Nov. 4, 1930. C. McCARROLL 1,780,431

AERO PROPELLER

Filed Oct. 8, 1925 3 Sheets-Sheet 1

FIG. 1

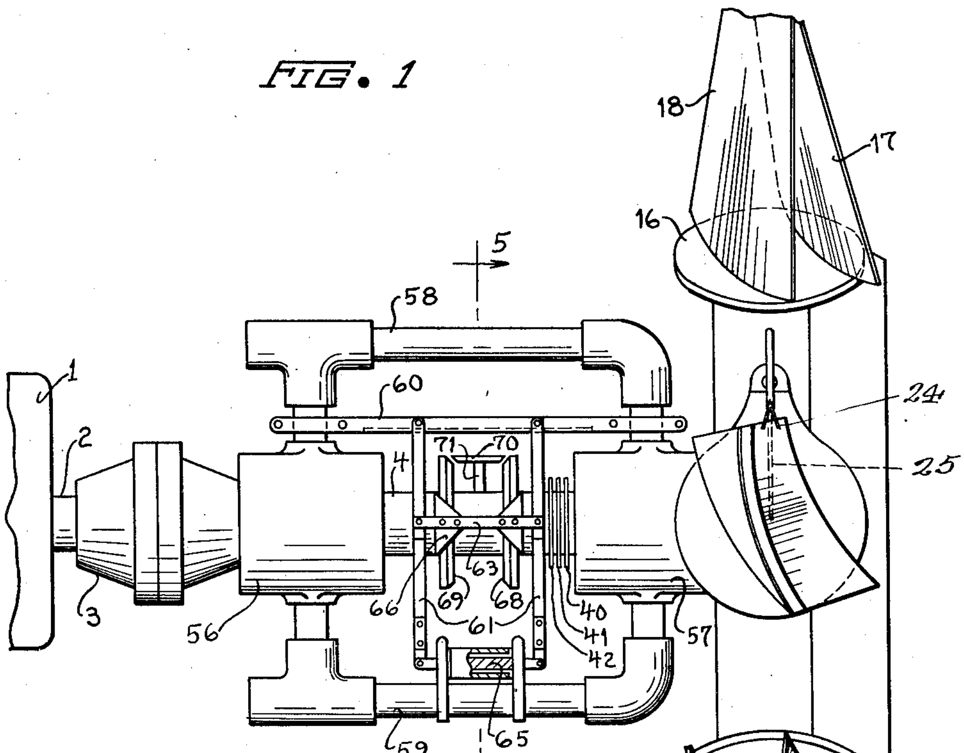
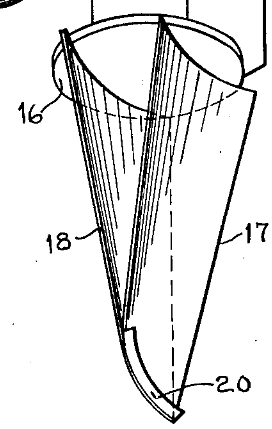
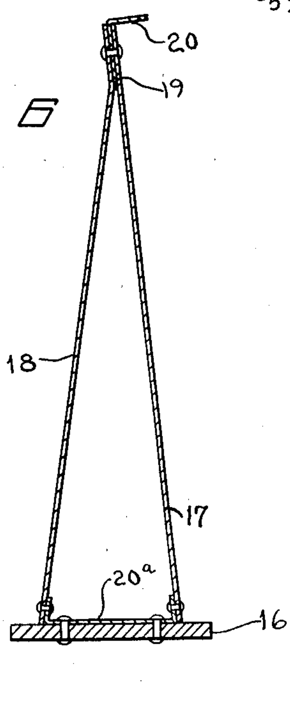



FIG. 6



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AERO PROPELLER

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FIG. 2

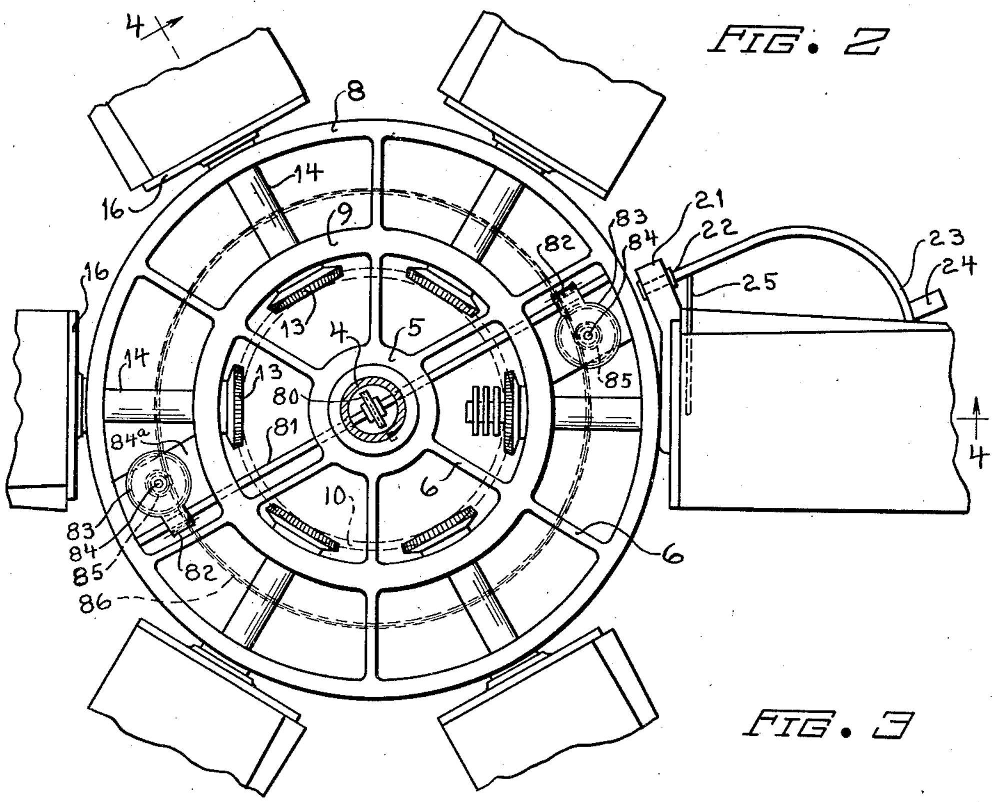

FIG. 3

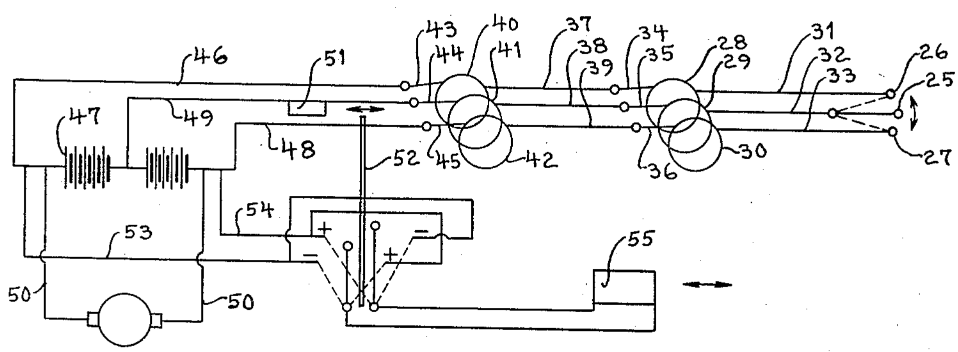

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FIG. 4

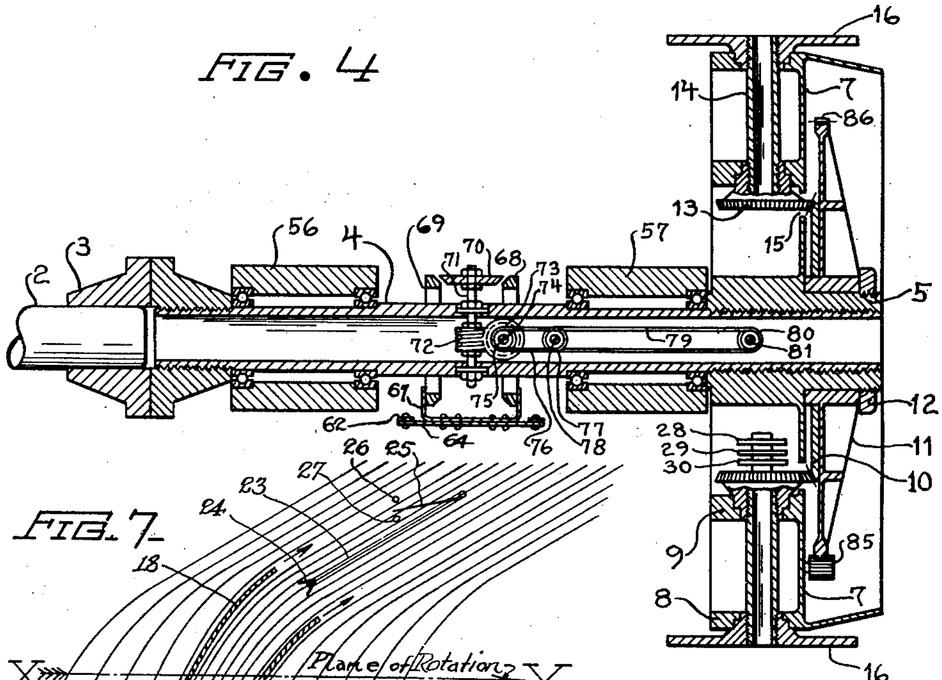


FIG. 7

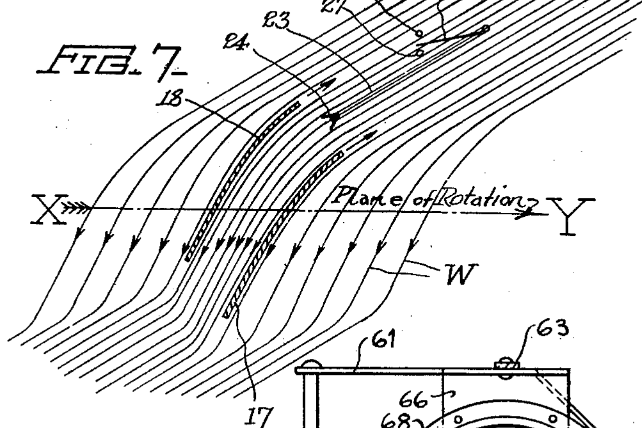


FIG. 5

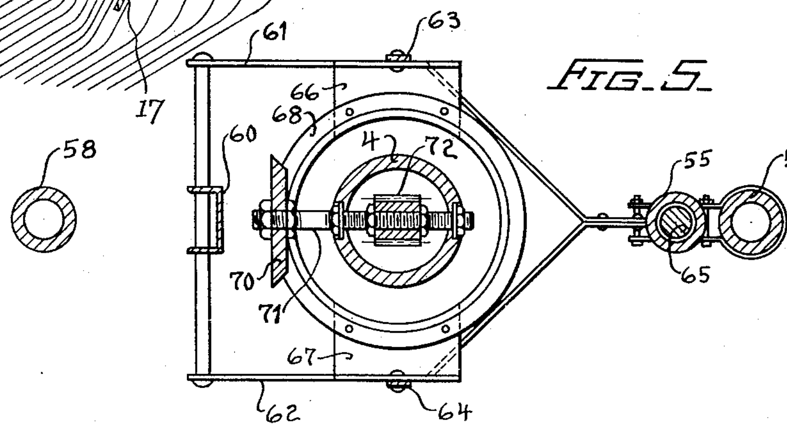
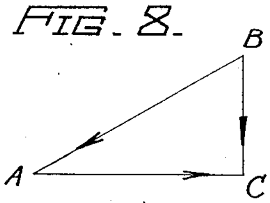


FIG. 8



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Patented Nov. 4, 1930

1,780,431

UNITED STATES PATENT OFFICE

CHARLES McCARROLL, OF HELENA, ALABAMA

AERO PROPELLER

Application filed October 8, 1925. Serial No. 61,320.

My invention relates to propellers for operating in any fluid medium wherein it is contemplated that a high efficiency will result from the provision of automatic means to cause the air or fluid medium to strike the forward edge of the curved revolving impeller blades in exact tangency.

Various conditions will affect the angle of approach of the currents of the air, which as hereinafter referred to is to be regarded as inclusive of any fluid medium, to the forward edge of the curved impeller blades, and I have conceived that means, such as a vane pilot, can be employed to control suitable operating mechanism which will automatically effect the angular adjustment of the blades about their long axes so as at all times to preserve the status of tangency between the air currents and the forward edge of the impeller blades. My present invention covers broadly such an idea and also a preferred arrangement of the vane pilot and its controlled mechanism for the adjustment of the blades.

My invention also comprises certain new and useful improvements in the detail structure of impeller blades and contemplates the formation of each blade by two outwardly convergent concavo-convex blades joined at their base to any suitable support mounted on the impeller shaft.

My invention further contemplates the provision at the tip of the blade of a reinforcing angle set at right angles to the axis about which its respective blade turns in being adjusted, the flange of the angle being turned rearwardly or in the direction of the movement of the propelled medium. This tends to prevent the radial slippage of the fluid medium over the impeller blade due to its inclination as well as to centrifugal force, and gives the blade a more efficient purchase on the fluid medium.

My invention further contemplates the organization within the propeller shaft of transmission mechanism controlled by the vane pilot for the adjustment of the several baldes by rotating their respective impeller shafts to maintain the status of tangency.

My invention also contemplates the provision of electrically-controlled means, responsive to displacement of a vane pilot, for actuating the transmission mechanism and adjusting the blades.

My invention further contemplates a very simple and effective arrangement of a blade-controlling vane pilot by means of which it is rendered sensitive only for the diversion of the air current from a position of tangency and is entirely unaffected by centrifugal force. This is attained by correctly mounting the vane pilot on an impeller blade support or disk, revoluble with the impeller blade on its axis, the vane pilot shaft defining a cone with its vertex at the point of intersection of the impeller axis and the propeller shaft when the impeller blade is revolved on its axis. Such an arrangement makes the effectiveness of the vane pilot unchanged by the various positions assumed throughout its controlling function.

My invention further comprises the novel details of construction and arrangements of parts, which are hereinafter more particularly described and pointed out in the claims, reference being had to the accompanying drawings which form a part of this specification, and which illustrate the preferred embodiment only of my invention.

According to the drawings:—

Fig. 1 is a side elevation of my improved aero propeller mechanism.

Fig. 2 is a front view of Fig. 1 with the propeller blades partly broken away.

Fig. 3 is a diagrammatic view of the electrical circuits for the automatic blade adjustment.

Fig. 4 is a longitudinal cross-sectional view taken on the broken line 4—4 of Fig. 2.

Fig. 5 is a cross-sectional view taken on the line 5—5 of Fig. 1.

Fig. 6 is a longitudinal detail cross-sectional view of one of the propeller blades.

Fig. 7 is a diagrammatic view showing, by way of example, a typical representation of the relative direction of approach of the propeller blades to, and of their departure from, the fluid medium in which they are operated; and

Fig. 8 is a graphic representation of the direction and velocity of the propeller blades, the direction and velocity of the fluid currents, and the relative direction and velocity of the fluid currents when the propeller is operating as shown in Fig. 7.

Similar reference numerals refer to similar parts throughout the drawings.

In the embodiment of my invention illustrated, which in Fig. 1 may be considered as being applied to a "pusher" type airplane, I show conventionally a motor 1 having its shaft 2 connected by a coupling 3 to the main tubular propeller shaft 4, which is threaded at its outer end and has screwed and keyed thereon the hub 5 of the propeller spider. This spider, as will be more clearly seen in Figs. 2 and 4, comprises radial spokes 6 integral with the web 7 and extending from the hub to the outer peripheral flange 8, which flange is concentric with an inner circumferential flange 9. A master gear 10 is secured on a gear wheel 11 mounted so that it can turn on the reduced outer end 5 of the propeller spider hub. A nut 12 secures the master gear assembly in position on the spider. The master gear has its bevelled teeth facing rearwardly or towards the motor and adapted to be engaged by a series of impeller shaft pinions 13, which are mounted fast on tubular impeller shafts 14 disposed radially of the spider and having suitable bearings in the spider flanges 8 and 9. The spider web is cut away opposite each bevel pinion 13 so that the teeth of the latter can project forwardly through the web to engage the master gear. These cut-outs are indicated at 15 in Fig. 4. Each impeller shaft, at its outer end beyond the flange 8, receives a circular impeller blade disk 16, upon each of which an impeller blade, which will be later described in detail, is mounted radially of the spider.

The impeller blades are formed by two concavo-convex plates 17 and 18 which are set so that they converge at their outer ends and are joined there, being riveted together through a reinforcing angle 19 set with its flange 20 disposed rearwardly. The inner ends are riveted to a flanged plate 20^a secured to the blade's disk 16 (see Fig. 6). One of the impeller blade disks is provided with a pilot base 21, formed integrally therewith or suitably attached thereto and projecting beyond its periphery at an angle so that the inner end 22 of a pilot shaft is pivotally secured in this carrier in radial relation to the spider wheel so that as it swings it will define a cone having its apex at the point of intersection of the axes of the propeller and impeller shafts. The outer end of the pilot shaft, indicated at 23, is bent through an arc of 90°, and has secured at its end a V-shaped vane pilot 24 disposed with its apex lying in the plane of the pilot shaft and with its axis parallel with the shaft end 22. The pilot will travel just in advance of the propeller blade that is mounted on the disk 16 carrying the pilot base 21. The end 22 of the pilot shaft has a circuit-closing stem 25 projecting inwardly between the blades of the adjacent impeller and adapted to co-act with a pair of contacts 26 and 27, shown in the electrical diagram in Fig. 3, and which are disposed between the propeller blades in such relation to the pilot stem that the latter will stand midway between the contacts when the air strikes the impeller blades at true tangency. As the air tends to depart from true tangency the pilot will revolve about its shaft end 22 as an axis and will swing the stem 25 until it engages contact 26 or 27, thereby closing control circuits which will be later described.

The impeller shaft carrying the pilot is provided at its inner end with three collecting rings 28, 29 and 30, connected by circuits 31, 32 and 33, respectively, to the contact 26, the circuit closing arm 25, and the contact 27, as will be seen more clearly in Fig. 3, these circuits running through the hollow propeller shaft for the spider. Brushes 34, 35 and 36, respectively, engage the collecting rings 28, 29 and 30 and are connected by circuits 37, 38 and 39 to the collector rings 40, 41 and 42 mounted on the propeller shaft and respectively engaged by brushes 43, 44 and 45. The brush 43 is connected by a circuit 46 to one end of a battery 47, the other end of which battery is connected by a circuit 48 with the brush 45. The battery at its neutral point is connected by a circuit 49 with the brush 44. A dynamo is connected by the leads 50 to the battery and a switch solenoid 51 is interposed in the circuit 49 and adapted to control a double-throw switch 52, which by circuits 53 and 54 from the batteries are adapted to control the energization of a set-works solenoid 55. By the circuit arrangement shown the battery circuits are controlled by the pilot stem 25 to attract or repel the double-throw switch 52 and connect the battery to throw the current in the desired direction through the set-works solenoid and thereby to retract or repel its core which controls the set works.

The various circuits described are carried on or through the rotating parts in any practical manner, and are omitted in detail from the construction drawings to avoid confusion.

Referring to Figs. 1 and 4, it will be seen that the propeller shaft is mounted in spaced bearings 56 and 57, which are connected by tubular frame members 58 and 59. To the parallel legs of the frame 58 standing radially to the propeller shaft, I clamp a channel iron 60, which has its web cut away so that its top and bottom flanges will straddle the frame ends and receive the clamping bolts on each side thereof. To the intermediate portion of both top and bottom flanges, I pivotally mount a pantograph frame-work comprising upper bars 61, lower bars 62, and upper and lower intermediate connecting bars 63 and 64, respectively. The upper and lower bars 61 and 62 of each pair have their free ends drawn together at an angle (see Fig. 5), and are riveted together with the end of one bar projecting sufficiently for pivotal connection to the adjacent end of the core 65 of the set-works solenoid which forms the outer connecting member of the pantograph. I mount brackets 66 and 67 on the opposite pairs of pantograph arms 63 and 64, respectively, and to each opposite pair of brackets I mount a non-rotatable friction track in the form of an annulus concentric with the propeller shaft and free of engagement therewith. I indicate the forward friction track as 68 and the rear friction track as 69, and their friction faces are of any suitable material, disposed at a bevel and spaced to co-act with one side or the other of a friction wheel 70, which is mounted upon a shaft 71 that pierces at right angles the propeller shaft and is suitably journaled thereon. On this shaft 71 within the propeller shaft I mount a worm 72, meshing with a worm gear 73 fast on a cross shaft 74 inside the propeller shaft, on which is secured a sprocket 75 connected by a sprocket chain 76 with a sprocket 77 fast on another shaft 78 within the propeller shaft. A second sprocket on this shaft 78 acts through a chain 79 and a sprocket 80 to drive a shaft 81 which extends through the propeller shaft and through the spider hub and is provided near each end between the flanges 8 and 9 of the spider with a worm 82 meshing with its respective worm gear 83. These worm gears 83 are mounted each on a shaft 84 suitably journaled in a block 84ª cast on the web of the spider wheel, and each carries on its forward end pinions 85 meshing with the pinion teeth 86 about the periphery of a master gear wheel 11.

Referring now to Fig. 7 there is shown diagrammatically the propeller blade elements 17 and 18 rotating in the plane and in the direction of the arrow XY, the relative direction of the wind currents being shown by the arrows W. The vane pilot 24 is shown forward of the propeller blade and in line with the relative direction of the approaching wind currents. It will be readily seen that should the relative direction of the wind currents change, the circuit closing stem 25 will be swung in accordance with said change in a direction to complete one of the circuits, as already described, and change the angles of the blade element to conform to the changed direction of the wind currents.

Referring to Fig. 8, the direction of rotation and velocity of the propeller blades, as shown in Fig. 7, are indicated graphically by the line AC; the direction and velocity of the wind currents are indicated graphically by the line BC; and the relative direction and velocity of the wind currents are indicated by the resultant BA. It will be seen that should the velocity of the propeller blades be changed to shorten or lengthen the line AC, or the direction or velocity of the wind currents change, to change the length of the line BC or to change the angle of the line BC with the line AC, the resultant AB will be changed and the angle BAC will be changed. Any change in the angle BAC affects the vane pilot 24 and effects a completion of one of the electric circuits through the member 25 and consequent adjustment of the pitch of the propeller blades in a manner which will now be described.

In the operation of my apparatus, first disregarding the action of the pilot, the motor drives through the main propeller shaft to the impeller spider and through the latter serves to drive the several impeller blades, which are held in the desired pitch relationship by the meshing of their respective pinions 13 with the master gear 10, and this drive continues without change in position of parts so long as the air strikes the impeller blades in true tangency. When tangency is departed from within predetermined limits, the pilot will move responsive thereto, and through its circuit-closing stem 25 will close the electric circuit from either line 46 or 48 to the line 49, in which it acts, according to the direction in which the pilot stem swings, to energize the switch solenoid 51, causing it to throw the double-throw switch so as to energize the set-works solenoid 55 to move its core and the set works to the right or the left so as to bring the forward or the rear friction track into contact with the friction wheel 70, which, being mounted to revolve with the propeller shaft, will be rotated clockwise or counter-clockwise according to whether it engages the forward or rear friction track. The rotation thus imparted to the shaft 72 of friction wheel 71 will, through the transmission described within the propeller shaft, turn the worm-carrying shaft 81, and through its worm and gear connections shown will act to rotate the master gear clockwise or counter-clockwise so as to turn the impeller blade shafts and change the pitch of the impeller blades in the direction required to restore the condition of tangency. Briefly stated, as the pilot is deflected by non-tangential currents it will, through the instrumentalities described, change the pitch of the impeller blades until they will strike the air in true tangency and this can be maintained within the predetermined limits allowed for the reversal of circuits by the pilot stem.

If operated in a calm, the electrical governor promptly starts adjusting the impeller blades to a condition of tangency at their leading edge. When true tangency is established it should be easily recognized by the healthy whistle of the impeller blades. Any variation in operating conditions will cause the electrical governor to make readjustments that will result in a condition of tangency. As the motor slows down the tendency is for the impeller blades to settle back into zero position, i. e., in a position parallel in the spider. When the propeller is mounted on a plane where the velocity of approaching air is constantly changing, the electrical governor will perfectly meet the changing conditions irrespective of what they are, be it a change in R. P. M., or change in velocity of approach of the air. If the motor slows down, the tendency is for the impeller blades, under direction of the governor, to approach the 90° position. But irrespective of everything, as regards possible operating conditions, as long as the motor is "turning over" this efficiency propeller is exercising a draw-bar pull which will be a maximum for power consumed and will bear a mathematical relation to the R. P. M.

The reason for the efficiency of the propeller is the avoidance of eddy currents, and the creation of a condition of steady, easy, accelerated flowage of air in very large volumes with low change in velocity. The screw propellers of recent design with their fixed impeller blades, of unalterable pitch, their enormously high number of R. P. M.'s, represent and are, only a nice refinement of the original idea.

The hereindescribed propeller is not a screw propeller in any accepted sense. It is an efficient tangency propeller, delivering a maximum of draw-bar pull with a minimum of power consumption and with a low R. P. M.

The blades in their structure are unusually strong, will obtain a very efficient purchase on the air, and the angles 20 at their tips will tend to hold the air from radial movement off the blades responsive to centrifugal pressure and the angular disposition of the blades. The pantograph mechanism shown is typical of any comparatively inexpensive means which can be utilized to shift the non-rotatable friction element into engagement with the friction wheel according to the direction in which it is desired to rotate the latter responsive to its revolution with the propeller shaft.

While it is contemplated that my invention should maintain an approximately exact condition of tangency between the air currents and the blade, nevertheless it is obvious that it can be easily adapted to maintain any desired angle of incidence, and where the expression tangency is used it contemplates any predetermined departure therefrom.

Though I have described with great particularity the details of the embodiment of the invention herein shown, it is not to be construed that I am limited thereto, as changes in arrangement and substitution of equivalents may be made by those skilled in the art without departing from the invention as defined in the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. A propeller mechanism, comprising a plurality of impeller blades, a shaft on which said blades are rotatably mounted for change in pitch, and means independent of the blades and responsive to variation in the approach of fluid currents to the blades to maintain a condition of tangency between the blades and the approaching fluid currents.

2. A propeller mechanism, comprising a plurality of impeller blades, a shaft on which said blades are rotatably mounted for change in pitch, and means movable independently of the blades and responsive to variation in the approach of fluid currents from a condition of tangency to the blades to change the pitch of the blades automatically until substantial tangency is restored.

3. A propeller mechanism comprising a shaft having impeller blades mounted thereon for change in pitch, and mechanism common to a plurality of blades and automatically responsive to the direction of approach of air currents to the blades for changing the pitch of the blades.

4. A propeller mechanism comprising a shaft having blades mounted thereon for change in pitch, a pilot rotatable with the blades and movable responsive to departure of the direction of approach of the fluid currents from tangency to the blades, and mechanism responsive to pilot movements for automatically changing the pitch of the blades to maintain tangency.

5. A propeller mechanism comprising a shaft having blades mounted thereon for change in pitch, a pilot rotatable with the blades and movable responsive to departure of the fluid currents from tangency to the blades, and electromagnetically controlled mechanism for changing the pitch of the blades to maintain tangency.

6. A propeller mechanism comprising a propeller shaft, a wheel mounted thereon carrying impeller blades, gear means to control and vary the pitch of the blades, and a pilot-controlled mechanism adapted, responsive to the direction of approach of fluid currents from a condition of tangency to the blades, to change the pitch of the blades to restore tangency.

7. A propeller mechanism, comprising a tubular propeller shaft, means to mount impeller blades on the shaft free for change in pitch, mechanism rotatable with the propeller shaft for changing the pitch of the blades comprising a revoluble friction drive wheel,

a transmission therefrom to the various impeller blades, stationary friction means adapted to co-act with the revoluble friction on opposite sides to drive it in the desired direction, and means responsive to a pilot for controlling the direction of drive of the friction wheel.

8. A propeller mechanism, comprising a propeller shaft, impeller blades mounted thereon free for change in pitch, and mechanism for varying the pitch of the blades comprising a rotatable friction wheel revoluble with the propeller shaft, coacting non-rotatable friction elements adapted to be brought into engagement, one at a time, with the friction wheel to rotate it in the desired direction as it revolves, a transmission controlled by the rotation of the friction wheel for adjusting the pitch of the blades, and a pilot controlled means for engaging the desired friction element with said friction wheel.

9. A propeller mechanism according to claim 8, in which the transmission mechanism comprises a master gear, gears on each impeller blade meshing the master gear, and a drive means connecting the revoluble friction wheel with the master gear.

10. A propeller mechanism according to claim 8, in which the transmission mechanism comprises a master gear, gears on each impeller blade meshing the master gear, a drive means connecting the revoluble friction wheel with the master gear which comprises in part mechanism housed in the propeller shaft and a transmission leading therefrom and including a worm drive to the master gear.

11. A propeller mechanism comprising impeller blades mounted for change in pitch and having individual controlling gears, a master gear meshing said gears, and vane pilot controlled means to move the master gear and vary the pitch of the blades comprising circuit closing means and electromagnetic means responsive to the circuit closing means for controlling the adjustment of the master gear.

12. In a propeller mechanism, a tubular propeller shaft, a friction wheel shaft mounted at right angles to and projecting through the propeller shaft, a friction wheel rotatable with its said shaft and revoluble with the propeller shaft, a pair of friction tracks disposed on each side of the friction wheel and normally disengaged therefrom, magnetically controlled pantograph mechanism for moving the desired track into engagement with said friction wheel, a transmission from the friction wheel shaft to the forward end of the propeller shaft, a cross shaft driven by said transmission, an impeller spider in which said cross shaft is mounted, a master gear connected by a worm drive with said cross shaft, impeller blades rotatably mounted in the spider and having gears meshing said master gear, a pilot mounted in advance of one of the impeller blades and adapted to be displaced when the fluid medium is not striking the blades as desired, and circuit control mechanism responsive to the displacement of the pilot for magnetically controlling, by movement of the pantograph, the actuation of the friction wheel.

13. In a propeller mechanism, blades mounted to rotate for change in pitch, a pilot independent of the blades and rotatable therewith and sensitive only to the approach of air currents thereto, and mechanism responsive to the pilot to change the pitch of the blades.

14. In a propeller mechanism, blades mounted to rotate for change in pitch, a V-shaped pilot rotatable with a blade and independent thereof and sensitive only to the approach of air currents thereto, and mechanism responsive to the pilot to change the pitch of the blades.

In testimony whereof I affix my signature.

CHARLES McCARROLL.