July 5, 1938. L. BREGUET 2,122,928

GYROPLANE

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Fig. 1

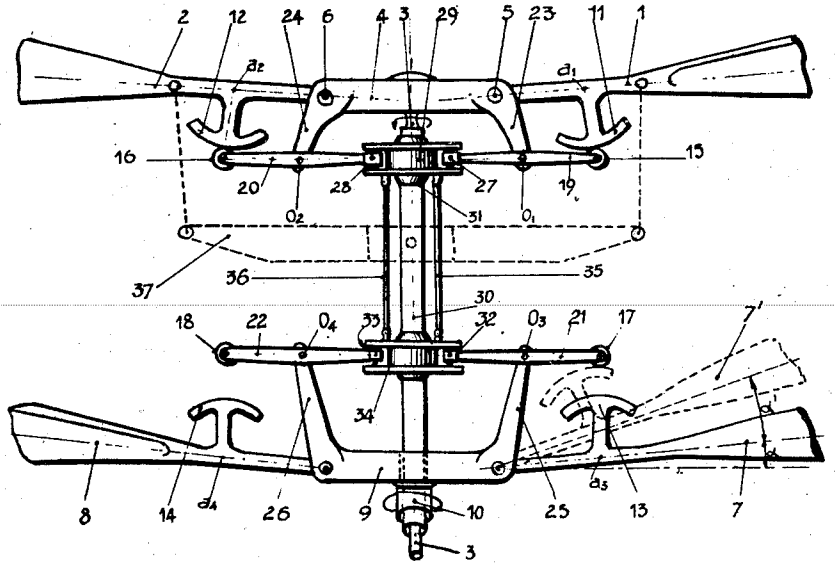
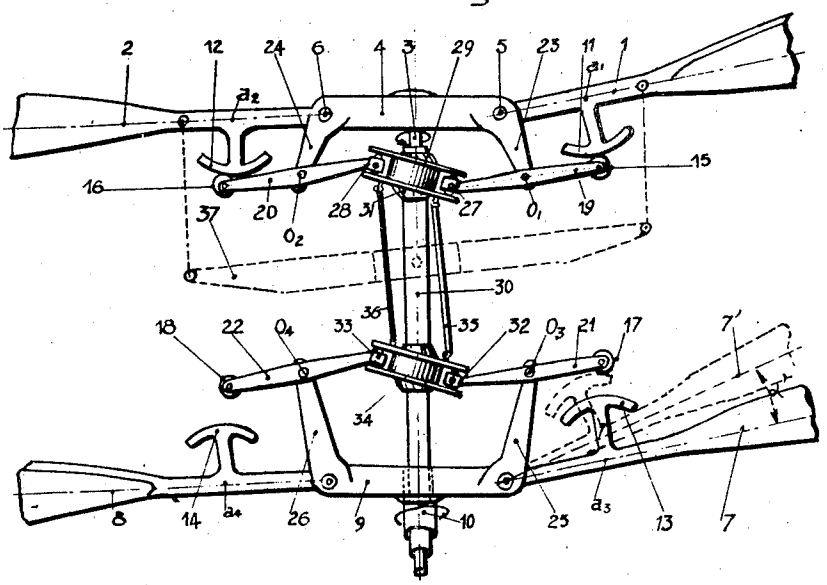


Fig. 2



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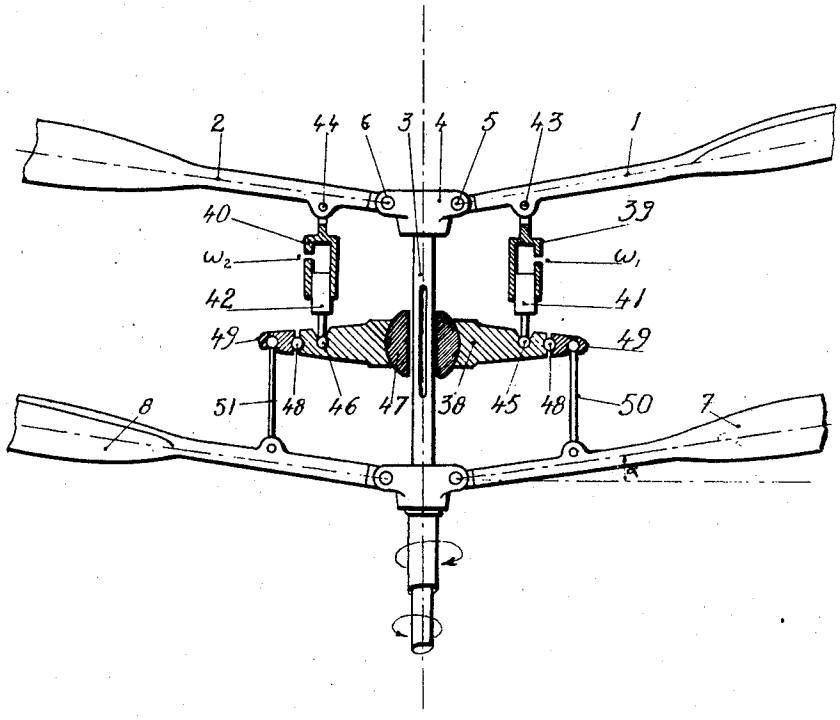
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Figure 3.



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UNITED STATES PATENT OFFICE

2,122,928

GYROPLANE

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7 Claims. (Cl. 244—17)

It is known that the revolving planes or blades of gyroplanes have a supporting, steering and propelling action, the incidences of the pivoted blades being adapted to vary periodically with respect to chosen planes of symmetry for producing the rolling and pitching effects necessary for piloting.

In addition to this imperative adjustment effected through the action of the controls, the blades undergo a self-regulating effect, such that their incidence decreases when they move above their position of rest, in accordance with a fixed ratio of control.

Consequently, these planes or blades assume a position of equilibrium under the combined effect of their inertia, of gravity, of the centrifugal force and of the aerodynamic lift, moving substantially along a cone the axis of which, under the effect of the controls, is not necessarily the same as that of the carrying shaft.

The obliquity of the cones corresponding to the movement of the respective groups of blades turning in opposite directions has for its consequence that the paths of movement of these respective groups grow nearer to each other in the upper portion of their movement, which reduces the interval of safety at their ends. Of course, it is possible to calculate and adjust the controls in such manner as to maintain a sufficient margin of safety in calm air. But, if it is considered on the one hand that the imperatively controlled vertical oscillations may be deeply perturbed by local eddies or interactions and on the other hand that these oscillations may accidentally be in resonance with the perturbing cause, it is clear that this safety interval may be further reduced and that it is desirable to provide a complementary device positively preventing any collision of the blades.

The object of the present invention is to provide a device affording this supplementary protection, while leaving the blades free to move with their normal displacement.

I might employ, for this purpose, a device constituted by circular abutments against which the blades would come to bear in case of abnormal vertical oscillations. However, account should be taken of the fact that such organs must not limit the angles of inclination of the blades with respect to fixed coordinates associated with the apparatus, but merely the negative angular displacements of the blades with respect to one another when their ends get near to one another.

When considering the function of these abutments from this point of view, it appears that they must be exactly adapted to the kinematics of the system of blades and must, in particular, be capable of being inclined and moved with respect to the axis of revolution of said system of blades. Their fixation will be extremely delicate if it is desired to take a full account of the numerous control and self-regulation elements of the gyroplane blades. Finally, in order that the angular limitations that are imposed may be accurate in all cases, these abutments must have profiles the tracing of which will involve very serious difficulties.

According to the essential feature of the present invention, these difficulties are obviated owing to the provision of a device for interrelating the respective groups of blades which transmits the thrust, through cams rigid with the blades and levers pivoted to the hub of these blades, to a system of movable annular elements or rings carried by the main shaft or its case. Said system is further adapted to permit all movements of the blade system, either controlled or not, but it imperatively opposes any negative angular displacement of the blades with respect to one another beyond a certain angle ensuring a safety margin.

Other features of the present invention will result from the following detailed description of specific embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described, with reference to the accompanying drawings, given merely by way of example, and in which:

Fig. 1 shows the revolving blades and the arrangement of the safety device according to the present invention in calm air and without any action of the controls;

Fig. 2 is a similar view, showing the same blades and the same device when the controls are being acted upon for producing a movement of the aircraft, for instance a rolling displacement thereof;

Fig. 3 shows, by way of example, a modification of the invention.

In the embodiment illustrated by Fig. 1, the upper group of blades, consisting of blades 1 and 2, turns, together with shaft 3, through the intermediate of the hub or head 4, on which said planes or blades are pivotally mounted at 5 and 6.

The lower group of blades, consisting of blades 7 and 8, is carried by hub 9 and turns in the opposite direction, together with tube or shaft 10.

The arms of blades 1 and 2 of the upper group

carry abutments or cams, of circular profile, 11 and 12, the center of curvature of which is located practically on their longitudinal axis, at a_1 and a_2. The lower blades are provided, in a likewise manner, with abutments 13 and 14, centered at a_3 and a_4.

Abutments 11, 12, 13 and 14 are respectively in contact or opposite rollers 15, 16, 17 and 18, carried by levers 19, 20, 21 and 22, pivoted at O_1, O_2, O_3, O_4, on lugs such as 23, 24, 25 and 26 carried by the hubs of the systems of blades or planes.

At the ends of levers 19 and 20, ball or roller cages 27 and 28 roll in a groove of circular element 29, which is not allowed to rotate, but can be inclined and moved axially with respect to the shaft case 30 through the sliding swivel element 31.

In a likewise manner, the ends 32 and 33 of levers 21 and 22 are engaged in a groove of annular member 34, which can be inclined and moved axially same as member 29 and is also prevented from turning.

Annular members 29 and 34 are interconnected through a plurality of rods such as 35 and 36, so that their translations and their inclinations are interrelated.

The drawings clearly show that the upward movement of the blades at the beginning of their rotary movement is necessarily combined with a downward movement of the system of annular elements 29 and 34. In Fig. 1, it is assumed that the inclination of the blades is then equal to angle α and that contact is maintained between abutment 11 and roller 15 on the one hand, abutment 12 and roller 16 on the other hand, whereas a material interval exists between abutments 13 and 14 and their respective rollers 17 and 18.

If, at this time, as a consequence of a local eddy or of any other cause, blade 7 moves upwardly and comes into position 7', having turned through a supplementary upward angle equal to α', abutment 13 comes into contact with roller 17 and tends, through lever 21 to move in a downward direction the part of annular member 34 which is located opposite it. But this downward movement is possible only if the connecting rods 35 are permitted to impart a corresponding movement to annular member 29, this movement producing a pivoting displacement of lever 19 and an upward rotation of blade 1. Therefore, the movements of two corresponding blades are associated in such manner that the angular difference α' existing between the upward displacements of these two blades remains substantially constant and that the margin of safety is preserved. Then, as the perturbing action ceases, normal working of the abutments is reestablished.

Dotted lines 37 diagrammatically show only one of the revolving plates adapted to be inclined for controlling the planes or blades of gyroplanes, clearly showing that the invention can be applied without requiring a modification of the parts described in my prior patents concerning similar machines.

Fig. 2 shows the device for limiting the vertical oscillations of the blades according to the present invention, this device being in the position it occupies when the whole of the system of blades, together with its shaft, is being inclined, for instance for imparting a rolling movement to the aircraft.

In the case shown by the drawings, blades 1 and 7 are lifted, whereas blades 2 and 8 are lowered. As a consequence of the effect of the abutments, and of the rollers and levers 11 to 22, annular members 29 and 34 are turned on their swivel parts in a direction opposed to that of the blades, while maintaining the same possibilities of relative displacement of the systems of blades as in the preceding case. But if, at this time, a blade such as 7 reaches, with respect to blade 1, the maximum relative angular displacement α' above mentioned, abutment 13 comes into contact with roller 17, lever 21 tends to move annular member 34 downwardly and, through rod 35, also to move annular member 29 in a downward direction, so that, through lever 19, roller 15, and abutment 11, blade 1 tends to be moved in an upward direction.

It should be noted that the profiles of the blade abutments 11, 12, 13 and 14 are not necessarily circular arcs.

As a matter of fact, it may be desirable to vary the margin of safety as a function of the mean position of the blades. It may be considered that there are less risks of collision at high angular velocities of the blades, when the centrifugal component has a preponderating action, and the angle of the cone traced by the blades is very obtuse, than at low angular velocities, when this component is of little importance and this angle is very variable. Such a case occurs, in particular, when starting and stopping. Furthermore, and even if it is admitted that the blades in a corresponding vertical plane remain parallel to each other, their distance decreases when the angle of said blades with a horizontal plane increases (in the upward direction). Therefore, it may be found necessary to conjugate the groups of blades without any play when this angle exceeds a given value, taken as a limit. It is even possible to utilize the device according to the present invention for artificially increasing, beyond this limit, the interval between the blades, corresponding to normal equilibrium of said systems of blades.

It suffices, for this purpose, to replace the circular profile of abutments 11, 12, 13 and 14 by a specially adapted profile, such as an arc of a conical or other curve, determined by a simple tracing.

On the other hand, Figs. 1 and 2 show that the system constituted by rollers 15 and 17 (for instance), levers 19 and 21, annular members 29 and 34, and rod 35 constitutes, in the plane of the drawings, a parallelogram the sides of which are articulated to one another, one of the sides of this parallellogram being angularly fixed with respect to the axis of the system of blades, and the small sides turning in opposite directions, each with the corresponding system of blades.

The same remark may be made with reference to Fig. 3, which shows a modification of the invention and which further discloses a shock absorbing and abutment device interposed between the blades.

In this embodiment of the invention, blades 1 and 2, which are carried by hub 4, which rotates together with shaft 3, are connected to a disc or plate 38 through cylinders 39 and 40 and pistons 41 and 52 respectively pivoted at 43, 44, 45 and 46 through hinges or pins to the blades and through swivel joints to plate 38. This plate is mounted on the central shaft through a sliding swivel 47 and turns together with said shaft.

By means of a roller bearing 48, or any other equivalent means, this plate 38 carries an annular member 49 to which the lower blades 7 and 8 are connected through rods 50 and 51 hingedly piv-

oted to the blades and connected to said annular member through swivel joints.

Plate **38** turns together with the upper set of blades, whereas annular member **49** follows the rotary movement of the lower set of blades, but their vertical positions remain always conjugated. When a blade such as **7** tends to move upwardly, plate **38**, urged by annular member **49**, tilts in the corresponding direction under the action of the connecting rod **50**. Piston **41** is driven into cylinder **39** but it does not meet with any substantial resistance because this cylinder **39** is provided with a port ω_1 which allows the compressed air to escape. According to the size of this port, the whole of the cylinder and its piston may constitute a shock absorbing device or dash-pot of a usual type. From the time when port ω_1 is stopped by the piston, an elastic abutment effect is produced, which tends to move blade **1** upwardly, that is to say to maintain between blades **1** and **7**, the minimum interval which is considered as being necessary.

In the course of the tilting of plate **38**, piston **42** may partly leave cylinder **40**, the only resistance to this movement being that corresponding to the inflow of air through port ω_2. It follows that the blades are free to move upwardly and downwardly with the only exception of the case in which the limit angular difference above mentioned tends to be exceeded, when the blades cross one another, as above explained.

My invention extends to any device ensuring the interconnection of the sets of blades through an articulated parallellogram, either real or not, this device being adapted to limit the relative vertical displacements of the blades with respect to one another when they cross one another, and producing a minimum margin of safety.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. In connection with a gyroplane including at least two sets of revolving blades adapted to turn in opposite directions respectively about a common axis and free to move in vertical planes passing through said axis, a safety device which comprises, in combination, two circular elements having each its center on said axis and correlatively movable with a translatory movement parallel to said axis and a pivoting movement about an axis at right angles to said first mentioned axis, and means for connecting said two sets of blades to said two circular elements respectively, said means being operative in only one direction of transmission of movement, so as to limit the relative angular displacements of the respective blades of the two sets toward one another.

2. In connection with a gyroplane including at least two sets of revolving blades adapted to turn in opposite directions respectively about a common axis and free to move in vertical planes passing through said axis, a safety device which comprises, in combination, two circular elements having each its center on said axis and correlatively movable with a translatory movement parallel to said axis and a pivoting movement about an axis at right angles to said first mentioned axis, and means for connecting said two sets of blades to said two circular elements respectively, said means being adapted to act in opposite directions respectively, with a predetermined play in at least one of said means, whereby the relative angular displacements of the respective blades of the two sets toward one another are limited.

3. In connection with a gyroplane including at least two sets of revolving blades adapted to turn in opposite directions respectively about a common axis and free to pivot in vertical planes passing through said axis, a safety device which comprises, in combination, two circular elements having each its center on said axis and both movable together with the same combined translatory movement parallel to said axis and pivoting movement about an axis at right angles to said first mentioned axis, means, interposed between one of said circular members and one set of blades for positively transmitting to said blades this combined translatory and pivoting movement of said member, and means, interposed between the other circular member and the other set of blades with a predetermined play, for transmitting to the second mentioned set of blades the combined translatory and pivoting movement of said second mentioned set of blades, in such manner as to limit the relative angular displacements of the respective blades of the two sets toward one another.

4. In connection with a gyroplane including at least two sets of revolving blades adapted to turn in opposite directions respectively about a common axis and free to pivot in vertical planes passing through said axis, a safety device which comprises, in combination, two parallel annular members having each its center on said axis, and both axially slidable and pivotable with respect to said axis, interconnecting means for keeping said annular members in parallel relation with each other, a hub for each of said sets of blades, arms rigid with each of said hubs located in the respective radial planes of said blades, levers pivoted to said arms and having their inner ends adapted to roll along the periphery of said annular members, and cams carried by said blades and adapted to cooperate with the respective other ends of said levers, with a predetermined normal play between the cams of one set of blades and the corresponding levers, in such manner as to limit the relative angular displacements of the respective blades of two sets toward one another.

5. A safety device according to claim 4 in which said cams are of circular outline.

6. In connection with a gyroplane including at least two sets of revolving blades adapted to turn in opposite directions respectively about a common axis and free to pivot in vertical planes passing through said axis, a safety device which comprises, in combination, a circular member having its center on said axis and mounted in an axially slidable and swivelling manner on said axis, an annular member surrounding said circular member and rotatable about it, connecting rods interposed between one of said members and one set of blades, and connecting rods, associated with shock absorbing means, interposed between the other member and the other set of blades, respectively, whereby the relative angular displacements of the respective blades of the two sets toward one another are limited.

7. In connection with a gyroplane including at least two sets of blades adapted to turn in opposite directions respectively about a common axis

and free to pivot in vertical planes passing through said axis, a safety device which comprises, in combination, a circular member having its center on said axis and rotatable together with said one of said sets of blades, said member being mounted in an axially slidable and swivelling manner with respect to said axis, an annular member surrounding said circular member and rotatable about it, connecting rods interposed between said annular member and one of said sets of blades, cylinders pivoted to the other set of blades, and pistons pivoted to the circular member, said cylinders being provided with a port at one point of their length, so as to act both as braking means and cushioning means, whereby the relative angular displacements of the respective blades of the two sets toward one another are limited.

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