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GYRO CONTROL APPARATUS

Filed March 3, 1941

Serial No.
381,604
3 Sheets-Sheet 1

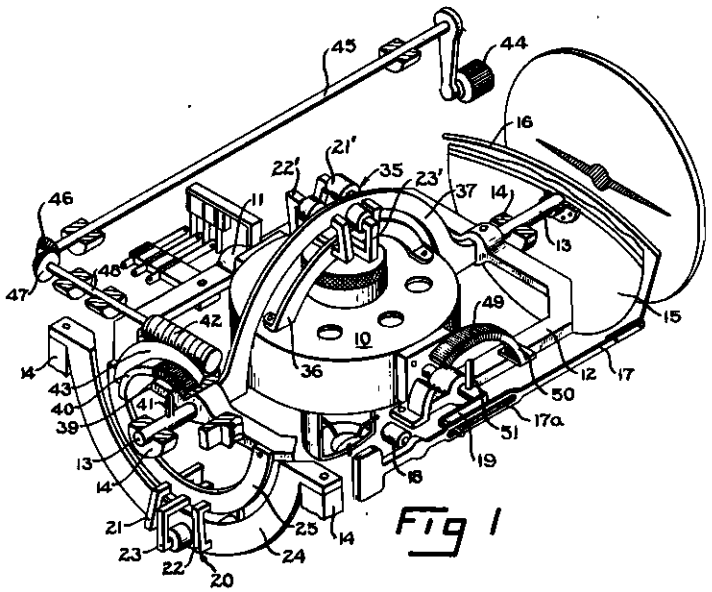

Fig 1

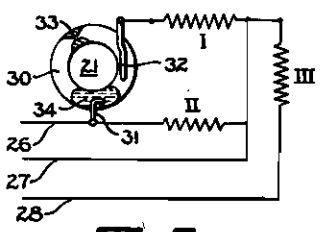

Fig 2

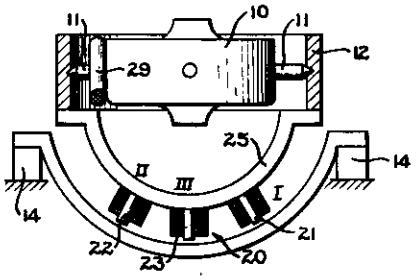

Fig 3

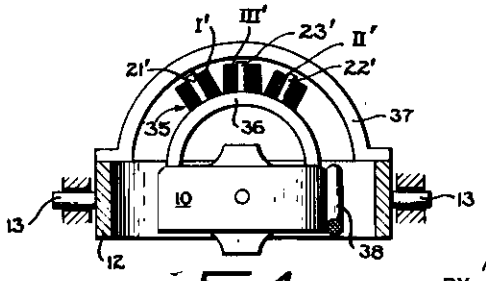

Fig 4

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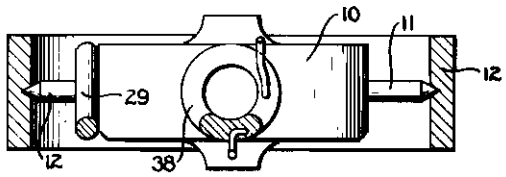

Fig 5

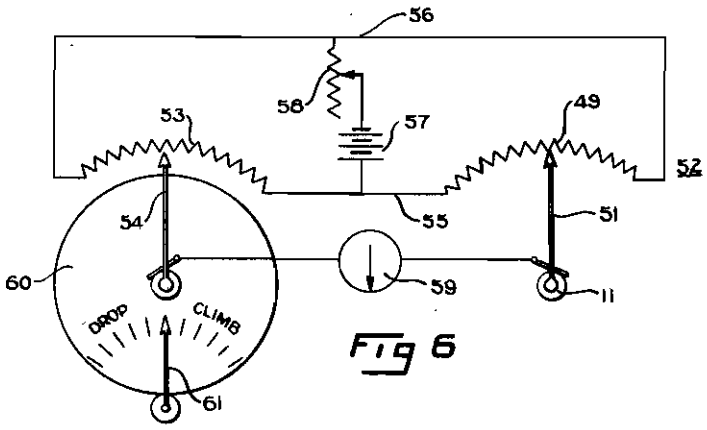

Fig 6

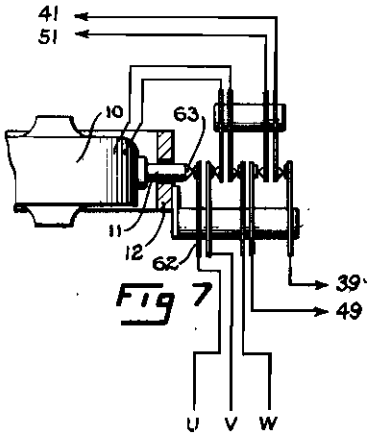

Fig 7

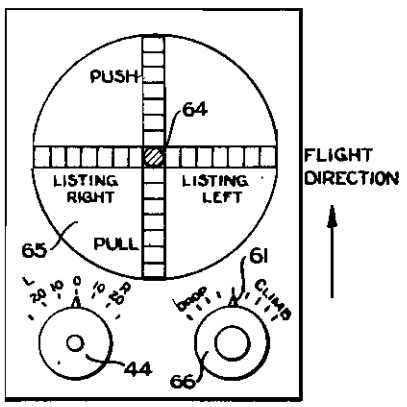

Fig 8

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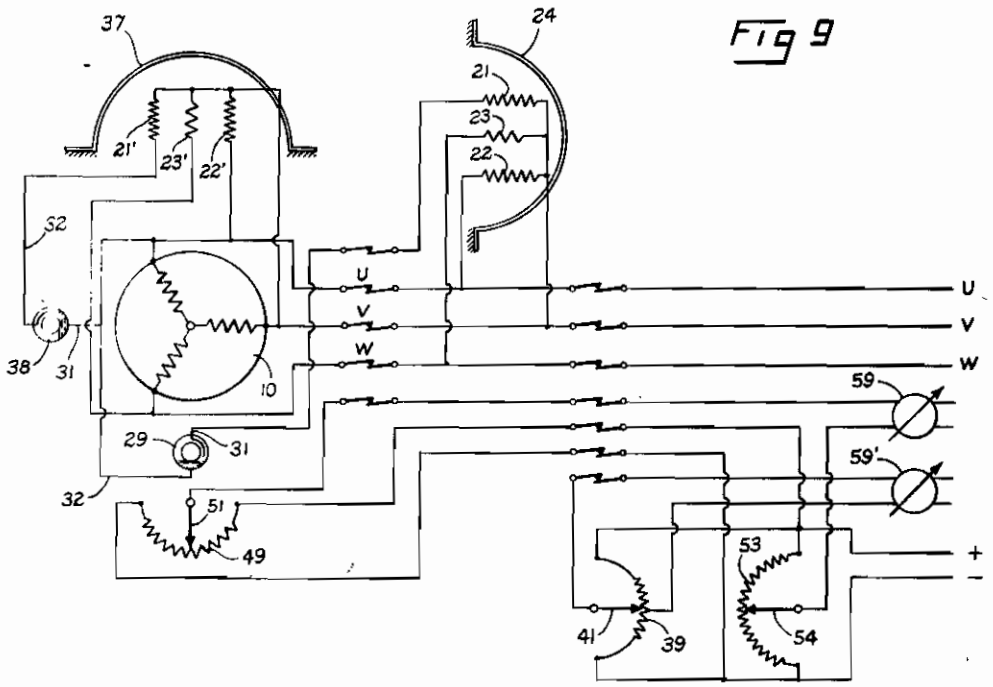
Fig 9



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ALIEN PROPERTY CUSTODIAN

GYRO CONTROL APPARATUS

Friedrich Lauck, Lübeck-Travemünde, Germany;
vested in the Alien Property Custodian

Application filed March 3, 1941

This invention relates to gyro control apparatus, and more particularly to means for stabilizing a rotor of a gyroscopic horizon.

In gyroscopic horizons heretofore proposed for use in vehicles such as aircraft, means have been employed for maintaining the axis of rotation of the gyro rotor in the true vertical comprising, for example, pendulums which upon a deviation of said axis of rotation from the vertical actuate torque producing means which exert turning moments upon said rotor causing it to precess back into the desired position. The pendulums, of course, are mounted upon a suspension for the rotor in such a manner that they respond to movements of the rotor from the predetermined position. The pendulums in prior devices have governed, for example, air currents, the recoil of which is adapted for exerting a turning moment about one or the other of the axes of the rotor suspension about which precession occurs, such axes being known as "precession axes". A turning moment acting about one of said axes produces a precessing moment about the other of these axes. In prior apparatus of this character there have also been employed pendulums which control magnetic fields produced, for example, by direct current, which exert moments upon the gyro rotor suspension for causing precession into a desired position. In most of these devices it has been necessary to have a separate source of energy for driving the gyro rotor and for exerting said moments, thereby complicating the apparatus by necessitating at least two different systems for conducting energy. Also, magnetic fields created in the above devices have proved disturbing to magnetic instruments adjacent thereto, for example, on the dash board of an aircraft.

One of the objects of the present invention is to provide novel means for maintaining a gyro rotor in a predetermined position, which means have no disturbing effect upon adjacent magnetic instruments.

Another object of the invention is to provide a novel gyro stabilizing apparatus which is extremely simple.

A further object is to provide a novel device for controlling the position of a gyro rotor, which is light in weight, and compact; therefore especially adapted for use aboard vehicles such as aircraft.

An additional object is to provide novel means for stabilizing an artificial horizon, which means are extremely sensitive.

Another object is to provide a novel stabilized navigational apparatus which is impervious to magnetic fields external to said apparatus.

A still further object is to provide novel means of the above character which employ a common source of energy for stabilizing a gyro rotor and for driving the rotor.

The above and further objects and novel features will more fully appear from the following detailed description when the latter is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for purposes of illustration only and are not intended as a definition of the limits of the invention, reference for this latter purpose being had to the appended claims.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is an isometric view with parts broken away of one embodiment of the present invention;

Fig. 2 is a diagrammatic illustration of a part of a stabilizing means which is employed in the present invention;

Fig. 3 is a diagrammatic illustration of means employed in Fig. 1 for controlling a position of the gyro rotor about one of the axes of a suspension therefor;

Fig. 4 is a diagrammatic view of means employed in Fig. 1 for controlling the position of the gyro about another of the axes of a suspension therefor;

Fig. 5 is a sectional view with parts broken away of a portion of the embodiment of Fig. 1, showing a portion of the stabilizing means;

Fig. 6 is a wiring diagram of means employed in the present invention for indicating the position of the gyro rotor;

Fig. 7 is a detailed view partly in section and with parts broken away of current conducting means for the gyroscope; and

Fig. 8 is a diagrammatic illustration of a face plate to be employed with the present invention.

The form of the invention illustrated in the accompanying drawings, by way of example, comprises means for stabilizing the position of a gyro rotor in gimbal ring suspension, the gyro rotor being employed to establish an artificial horizon for vehicles such as aircraft. The gimbal ring suspension includes an inner and an outer gimbal ring, each having conventional trunnions. A stationary member is employed for supporting the trunnions of the outer ring. Stabilizing torques are exerted upon the rotor suspension by means of field coil members which create rotating electric fields. The latter cooperate electrically with suitable armature members in re-

sponse to movements of the rotor from a predetermined position. Means are mounted upon said outer ring for creating a rotating field which is adapted for electrically coacting with an armature mounted upon said stationary member in response to movement of the rotor about the axis of the inner gimbal ring trunnions. A pendulum responsive to movement of the rotor about said axis governs this field creating means. An armature is mounted upon the outer ring and is adapted for electrically coacting with a rotating field created by a field coil member mounted upon the inner ring in response to movement of the rotor about the axis of the outer gimbal ring trunnions. A pendulum which is responsive to movement of the rotor about the last-named axis governs said field coil member. Suitable means are provided for indicating the position of the rotor relative to the horizontal and for adjusting a zero or reference position thereof.

In the embodiment shown, the apparatus for establishing an artificial horizon is constituted by a rotor (not shown) in a suitable housing 10 which is employed as an inner gimbal ring having trunnions 11. The latter rest in a conventional manner upon a gimbal frame 12 having trunnions 13 which are supported by suitable bearings upon a stationary member 14. The axes of trunnions 11 and 13 comprise respectively the transverse and longitudinal axes of the apparatus.

Operatively connected to one of the outer trunnions 13 is an indicator element 15 which provides a reference horizontal line from which transverse inclinations can be measured. An arm 16 is provided adjacent member 15 for indicating fore-and-aft or longitudinal inclinations. The arm is operatively connected to the rotor and suspension by means of a lever 17 which is pivotally mounted upon ring 12 at 19 and provided with a slot 17a, the latter being engaged by a crank lever 19 attached to one of the inner gimbal trunnions 11.

Suitable means are provided for causing the rotor to precess about the axis of trunnions 11 in response to deviations of the rotor from a desired position comprising a field coil member 20 or rotating field generator having three coils, I, II, and III, preferably mounted upon cores 21, 22, and 23, respectively, which are of laminated construction. Coil III is preferably disposed adjacent but in spaced relation to one side of an armature 24, to be described hereinafter, whereas coils I and II are upon the opposite side of the armature (Fig. 1). Cores 21, 22, 23 are mounted upon a bracket 25 which is rigidly attached to the outer ring 12 in such a manner that the cores and coils thereon are angularly shiftable with said ring about the axis of trunnions 13. The coils are energized by a three phase current and are electrically interconnected, for example, in a Y connection (Fig. 2) having leads 26, 27, 28, respectively, connected to coil II, a central point of the Y, and to coil III. The three phase current is preferably employed for driving the gyro rotor in addition to energizing the field generator.

In order that the field generator be able to exert torques in both clockwise and counter-clockwise directions in response to deviations of the gyro rotor from the horizontal in clockwise or counter-clockwise directions about the trunnions 11, a pendulum 29 of the mercury type is provided for controlling a flow of current to coil I. The strength of a field produced by coils II and III is numerically one-half as great and opposite in direction to that of coils I and III. Consequently, if the torque of coils II and III is +T, then that of coils I and III will be −2T, producing a resultant of −T.

The pendulum 29 (Fig. 2) comprises, for example, a glass tube 30 of circular shape, having two electrodes 31, 32 fused therein. Within the tube is a throttle or restricted portion 33 for controlling the movement of a mercury mass 34. The pendulum is preferably mounted in such a manner that mass 34 moves about the axis of trunnions 11 as a center.

The armature 24 which is fixedly mounted upon stationary member 14 is employed for electrically coacting with the field of member 20 to produce the above mentioned torque or turning moment about the axis of trunnions 13, thereby causing precession about the axis of trunnions 11. In the form shown, armature 24 is semi-circular in shape, is preferably of copper or aluminum, and is in the plane of angular motion of the rotating field generator 20, or in a plane parallel thereto.

Analogous torque producing means are provided for causing the rotor to precess about the axis of trunnions 13 in response to deviation or movement of the rotor from its predetermined position about the latter axis, comprising a field coil member or rotating field generator 35 (Figs. 1 and 4) mounted by means of a suitable bridge or bracket element 36 upon the housing 10. Member 35 is constituted by cores 21', 22', 23', and coils I', II', and III' analogous to those above described in construction and interconnection. This rotating field generator electrically cooperates with an armature member 37 which is rigidly mounted upon the outer gimbal ring 12. Member 37 is preferably semi-circular in shape, as is armature 24, and is in the plane of angular motion of field coil member 35 or in a plane parallel thereto. The member 36 is therefore adapted for angular motion about the axis of trunnions 11, whereas member 37 cannot move about the axis. The coils I', II', III' are disposed relative to armature 37 in a manner analogous to that of coils I, II and III relative to armature 24.

A mercury pendulum 36 which is mounted upon housing 10 at a point 90° removed from pendulum 29 is employed for controlling the action of field coil member 35 in a manner similar to that of the latter pendulum.

Suitable means are provided for "picking up" or communicating to an indicator the position of the gyro rotor relative to the craft comprising, for example, a potentiometer coil 39 which is mounted upon a bracket element 40 and adapted for "picking up" transverse inclinations of the craft or inclinations about the longitudinal axis of said craft. An arm 41 of the potentiometer is mounted upon a trunnion 13 and adapted for contacting coil 39 in a conventional manner. Bracket element 40 is normally stationary but is angularly shiftable by means of a worm and worm wheel section 42, 43, respectively, the latter being mounted upon element 40. A manually operable crank 44 is operatively connected to the worm 42 by shaft 45, gears 46, 47, and a shaft 48. A suitable electrical device (not shown) for indicating the relative positions of arm 41 and coil 39 is operatively connected to the potentiometer. By means of the above worm and wheel means, the reference or "zero" position of the potentiometer can be varied or adjusted.

The angles of longitudinal inclination of the craft relative to the rotor are "picked up" by

means of a potentiometer device having a coil 49 upon a bracket 50, the latter being mounted upon ring 12. An arm 51 which is movable with one of the trunnions 11 is adapted for contacting the coil 49.

In order that a predetermined inclination of the craft about the transverse axis thereof be maintainable by placing the craft in such an attitude that an indicator which is responsive to such an inclination registers at its zero or reference position, means are provided for adjusting such a reference position comprising an adjustable bridge hook-up 52 (Fig. 6) of which potentiometer coil 49 comprises two arms or branches thereof. The other two branches are constituted by a potentiometer coil 53 having a movable arm 54 in engagement therewith. Opposite extremities of coils 49 and 53 are interconnected by leads 55, 56 across which a source of electric energy 57 is connected in series with a variable resistance 58 which is adapted for controlling the potential of the bridge. A means for indicating the balance of the bridge is constituted by indicator 59 which is operatively connected to both of the arms 51 and 54 by means of a suitable slip ring and brush upon the respective shaft of each arm. The indicator 59 is therefore responsive to the longitudinal inclination of the craft.

The contact arm 54 is movable with a suitable dial 60 upon which is calibrated a scale for indicating desired angles of climb or descent. A pointer 61 is provided which, for example, by a geared interconnection is able to govern the angular position of dial 60, said pointer cooperating with the calibrations upon the dial.

When, for example, a desired angle of climb is indicated by pointer 61, the craft can be manually steered and "nosed" upwardly, thereby moving arm 51 relative to coil 49 until bridge equilibrium is established and indicator 59 is at zero in which attitude the craft can be maintained.

If the suspension is to be adapted for angular movement, for example, about the axis of trunnions 13 to the extent of 360° suitable slip rings can be employed for conducting current to the gyro, the field generators, and to the potentiometer. However, if it is not necessary that the suspension be movable within such wide limits, the current can be fed to the apparatus, for example, to the rotor by means of a contact arm 62 which engages a pointed extension 63 of housing trunnion 11 which moves in an insulated bearing.

In operation, when the axis of rotation of the rotor moves from its predetermined vertical position, for example, about the axis of trunnions 11, pendulum 29 will be shifted in position in such a manner that the field created by field member 20 in cooperation with armature 24 will produce, for example, a torque —T as above mentioned. This torque acts about the axis of trunnions 13 and causes a precession of the gyro rotor about the axis of trunnions 11 in a direction opposite to that of the first mentioned movement, that is, the torque created by the field member and armature causes a precession of the rotor which tends to restore the axis of rotation thereof to the vertical.

When a movement of the rotor occurs, from its desired position, about the axis of trunnions 13, an analogous operation of pendulum 38 and field coil member 35 in coaction with armature 37 occurs. Consequently, a torque is exerted upon the rotor suspension which acts about the axis of trunnions 11 but which produces a precession about the axis of trunnions 13 which tends to restore the axis of rotation to the vertical.

An indicator for artificial horizon readings having thereon directions for steering the craft in such a manner that a predetermined position is maintainable (Fig. 8) is preferably employed with the present invention. The indicator comprises a member 64 which is responsive to transverse and longitudinal inclinations and which is movable relative to a vertical and horizontal reference line, each of which is suitably calibrated upon a face 65. On the left of the vertical line is the indication that the craft is listing and that the control member of the craft, for example, the "stick" is to be moved to the right. An analogous indication is on the right of said line with a direction to move the "stick" to the left. Above and below the horizontal reference line are, respectively, directions to "push" and to "pull" the "stick."

Adjacent face 65 there is preferably mounted the control knob 44 which is movable adjacent a scale calibrated for right or left inclination. The scale mentioned above in connection with dial 60 is preferably adjacent face 65 also, there being a suitable control knob 66 operatively connected to pointer 61.

There is thus provided novel means for maintaining a rotor of a gyroscopic device in a predetermined position. The means are extremely sensitive and are able to exert sufficiently large torques upon the rotor to cause same to precess into a desired position even when the rotor moves a minute angular amount from its desired position. The novel device, furthermore, is adapted for producing restoring precession moments without subjecting the rotor suspension to disturbing friction. The apparatus, moreover, is very rapid in its reaction to deviations of the rotor from a desired position because the mercury mass in each pendulum oscillates or swings continuously as a result of accelerations occurring in flight.

Although only one embodiment of the present invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. For example, the field coil member of each torque producing means can be interchanged in position with its respective armature. The novel apparatus instead of stabilizing a gyro horizon can be employed in any device where it is necessary to create predetermined torques when a deviation from the vertical occurs. It would also be possible, for example, to maintain the axis of rotation of an azimuth gyro at a predetermined angle relative to the vertical. Various changes in the design and arrangement of the parts can be made without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art. For a definition of the limits of the invention, reference will be had primarily to the appended claims.

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