

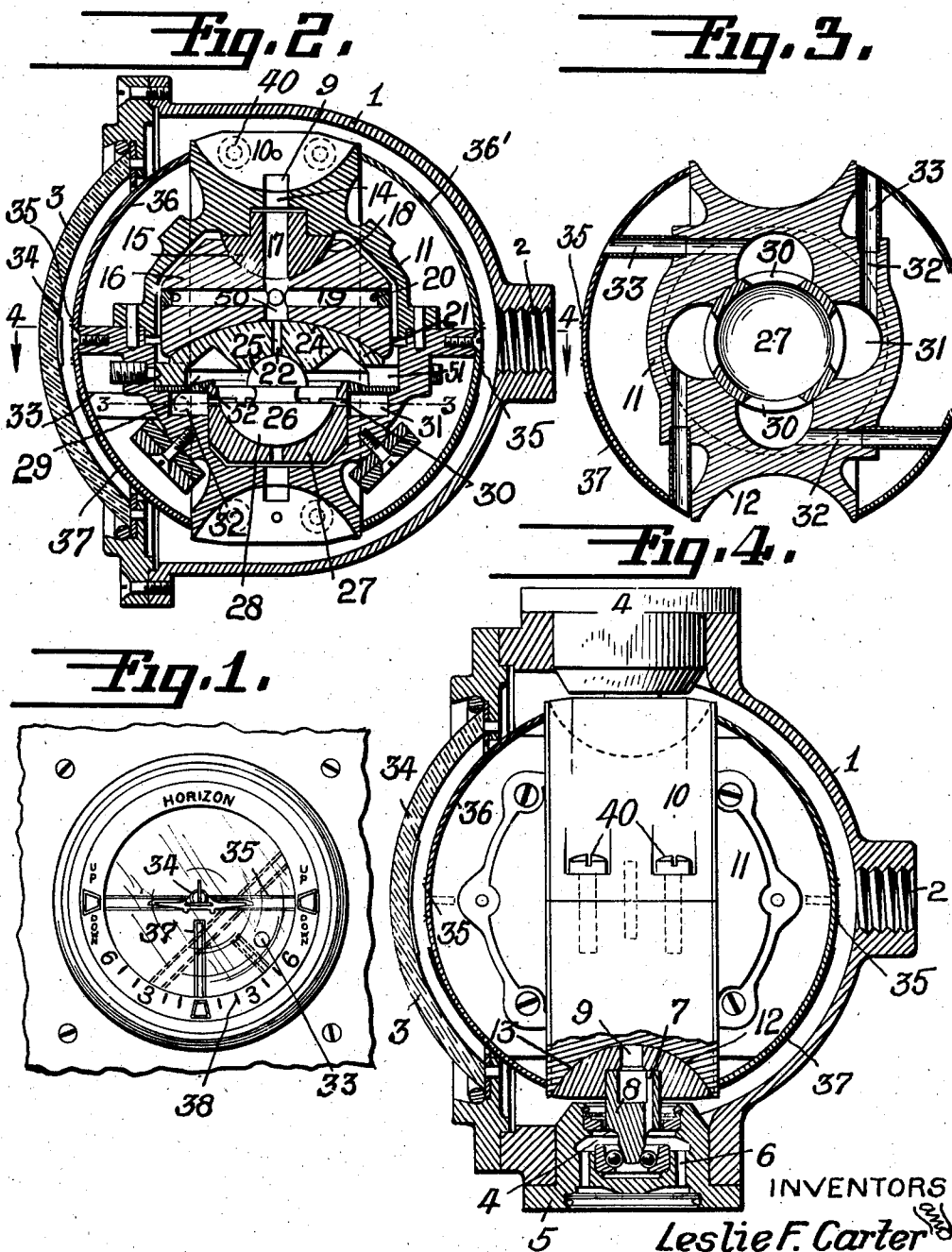
July 13, 1937.

L. F. CARTER ET AL

2,086,897

AIR BORNE ARTIFICIAL HORIZON

Original Filed May 14, 1935 2 Sheets-Sheet 1



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Fig. 5.

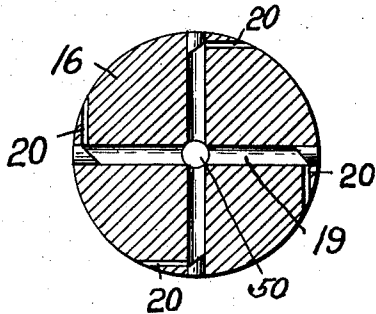


Fig. 6.

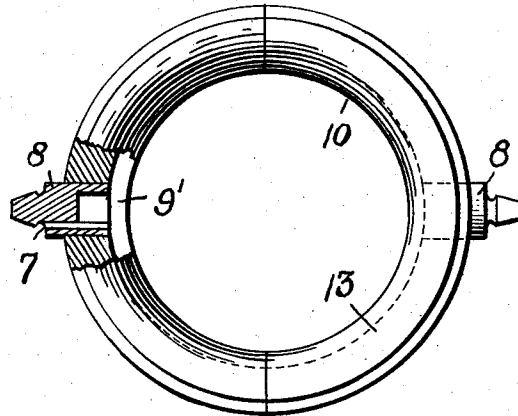
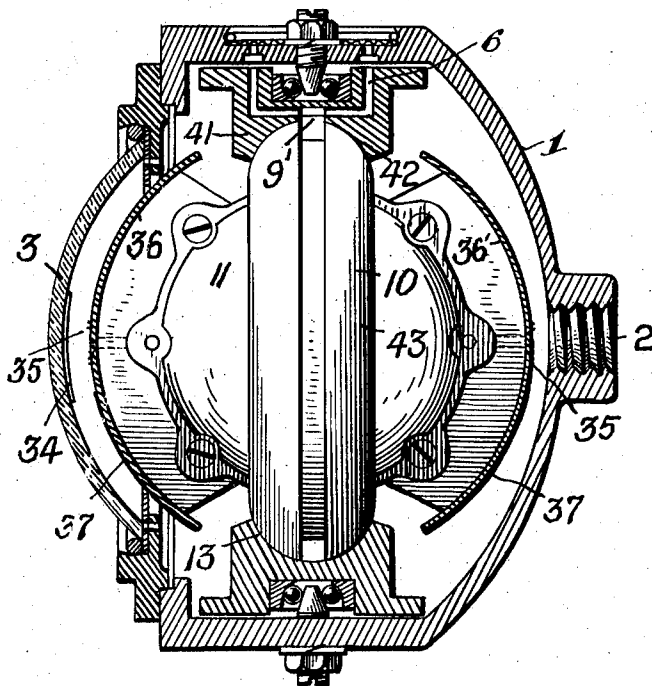


Fig. 7.



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AIR BORNE ARTIFICIAL HORIZON

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10 Claims. (Cl. 33—204)

This invention relates to air borne gyroscopic instruments, especially to gyroscopic artificial horizons or gyro verticals. In such instruments there are usually four or five sets of bearings, all of which are subject to friction and wear and consequently give rise to uncertain performance. One object of the present invention is to so design and construct a gyroscopic instrument of this type that the major portion, if not all, of said bearings are of the air borne or air floated type so that friction is reduced to a minimum, the weight reduced and the design simplified.

Another object of the invention is to design a gyroscopic artificial horizon for airplanes which can be used after complex airplane maneuvers or stunting, without resetting.

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

Fig. 1 is a face view of our artificial horizon as it appears from the front of the instrument panel on aircraft.

Fig. 2 is a vertical section of the device.

Fig. 3 is a transverse section of the inner portion of the device on line 3—3 in Fig. 2.

Fig. 4 is a transverse section on line 4—4 in Fig. 2, looking in the direction of the arrows.

Fig. 5 is a horizontal section of the gyro rotor, showing the spinning jets.

Fig. 6 is a detached front elevation of the vertical ring employed in the gyroscope.

Fig. 7 is a plan view, partly in section, of a modified form of gyroscope constructed according to our invention.

According to the present invention, the entire device may be enclosed within a hemispherical casing 1, from which air may be continuously exhausted through threaded opening 2 by a suitable pump or Venturi tube (not shown). Said casing is shown as provided at its front with a curved window 3 through which the movable indicating element on the instrument is visible. The gyroscopic element is shown as mounted for oscillation about a transverse horizontal axis 4—4 by suitable bearings, which may be of the air borne type, as are the other bearings of the gyroscope, but which are herein shown as of the ball bearing type. The housings 5 for the bearings, which are fixed in the casing 1, are shown as having apertures 6 therethrough so as to admit air at atmospheric pressure into the interior of the casing, the air passing through a channel 7 in the pivot stud 8 and thence into a circular channel 9 in a split ring 10 which surrounds the gyroscope and which normally lies in a vertical plane. Said ring has

a substantially semicircular cross section and surrounds the casing 11 of the gyro rotor, the two halves being clamped together by set screws 40. The exterior of said casing has a peripheral concavity surrounding the same, in which said ring loosely but closely fits so that when air is supplied between the exterior concave surface 12 of the casing and the interior convex surface 13 of the ring, a circumferential air bearing is formed around the gyroscope, the central plane of which lies preferably in the plane of the spin axis of the rotor 16 and which gives the gyroscope freedom about a horizontal axis at right angles to the axis 4—4 and to the spin axis. Air is supplied between said surfaces from channel 9 in the ring 10, and part of said air passes through apertures 14 in said casing and through bores 17 in interior button 15 secured therein to supply an air film to the rotor bearings providing the normally vertical spin axis. The bearings are shown as provided by said buttons 15 and co-operating concavities 18 in the gyro rotor 16, between which an air flow is maintained. The air is shown as passing down through aperture 17 in the upper button 15, part of it escaping between said button and the upper concavity 18 in the gyro rotor. Another portion of said air passes into the center of the rotor through center bore 50 and radially outwardly through bores 19, whence it is directed tangentially in the form of jets 20 to spin the rotor. Another portion of said air passes through the rotor and emerges between the lower button 21, which, it should be noted, is of larger area than the upper button 15, and the concave lower surface 24 of the rotor. The air from the rotor and bearing passes downwardly and through passages 51 into a chamber 29.

The gyroscopic system is preferably supported in neutral equilibrium within the casing and the erection obtained by means of an auxiliary pendulum controlling differential air torques about a horizontal axis at right angles to the angle of inclination. Preferably said auxiliary pendulum is also air supported, as by causing another portion of the air to pass down through the center bore 22 in said concave lower bearing and thence outwardly between a concavity formed in the casing and the button 25 formed on said small pendulum 26 which acts to control the erecting force on the gyroscope. Air also comes up from below through a concave bearing block 27, passing between said block and the lower button 28 forming a part of the pendulum 26, by means of which the pendulum is floated. While buttons 24 55

and 28 have different radii of curvature, they preferably have the same center of curvature, so that the member 26 is universally mounted or floated on air. The air entering the inner chamber 29 from both said bearings and the rotor, as described above, passes outwardly through narrow slots 30 in the member 27 and thence outwardly into chambers 31, separated from chamber 29 by ring 52, whence the air is directed at right angles to the inclination and outside of the gyro casing through channels 32 and short pipe 33 so as not to disturb the gyroscope. When the gyro casing becomes inclined with respect to the small pendulum 26, the balance of the air flow through the passages 27 and 33 is disturbed and a torque exerted at right angles to the inclination by the fact that the tubes 33 extend at right angles to the inclination of the pendulum. This operates directly to restore the gyroscope to the vertical.

To indicate the horizon, a miniature airplane 34 may be affixed to the front face 3 and a horizon bar or other index member 35 may be painted on or secured to spherical shells 36, 36' secured to the gyro casing. Preferably such a bar is painted on both the front and back shells 36 and 36' so that the instrument will be read correctly no matter which face is toward the window and regardless of somersaulting. Said shells may also have a normally vertical index 37 readable on fixed annular graduations 38 to show the angle of bank. The dotted line position shows how the horizon bar 35' would appear on a steep bank and slight downward pitch, while the vertical index would appear as shown at 37' (Fig. 1).

We are aware that gyroscopic artificial horizons have been proposed which may be read from either side, such as shown in the patent to Carlson and Narvesen, No. 1,939,825, dated December 19, 1933. In such a device, however, it is difficult to provide a horizon member on account of the fact that the gimbal ring lies between the gyro casing and the front window. It is therefore necessary to make a complicated forward pivot and carry the trunnion of the casing through the gimbal ring. According to our present invention, however, the vertical ring 10 replaces the ordinary gimbal of the prior art and, since the said ring 10 is circumferential and lies in a vertical plane, it does not interfere with the full view of the movements of the gyro casing as indicated by the bars 35 secured to the masks 36, 36' on both sides of the gyroscope. Our invention is especially adapted, therefore, to this type of horizon, designed for permitting somersaulting and looping the loop, since there are no parts to strike under these conditions. Preferably, as shown in the drawings, all three perpendicular axes of freedom of the gyroscope (i. e., the normally vertical spin axis of the rotor, the normally horizontal axis about which ring 10 turns and the second horizontal axis 8-8) intersect at the center of the rotor, so that one indicator 35 may be used to show the true angles of both pitch and roll.

It is obvious that the convex and concave parts may be interchanged at will. Fig. 7 illustrates a modification in which the vertical ring 41 is concave in cross section on its inner surface 42 and the gyro casing is provided with an annular ridge 43 convex in cross section having an annular channel 9' for the air.

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 obtain by Letters Patent is:

1. In an air borne gyroscope, a rotor, a casing in which said rotor is journaled for spinning about an axis, a ring within which said casing is mounted for oscillation, said ring and casing having complementary interfitting curved surfaces extending circumferentially of said ring and the central plane of said ring lying in the same plane as said rotor spin axis, and means for supplying an air flow between said surfaces to float said casing within said ring for oscillation about an axis at right angles to said central plane and to the rotor spin axis.

2. In an air borne gyroscope, a rotor, a casing in which said rotor is journaled for spinning about an axis, a ring within which said casing is mounted for oscillation about an axis at right angles to the rotor spin axis, said ring and casing having complementary interfitting curved surfaces extending circumferentially of said ring, and means for supplying an air flow between said surfaces to float said casing within said ring.

3. In an air borne artificial horizon, a rotor, a casing therefor, spaced spherical air bearings between said rotor and casing mounting said rotor for spinning about a normally vertical axis, a pendulous member floated between air bearings in said casing, there being ports leading without said casing adapted to be differentially covered by said member on relative tilting of said member and said casing and to exert torques on said casing about axes at right angles to the axes about which the tilt occurs, and means for supplying air flow between said bearings and through said ports.

4. In a gyroscope, a universally mounted casing, means for causing continuous air flow from within to without said casing, a plurality of ports in said casing lying in the same horizontal plane, a pendulous member having an edge lying adjacent said ports to vary the relative opening thereof upon relative tilting of said casing and member, said member having upper and lower buttons thereon of different radii but a common center of curvature, cooperating concavities formed within said casing, the aforesaid air flow passing in part between said buttons and concavities.

5. An air driven air supported artificial horizon for aircraft, comprising a normally horizontal rotor, a rotor bearing casing, upper and lower spherical air bearings for the rotor in said casing, an outer ring, said ring and casing having interfitting curved surfaces circumferentially of the ring to form a single circumferential air bearing, and air erecting means on said casing.

6. In a gyroscope, a rotor member, a rotor bearing frame member, a pair of spaced bearings between said members comprising a pair of spherical projections on one of said members, there being complementary cup shaped sockets in the other of said two members, and registering apertures through said cups and projections for leading air under pressure between the bearing surfaces so formed, the rotor having an axial aperture and a plurality of tangential apertures, said axial aperture connecting at least one pair of said registering apertures with said tangential apertures for spinning the rotor by reaction, a pendulous member having upper and lower but-

tons thereon, there being cooperating concavities in said casing for universally mounting said pendulous member, a portion of the air passing through said rotor also flowing between at least one of said buttons and its supporting concavity.

7. A gyroscopic artificial horizon for aircraft comprising a rotor, a rotor bearing casing in which said rotor is mounted for spinning about a normally vertical axis, a normally vertical ring surrounding said casing and slidably supporting the same for turning about the normally horizontal axis of the ring, an outer casing in which said ring is mounted for oscillation about a horizontal axis perpendicular to the axis of said ring, all three of said axes intersecting at a common point at the center of the rotor, and said rotor bearing casing having single means thereon for indicating both pitch and bank of the aircraft, visible from the front of said casing.

8. A gyroscopic artificial horizon for aircraft comprising a rotor, a rotor bearing casing, a normally vertical ring surrounding said casing and having an inner periphery of curved cross section, said casing having its exterior of a complementary curved section and slidably fitting the inner periphery of said ring, means for supplying air flow between said ring and casing thereby slidably supporting the casing for turning about the normally horizontal axis normal to the plane of the ring, an outer casing in which said ring is mounted for oscillation about a horizontal axis perpendicular to the said first mentioned axis of said ring, said rotor bearing cas-

ing having single means thereon for indicating both pitch and bank of the aircraft, visible from the front of said casing.

9. In an artificial horizon, a universally mounted casing, means for causing continuous air flow between the interior and the exterior of said casing, means for spinning the horizon rotor by said air flow, a plurality of ports in said casing lying in the same horizontal plane, a pendulous member having an edge lying adjacent said ports to vary the relative opening thereof upon relative tilting of said casing and member, said member having upper and lower buttons thereon of different radius but a common center of curvature, cooperating concavities formed within said casing, the aforesaid air flow passing in part between said buttons and concavities to float said pendulous member on air bearings.

10. In an air borne gyroscope having three degrees of freedom, a universally mounted rotor bearing casing, a pendulous erecting or damping device therein comprising a pendulous member having upper and lower spherical surfaces, there being cooperating upper and lower cups in said casing, means for supplying air films to float said member between said cups, there being ports in said casing from which said air escapes, said pendulum differentially uncovering said ports upon relative inclination of said casing and pendulum.

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