Oct. 4, 1932. W. P. VAN LAMMEREN 1,880,302

PROPELLER FOR HELICOPTERS

Filed Nov. 27, 1930 2 Sheets-Sheet 1

Fig. 1

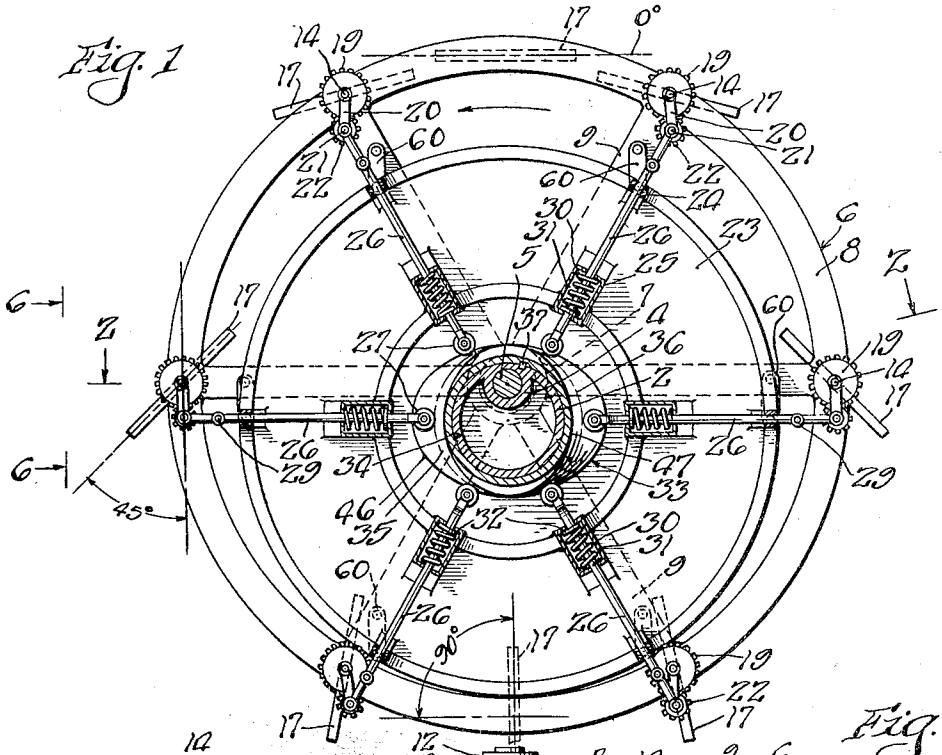
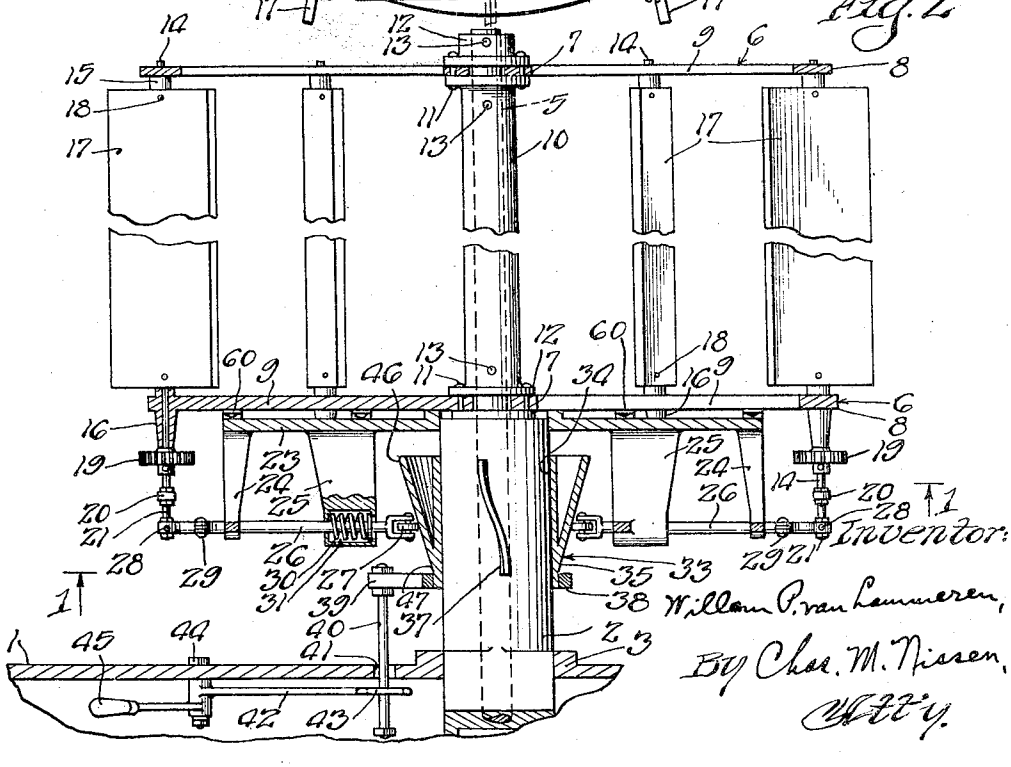


Fig. 2



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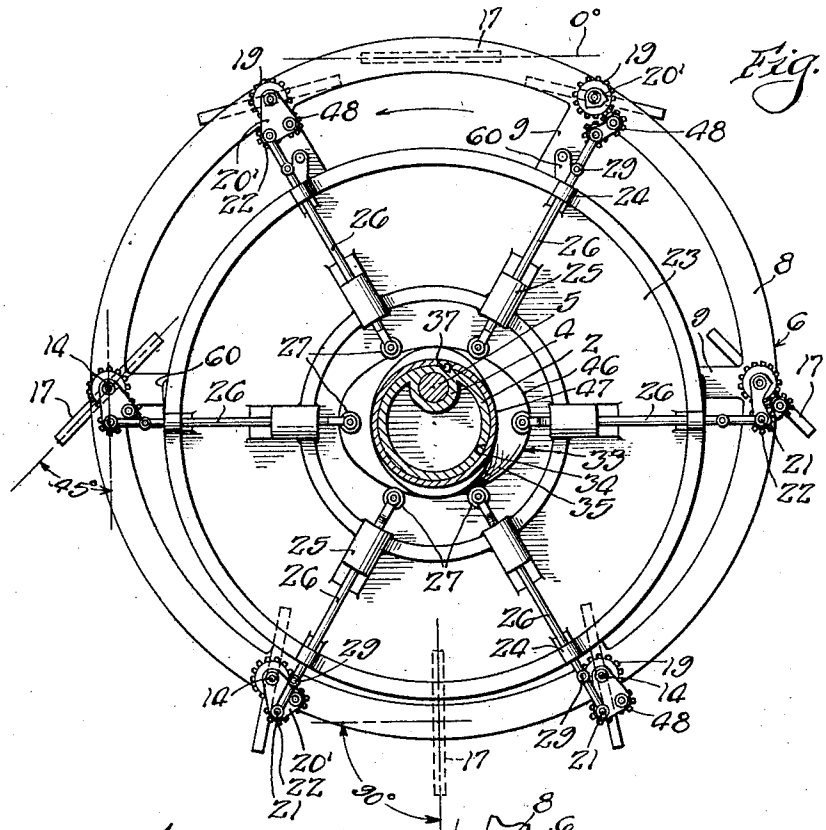

Fig. 3

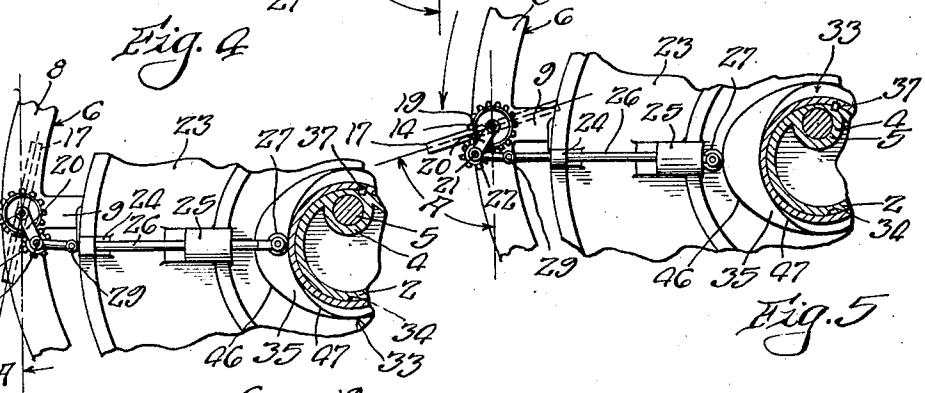

Fig. 4

Fig. 5

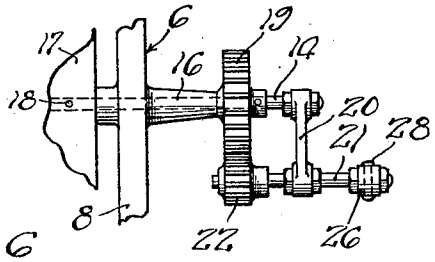

Fig. 6

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1,880,302

UNITED STATES PATENT OFFICE

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PROPELLER FOR HELICOPTERS

Application filed November 27, 1930, Serial No. 498,518, and in Great Britain December 3, 1929.

This invention relates to propellers of the type comprising symmetrical blades or wings rotatably mounted on axes disposed around a common axis about which the rotary propeller is rotatable as a unit.

One object of the present invention is to provide means for feathering the blades or wings during the rotating of the propeller for effective driving purposes in a single direction.

According to the present invention the propellers are each provided with one or more symmetrically shaped blades or wings and with means for feathering the blade to give the same a positive angle of incidence, which increases from zero to a right angle during one-half of the rotation of the propeller, and during the other half of the rotation there is a negative angle of incidence which decreases from a right angle to zero. The increase may be from an angle slightly more or less than 0° to an angle of more or less than 90°.

In order to best carry out the feathering movement, it is necessary to impart a varying angular movement to each blade relative to the uniform movement of the rotary propeller. Moreover, if the rotating of the propeller is in a clockwise direction, the rotation of the blades should be in an anti-clockwise direction and vice-versa.

Another object of this invention is to provide a means whereby the variation of the positive and negative angles of incidence of the blades may be changed. For example, the angles may increase or decrease more or less rapidly in the first part of their respective half revolutions than in the latter part thereof.

More specifically my invention has for its object the provision of means which will impart a small reverse movement to each blade during its stroke in the direction in which the propeller moves bodily, or is to be moved, the said reverse movement corresponding to a decreasing negative angle of incidence during the first part of the said stroke, and an increasing positive angle of incidence during the second part of the said stroke. The propeller as a whole is bodily movable in the direction in which the helicopter moves, or is adapted to be moved under the influence of the propeller. During the stroke of the blade in the direction opposite to the aforesaid direction of bodily movement of the propeller, a comparatively large reverse movement is imparted to the blade corresponding to the amount of movement required in order to keep the blade at right angles or substantially at right angles to the said direction of bodily movement.

Another object of this invention is to make the propeller blades symmetrical in view of the fact that each blade rotates 180° about its own axis during one complete rotation of the propeller.

Still another object of this invention is to provide a cam operating on an eccentric rod and gearing to rotate the blades about their own axes during the rotation of the propeller about its axis. Preferably the cam comprises a plurality of portions having different cross-sections, the various portions merging into each other to form a unitary cam. At one point along the cam the same is substantially circular in cross-section, but the portions on each side of the portion having a circular cross-section are elliptical in shape, and the ellipses on opposite sides of the portion having a circular section, have their major axes at right angles to each other.

Mechanism is provided for shifting the cam to present different portions of the cam surface to the eccentric rods which, together with the gearing, rotate the blades. My invention also contemplates moving a cam about its axis, either simultaneously with the movement in the direction of its axis, or independently of that movement. This arrangement enables me to vary the direction of the driving force exerted upon the propeller by the helicopter or like machine to which it is fitted.

Other objects of this invention will appear hereinafter as the description thereof proceeds, the novel features and combinations being set forth in the appended claims.

In the drawings—

Fig. 1 represents an elevational view of a propeller for a helicopter or like device embodying my invention, the view being taken

substantially along the line 1—1 of Fig. 2;

Fig. 2 is a cross-section taken along the line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1 showing a modified arrangement for my device;

Figs. 4 and 5 are fragmentary views of portions of the mechanism shown in Figs. 1 and 2, but show the parts in a position of adjustment slightly different than that illustrated in Figs. 1 and 2; and

Fig. 6 is a view looking in the direction 6—6 of Fig. 1.

The reference numeral 1 indicates the fuselage of a helicopter or like device to which my invention is to be applied, it being understood that generally speaking there will be at least two units such as illustrated in the drawings, one on each side of the fuselage. This arrangement is shown clearly in Fig. 3 of my Patent No. 1,772,119 granted August 15, 1930.

A tube 2 mounted in a bearing 3 of the fuselage has an eccentric bearing 4 therein adapted to rotatably support the main driving shaft 5 upon which the propeller blades of the helicopter are carried.

The shaft 5 supports the framework 6 which comprises inner and outer rings 7 and 8 and radial struts 9. There are two frameworks 6, each of which is in effect a wheel with six spokes 9, a hub portion 7 and a rim portion 8. The frameworks 6 are spaced from each other by a tubular member 10, and rivets 11 or like fastening means pass through the hub portions 7 and flanges on the ends of the tube 10 through the bearing members 12 to clamp the frameworks 6 in adjusted position relatively to each other. Pins 13 pass through the tube 10 and bearing members 12, and also through the shaft 5 to cause the frameworks 6 to rotate in unison with the shaft 5. Any suitable mechanism may be used to rotate the shaft 5. Shafts 14 are rotatably mounted in bearings 15 and 16 on the frameworks 6, and propeller blades 17 are symmetrically arranged on the shafts 14 and are secured thereto by fastening means such as the rivets 18 or the like. The blades 17 are symmetrical with respect to the shafts 14, both in shape and in the amount of each blade which extends on either side of the shaft. This is for a purpose which will appear later.

To one end of each of the shafts 14, I secure a gear 19. One end of a link 20 is rotatably mounted on the shaft 14 between two nuts 15 as illustrated in Fig. 6. The other end of the link 20 rotatably receives the short shaft 21 to which is secured a pinion 22 which is one-half the diameter of the gear 19.

Rotatably mounted upon the tube 2, is a circular plate 23. Links 60 pivoted to the arms 9 and to the circular plate 23 constrain the frameworks 6 and plate 23 to rotate in unison with each other although about different axes. Upon the plate 23 are mounted the arms 24 and 25 which extend in a direction substantially parallel of the axis of the tube 2. Each of the arms 24 and 25 has openings therein at the outer ends thereof acting as bearings for the slidable rods 26. Each slidable rod is provided with a roller 27 rotatably mounted on its inner end, and each of the rods is secured by means of a pin 28 to the shaft 21. The rods 26 are preferably made in two sections pivoted together at 29 so as to permit a certain amount of lateral movement of the outer end of the rod, and for a purpose which will appear later.

Springs 30 surround the rods 26, and are arranged within the openings 31 which are provided in the outer ends of the arms 25. Each of the springs 30 abuts against that portion of the arm 25 which forms a bearing for the rod 26. The other end of each spring abuts against a collar 32 secured to the rod 26 about which the spring is arranged.

On the tube 2 is mounted a cam member 33. This cam member has a bearing surface 34 which fits the outer surface of the tube 2, and a cam surface 35 which has the following shape: The central portion or the portion substantially at the center of the cam surface 35 is circular in cross-section as indicated by the dotted line 36 in Fig. 1. The cam surface is adapted to be engaged by the rollers 27 and control the positions of the rods 26.

The cam changes its shape towards the opposite ends thereof, the opposite end portions being ellipses, with the major axes of the ellipses on opposite sides of the central portion 36, at right angles to each other. The various sections of the cam merge into each other so as to form a continuous surface on the cam thereby enabling the cam to be shifted longitudinally of its axis while the propeller is in action.

Preferably, but not necessarily, I provide means for rotating the cam about the tube 2 at the same time that I shift the cam longitudinally of its axis. This means comprises a spline 37 on the tube 2, and a corresponding groove in the bearing portion 34 of the cam as was best illustrated in Fig. 2. The spline is substantially helical in shape, thereby causing the cam to rotate about the tube 2 when the cam is shifted longitudinally of the tube, or if the cam is rotated, then the spline will cause a longitudinal movement of the cam along the tube.

In order to shift the cam, I secure a collar 38 to one end of the cam. This collar is provided with an arm 39, having a laterally extending rod 40 extending through an arcuate slot 41 in the fuselage. An arm 42 having a forked end 43 straddling the rod 40, is pivoted at 44 to the fuselage, and is operated by means of the handle 45 or the like. The rocking of the arm 42 causes a corresponding rocking movement in a reverse di-

rection of the arm 39. This rotates the cam in a corresponding direction, and as the cam is rotated, it slides longitudinally of the tube 2. The cam may also be shifted by exerting a pull or push on the rod 40 in the direction of the axis of the cam. It is within the scope of my invention to provide a straight spline 37 parallel to the axis of the cam, or reverse the helix of the spline to cause the cam to rotate in the opposite direction.

The operation of my device is as follows:

The framework which supports the blades is caused to rotate by rotating the shaft 5, and the tube 2 is correspondingly rotated at the same speed as the shaft 5. We will assume to begin with, that the cam is adjusted so that the rollers travel about the circular portion 36 thereof. Since the framework 23 has the same axis as the axis of the cam, it will be ssen that when the rollers travel along the portion 36 of the cam, that the rods 26 will not move inwardly or outwardly with respect to the axis of the tube 2, as the springs 30 hold the rollers 27 in engagement with the cam at all times. The length of each link 20 is the same as the distance between the center of rotation of the shaft 5 and the axis of the tube 2. This arrangement causes the links which connect the blades to their respective rods, to remain parallel to each other during the entire rotation of the propeller. As illustrated in Fig. 1, the blade occupies a horizontal position when it is directly above the shaft 5, and has a 0° angle of incidence with the path through which its center of rotation travels, this path being a circle having its center at the center of the shaft 5. My invention contemplates having the angle of incidence approximately 45° when the blade reaches the extreme left hand position of its travel when the rollers are traveling over the circular portion of the cam. The angle of incidence of the blades at their lowermost position is 90°. This angle of incidence continuously changes from 0° to 90° and then from 90° back to 0 during the last half of the rotative movement of the propeller about the shaft 5 as is clearly illustrated in the drawings. During a complete rotation of the propeller, each blade rotates 90° about its own axis thereby necessitating the symmetrical arrangement of the blades described previously, as the second revolution of the blades is exactly the same as the first.

With this arrangement, it will be seen that the rotation of the propeller causes the propelling of the helicopter or other device in a direction toward the left. A reverse rotation of the propeller unit causes a movement of the helicopter to the right.

When the cam is shifted so as to move the same longitudinally of the shaft in a downward direction as viewed in Fig. 2, the large elliptical portion 46 of the cam is brought into alignment with rollers so that when the blades are at the extreme left hand position, the rollers are moved outwardly against the action of the springs in the manner illustrated in Fig. 5, thereby increasing the angle A to more than 45°. Similarly when the cam is shifted in the opposite direction, the smaller elliptical portion 47 is brought into alignment with the rollers and when the blades are at the extreme left hand position, the angle A is less than 45° as is illustrated in Fig. 4. Of course, it will be understood that there is a gradual increase of the angle of incidence from the uppermost position to the extreme left hand position, and that thereafter there is an increase in the angle of incidence to the lowermost position. If the cam is merely shifted longitudinally and is not rotated by a spline such as 37, then the angle of incidence at the top and at the bottom are the same as that illustrated in Fig. 3. Since the cam at these points have their surfaces parallel to the axis of the tube 2, when the cam shown in 52 is moved down from the position shown therein, the angle of incidence increases very rapidly during the first 90° of revolution from the uppermost position of the blade. Through the next 90° of revolution, the increase is relatively slow. Through the next 90° the increase is again very slow and gives in effect a negative angle of incidence. Through the last 90° the change in the angle of incidence is very rapid as in the first 90° of revolution. This arrangement is such that the angle is rapidly changing as the blade moves from right to left, but is changing slowly when moving from left to right.

The reverse is true when the cam shown in Fig. 2 is moved upwardly to bring the smaller elliptical portion into engagement with the rollers 27. That is, there is a relatively slow change in the angle of incidence during the movement of the blade from right to left, and a relatively rapid change in the angle of incidence as the blade moves from left to right.

When the rollers contact with the larger elliptical portions of the cam, there is more of a tendency for the propeller to lift the helicopter than to move it toward the left, whereas, when the rollers are in contact with the smaller elliptical portions of the cam, there is more of a tendency to move the helicopter toward the left and less tendency to lift the same.

When a spline is used to cause rotation of the cam when the same is moved longitudinally, the result is that the angle of incidence at the top instead of being zero is either a slight positive angle, or slight negative angle, depending upon the direction in which the cam is shifted along the tube 2, and the succeeding positions of the blades are increased or decreased by a corresponding amount. As

will be understood, the axial movement of the eccentric, changes the variation in the angle of incidence, while the angular adjustment of the eccentric, changes the direction of the driving force exerted by the propeller upon the helicopter, or like machine to which it is fitted. In practice, in the embodiment shown, each blade during its travel to the right is kept substantially at right angles to its direction of movement, while during the movement of the blade to the left, it is held at a decreasing angle of incidence and then at an increasing positive angle of incidence as it traverses its downward stroke.

The arrangement shown in Fig. 3 is substantially the same as that shown in Figs. 1 and 2, with the exception that the link 20′ corresponding to the link 20, carries an additional gear 48 which is rotatably mounted on the link 20′ and meshes with the gears 19 and 22. This gear 48 acts as an idler gear. It will be understood that the ratio of the gears 19 and 22, is two to one, as in the embodiment shown in Figs. 1 and 2.

Obviously those skilled in the art to which this invention pertains may make various changes in the construction and arrangement of parts without departing from the spirit of this invention, and therefore I do not wish to limit myself except as hereinafter set forth in the claims.

Having thus fully described my invention, what I desire to secure by Letters Patent of the United States is:

1. In a rotary propeller, the combination with a rotary supporting member, blades rotatable on said member, means for rotating each blade about its own axis through substantially 90° as said member rotates about its axis through substantially 180°, means for rotating said blades about their own axes another substantially 90° while said member rotates through substantially another 180°, and mechanism for varying the rate of rotation of said blades about their own axes.

2. In a rotary propeller, the combination with a rotary supporting member, blades rotatable on said member, means for rotating each blade about its own axis through substantially 90° as said member rotates about its axis through substantially 180°, means for rotating said blades about their own axes another substantially 90° while said member rotates through substantially another 180°, and mechanism for varying the rate of rotation of said blades about their own axes, so that said blades rotate more rapidly in the first parts of the respective 180° movements of said member than in the latter parts thereof.

3. In a propeller, the combination with a framework, of a plurality of blades rotatably mounted on said framework so as to rotate about parallel axes, shafts forming bearings for said blades and rigid therewith, said shafts being rotatable in bearings in said frame, a gear secured to each shaft, a second gear meshing with each of said first mentioned gears, links connecting the pivots of each pair of said gears, rods pivoted to said links and secured to said second gears, a cam having elliptical and circular surfaces thereon adapted to actuate said rods, and means for selectively moving said cam to position one of said surfaces in operative engagement with said rods.

4. In a propeller, the combination with a shaft, of a framework on said shaft, a plurality of parallel shafts rotatably mounted on said framework, a blade secured to each shaft, links rotatable on said shafts, gears secured to said shafts, a second gear rotatably mounted on each of said links and out of mesh with said first gear, idler gears meshing with both of said gears on each link, rods rigidly connected to each of said second mentioned gears, a cam for actuating said blades, and means for shifting said cam about its axis to change the time of rotation of said blades to various angular positions, said gears being controlled by movements of said cam to rotate said blades.

5. A device as set forth in claim 3 in which the rods rotate in unison with the blades but about a different axis, thereby causing rotation of said blades relative to said framework as said blades and rods rotate and through the intermediary of said links.

6. A propeller comprising a member rotatable about an axis, a blade rotatably supported by said member and rotatable about its own axis while bodily movable with said member about the axis of rotation of said member, and mechanism for varying the angle of incidence of said blade relative to the path of travel of the axis of rotation of said blade comprising means for varying the angle of incidence of said blade from substantially zero degrees at one position to substantially 90° half way along said path and for again changing the said angle back to substantially zero degrees during the movement of said blade along the last half of said path, said mechanism including means for changing the rate of rotation of said blade about its own axis.

7. In a propeller, the combination with a frame-work rotatable upon a substantially horizontal axis, rotary blades carried by said frame-work and rotatable about axes substantially parallel to said first axis, a cam, and gearing connecting said cam and blade to rotate said blade through substantially 90° about its own axis during substantially the first 180° of the rotation of said frame-work, and for rotating said blades another 90° about their axes during the next 180° of rotation of said frame-work, said cam having different operative

surfaces thereon selectively cooperating with said gearing to vary the rate of rotation of said blades about their axes during each of said 90° of rotative movement about their own axes.

8. In a propeller, the combination with a frame-work, of a plurality of blades rotatable upon said frame-work about parallel axes, a cam and gearing operatively connecting each of said blades, said cam comprising a second gear meshing with the gear secured to said blade, rods to which said second gears are rigidly secured, and means for maintaining said gears in mesh with each other, the movement of said rods causing rotation of said blades through the intermediacy of said gears, said cam mechanism having a plurality of surfaces selectively movable to operative position to operate said rods selectively at different rates to thereby impart different rates of movement of rotation to said blades.

9. In a propeller, the combination with a frame-work, of a plurality of blades rotatable upon said frame-work about parallel axes, a cam and gearing operatively connecting each of said blades, said cam comprising a second gear meshing with the gear secured to said blade, rods to which said second gears are rigidly secured, and means for selectively moving the desired cam surfaces into operative relation with said rods.

10. In a propeller, the combination with a frame-work, of a plurality of blades rotatably mounted on said frame-work so as to rotate about parallel axes, shafts forming bearings for said blades and rigid therewith, said shafts being rotatable in bearings in said frame, a gear secured to each shaft, a second gear meshing with each of said first mentioned gears, links connecting the pivots of each pair of said gears, rods pivoted to said links and secured to said second gears, a cam having elliptical and circular surfaces thereon adapted to actuate said rods, and means for moving said cam about its axis to vary the time at which the blades occupy given positions with respect to a fixed plane parallel to the axis of rotation thereof.

11. In a propeller, the combination with a frame-work, of a plurality of blades rotatably mounted on said frame-work so as to rotate about parallel axes, shafts forming bearings for said blades and rigid therewith, said shafts being rotatable in bearings in said frame, a gear secured to each shaft, a second gear meshing with each of said first mentioned gears, links connecting the pivots of each pair of said gears, rods pivoted to said links and secured to said second gears, a cam having elliptical and circular surfaces thereon adapted to actuate said rods, and means for moving said cam to position different ones of the operative surfaces thereof in a position to actuate said rods and simultaneously change the angular position of said cam.

12. In a helicopter, the combination with a blade carrying frame having a fixed axis of rotation, blades rotatably mounted on said frame, a cam having an axis of rotation substantially parallel to but spaced from the axis of rotation of said frame, a plurality of operating rods bodily movable about the axis of rotation of said frame for operating said blades and for rotating said blades about their axes of rotation as said blades revolve about the axis of rotation of said frame, said cam having surfaces spaced longitudinally of its axis being respectively in the shape of ellipses having their major axes at different angles with respect to each other, a circular surface and intermediate surfaces gradually merging into one another, and means for shifting said cam longitudinally of its axis of rotation to position different cam surfaces in operative position to vary the rate of angular rotation of said blades about their axes.

In testimony whereof I have signed my name to this specification on this 17th day of November A. D. 1930.

WILLEM PETRUS VAN LAMMEREN.