May 9, 1933. H. ALFARO 1,908,212

ROTATIVE WINGED AIRCRAFT

Filed June 24, 1931

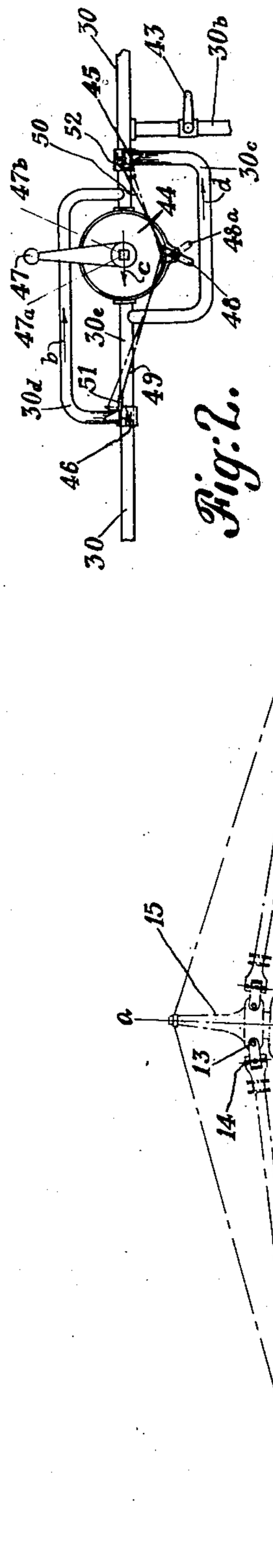

Fig: 2.

Fig: 1.

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Patented May 9, 1933 1,908,212

UNITED STATES PATENT OFFICE

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ROTATIVE-WINGED AIRCRAFT

Application filed June 24, 1931. Serial No. 546,622.

This invention relates to rotative-winged aircraft, and particularly to that type of craft in which the rotative wings are swingingly or articulatively connected to a common rotative mounting above the body of the craft in such manner that the craft is pendularly supported from the rotative surfaces, which latter are free to move individually to positions of substantial equilibrium between the major forces acting upon them in flight, whether the forward propulsion means of the craft is operating or not operating.

In the copending application of Juan de la Cierva, Serial No. 546,680, filed June 25th, 1931, there are disclosed and claimed certain general arrangements devised for the purpose of obtaining proper stability and control in various attitudes of flight, and further in said application are disclosed certain novel features of construction which involve the location of the center of gravity, considered longitudinally of the aircraft, at a point approximately intermediate the average lift line of the rotor in full forward flight and the average lift line thereof in substantially vertical descent. The present invention contemplates certain improvements over the construction shown in the aforesaid application, and in general, a novel means for improving longitudinal balance of craft of this general nature, not only under different flight attitudes and speeds but also under varying conditions of loading and of operation.

I am aware that in airplane practice it is customary to provide means for longitudinal stabilization or balance, a convenient form of which is the adjustable horizontal stabilizer, such devices being ordinarily quite adequate to longitudinal stability in an airplane owing to the fact that all heavier than air machines of the airplane type must maintain a minimum flying speed, on the average, of between forty and fifty-five miles per hour, and being incapable of normal vertical descent on a horizontal keel. In aircraft of the pivotally mounted rotative-winged type, however, in which the body of the craft is, as it were, supported from a central point, and of which vertical descent is a normal function, the conditions are totally foreign to those encountered in airplane practice.

In accordance with the invention of the aforementioned application of Juan de la Cierva, the normal center of gravity is placed slightly forward of the rotor lift line in vertical descent. I have found that conditions of loading and of operation affect the normal location of the center of gravity, and I have further found that if the center of gravity moves too far forwardly there is, in vertical descent, insufficient elevator control to hold the fuselage level and as a result the ship tends to go into a glide; whereas, if the center of gravity moves too far back it is likely that the pilot cannot bring the ship out of vertical descent, if he desires, without use of the motor. It is highly desirable that the pilot should be able, with or without power available, to place the ship into a forward glide or into true vertical descent, at will, and to accomplish this end is the primary purpose of the present invention.

The invention further contemplates the combination, in aircraft of this character, of a normal stabilizer adjustment to correct variation in aerodynamic balance for different forward speeds, and a means which shifts the actual static balance longitudinally of the craft to a degree which renders the stabilizing system capable of correcting the balance for any normal variation in loading so as to obtain perfect stability and control in all attitudes and conditions of flight. It will be readily appreciated that in the slow flight and vertical descent of which this type of machine is capable the aerodynamic action of the ordinary stabilizing plane is small as compared with the aerodynamic action of a stabilizing plane at the minimum speed of an ordinary airplane.

In addition to the foregoing, the present invention contemplates the employment, in a pendularly supported aircraft of the type referred to, of a longitudinal trimming or balance means which utilizes a transferal or movement of weight longitudinally of the craft and this in a very simple manner and by the use of simple and inexpensive equipment.

Other objects of the invention include: utilizing, for balance, the smallest weight possible, and transferring it a considerable distance so as to increase its effective lever arm with respect to the point of pendular support; employing a fluid for accomplishing the purpose, and either manual or power means for transferring the fluid; varying the weight as between two relatively fixed locations in the fuselage, so that fuselage design and structure is affected only slightly for the application and operation of the mechanism; employing the normal forward propulsion engine as a power means for moving the balancing fluid; employing fluid tank means in the system, and this in such manner that the balancing fluid itself may be in the form of a normal or a reserve supply of water, fuel, or oil; the installation of the device, as by means of small tubing, in such manner that normal structure of the machine, accessories, and installation of various parts, are not disturbed; so arranging the mechanism that either motor or manual operated transfer means may be readily controlled from the pilot's cockpit, and further so arranging the mechanism that a simple uni-directional or, alternatively, a reversible hand pump may be inserted in the system; and so combining the weight transfer system with the adjustable stabilizing surface that they are complementary to each other and both act very closely along the line of the longitudinal axis of the craft.

How the foregoing objects and advantages, together with others which may be incident to the invention, are obtained, will be evident from the following description, taken with the accompanying drawing, in which

Figure 1 is a diagrammatic or skeleton side elevational view of an aircraft of the type referred to, showing in full lines the chief elements of the present invention; and

Figure 2 is an enlarged diagrammatic detail of a modification of part of the apparatus of the invention.

In Figure 1, I have indicated, in outline, an aircraft of the nature referred to, in which the problems hereinbefore discussed are peculiarly met with, the said craft, comprising in general, a body or fuselage 2, a forward propulsion means including engine and propeller 3, 4, and alighting mechanism indicated generally at 5, 6, a rudder 7 and elevator 8, a fixed vertical fin 9, forward and rear cockpits 10 and 11, and a freely articulated, rotative sustaining unit comprising a plurality of blades or wings 12 mounted as by means of horizontal and vertical pivot pins 13, 14, upon a central rotative axis or hub structure 15, which latter is, in turn, mounted above the craft by a suitable pylon formed of legs or posts 16, 17.

The axis *a*—*a* of the rotor is, in accordance with the disclosure of the aforementioned Juan de la Cierva application, slightly rearwardly inclined in an upward direction with respect to the longitudinal axis *x*—*x* of the craft, and the design of the aircraft and of the rotor and the location and angularity of the rotor axis are all made in such manner that the normal center of gravity indicated at *g* lies close to or slightly ahead of the rotational axis line *a*—*a* which line approximately coincides with the average lift line of the rotor in normal vertical descent. It will be readily seen that differences in loading, either as to pilot and passengers in the cockpits 11 and 10, or as to baggage, fuel loads, etc., and differences in flight operation, will effect variations in the longitudinal position of the center of gravity *g*, or in the relation between the position of the center of gravity and the line of lift of the rotor.

In rapid forward flight, the pendular stability of the craft, coupled with the actuation of the rudder 7, elevator 8 and ailerons 18 will give good control; and for proper balance and stability the fixed wings 19 with their upturned tips 20, and the vertical fin 9 and stabilizer 21 will be quite effective in rapid forward flight; and to enhance longitudinal stability, in forward flight, the stabilizer 21 may be angled slightly about its pivot 22, as by means of a control mechanism such as the threaded rod 23, pulleys 24 and 25, cable 26 and crank 27.

In vertical descent, however, or in slow forward motion, both of which are peculiar to this type of craft, I may supplant, or preferably supplement, the control of the stabilizer 21 by the means now to be described.

Closely adjacent the forward and rear ends of the fuselage I provide a pair of small tanks 28, 29, the forward container or tank 28 being located in the vicinity of the engine 3 so that it may be used as a primary, or more preferably, as an emergency, fuel tank, or the like; and I have shown piping 30*a*, 30*f*, for this purpose (which latter may lead to the carburetor), controlled by valve 53, and pull-rod and control knob 54, 55. The rear container or tank 29 is located above the tail skid 6 and closely adjacent to the stabilizer 21, both tanks being also arranged close to the longitudinal axis line *x*—*x* of the craft. Tubing 30 extends longitudinally of the craft to connect the two tanks, and interposed in said tubing, at a convenient location in the pilot's cockpit 11, is a small fluid pump 31 having a manually oscillatable lever 32 and a reversing lever 33. This pump 31 may be of any suitable, reversing type, commercially available, and may be of quite small size, since the quantity of fluid to be transferred need not be great, since the tanks 28 and 29 are placed a substantial distance from the center of gravity *g* and the point of pendular support.

A still smaller pump, and a smaller ca-

pacity and lighter weight tubing may be employed, by utilizing a higher speed, power driven, pump 34, although I prefer to provide both the power driven pump and the manually operated pump, so that in the event of engine failure, complete control of balance for vertical descent may still be obtained. I have therefore shown a combination of both systems, the power and the manual, although it will be understood that in small ships, or in any other installation where minimum weight is essential, either one of the two systems may be employed separately. The circuit from the pump 34 is completed by means of tube 30*a* to tank 28, and tubing 30*b* and 30 to tank 29. Pump 34 is preferably of the rotating, rather than of the oscillating, type, so that reversal of the drive of the pump may be obtained simply by urging the rotative shaft 35 of the pump against one or the other of two opposed discs 36, 37 which are mounted on a common shaft 38 driven by the engine 3.

The pump shaft 35 may have a flexible connection to the pump and is preferably extended through a control collar 39 operated through a link 40 by the control lever 41 which is pivoted at 42 in the cockpit 11.

To operate the motor pump 34 in one direction and thus move the fluid balance means forwardly, it is only necessary to throw the lever 41 forwardly to the position *y*; and to reverse the operation it is only necessary to move the lever rearwardly to the position *z*. In other words the operation is extremely simple and rapid, and the direction of throw of the pump control can readily be made to correspond to the direction in which it is desired to throw the balancing weight, so that the motion is almost instinctive and does not require diversion of the pilot's attention from the main controls of the craft.

If it is desired, however, as in case of engine failure, to operate the reciprocating hand pump 31, it is only necessary to close valve 43 in the line 30*b*, and then, with the reversing lever 33 in forward or rear position, as the case may be, to oscillate or reciprocate the pump lever 32.

By utilizing flexible connections in the pump operating link 40, or by mounting said pump and its drive mechanism toward one side of the engine 3 where it can be driven by one of the auxiliary shafts of the engine, and by utilizing a flexible cable or chain 26 for the stabilizer 21, and especially by the utilization of small flexible or metallic tubing 30*a*, 30*b* and 30*f*, all the controls, to wit: the stabilizer crank or lever 27, the motor pump control lever 41, the shut-off valve 43, the hand pump controls 32 and 33, and the emergency fuel supply control 55, may all very readily be placed at one side or the other, or at the front, of the cockpit 11, and all in close proximity, where they can be actuated successively or alternatively, as desired, by one hand of the pilot. If preferred, the flexibility of the arrangements readily permits of locating one or more such controls on one side of the cockpit and the remainder of them on the other side of the cockpit, and in either event they can be made quite small and can readily be closely associated in a single cockpit, so as to be under common control.

Refering now to Figure 2, it will be seen that a uni-directional hand pump may readily be applied to the mechanism shown in Figure 1. In the line 30, forward of the motor pump line 30*b*, the uni-directional pump 44 is placed, in substantially the same location normally occupied by the reversible pump 31, and to provide for the reversal of fluid flow, a by-pass line 30*c* and another by-pass line 30*d* are provided. With a pump which operates in the direction of the arrow *c*, transmission of fluid forwardly is effected by placing the valves 45 and 46 in their horizontal positions to shut off the two by-pass pipes. The pump lever 47 is then reciprocated back and forth to the positions 47*a* and 47*b*. To reverse the flow the reversing lever 48 is moved to position 48*a*, which, through the intermediation of rods 49 and 50, and levers 51 and 52, which levers are fixed on the pivot pins of valves 46 and 45, respectively, the valves are swung into their vertical positions, in which they close the two ends of the pipe section 30*e* and open both by-passes. The fluid then flows, upon actuation of the pump lever 47, in the direction of the arrows *b*, *c*, *d*.

It is assumed, in the foregoing, that the motor pump pipe line 30*b* has been closed by valve 43 and that the motor pump control lever 41 is in neutral position. When it is desired to use the motor pump, the hand pump lever 47 is left in its neutral or mid position, the valve 43 is opened, and the lever 41 is moved forwardly or rearwardly, as desired.

With the motor pump device, or with either form of manual device, or by a combination of motor and manual devices, the objects and advantages hereinbefore fully set forth can be readily attained; and under normal operating conditions, the static balance means may be used for large variations in loading, the finer or "micrometer" adjustments for forward flight being obtainable by the adjustable stabilizer 21. In case of descent with a "dead" engine, however, complete adjustment for any attitude from that needed for a shallow glide to that needed for pure vertical descent, can readily be obtained by the static balance mechanism.

What I claim is:—

1. In an aircraft, a body, a freely rotative sustaining rotor mounted thereabove and having aerodynamically actuated wings pivoted for swinging movement, a separate means for forward propulsion of the craft,

by which combination various styles of flight between high speed forward flight and substantially vertical descent are obtainable, the wings having a generally upright rotational axis the lift line of which extends generally upwardly through the normal average location of the center of gravity of the craft as a whole but varies in position with different styles of flight, compartments in the craft for the reception of variable loads whereby additional variations of said lift line with respect to said center of gravity occur, weight means shiftable generally in a horizontal plane to shift the center of gravity of the body of the craft with respect to said rotor and its lift line, the effect of the weight means upon the attitude of the body of the craft being progressively greater as the vertical descent style of flight is approached, and an adjustable air surface located within the influence of airflow deflected from said rotating wings in all styles of flight and within the influence of the slipstream from the forward propelling means, the dynamic effect of said surface upon the attitude of the craft being progressively greater as the top forward speed of the craft is approached, whereby the diminishing effect of one of said means of balance is compensated for by the increasing effect of the other, with change in the style of flight, and vice versa.

2. In an aircraft, sustaining wing means, a body having its longitudinal center of gravity located approximately in the vicinity of the center of lift of the wing means, and a mechanism for controlling the longitudinal balance of the craft including longitudinally shiftable weight means, a member for controlling the shifting of the weight means, said member being movable generally fore and aft and being manually operable to shift weight forwardly upon forward movement of the control member and to shift weight rearwardly upon rearward movement of the control member, so that the balancing of the craft is effected instinctively by the pilot.

3. In an aircraft, sustaining wing means, a body having its longitudinal center of gravity located approximately in the vicinity of the center of lift of the wing means, and a mechanism for controlling the longitudinal balance of the craft including a fluid container disposed well forwardly of the center of gravity of the craft, a fluid container disposed well rearwardly of the center of gravity, means for transferring fluid in either direction between said containers, and a member for controlling the transfer, said member being manually movable forwardly to provide for the transfer of fluid to the forward container and rearwardly to transfer fluid to the rear container.

4. In an aircraft, a system of rotative sustaining wings constituting the primary means of sustension for the craft, a body normally suspended from said system in flight from substantially a single point located approximately vertically above the center of gravity of the craft as a whole, and a mechanism for controlling the longitudinal balance of the craft including a fluid container disposed well forwardly of the center of gravity, a fluid container disposed well rearwardly of the center of gravity, means for delivering fluid to and for removing fluid from said containers, and a control member for the means last mentioned arranged for manual movement in a generally forward direction to deliver fluid to the forward container and for manual movement in a generally rearward direction to deliver fluid to the rear container.

5. In an aircraft, a body, a system of freely rotative sustaining wings mounted for swinging movements in addition to their rotative movement under the influence of aerodynamic and other forces in flight, a separate means for forward propulsion of the craft, by which combination various styles of flight between high speed forward flight and substantially vertical descent are obtainable and in which construction the lift line of the rotative sustaining wings shifts to positions offset with respect to the center of gravity of the craft as a whole with changes in style of flight, and a weight balance or trimming mechanism for the craft including weight means shiftable in different directions to compensate for offsetting of the lift line as determined by the style of flight, the balancing or trimming mechanism being of progressively increasing effect as substantially vertical descent is approached whereby provision is made for accurate trimming or balancing during relatively steep and substantially vertical descent.

In testimony whereof I have hereunto signed my name.

HERACLIO ALFARO.