

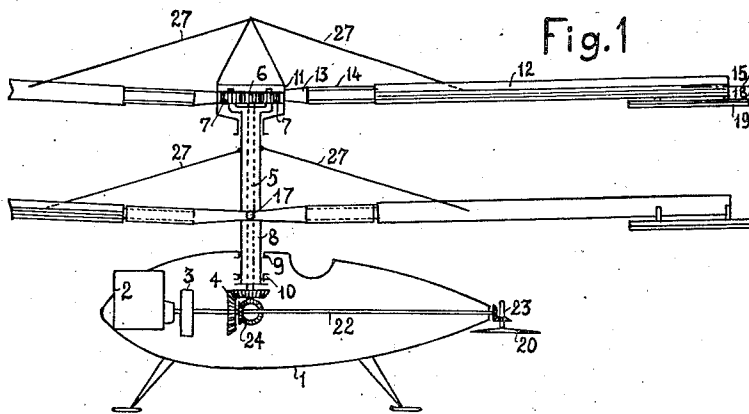
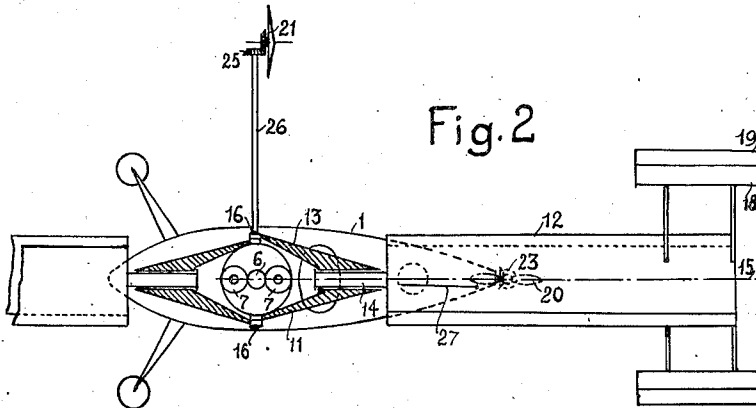
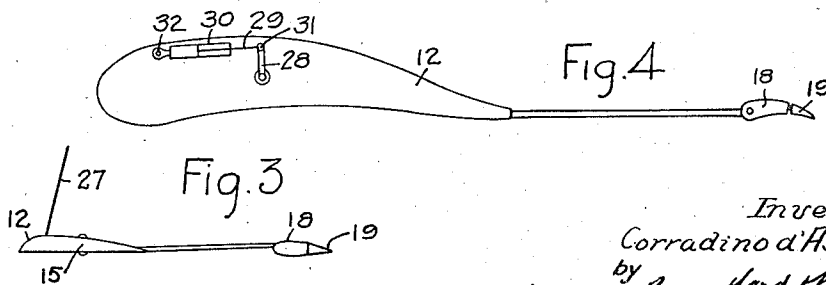
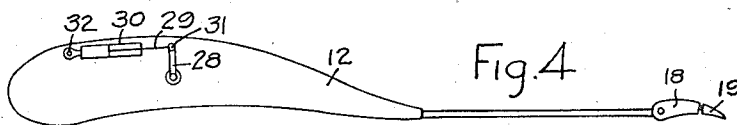
May 22, 1934.

C. D'ASCANIO

1,960,141

HELICOPTER

Original Filed Feb. 5, 1930 2 Sheets-Sheet 1



Inventor:
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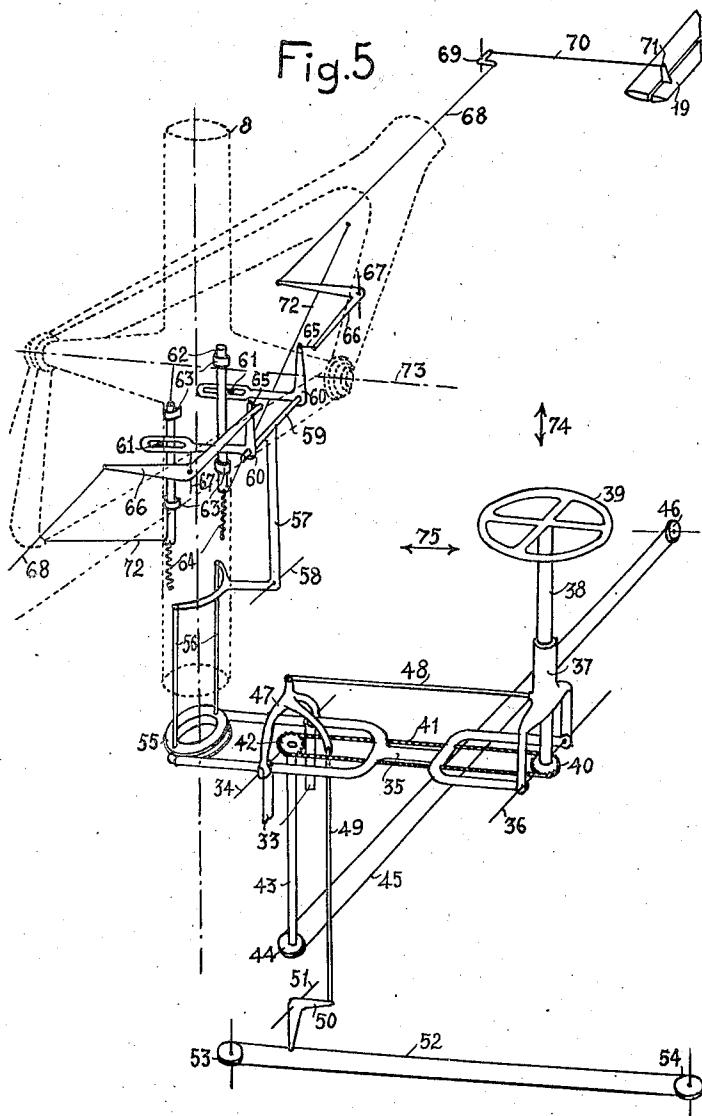
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Original Filed Feb. 5, 1930 2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

1,960,141

HELICOPTER

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Renewed October 31, 1933. In Italy February
9, 1929

20 Claims. (Cl. 244—19)

The invention relates to helicopters and its object is to construct a helicopter which is substantially characterized by the fact that the blades of its two or more coaxial horizontal propellers revolving in opposite directions and provided with tail wings or horizontal rudders, are tiltable about their longitudinal axis of gravity and are also freely movable about an axis which is perpendicular to, and passes through the axis of rotation of the propellers. The axis of gravity of the blades, about which they are tiltable, passes through the axis of rotation of the propellers and extends in proximity of the centres of aerodynamic pressure of the combined blades and rudders.

When the propellers are rotating each blade takes up a longitudinal position in accordance with the resultant of the aerodynamic thrust and of the centrifugal force, and a transverse position which depends on the action of the horizontal rudders. Further, when the motor is stopped, the said rudders cause the blades to take up automatically a position in accordance with the optimum angle of incidence of a gliding flight, and they thus sustain the machine while continuing to rotate, so that the machine will descend with a small speed which depends on the load and on the aerodynamic features of the blades and the rudders.

The tail wing of the blades of the propellers is provided with movable parts which may be operated by the pilot and which control the vertical movements of the machine, so that through a movement of the said movable parts the angle of incidence of the blades respecting the wind and therefore the movement of the machine in a vertical direction are being controlled.

When using two propellers revolving in opposite directions, they may be driven by means of an epicyclic gear whose driving wheel is rotated with a high angular speed by the motor, the propellers following respectively the rotation of the planet wheels and the rotation of the crown wheel of the epicyclic gear, so that an automatic equilibrium of the couples of reaction of the two propellers revolving in opposite directions is set up.

In this latter case, in order to control the vertical movements of the machine, only the tail wings of the lower propeller may be provided with movable parts under the control of the pilot, while the tail wings of the upper propeller are immovable and its blades therefore move with a constant angle of incidence. The vertical movements of the machine are then controlled

by varying the angle of incidence of the blades of the lower propeller through manoeuvring the movable parts of its tail wing so that the upward thrust of the two propellers will be altered through a variation of the angle of incidence of the blades of the lower propeller and through an automatic increase or decrease of the angular speed of the blades of the upper propeller produced by the variations of reaction of the lower propeller.

One or more additional smaller propellers whose blades may be operated by the pilot and which are driven by the motor and rotate about axes which are substantially at right angles respecting the axis of rotation of the main propellers and far apart therefrom, render it possible, when their pitch is being altered, to create a lateral thrust adapted to compensate the couple of differential reaction of the main shaft which rotates at a high angular speed, and thus capable of steering the apparatus in the desired direction.

One or more other additional propellers whose blades may be controlled by the pilot and which are driven from the motor and rotate about axes which are substantially parallel with the axis of rotation of the main propellers, render it possible, when their pitch is being altered, to create a vertical thrust which produces an inclination of the axis of the machine and thus creates a horizontal component of the thrust due to the main propellers, which said component produces the forward flight of the whole machine.

There are also provided devices, such as will hereafter be described, for automatically controlling the horizontal rudder when the longitudinal axis of the blade inclines beyond a pre-established limit above the horizontal, for automatically causing the blades to tilt about their longitudinal axis in order to increase their incidence during landing, for elastically or rigidly connecting between them the blades of each propeller, for allowing the blades to continue to rotate freely even when the motor has been stopped, and for damping abrupt movements of the blades of the propellers about their longitudinal axes.

The invention is shown by way of example in the accompanying drawings wherein

Fig. 1 is a side view, partly in section, of the helicopter,

Fig. 2 is a plan view thereof, the blade supporting arms being shown in section,

Fig. 3 shows a blade of the propellers seen in the direction of its longitudinal axis,

Fig. 4 shows a form of shock absorber upon the various blades, and

Fig. 5 shows schematically the controlling apparatus of the machine.

5 The helicopter as illustrated in Figures 1 and 2 comprises a fuselage 1 which is mounted on a resilient landing gear. The fuselage contains the cockpit and the necessary spaces for the gears, the tanks and so on, and also a motor 2 which
10 through a friction gear 3 adapted to be operated by the pilot, and through a bevel gearing 4 transmits its motion to a vertically arranged shaft 5 which rotates with a high angular speed. This shaft 5 is connected at its upper end to the driving
15 wheel 6 of an epicyclic gear. The planet pinions 7 of this gear are mounted on the upper end of a tubular shaft 8 which surrounds the shaft 5 and is coaxial therewith. The shaft 8 is secured to the fuselage by, and rotates in, bearings 9 and 10. Its upper end carries on suitable
20 bearings the crown wheel 11 of the epicyclic gear.

The sets of blades of the two propellers of the helicopter are respectively secured to the crown wheel 11 of the epicyclic gear and to the shaft 8. Each blade comprises an arm 13 and a wing element or blade proper 12. The blade 12 is secured with its prolongation 14 to the respective arm 13, for example with the interposition of suitable bearings, so that the blade is capable of
30 tilting on the arm about a longitudinal axis of gravity 15 which extends in proximity of the centres of aerodynamic pressure of the various sections of the blade. The arms 13 are pivoted to the shaft 8 and to the crown wheel 11 respectively
35 by means of pins 17 and 16 arranged respectively in pairs on an axis which is perpendicular to the axis of rotation of the propeller and crosses this axis.

Each blade is provided with a stabilizing surface arranged at a suitable distance from its exit edge towards its outer end, this surface being thus in the zone of the maximum circumferential speed. The stabilizing surface like the horizontal wing of a common airplane, consists of two members, of which the member 18 is secured rigidly
45 to the blade, while the member 19 is hinged to the first member and may be operated by the pilot after the manner of the horizontal rudder of an airplane.

50 The fuselage carries at a suitable distance from the central vertical axis two small propellers 20 and 21, of which the propeller 20 is arranged at the tail end of the fuselage, its axis being parallel to the shaft 8, while the propeller 21 is arranged laterally of the fuselage with its axis in a horizontal position. The propeller 20 is driven by the motor through a shaft 22 arranged in line with the driven shaft of the friction gear, and
60 through a small bevel gearing 23, or in any other suitable way, while the propeller 21 is driven by means of two sets of bevel gears of which one set 24 is arranged in the carter of the bevel gear 4 and is concentric therewith, while the other set 25 is arranged on the end of the driving shaft
65 26. The blades both of the propeller 20 and of the propeller 21 may be controlled by the pilot. For stabilizing purposes two propellers 21 may be arranged symmetrically respecting the axis of the helicopter.

70 The machine works in the following way. On the motor being thrown into gear and the movement being transmitted to the epicyclic gear, by means of the friction gear or in other ways, the two main propellers which are respectively con-

nected to the crown-wheel 11 and to the shaft 8, start to rotate in opposite directions with such angular speeds as to set up an equilibrium between the two couples of reaction of the two propellers. In this way, the machine is influenced
80 only by the couple of reaction due to the secondary shaft 5, which couple however is very small in view of the high angular speed of the secondary shaft, and may thus readily be compensated by the small lateral propeller which with its horizontally arranged blades serves also for steering
85 the machine which will deviate in one direction or the other or will not deviate at all according to whether the moment of the thrust of the lateral propeller respecting the central axis of the machine is greater or smaller than, or equal to, the couple of reaction of the shaft 5.

When the main propellers are in motion, each blade will take up under the action of its tail wing a certain angle of incidence respecting the wind and thus produce a thrust which will raise the machine. Abrupt movements of the blades
95 of the main propellers about their longitudinal axis are damped by shock-absorbers, for example of the hydraulic type, not shown in the drawings. As further the blade is pivoted through the intermediary of its arm either to the crown wheel of the epicyclic gear or to the central shaft 8, it will take up a longitudinal position in accordance with the force resulting from the centrifugal
105 force and the thrust.

By operating the horizontal rudders of the blades their angle of incidence respecting the wind and therefore the vertical thrust of the two propellers may be varied. It will thus be easily
110 understood that with the arrangement described a perfect stability of the machine is assured. A gust of wind which invests the blades unequally cannot produce a canting of the apparatus, as the centre of pressure of the two sets of blades
115 remains unaltered and passes always through the pivots and thus through the central axis of the machine. On the other hand, the controls for raising the machine are just as easily managed and act quite as semi-automatically as in ordinary
120 airplanes, as they are realized in a quite similar manner.

For the forward drive of the machine it is sufficient to act on the tail propeller which through a suitable manœuvre of its blades will produce
125 an upward thrust which tends to incline the central shaft forward and thus creates a horizontal component of the thrust of the main propellers, which will cause the machine to advance. Through an inverse manœuvre the machine may
130 be braked during its horizontal flight or its direction of flight may be inverted.

It will also be evident that it is also possible to control the rise of the machine by acting only on the blades of the lower propeller, in which
135 case only these blades will be provided with the horizontal rudder 19, while the blades 12 of the upper propeller will be provided only with the fixed wing 18 and thus rotate with a constant angle of incidence. When varying the incidence
140 of the blades of the lower propeller by means of a manœuvre of the horizontal rudder 19, a variation of the upward thrust of the two propellers will be obtained through the said variation of the angle of incidence of the blades of the lower
145 propeller and through an increase or a decrease of the angular speed of the upper propeller due to the variations of the reaction of the lower propeller.

The connection between the blades and the 150

shaft may also be obtained in other ways, for example in the way shown in Figure 4. The blades 12 during their rotation about their own axes are damped by means of a shock absorber 5 which acts between an arm 28 secured to each of the said axes and a point 32 upon the blade. The shock absorber comprises a piston 29 which slides in a cylinder 30 containing oil or the like and which is pivoted at 31 to the arm 28, while 10 the cylinder 30 is pivoted at 32. The sets of the blades are again pivoted respectively to the central shaft 8 and to the crownwheel 11 and if the propeller has two blades a pivot like the one above described will be employed, while if the propeller 15 has more than two blades a universal joint will be used. Thus, while the resultant of an aerodynamic action on the blades passes always through the pivot of the set on the central shaft 8, the angular speed of this shaft may be reduced 20 at will, as it is no longer necessary that a given centrifugal force should be generated on the blades to maintain their longitudinal axis suitably inclined.

By the described arrangement the machine is 25 rendered capable of descending slowly even if the motor has been stopped. The single blades working as elementary airplanes, will then automatically take up a position corresponding to the optimum angle of gliding flight, and will continue to rotate under the action of the horizontal 30 components of the gravity. The speed of descent depends on the shape of the blades, on the load and on the aerodynamic features of the combined blades and wings, and the various members may 35 thus be constructed so as to reduce the said speed to a preestablished limit in accordance with the capacity of the landing gear of absorbing the kinetic energy.

The transmission between the motor and the 40 blades may have inserted in it a free wheel or several free wheels (not shown in the drawings) which when the motor stops permit the blades to rotate freely without their having to trail heavy moving parts or without it being necessary to operate the friction gear. 45

Suitable elastic ties 27 sustain the blades in a given position of rest. These ties are secured to the blades in a point slightly in front of the longitudinal axis of the blades so that the shock 50 imparted to the whole arrangement when the machine lands, will cause the various blades to be automatically tilted so as to increase their angle of incidence, whereby the shock will be damped and the propellers be braked.

55 The whole machine is controlled by the aid of one single hand-wheel arranged within reach of the pilot. A perspective view of the control is shown in Figure 5 wherein dotted lines indicate the central shaft 8 with two blade arms secured 60 thereto, in order to illustrate the position of the control respecting said shaft.

Two brackets 33 are rigidly secured to the fuselage and carry a double-forked lever 35 adapted to rock about an axis 34 at right angles respecting 65 the central shaft 8. To the rear end of this lever 35 is secured a forked lever 37 adapted to rock about an axis 36 which is parallel to the said axis 34. This lever 37 carries a tubular lever 38 which may rotate about its axis. On the upper end of 70 this lever is rigidly secured the driving wheel 39, while the lower end has secured to it by means of a universal joint a sprocket 40 which is arranged at the point where the axis of the tubular lever meets the axis 36. A chain 41 passes round the 75 said sprocket 40 and round a sprocket 42 secured

by means of a universal joint to the upper end of a small shaft 43 and arranged at the point where the axis 34 meets the longitudinal axis of the lever 35. The lower end of the shaft 43 carries a pulley 44 on 80 which trains a small cable 45 which transmits the rotation of the pulley 44 to a pulley 46 whose movements produce variations of the pitch of the lateral propeller by the aid of one of the usual devices.

The axis 34 has pivoted to it a lever 47 which is 85 connected by means of a rod 48 with the lever 37 and is also connected by means of a rod 49 with one arm of a bell crank lever 50 adapted to rock about an axis 51 which is parallel to the axis 34, while the other arm of the said lever 50 is connected 90 with a small cable 52 which passes round two pulleys 53 and 54. The rotation of the pulley 54 causes variations of the pitch of the tail propeller in a manner similar to the pulley 46.

The ends of the front fork of the lever 35 enter 95 a groove of a collar 55 which is coaxial with the shaft 8. This collar rotates together with the shaft 8 and may be displaced in an axial direction. The collar is connected by means of small 100 rods 56 with the forked end of a bell crank lever 57 adapted to rock about an axis 58 which is carried by the shaft 8 at right angles thereto. The upper end of the lever 57 carries a spindle 59 which is parallel with the axis 58 and has pivoted 105 to it two bell crank levers 60. The horizontal arms of these levers are provided with grooves which slide on two pins 61 secured to rods 62 which may be displaced in a parallel direction respecting the axis of the shaft 8 and are guided by 110 sleeves 63 secured to the shaft 8. The rods 62 are normally maintained in their lower position by means of springs 64.

The ends of the vertical arms of the levers 60 are connected by means of small rods 65 to bell 115 crank levers 66 which rock on the axes 67 on the blade supporting arms. These levers 66 are further connected by means of rods 68 arranged inside the blades, of a bell crank lever 69 and of a small rod 70 with the lever 71 of the horizontal 120 rudder 19 of the tail wing on each blade.

The lower ends of the rods 62 are fastened by 125 means of cables 72 of a certain length to points on the blade supporting arms at a suitable distance from the axis of rotation of the said arms.

The devices now described work as follows. 126

The machine is controlled in a vertical direction 130 through moving the hand wheel 39 axially in the direction of the arrow 74, whereby the lever 35 is caused to rock about the axis 34 and produces by means of the described transmissions of rods and levers a movement of the horizontal rudder 135 of the tail wing of each blade, the angle of incidence of the blade and its vertical thrust being thus altered.

The forward flight of the machine is controlled 140 by moving the hand wheel in the direction of the arrow 75, viz. in the direction of the longitudinal axis of the fuselage. In this case the lever 37 rocks about the axis 36 and produces by means of the rod 48, the lever 47, the rod 49 and the lever 50 a movement of the cable 52 in one direction or 145 the other and thus a rotation of the pulley 54, whereby the thrust of the tail propeller will be altered and the axis of the machine will be given the inclination which is required to create the forward thrust. 150

For steering the machine in the desired direction it is necessary to turn the hand wheel about its own axis, as this rotation produces by means of the chain 41 and the cable 45 a rotation of the 155

pulley 46 and thus a variation of the thrust of the laterally arranged propeller.

As above said, the blade supporting arms which are pivoted to the shaft, take up automatically a certain inclination above the horizontal, this inclination being the resultant of the centrifugal force and the vertical thrust. The cables 72 have such a length that they become tight when the arms surpass the said normal inclination, while they are slack when the arms move downward. If on account of a sudden gust of wind or of a larger speed of the blade moving against the wind during the forward flight, or on account of a false manoeuvre, the vertical thrust surpasses a certain limit and the inclination of the arms thus surpasses their normal inclination, the rise of the arms produces an upward movement of the rods 62, which by means of the pins 61 displace the levers 60 and the movable tail surface 19 so as to increase the angle of incidence of the respective blade and thus its vertical thrust.

What I claim is:

1. A helicopter comprising a rotation shaft, a propeller, the blades of said propeller being hinged to said shaft to vary the dihedral angle, said blades also being rotatably mounted to vary the angle of incidence, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade and means for controlling said controlling planes.

2. A helicopter comprising a rotation shaft, a propeller, the blades of said propeller being hinged to said shaft to vary the dihedral angle, said blades also being rotatably mounted to vary the angle of incidence, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, means for controlling said controlling planes, and means for varying the direction of the thrust of said propeller.

3. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade and means for controlling said controlling planes.

4. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, means for controlling said controlling planes and means for varying the direction of the thrust of said propeller blades.

5. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, means for controlling said controlling planes and a second propeller for varying the direction of the thrust of said propeller blades.

6. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and a propeller offset from said rotation shaft for equalizing the difference in torque set up by said rotation shaft and said tubular shaft.

7. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a

fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft and propeller blades mounted on said last-named arms.

8. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft and propeller blades rotatably mounted on said last-named arms.

9. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and means for varying the direction of the thrust of said propellers.

10. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and means for equalizing the difference in torque set up by said rotation shaft and said tubular shaft.

11. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and a propeller offset from said rotation shaft for equalizing the difference in torque set up by said rotation shaft and said tubular shaft.

12. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and means for damping the rotative movement of said blades in said arms.

13. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, means for controlling said controlling planes and means for damping the rotative movement of said blades in said arms.

14. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a tubu-

lar shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and means for damping the rotative movement of said blades in said arms.

15. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, means for controlling said controlling planes and means for automatically increasing the angle of incidence of said blades upon landing.

16. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and means for automatically increasing the angle of incidence of said blades upon landing.

17. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and means for automatically increasing the angle of incidence of said blades upon landing.

18. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, means for controlling said controlling planes and elastic ties secured to said blades slightly in front of their longitudinal axes so as to increase automatically the angle of incidence of said blades upon landing.

19. A helicopter comprising a rotation shaft, arms pivotally mounted upon said shaft, propeller blades rotatably mounted in said arms, a tubular shaft encircling said rotation shaft, means rotating said tubular shaft in counter direction to said rotation shaft, arms pivotally mounted upon said tubular shaft, propeller blades mounted on said last-named arms and elastic ties secured to said blades slightly in front of their longitudinal axes so as to increase automatically the angle of incidence of said blades upon landing.

20. A helicopter comprising a rotation shaft, a propeller, the blades of said propeller being hinged to said shaft to vary the dihedral angle, said blades also being rotatably mounted to vary the angle of incidence, a fixed stabilizing plane upon each blade, a movable controlling plane upon each blade, means for controlling said controlling planes and elastic ties secured to said blades slightly in front of their longitudinal axes so as to increase automatically the angle of incidence of said blades upon landing.

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