J. S. LANG.

GYROSCOPIC CONTROL.

APPLICATION FILED APR. 17, 1912.

**1,096,253.**

Patented May 12, 1914.

4 SHEETS—SHEET 1.

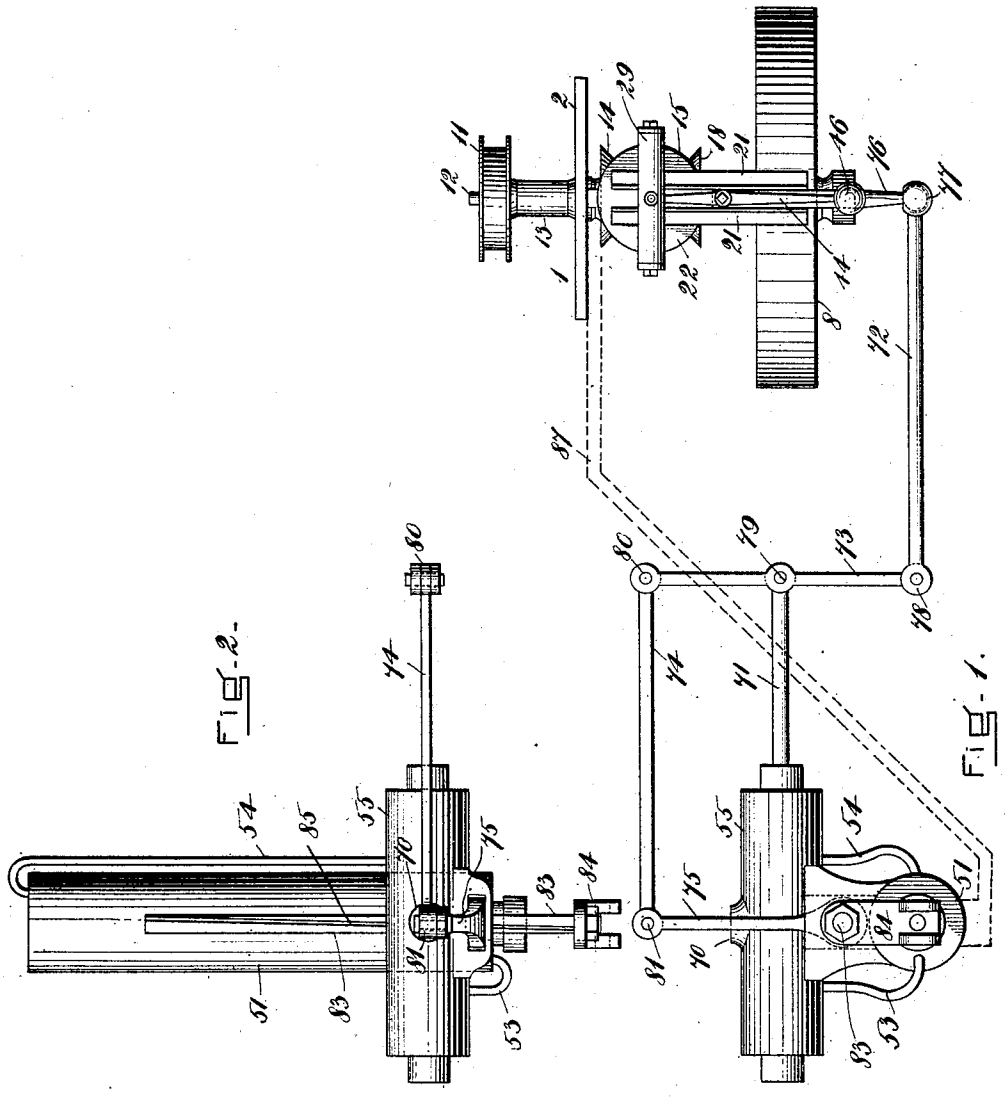


Fig. 2.



Fig. 1.

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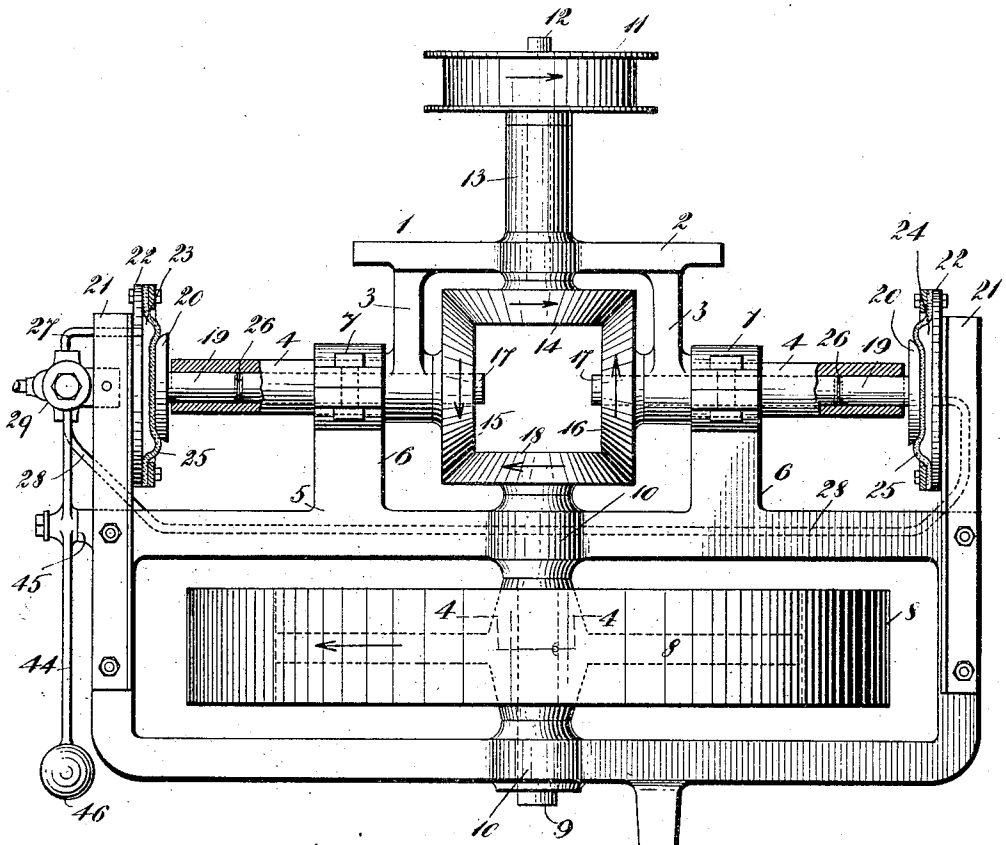



Fig. 3.

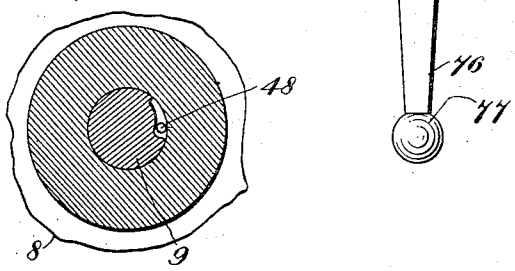



Fig. 4.




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4 SHEETS—SHEET 3.

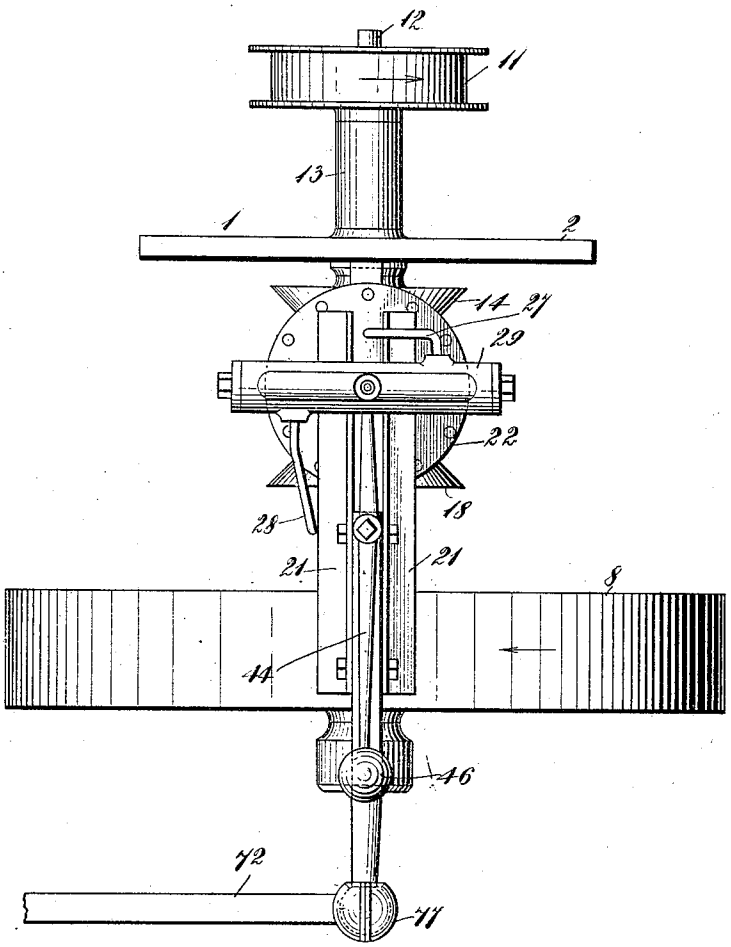



FIG. 5.

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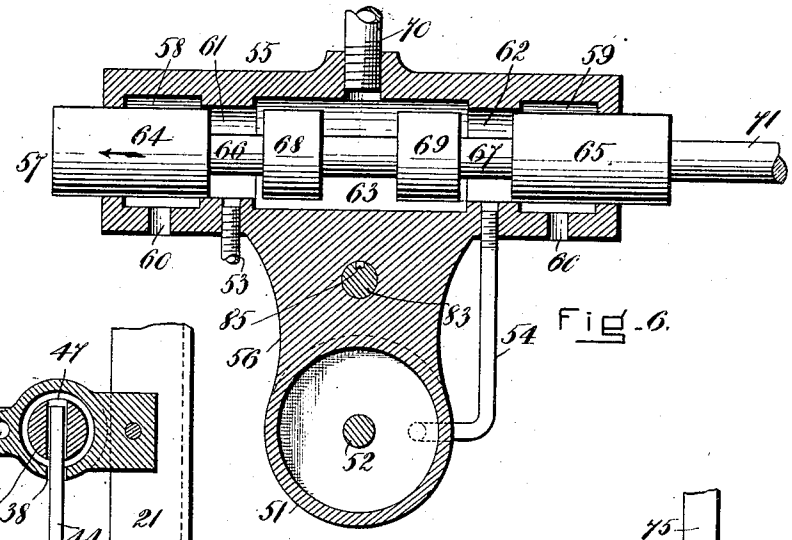



Fig. 6.




Fig. 7.

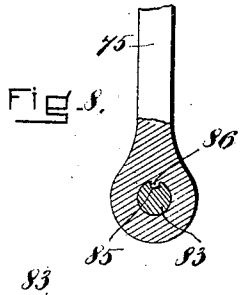



Fig. 8.




Fig. 9.

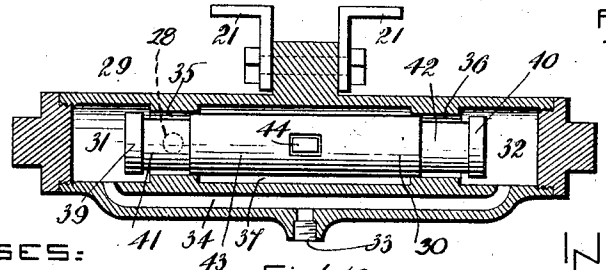



Fig. 10.

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# UNITED STATES PATENT OFFICE.

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## GYROSCOPIC CONTROL.

1,096,253. Specification of Letters Patent. Patented May 12, 1914.

Application filed April 17, 1912. Serial No. 691,420.

*To all whom it may concern:*

Be it known that I, JAMES S. LANG, of Boston, in the county of Suffolk and State of Massachusetts, have invented a new and useful Improvement in Gyroscopic Controls, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification, in explaining its nature.

My present invention comprises for its subject matter a gyroscopic apparatus operating on principles similar to those referred to in my copending application for Letters Patent of the United States, filed November 16, 1909, Serial No. 528,318, and which present apparatus like the apparatus referred to in said application is essentially adapted for effecting the automatic control of aeroplanes or other aerial machines employing planes or wings and by which means such machines may be maintained in or restored to a condition or state of normal or proper equilibrium or balance. As described in said application, a gyroscope is employed pivotally hung from a main axis of the flying machine or from an axis parallel with the main axis. The gyroscope thus pivotally hung tends to maintain a constant position as other parts of the machine turn about said axis upon the machine becoming unbalanced, the gyroscope or frame carrying the same then becoming an unbalanced base of resistance against which forces may act tending to correct the displacement of the machine and restore it to its normal position. As described in said application, the gyroscope tends to maintain a constant position by reason of its very rotation as is customary in such kind of devices, and is further maintained or restored to such constant position in case of the accidental displacement thereof by forces inherent in the gyroscopic apparatus itself or transmission connecting therewith. To this extent the apparatus to be described in the present case is like that described in said application, excepting that in said application the gyroscope is in the nature of a gyroscopic engine and the forces tending to restore the gyroscope to its normal position in case of displacement are reactive forces set up in the transmission through which the force generated by the gyroscopic engine is transmitted to the propeller of the machine for driving it. In the present case, however, the gyroscope is a driven object, the same being driven by extraneous power which is transmitted to the gyroscope for rotating it, and the force tending to restore the gyroscope to its normal position in case of its displacement is not a reactive force but a direct force transmitted to the gyroscope for rotating it, which by the manner of its application or transmission tends to restore the gyroscope to its original position in case of its accidental displacement from such position. According to said application the gyroscope or gyroscopic engine employed is of such size and power as would enable it or the frame carrying it to withstand as a base of resistance the action of forces acting directly against the same and tending to right the machine in case of its displacement. The gyroscope to be referred to in the present case may be of such size and power as to act in a similar way, although I have also described a means whereby a relatively small gyroscope and gyroscopic control may be employed and which of itself would not be sufficient to withstand the reaction of forces tending to right the machine, but which will act as a means of automatically controlling the operation of other forces having a power sufficient to control the machine in case of its displacement and of restoring it to its normal and proper balance.

My invention can best be seen and understood by reference to the drawings, in which—

Figure 1 shows the apparatus in front elevation. Fig. 2 is a plan of a portion of the same. Fig. 3 shows a portion of the apparatus in side elevation. Fig. 4 is a section on line 4—4 of Fig. 3. Fig. 5 is an end elevation of a portion of the apparatus. Fig. 6 is a view partly in section and partly in side elevation of the piston valvular control to which reference will hereinafter be made. Fig. 7 shows in section a portion of the valvular control shown in Fig. 10. Fig. 8 is a sectional view of a detail of construction to which reference will hereinafter be made. Fig. 9 is a view partly in section and partly in plan of the cylinder, piston and valvular control therefor which will hereinafter be described. Fig. 10 is a view partly in vertical section and partly in plan of the valvular control for the gyroscope.

Referring to the drawings:—1 represents a fixed frame consisting of a body 2 pro-

vided with separate, spaced, down-turned arms 3 bearing, respectively, long out-turned hubs 4 which project horizontally from the ends of the arms 3 in alinement with one another.

5 represents a pivoted frame consisting of bars rectangularly arranged and hung from the respective hubs 4 by straps 6 bearing boxes 7 which fit around the respective hubs by which the frame 5 may turn pivotally thereon as an axis.

Carried by the pivoted frame 5 is a gyroscope 8 fixed to a spindle 9 which turns within hubs 10 borne by the respective top and bottom bars of the frame 5. The arrangement of these hubs is such that when the hubs 4 are occupying a horizontal position and the frame 5 a gravitated position the gyroscope will be turning upon a vertical axis in a horizontal plane. The gyroscope is driven by an engine or motor (not shown) the power of which is imparted to a pulley 11 and from this pulley to the gyroscope through a chain of transmission to which reference will now be made. The pulley 11 is fixed to a shaft 12 which turns within a sleeve or hub 13 borne by the body 2 of the fixed frame. The disposition and arrangement of this hub is such that the shaft 12 turning within it will turn upon an axis at right angles to the axis defined by the hubs 4 and accordingly when the axis defined by the hubs 4 is occupying a horizontal plane the shaft 12 will turn on a vertical axis according to the disposition and arrangement of the parts. Fixed to the end of the pulley shaft 12 is a friction disk 14. Arranged to have working engagement with this disk upon opposite sides thereof in the manner of a couple are disks 15 and 16, respectively. These disks are fixed to shafts 17 which are journaled to turn within the hubs 4, the respective shafts also being slidable longitudinally within said hubs by which the respective disks 15 and 16 may be moved into and out of working engagement with the disk 14. It is also to be observed that the shafts 17 extend only part way through the hubs 4. The disks 15 and 16 have working engagement on opposite sides of a disk 18 arranged upon the projecting end of the spindle 9 bearing the gyroscope. The disposition and arrangement of the disk 18 and the coöperating parts are such that both disks 15 and 16 will only have engagement with the disk 18 when they are both in working engagement with the disk 14. In other words, either one or the other of the disks 15 or 16 may assume a disengaging position with respect to the disks 14 and 18. Though the disk 18 is carried by the pivoted frame 5 bearing the gyroscope yet this disk will have working engagement with either one or both of the disks 15 and 16 whatever the position of the frame 5 may be, inasmuch as the disk will turn around the axis defined by the hubs 4 or the axis in which the disks 15 and 16 are turning.

In order to understand the purpose and function of the parts to which I shall hereinafter refer it will be desirable at this point to explain the function and operation of the parts already described.

The power imparted by the engine to the pulley 11 will through the shaft 12 be transmitted to the disks 14, 15, 16 and 18, thence to the spindle 9 rotating the gyroscope. During this operation the disk 14 will tend to turn the disks 15 and 16 in opposite directions (assuming that both disks are in engagement with the disk 14). Inasmuch as the disks 15 and 16 are being turned in reverse directions they will accordingly set up or create forces against the disk 18 tending to move the disk, the frame 5 and gyroscope carried by it in the direction the disks 15 and 16 are turning. These forces, however, being in reverse and opposite directions neutralize one another and accordingly have no effect upon the disk 18 through the spindle 9 to change the normal suspended position of the frame 5 and gyroscope carried by it. It will now be assumed that the pulley 11 is being driven in the direction indicated by the arrow thereon and the respective disks and gyroscope are accordingly being turned in the directions indicated by the arrows thereon as shown in Fig. 3. It will also be assumed that one or the other of the disks 15 and 16, as for example the disk 15, is not in engagement with the disks 14 and 18, but that only the disk 16 is in working engagement therewith. The resultant effect is that the displacing influence of the disk 16 no longer being neutralized acts through the disk 18 and spindle 9 of the gyroscope to move or turn the frame 5 and gyroscope carried by it from their normal positions of suspension and will cause the same to pivotally move or turn in the direction induced by such force, or to move pivotally around the axis of the hubs 4 in a rotary direction the same as that of the disk 16. This effect continues as long as this disk is in sole engagement with the disks 14 and 18. On the other hand, if the disk 16 is in a disengaging position with respect to the disks 14 and 18 and the disk 15 in sole engagement therewith then the influence of the disk 15 acting through the disk 18 and spindle 9 of the gyroscope will exert a force tending to pivotally incline the frame 5 and gyroscope carried by it in a direction the same as that of the rotation of the disk 15 or one just reverse to that set up by the disk 16 as above described.

Reference will now be made to the means employed by which an automatic control may be effected in the working positions of

the respective disks 15 and 16, and this dependent upon the position of the pivoted frame 5 and gyroscope carried by it. In this connection it is to be observed that the automatic control, to which reference will now be made, is such that as long as the frame and gyroscope are occupying a proper and normal gravitated position of suspension, both of the disks 15 and 16 are controlled to have working engagement with the respective disks 14 and 18 by which the power of the engine is imparted to the gyroscope for rotating it through all of the respective disks, and the displacing influences exerted thereby being neutralized, no influence is exerted to disturb the normal and proper gravitated position of the frame 5 and gyroscope. In case, however, the gyroscope and frame 5 should become displaced from their normal positions, although the tendency of the gyroscope is to maintain that plane in which it is normally arranged to rotate, then the means for control is such that one or the other of the disks 15 or 16 will assume a disengaging position depending upon the influence desired to be obtained for restoring the gyroscope to its original and proper position.

As previously explained, the disks 15 and 16 are arranged upon shafts 17 socketed to turn in the hubs 4 and slidable longitudinally therein by which the disks 15 and 16 may be moved into working engagement with the disks 14 and 18. Located also in the hubs and slidable longitudinally therein to bear against the ends of the shafts 17 are plungers 19 bearing upon their respective ends beyond the ends of the hubs 4 heads 20, the arrangement of the parts being such that upon the application of pressure to the heads 20 the plungers will be forced against the ends of the shafts 17 and accordingly move the disks 15 and 16 into their working positions. The force applied to the heads 20 for holding the respective disks in their working positions is compressed air and is applied in the following manner:—The pivoted frame 5 is provided with extension pieces 21 which extend by the ends of the heads 20. Upon the side of these extension pieces facing the respective heads are arranged disks 22 which form the rear walls of air compression chambers 23 and 24, respectively. The front walls of these respective chambers are formed by movable diaphragms 25 which when the respective compression chambers are filled with air are extended to bear against the respective heads 20 and force the friction disks 15 and 16 into working engagement with the other friction disks.

I prefer to locate between the ends of the plungers and shafts 17 a set of ball bearings 26 on which the respective shafts may turn while receiving the thrust of the plungers. This eliminates friction which might otherwise arise at this point owing to the fact that the shafts 17 rotate with the disks while the plungers do not rotate though capable of a slight pivotal movement as the frame 5 of the device becomes turned.

Air is admitted to the respective compression chambers 23 and 24 by way of pipes 27 and 28, respectively, the pipe 27 connecting with the compression chamber 23 and the pipe 28 with the compression chamber 24. Both the pipes 27 and 28 connect with a valve casing 29 located on the outside of the extension 22 of the pivoted frame 5. This casing contains a sliding valve 30 which acts to convey air under compression admitted through the pipes 27 and 28 to the respective compression chambers. The casing 29 containing the valve is an elongated casing, the ends thereof being designed to provide air-receiving chambers 31 and 32, respectively. Air under compression from any suitable source of supply is admitted to these respective chambers by way of an inlet 33 and by-pass 34. Extending inwardly from the air-receiving chambers 31 and 32 the casing is formed to provide the respective ports 35 and 36 which connect with an enlarged central chamber 37 which is open to the atmosphere by a slot or opening 38 formed in the bottom of the casing. The valve itself consists of the respective head or end portions 39 and 40, the contracted neck portions 41 and 42 and a central body portion 43. The head or end portions and the body portion of the valve are of substantially the same diameter and have a snug sliding fit within the contracted portion of the casing forming the respective ports 35 and 36 therein. The length of the valve is such that when it is in a balanced central position as shown in Fig. 10 both of the heads 39 and 40 of the valve will lie within the respective chambers 31 and 32 of the casing just beyond the ports 35 and 36. The body 43 of the valve will then be in a position where the ends thereof will fit in both ports 35 and 36 and close the inner ends of these ports and chambers 31 and 32 from the central chamber 37 of the casing. When the valve is in this position air admitted as aforesaid through the inlet 33 and by-pass 34 to the respective chambers 31 and 32 of the casing will pass around the respective heads or ends of the valve into the respective ports 35 and 36 by the contracted portion or neck 41 and 42 of the valve and thence to the respective pipes 27 and 28. When, however, the relative positions of the valve and casing become changed, as for example, by moving the valve within the casing, then in such event the supply of air to the one or the other of the pipes 27, 28, will be cut off depending upon the direction the valve is moved, for as the valve is moved within the casing one head or the other of

the valve will draw into the one or the other of the ports 35, 36, and so will shut off the air entering that port. Moreover as one head of the valve draws into its adjacent port closing it the adjacent central body portion 43 of the valve entering that port will draw out of the same allowing the compressed air in the pipe connecting therewith and compression chamber with which the pipe connects to have outlet to the atmosphere by way of the central chamber and opening 38.

The relative position of the valve within the casing is controlled by a weighted lever or pendulum 44. It will be observed by reference to Fig. 5 that the valve casing 29 is arranged crosswise upon the outer side of the extension 22 of the pivoted frame 5. The disposition of the casing and valve within it is such also that when the pivoted frame is in its normal and proper position of suspension both the casing and valve will occupy a horizontal position at right angles to the extension 22 of the frame to which these parts are secured. The lever 44 is pivoted to the side of the extension piece 22 at a point 45 below the casing and valve. The lever is maintained in a normal upright vertical position by a weight 46 upon the lower arm thereof. The upper or working arm of the lever passes upwardly through the slot 38 in the casing and enters a socket 47 formed in the body of the valve, the end of the lever arm fitting loosely within this socket.

The disposition and arrangement of the parts are such that as long as the frame 5 to which the weighted lever is pivoted maintains its normal and proper position the lever will operate to so maintain the valve in a central balanced position within the valve casing 29 that compressed air passing through the casing as aforesaid may be directed to enter both pipes 27, 28, and thereby be admitted to both compression chambers, the diaphragms of which acting against the heads of the respective plungers will operate the same to hold both of the disks 15 and 16 in their proper working positions, or, in other words, both in contact with the disks 14 and 18.

Upon the pivoted frame 5 and gyroscope carried by it becoming changed from their normal and proper positions of suspension to occupy inclined positions, by the frame 5 turning pivotally on the hub 4, the valvular parts and weighted lever 44 will turn with it, but the lever will continue to maintain a vertical position and accordingly will act to move the valve within the valve casing in one direction or the other dependent upon the direction in which the pivoted frame 5 turns. The resultant effect is therefore obtained that as the valve is moved in the casing air will be shut off from the one or the other of the pipes 27, 28, and the pressure removed from the one or the other of the compression chambers, which accordingly leaves but one of the disks 15 and 16 in frictional working contact with the disks 14 and 18. Thereupon the influence above referred to will arise and the pivoted frame and gyroscope carried by it will be moved in a direction dependent upon which one of the disks 15 or 16 is left in working engagement with the disks 14 and 18. In this connection it will be observed that the adaptation and arrangement of the parts is such that if the pivoted frame 5 and gyroscope have become displaced from their normal positions in the direction that the disk 15 is turning then this disk is released into a disengaging position and the transmission will operate to turn the frame and gyroscope back to their normal positions. On the other hand, if the frame 5 and gyroscope become displaced in the direction that the disk 16 is turning then the disk is released into a disengaging position and the transmission will operate to turn the frame 5 and gyroscope back to its original position.

In applying the apparatus to a flying machine it is so arranged that the axis defined by the hubs 4 of the apparatus on which the frame 5 bearing the gyroscope is pivotally mounted, is arranged to lie in or parallel with the lateral or longitudinal axis of the flying machine depending as the apparatus is employed in effecting the lateral or longitudinal balance and control of the machine. When the apparatus is employed in effecting the lateral control of the machine the hubs 4 are arranged in or parallel with the longitudinal axis thereof and vice versa when the apparatus is employed for effecting the longitudinal control of the machine the hubs 4 are arranged in or parallel with the lateral axis thereof. On whatever axis the apparatus is arranged the frame 5 bearing the gyroscope and gyroscope carried by it tend to maintain their original positions or in case of displacement become restored as above described to such original position whatever the changed position of the machine may be with respect to such axis, for as the machine becomes unbalanced from its original position it will tend to turn about the axis to which the apparatus is pivoted, the portion of the machine on one side of the axis being displaced in one direction and the portion of the machine on the other side of the axis being displaced in a reverse direction. Accordingly, a portion of the machine will tend to draw toward the gyroscope and frame carrying it as another portion thereof draws away therefrom. The gyroscope or rather the frame 5 carrying it maintaining its original position, becomes a base of support to which any suitable connections or linkages may be secured and which may connect, also, with planes or

other suitable devices for controlling the machine and which become operative with a draw and thrust motion as the different parts of the machine draw toward the frame carrying the gyroscope or move away therefrom as is well known to those skilled in the art. In order to thus act as a base of resistance to the various forces which may tend to right the machine, the frame bearing the gyroscope must be maintained by a force sufficient to withstand the forces tending to displace it and right the machine. It is the gyroscope of course which tends to accomplish this by rotating in its original plane and if the gyroscope is of sufficient size and power it will operate as a base having such degree of stability as to withstand the forces tending to displace it from its original position, meaning those forces which are operating to right the machine. It may be desirable, however, not to employ a gyroscope of such size as will maintain the frame bearing it with such degree of stability that the frame itself will act as a base to withstand the reactions of a draw and thrust movement directly connecting therewith and with the planes of the machine. I have accordingly shown means whereby a relatively small gyroscopic control may be employed and which in itself acting as a constant base of resistance operates to control or set in operation other forces having a power sufficient to control the machine and which may operate with a proper draw and thrust or reverse movement sufficient to insure a proper and efficient mode of control.

The main control which I have indicated in the drawings and which is itself controlled automatically from the gyroscopic control above referred to, consists of a piston 50. This piston is arranged to be movable in a cylinder 51 and is provided with a piston rod 52 extending through the end of the cylinder. The piston is controlled by any suitable fluid pressure and preferably by compressed air which is admitted to the respective ends of the chamber of the cylinder on opposite sides of the piston by pipes 53 and 54, respectively, of which the pipe 53 connects with the forward end of the cylinder and the pipe 54 with the rear end thereof. Both the pipes 53 and 54 connect with a valve casing 55 mounted upon a block 56 arranged upon the forward end of the cylinder. The casing 55 contains a sliding valve 57 which acts to control the air under compression to the pipes 53 and 54 connecting with the cylinder. The valve casing 55 is an elongated casing, the ends thereof being designed to provide exhaust chambers 58 and 59, respectively, which connect with the atmosphere through an opening 60 leading through the wall of the casing. Extending inwardly from the chambers 58 and 59 the casing is formed to provide ports 61 and 62, respectively, while between these ports the casing is enlarged to form a central air-receiving chamber 63.

The valve 57 consists of the respective head or end portions 64 and 65, respectively, contracted portions 66 and 67, and interior portions 68 and 69, respectively. The head or end portions of the valve, 64 and 65, are arranged to slide into and out of the ports 61 and 62, and control these ports from the exhaust chambers 58 and 59 connecting with the atmosphere as aforesaid. The interior portions 68 and 69 are arranged to slide respectively into and out of the ports 61 and 62 and control these ports with respect to the central chamber 63 of the valve casing. Air under compression is admitted to the chamber 63 through an inlet pipe 70. The pipes 53 and 54, which connect with the cylinder as aforesaid, connect also with the valve casing at the points of the respective ports therein, the pipe 53 connecting with the valve casing at the point of the port 61 and the pipe 54 connecting with the valve casing at the point of the port 62. The length of the valve is such that when it is in a balanced central position as shown in Fig. 6, both of the heads, 64 and 65, of the valve will lie within the outer ends of the ports 61 and 62 closing these ports from the respective exhaust chambers 58 and 59 and from the atmosphere. The interior portions 68 and 69 of the valve will then be in a position where they will lie just adjacent the inner ends of the ports 61 and 62 but in a position whereby air admitted to the chamber 63 will enter the respective ports and thence be admitted to both pipes 53 and 54 connecting with the cylinder and accordingly be admitted to opposite sides of the piston 52, balancing the piston. When, however, the relative position of the valve becomes changed within the casing, as for example by moving the valve inwardly or in the direction indicated by the arrow thereon (see Fig. 6), the portion 68 of the valve will draw into the port 61, closing this port and the entrance of air thereto from the air-receiving chamber 63. This port being then closed, air will no longer enter through the pipe 53 which connects with the forward end of the cylinder. At the same time the end 64 of the valve will draw out of the port 61 and communication will thereby be effected between this port and the exhaust chamber 58 open to the atmosphere, providing accordingly an exhaust from the chamber of the cylinder forward of the piston backwardly through the pipe 53, port 61 and exhaust chamber 58 to the atmosphere. Pressure will still continue to be admitted through the port 62 and pipe 54 to the outer end of the cylinder, wherefore the piston 50 will be advanced within the cylinder and the piston rod 52 moved outwardly. Pre-

cisely the reverse operation occurs when the valve 57 is moved outwardly or in a direction reverse to that of the arrow indicated thereon. In such case compressed air will be excluded from the port 62, pipe 54 and the outer end of the cylinder, the air therein exhausting therefrom, as air is admitted through the port 61 and pipe 53 to the forward end of the cylinder with the effect of retracting the piston therein and withdrawing the piston rod 52. It will thus be seen that the piston rod 52 will be controlled to have a backward and forward thrust movement depending upon the relative position of the valve 57 in the valve casing, it being moved in one direction or the other as air is admitted to one end or the other of the cylinder and being held in a balanced position when air is admitted to both ends thereof.

Connecting with one end of the sliding valve 57 to extend outwardly therefrom and in extension thereof is a rod 71. This rod connects with a system of links consisting of the links 72, 73, 74 and 75. Of these links the link 72 connects with the frame 5 bearing the gyroscope. This connection is made by an arm 76 projecting downwardly from the lower bar of the frame 5 and to which the end of the link 72 is pivotally secured, preferably by means of a ball and socket joint 77, in order that the link may move freely with respect to the arm secured to the frame. The link 72 is preferably arranged to project at about right angles to the plane of the frame 5 when in its normal suspended position. Pivotally connecting with the outer end of the link 72 at the point 78 is the link 73 preferably arranged to extend upwardly at about right angles to the link 72, the link extending by the outer end of the rod 71 which has pivotal connection with this link at the point 79 about central of the link's extension. The link 74 pivotally connects with the link 73 at the point 80 and is normally arranged to extend forward from the link 73 at right angles thereto and maintain a position substantially parallel with the link 72. Pivotally connecting with the outer end of the link 74 at the point 81 is the link 75. This link is arranged to extend downwardly at right angles to the link 74 and in a position substantially parallel with the link 73. The disposition and arrangement of this link is also such that the lower end thereof will become loosely socketed between the side of the block 56 bearing the valve casing 55 and a plate 82 arranged parallel to the face of the block, spaced therefrom, and secured to the cylinder 51 (see Fig. 9). The link 75 thus socketed is arranged upon a sliding shaft 83. This shaft is arranged parallel with the piston rod 52. It extends through the block 56, plate 82 and the end of the link 75 socketed between the block and plate. The link is arranged to slide through these parts as it is moved by the piston 50, the link being secured to the piston rod 52 to move in unison therewith by means of a connection 84 which connects the ends of the respective shaft and rod outside the cylinder 51 containing the piston. As the shaft 83 is operated to slide through the end of the link 75, according to the movement of the piston, it operates to impart to the link a rocking movement corresponding relatively with the extent of its movement, this effect being obtained by means of a spiral groove 85 cut in the shaft and into which groove there projects a finger 86 from the link 75 (see Fig. 8).

The operation of these parts is as follows:—It will be observed that the series of links 72, 73 and 74 are so arranged as to be extensible and retractable, the links being extended if the cylinder 51 be moved away from the end of the arm 76 secured to the frame bearing the gyroscope or retracted upon the cylinder 51 becoming returned to its initial position. As the links are drawn out or extended draft will be applied to the rod 71 and the valve 57 moved in its casing in a direction reverse to that indicated by the arrow upon it. By such movement of the valve air will be cut off from the outer end of the cylinder 51 at the rear of the piston and allowed to exhaust. Air will continue to be admitted, however, to the inner or front end of the cylinder 51 forward of the piston. The piston will then be moved backward in the cylinder 51 by the pressure a distance which is relatively commensurate with the changed position of the cylinder with respect to the arm 76 to which the linkage is secured as aforesaid. The piston will be moved such relative amount only, for as the piston moves the shaft 83 will move with it and sliding through the end of the link 75 will rock this link and thereby, through the other connecting links, operate to restore the valve 57 to its initial balanced position when air will be admitted to both ends of the cylinder 51 and accordingly operate to hold the piston in the position to which it has been moved and which relatively corresponds, as aforesaid, with the changed position of the cylinder. It will now be assumed that the cylinder 51 is restored to its original position. The links 72, 73 and 74 will by such action be contracted. Their relative positions will have become changed, however, in such manner that as the cylinder is brought back to its original position the resulting contraction of the links will then cause the same through the shaft 71 to push the valve in the direction indicated by the arrow thereon, thereby shutting off the air from the front end of the cylinder forward of the piston, though continuing to be admitted to the rear end of the cylinder back

of the piston. The piston will then be driven forward until the rod 84 will through the link 75 have changed the positions of the links 72, 73 and 74 into their original positions when they will operate to hold the valve in a balanced position, admitting air to both ends of the cylinder and both sides of the piston therein, the piston then, in other words, assuming and being maintained in its original position within the cylinder and which corresponds with the original position thereof.

Precisely a reverse operation to that described above will occur if the cylinder be first moved inwardly from its original position (assuming the end of link 72 is held fixed as before). The links 72, 73 and 74 will become contracted and the valve 56 moved in the direction of the arrow placed thereon. Air will then become cut off from the forward end of the cylinder and front side of the piston, the exhaust therefor becoming open. Air will continue to be admitted to the other end of the cylinder at the rear of the piston which will accordingly be driven forward in an amount and to a position proportionally commensurate with the changed inward position of the cylinder. As the cylinder becomes restored to its original position, the linkage will change the valve to admit air to the forward end of the cylinder, driving back the piston to its original position in the cylinder and which corresponds with the original position thereof, the piston being maintained in such position by the compressed air admitted to both sides thereof until the position of the cylinder becomes again changed. With the parts thus operating, the piston and rod 52 carried by it will be moved inwardly or outwardly from a normal position with a backward thrust movement depending on whether the cylinder is moved outwardly or inwardly, the movements of the piston and piston rod being commensurate with the relatively changed position of the cylinder, and in either case the piston and piston rod becoming restored to their original positions when the cylinder becomes restored to such position.

By reference to Fig. 1 it will be observed that the cylinder 51 is fixed to a main supporting frame 87 to which the frame 1 of the gyroscopic apparatus is also fixed. The frame 87 may indicate diagrammatically a portion of the frame of a flying machine. According to the disposition and arrangement of the parts the pivoted frame 5 bearing the gyroscope will hang from the hubs 4 forming a part of the frame 1. The arrangement of these hubs with respect to the frame 87 is such that the axis defined by the hubs will lie in or parallel with the axis of the frame 87. Accordingly the frame 87 may turn pivotally with respect to the frame 5 and gyroscope, maintaining a normal gravitated position whatever the position of the frame 87 may be. The pivotal movement of the frame 87 with respect to the frame 5 and gyroscope may indicate the different displaced positions of the flying machine from its normal position when the machine is in flight and in a proper balance. The cylinder 51 is fixed to the frame 87 at a point laterally removed from the frame 5 bearing the gyroscope and occupies a normal position in about the same horizontal plane as that in which the end of the arm 76 lies, extending from the lower bar of the frame 5 bearing the gyroscope or, in other words, the ball and socket connection 77 to which the link 72 is secured. The series of links 72, 73 and 74 are arranged to extend at substantially right angles to the plane of the pivoted frame 5. The disposition of the cylinder 51 is also at substantially right angles to that of the extension of the links 72, 73 and 74 so that as the piston is moved within the cylinder it will operate the link 75 to properly control the other links in the manner previously described. The end of the link 72 connects with the arm 76 secured to the pivoted frame 5 bearing the gyroscope which acts as a stable base or fixture of support or a support that maintains, as before described, a normal position or becomes restored to such position in case of displacement whatever the position of the frame 87 may be. Consequently as the frame 87 becomes turned upwardly from the position indicated in the drawing, which may represent the normal balanced position of the flying machine, the links 72, 73 and 74 will thereupon, acting against the gyroscopic apparatus furnishing a stable base of support, become drawn out or extended with the resulting effect that the piston 50 is moved backward in an amount proportionate to the pivotally displaced position of the frame 87 and becomes moved forward to its original position in the cylinder when the frame 87 becomes restored to its original position. Just the reverse happens if the frame 87 becomes pivotally turned downward with respect to the axis upon which it turns. In such case the links 72, 73 and 74 become contracted with the resulting effect that the piston within the cylinder becomes thrust forward in an amount relatively proportionate to the displaced position of the frame 87 and becomes restored to its original position in the cylinder when the frame 87 is turned back to its normal position. With the parts thus operating, the piston 50 will be controlled to have a backward and forward thrust movement in a direction relatively corresponding with and proportionate to the displacement of the frame 87 and accordingly may operate to control planes or wing (not shown) which will act to correct the

displaced position of the frame 87 (assumed to be the frame of a flying machine) and will restore it to its original position or position of normal equilibrium. For such purpose the piston may be provided at the working end thereof with an eye 88 by which suitable connections may be made to the piston for operating the wings or planes (not shown) as above described.

Having thus fully described my invention, I claim and desire to secure by Letters Patent of the United States:—

1. In a gyroscopic apparatus, a gyroscope, a pivoted support bearing the same, and means whereby force may be applied to said gyroscope for rotating it and such force exert either no influence to disturb the pivoted position of said gyroscope or an influence to disturb the same dependent upon the manner of its application.

2. In a gyroscopic apparatus, a gyroscope, a pivoted support bearing the same, and means whereby force may be applied to said gyroscope for rotating it and such force exert no influence to disturb said gyroscope when occupying a normal pivoted position, but will operate to change the pivoted position thereof and restore the same to its normal pivoted position in the event of its displacement.

3. In a gyroscopic apparatus, a gyroscope, a pivoted support bearing the same, and a changeable transmission through which force is applied to said gyroscope for rotating it, said transmission having such adaptation that the force transmitted by it for rotating the gyroscope will either exert no influence to disturb the pivoted position of said gyroscope or will exert an influence to change the pivoted position thereof upon a change induced in said transmission.

4. In a gyroscopic apparatus, a gyroscope, a pivoted support bearing the same, a changeable transmission through which force is applied to said gyroscope for rotating it, said transmission having such adaptation that the force transmitted by it for rotating the gyroscope will either exert no influence to disturb the pivoted position of said gyroscope or will exert an influence to change the pivoted position thereof upon a change induced in said transmission, and means for controlling said transmission whereby a change may be induced therein for changing the pivoted position of said gyroscope and restoring it to a normal pivoted position in the event of its displacement from said normal position.

5. In a gyroscopic apparatus, a gyroscope, a pivoted support bearing the same, a transmission through which force is transmitted to said gyroscope for rotating it, said transmission comprising a series of parts adapted and arranged to the end that the force transmitted by them may either exert an influence to change the pivoted position of said gyroscope or an influence to move the same depending upon the normal or changed working relationship of said parts of the transmission to one another, and means for controlling said parts of the transmission whereby they may occupy either a normal or changed working relationship to one another depending upon the normal or displaced pivoted position of said gyroscope.

6. In a gyroscopic apparatus, a gyroscope, a pivoted support bearing the same, a transmission through which force is transmitted to said gyroscope for rotating it, said transmission comprising a series of parts adapted and arranged to the end that the force transmitted by them may either exert no influence to change the pivoted position of said gyroscope or an influence to change the same depending upon the normal or changed working relationship of said parts of the transmission, means for maintaining the parts of the transmission in normal working relationship with one another, and means controlling said transmission whereby a change may automatically be effected therein and in the working relationship of its parts upon displacement of said gyroscope from its normal pivoted position and the force for rotating said gyroscope then exert an influence through said transmission to change the displaced pivoted position thereof and restore said gyroscope to its normal position.

7. In a gyroscopic apparatus, a gyroscope, a pivoted support bearing the same, a transmission through which force is transmitted to said gyroscope for rotating it, said transmission comprising a series of parts adapted and arranged to the end that the force transmitted by them may either exert no influence to change the pivoted position of said gyroscope or an influence to change the same depending upon the normal or changed working relationship of said parts of the transmission, releasable mechanism for holding the parts of said transmission in working engagement with one another, and means for controlling said mechanism to release portions of said transmission into a disengaging position dependent upon the position of said gyroscope and pivoted support bearing the same.

8. In a gyroscopic apparatus, a frame, a gyroscope, a support for the gyroscope pivoted to said frame, a changeable transmission through which force is applied to said gyroscope for rotating it, said transmission comprising in part a rotary member carried by said pivoted support and rotating with said gyroscope, and other rotary members arranged on opposite sides of said single rotary member and carried by said frame, and other means whereby force may be applied to said gyroscope for rotating it through

both or either of said other rotary members depending upon the position of said gyroscope and pivoted support bearing the same.

9. In a gyroscopic apparatus, a frame, a gyroscope, a support for the gyroscope pivoted to said frame, a changeable transmission through which force is applied to said gyroscope for rotating it, said transmission comprising a rotary member carried by said pivoted support and rotating with said gyroscope, other rotary members carried by said frame and engaging said rotary member on opposite sides thereof, means for mounting said other rotary members to turn in the line of the axis of said pivoted support and positioned to engage said rotary member, and means for controlling said transmission whereby the force applied to said gyroscope for rotating it may be transmitted through both said other rotary members or through either of them dependent upon the suspended position of said gyroscope.

10. In a gyroscopic apparatus, a frame, a gyroscope, a support for the gyroscope pivoted to said frame, a transmission through which force is applied to said gyroscope for rotating it, said transmission having a driven rotary member rotating with said gyroscope and other rotary members having working engagement with said driven rotary member on opposite sides thereof, and means for controlling said transmission whereby force transmitted to said gyroscope for rotating it may be transmitted through all of said members when said pivoted frame and gyroscope carried by it are in their normal suspended positions, or through said driven rotary member and one or the other of said other rotary members when said pivoted support and gyroscope are occupying positions displaced from their normal position of suspension and this dependent upon the direction of their displacement.

11. In a gyroscopic apparatus, a frame, a gyroscope, a support for the gyroscope pivoted to said frame, a transmission through which force is applied to said gyroscope for rotating it, said transmission comprising a series of changeable parts adapted and arranged to the end that the force transmitted by and through them may either exert no influence to change the suspended position of said gyroscope and pivoted support, or an influence to change the same dependent upon the working relationship of the working parts of said transmission, and means for controlling said transmission whereby a change may be effected in the working relationship of its parts upon displacement of said gyroscope and support from their original positions and the force applied to said gyroscope for rotating it exert an influence through said transmission or portion thereof to change the displaced suspended position of said gyroscope and its pivoted support and restore them to their original positions, said means comprising in part an overweighted lever adapted and arranged to occupy and maintain a constant gravitated position whatever the relative position of said gyroscope and pivoted support may be.

12. In a gyroscopic apparatus, a frame, a gyroscope, a support for the gyroscope pivoted to said frame, a transmission through which force is applied to said gyroscope for rotating it, said transmission comprising a series of parts adapted and arranged to the end that the force transmitted by and through them may either exert no influence to change the normal suspended position of said gyroscope and pivoted support, or an influence to change the same dependent upon the working relationship of the working parts of said transmission, and means for controlling said transmission whereby a change may automatically be effected in the working relationship of its parts upon a displacement of said gyroscope and pivoted support from their normal suspended positions and the force applied to said gyroscope for rotating it exert an influence through said transmission or portion thereof to change the displaced suspended position of said gyroscope and pivoted support and restore them to their original positions, said means comprising in part a valvular mechanism carried by said pivoted support, an overweighted lever pivotally connected to said support and coöperating with said valvular mechanism for controlling it.

JAMES S. LANG.

Witnesses:
JOHN E. R. HAYES,
M. E. FLAHERTY.