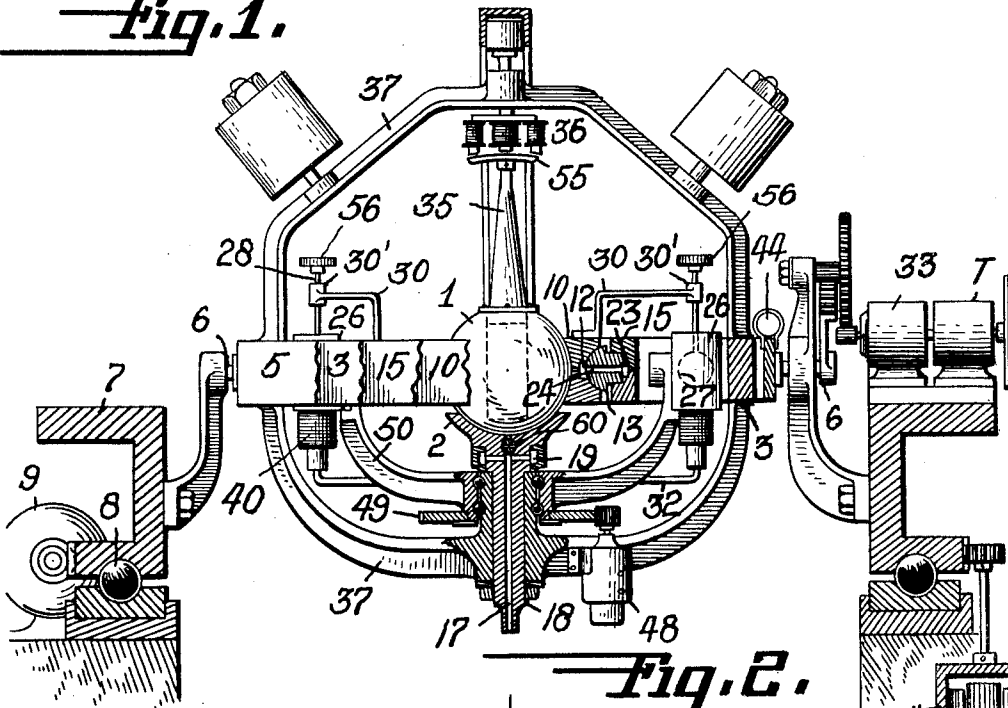


Fig. 2.

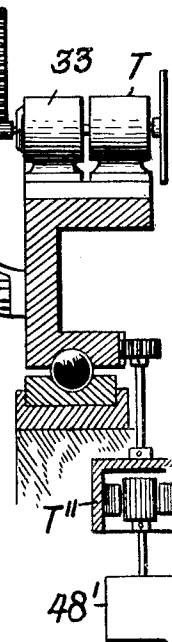
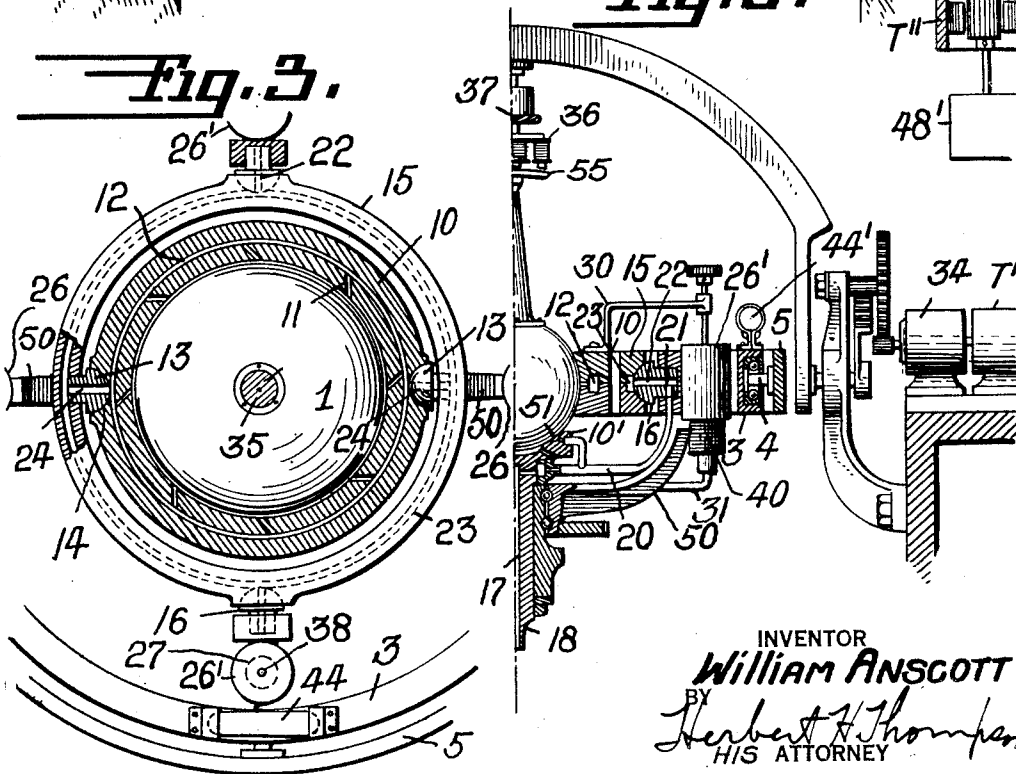


Fig. 3.



INVENTOR
William ANSCOTT
BY
Herbert H. Thompson
HIS ATTORNEY

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2 Sheets-Sheet 2

Fig. 4.

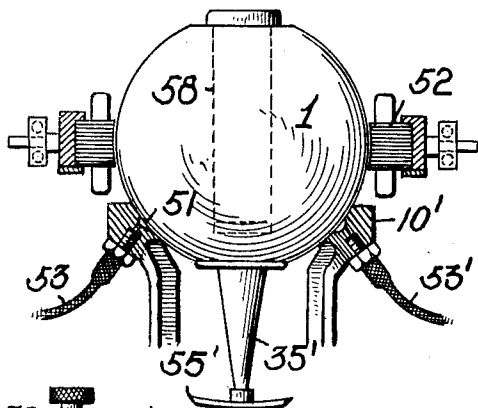
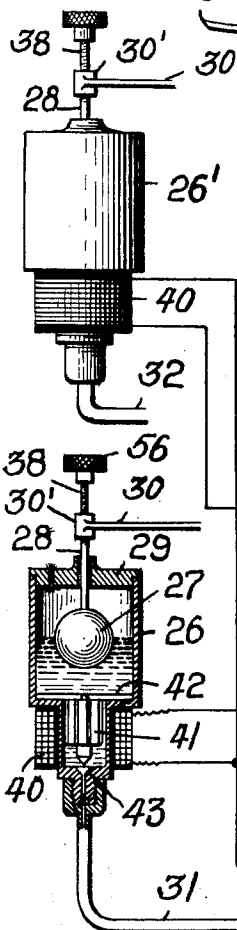


Fig. 7.

Fig. 5.

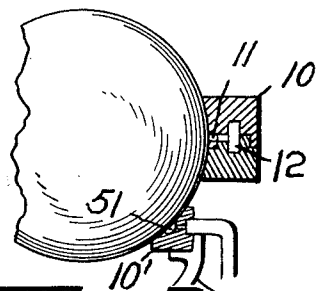
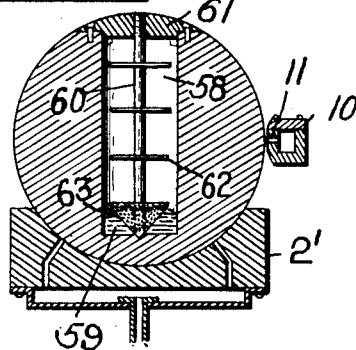


Fig. 6.



INVENTOR
William Anscomb
BY
Herbert H. Thompson
HIS ATTORNEY.

UNITED STATES PATENT OFFICE

2,087,961

BALL GYRO VERTICAL

William Anscott, Woodhaven, N. Y., assignor to
Sperry Gyroscope Company, Inc., Brooklyn,
N. Y., a corporation of New York

Application September 14, 1935, Serial No. 40,560

14 Claims. (Cl. 33—204)

This invention relates to a ball type of air supported gyroscopes and, more especially, to gyro verticals or artificial horizons for maintaining a horizontal plane on shipboard for fire control and other purposes.

This invention constitutes an improvement on the type of artificial horizon disclosed and claimed in the prior application of applicant and Bruno A. Wittkuhns, Serial No. 562,282, filed September 11, 1931, the improvements being mainly in the air supporting cup or bearing for the ball and in the gravitational control for the spinning means for the ball. In the prior invention a pendulous element was made use of as the base from which to control the position of the spinning means, by means of which the position of the spinning axis of the ball was controlled. A purely pendulous device is, of course, subject to lateral acceleration pressures, thus giving rise to certain errors during rolling and pitching of the ship. According to the present invention, I make use of a liquid level device to control the position of the spinning means, the flow of liquid being throttled so that it is out of phase with the rolling and pitching of the ship.

Certain features of this invention have application to other types of gyroscopes, as will readily be apparent from the following description.

Referring to the drawings,

Fig. 1 is a front elevation, partly in section, of one form of gyro vertical.

Fig. 2 is a side elevation of the same, showing also a slight modification in the air bearing support for the ball.

Fig. 3 is a horizontal section through the horizontal axis of support of the ball, on a larger scale, the ball being shown in elevation.

Fig. 4 is a vertical section of a modified form of air support, showing an electrical spinning means for the ball.

Fig. 5 shows a combined air spinning means and air support for the ball, this form also being shown in Fig. 2.

Fig. 6 shows a vertical section of a modified form of ball and air support therefor.

Fig. 7 shows an automatic means for shutting off the flow of liquid on change of speed or course of the ship.

As stated, the gyro rotor of the invention is preferably in the form of a ball or sphere 1 which is supported for spinning about a vertical axis on an air bearing or bearings which may be provided by means of a cup 2 under the lower portion of the ball. The cup is shown as

supported on a spider 37 secured to ring 3 which is gimballed on horizontal axis 4 within the gimbal ring 5, the latter, in turn, being trunnioned on horizontal axis 6—5 within a main frame 7. The frame 7, in turn, is shown as mounted for rotation about a vertical axis on bearings 8, the position in azimuth being controlled from a motor 9, which is preferably governed by the position of the trunnion axis of the guns on the ship.

The ball is shown as spun from an independently supported spinning means 10. This may be in the form of an equatorial ring in which is provided a plurality of spinning jets 11 which tangentially engage the ball and communicate with an annular channel 12, into which air is introduced through the supporting trunnions 13. Preferably such trunnions are of the air borne type, being shown as in the shape of buttons engaging spherical cavities 14 in ring 10. Said buttons or trunnions are secured in an inner gimbal ring 15 which, in turn, is journaled for oscillation about a second horizontal axis within a spider 50 journaled for freedom about a vertical axis within ring 3. Similar buttons 16 are provided for this purpose.

Air is admitted, both for spinning and supporting the ball and lubricating the air bearings for the trunnion axis, through bore 17 in a vertical stem 18 secured to the cup, the air passing upwardly through the stem and into an annular channel 19, from which it passes through pipes 20 into the central bores 22 in the buttons 16, and thence into an annular channel 23 in gimbal ring 15, a portion of the air lubricating or floating the ring 10 by escaping between the buttons 16 and the ring. Thence the air passes through the central bores 24 in the buttons 13 and into an annular channel 12 in the ring 10, a portion of the air, however, escaping between the button and ring to float the ring on the buttons. The spinning nozzles 11 communicate with the channel 12 to spin the ball, as above described.

The spinning ring 10 is maintained in a normally horizontal plane by a liquid level device, shown as comprising a plurality of pairs of mercury containers 26 and 26' which are secured to said spider 50, rotatably mounted on the central vertical stem 18. Four such containers are shown, placed in quadrature. In each container there is a ball float 27 having a stem 28 passing through the top 29. Said stem is adjustably secured to an arm 30 which, in turn, is secured to the spinning ring 10. The diametrically oppo-

site containers are cross connected by restricted pipes 31, 32 so that the flow of liquid between the containers is sufficiently retarded or out of phase with the roll of the ship so that rolling or pitching of the ship does not cause errors. The average position of the liquid, however, is of course level regardless of the tilt of the supporting gimbal system. It will also be understood that the gimbal system itself is stabilized about both axes by means of the repeater motors 33 and 34, which are actuated from a suitable controller operating between an armature 55 on a stem 35 on the ball 1 and a complementary inductive controller 36 on a framework 37 on the gimbal ring 3, as explained in the aforesaid application Serial No. 562,282, and also more completely in the prior patent to Gillmor and Wittkuhns, No. 1,984,874, dated December 18, 1934, for Gyro verticals. Therefore the mercury containers are not subject to temporary tilting during lateral acceleration pressures, due to turning or change of speed of the ship or to roll and pitch.

In order to maintain the spin axis of the ball vertical in spite of changes in latitude, it is important that means be provided to tilt the spinning means in the east-west plane an amount dependent on the latitude. A convenient means for effecting this purpose is provided by making the stems 38 of the floats 27 threaded and correspondingly threading the enlarged ends 30' of the arms 30 so as to change the relation between the east-west floats 26 and the position of the spinning means 10 by turning knobs 56.

As an additional means for preventing flow of the liquid during turning or changing speed of the ship, I may provide a solenoid 40 at the base of the containers which, when excited, draws downwardly an armature 41 normally floated in the bottom of the mercury and prevented from rising above a predetermined position by a stop bar 42. When the solenoid is excited it will draw the armature downwardly, closing a valve 43. The solenoid is shown as controlled from small tanks or tubes 44, 44' placed on a stabilized part of the device, at right angles to one another and having three normally separate pools of mercury 45, 46 and 47. It will readily be apparent that if an acceleration pressure occurs in any direction in azimuth, mercury will overflow from one compartment into the other of one of tubes 44 or 44', thus completing a contact to excite the solenoids and close the valves. As soon as the acceleration is concluded, the contact will again be broken, permitting the valves to open.

In order to maintain the latitude correction set properly, the containers are preferably maintained fixed in azimuth regardless of the turning of the ship or guns, by means of repeater motor 48 (Fig. 1) actuated from transmitter T'' and secured to the framework 37 and geared to a gear 49 which is secured to a framework 50 which supports the mercury containers. 48' is a compass repeater motor, while T, T' and T'' are transmitters for transmitting the position of the gyro-vertical to the guns, the last named transmitter being of the differential type, the field being turned from support 7 and the armature from motor 48', as described more completely in the aforesaid application No. 562,282.

Experience has shown that in many instances superior results are secured by omitting the cup 2 underneath the gyro rotor and replacing it by an annular air bearing support. This is especially true where air is supplied continuously to

the bearing. Such a construction is shown in Figs. 2, 4 and 5. In Figs. 2 and 5 the air spinning means is retained, but in place of the lower cup, a ring 10' is provided which has a plurality of radial apertures 51 which float the ball on an annular bearing below the equator thereof. Fig. 4 is similar, except that in this case the spinning means constitutes an electric stator 52, the air for ring 10' being shown as supplied through separate pipes 53 and 53'. This figure also shows that with this construction the inductive controller 55' may be placed underneath the ball instead of on top, as in Fig. 1. With this construction the air escapes in both directions, that is, both upwardly and downwardly from the annular ring 10', so that it flows in both directions from the middle of the annulus, which seems to have a steadying effect on the ball.

Fig. 6 shows the preferred interior construction of the ball. Preferably the vertical axis thereof is hollowed out to form an axial cavity 58 sealed at both ends and in which is placed a small amount of mercury 59. The mercury has the effect of quickly damping out nutations of the ball, and to aid in this result, a vertical stem 60 is secured to the detachable cap 61 and provided with a plurality of discs 62 and a lower perforated hollow cone 63. The cone breaks up the surface tension of the mercury and distributes it evenly in starting up, so as to prevent surging thereof. The discs assist in securing the same result by breaking up the separate drops of mercury that may rise on the sides of the cavity. In this figure a modified form of cup 2' for supporting the ball and air bearing is also shown.

From the foregoing, the operation of my invention will be readily apparent. The gravitational control element for the ball in this instance will remain truly horizontal, since the liquid containers 26, 26' are mounted on a part stabilized from the ball and since the mercury level will be maintained in spite of temporary acceleration pressures, due either to the restricted passages 31, 32 between the containers or to the shut-off valves 41 and 43, or both. Exceptional freedom is provided about all axes by the air bearings both for the ball and gimbal rings. In the preferred form of ring or open bottom cup support for the ball shown in Figs. 2, 4 and 5, an important advantage is secured over the cup form shown in Fig. 1, since with the cup form, vibrations or nutations are likely to develop in the ball, especially when air is continuously supplied thereto for providing an air bearing within the cup, which is not the case when the cup is made in the form of an annulus. Also, vibrations may be avoided by shutting off the air supply so that the rotation of the ball supplies its own air film. This may be accomplished in Fig. 1 by closing the valve 60 which leads to the air supply passage 17, after the ball is up to speed.

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 ball gyro vertical, the combination with the ball and a support therefor, of a universally supported spinning means for the ball, a mercury level device, and floats therein connected to said

spinning means for maintaining said means in a fixed relation to the horizontal.

2. A ball gyro vertical as claimed in claim 1, in which means are provided for adjusting the relation between the mercury level and the spinning means for different latitudes.

3. In a ball gyro vertical, the combination with the ball and a support therefor, of a universally supported spinning means for the ball, a level device including spaced mercury containers for maintaining said means in a fixed relation to the horizontal, means for orienting said device to maintain a pair of said containers E—W regardless of turning of the ship, and means for adjusting the angular relation between the east-west mercury containers and the spinning means for different latitudes.

4. In a ball gyroscope, the combination with the ball, of a ring or open bottom cup for supporting the same around an annulus between the equator of the ball and its lower pole, means whereby air may be supplied between the ball and ring to float the ball on an annular air bearing permitting the escape of air both at the top and bottom of said ring, and means for spinning the ball.

5. In a ball gyro vertical, the combination with the ball, of a ring or open bottom cup for supporting the same around an annulus between the equator of the ball and its lower pole, means whereby air may be supplied between the ball and ring to float the ball on an annular air bearing permitting the escape of air both at the top and bottom of said ring, and means for spinning the ball about a substantially vertical axis.

6. A ball gyro vertical as claimed in claim 1, having means responsive to lateral acceleration pressures for temporarily preventing the flow of mercury in the level.

7. In a gyro vertical, the combination with the ball, of an equatorial ring surrounding the same to spin it, said ring having spinning jets therein, and a universal gimbal mounting for said ring including air borne hollow gimbal bearings of the ball and cup type adapted to both float the ring in air bearings and to lead the spinning air into said jets.

8. In a ball gyro vertical, the combination with the ball and a support therefor, of a universally supported spinning means for the ball, a level device comprising a pair of mercury containers con-

nected by a restricted tube, a float in each container and means connecting each float to said spinning means.

9. A gyro vertical as claimed in claim 8, having a part stabilized from the ball, said containers being mounted thereon, whereby said containers are not tilted by lateral acceleration pressures.

10. In a ball gyro vertical, a ball having a normally vertical axial cavity adapted to contain a small quantity of liquid, and a perforated inverted cone at the bottom of said cavity for the purpose specified.

11. A ball gyro vertical as claimed in claim 10, in which substantially horizontal baffle plates are also provided within said cavity in vertically spaced relation.

12. In a ball gyro vertical, the combination with the ball, of an equatorial spinning means therefor, an annulus surrounding said ball below the equator and above its lower pole having its inner upper surface closely fitting said ball, and means for supplying air under pressure between said surface and the ball at mid points, whereby the air escapes both upwardly and downwardly from said annulus.

13. In a ball gyro vertical, the combination with the ball and a support therefor, of an independent universally supported spinning means for the ball, a mercury level device for maintaining said means in a fixed relation to the horizontal, means for orienting said device to maintain it fixed in azimuth regardless of the turning of the ship, and means for adjusting the relation between the mercury level and spinning means for different latitudes.

14. In a ball gyro vertical, a gimbal mounting mounted for rotation about a vertical axis, means for maintaining the gimbal axes of said mounting in a predetermined position with respect to the trunnion axis of a gun, a ball gyroscope within said mounting, a second gimbal mounting for universally mounting said ball therein, a spinning means for the ball, a member universally mounted within said first named gimbal mounting for rotation in azimuth for supporting said second gimbal mounting, a mercury level device on said member for maintaining said spinning means horizontal, and means for maintaining said member fixed in azimuth regardless of the turning of the ship or guns.

WILLIAM ANSCOTT.