Aug. 11, 1931. E. A. SPERRY 1,818,104

MEANS FOR CONTROLLING DIRIGIBLE AIRCRAFT

Filed Nov. 22, 1928

Fig. 1.

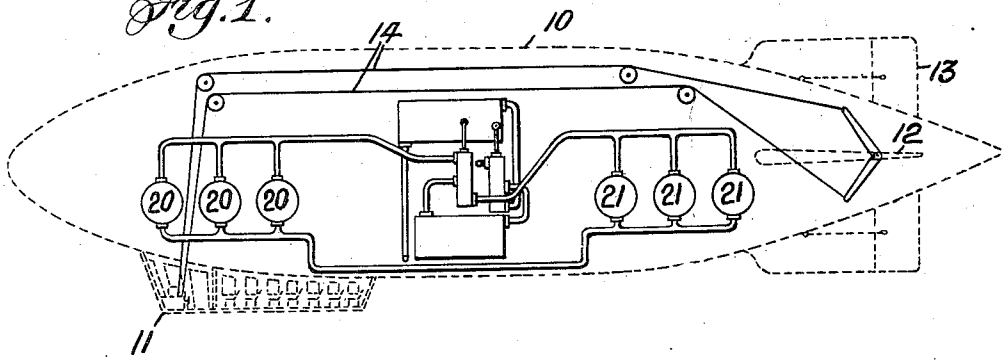


Fig. 2.

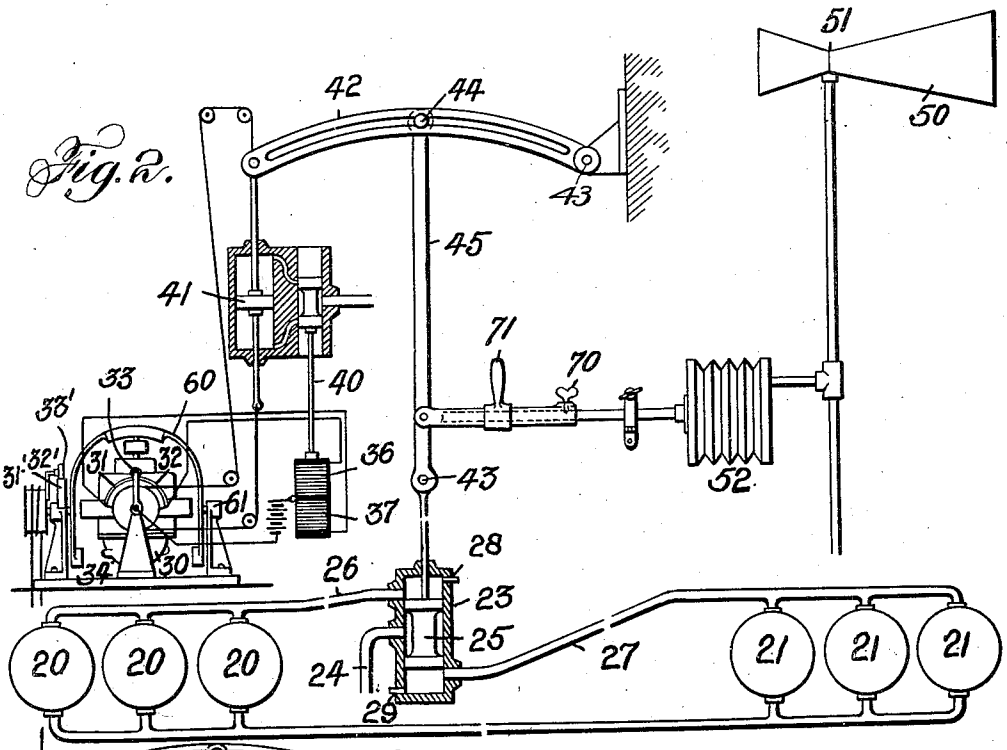
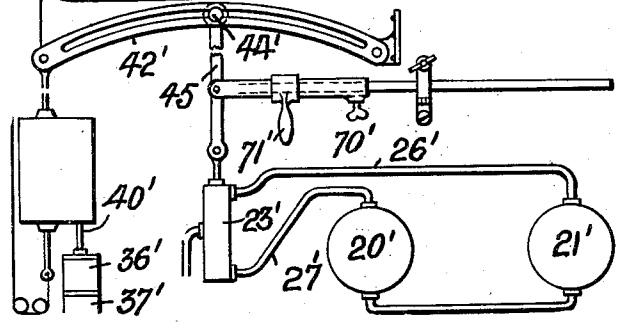


Fig. 3.



INVENTOR
ELMER A. SPERRY.
BY
Herbert A. Thompson
his ATTORNEY.

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UNITED STATES PATENT OFFICE

ELMER A. SPERRY, OF BROOKLYN, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO SPERRY GYROSCOPE COMPANY, INC., OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK

MEANS FOR CONTROLLING DIRIGIBLE AIRCRAFT

Application filed November 22, 1928. Serial No. 321,128.

This invention relates to means for facilitating the control of a dirigible aircraft of the gas-filled type. It is well known that in the steering of such craft the effectiveness of the horizontal rudder diminishes with diminishing speed and below a certain critical speed is substantially ineffective for the purpose of controlling the pitch of the craft. It is the principal object of my invention to provide means which may be brought into action when the speed of the craft diminishes below a predetermined critical speed for assisting in changing the inclination of the craft about its horizontal axis.

It is a further object of my invention to provide means which is automatically effective upon pitching of said craft to set into operation a suitable restoring force and to provide means for rendering the automatic means ineffective when the craft has been restored to horizontal position.

It is a further object of my invention to provide automatic means for counteracting the rotation of the craft about its fore and aft axis, that is, the rolling movement of the craft. For this purpose I may employ mechanism similar to that described above for counter-acting the pitching movements of the craft.

My invention is capable of embodiment in several forms which will be described in the following detailed description thereof and further advantages of the invention will become apparent from said description.

In the accompanying drawings;

Fig. 1 is a side elevation of a gas-filled dirigible craft showing one form of my invention applied thereto.

Fig. 2 is an assembly view, partly sectioned vertically and partly diagrammatic, of the means for counteracting pitching movements and the control mechanism therefor.

Fig. 3 is a view of the mechanism used in conjunction with the pitch counteracting mechanism for counteracting the rolling of the craft about its fore and aft axis.

Referring to the drawings, there is shown in Fig. 1 in dotted outline a gas filled dirigible craft 10 having a pilot house 11, horizontal rudders 12 and vertical rudder 13. Said rudders may be controlled from the pilot house by the usual cable connections, such as cables 14, shown connected to the horizontal rudders 12. When the craft tilts about a lateral axis, that is, when there is a pitching movement upwardly or downwardly, the rudders 12 are operated to counteract such movement to bring the craft back to its horizontal position. If, however, the upward or downward movement of the craft is desired, the rudders 12 are operated in such manner as to move the craft out of the horizontal position to cause the desired climbing or descending movement of the craft. This invention has to do with the condition wherein the craft is to be maintained horizontal. When the speed of the craft slows down below a certain critical speed, it is found that should the horizontality of the craft be destroyed by upward or downward tilting, the horizontal rudders 12 are then substantially ineffective to counteract such pitching movement and are insufficient to restore the craft to the horizontal. For this reason I employ the following ballast system and control therefor:

The ballast system may comprise a plurality of tanks 20 at one end of the craft interconnected with a plurality of tanks 21 at the other end of the craft, the entire system comprising a predetermined quantity of fluid which may be forced into or out of tanks 20 and 21. The ballast system includes a control valve mechanism 23 for controlling the supply of a source of fluid under pressure, such as compressed air, which may enter by pipe 24 and which through a valve 25 may be connected to tanks 20 or 21, respectively, via pipes 26 and 27, respectively, depending upon the direction of movement of valve 25. When said valve 25 is in its raised position the source of pressure 24 is connected with pipe 26 to force fluid out of tanks 20 and into tanks 21. When the valve 25 is in lowered position the source of pressure from pipe 24 enters pipe 27 to force liquid out of tanks 21 into tanks 20. The air from the tanks that are being filled may be discharged through suitable vents 28—29 provided in the valve casing 23.

In order to control the operation of the

hereinbefore described ballast system automatically, I may provide means responsive to inclination of the craft about a lateral axis, that is, in response to pitching movement of the craft to bring said ballast system automatically into action. For this purpose I may provide a gyro vertical 30 which may be of the type described in the patent to Mortimer F. Bates No. 1,518,892 granted December 9, 1924 for self damping gyro pendulums, or as disclosed in the patent to Lawrence B. Sperry No. 1,415,003 granted May 2, 1922 for automatic pilot for airplanes. It will be understood that this gyro maintains its vertical axis always vertical and may be provided with a set of live contact segments 31—32 separated by a strip of insulation with which cooperates a contact or trolley 33 which may be carried by the frame 34 fixed to the aircraft. Upon tilting in a fore and aft direction, the frame 34 tilts with the craft carrying the contact 33 into engagement with contact 31 or 32 depending upon the direction of tilt to energize one or the other of a pair of solenoids 36—37 which actuates a valve stem 40 upwardly or downwardly to cause actuation of a piston 41 in one direction or the other which actuates a lever arm 42 pivoted at 43, said lever arm having a pin and slot connection 44 with the upper end of a link 45 connected to the valve stem of valve 25. It will thus be seen that in response to inclination of the craft in a fore and aft direction valve 25 will be actuated to raised or lowered position, and it will be understood that the connections are such as to cause the ballast fluid to be driven into the forward or rearward tanks, as the case requires, to restore the craft to the horizontal.

In order that the ballast fluid shall not be excessively actuated beyond what is necessary for the restoring couple, a follow-up is provided between the piston 41 or link 42 and the contact or trolley 33 to cause said trolley to follow after the insulated segment until it is again on said insulated portion whereupon the circuit through the solenoids 36—37 is broken. As soon as the craft begins to tilt in the other direction, trolley 33 makes contact with the other contact segment 31—32 to reverse the position of valve 25 to cause the ballast fluid to be actuated in the opposite direction.

As hereinbefore described, the ballast system is necessary particularly when the speed of the craft diminishes below a certain critical or predetermined speed. I, therefore, provide means whereby the automatic control of the ballast fluid is ineffective until the speed falls below the said critical speed. For this purpose I provide a speed responsive means which may take the form of a Venturi tube 50 so that the suction at the narrowest point 51 will be a function of the speed of the craft through the air. When the speed falls below a certain critical speed, the suction at 51 will diminish and a syphon tube 52 will expand to shift pivot 44 of link 45 to the left in Fig. 2, so that the movements of piston 41 will impart to link 45 a sufficient movement to raise 25 or lower the same a sufficient distance to bring pipe 24 into communication with pipes 26 or 27. When, however, the speed of the craft is above said critical speed, the suction at 51 is relatively great and tube 52 collapses to such extent as to move pivot 44 to the right in Fig. 2 so that the movement of piston 41 cannot impart sufficient movement to link 45 to move valve 25 sufficiently to bring pipe 24 into communication with either pipe 26 or pipe 27.

If desired, the speed control may be eliminated by unscrewing the swing set screw 70 and the amount of the control varied manually from handle 71. Said screw 70 also furnishes a convenient means for varying the degree of control from the speed by varying the relative adjustment of the sleeve and rod.

It will also be understood that the usual means for actuating the horizontal rudder by hand (not shown) is provided so that the pilot may operate the rudders regardless of whether or not the ballast system hereinbefore described is functioning.

I may utilize the gyro vertical hereinbefore described for controlling a ballast system similar to that hereinbefore described and comprising a series of tanks 20′ and a series of tanks 21′ for counteracting the rolling of the craft around a fore and aft axis (Fig. 3). Such rolling movements may be detected by the gyro vertical by causing said gyro to engage in a frame 60 pivoted at 61 in the frame 34 about an axis at right angles to the axis of movement of trolley 33. Said frame 60 will thus maintain the vertical in a plane at right angles to the plane of movement of trolley 33 and may be caused to carry therewith a set of contacts 31′—32′ similar to 31—32 and similarly separated by an insulating segment. With said contacts 31′ and 32′ there may engage a trolley 33′ carried by the frame 34 so that upon rolling of the craft about a fore and aft axis trolley 33′ will be carried into engagement with one or the other of contacts 31′—32′ to control a valve within a housing 23′ in all respects similar to the valve within housing 23. The ballast is similarly controlled to counteract the rolling movements. A follow-up may again be provided to the trolley 33′ similar to the follow-up to the trolley 33.

In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I 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 my invention, what I claim and desire to secure by Letters Patent is:

1. In combination with a dirigible aircraft, means responsive to tilting movements of said craft, a distributed ballast system suitably disposed with respect to the craft, means for causing movement of the said ballast, means whereby said first-named means controls the said movement of the ballast for generating and delivering to the craft a counteracting torque, and means whereby said first means is graduated as to its control of said ballast when the speed of the craft exceeds a predetermined speed.

2. In combination with a dirigible aircraft having a rudder and hand-operated means for actuating said rudder, means responsive to tilting movements of said craft, said rudder being so positioned that actuation thereof delivers to said craft a counteracting torque, ballast means suitably disposed with respect to said craft, automatic means for controlling said ballast to generate and deliver to said craft a counteracting torque, and means whereby said first means affects the action of said automatic means.

3. In combination with a dirigible aircraft having a rudder, hand-operated means for actuating said rudder, means responsive to tilting movements of said craft, said rudder being so positioned that actuation thereof delivers to said craft counteracting torque, ballast means suitably disposed with respect to said craft, automatic means for controlling said ballast to generate and deliver to said craft a counteracting torque, means whereby said first means varies the application of said automatic means, and means whereby said first means is rendered ineffective to control said automatic means when the speed of the craft exceeds a predetermined speed.

4. In combination with a dirigible aircraft, means responsive to tilting movements of said craft, a distributed ballast system suitably disposed with respect to the craft, means for causing movement of the said ballast, means whereby said first-named means controls the said movement of the ballast for generating and delivering to the craft a counteracting torque, and means whereby said first means is graduated in its effective control of said ballast, responsive to the speeds of the aircraft.

5. In combination with a dirigible aircraft having a horizontal rudder, a ballast system disposed about an athwartship axis, means responsive to tilting of the craft, means whereby said first means actuates said ballast system, and means whereby said first means is rendered effective when said horizontal rudder is rendered ineffective due to insufficient speed of the craft.

6. In combination with a dirigible aircraft having a horizontal rudder, a ballast system disposed about an athwartship axis, means responsive to tilting of the craft, means whereby said first means actuates said ballast system, and means whereby said first means is maintained ineffective when the speed of the craft is sufficient to render said horizontal rudder effective.

7. In combination with a dirigible aircraft having a horizontal rudder, a ballast system disposed about an athwartship axis, means responsive to tilting of the craft, means whereby said first means actuates said ballast system, and means whereby said first means is rendered effective when said horizontal rudder is rendered ineffective due to insufficient speed of the craft and whereby said first means is rendered ineffective when the speed of the craft is sufficient to render said horizontal rudder effective.

8. In combination with a dirigible aircraft having a horizontal rudder, a ballast system disposed about an athwartship axis, means responsive to tilting of the craft, means whereby said first means actuates said ballast system, said last-named means including a variable leverage, and means whereby said leverage is varied in accordance with the speed of the craft.

9. In combination with a dirigible aircraft having a horizontal rudder, a ballast system disposed about an athwartship axis, means responsive to tilting of the craft, means whereby said first means actuates said ballast system, said last-named means including a lever controlled by said first means and a linkage adjustably connected to said lever, and means whereby said link is adjusted with respect to said lever in accordance with the speed of the craft.

10. In combination with a dirigible aircraft having a horizontal rudder, a ballast system disposed about an athwartship axis, means responsive to tilting of the craft, means whereby said first means actuates said ballast system, said last-named means including a lever pivoted at one end and having its other end controlled by said first means, and a link adjustably connected at one end to said lever, and means whereby said end of said link may be adjusted in position with respect to the pivot of said lever in accordance with the speed of the craft.

In testimony whereof I have affixed my signature.

ELMER A. SPERRY.