April 21, 1931. L. F. CARTER ET AL 1,801,329

MEANS FOR MAINTAINING REFERENCE PLANES

Filed April 8, 1926 2 Sheets-Sheet 1

Fig. 1.

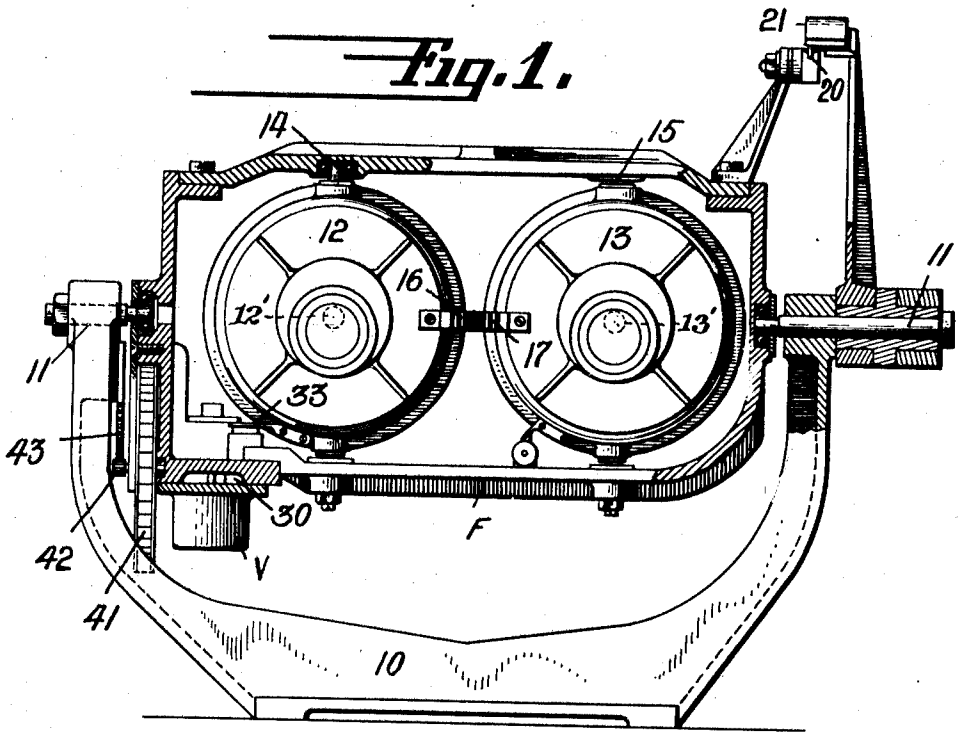


Fig. 2.

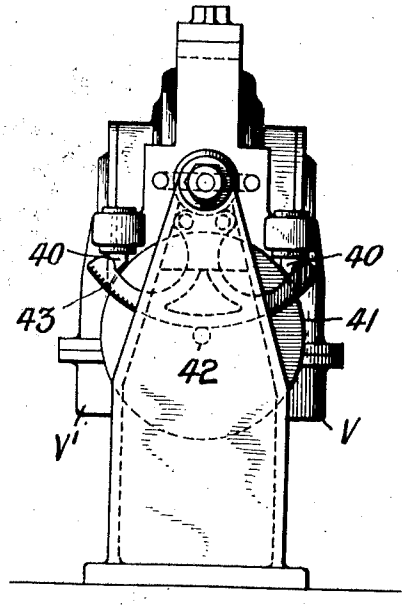
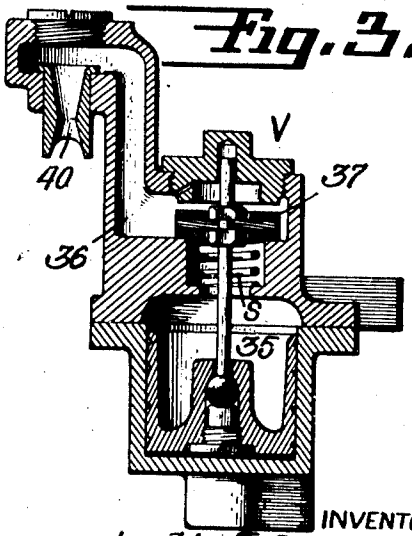


Fig. 3.



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Fig. 4.

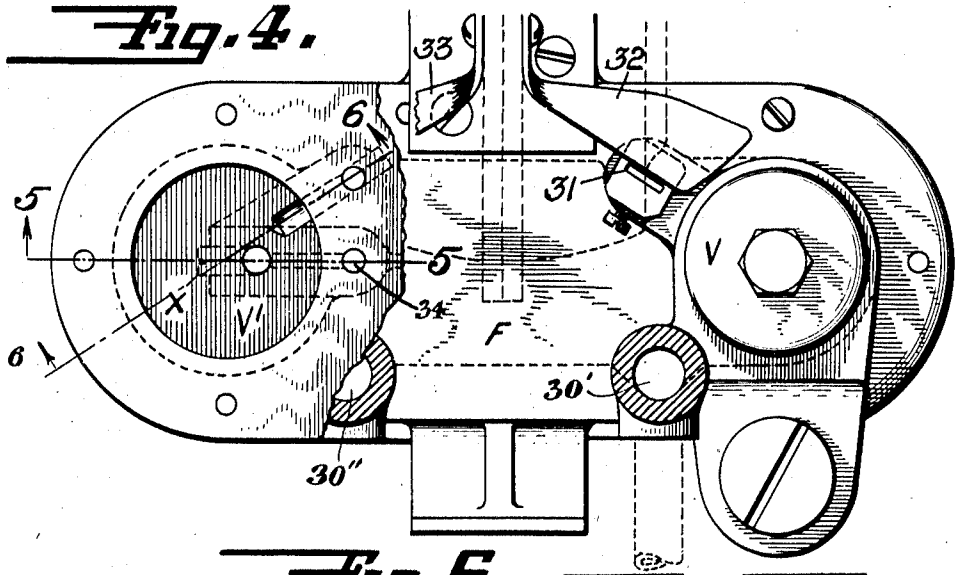


Fig. 6.

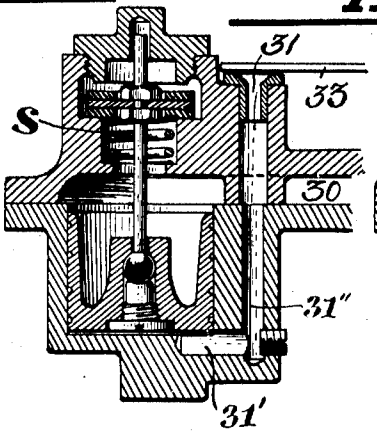
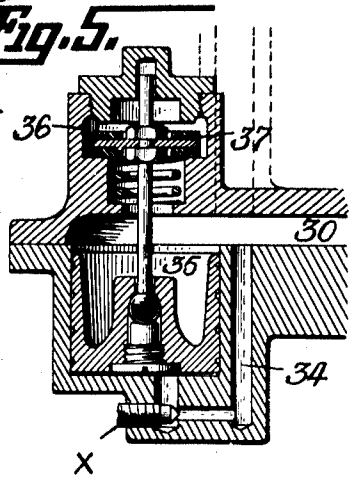


Fig. 5.



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UNITED STATES PATENT OFFICE

LESLIE F. CARTER, OF LEONIA, NEW JERSEY, AND MORTIMER F. BATES, OF BROOKLYN, NEW YORK, ASSIGNORS, BY MESNE ASSIGNMENTS, TO SPERRY GYROSCOPE COMPANY, INC., A CORPORATION OF NEW YORK

MEANS FOR MAINTAINING REFERENCE PLANE

Application filed April 8, 1926. Serial No. 100,737.

This invention relates to means for maintaining a true base line or reference plane from which variations may be indicated. The invention relates more specifically to gyroscopically maintained verticals, and has for one of its objects the provision of a gyro-vertical which shall remain unaffected by acceleration forces due to variations in speed in a straight line or to movements around a curve. Such a vertical is particularly serviceable in track recording instruments, since the latter are mounted on railroad cars subject to all manner of variations in speed and to changes in the direction of travel. The invention is, however, capable of broad application wherever a fixed reference plane is to be maintained, especially upon moving vehicles or objects.

For a full complete description of our invention, together with a disclosure of other objects and advantages of our invention, reference should be had to the following specification and to the drawings in which

Fig. 1 is a side elevation, partly sectioned vertically, of what we consider to be a preferred form of our invention.

Fig. 2 is a front elevation of the Fig. 1 device.

Fig. 3 is a vertical section through an air-control valve forming part of the invention disclosed in Figs. 1 and 2.

Fig. 4 is a plan view of a portion of the Figs. 1 and 2 device, with parts broken away to disclose the underlying structure.

Fig. 5 is another section through the air-control valve taken on the line 5—5 of Fig. 4.

Fig. 6 is still another section through the air-control valve taken on the line 6—6 of Fig. 4.

Referring to Fig. 1 of the drawings, there is shown a support 10 adapted to be mounted on a body whose movements with respect to a predetermined reference plane it is desired to ascertain. In the present case the invention is illustrated in connection with a track-recorder for recording deviations from a vertical plane in the fore and aft axis of a car traveling on said tracks, but it will be obvious from the following description that the invention is capable of broad application wherever a fixed reference plane is to be maintained. Pivotally mounted in said support upon horizontal bearings 11 is the means for maintaining a fixed reference plane, in this case, a true vertical plane. This means in the present invention may comprise a frame F supported for oscillation upon said bearings 11, and within said frame are mounted a pair of gyroscopes. The gyroscopes may be of the usual form and are shown as enclosed within casings 12 and 13 so as to spin about horizontal axes normally perpendicular to the plane of the paper in Fig. 1 as indicated by the dotted circles 12′—13′ representing the ends of the rotor shafts within the casings, the larger non-concentric circles representing the oil wells. Said casings in turn are mounted in said frame for precession about vertical axes 14, 15. The gyros are adapted to be rotated in opposite directions to cause opposite precession thereof in response to such forces as tend to cause precession, i. e., one gyro will precess in clockwise direction while the other will respond to the disturbing force by rotating in a counterclockwise direction to the same degree.

Gyros, having three degrees of freedom, would ordinarily maintain their position in space regardless of the movements of the support 10. Thus, if the gyros were originally in the same vertical plane as the support, and the latter was turned into a different plane, the gyros would turn with respect to the support about their axes 14, 15 and stabilization would be effected in a different vertical plane from that of the support. To obviate this condition we gear the two gyro casings together by gear segments 16, 17 so that it is impossible for the two gyros to turn about their vertical axes in the same direction,—which would be the case if the support were turned into a different vertical plane,—but allows only movement of the gyros due to precession, i. e., in equal and opposite directions. In this manner the gyro vertical element consisting of the two gyros and the frame is caused to maintain the vertical in whatever plane the support is turned, because it necessarily follows the support into the new plane.

From the above description it is apparent that if the device were mounted upon a moving vehicle, e. g., a railroad car, with the pivotal axis 11 of the frame F in the fore and aft axis of the car, the gyro vertical would be unaffected by the turning of the car, nor would it be affected by changes in speed of the car in said fore and aft direction since the forces due to such changes in speed do not cause precession of the gyros. The frame F and the gyros carried thereby are slightly pendulous with respect to the supporting axis 11 so that the frame will seek the vertical should it be displaced therefrom for any reason.

The pendulousness of frame F will render it subject to centrifugal force which would tend to turn the frame about its pivots. It will be seen that no actual turning of the frame would take place, but instead, in accordance with the fundamental laws of the gyroscope, the gyros would precess and in so doing would exert an equal and opposite force upon the frame. This is true provided no force, such as retarding springs, etc., are introduced to oppose precession; in other words provided the gyros are free to precess. The net result would be that the frame would remain fixed in position and the gyros would be precessed in equal and opposite directions, the latter movement being permitted by the interlocking gearing 16,17. From this action of the apparatus it will at once be seen that if the frame is originally set in vertical position it will maintain said position regardless of changes in speed, changes in course, or disturbing forces tending to cause precession. The frame obviously therefore forms a most reliable base plane from which deviations may be measured. If the device is to be used in track recorder mechanism to measure the inclination of the car body, i. e., difference in elevation between the tracks and inclination of the car body relative to the car truck, as in copending application Serial No. 690,930, of Elmer A. Sperry, filed February 6, 1924, the frame may be caused to carry a trolley 20 which cooperates with contact segments 21 to control a recorder in any suitable manner, e. g., as disclosed in the said Sperry application.

It has become apparent in the above description that when a force is applied to the frame which tends to turn said frame about its pivots no actual turning takes place but the gyros precess, and in so doing exert a torque upon the frame equal and opposite to the disturbing force, which results in the frame remaining fixed. The gyros, however, are in precessed position and, unless restored, might eventually be rotated about their vertical axes until they are inoperative, i. e., until they have been turned through substantially 90°. In order to restore the gyros to their original or centralized positions in the plane of the support, we provide means for exerting an equal and opposite force upon the frame so that the gyros will precess back to the same extent and so reach their initial positions. For this purpose we may provide an air impressor which may include any suitable source of air under pressure, such as an air-pump (not shown), said air being delivered to a pair of air-control valves V, V′ positioned one on each side of the vertical plane to be maintained (see Fig. 2). The air normally enters said valves through inlet passages 30 (see Figs. 5 and 6) connected to inlet pipes 30′ and 30″. Passages 30 enter the cylinders above the piston 35 so that pressure is exerted downwardly thereon and also upwardly on the smaller surface on the under side of the valve 37. Each passage 30 also communicates with a bore 34 connected through an adjustable needle valve X to the clearance space in the cylinder under piston 35. Said clearance space is also connected by lateral bore 31′ with a vertical passage 31″ in communication with slot or aperture 31. Normally the compressed air passes out through orifices 31 which are positioned one on each side of the vertical plane of the support. One of the gyros (in this case gyro 12) is provided with fins or shutters 32, 33 adapted to cooperate with the respective orifices 31 and so shaped that when the gyros are in unprecessed positions the fins just uncover the orifices (as shown in Fig. 4) permitting the air to escape.

When precession takes place, it will be obvious that one or the other of the orifices (depending upon the direction of precession) will be partly or wholly closed and the air in the respective valve, not being able to escape, will build up a back pressure by way of passage 31 to the under side of a piston 35 in the valve casing sufficient to balance the pressure on the top thereof. The pressure on valve 37 plus that of spring S raises said piston and thus opens a passage 36, by lifting valve 37 carried by said piston rod (see Fig. 3), to a jet 40 on one side of the vertical plane. It will be understood that each valve V, V′ is provided with a jet, said jets being positioned on opposite sides of the vertical plane. The air escaping through said jet impinges upon a turbine wheel 41 (see Fig. 1) journaled on the frame and geared through gearing 42, 43 to the support 10, the organization of air jet and turbine wheel constituting what may be termed an air-blast motor or motive means. While the air blast could be impressed on the frame directly, the gearing 42, 43 serves to multiply the applied force while permitting the frame F to maintain the reference plane even though the support 10 tilts relative to said frame. The device is so organized that an air blast from the proper jet will impinge upon that side of the wheel to cause preces-

sion of the gyros back to original positions. As soon as the gyros reach their unprecessed positions both orifices 31 are open, the piston 35 within the actuated valve descends to close passage 36 and the air blast is cut off from the turbine wheel. It will be obvious that if the gyros had precessed in the opposite directions the other air-control valve would have been actuated, to cause a blast from the other jet to impinge upon the turbine wheel and apply a force to the frame in the opposite direction to cause the gyros to precess back to original positions.

The various sections of the air-control valves shown in Figs. 3, 5 and 6, show that the air normally enters through inlet 30 and exerts a greater downward pressure on the greater area of the piston 35 than upon the valve member 37 so that said valve member normally maintains the passage 36 to the jet closed. When, however, the respective orifice 31 is closed, pressure builds up quickly beneath the piston becoming equalized with the pressure above by means of passage 34 and regulating valve X. The valve then opens due to the unbalanced pressure on the underside of valve member 37 and a spring S. Said spring is normally insufficient in itself to raise the valve but when said valve has been raised, as described above, it will maintain the valve in open position, thus relieving the air pressure of the necessity for performing this duty.

In accordance with the provisions of the patent statutes, we have herein described the principle and operation of our invention, together with the apparatus which we now consider to represent the best embodiment thereof, but we desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

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

1. In a device for maintaining a fixed reference plane, a pair of gyros adapted to be oppositely rotated, a frame in which said gyros are mounted for oscillation about parallel axes, means preventing all precession of said gyros about said axes except equal and opposite precession, said frame being mounted for oscillation about an axis at right angles to the first-named axes, an air blast motor connected to the frame, means whereby said motor exerts a force thereon in either direction about its supporting axis, and means whereby the precession of said gyros controls the air blast from said motor for applying a force to said frame about its supporting axis in a direction to cause precession of said gyros toward their centralized position.

2. In a device for maintaining a fixed reference plane, a pair of gyros adapted to be oppositely rotated, a frame in which said gyros are mounted for oscillation about parallel axes, means preventing all precession of said gyros about said axes except equal and opposite precession, said frame being mounted for oscillation about an axis at right angles to the first-named axes, means mounted on said frame for supplying an air blast on opposite sides of said frame for applying a force to said frame, said blast being normally ineffective, and means controlled by precession of said gyros for rendering effective the air blast on that side of the frame to apply a force on the frame causing precession of said gyros toward their centralized position.

3. In a device for maintaining a fixed reference plane, the combination with a support, of a pair of gyros adapted to be oppositely rotated, a frame in which said gyros are mounted for oscillation about parallel axes, said frame being mounted on said support for oscillation about an axis at right angles to the first-named axes, a geared-up air blast motor connected to said frame and support, and means whereby the precession of said gyros controls the blast from said motor for applying a force to said frame in a direction to cause precession of said gyros toward initial unprecessed positions.

4. In a device for maintaining a fixed reference plane, a pair of gyros adapted to be oppositely rotated, a frame in which said gyros are mounted for oscillation about parallel axes, said frame being mounted for oscillation about an axis at right angles to the first-named axes, a jet positioned on opposite sides of said frame, mean for supplying air blasts to said jets for applying a force to said frame, means including an orifice for each jet and a relay valve controlled thereby for rendering said blasts normally ineffective, and means whereby precession of said gyros selectively closes said orifices to render the blast from the respective jet effective for applying a force to said frame in a direction to cause precession of said gyros toward the centralized position.

5. In a device for maintaining a fixed reference plane, a pair of gyros adapted to be oppositely rotated, a frame in which said gyros are mounted for oscillation about parallel axes, said frame being mounted for oscillation about an axis at right angles to the first-named axes, means for supplying a plurality of air blasts to said frame, a pair of valves for controlling said blasts, said valves being normally closed to render said blast ineffective, and means whereby precession of said gyros selectively controls said valves to cause said blast to apply a force to said frame

in a direction to cause precession of said gyros toward the centralized position.

6. In a device for maintaining a fixed reference plane, a pair of gyros adapted to be oppositely rotated, a frame in which said gyros are mounted for oscillation about parallel axes, said frame being mounted for oscillation about an axis at right angles to the first-named axes, means for supplying an air blast to said frame, a pair of valves for controlling said blast, means including relief orifices through which said blast discharges for normally maintaining said valves closed to render said blast ineffective, and means whereby precession of said gyros selectively closes said orifices to open the respective valve and permit a blast to apply a force to said frame in a direction to cause precession of said gyros toward the centralized position.

7. In a device for maintaining a fixed reference plane, the combination with a support, of a pair of gyros adapted to be oppositely rotated, a frame in which said gyros are mounted for oscillation about parallel axes, said frame being mounted on said support for oscillation about an axis at right angles to the first-named axes, an air blast motor connected to the frame and support and adapted to exert a force thereon in either direction about said supporting axis, and means whereby the precession of said gyros controls said air blast for applying a force to said frame in a direction to cause precession of said gyros toward their centralized position.

8. In a gyroscopic pendulum, a frame mounted for oscillation about a horizontal axis, a plurality of gyroscopes within the frame mounted for turning about axes at an angle to the first-named axis, air blast motive means connected to said frame for exerting torques on the frame, an air vent and a shutter on said frame and gyroscope, and connections between said air vent and air blast motive means including a relay valve responsive to variations in pressure in said connections whereby the relative movements of the shutter and vent control the air blast for the purpose specified.

In testimony whereof we have affixed our signatures.

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