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DIRECTIONAL INDICATION AND CONTROL

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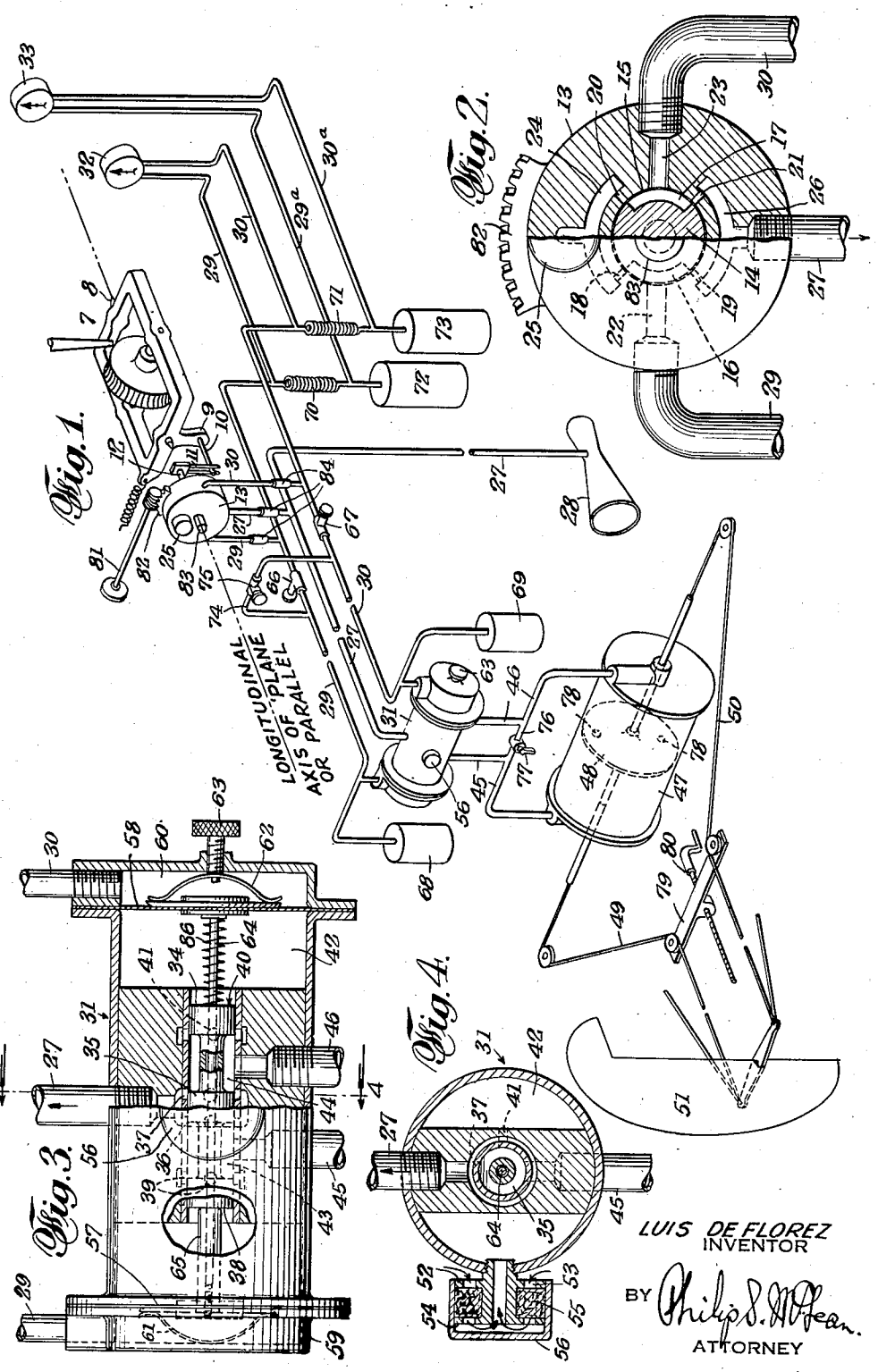


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

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DIRECTIONAL INDICATION AND CONTROL

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This invention relates to directional indication and control. More specifically, it relates to the directional indication and control of various types of moving craft and more particularly aircraft.

In view of the inherent stability characteristics, modern aircraft can be flown and maintained on a course, practically by rudder control alone.

The broad objects of this invention are to provide a mechanical system readily applicable to the modern airplane and adapted either or both to indicate deviations from course and to automatically return the ship to or maintain it on the proper course.

Various methods of control have been proposed heretofore, including electrical and pneumatic systems, and combinations of both. For the most part, these have been heavy and complicated and too expensive for ordinary adoption. Furthermore, difficulties have been experienced in the matter of over-control. If the system was sufficiently responsive, the tendency was to over-correct, calling for immediate correction in the opposite direction and setting up a "hunting" effect, causing the ship to swing first to one side and then to the other, instead of maintaining the true course.

This swinging effect is particularly pronounced with simple, pneumatic control systems, the off-course movement having a tendency to initiate a series of accelerating or ever-increasing side-to-side oscillations.

Special objects of the present invention are to provide a simple and reliable form of pneumatic equipment for control and indication purposes, inexpensive enough for general adoption and which will maintain stable on-course direction, without the objectionable hunting or swinging effect above mentioned.

The foregoing and other desirable objects are attained in this invention by the novel features of construction, combinations and relations of parts hereinafter described, illustrated in the accompanying drawing and broadly covered in the claims.

The drawing accompanying and forming part of the specification illustrates one of the practical commercial embodiments of the invention, it being understood that modifications and changes may be made as required or considered desirable, all within the true intent and broad scope of the invention.

Figure 1 is a generally diagrammatic view illustrating application of the invention to rudder control of an inherently stable ship.

Figure 2 is an enlarged broken sectional detail of the gyroscopically controlled air valve.

Figure 3 is a broken part sectional view of the booster valve controlled by the gyro valve.

Figure 4 is a broken cross sectional detail on substantially the plane of line 4—4 of Figure 3.

In Figure 1 a rate of turn sensitive instrument is indicated in the form of gyroscope 7 pivoted at 8 on the longitudinal axis or parallel to the longitudinal axis of the craft so that with turn in one direction or the other it will rock to cause the arm 9 to swing left or right. This arm carries a pin 10 engaging between parallel pins 11 dependent from rock shaft 12 journaled in casing 13 of the air control valve.

Details of the sensitive control valve are shown in Figure 2, where a valve element is indicated at 14, carried by shaft 12 and operating freely in a cylindrical valve chamber 15. This valve element is shown as having segmental recesses 16, 17, in opposite sides of the same adapted in the intermediate position shown, to register equally with top and bottom ports 18, 19 and 20, 21, as well as with the intermediate side ports 22, 23 in the valve casing. The upper pair of ports 18, 20 lead from an arcuate top chamber 24 which opens to atmosphere through a suitable air filter 25. The lower ports 19, 21 lead from an arcuate chamber 26 which is connected by suction tubing 27 with a venturi 28. The two side ports 22, 23 are connected by tubing 29, 30 with the opposite ends of the monitor or booster valve 31 and with the rate of turn gage 32 and the integrating turn gage 33.

From the description thus far it will be evident that turning of the valve element 14 by the gyro, say in a right-handed direction, Figure 2, will have the effect of fully opening port 18 and closing port 20 at the top and closing port 19 while fully opening port 21 at the bottom, resulting in the line 29 at the left being connected with atmospheric chamber 24 and cut off from suction chamber 26 and line 30 at the right being cut off from atmospheric chamber 24 and fully connected with suction chamber 26. Thus, pressure in the right-hand line will be reduced, while pressure in the left-hand line will be restored to atmospheric or approximately so. Reverse rotation of the valve element will have the reverse effect, reducing pressure in the line 29, while admitting atmospheric pressure to line 30.

The booster valve 31 is shown in Figures 3 and 4 as consisting of a piston valve element 34 having an intermediate valve head 35 controlling spaced suction ports 36, 37, and one end head 38

controlling ports 39 and an opposite end head 40 controlling ports 41. Ports 39 and 41 provide communication between the chamber 42 and spaces 43, 44, between the valve heads and respectively connected by tubing 45, 46 with the opposite ends of the servomotor cylinder 47 in which operates piston 48, connected at opposite sides by cables 49, 50 with the rudder 51. The chamber 42 in the booster valve is open to atmosphere through an air filter similar to that shown at 25, Figure 1, and consisting of a tubular stud 52 screwed into chamber 42 and having outstanding spaced perforated flanges 53, 54 with filter material 55 therebetween. A cap 56 engaged over these flanges forces the air to enter through perforations in the base flange 53, pass through the filter material and thence through the outer flange 54 and down the passage in the tubular stud into the chamber.

In the intermediate position indicated in Figure 3, the middle valve head 35 opens the suction ports 36, 37 equally to the chambers 43, 44 in communication by piping 45, 46, with opposite ends of the servomotor and the end valve heads 38 and 40 open the ports 39, 41 equally to the spaces 43, 44, so that pressure on opposite sides of the servomotor piston is equalized for holding the rudder in an intermediate position.

The valve element 34 of the booster is reversely acted on by diaphragms 57, 58 in chambers 59, 60 at opposite ends of the valve casing and connected respectively with tubing 29, 30 from the control valve. These diaphragms are shown as pressed toward each other by springs 61, 62 and the latter is indicated as adjustably tensioned by hand screw 63. A rod 64 is connected at opposite ends with the two diaphragms and extends loosely through the valve element 34. The left-hand diaphragm is shown as having a hub 65 providing an abutment for the adjoining end of the valve element and a spring 66 is shown interposed between the other diaphragm and the opposite end of the valve. By this construction the valve is enabled to move freely and smoothly under the slightest impulse from the diaphragms, one way or the other. Thus, sensitive valve movement is effected, without any binding or cramping effects from the diaphragms.

To overcome the hunting and swinging tendencies to which systems of this character have heretofore been subject, orifices or restrictions are placed in the lines and cushions in the nature of volumetric capacities are connected with the lines.

In the particular example given in Figure 1, variable orifices are located in lines 29, 30, in the form of needle valves 66, 67 and closed tanks 68, 69 are connected with the ends of these lines. In the lines 29*a*, 30*a* extended to the integrating turn gage 33, restrictions are interposed in the form of capillary tubes 70, 71 and these extended lines have the closed tanks 72, 73 connected therewith.

The rate of turn gage 32 and the integrating turn gage 33 may be simple differential gage instruments, the first subjected to the varying differential pressure in lines 29, 30 controlled by the gyro valve and showing directly the rate of turn and the second subjected to these same pressures, through the restrictions and capacity tanks and integrating the rate of turn accordingly.

In operation, as a turn is started, the gyroscope will rotate the valve element 14, Figure 2, one way or the other, to apply greater suction through one line 29 or 30 to one or the other diaphragm 57, 58 of the booster valve and to accordingly shift valve element 34, Figure 3, to variably apply suction to one side and atmospheric pressure to the other side of the servomotor piston 48 through lines 45, 46, thus to effect adjustment of the rudder for bringing the ship out of the turn and back on the course.

The rate of turn gage 32 being directly subjected to the differential pressures in lines 29 and 30 effected by the control valve, shows immediately the rate of turn and the return back to course. The flow restricting adjustable orifices 66, 67 in the lines 29, 30 reduce the rate of correction at the booster valve diaphragms sufficiently to prevent over-correction and this compensating or correctional control is further effected by the so-called vacuum accumulator tanks 68, 69, which by providing vacuum cushions, slow up the actual control movement of the booster valve and apply a corrective force, tending to restore the original on-course steering conditions. By adjustment of orifices 66, 67, the timing of these corrective forces can be accurately regulated to bring the ship back to the correct course with the desired rapidity and without appreciable or objectionable over-swing.

The effect at the integrating turn gage 33 is generally similar, the capillary tubes 70, 71 having a restrictive effect, delaying movement of the needle and the vacuum tanks 72, 73 having a capacity effect enabling this meter to integrate turn movements. As a practical example, the rate of turn indicator at 32 responding instantly to turn movements, may show immediate turns and returns to course while the integrating gage will give a straight on-course indication, constituting the average or "mean" directional movement of the plane.

The mechanism may be immediately equalized for a new course by directly connecting the two differential lines 29, 30, as by means of a cross connection 74 having a hand valve 75. Upon opening this valve the differential lines will be balanced and then with the turn to the new course manually completed by the pilot and the gyro stable on the new course, this valve may be closed to again put the gyro and pneumatic system in control.

Also, in the illustration, the servomotor may be immediately cut out of action at any time by a cross connection shown at 76, Figure 1, containing a hand cock 77 which may be turned to couple the opposite ends of the servomotor cylinder together so that piston 48 will not impede manual adjustments of the rudder. Further, to prevent this piston of the motor or power cylinder from acting as a drag in case of a sudden, necessary rudder adjustment by the pilot, said piston may have reversely acting spring closed relief valves 78 therein.

In addition, there is indicated a slacking off device 79, operable by hand screw 80 for releasing cables 49, 50, so they will exert no control over the rudder.

To adjust the system for change in course, there is indicated in Figure 1, a hand operated worm 81 engaging a worm sector 82 on the case 13 of the control valve, the latter being for the purpose mounted to rotate about the center 83 in respect to the contained valve element 14. The rubber or other flexible couplings 84 in the tubes 27, 29, 30, permit such adjustments of the valve casing. By proper setting at this point,

the control valve will be enabled to keep the plane on a straight course, or if desired, on a curved course. Equivalent results are obtainable by adjustment of the spring **62** for adjusting spring tension on the diaphragm **58**, Figure 3, of the booster valve.

While the venturi provides a desirable form of pressure creating means it will be realized that a pump or the like may be used instead as a means for creating either a negative or positive pressure for operation of the system. The booster valve is of advantage where operation of the rudder may require considerable power, but in smaller installations, the booster valve may be eliminated and the differential connections from the control valve be direct to the servomotor, for which instance the differential lines **29**, **30** may be considered as directly connected with lines **45**, **46**, instead of indirectly through the booster valve. The valved line **74** for equalizing the two differential pressure lines **29**, **30** may be considered simply as a bypass for short-circuiting the control valve lines.

I claim:

1. Automatic control for aircraft comprising a turn sensitive device, fluid pressure creating means, directional controlling means, differential fluid pressure mechanism for operating said directional controlling means, valve means operable by said turn sensitive means for differentially connecting said differential mechanism with said fluid pressure creating means, means restricting the flow between said first means and said mechanism, fluid accumulator tanks operatively connected between said first means and said mechanism.

2. Automatic control for aircraft and the like comprising in combination with a fluid differential pressure directional control motor, a fluid pressure source, means connecting said source and motor comprising differential pressure valve means interposed between said fluid pressure source and said differential pressure motor, directional sensitive means for actuating said differential valve means and means for damping said differential pressure changes including pressure differential tanks in communication with said connecting means.

3. Automatic control for aircraft and the like comprising in combination with a fluid differential pressure directional control motor, a fluid pressure source, means connecting said source and said motor comprising differential pressure valve means interposed between said fluid pressure source and said differential pressure motor, directional sensitive means for actuating said differential valve means, means restricting the flow between said first means and said motor and pressure differential accumulator tanks in communication with said connecting means.

4. In combination, a directional sensitive instrument, a pressure source, differential pressure valve means operable by said directional sensitive instrument, said pressure source being connected with said differential pressure valve means, a differential pressure gage connected for differential operation by said valve means, a second integrating differential pressure gage connected in parallel with said first gage and flow restrictive means in the connections to said second integrating gage.

5. In combination, a directional sensitive instrument, a pressure source, differential pressure valve means operable by said directional sensitive instrument, said pressure source being connected with said differential pressure valve means, a differential pressure gage connected for differential operation by said valve means, a second integrating differential pressure gage connected in parallel with said first gage and flow restrictive means in the connections to said second integrating gage, said flow restrictive means comprising capillary tubing.

6. In combination, a directional sensitive instrument, a pressure source, differential pressure valve means operable by said directional sensitive instrument, said pressure source being connected with said differential pressure valve means, a differential pressure gage connected for differential operation by said valve means, a second integrating differential pressure gage connected in parallel with said first gage, flow restrictive means in the connections to said second integrating gage and accumulator tanks in connection with said second integrating gage.

7. In combination, a pneumatic directional controlling servomotor, a pneumatically actuated booster valve connected to control said servomotor, a control valve, a venturi connected with said control valve and with said booster valve, differential pressure control lines from said control valve to said booster valve, a directional sensitive instrument governing operation of said control valve and means connected with said differential pressure lines for preventing over-control of said servomotor, including fluid pressure restrictive and accumulator means.

8. Automatic control for aircraft, comprising in combination, a fluid differential pressure directional control motor, a fluid pressure source, means connecting said fluid pressure source and said differential pressure control motor comprising differential pressure valve means and differential pressure connections between said valve means and motor, directional sensitive means for controlling said differential valve means, fluid pressure accumulator tanks of fixed capacity connected with the respective differential pressure connections and flow restrictive valve means in the individual differential pressure connections for independent adjustment of said differential pressure connections.

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