

Dec. 27, 1938.

L. F. CARTER

2,142,018

BALL GYROCOMPASS

Filed Nov. 21, 1935

3 Sheets-Sheet 1

Fig. 1.

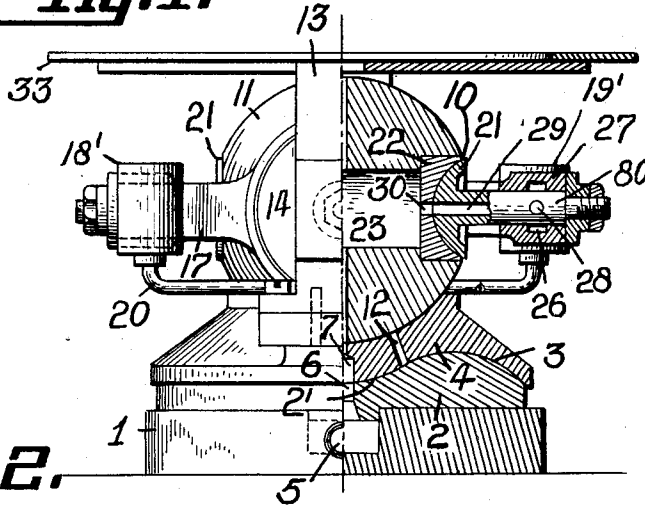


Fig. 2.

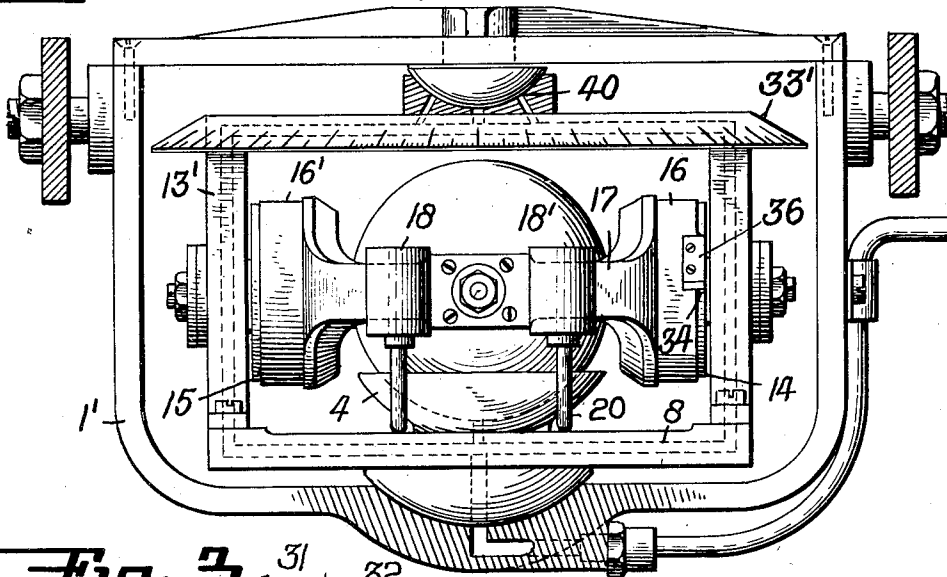


Fig. 3.

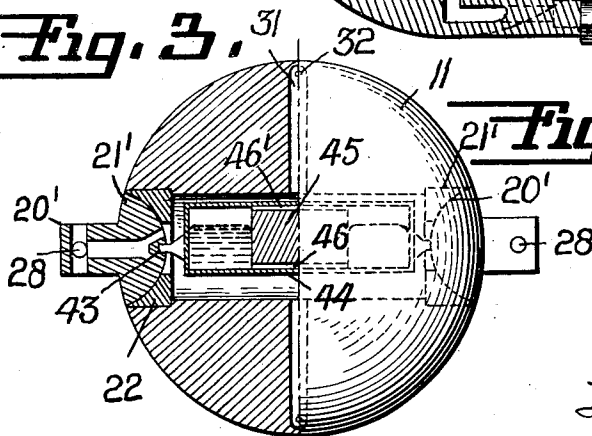
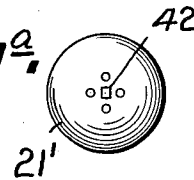


Fig. 3a.



INVENTOR
LESLIE F. CARTER
BY *Herbert F. Thompson*
HIS ATTORNEY

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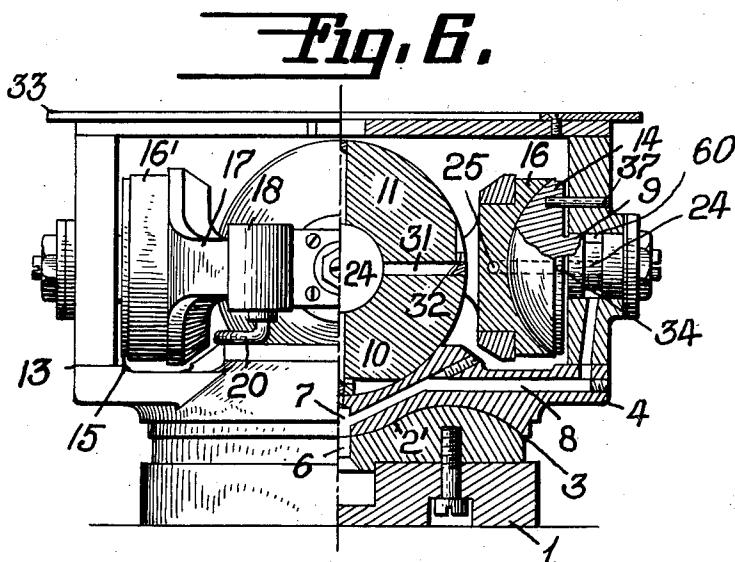
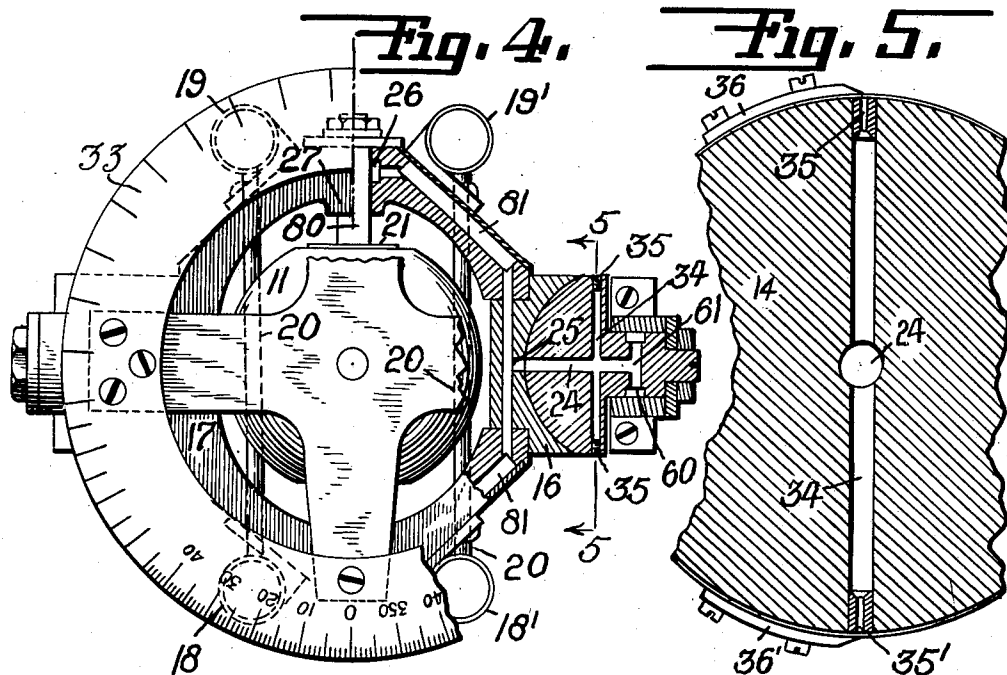
L. F. CARTER

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3 Sheets-Sheet 2



INVENTOR
LESLIE F. CARTER
BY
Herbert H. Thompson
HIS ATTORNEY

Dec. 27, 1938.

L. F. CARTER

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BALL GYROCOMPASS

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3 Sheets-Sheet 3

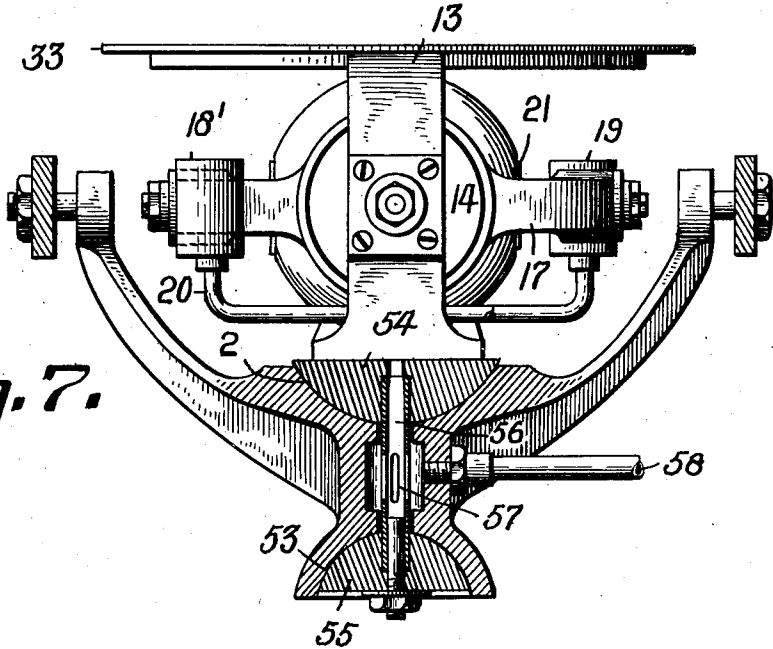


Fig. 7.

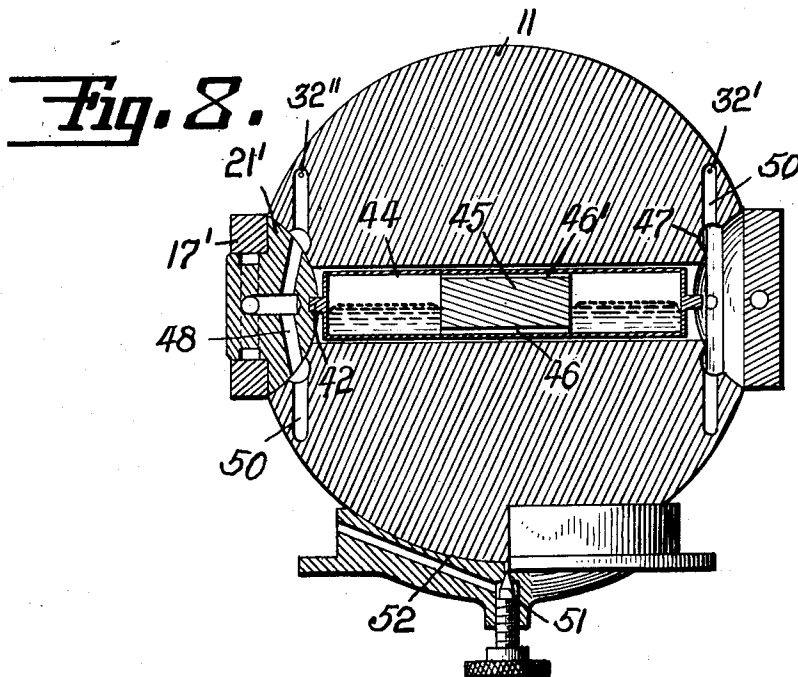


Fig. 8.

INVENTOR
LESLIE F. CARTER
BY *Herbert H. Thompson*
HIS ATTORNEY.

UNITED STATES PATENT OFFICE

2,142,018

BALL GYROCOMPASS

Leslie F. Carter, Leonia, N. J., assignor to Sperry Gyroscope Company, Inc., Brooklyn, N. Y., a corporation of New York

Application November 21, 1935, Serial No. 50,846

11 Claims. (Cl. 33—226)

This invention relates to a ball type gyroscopic compass.

While such gyrocompasses have been proposed, difficulty has been experienced in the past in securing proper gravitational control, especially where a stationary stator has supplied the spinning torque to the ball. In such cases a certain amount of coupling takes place between the stator and the ball, so that the gyroscope is not entirely free. Also, difficulty has been experienced in applying a gravitational control to a spinning ball which is otherwise free about all three axes.

According to my invention, I overcome the defects of the prior ball type compasses by spinning the ball by reaction jets which emerge from the rotor itself, so that there is virtually no coupling between the rotor and its supporting parts. In addition, I secure the gravitational element to the ball by means of air bearings positioned along the spinning axis of the ball so that the gravitational element partakes of all tilting and azimuthal movements of the ball axis but does not rotate with the ball.

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

Fig. 1 is an elevation, looking east, partly in section, of a ball gyroscopic compass constructed according to my invention.

Fig. 2 is an elevation, looking south, of a modified form of ball compass.

Fig. 3 is an elevation, looking east, partly in section, of a ball rotor, showing a modified form of gravitational control.

Fig. 3A is a face view of the button forming part of the air bearing of Fig. 3.

Fig. 4 is a plan view, partly in section, of the form of compass shown in Fig. 1.

Fig. 5 is a sectional detail through the bearing between the gravitational element and supporting frame, showing how damping is secured. (See line 5—5, Fig. 4.)

Fig. 6 is an elevation, looking south, partly in section, of the form of the invention shown in Fig. 1.

Fig. 7 is an elevation, looking south, partly in section, of a still further modification.

Fig. 8 is a sectional view of the rotor, showing a modified form of rotor and ballistic or gravitational control.

In illustrating my invention, I have not undertaken to show any repeater system or power driven follow-up, but it will be understood that such may be added if desired.

Referring first to Figs. 1 and 4 to 6, the compass is shown as supported on a base 1 on which

is fixedly mounted a cup-shaped bearing member 2. If no top bearing is used, the member 2 has both a central convex surface 2' and an outer concave surface 3, thus providing a means whereby a complementary shaped supported part 4 cannot turn about any except the vertical axis. Air under pressure enters the base 1 through a suitable coupling 5, whence it passes upwardly through a central aperture 6 in block 2. Part of this air escapes between the block 2 and the supported member 4 so that the member 4 is floated on an air bearing for freedom about the vertical axis. The greater portion of the air, however, passes upwardly through a central bore 7 in support 4 and thence passes laterally through holes 8 and up into horizontal bearings 9 on which the ballistic element is floated. Some of the air may also pass upwardly from the aperture 7 to emerge within a cavity or cup 10 formed in the top of the block 4, which acts as a support for the ball or rotor 11. This action is also assisted by aperture 12 connecting the two cups 10 and 2'. The ball rotor is hence supported for freedom about all three axes in the hollow, spherical cup 10 of member 4.

The member 4 is also mounted for turning about the vertical axis with the ball and carries the horizontal bearings 9 for the ballistic. To this end, the member 4 carries a frame 13 which supports at opposite ends button-like bearing members 14 and 15 of bearings 9. Said members have cylindrical shanks having circumferential grooves 16 therein with which bore 8 communicates. A cross bore 16' therein leads air from said groove to axial bore 24. A compass card 33 is shown as mounted on top of the framework 13. Freely mounted on said button members for oscillation about the horizontal axis, are complementary shaped cups 16, 16', to which a normally horizontal ring 17 is secured, which carries the liquid containers or cups 18, 19 and 18', 19'. These cups normally contain mercury or other liquid and the members of each pair are cross connected by restricted pipes 20 so that the liquid will flow to the low side of the device, thus effecting gravitational control as well known in the art. The ring 17 has secured thereto at 90° from cups 16, 16', hollow stub shafts 20, on the inner end of each of which is a button 21 forming half of an air bearing, the outer half being formed by cup member 22 inserted axially into the rotor 11, the central bore 23 of which is enlarged at each end to receive the cup member. It will therefore be seen that while the ballistic element, comprising the ring 17 and the liquid containers sup-

ported thereby, is supported about the horizontal axis 9 on the member 4, about the other axis 80, which is co-axial with the spin axis of the ball, it is connected to the ball so that any displacement of mercury will exert a gravitational torque on the ball. It is also coupled to the ball about the vertical axis by this same coupling, so that as the ball precesses in azimuth, the ballistic system will be carried with it, including the member 4 and framework 13.

Air for spinning the rotor is carried from the channels 8 through central apertures 24 in the button members 14 and 15 and into bores 25 in cups 16, which are connected with the circumferential channel 81 in ring 17. This connects with a circular channel 26 within the boss 27 on ring 17 surrounding the stub shaft 80, and radial holes 28 in said shaft connect with an axial hole 29 leading the air through a registering aperture 30 in button 22, whence it passes within the chamber 23 in the ball. The air then passes outwardly through radial channels 31 in the ball, whence it is directed tangentially by a plurality of nozzles 32 at the periphery of the ball. It will be understood that at points where the air passes from one part of the air bearing member to another, such as between button 14 and cup 16 and between button 21 and cup 22, a portion of the air escapes between each button and cup to provide an air bearing support, as now understood in the art.

Damping of the compass is secured by the use of baffles and air jets which results in torque being applied about the vertical axis of the compass upon tilt, and in a direction to reduce the tilt. This is secured by tapping a small bleeder hole 34 through one of buttons 14, this feature being shown best in Figs. 2, 4 and 5. The air normally emerges equally through horizontally directed apertures 35 and 35' at the end of transverse bore 34. The cup 16, however, has secured thereto a pair of knife edge baffle plates 36 and 36' which normally equally and partially overlie the apertures. When, however, the ballistic element tilts with respect to the button 14, which is held against turning within frame 13 by means such as pin 37, a greater amount of air will emerge from one hole than the other, resulting in a torque about the vertical axis which is transmitted to the rotor through the ballistic bearings.

The arrangement shown in Fig. 2 is substantially similar to that in Figs. 1 and 4 to 6, except that an additional air bearing 40 is placed at the top of the frame 13' in order to provide an upper vertical guide bearing for the frame with respect to the outer supporting frame 1'. In this instance the base 1' is made in the form of an enclosing frame and is shown as gimbal supported.

Fig. 3 illustrates how the ballistic or gravitational element may be mounted entirely within the ball. In this form the studs 20' which carry the buttons 21' are formed with a square slot or keyway 42, as shown in Fig. 3A, in which fits a square key 43 projecting from an elongated liquid container 44 within the ball. This container is shown as provided with a central block or partition 45 dividing it into two parts and having upper and lower small apertures 46 and 46' connecting the two parts so that the liquid may flow from one part to the other upon tilt. The principle of operation is the same as in the other forms.

Fig. 8 is also closely similar as to the ballistic element, which is correspondingly numbered. In

this figure, on the other hand, the cups 22 are omitted and a spherical shaped cavity 47 made in each end of the ball. The buttons 21' function as before, being supported by ring 17', but in this case the rotor is shown as spun by tangential jets 32', 32'', which are not placed on the equator of the ball, but are placed nearer the poles around symmetrically placed parallels preferably located beyond the rim of the cup 52. Air to said jets is supplied through holes 48 through the buttons 21', which emerge into annular channels 47 in the ball which, in turn, lead to the radially directed channels 50 leading to the jets 32', 32''. A needle valve 51 is for the purpose of regulating the amount of air supplied to the air bearing between the cup 52 and the ball. No air need be supplied after the ball is in rotation, although in many cases I prefer to continue the air supply. This form of the invention has the advantage that the spinning air does not emerge between the cup and the ball, resulting in quieter and more efficient operation.

In Fig. 7 the lower cup bearing is of somewhat different form than in the other figures. According to this figure, a guide bearing 53 is placed below the cup 2 instead of above the same, as in Fig. 2. The two buttons 54 and 55 are connected by a central stem 56, the middle portion of which is hollow, air entering the same through slots 57. The air passes in both directions to supply air between the cups and the respective buttons, as in the other forms of the invention, the air being supplied through a pipe 58. In this manner the compass is supported and guided about the vertical axis and is held from bouncing out of the lower thrust bearing 2.

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 type gyro-compass, the combination with the ball, a cup in which said ball rests and spins on a normally horizontal axis, air bearing means for mounting said cup for rotation about a vertical axis, a gravitational factor pivotally mounted on said cup for oscillation about a normally horizontal axis at right angles to the spin axis of said ball for imparting meridian seeking properties thereto, and bearing means connecting said factor and ball along its spin axis and coupling the two for movement in unison except about the said spin axis.

2. In a ball type gyro-compass, a ball, a cup for universally supporting said ball on an air bearing, and a second cup on which said first cup is mounted on an air bearing, said first cup having a concavo-convex lower surface and said second cup having a complementary concavo-convex upper surface on which said first cup rests, said surfaces being normally separated by an air film and limiting the freedom of the first cup to freedom about the vertical axis only.

3. In an air borne gyro-compass, an air bearing for supporting a part thereof for oscillation about a horizontal axis, including a complementary cup and button, one of which is stationary and the other oscillatable as a unit with said part, said stationary part having an air passage therethrough to supply air to said bear-

ing, a transverse passage connecting said first passage and leading to the atmosphere, and a pair of baffles on the other part adapted to differentially intercept the two outlets of said passage upon oscillation of said part as aforesaid to cause a torque about the vertical axis of the compass and thereby damp the same.

4. In an air borne gyro-compass having a ring tilting with the compass and a relatively vertical part on which said ring is pivoted, a horizontal air bearing between said ring and part including two portions, viz. a cup and a button, one of which is on said ring and the other on said part, there being laterally directed holes in the portion of the air bearing on said part permitting the escape of some air from said bearing, and a shield adapted to differentially cover said holes, said shield and holes being one in said cup and the other in said button, whereby a damping torque is developed upon inclination of the ring.

5. In a ball type gyroscope, a ball rotor, a cup supporting the same on an air bearing for freedom about three axes, means for leading an air supply within the ball along its spin axis, and circumferential air reaction jets in said ball fed from said supply for spinning the same.

6. In an air borne gyro-compass, a sensitive element, upper and lower air flotation buttons and cups providing freedom about the vertical axis only for said element, a gravitationally responsive element, and air flotation bearings for coupling said gravitational element to the sensitive element for tilt about the E-W axis only and for orientation therewith.

7. In a ball type gyroscope, a ball rotor, a cup supporting the same on an air bearing for freedom about three axes, means for supplying air flow between said cup and rotor, means for leading an air supply within the ball along its spin axis, and two sets of air reaction spinning jets fed from said supply and placed around parallels equally spaced from the equator of the ball beyond the cup.

8. In a ball type gyro-compass, a ball rotor mounted for freedom about three axes, a liquid level gravitational factor connected to said ball for movement therewith about all axes except the spin axis of said ball, and means for supporting the weight of said factor independently of the rotor.

9. In a ball type compass, a ball rotor mounted for freedom about three axes, a gravitational factor connected to said ball for movement therewith about all axes except the spin axis of said ball, air bearings between said factor and rotor along the spin axis thereof, means for leading compressed air within the ball through said bearings, and circumferential air reaction jets in said ball for spinning the same.

10. In a ball type compass, a ball rotor mounted for freedom about three axes, said ball having an axial bore, interconnected liquid containers within said bore spaced along the spin axis thereof, an outer frame turnable about the vertical axis of the ball, a ring pivoted thereon on a horizontal axis normal to the spin axis of the ball, and bearing members between said ring and ball engaging said ball along its spin axis, said containers being connected to the portions of said bearing members fixed in said ring, whereby said containers are connected with said ball for movement about all axes except the spin axis of the ball.

11. In a ball type compass, a ball rotor mounted for freedom about three axes, said ball having an axial bore, and a gravitational factor connected to said ball for movement therewith about all axes except the spin axis of the ball, comprising a tube within said bore having axial spaced compartments, an outer tiltable frame supporting said tube at its ends, and rotor bearings between said frame and ball adjacent the ends of said axial bore and supporting said tube within said bore without spinning with the ball.

LESLIE F. CARTER.