March 11, 1952 C. E. BARKALOW 2,588,607

STARTING ARRANGEMENT FOR GYROSCOPIC INSTRUMENTS

Filed June 28, 1949

Fig. 1.

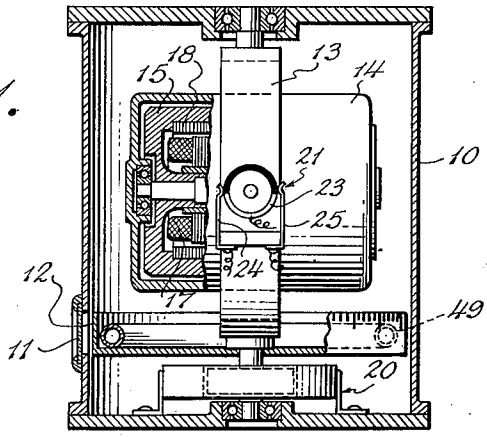


Fig. 2.

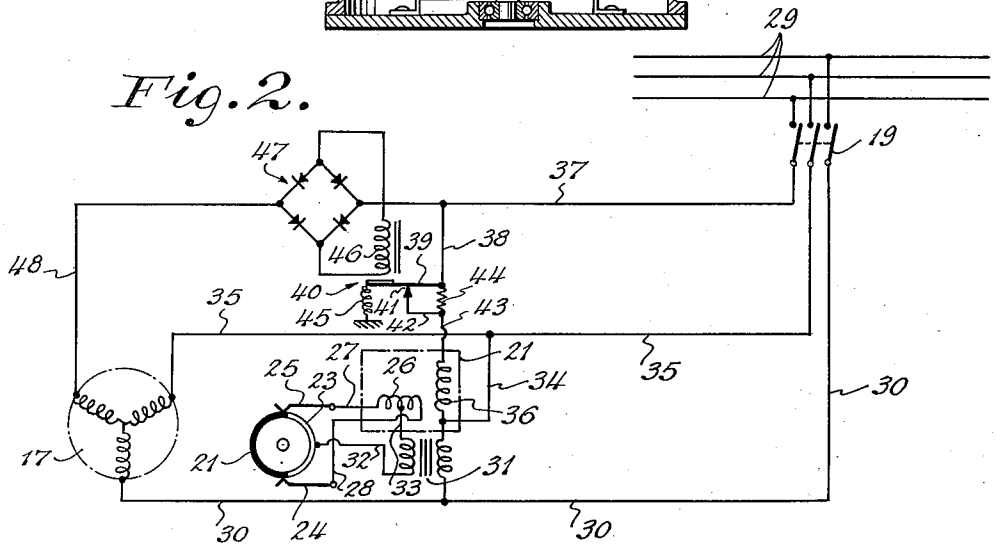


Fig. 3.

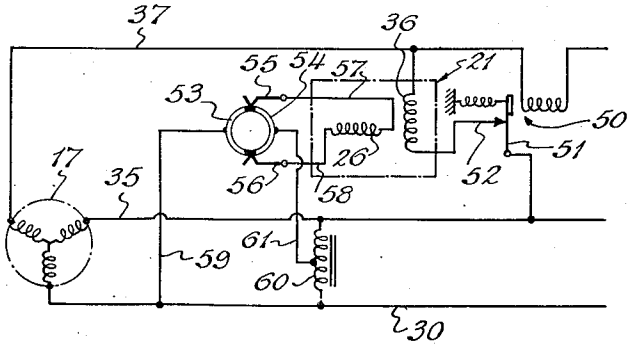
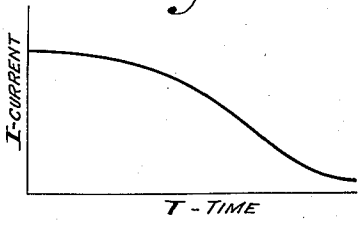


Fig. 4.



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STARTING ARRANGEMENT FOR GYROSCOPIC INSTRUMENTS

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8 Claims. (Cl. 74—5.47)

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This invention relates to a starting arrangement for electrically operated gyroscopic instruments. The improved arrangement includes means that are effective during starting conditions to render ineffective the normally operable torque exerting means normally used to level or erect the gyroscope. In accordance with the invention, such means is made sensitive to the current drawn by the motor adapted to spin the gyroscopic rotor of the instrument, the motor being of a character that draws a decreasing amount of electric current as the gyroscopic rotor accelerates from a standstill condition to reach normal operating speed. Upon arrival at the normal operating speed of the rotor, the means is effective to restore the torque exerting means to normal operation.

Particularly, in directional gyros, the levelling torque exerting means for the rotor frame adds to the starting nutation of the instrument as the gyroscopic rotor is brought up to speed. By disabling or rendering ineffective this torquing means under starting conditions, the duration and extent of the starting nutation of the instrument is reduced advantageously.

A further advantage attained by the improved starting arrangement is that the instrument is usable as a reference before the rotor is up to speed. A normal levelling torque added to the torque due to the reaction of the accelerating rotor during starting provides a levelling rate that is too high for the instrument to be used as a reference before the rotor has attained normal speed. This is because of the fact that an excessive levelling rate necessarily causes an excessive azimuth error during turns. With the present invention in which the normal levelling torque is reduced to null or substantially cut down at starting, the instrument is usable as a reference while the rotor is still accelerating. The improved arrangement is particularly advantageous in instances where a rotor is employed of the character that takes a relatively long time to get up to speed.

Other advantages and novel features of the invention are hereinafter more particularly set forth in the description of the invention relative to the accompanying drawing in which,

Fig. 1 is a side elevation of a gyroscopic instrument embodying the present inventive concepts. The housing of the instrument shown in Fig. 1 is in section as is a portion of the rotor frame;

Fig. 2 is a circuit diagram showing the elements of the present invention arranged in a preferred relation;

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Fig. 3 is a view similar to Fig. 2 showing a modified form of the invention; and

Fig. 4 is a curve showing the current-time characteristic of the rotor spinning motor of the arrangement during the starting period.

With reference to Fig. 1 of the drawing, a gyroscopic instrument of the directional gyro type is illustratively employed to show a practical embodiment of the present inventive concepts. An azimuth reference instrument of this character, as shown, includes a housing or casing 10 that may provide a window 11 having a lubber line thereon (not shown) readable on a compass card 12 in accordance with conventional construction. The instrument is fixedly mounted on the craft on which it is used with the gimbal or vertical ring 13 within the housing 10 supported with freedom about a normally vertical axis. The rotor frame 14 is supported on the ring with freedom about a normally horizontal axis. Relative to the housing 10, the frame 14 is universally mounted with freedom about two mutually perpendicular axes. As shown in Fig. 1, the gyroscopic rotor 15 of the instrument is pivotally mounted in the frame 14 to spin about a horizontal axis that is normally perpendicular to both the axes of freedom of the frame. The card 12 is shown as suitably fixed to the ring 13.

The electric motor for spinning the gyroscopic rotor 15 herein shown is a three phase A. C. induction motor whose wound stator is indicated at 17. The squirrel cage type rotor 18 of the spinning motor is included as a portion of the gyroscopic rotor 15.

This electric motor has the starting characteristic that the wound stator thereof draws a decreasing amount of electric current from the line as the gyroscopic rotor accelerates from a standstill condition to reach normal operating speed. As shown by the curve in Fig. 4, the current drawn from the line by the motor is at its maximum when the motor is first connected to the line by the closure of the starting switch 19. As the rotor picks up to speed, the current decreases with passage of time. With the rotor up to speed, the current levels off at a relatively low value of about one-tenth of that required during the motor accelerating period. Electric motors for spinning the gyroscopic rotor of an equivalent type to that described whose starting characteristics are the same may obviously be employed in carrying out the teaching of the present invention. The illustrated and described spinning motor per se is of well known construction in the motor art.

In accordance with the present invention, means are provided including motive means operable to exert a torque about an axis of the rotor frame 14 and in particular, in this instance, a levelling torque about the axis of ring 13. Such means may be of the character shown in U. S. Patent No. 2,381,438 of August 7, 1945, to R. S. Curry, Jr., in the form of a torque motor generally indicated at 20 and a commutator and brush type selector switch generally indicated at 21. The torque motor may be an A. C. induction motor of the squirrel cage type whose inductive rotor is fixed to the housing 10 and whose polyphase wound stator is fixedly connected to the ring 13. Motor 20 operates to exert a torque about the axis of ring 13 to cause precession of the frame 14 about its normally horizontal axis on the ring 13 so that the spin axis of the rotor 15 is maintained horizontal. The selector switch 21 detects tilt of the frame 14 relative to the ring 13 and as shown in the above identified patent may include a commutator segment 23 fixed to the trunnion extending from the frame 14 and two brushes 24, 25 that are suitably fixed to the ring 13. This type of switch 21 is also shown in Fig. 2. In the arrangement shown, the switch 21 conducts electrical energy only when there is relative tilt between the frame and ring from a normal relation. Otherwise, the same breaks the circuit to the torque motor the brushes then engaging the insulating area of the switch.

In the form of the invention shown in Fig. 2, one of the windings of the torque motor 21 is indicated at 26. This is connected by lead 27 to brush 25 and by lead 28 to brush 24. The winding 26 is energized, as shown, from a suitable source of electrical energy or A. C. main 29 by way of switch 19, lead 30, and transformer 31 whose secondary winding is connected by lead 32 to segment 23 and by lead 33 to a center tap position on the winding 26. The return connection of the primary winding of the transformer 31 includes leads 34 and 35 to the switch 19 and main 29. Winding 26 of torque motor 21 is energized only when the frame 14 is tilted relative to the ring 13 and brushes 24 or 25 engage the conducting segment 23. Winding 36 of the torque motor 21 is normally energized from main 29 by way of switch 19, lead 37, lead 38, the armature 39 of a D. C. relay 40, contact 41, lead 42, lead 43, the winding 36, and leads 34, 35 to the switch 19 to the main. In this form of the invention, a resistor 44 is arranged in the circuit to the winding 36 in shunt relation to the armature 39 of the relay. Spring 45 of the relay normally maintains the armature 39 engaged with contact 41 so the resistor 44 in the circuit to the winding 36 is bypassed and the winding fully energized. When the armature 39 is out of engagement with the contact 41 as hereinafter described, the resistor 44 is situated in the circuit to the winding 36, the same operating to substantially decrease the energization thereof from the main. The winding 46 for the relay 40 is controlled by the output of a rectifying bridge 47 that may be formed of four selenium rectifiers arranged as shown. The bridge 47 passes A. C. to lead 48 from lead 37. As shown in Fig. 2, the windings of the stator 17 of the spinning motor are energized from the main by way of switch 19 and leads 37, 48, lead 35 and lead 30. Relay 40 in accordance with the present invention provides a means sensitive to the current drawn by the spinning motor of the instrument under starting conditions that operates to render the torque motor

21 ineffective while the rotor is accelerating. The relay is adjusted so that as long as the current is above that required for normal operation with the rotor up to speed, the field of the winding 46 is sufficiently strong to overcome the spring 45 and pull the armature 39 away from engagement with contact 41. The shunted resistor 44 is now included in the circuit to the winding 36 of the torque motor. As soon as the rotor reaches normal operating speed and the current drawn by the spinning motor is at its normal value, spring 45 of the relay closes the armature 39 and contact 41 to shunt out resistor 44 so that the winding 36 is restored to normal operation. When the instrument is started from a stand-still condition by closing switch 19 to energize the spinning motor, the frame 14 is in a tilted condition relative to the ring 13 so that depending in the tilt there would be a continuous torque exerted in one direction about the axis of the ring if the torque motor were not rendered ineffective or disabled. This torque adds to the starting nutation of the instrument and may lengthen the duration of the same considerably. By eliminating the torque under starting conditions the duration of nutation is appreciably decreased. The starting nutation of the instrument may be damped by means of a damping ring 49 which is a hollow circular tube filled with a damping fluid that is shown in Fig. 1 as fixedly mounted in concentric relation to the ring 13. In the arrangement shown, the ring is suitably fixed to the compass card 12. During the acceleration of the rotor of the instrument, a reaction torque due to the acceleration is present that operates in a direction to level the frame 14 relative to the ring 13. Such a torque if added to the normal levelling torque during the starting period provides a levelling rate that is too high for the instrument to be used as a reference if the craft using the instrument enters a turn or assumes a banked condition. By means of the present invention, the normal levelling torque means is rendered ineffective during the starting period, so that the instrument is usable as a reference even before the rotor gets up to its normal operating speed.

In the modified form of the invention shown in Fig. 3, an A. C. relay 50 is substituted for the D. C. relay 40 and bridge 47 in Fig. 2. Also, the armature 51 and contact open the circuit including the winding 36 of torque motor 21 to disable the torque motor during the starting period. Relay 50 is sensitive to the current drawn by the spinning motor from the line and does not reclose the torque motor circuit until the rotor from the instrument is spinning at normal speed and drawing the normal current from the line.

The tilt detecting switch for energizing winding 26 of torque exerting means 21 is shown in the form of a pair of conducting commutator segments 53, 54 and a pair of brushes 55, 56. Like switch 21, the spaced segments are fixed to the trunnion of frame 14 and the brushes are fixed to the ring 13. Winding 26 is conected to brushes 55 and 56 by way of leads 57 and 59. Lead 58 connects segment 53 and lead 30. Energy is supplied from the line by way of auto transformer 60 connected across leads 35 and 30 by way of a tapped connection and lead 61 to the segment 54. With the brushes 55, 56 engaging the insulating spaces between the segments 53, 54, the switch is non-conducting and the winding 26 is not energized. With tilt of the parts from a normal condition, brush 55 contacts segment 53 or

54 and brush 56 contacts segment 54, or 53 and the winding 26 is energized. The operation of this form of the invention is identical with that hereinbefore set forth in connection with Fig. 2 of the drawing.

Since 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.

I claim:

1. In a directional gyro having a ring mounted with freedom about a vertical axis, a rotor frame mounted on said ring with freedom about a horizontal axis and a gyroscopic rotor mounted in said frame; a starting arrangement including an electric motor for spinning said rotor of the character that draws a decreasing amount of electric current as the rotor accelerates from a standstill condition to reach normal operating speed, means including motive means operable to exert a torque about the axis of the ring, and means sensitive to the current drawn by the spinning motor operable to render said torque exerting means ineffective while the rotor is accelerating.

2. In a directional gyro having a ring mounted with freedom about a vertical axis, a rotor frame mounted on said ring with freedom about a horizontal axis and a gyroscopic rotor mounted in said frame; a starting arrangement including an electric motor for spinning said rotor of the character that draws a decreasing amount of electric current as the rotor accelerates from a standstill condition to reach normal operating speed, means including motive means operable to exert a torque about the axis of the ring, and means sensitive to the current drawn by the spinning motor for disabling said torque exerting means until the rotor reaches normal operating speed.

3. In a directional gyro having a ring mounted with freedom about a vertical axis, a rotor frame mounted on said ring with freedom about a horizontal axis and a gyroscopic rotor mounted in said frame; a starting arrangement including an A. C. induction motor for spinning said rotor, means including an A. C. induction motor for exerting a torque about the axis of the ring, and current sensitive means for rendering said torque exerting motor ineffective while the current drawn by said spinning motor is above that required when the rotor is spinning at its normal operating speed.

4. In a directional gyro having a ring mounted with freedom about a vertical axis, a rotor frame mounted on said ring with freedom about a horizontal axis and a gyroscopic rotor mounted in said frame; a starting arrangement including an electric motor for spinning said rotor of the character that draws a decreasing amount of electric current as the rotor accelerates from a standstill condition to reach normal operating speed, means including an electric motor operable to exert a torque about the axis of the ring; a source of electrical energy, a circuit connecting said source and spinning motor, a circuit connecting said source and torque exerting motor, and means situated in the circuit to said spinning motor sensitive to the current therein for disabling said torque exerting motor circuit while the rotor is accelerating.

5. In a directional gyro having a ring mounted with freedom about a vertical axis, a rotor frame mounted on said ring with freedom about a horizontal axis and a gyroscopic rotor mounted in said frame; a starting arrangement including an A. C. induction motor for spinning said rotor, means including an A. C. induction motor operable to exert a torque about the axis of the ring, an A. C. source of electrical energy, a circuit connecting said source and spinning motor including a current sensitive relay having an armature, a circuit connecting said source and torque exerting motor including the armature of the relay and a shunting resistor, said relay operating by its armature to include the resistor in the circuit to the torque motor until the spinning motor has substantially reached its normal operating speed.

6. In a directional gyro having a ring mounted with freedom about a vertical axis, a rotor frame mounted on said ring with freedom about a horizontal axis and a gyroscopic rotor mounted in said frame; a starting arrangement including an A. C. induction motor for spinning said rotor, means including an A. C. induction motor operable to exert a torque about the axis of the ring, an A. C. source of electrical energy, a circuit connecting said source and spinning motor including a current sensitive relay having an armature, a circuit connecting said source and torque exerting motor including the armature of the relay and a shunting resistor, said relay operating by its armature to include the resistor in the circuit to the torque motor until the spinning motor has substantially reached its normal operating speed.

7. A starting arrangement for an electrically operated directional gyro instrument with a vertical ring comprising an A. C. induction, rotor spinning, motor; an A. C. induction motor for exerting a torque about the axis of the ring; an A. C. source; a circuit connecting said source and spinning motor including a relay having an armature; a circuit connecting said source and torque exerting motor including the armature of said relay; said relay operating by its armature to open the circuit to the torque motor until the spinning motor has substantially reached its normal operating speed.

8. An arrangement for reducing the starting nutation of an electrically operated gyroscopic instrument comprising a rotor spinning electric motor of the character that draws a decreasing amount of current as the motor accelerates from a standstill condition to reach normal operating speed, a levelling torque exerting electric motor, a source of electrical energy, a circuit connecting said source and spinning motor, a circuit connecting said source and torque exerting motor, and means sensitive to the current in the circuit of said spinning motor operable to render said torque exerting motor circuit ineffective until the spinning motor has substantially reached its normal operating speed.

CLARE E. BARKALOW.

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