Oct. 12, 1937. L. F. CARTER ET AL 2,095,313
AIR BORNE GYROCOMPASS
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Fig. 1.

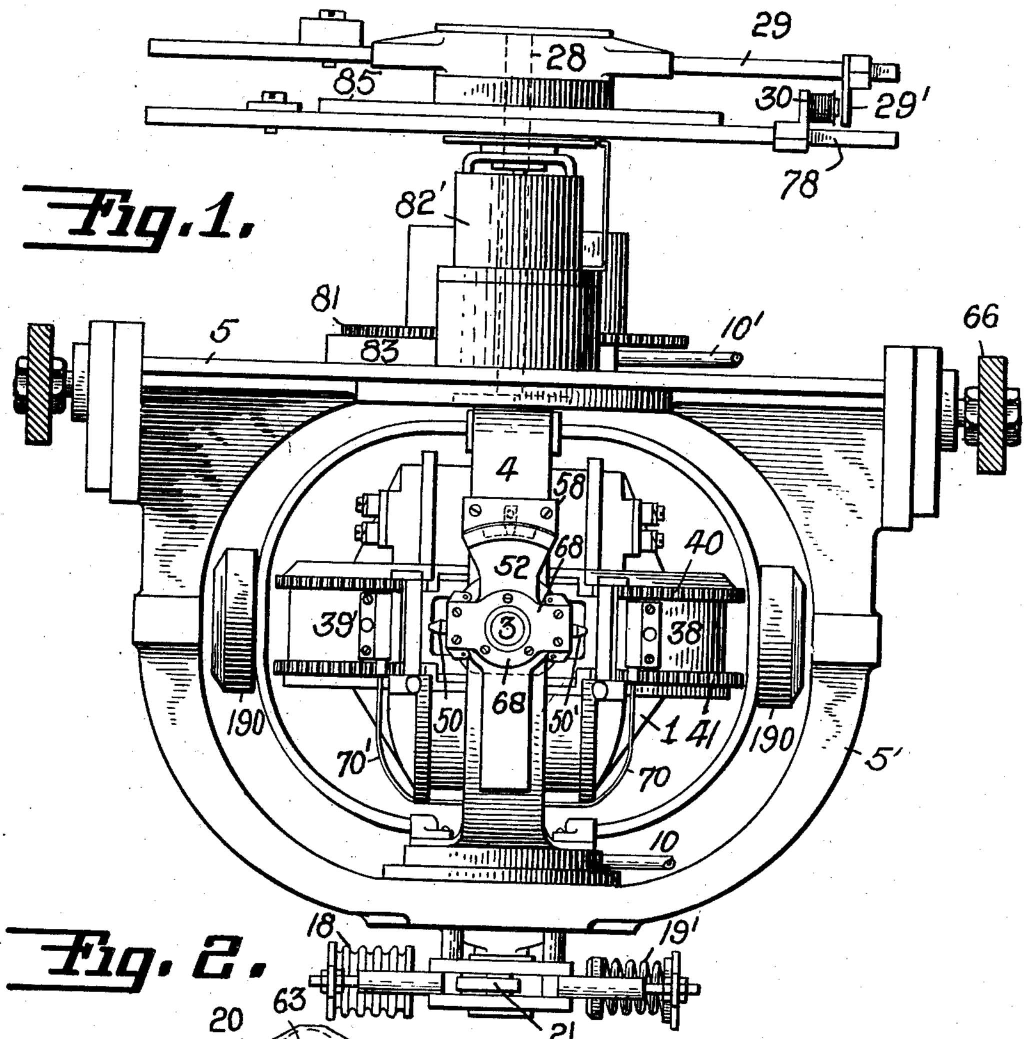


Fig. 2.

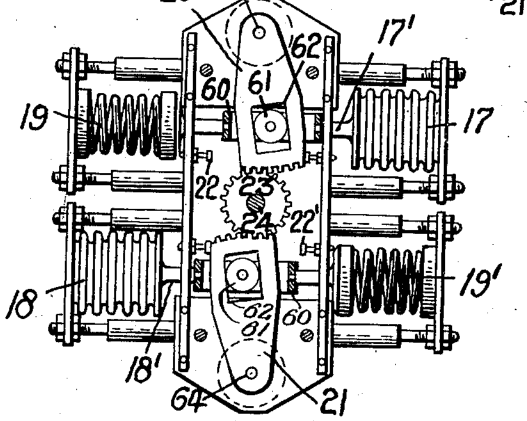


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Fig. 3.

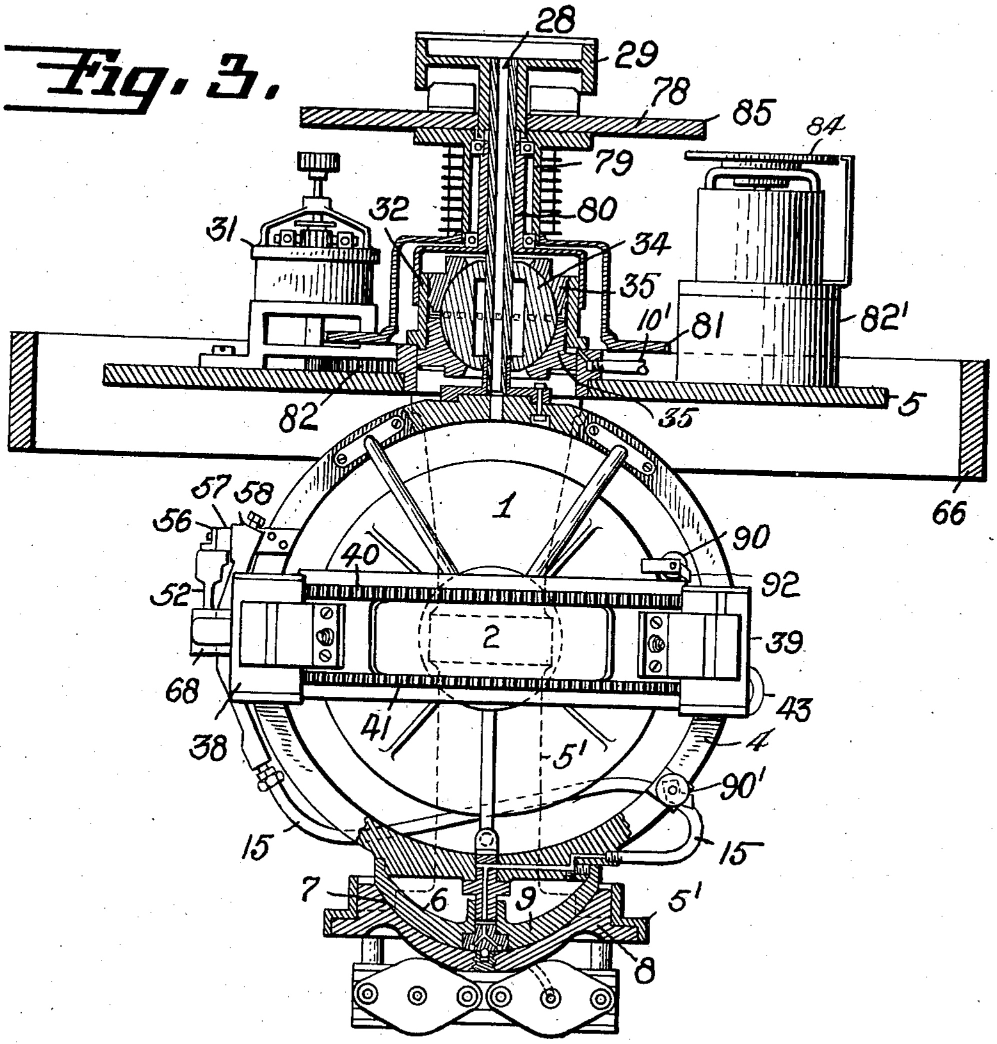


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Fig. 4.

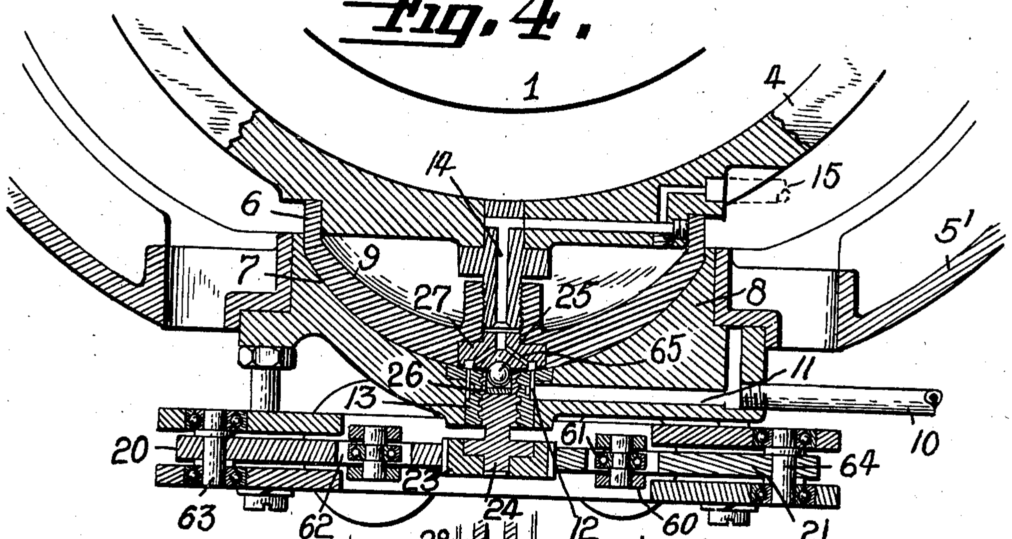


Fig. 5.

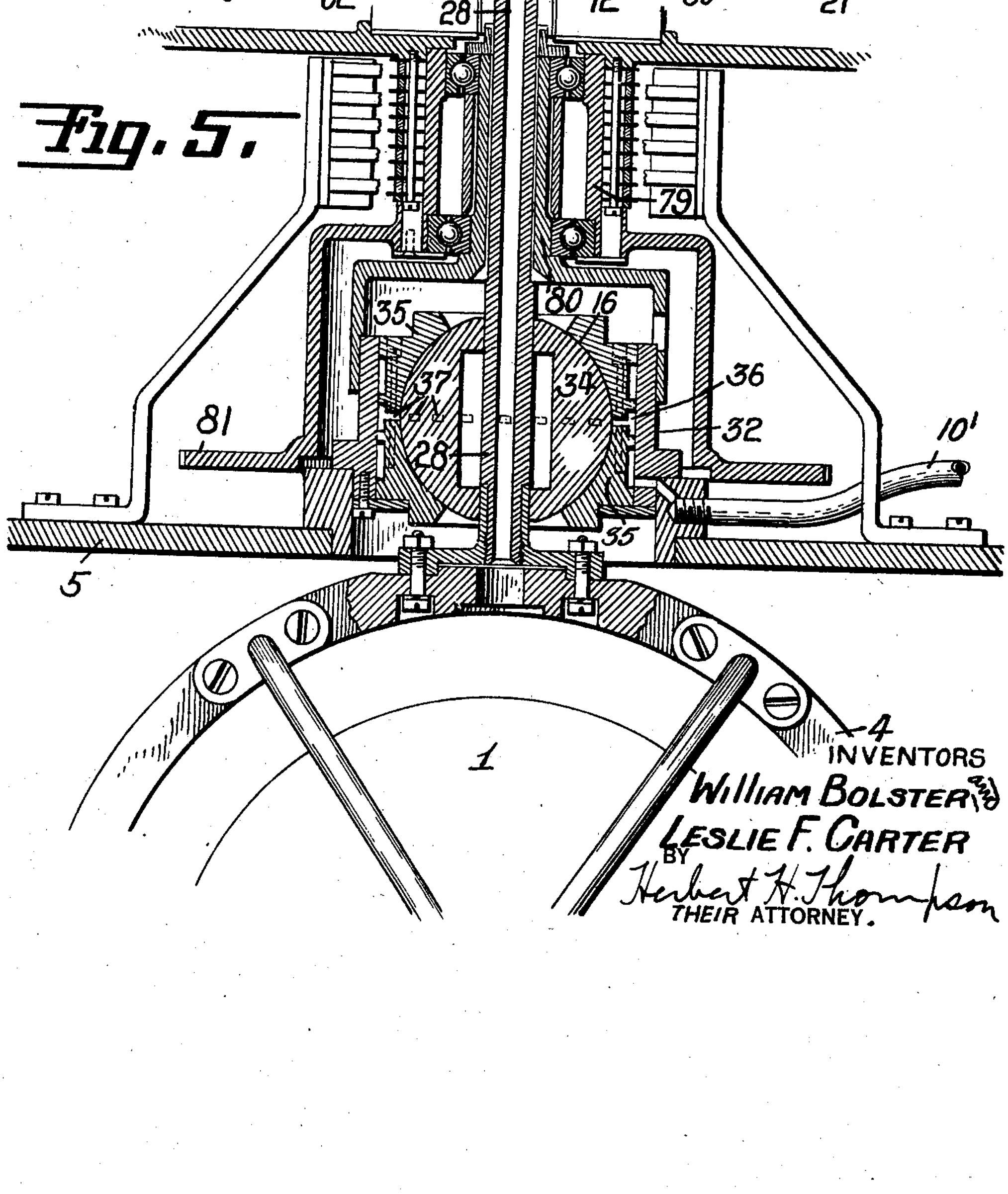


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Fig. 6.

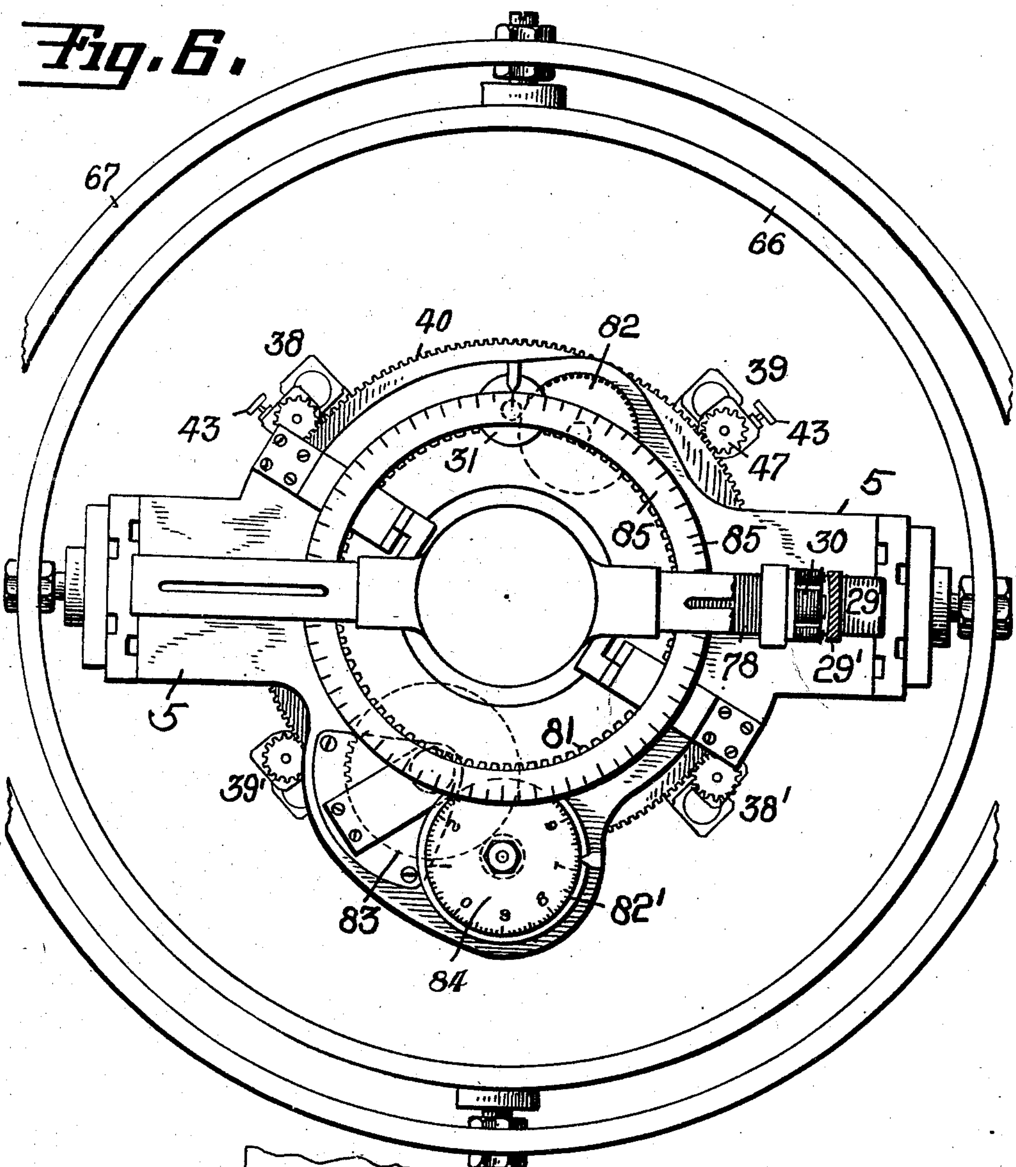


Fig. 7.

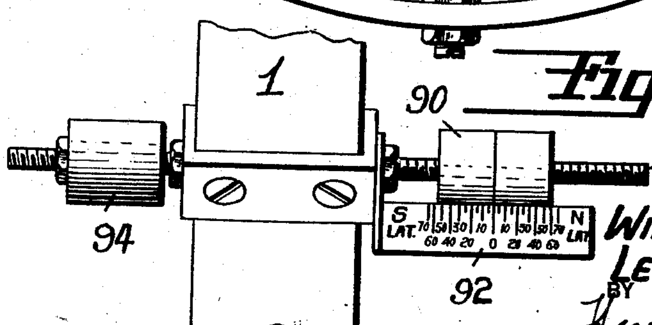


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Fig. 8.

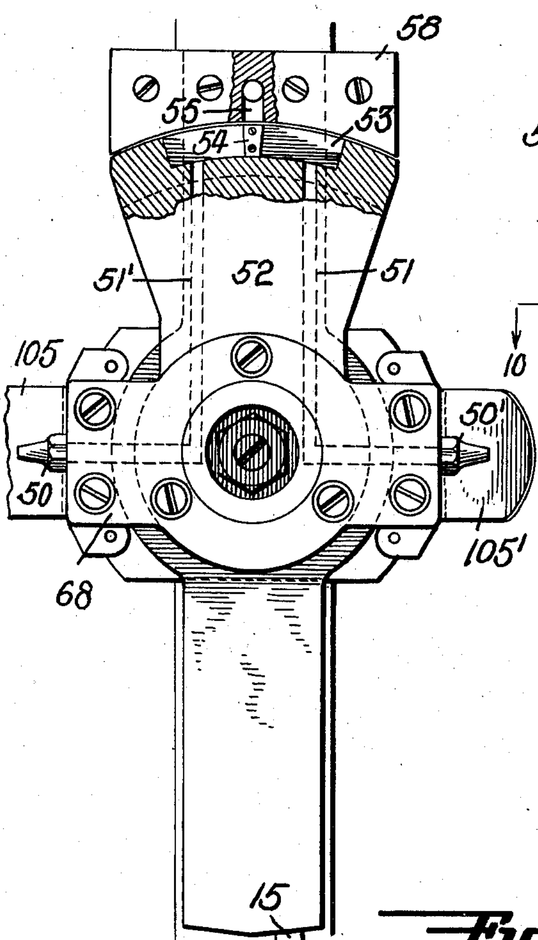


Fig. 9

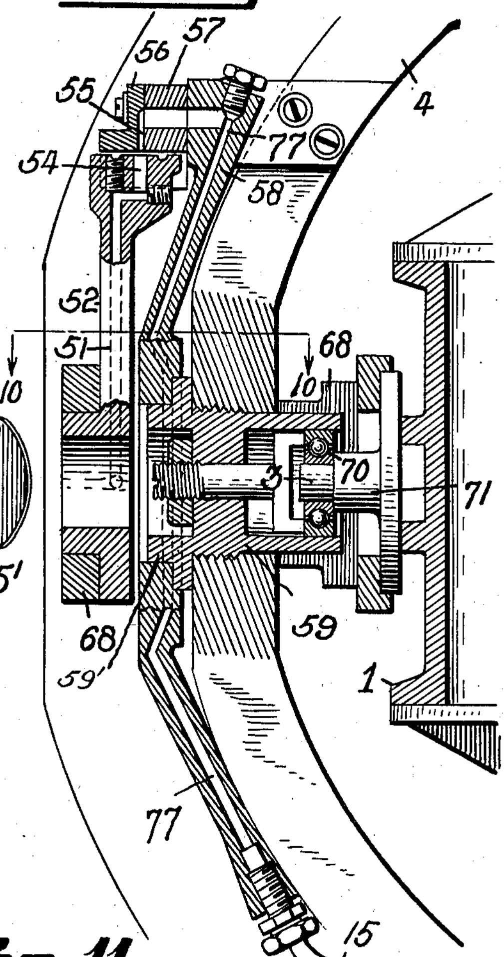


Fig. 10.

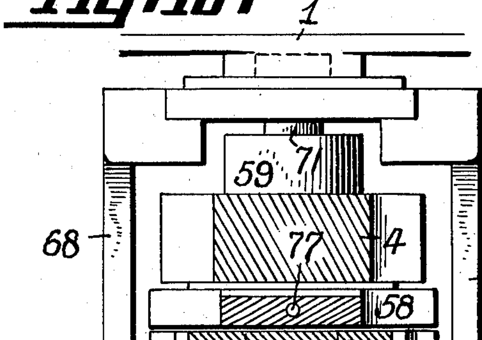


Fig. 11.

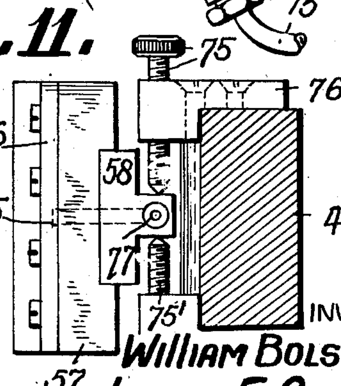


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Fig. 12.

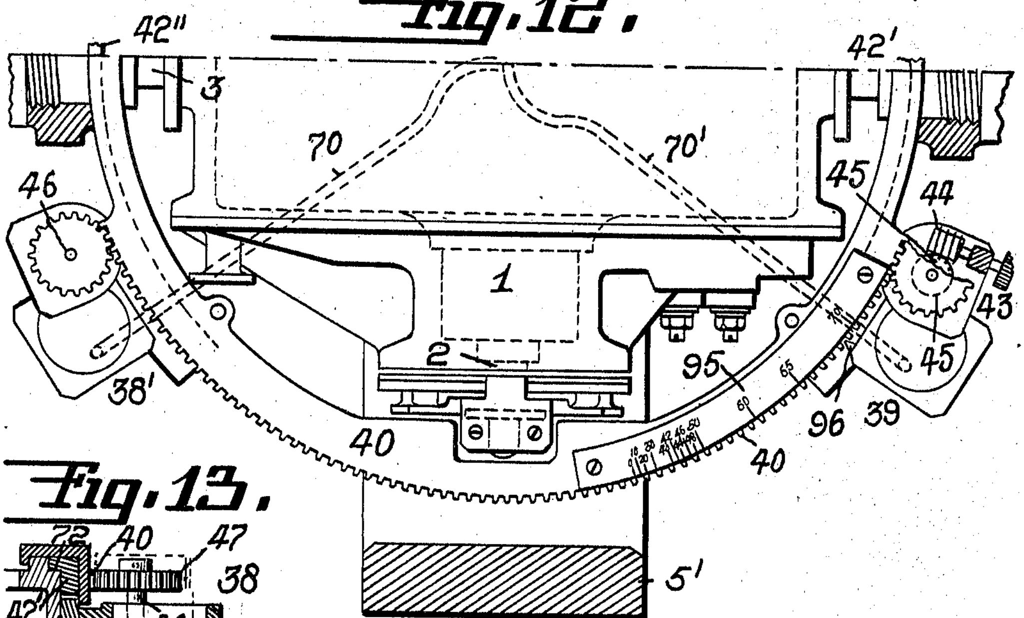
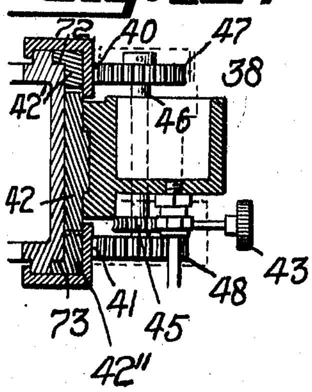



Fig. 13.

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Patented Oct. 12, 1937 2,095,313

# UNITED STATES PATENT OFFICE

2,095,313

## AIR BORNE GYROCOMPASS

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Application October 3, 1935, Serial No. 43,316

8 Claims. (Cl. 33—226)

This invention relates to gyroscopic compasses of the air borne or air supported type. In the present form of gyroscopic compass most widely in use, the sensitive element is supported within a follow-up element or support, being suspended therefrom by a bundle of fine wires to provide a more or less torsionless suspension. In such a system any failure of the power drive to the follow-up element will soon result in upsetting the compass on account of the fact that the dead follow-up element may turn with the ship away from the sensitive element, causing striking of the parts or torsion in the suspension. One of the purposes of the present invention is to eliminate such wire suspension by using a form of air bearing support about the vertical axis which is substantially frictionless, so that a follow-up support becomes unnecessary. While we are aware that it has been proposed to float small gyroscopic instruments on air film bearings, the provision of such bearings for a standard gyroscopic compass, the weight of which is on the order of 200 pounds, presents serious difficulties and, so far as we are aware, has not been successfully accomplished in practice prior to this invention.

By our invention we have also improved the methods of mounting the ballistic on the compass for latitude adjustments.

Further features of the invention will be apparent from the following description and claims.

Referring to the drawings, showing one form our invention may assume,

Fig. 1 is an east-west elevation of our compass.

Fig. 2 is a detail, in plan, of the auxiliary means used to prevent damage to the main air bearing in case the air supply fails.

Fig. 3 is a north-south elevation of the compass, partly in section.

Fig. 4 is an enlarged vertical section of the lower or main air bearing for the compass.

Fig. 5 is an enlarged vertical section of the upper guide bearing of the compass.

Fig. 6 is a plan view thereof.

Fig. 7 is a detail of the latitude adjusting weights.

Fig. 8 is a side elevation, partly in section, of the damping means employed in the compass.

Fig. 9 is a vertical section of the same, taken at right angles to Fig. 8, showing adjacent parts of the gyroscopic structure.

Fig. 10 is a transverse section taken on line 10—10 of Fig. 9.

Fig. 11 is a detail, in plan, showing the adjustable mounting of the air nozzle of the damper.

Fig. 12 is a plan view, partly in section, of the gyroscope, showing the mercury box adjustments.

Fig. 13 is a sectional detail of one of the mercury boxes.

The compass shown in the drawings is of the single gyroscope type, the gyro casing being shown at 1, in which the rotor is mounted for spinning about a normally horizontal north-south axis 2. The casing itself is supported for oscillation in neutral equilibrium about a horizontal axis 3 in a vertical ring 4. Said ring, in turn, is supported in the main supporting frame 5 for freedom about the vertical axis. Frame 5, in turn, has the usual universal mounting means of a gimbal ring 66 within a binnacle ring 67. It is the bearings between said vertical ring 4 and support 5 to which this invention largely relates. The main weight of the gyroscope 1 and ring 4, together with its attached compensating weights 190, usually referred to together as the sensitive element, is borne on a lower thrust bearing 6 the ring 5' forming a part of said frame. Said bearing is shown as in the shape of a cup 7 formed in a block 8 secured in the ring 5' depending from frame 5, and a complementary spherical button or dome 9 secured to the bottom of the vertical ring. A flow of air under pressure is provided between the surface of said button and cup from an air pump (not shown) through a pipe 10, the air passing through a channel 11 in said block and into an annular channel 12 in a sleeve 13 secured in said block (Fig. 4). The air passes upwardly through said channel and escapes outwardly between the block and button, thus furnishing an air film which supports the entire weight of the sensitive element on a frictionless air bearing. A certain amount of the air also passes upwardly through diagonal channels 65 in a central block 27 and on up through a central passage 14 in the vertical ring and thence outwardly either through the vertical ring or through a pipe 15 connected thereto, to carry an air supply to the damping means hereinafter described.

In order to prevent damage to the main bearing in case of failure of the air supply, we prefer to provide an independent means for supporting the vertical ring which is brought into action upon failure of the air supply. To this end, we have shown a pair of air pressure responsive members or sylphons 17 and 18 mounted underneath the follow-up ring. Each sylphon is connected to a piston rod 17', 18', against the other end of which rests a compression spring 19, 19', the air pressure normally holding the springs compressed. Each piston rod is made in two parts connected by a rectangular ring 60 having a roller 61 pivoted therein. Said rollers engage in a slot 62 in the gear sectors 20 and 21, pivoted at 63 and 64, respectively. When the air pressure is on, said sectors are rotated against the opposite stop pins 22, 22′ from the position shown in the drawings. In case the air pressure fails, however, the springs rotate said gear sectors to the position shown in the drawings, thus rotating an intermeshing pinion 23 clockwise. Said pinion has secured thereto at its center a vertical threaded shaft 24 threaded in the aforesaid sleeve 13. In a depression 26 at the top of said shaft is placed a steel ball 25 normally out of contact with a slight concavity in the bottom of a hardened metal block 27. As long as the air pressure is maintained, the steel ball is held away from said block so as not to interfere with the air bearing support. In case of failure of the air supply, the gear sectors are rotated as described, thus rotating the shaft 24 and lifting the ball to take the weight of the sensitive element off the air bearing. The bearing provided for the steel ball is also of low friction coefficient so that the compass will continue to operate even though the air supply fail for a time.

We prefer to use the upper bearing as a guide only and also to make it of the air borne type. As shown more particularly in Fig. 5, a vertical stem 28 is secured to the vertical ring 4, said stem passing upwardly through the guide bearing 16, and supports at the top thereof an arm 29 on which we mount one part 29′ of a controller for operating the follow-up motor 31, the complementary part 30 of said controller being on an arm 78 secured to a sleeve 79. Said controller may be of any suitable type, being shown as of the inductive type. Air is led from a pipe 10′ within a fixed sleeve 32 mounted on the top plate of the support 5. Said shaft 28 passes axially and freely through a hollow ball 34 which forms one part of the air borne vertical guide bearing. The other part is formed by a complementary hollow spherical shaped concavity within the bearing blocks 35 which are mounted within the sleeve 32, the air passing through annular channels 36 and through radial bores 37 in said blocks, where it emerges between the spherical surfaces to lubricate or float the vertical guide bearing, said bearing being of the universal type. Sleeve 79 is journalled on an inner sleeve 80 mounted on top of fixed part 32 on platform 5, shaft 28 passing through sleeve 80 without touching the same. To sleeve 79 is secured a gear 81 which is driven from motor 31 through reduction gears 82. Gear 81 also drives a transmitter 82′ at multiple speed through step-up gearing 83, a fine card 84 being placed on top of said transmitter. The main compass card is shown at 85 on top of sleeve 79, to which bar 78 is secured.

In this instance the gravitational control is in the form of a plurality of liquid containers 38, 38′ and 39, 39′ adjustably secured to the gyro casing and cross connected by restricted pipes 70 and 70′, that is, the N. E. container 38 is interconnected with the S. W. container 38′ and the N. W. container 39 with the S. E. container 39′. The position of these containers may be adjusted to vary the lever arm for different latitudes so as to maintain the period constant. For this purpose we have shown upper and lower annular racks 40 and 41 secured to the gyro casing, under or behind which shoulders or trackways 72 and 73 on said casing slidably support the liquid containers. Each container is secured to a plate 42 and the opposite plates of each pair are interconnected by semicircular channel bars 42′ and 42″, one sliding on upper shoulder 72 and the other on lower shoulder 73. Opposite containers therefore move together, so that if one container 38′ is adjusted to increase the lever arm towards the north, the diagonally opposite container 38 will be adjusted in the same angular direction to increase the lever arm towards the south. For this purpose adjusting knobs 43 are provided, the shaft of each of which is provided with a worm 44 meshing with a worm gear 45. On the shaft 46 of the latter are mounted a pair of gears 47, 48 meshing with the rack teeth 40 and 41, respectively. The boxes 38, 39, etc. are adjusted with reference to a latitude scale 95 on ring 40, a reference mark 96 being on the boxes for this purpose.

For damping purposes we have shown a pair of oppositely directed air nozzles 50 and 50′ (Fig. 8) adapted to exert a torque about the vertical axis of the gyro upon inclination thereof, in the proper direction to reduce the tilt. Air is shown as supplied to said nozzles through passageways 51 and 51′ through an arm 52 secured to a U-shaped bracket 68, which in turn is fastened to a trunnion on the gyro casing. Said passageways lead to a chamber 53 at the top of said arm, which is divided by a baffle or dividing plate 54. Air from a narrow slot or port 55 emerges against said baffle plate and when said plate is central with respect to said slot, as shown in Fig. 8, the air passes at equal velocities down through the channels 51 and 51′. In case, however, the gyroscope is inclined with respect to the vertical ring or other normally vertical base line, a greater amount of air will pass through one channel than the other, resulting in a torque about the vertical axis. This torque is always perpendicular to the rotor casing, since nozzles 50 and 50′ tilt with said casing. The slot 55 is shown as provided with a channel in a plate 56 secured in front of member 57, which in turn is secured to a tubular member 58 rotatably mounted at its center on the vertical ring 4. As shown, a central enlargement of member 58 surrounds and is journalled on the outer end 59′ of a hollow stud 59 which supports the bearing 70 for one of the horizontal trunnions 71 of the gyro casing. Lateral adjustment of the port 55 is effected by adjusting opposite set screws 75, 75′ in brackets 76 on ring 4, the inner ends of said screws clamping between them the top part of member 58. Baffle plates 105 and 105′ may be provided to keep the air ejected from the nozzles 50 and 50′ from striking adjacent parts of the gyroscope and disturbing the same.

In order to maintain the compass level in all latitudes, we have shown a mass 90 threaded on a rod 91 secured to rotor casing 1 and extending in a north-south direction, a latitude scale 92 being provided, by which the mass is set. Mass 94 is for counterbalancing purposes. Balance about the vertical axis is maintained by a second adjustable like mass 90′ on the vertical ring 4, which is adjusted exactly like mass 90.

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 our invention, what we claim and desire to secure by Letters Patent is:

1. In a gyroscopic compass, an outer frame, a vertical ring within which the gyroscope is mounted, a vertical thrust bearing for supporting the weight of said ring and its supported parts at the bottom within said frame, characterized by a curved cup in said support and a complementary button on said gyroscope of substantially the same curvature as said cup, and means for forcing a continuous air film between said button and cup, and an air borne guide bearing at the top of said ring and between the same and said frame.

2. A vertical bearing means for supporting a gyroscopic compass for freedom about a vertical axis, comprising a single air borne universal thrust bearing for supporting the entire weight of the compass, and a single air borne spherical guide bearing at the end of the gyroscope opposite from said thrust bearing.

3. A vertical bearing means for supporting a gyroscope compass for freedom about a vertical axis, comprising a single air borne universal thrust bearing for supporting the entire weight of the compass, means for supplying air under pressure to said bearing, an auxiliary normally inoperative thrust bearing, and means brought into action by failure of the air pressure of said supplying means for bringing said last named bearing into action to take the load off the air bearing.

4. A vertical bearing means for supporting a gyroscopic compass for freedom about a vertical axis, comprising a single air borne universal thrust bearing for supporting the entire weight of the compass, a single air borne spherical guide bearing at the end of the gyroscope opposite from said thrust bearing, said guide bearing permitting limited lifting of the compass, an auxiliary thrust bearing having a ball normally out of contact with the compass, and means for lifting said ball for supporting the weight of the compass thereon in case the air supply at said thrust bearing fails.

5. In a gyroscopic compass, a pair of gravitational responsive members on opposite sides of said compass for imparting meridian seeking properties, a generally circular trackway carried by the compass and extending substantially around the same, means for slidably mounting said members in said trackway, and means for adjusting said members around said trackway in accordance with the latitude to keep the period constant.

6. A gyroscopic compass as claimed in claim 5, in which said mounting means includes an annular slide mounted in said trackway on which both of said gravitationally responsive means are mounted to move together equally in the same angular direction but in opposite axial component directions on opposite sides of and with respect to the spin axis of the compass.

7. In a gyroscopic compass, a rotor and a rotor bearing casing, a circular trackway around said casing, a pair of annular slides slidably mounted in said trackway, two pairs of interconnecting liquid containers, one pair being mounted on each slide and located in the north-east and south-west quadrants and in the north-west and south-east quadrants, and means for adjusting each slide around said casing in accordance with the latitude.

8. In an air borne gyroscope, a vertical ring for supporting the gyroscope for oscillation about a horizontal axis, spherical air borne thrust and guide bearings for mounting said ring for free turning about a vertical axis, a source of supply of air under pressure for said bearings, an auxiliary, normally inoperative thrust bearing for said ring, and means for raising said bearing into operative position upon failure of said air supply, including a spring biased air pressure device and a screw member for raising and lowering said auxiliary bearing, said device rotating said screw to raise said bearing on failure of the air supply.

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