March 3, 1936. J. F. BROWN 2,032,790

PROPELLER

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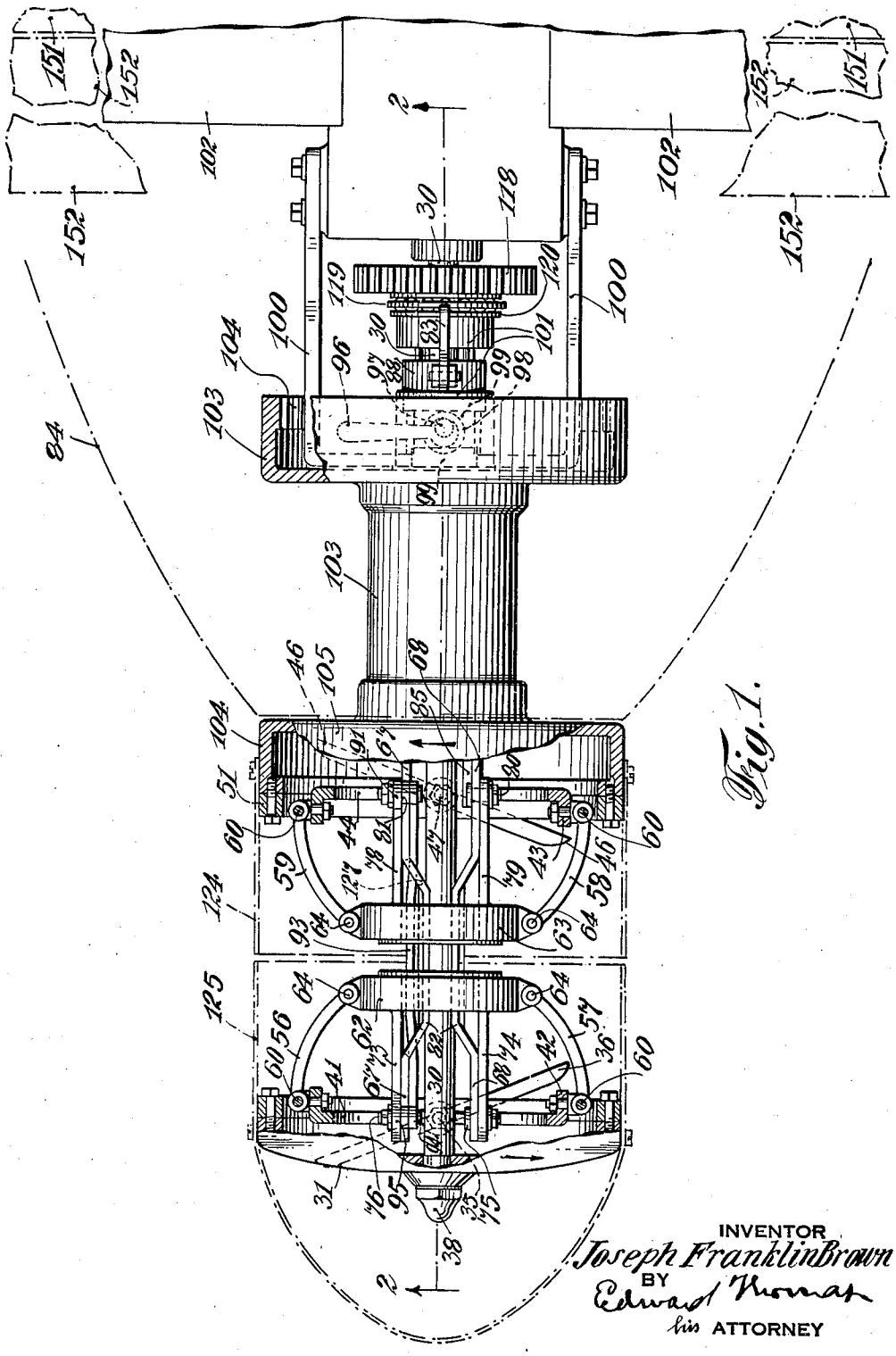


Fig. 1.

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PROPELLER

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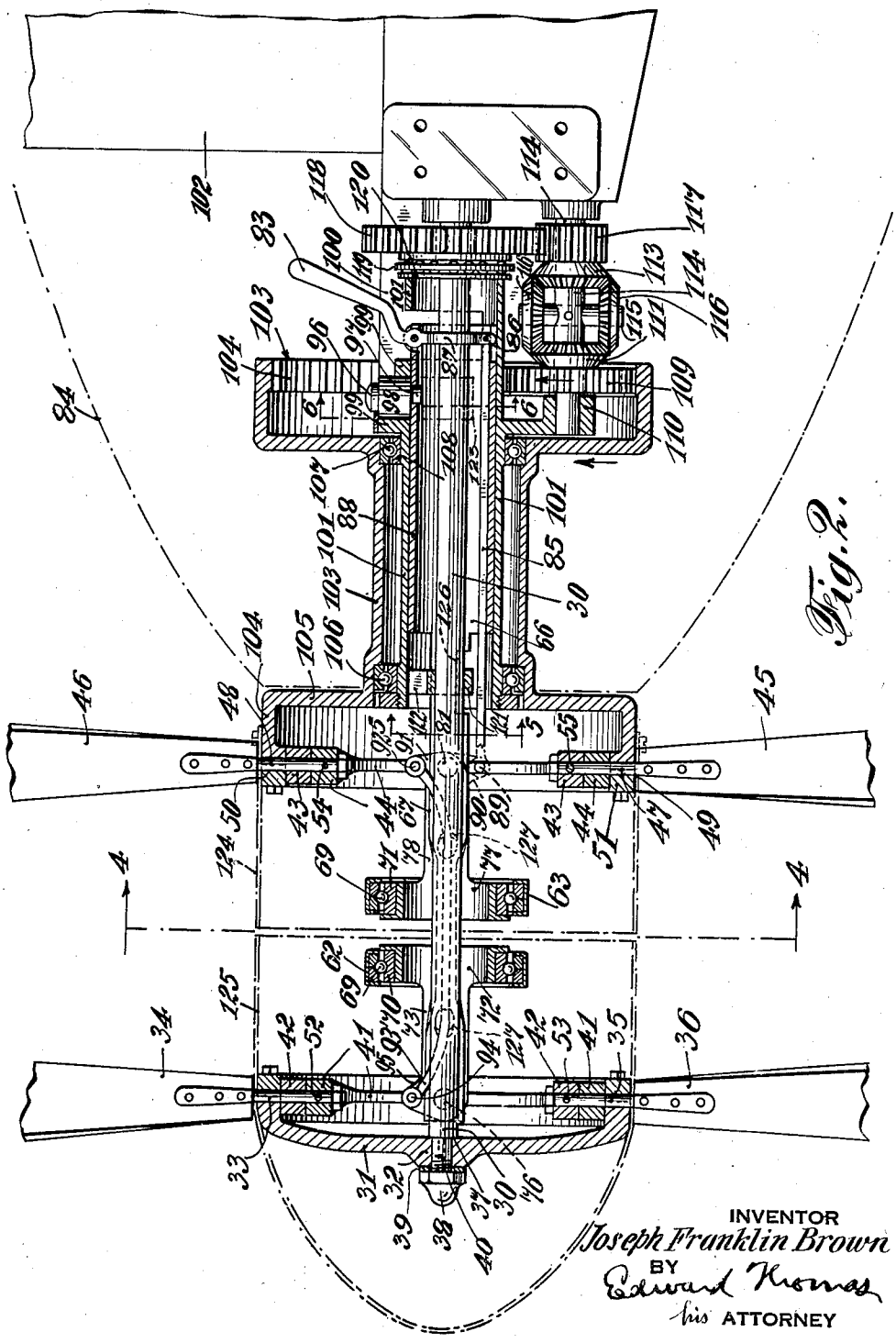


Fig. 2.

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PROPELLER

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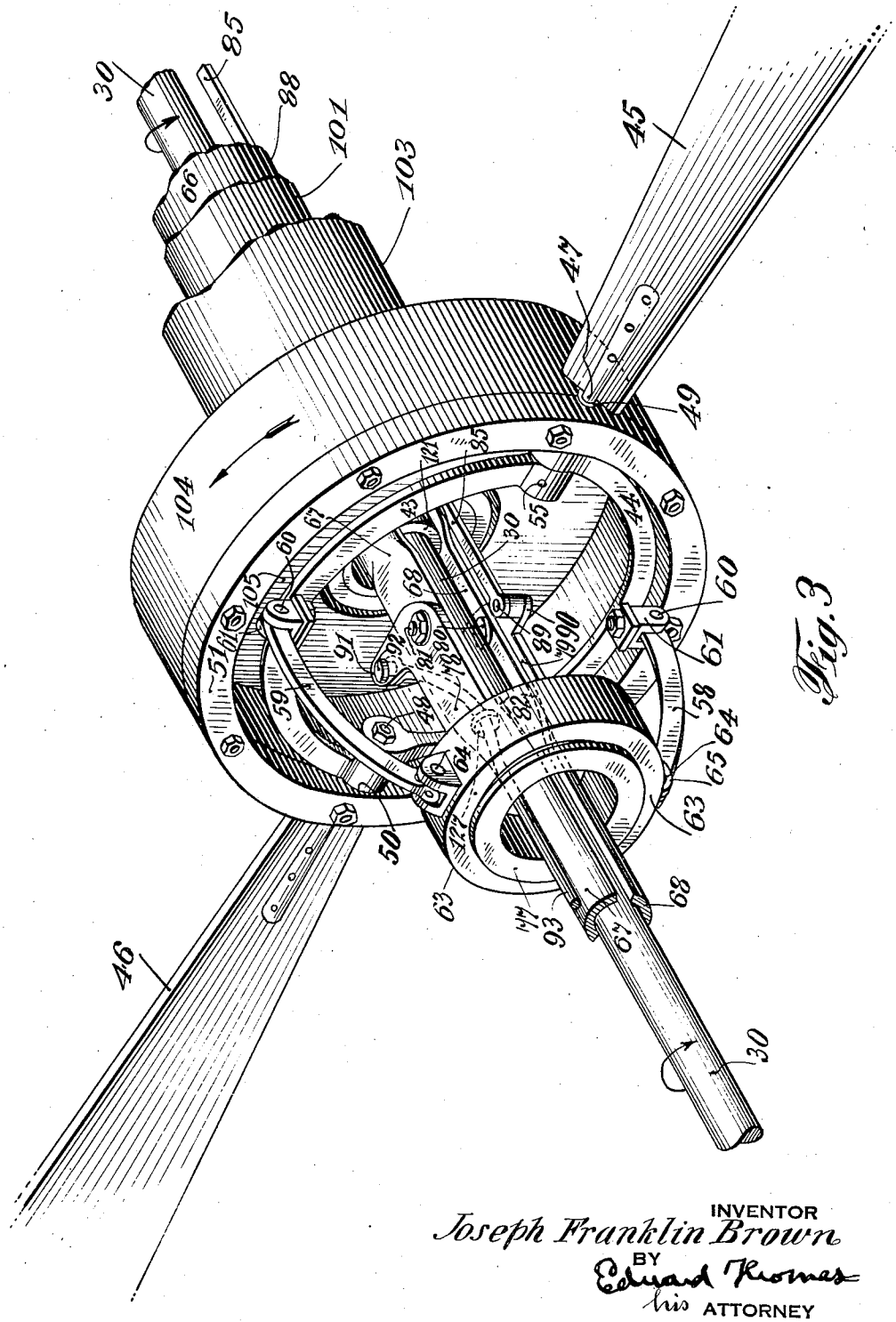


Fig. 3

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PROPELLER

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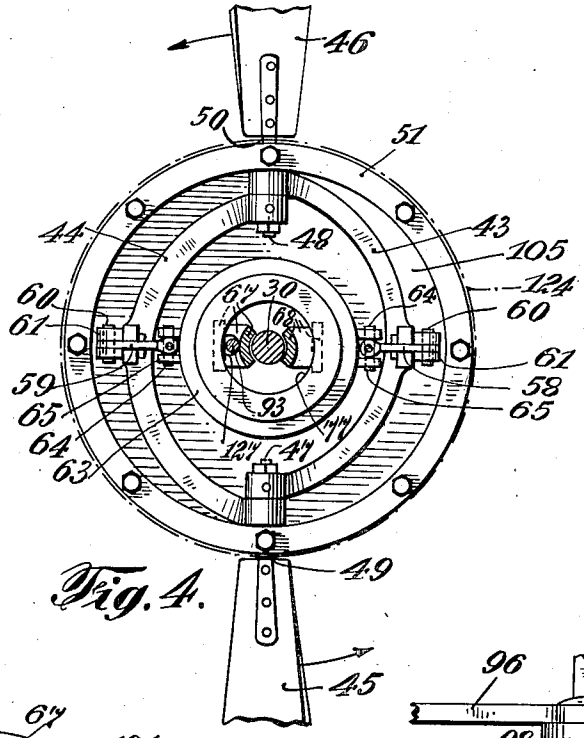


Fig. 4.

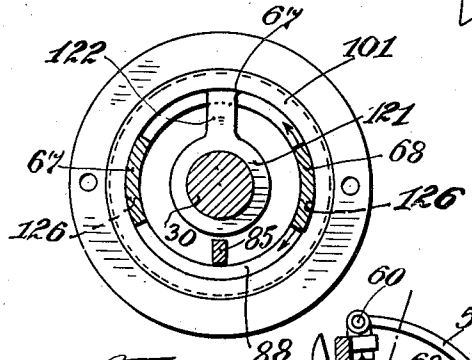


Fig. 5.

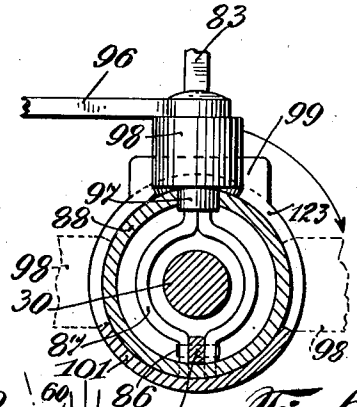


Fig. 6.

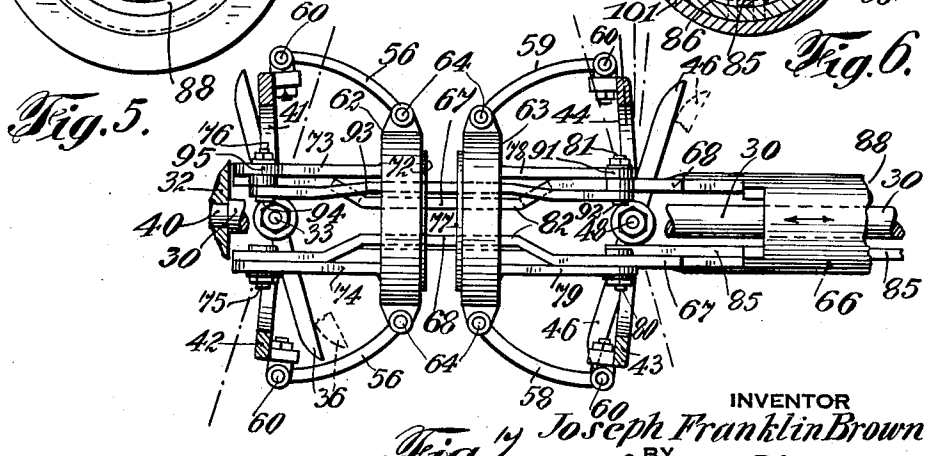


Fig. 7.

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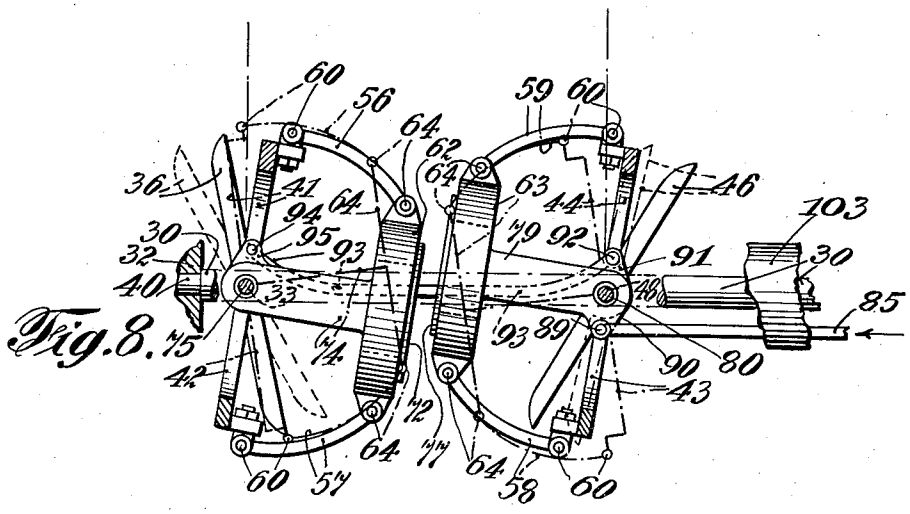


Fig. 8.

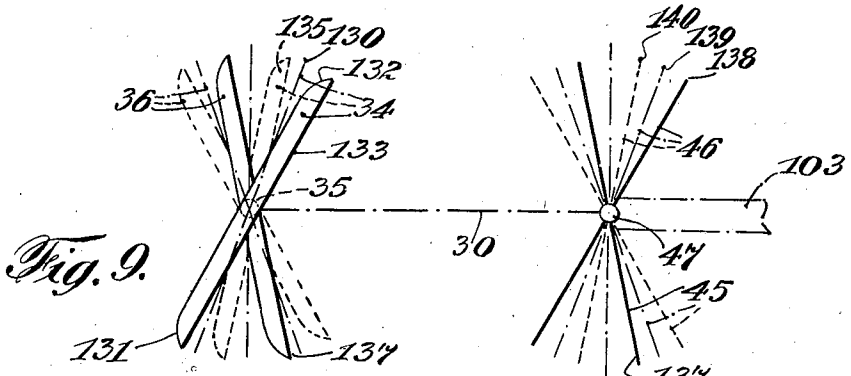


Fig. 9.

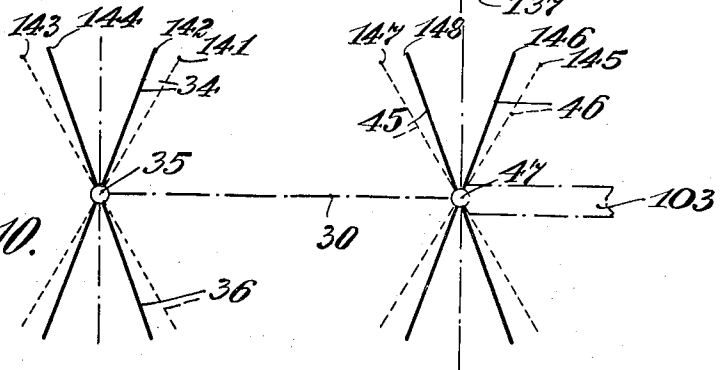


Fig. 10.

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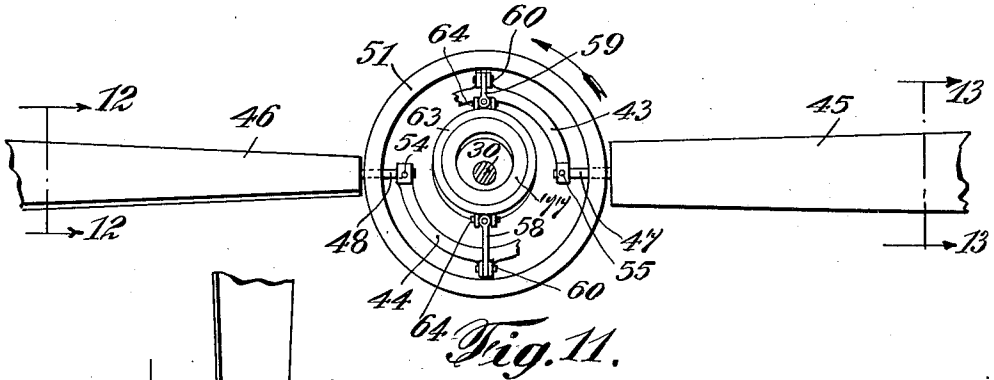


Fig. 11.

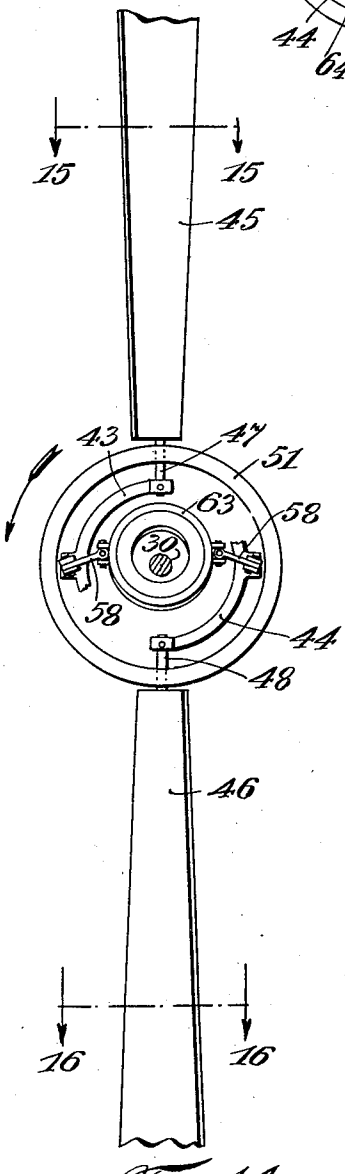


Fig. 14.

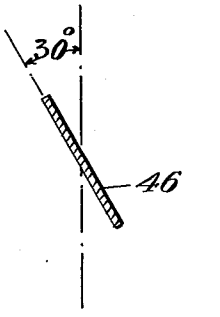


Fig. 12.

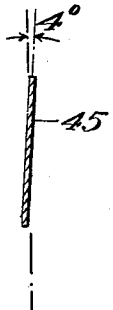


Fig. 13.

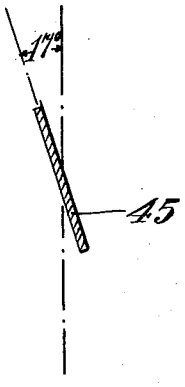


Fig. 15.

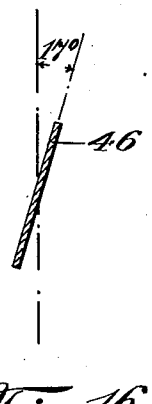


Fig. 16.

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PROPELLER

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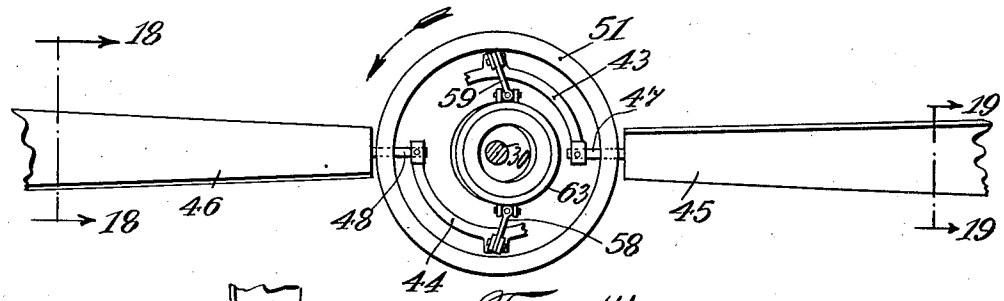


Fig. 17.

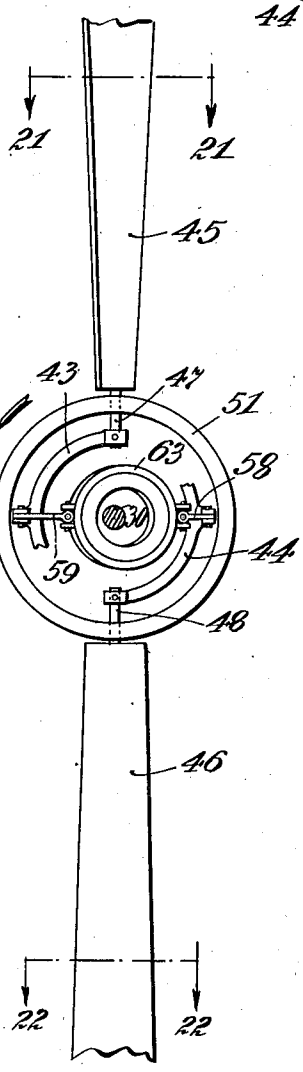


Fig. 20.

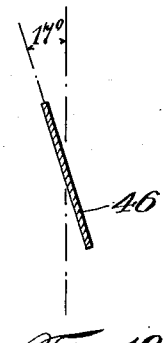


Fig. 18.

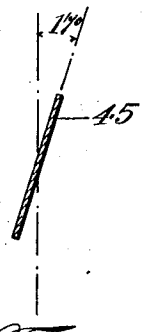


Fig. 19.

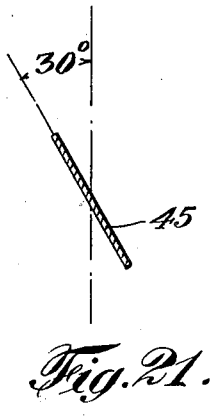


Fig. 21.

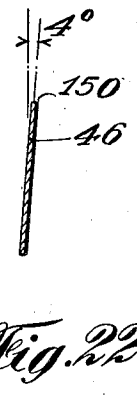


Fig. 22.

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Patented Mar. 3, 1936 2,032,790

UNITED STATES PATENT OFFICE

2,032,790

PROPELLER

Joseph Franklin Brown, New York, N. Y.

Application April 21, 1934, Serial No. 721,694

11 Claims. (Cl. 170—163)

This invention relates to propellers and is herein illustrated in some detail as embodied in a propeller especially constructed for airplane use and as mounted upon an airplane.

In driving airplanes through air or vessels through water or in lifting helicopters it has hitherto generally proved feasible only to use propellers with fixed blades, with the result that the propeller drove its plane or vessel only ahead or supported its helicopter stationary and, moreover, worked most efficiently at only a single speed.

According to the present invention a propeller for any of these purposes may have devices for varying the pitch of the propeller blades, and may also have devices for causing the pitch of any blade to vary or feather as the turning shaft carries it through the water or air, with the result, for example, that the blade exerts a thrust transverse to its shaft as well as axially of the shaft.

As a result a propeller may give a sidewise thrust to the airplane or vessel or helicopter which it drives, or may give an upward thrust to the airplane.

In the form shown in some detail below each propeller blade is mounted upon a stub shaft or hub which extends radially through a shaft hub on its driving member so that a rock arm or bail, fast to the stub shaft within the shaft hub may be rocked to turn the propeller blade, thereby altering its pitch. Usually the bail fast on the stub shaft of one propeller blade is journalled on the stub shaft of the other blade, and from each bail at its center extends a link to a slidable collar surrounding the shaft. Whenever the collar slides axially of the shaft it draws on the links and turns the propeller blades identically to vary the pitch.

In the form of the invention herein illustrated the feathering of the propeller blades is effected by tilting the collar as it turns with the drive shaft. By holding the point of tilt stationary as the drive shaft rotates the point at which the turning propeller blades feather is held stationary, thus causing the blades to increase or decrease their pitch as they successively approach and then pass the point of extreme tilt.

The blade tilted to its sharpest pitch at any moment exerts then a thrust transverse to the drive shaft which is not balanced by an equal opposing transverse thrust of the opposite blade. As a result of this unbalanced side thrust the propeller pushes sideways as well as forwardly.

The transverse thrust of the feathering blade action is herein illustrated as shiftable by the pilot to any angle to the vertical in an airplane, or, correspondingly at any horizontal in a helicopter.

If an airplane is to turn a corner, a side thrust will turn it at a more acute angle, in less space and less time.

If the airplane has been rising rapidly and stalls or tends to stall, a downward thrust will restore the airplane to a flatter course.

If the airplane is out of balance for any reason the appropriate side thrust or a diagonally downward thrust will restore its balance.

If the motor fails and the blades are revolved by the inertia motion of the plane, feathering the blades will keep the plane in control, or if propellers are still turning from their momentum a lifting thrust by them is obtainable.

Apparently a properly designed propeller and plane will permit the plane to loop in its own length.

In the form of the invention herein illustrated the plane is provided with two coaxial propellers which are shown as driven by a differential gearing from a single motor. When two identical propellers are thus driven, the rear propeller working in the wake of the front will automatically take its share of the load, turning faster through the differential gearing.

In an airplane, the form of the invention herein illustrated, the feathering of the two propellers is preferably always identical and is, therefore, effected by a single control. The pitch of the blades of the two propellers in an airplane is also preferably always identical, being usually much steeper than the pitch in a helicopter, and in an airplane is effected by a single control. Thus it is simple for a pilot to climb with a low pitch, and cruise with a high pitch which increases as the altitude increases.

In landing the pilot can utilize both varying pitch and varying feathering, besides altering the angle of the feathering, and, as a result, has the airplane under a control hitherto deemed impossible.

Other features and advantages will hereinafter appear.

In the accompanying drawings:

Figure 1 is a plan view, partly broken away, of the front of an airplane with the propeller devices of the present invention, partly diagrammatic.

Figure 2 is a sectional side view of the same on the line 2—2 of Figure 1.

Figure 3 is a fragmentary perspective view of a propeller and some adjacent parts.

Figure 4 is a section on the line 4—4 of Figure 2.

Figure 5 is a section on the line 5—5 of Figure 2.

Figure 6 is a section on the line 6—6 of Figure 2.

Figure 7 is a fragmentary side view of the propeller blade variable pitch connections with the propellers diagrammatically shown partly varied from normal.

Figure 8 is a similar view showing the parts set for feathering.

Figure 9 is a diagram to illustrate the feathering action.

Figure 10 is a diagram to illustrate varying pitch.

Figure 11 is a fragmentary view showing how upward thrust is produced.

Figures 12 and 13 are sections on the lines 12—12 and 13—13 of Figure 11.

Figure 14 shows the same parts after the propeller has turned 90°.

Figures 15 and 16 are sections on the lines 15—15 and 16—16 of Figure 14.

Figure 17 is a fragmentary view of parts in position adapted to exert a right thrust on the plane as the propellers turn.

Figures 18 and 19 are sections on the lines 18—18 and 19—19 of Figure 17.

Figure 20 shows the parts seen in Figure 17 when actually producing the left thrust on the plane as the propellers turn.

Figures 21 and 22 are sections on the line 21—21 and 22—22 of Figure 20.

A drive shaft 30, Figure 2, carries a main hub or dished plate 31 forming the bearings 32 for the hub 33 of a variable pitch propeller blade 34 and the hub 35 of a second variable pitch propeller blade 36, rotating in the opposite direction. The rotating drive shaft 30 rotates the plate 31 around with it, because the plate 31 sets against a shoulder 37 on the shaft 30 and is held against the shoulder by a nut 38 screwed down on to a washer 39 which lies around the reduced extension 40 of the shaft 30.

The hubs 33 and 35 extend inwardly from the bearings 32 so that rock arms or turning bails 41 and 42 may alter the pitch of the blades. The form of the invention disclosed herein in detail includes two propellers, for reasons which will appear later. In the interest of economy only that form of the invention is illustrated, and, instead of illustrating the propellers 34 and 36 in detail, similar turning bails 43 and 44 are shown in perspective in Figure 3 for turning the similar propeller blades 45 and 46 having similar internally projecting hubs 47 and 48, which are journalled at 49 and 50 in an annular drive collar 51. The other principal functions and many features of these similar blades, hubs and bails will be described later. It will suffice to say now that the blades 34 and 36 turn in one direction with a given pitch and speed while the blades 45 and 46 turn in the opposite direction with about the same pitch and a speed which gives the same effective result. As best shown in Figure 3 each turning bail 41, 42, 43, 44 is a semicircular member keyed as at 52, 53, 54, 55 to the hub 33 or 35 of one blade 34 or 36 and journalled on the hub 35 or 33 of the respective opposing blades 36 or 34, so that tilting any bail 41, 42, 43 or 44, rotates its blade 34, 36, 45 or 46 in the hub, thereby changing the pitch of its blade.

To control the changing of the pitch, and, also, to hold the blade set at any pitch, each bail 41, 42, 43 and 44, is provided with a control link 56, 57, 58, 59, see Figure 1, and, for two of the links, see Figure 3, each control link held by a pivot pin 60 between ears 61 on its bail and moved by moving a control collar 62 for the links 56 and 57, and by moving a control collar 63 for the links 58 and 59. For this purpose each control link 56, 57, 58, 59 is connected by a pivot pin 64 to its respective control collar 62 or 63, the pin passing through ears 65 on the collar. Thus by moving the collar 62 axially of the shaft 30 the two links 56 and 57 twist their respective blades 34 and 36 on their hubs 33 and 35, thereby varying the pitch of the two blades simultaneously. When the control collar 62 moves axially in a straight line, it alters the pitch of both propeller blades 34 and 36 identically.

To thus alter the pitch of the blades 34 and 36 there is provided a shift sleeve 66, Figure 7, provided with rigid extensions 67 and 68. By pushing the shift sleeve 66 to the left as is shown in Figure 7, the control collars 62 and 63 have been moved axially from the Figure 1 or 2 position to the Figure 7 position, thus pushing the control links 56 and 57 and pulling the control links 58 and 59. This has rotated the turning bails 41, 42, 43, 44 and thereby has rotated the hubs 33, 35, 47, 48 to simultaneously alter the pitch of all the propeller blades 34, 36, 45, 46 to approximately same amount.

To render possible this shifting of the shift sleeve 66, the control collars 62 and 63 are each journalled on internal ball bearings 69 having respective internal races 70 and 71. The internal race 70 of the control collar 62 is fixed in a stirrup 72 having ears 73 and 74 which are respectively pivoted at 75 and 76 respectively to the rigid extensions 67 and 68 of the shift sleeve 66.

In a somewhat similar manner the internal race 71 of the control collar 63 is fixed in a stirrup 77 having ears 78 and 79 pivoted at 80 and 81 to the rigid extensions 67 and 68 of the shift sleeve 66.

The structure illustrated and described above is especially designed for a propeller device having two oppositely rotating propellers. Where the structure includes only one propeller, many of the parts may be omitted. In order to enable the rigid extensions 67 and 68 to move clear of other parts as they shift, each rigid extension 67 and 68 is bent toward the shaft 30 so that a stretch 82 of each extension lies near the shaft 30 where the extensions lie within the stirrups 72 and 77, but lies far enough from the shaft 30 at the pivots 75, 76, 80 and 81 to ensure free working of the parts.

In the form of the invention shown provision is made for varying the pitch of the propeller blades as the blades turn with the shaft 30. Where two propellers are provided, as in the form of the invention illustrated, the propellers preferably turn in opposite directions and then the pitch of the blades may be so varied as to cause them to exert a thrust transverse to the shaft 30.

In the form of the invention shown, the blade 34 is caused to vary its pitch as the shaft 30 turns by tilting the control collar 62 as shown, somewhat diagrammatically, in Figure 8 which may be compared with the normal pitch position of parts seen in Figure 1.

In the form shown, which is a two-propeller device, the control collar 62 is tilted from the normal Figure 1 position to the Figure 8 position by pulling on a handle 83 diagrammatically shown

within the stream-line fuselage 84, see Figure 2, thus thrusting forward a push rod 85 pivoted at 86 to a loose collar 87 surrounding, but spaced from the shaft 30. The collar 87 is pivoted to the movable housing 88 which surrounds the shaft 30 and which will be described later.

The push rod 85 is held by a pivot pin 89 in a depending ear 90 of the stirrup 77 so that the stirrup 77 tilts forward or back as the push rod 85 slides backward or forward. Thus when the push rod 85 has been pushed to the left, as in Figure 8, the stirrup 77 and its control collar 63 are tilted to the right, as shown.

To oppositely tilt the control collar 62 at the same time the stirrup 77 carries a second ear 91 to which is pivoted, at 92, a link 93 pivoted at 94 to a corresponding ear 95 on the stirrup arm 73. Thus the two ears 91 and 95 by the link 93 always tilt together.

The movable housing 88 is herein illustrated as an extension of the shift sleeve 66, and is movable back and forth to shift the shift sleeve 66 by operating a handle 96, Figure 1.

To enable the handle 96 to shift the shift sleeve 66 longitudinally to alter the pitch of the propeller blades as described above, the handle 96 is pivoted in the housing 88 by a downwardly projecting stud 97, and carries a cam hub 98 lying between rails 99 on the fixed bracket 100, so that the housing 88 is forced backward or forward by rotating the handle 96, thereby varying the pitch of the propeller blades.

The housing 88 is also rotatable for part of a revolution in the fixed sleeve 101 which extends out from the fixed bracket 100, thus carrying around with it the handle 83 which effects the varying of propeller blade pitch during each revolution of the propellers. As a result of carrying the housing 88 around, together with the handle 83 and its connected structures, the stirrups 72 and 77 are rotated axially of the shaft with the result that the tilting shown in Figure 8 takes place in another plane.

While the shaft 30 has been described as a drive shaft, it is, in the structure shown, not driven directly by the motor diagrammatically shown at 102, for the reason that the drive mechanism is shown as driving both the shaft 30 and the drive sleeve 103 of the propeller blades 45 and 46, driving them in opposite directions.

The hubs 47 and 48 of the blades 45 and 46 are shown as journalled in the turned-over 104 edge of a drive plate or main hub 105, which forms part of the drive sleeve 103. In the form shown the drive sleeve 103 is carried on front and rear ball bearings 106 and 107 having internal races 108 supported on the fixed sleeve 101 carried by the bracket 100. And the drive sleeve 103 is provided with an enlarged internal gear 104 meshing with a small spur drive gear 109 journalled in a boss 110 of the fixed sleeve 101. The motor 102 is shown as driving the spur gear 109 by a familiar type of differential gearing which includes a bevel gear 111 fast to the spur gear 109, and an opposite bevel bear 113 loosely journalled on the motor shaft 114. Between the bevel gears 113 and 111 extends the motor shaft 114 carrying a transverse shaft 115 on which are loosely journalled two identical bevel gears 116. The turning shaft 114 carries with it the transverse shaft 115 thus carrying around with it the identical bevel gears 116. The bevel gears 116 turn the bevel gear 111 because opposite bevel gear 113 carries the load of turning the propeller blades 45 and 46. For this purpose the bevel gear 113 is fast to a spur gear 117 turning loosely on the motor shaft 114, said spur gear 117 meshing with a spur gear 118 fast on the drive shaft 30 so as to turn the shaft. The shaft 30 is diagrammatically shown as having a ball bearing 119 supported by a thrust plate 120 fast on the fixed sleeve 101. The drive shaft 30 is also shown as supported in a journal 121 carried in a lug 122 at the outer end of the fixed sleeve 101, see Figure 5. The lug 122 is fairly narrow to give room for rotating the sleeve 88 to alter the feathering plane of the propeller blades. For the same reason sleeve 88 is cut away at 123 to allow the handle 83 to turn with the sleeve 88.

The structure is shown as provided with a streamline cover 124 for hubs and adjacent mechanism of the blades 45 and 46 and rotating with them. The cover 124 is shown as revolving close to the cover 84 of the fuselage, and also as revolving close to the partly conical stream-line cover 125 of the hubs and adjacent mechanism of the propeller blades 34 and 36.

As appears from Figure 1, handle 93 can be tilted forward or backward. When shifted backward it causes the push rod 85 to tilt the control collar 63 to the left in Figure 2, causing the propeller blades 45 and 46 to feather at one point in their revolution. When shifted forwardly the handle 83 tilts the control collar 63 to the right in Figure 2, causing the blades 45 and 46 to feather at the opposite point in their revolution. The arc through which the handle 83 is thrown may vary at will to vary the amount of feathering.

The point at which the blades 45 and 46 feather in their revolution may be angularly turned by turning the sleeve 88, by either pushing or pulling the handle 83 sidewise, as the case may be. When the sleeve 88 thus turns it turns with it the extensions 67 and 68, thus turning the stirrups 72 and 77 so that they turn around their pivots 75 and 76 in new planes which set the new planes in which the blades 43 and 45 feather. What has been said about the blades 46 and 45 applies equally to the blades 34 and 36.

To permit the sleeve 88 to thus turn, the extensions 67 and 68 are cut away at 126 at the lug 122, see Figures 2 and 5 so that the sleeve rotates, if need be, a little over 180° to alter the plane of feathering. The cut away 126 is long enough to permit the handle 96 to throw the sleeve 88 to the full distance the handle 96 can move it.

In order to permit the links 58 and 59, and 56 and 57 to accurately and smoothly shift and hold the respective bails 43, 44, 41, 42, each link is swivelled on its pivot 60, 64.

To provide room for the link 93 to operate, it may be carried through an opening 127 in the extension 67 of the sleeve 88.

In Figure 9 is a diagrammatically shown the feathering action of the near propeller blade 34 which, in normal action revolves in the plane of the dot and dash line 130. The propeller blade 34 is seen end on and is shown, diagrammatically as a flat board having a rounded-off leading edge 131, a rounded off trailing edge 132 in normal forward flight, to the left in that figure. In feathering for upward thrust the blade 34, which occupied a plane corresponding to the normal line 130 at the vertical position, has turned to the heavy line position 133 of greater pitch, thus thrusting down a greater area of air than it thrusts in the vertical position corresponding to the line 130, consequently thrusting the airplane upward. As the shaft, diagrammatically

shown by the line 30, turns further, the blade 34 turns on its hub or stub shaft 35 back to the plane corresponding to the line 130, at the bottom point of its travel and then continues to turn until it extends horizontally at the far side of the shaft 30. In this horizontal position 135 it has turned from normal 130 toward the no-pitch flat position, and is exerting little upward pressure on the air as it rises, with the result that the airplane is lifted by the other blade of the propeller, now occupying the position shown for blade 34 in the drawings.

The showing in Figure 9 is necessarily diagrammatic and the turning blade 34 instead of really occupying the position 135 has moved into the position 137 shown for the blade 36.

In the meantime the blades 45 and 46 of the rear, right hand propeller, are turning in the opposite direction with opposite pitch, so that the nearer blade 45 of that propeller as rising with the minimum pitch shown at the full line 137, whereby it exerts almost no upward pressure on the air as it rises, while the further blade 46 of that propeller is falling with its maximum pitch as seen at the full line 138, the line of normal pitch being indicated at 139 and the line of minimum pitch, which it will assume on rising, indicated at 140.

The blades 36 and 45 follow the movements of their respective blades 34 and 45 as they are carried around by the shaft 30 or driving sleeve 103.

One position of the propeller blades 45 and 46 when exerting an upward thrust is shown in Figure 11. Here the blade 45 is standing at an angle of 30°, shown in Figure 12 and the blade 45 is standing at an angle of 4°, with the result that the blades turning in the direction of the arrow exert a lifting effect, obtained by the tilting of the collar 63.

As the blades turn from the Figure 11 position to the Figure 14 position they assume a normal pitch, illustrated here as 17° in Figures 15 and 16.

In Figure 17 the collar 63 is shown as turned to the right with the result that the blades 45 and 45, still turning in the same direction, are not altered at the horizontal position from the normal pitch shown in Figures 18 and 19 as 17°. But as the blades 45 and 46 turn to the vertical position of Figure 20, the blade 45 turns toward the horizontal and the blade 45 turns its leading edge away from the air it strikes and the blade 46 turns its leading edge 150 almost edgewise, shown as 4° from the flat, to the air it strikes. As a consequence the resistance of the air to the propeller blade 45 pushes the shaft 30, in said figure, toward the right.

Thus the pilot by feathering action, or by varying the pitch to reversing if need be, with the aid of properly directable ailerons 151, see Figure 1, located as usual at the back of the wings 152, may be able to bring down the airplane safely, even though it is without any horizontal velocity. An aileron 151, capable of swinging up vertically as the stationary airplane settles through the air, may be swung to horizontal to arrest rolling, while the propellers may exert upward or downward thrust as needed, or even a diagonally upward or downward thrust, if need be.

The shifting of blade pitch to vary the pitch without feathering is illustrated in Figure 10 in which the line 141 may represent the normal pitch of the blade 34, which happens to be 28° in the diaphragm shown. When the pitch is shifted to the line 142 to lessen the pitch the blade 36 shifts at the same time from the line 143 to 144, by an identical angle. At the same time the blade 46 shifts from the line 145 to the line 146 and the blade 45 shifts from the line 147 to the line 148, all by a single operation of the shift sleeve 88.

It will be noted that provision is made for altering the pitch by the sleeve 88 sufficiently to reverse the pitch, thus enabling the propeller, without gear shifting, to arrest the airplane, as is useful especially in landing.

Having thus described certain embodiments of the invention, what is claimed is:

1. A propeller device including a shaft, radial bearings on the shaft, propeller blades having hubs rotatable in said bearings, a member slidable axially of the shaft, a bail fast on each hub within its bearing and journalled on an opposite hub, a link from the slidable member pivotally connected to each bail, a bearing member surrounding the shaft on which the slidable member is journalled, and means for moving the bearing member axially of the shaft to cause the slidable member to slide to turn the hubs to vary the pitch of their blades.

2. In an airplane, a pair of oppositely rotating propellers, having blades, means for varying the pitch of the propeller blades in several planes as they turn so as to have one pitch at one point in their revolution and another pitch at another point with the result that the blades may exert a direct upward or downward thrust, and an airplane wing behind the propellers for supporting the airplane as it travels to form a fulcrum around which the plane turns in a vertical plane.

3. In a propeller device including two hubs, two propellers having opposite pitches but turning on a common axis, a single motor for the two propellers, and a differential gearing driven by the motor and driving one propeller by one side of the gearing and the other propeller by the other side of the gearing.

4. In a propeller device including two hubs, two propellers having opposite pitches but turning on a common axis, a single motor for the two propellers, a differential gearing driven by the motor and driving one propeller by one side of the gearing and the other propeller by the other side of the gearing, and means for varying the pitch of each propeller.

5. In a propeller device including two hubs, two propellers having opposite pitches but turning on a common axis, a single motor for the two propellers, a differential gearing driven by the motor and driving one propeller by one side of the gearing and the other propeller by the other side of the gearing, and means for variably feathering the propellers as they turn.

6. In a propeller device including two hubs, two propellers having opposite pitches but turning on a common axis, a single motor for the two propellers, a differential gearing driven by the motor and driving one propeller by one side of the gearing and the other propeller by the other side of the gearing, a manually operated device for varying the pitch of the propellers together, and a manually operated device for variably feathering the propellers as they turn.

7. In a propeller device including two hubs, two propellers having opposite pitches, a shaft carrying one hub and its propeller, a sleeve revoluble around the shaft carrying the other hub and its propeller, a control sleeve between the shaft and the revoluble sleeve, a differential drive

common to the revoluble sleeve and shaft, and means carried by the control sleeve for varying the pitch of the propellers.

8. In a propeller device including two hubs, two propellers having opposite pitches, a shaft carrying one hub and its propeller, a sleeve revoluble around the shaft carrying the other hub and its propeller, a control sleeve between the shaft and the revoluble sleeve, a differential drive common to the revoluble sleeve and shaft, and means carried by the control sleeve for variably feathering the propellers at a point determined by the sleeve.

9. In a propeller device including two hubs, two propellers having opposite pitches, a shaft carrying one hub and its propeller, a sleeve revoluble around the shaft carrying the other hub and its propeller, a control sleeve between the shaft and the revoluble sleeve, a differential drive common to the revoluble sleeve and shaft, and devices carried by the control sleeve for varying the pitch of the propellers and for variably feathering the propellers at a point determined by the rotation of the control sleeve.

10. In a propeller device the combination with a drive shaft and a hub, of a rotatable drive sleeve and a hub, a propeller on each hub, a device at each hub for feathering its propeller, a journal for each of said devices, a control sleeve, a handle for variably feathering the propellers by shifting their journals, and a handle for turning the control sleeve to rotate the point at which they feather.

11. In a propeller device the combination with a drive shaft and a hub, of a rotatable drive sleeve and a hub, a propeller on each hub, devices at each hub for varying its propeller pitch, a journal for each of said devices, a control sleeve shiftable along the shaft to vary the propeller ptches, a connection for tilting the journals to cause the propellers to feather, and a device for rotating the sleeve to rotate the point at which the propellers feather.

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