June 23, 1936. R. R. HAYS 2,045,355

PITCH DIFFERENTIAL MEANS FOR LIFTING PROPELLERS

Filed April 27, 1935 2 Sheets-Sheet 1

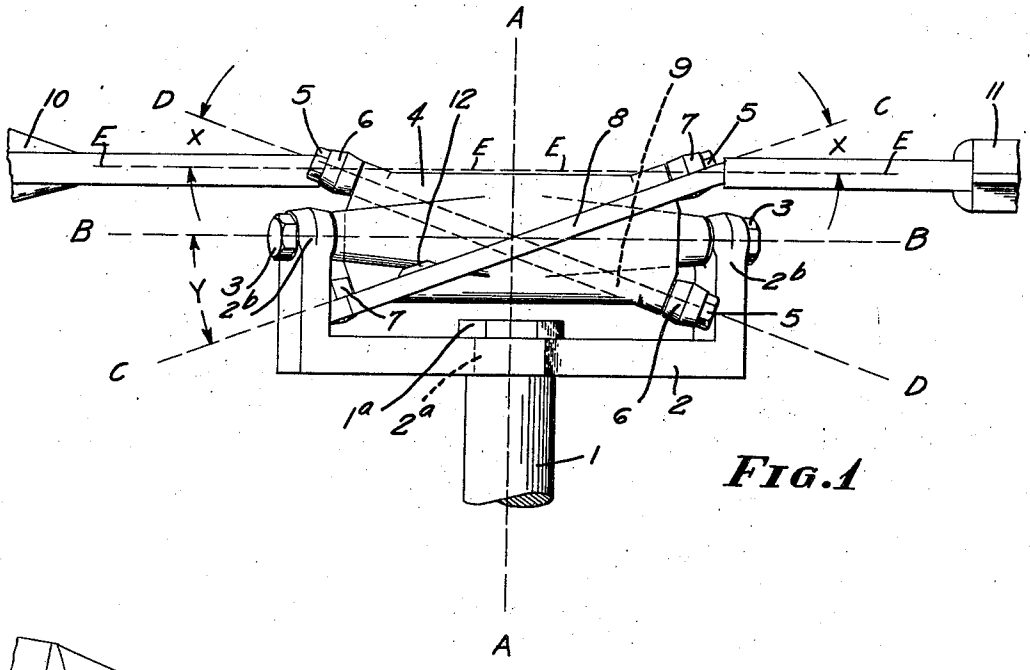


FIG. 1

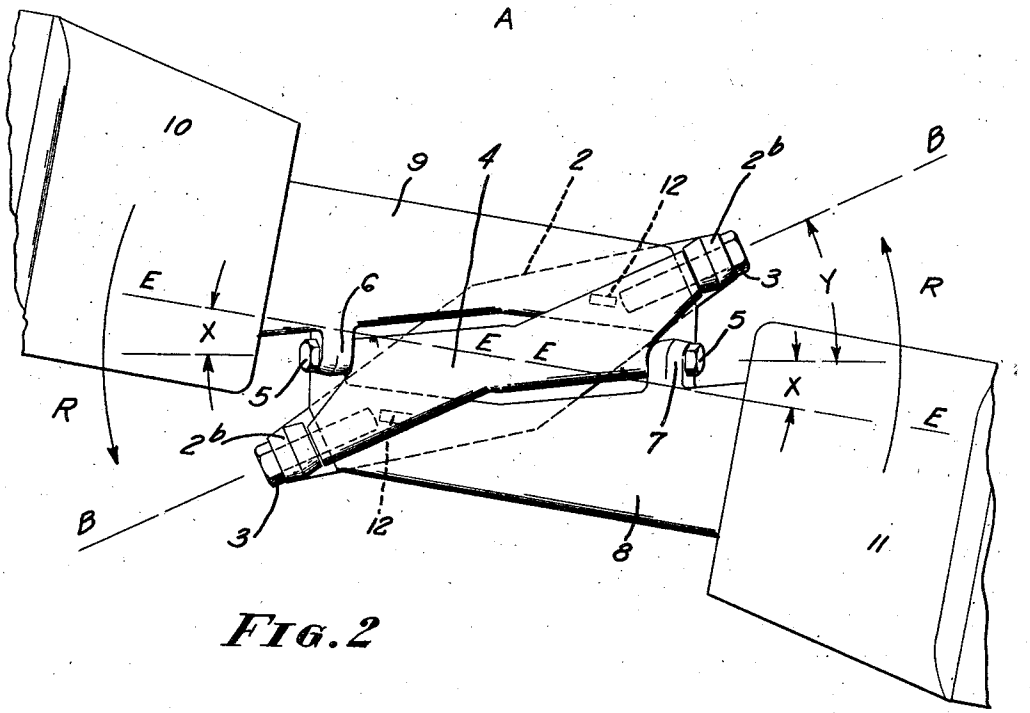


FIG. 2

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Russell R. Hays

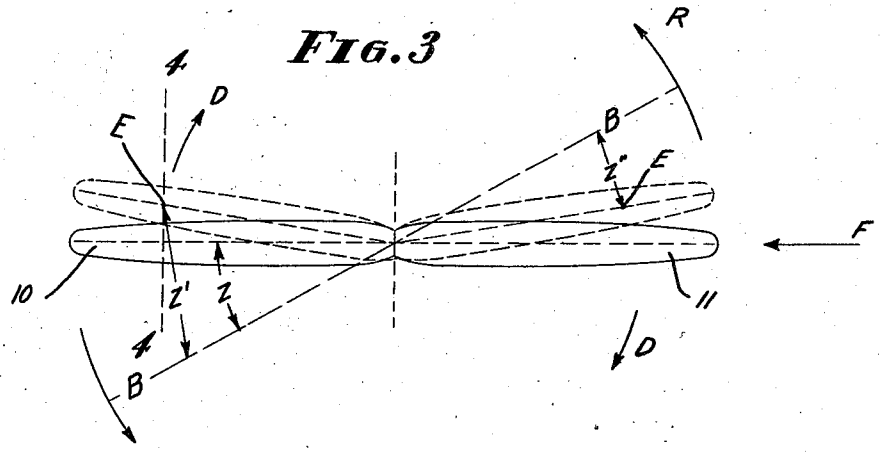
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PITCH DIFFERENTIAL MEANS FOR LIFTING PROPELLERS

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FIG. 3



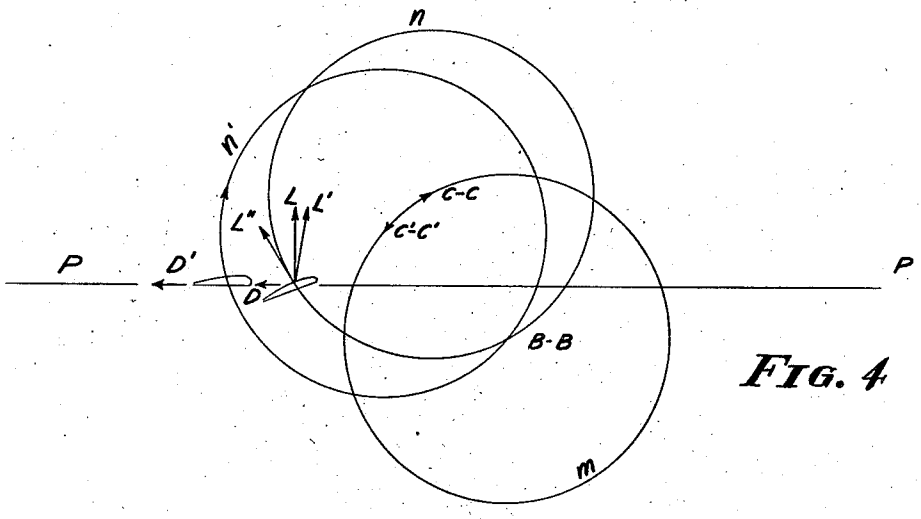


FIG. 4

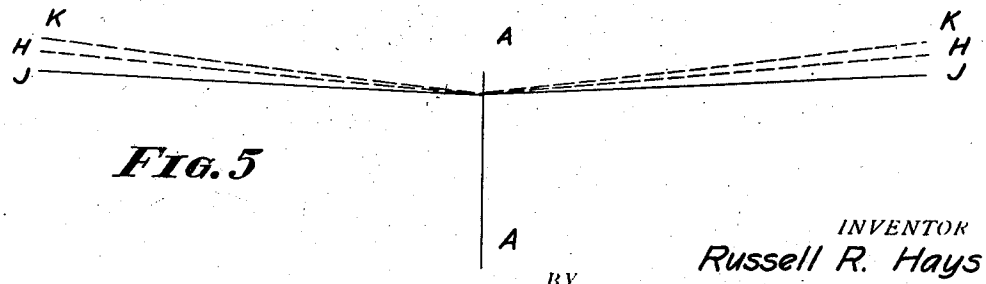


FIG. 5

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UNITED STATES PATENT OFFICE

2,045,355

PITCH DIFFERENTIAL MEANS FOR LIFTING PROPELLERS

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Application April 27, 1935, Serial No. 18,648

20 Claims. (Cl. 170—162)

My invention relates to means for varying the pitch of blades of lifting propellers at different moments of rotation, more particularly to means of effecting such variation by reason of the drag dissymmetry.

In testing articulative blades which are so mounted that variation in their lift and centrifugal equilibrium produces a feathering action, it has been found that dissymmetry of the drag of the opposed blades occurs at moments anticipating the lateral airflow dissymmetry resultant to horizontal translation. Consequently rolling and pitching moments of the propeller are reduced and its operation facilitated by utilizing this drag dissymmetry to effect pitch variations anticipating airflow variations.

With the above in mind, the objects of my invention are:

First, to provide a hinged mounting for the blades of a lifting propeller whereby they are free to oscillate within their plane of rotation and in which said oscillation automatically produces a change in their pitch;

Second, to provide a yieldable mounting for articulative blades of a rotating blade structure whereby the drag of the opposed blades is momentarily balanced across the axis of rotation and movement of this point of balance away from the axis of rotation produces a decrease in the pitch of one blade and an increase in the pitch of the opposite blade;

Third, to provide a hinged mounting for blades of this class in which the drag dissymmetry produces a dissymmetry of the blades in plan form with a consequent movement of the blades in planes perpendicular to the plane of rotation;

Fourth, to provide a hinged mounting for propeller blades which permits articulation of the blades within and at right angles to their plane of rotation, such articulation not being directly responsive to the driving torque;

Fifth, to provide a hinged mounting for articulative blades of a rotating blade structure whereby the blades are free to oscillate within their plane of rotation which results in a feathering action of the blades, such oscillation being independent mechanically of the oscillation perpendicularly to their plane of rotation, which also produces a feathering reaction of the blades;

Sixth, to provide a means that is automatically operative in case of engine failure to convert a lifting propeller having the foregoing characteristics into an auto-rotative blade structure of the gyroplane type;

Seventh, to provide a means of this class which will reduce to a minimum the vibration in the operation of propeller blades of this class;

Eighth, to provide a means of this class which will reduce to a minimum the usual extreme stresses in connection with propeller blades of this class; and

Ninth, to provide a means of this class which is very simple and economical of construction, efficient in its action, durable, and which will not readily deteriorate or get out of order.

With these and other objects in view as will appear hereinafter, my invention consists of certain novel features of construction, combination and arrangement of parts and portions as will be hereinafter described in detail and particularly set forth in the appended claims, reference being had to the accompanying drawings and to the characters of reference thereon which form a part of this application, in which:

Figure 1 is a side elevational view of my differential hinge structure shown in connection with a fragmentary portion of the propeller blades and showing the varying axial lines diagrammatically; Fig. 2 is a top or plan view of the same; Fig. 3 is a diagrammatic plan view of a propeller differentially mounted showing the varying positions of the blades resultant to drag dissymmetry; Fig. 4 is a diagrammatic sectional view taken along the line 4—4 of Fig. 3 illustrating the pitch variation occurring by reason of the movement of the axes of the differential, and Fig. 5 is a diagrammatic view showing the limitation of the coning angle resultant to engine failure whereby the propeller is converted into an auto-rotative blade system.

Similar characters of reference refer to similar parts and portions and diagrammatic relation throughout the several views of the drawings.

Referring to Figs. 1 and 2 of the drawings, there is provided a drive shaft 1 which is rigidly secured to a head bracket member 2 by means of a reduced portion 2*a* extending through a conforming hole in the member 2 and upon which is mounted a nut 1*a*. This bracket 2 is provided with upwardly extending journal portions 2*b* in which are mounted journal bolts 3 which may be tap bolts rigidly screwed into the differential bracket 4 which differential bracket is free to rotate about a main horizontal axis B—B to the center of the journal bolts 3, said axis B—B being at right angles to and intersected by the axis A—A of the drive shaft 1. This differential bracket 4 is substantially a rectangular piece of metal, the shorter axis of which coincides with the axis A—A of rotation, and the longer axis of

which is intersected by and makes an acute angle equal to the value of Y, as shown in Fig. 2, with the axis B—B rearwardly to the propeller's direction of rotation R. Each of the corners of the rectangular bracket member 4 carries a journal bolt 5 alined with the diagonals of the rectangle and comprises axes C—C and D—D for the hinge members 8 and 9 which are held by the hangers 7 and 6, respectively. The axes C—C and D—D make acute angles Y with the main horizontal axis B—B rearwardly and downwardly. The outer ends of the hinge members 8 and 9 extend from the upper hangers and are secured to the propeller blades 10 and 11 in such a manner that the longitudinal axes E—E of the blades form an acute angle X with the axes C—C and D—D downwardly and forwardly. Consequently the blades 10 and 11 are free to rotate about the axes C—C and D—D downwardly until the hinge members contact the differential bracket 4, and upwardly until their movement is arrested at auto-rotative attack angles by reason of the projections 12 on the hinge members 8 and 9 contacting the differential bracket 4, shown best in Fig. 1 of the drawings.

It will be here noted that all the parts and portions are symmetrically disposed and the positioning of the blades 10 and 11 is such that they have an effective attack angle when in equilibrium between the lift and centrifugal forces generated by rotation with the driving torque. In this instance the angle Y has a value equal to the angle X but it is obvious that it may have a greater or less value. The axes C—C and D—D may be set slightly apart, or the axis B—B raised or lowered relatively to them without departing from the general structure disclosed.

The operation is as follows: It is obvious that where the inflow of air is uniform the equilibrium of the blades will remain constant and hence there will be no oscillation. However, with translation, the inflow ceases to be uniform and consequently the lift on the blade advancing in the direction of the air motion increases, whereas that on the retreating blade decreases. When this occurs the consequent movement of the blade is about the axis B—B rather than either the axis C—C or D—D since the lift L of the blades, shown best in Fig. 4, has a more nearly vertical component L' and hence leverage effect to the axis B—B, than the component L'' to the axis C—C. Therefore, since the longitudinal axis E—E (see Fig. 3) of the blade has a sweepback angle Z to the axis B—B in plan form, Fig. 3, a feathering action results as is well known in the art with a consequent tilting of the plane of rotation P—P, Fig. 4. Simultaneously with the creation of such feathering action the differential bracket 4 becomes effective. The primary reaction is that due to feathering the drag on the blades at rearward moments of rotation becomes greater than the drag at forward moments, hence destroying the equilibrium relative to the center point of the differential bracket and consequently producing rotation of the bracket in the direction of the rearwardly working blade.

With such rotation of the differential bracket, the axes C—C and D—D describe a conical path about the axis B—B in opposite directions relatively to the direction of rotation of the attached blades 10 and 11. At the same time the longitudinal axes E—E of the blades having sweepback to the axes C—C and D—D also describe conical paths relatively to the latter. Due to the fact that the blades are held in their plane of rotation by lift and centrifugal forces and since movement at right angles to the lift is confined to this plane, it will be seen that rearward movement of the blade, Fig. 3, produces rotation of the axis C—C about axis B—B along a path M Fig. 4 to a point C'—C' and at the same time a counter rotation of the blade axis E—E about the axis C—C along a path N which has moved back to the position N' with a consequent decrease in pitch. At the same time the reverse rotation of axes takes place on the opposed blade with resultant increase in pitch.

The secondary reaction of the differential bracket results from the fact that by this arrangement of axes rearward movement of one blade produces a corresponding forward movement of the opposite blade, thus the angle Z, Fig. 3, increases to Z' on the rearwardly working blade, whereas the angle Z decreases to Z'' on the forwardly working blade. Consequently the lift L of the former blade has a greater leverage effect relatively to the axis B—B than the lift on the latter, thereby producing rotation of the propeller about the axis B—B with a resultant decrease in the pitch of the rearward blade and an increase of the pitch in the forward blade.

Inasmuch as the greatest lift dissymmetry on a lifting propeller in translation occurs at lateral moments of rotation, whereas the greatest drag dissymmetry occurs at longitudinal moments of rotation, and since as a result of lag, means responsive to either dissymmetry persist over a quarter of a revolution, it is readily apparent that pitch variation which anticipates airflow variation will greatly reduce pitching and rolling moments of the propeller as well as increase its efficiency.

In the case of engine failure and with the use of an over-running clutch as is conventional in the art, the equilibrium of the blade changes thereby increasing its coning angle. With the use of small values of angles X, Figs. 1 and 2, such an increase in the propeller's coning angle throws the pitch into extreme negative angles, therefore the projections 12 on the hinge members 8 and 9 are utilized to restrict this coning at a point giving an effective auto-rotative pitch setting of the blades. Thus as shown in Fig. 5, the normal coning pitch J—J of the blades would tend to increase to K—K but is restricted at the position H—H. This in effect locks the action of the differential bracket as responsive to the drag dissymmetry and consequently the propeller is automatically converted to a rigid blade structure of the gyroplane type as is well known to the art.

From the foregoing description it will be seen that I have provided a selective differential for an articulative blade of a rotating blade structure whereby variation of the airflow encountered by the blade at different moments of rotation produces rotation of the elements about three separate axes. It is obvious that such a means is capable of broad modification, as for instance, a rearrangement of the three axes to permit the use of more than two blades, or for use with a freely rotative blade structure thereby facilitating feathering, reducing lag, and making it non-gyroscopic; therefore, I do not wish to be limited to the particular construction, combination and arrangement of parts and portions as hereinbefore described, but desire to include in the scope of my invention the construction, combination and arrangement substantially as set forth in the appended claims.

Having thus described my invention, what I

claim as new and desire to secure by Letters Patent is:

1. In a pitch differential means for lifting propellers, a main bracket member provided with a main horizontal axis and axes at acute angles thereto.

2. In a pitch differential means for lifting propellers, a main bracket member provided with a main horizontal axis and with axes at acute angles thereto, a journal bracket journaled on said main bracket member at the main horizontal axis thereof.

3. In a pitch differential means for lifting propellers, a main bracket member provided with a main horizontal axis and with axes at acute angles thereto, a journal bracket journaled on said main bracket member at the main horizontal axis thereof, and propeller blades mounted on said acute angle axes in opposed relation to each other.

4. In a pitch differential means for lifting propellers, a main bracket member provided with a main horizontal axis and with axes at acute angles thereto, a journal bracket journaled on said main bracket member at the main horizontal axis thereof, and propeller blades mounted on said acute angle axes in opposed offset relation to each other.

5. In a pitch differential means for lifting propellers, a main bracket member provided with a main horizontal axis and with axes at acute angles thereto, a journal bracket journaled on said main bracket member at the main horizontal axis thereof, and propeller blades mounted on said acute angle axes in opposed relation to each other, said propeller blades arranged to engage said main bracket member to limit the feathering action of said blades.

6. In a device of the class described, a main bracket member provided with a central normally horizontal axis and with a plurality of axes intersecting said central axis at acute angles to each other.

7. In a device of the class described, a main bracket member provided with a central normally horizontal axis and with a plurality of axes intersecting said central axis at acute angles to each other, means for supporting said main bracket member on a normally horizontal axis.

8. In a device of the class described, a main bracket member provided with a central normally horizontal axis and with a plurality of axes intersecting said central axis at acute angles to each other, means for supporting said main bracket member on a normally horizontal axis, propeller blades pivotally mounted on said second mentioned axes in opposed relation to each other.

9. In a rotative blade structure for aircraft, means for universally mounting the blades comprising a plurality of axes, one of which is fixed in its position relative to the axis of rotation of the structure, and a bar journaled for movement about the first axis carrying a second axis on which is pivotally mounted the blade.

10. In a rotative blade structure for aircraft, means for universally mounting the individual blades comprising a plurality of axes forwardly disposed to the blade, one of which is fixed relative to the axis of rotation, a bar journaled for movement about the first axis carrying a second axis to which is hinged the blade, this axis lying between the first axis and the longitudinal axis of the blade, and making an acute angle with the plane defined by the last two axes.

11. In a rotative blade structure for aircraft, means for differentially mounting the blades comprising a plurality of axes, a fixed axis forwardly disposed to the lift line of the blades providing a pivot for simultaneous movement of opposed blades at right angles to their plane of rotation, a bar pivoted to the fixed axis and carrying symmetrically disposed axes to which are pivotally mounted opposite blades.

12. In a rotative blade structure for aircraft, means for differentially mounting the blades comprising a plurality of axes, a fixed axis forwardly disposed to the lift line of the blades providing a pivot for simultaneous movement of opposed blades at right angles to their plane of rotation, a bar pivoted to the fixed axis and carrying symmetrically disposed axes to which are pivotally mounted opposed blades, these latter axes making acute angles with each other, with the fixed axis, and with the longitudinal axes of the attached blades.

13. In a rotating blade structure for aircraft, means comprising a plurality of oblique axes for universally mounting the individual blades for simultaneous movement in a plane at right angles to articulative movement of the blades.

14. In a rotative blade structure for aircraft, means for universally mounting articulative blades comprising a plurality of oblique axes vertical planes through which make acute angles.

15. In a rotative blade structure for aircraft, means for differentially mounting articulative blades comprising a plurality of oblique axes vertical planes through which make acute angles.

16. In a rotative blade structure for aircraft, means for universally mounting articulative blades comprising a plurality of oblique axes, and differential means responsive to the first means.

17. In a rotative blade structure for aircraft, means for universally mounting articulative blades comprising a plurality of oblique axes vertical planes through which make acute angles, differential means responsive to the first means.

18. In a rotative blade structure for aircraft, means for universally mounting the individual blades comprising a plurality of oblique axes forwardly disposed to the lift line of the blade relative to its direction of rotation.

19. In a rotative blade structure for aircraft, means for universally mounting the blades comprising a plurality of oblique axes forwardly disposed to the center of pressure of the blade, means arranged for relative movement of these axes coincident with fore and aft movement of the blade within its plane of rotation.

20. In a rotative blade structure for aircraft, means for differentially mounting the blades comprising a plurality of oblique axes, and means operative to rotate the blades about their longitudinal axes with relative fore and aft movement within their plane of rotation.

RUSSELL R. HAYS.