

Nov. 22, 1938.

W. W. ROTHENHOEFER

2,137,952

AIRPLANE

Filed June 25, 1936

4 Sheets-Sheet 1

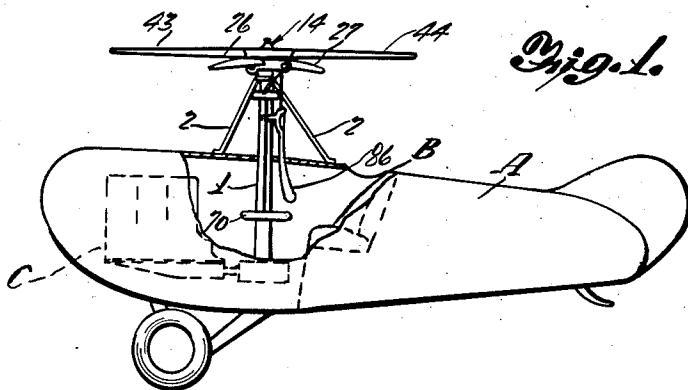


Fig. 1.

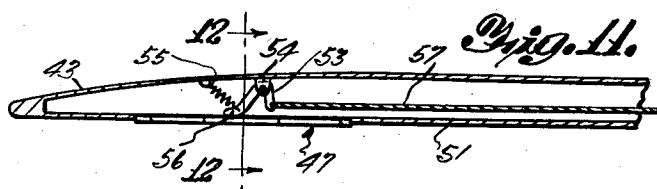


Fig. 11.

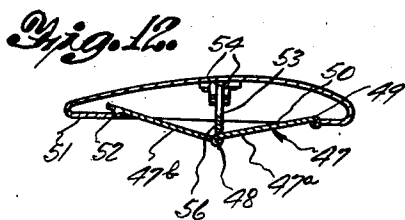


Fig. 12.

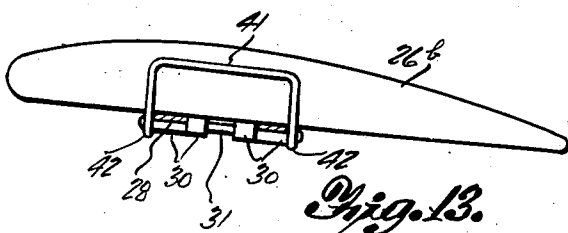


Fig. 13.

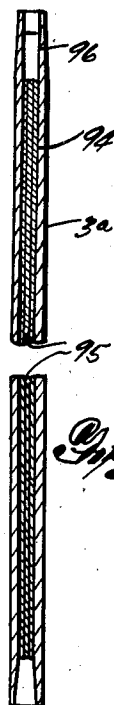


Fig. 14.

Walter W. Rothenhofer
INVENTOR

Nov. 22, 1938.

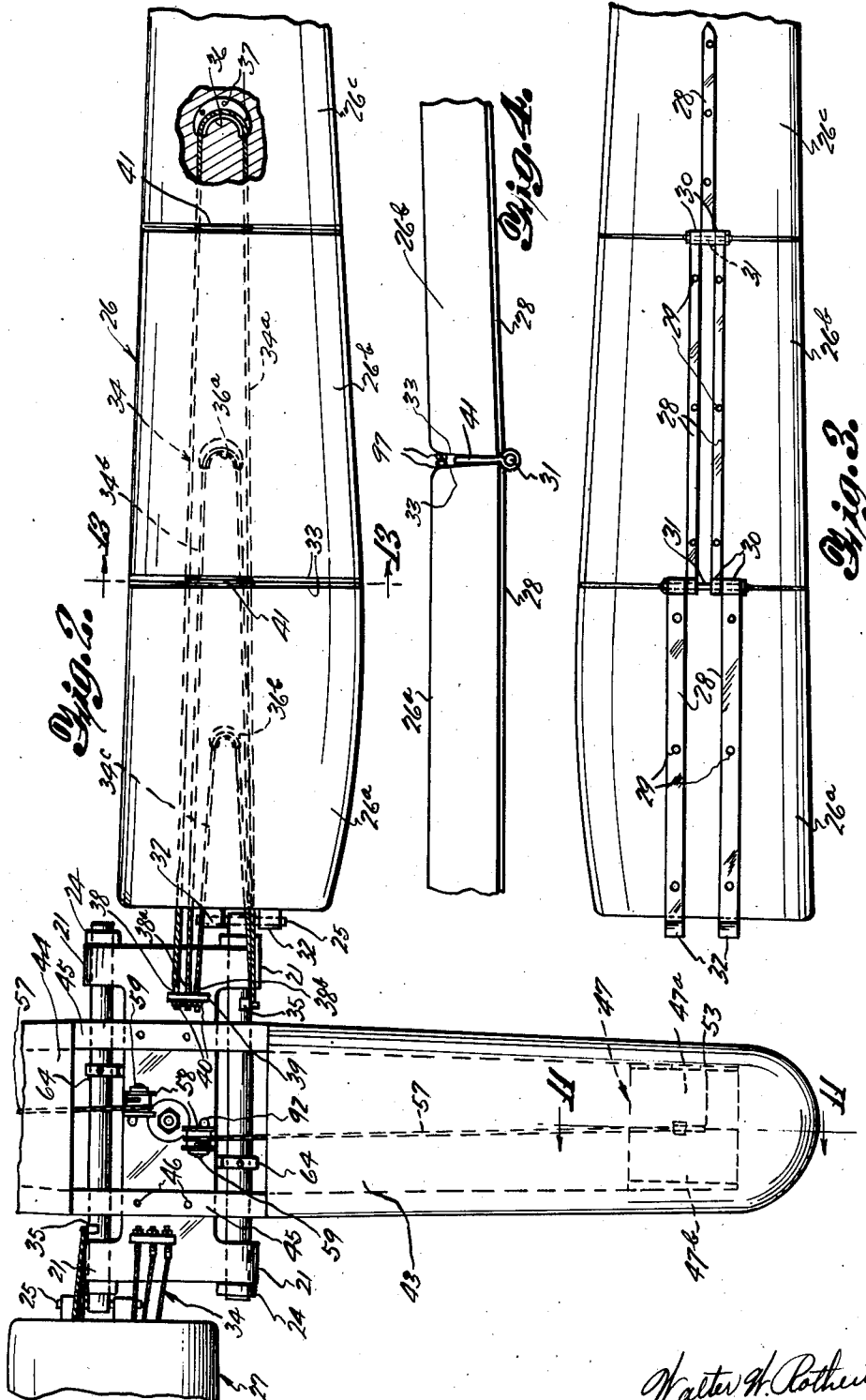
W. W. ROTHENHOEFER

2,137,952

AIRPLANE

Filed June 25, 1936

4 Sheets-Sheet 2



Walter H. Rothenhofer
INVENTOR

Nov. 22, 1938.

W. W. ROTHENHOEFER

2,137,952

AIRPLANE

Filed June 25, 1936

4 Sheets-Sheet 3

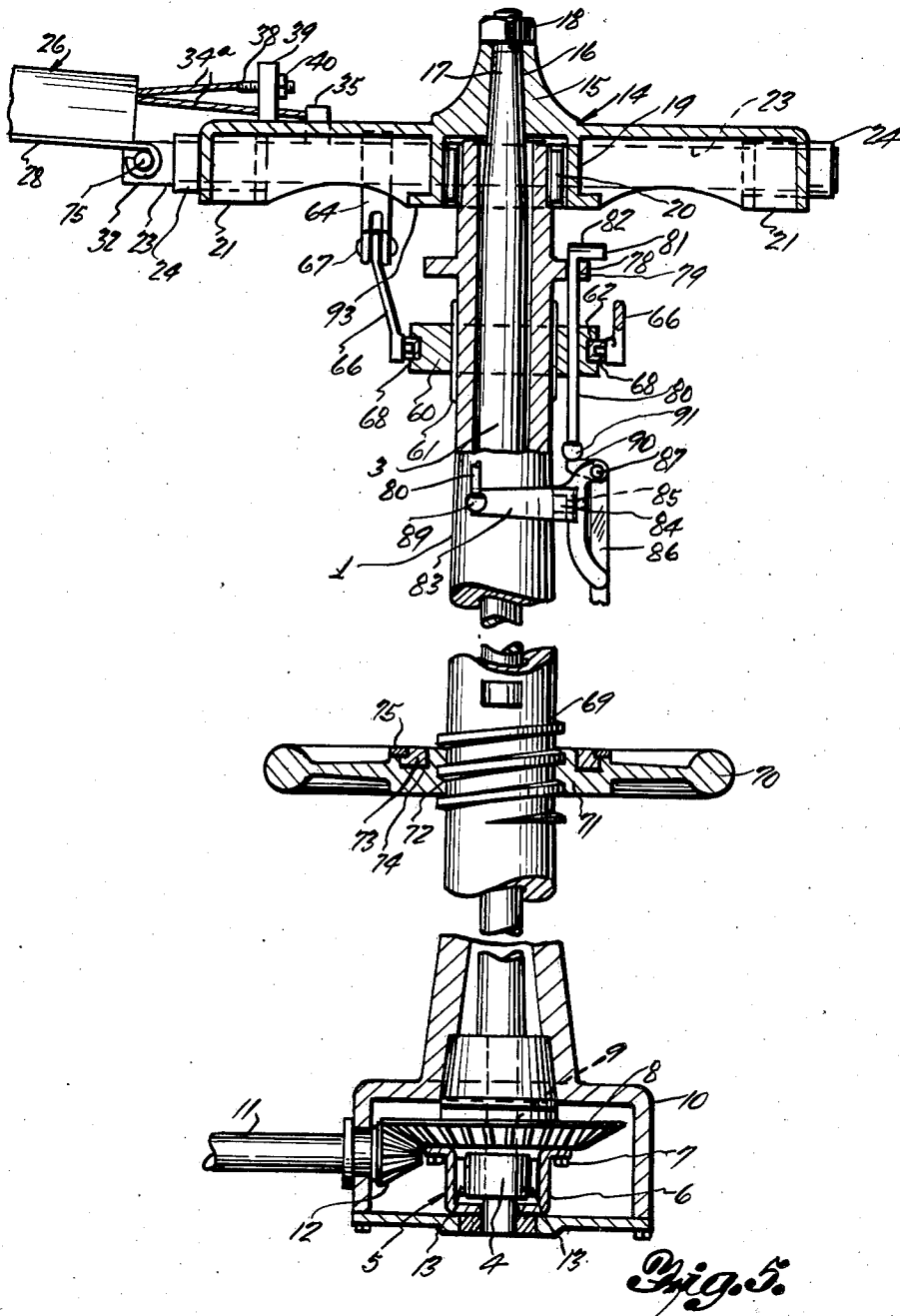


Fig. 5.

Walter W. Rothenhofer
INVENTOR

Nov. 22, 1938.

W. W. ROTHENHOEFER

2,137,952

AIRPLANE

Filed June 25, 1936

4 Sheets-Sheet 4

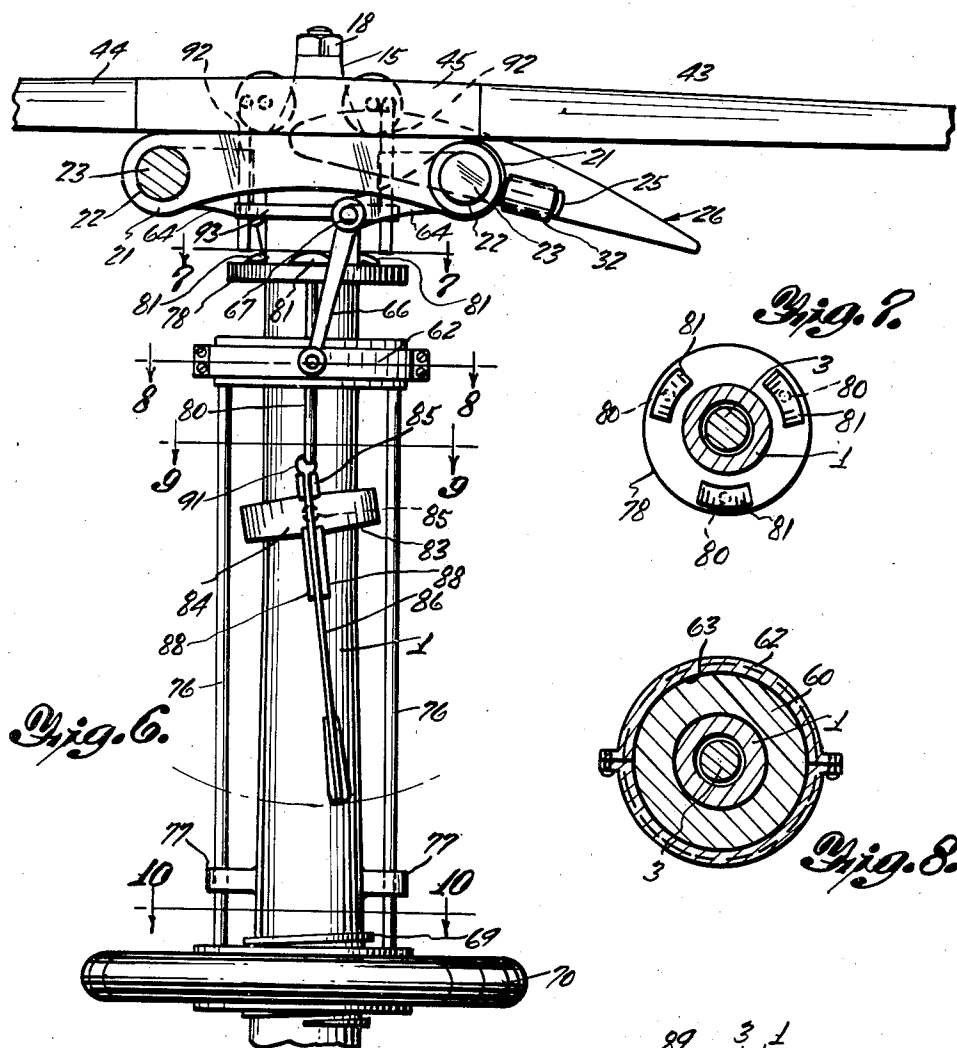


Fig. 6.

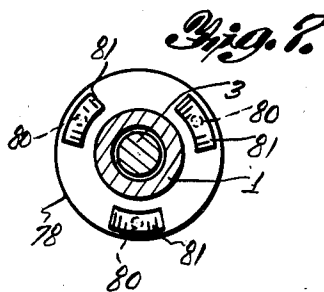


Fig. 7.

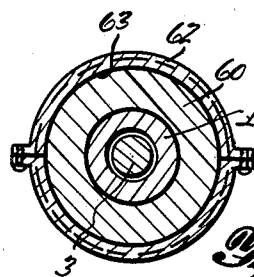


Fig. 8.

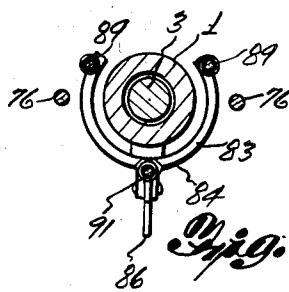


Fig. 9.

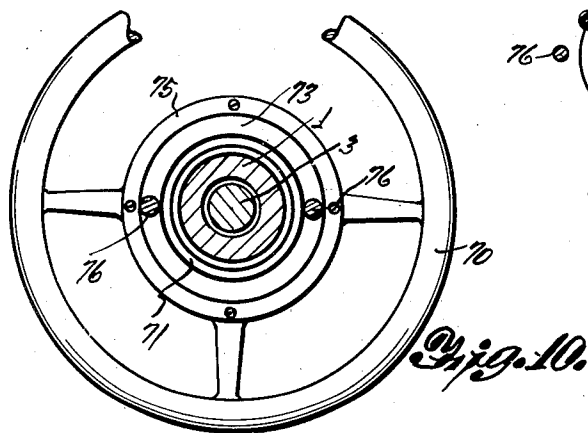


Fig. 10.

Walter H. Rothenhofer
INVENTOR

UNITED STATES PATENT OFFICE

2,137,952

AIRPLANE

Walter W. Rothenhoefer, St. Louis, Mo.

Application June 25, 1936, Serial No. 87,146

6 Claims. (Cl. 244—17)

My invention relates to improvements in airplanes of the helicopter type wherein a rotor is employed operating on a vertical axis to permit vertical ascent and descent of the plane.

5 The main object of my invention is to provide an improved sustaining rotor of this kind in which the blades have manually or mechanical adjustable and reversible pitch whereby their lift may be adjusted as needed in flight.

10 Another object is to provide a rotor of this kind having connection to an engine through an over-running clutch whereby the rotor will be positively driven in one direction but should the engine fail the rotor may continue to operate and by reversing its pitch will permit safe descent to the ground, this action being similar to that described in my co-pending applications, Serial Numbers 36,786, and 729,810, filed August 19, 1935, and June 9, 1934, respectively.

20 Another object is to provide an improved rotor having, in addition to the variable pitch blades described, intermediate short fixed central stubs or blades having lift control means operatable under manual control at several points around 25 their orbital path to increase their lift and enable steering of the plane thereby.

Another object is to provide a novel and effective control mechanism for the pitch and lift variation described.

30 Another object is to provide an improved blade structure made up of a plurality of segments hinged together and held in alignment by cables extended lengthwise through the segments.

35 With these and other objects in view the invention resides in the novel construction and arrangement of parts as hereinafter fully set forth and claimed, reference being had to the accompanying drawings as showing a preferred embodiment of my invention for purposes of exemplification.

In the drawings:

Figure 1 is a side elevation, partly broken away, showing an airplane equipped with my rotor.

45 Figure 2 is an enlarged fragmentary plan view showing the rotor hub and one each of the lifting blades and the control stubs.

Figure 3 is a fragmentary inverted plan view of one of the lifting blades alone.

50 Figure 4 is an enlarged fragmentary edge view of one of the lifting blades.

Figure 5 is an enlarged vertical section through the rotor hub and housing assembly.

55 Figure 6 is a fragmentary rear elevation of the rotor hub and housing assembly.

Figure 7 is a cross section along the line 7—7 in Figure 6.

Figure 8 is a cross section along the line 8—8 in Figure 6.

Figure 9 is a cross section along the line 9—9 in Figure 6.

Figure 10 is a cross section along the line 10—10 in Figure 6.

Figure 11 is a cross section along the line 11—11 in Figure 2.

Figure 12 is a cross section along the line 12—12 in Figure 11.

Figure 13 is a cross section along the line 13—13 in Figure 2.

Figure 14 is a longitudinal section through a cable-centered rotor shaft.

In carrying out my invention I provide a tubular elongated housing 1 which is mounted vertically through the upper portion of the fuselage A of the airplane and supported thereon by braces 2. This fuselage A may be of any suitable form and has a pilot's seat B near and behind the housing 1 to place the pilot convenient to the controls to be mounted on the housing. The housing is of course mounted at about the center of gravity of the fuselage.

A drive shaft 3 is journaled through the housing 1 from end to end thereof and at its lower end the shaft is secured to the rotor or cam 4 of a conventional form of over-running or free-wheeling clutch 5 which runs in a housing 6 secured at 7 to the drive gear 8. This drive gear 8 is journaled freely at 9 on the shaft 3 and runs in a drum 10 formed at the lower end of the housing 1. A motor shaft 11 running to the engine C which may be of any suitable form passes through the side of the drum 10 and carries a drive pinion 12 meshing with the drive gear 8. As the engine C runs it will thus turn the gears 8 and 12 and the housing 6 and in the direction of rotation, hereinafter termed the forward direction, the clutch dogs 13 will lock the housing 6 and clutch rotor 4 together causing rotation of the drive shaft 3 in that direction. The shaft 3 may however turn free of the gears 8, 12 and the engine C in the opposite or backward direction.

A rotor hub 14 is provided and same is of substantially rectangular form with a central boss 15 bored as at 16 to receive the tapered upper end 17 of the drive shaft 3 to which it is secured by a nut 18. The hub 14 has an annular bearing 19 beneath the boss 15 which fits over the upper end of the housing 1 and runs on a roller bearing 20 thereon. Suitable thrust and roller bearings are

provided wherever needed in accordance with usual practice.

Bearing supports 21 are extended laterally from each corner of the hub 14 and are bored out as at 22 to receive elongated bearing pins 23 which are journaled therethrough one along each side of the hub. Collars 24 are secured to the pins 23 and prevent axial movement of the pins through the bearings. One end of one pin 23 is extended endwise from the hub 14 and provided with a heavy cross or hinge pin 25 and the opposite end of the other pin 23 is similarly extended and provided also with a hinge pin 25. The variable pitch lifting blades now to be described are attached by the pins 25 to these bearing pins 23.

The lifting blades are designated generally at 26 and 27 and since each is identical one only will be described in detail. The blade 26 is of substantially the shape, contour and cross-section of a usual airfoil and is made up of a plurality of sections or segments 26a, 26b and 26c which may be of any desired number and are arranged end to end to form a blade of any desired length. These segments are hingedly connected at their adjacent or mounting ends by hinge straps 28 which are secured at 29 to the undersides of the segments and are arranged at their ends in interdigitating relation. These ends are curled to form hinge eyes 30 through which hinge pins 31 are placed to pivotally secure them together. The extreme inner ends of the straps 28 on the innermost segment 26a are likewise curled to form hinge eyes 32 which are pivotally mounted on the aforesaid cross pin 25 of one bearing pin 23 to attach the blade to the pin. Of course any number of the straps 28 may be used as desired.

The meeting ends 33 of the blade segments are slightly beveled off as shown in Figure 4 to allow limited upward swinging movement of each segment relative to the other.

To maintain the blade segments in alignment and to prevent endwise strain thereon from separating the sections while they are rotating in flight I provide cables shown generally at 34 arranged as will now be described. An anchor lug 35 is extended rigidly from the bearing pin 23 to which the blade is attached inwardly of the bearing 21 and a cable 34a is attached to this lug, extended out through suitable grooves in the segments 26a, 26b and around a bearing plate 36 secured at 37 in the outermost segment 26c. The cable then is passed inwardly again and has its inner end attached to an adjustment screw 38 which is adjustably mounted through an anchor block 39 formed atop the adjacent end of the hub 14. In similar manner other cables 34b and 34c (one for each blade segment) are attached to the lug 35, passed out through the blade around bearing plates 36a and 36b and back to other adjustment screws 38a and 38b in the anchor block 39. Then by screwing up the nuts 40 the cables 34a, 34b and 34c may be put under tension and since they pass above the hinge joints of the blade segments 26a, 26b and 26c these segments will be held up by the cables. By individual adjustment of the cables the segments are drawn up so that the wing curls upward slightly toward its outer end when at rest and then as it is put in rotation centrifugal force will cause it to straighten out as the cables reach their limit of tautness. As stated the other blade 27 is similarly made and provided. Yokes 41 are attached at their ends 42 to the hinge pins 31 and enclose and

overlie the cables between the blade segments to hold the cable in place as shown in Figure 13.

Relatively short stub blades 43 and 44 are provided and same are extended from the hub 14 midway between and at right angles to the lifting blades 26 and 27. These blades 43 and 44 are set perfectly level without any angle of incidence and hence as they turn exert no lifting force of themselves. Each blade has the common front and rear spars 45 which extend across the hub 14 and are secured at 46 thereto to hold the blades on the hub. Adjacent their outer ends each blade 43 and 44 has a lift panel 47 made up of two sections 47a and 47b hinged together at 48 and hinged by one margin at 49 to the blade at the frontal edge of an opening 50 formed in the lower surface 51 of the blade. This forward edge is so termed by its frontal disposition in the normal forward turning of the rotor assembly. The rear or trailing edge of the panel section 47b has sliding engagement at 52 with the rear edge of the opening 50.

A bell crank lever 53 is fulcrumed in brackets 54 above the center of each panel 47 and a retractile coil spring 55 stretched between the lever and an adjacent part of the blade normally holds the lever foot 56 upward. A cable 57 extends from each lever 53 inward through each blade 43 and 44 to a drum 58 journaled at 59 on the hub 14. Rotation of the drums 58 will pull on the cables 57 and swing the lever feet 56 downward causing them to press the centers of the lift panels 47 downward as shown in Figure 12 to cause a lift to be exerted by the blades as will be understood. When the feet 56 again raise the pressure of wind flowing past the blades 43 and 44 will collapse or flatten the panels 47.

A collar 60 is slidably keyed as 61 on the housing 1 some distance below the upper extremity thereof and a bearing ring 62 is journaled in a peripheral groove 63 in this collar. Crank arms 64 are secured to the bearing pins 23 and extended radially inward therefrom toward opposite sides of the collar 60. Links 66 are pivoted at 67 to the free ends of the arms 64 and have pins 68 by which they are connected at their opposite ends to the bearing ring 62. Thus upward and downward movement of the collar 60 on housing 1 will cause a rotating or rocking motion of the bearing pins 23. This motion transmitted to the lift blades 26 and 27 will vary their pitch or angle of incidence and hence will vary the lift afforded by their rotation.

Some distance below the upper wall of the fuselage A the housing 1 has spiral threads 69 and a hand wheel 70 is provided having a hub 71 threaded at 72 on these threads 69 so that rotation of the wheel will cause it to move up or down the housing 1. A bearing ring 73 is journaled in a groove 74 in the upper face of the hub 71 and is held in place by a ring 75. Push rods 76 are secured at their ends to diametrically opposite points on the collar 60 and ring 73 and extend alongside the housing 1 between these parts. The rods 76 pass slidably through apertured ears 77 extended radially from the housing a short distance above the hand-wheel 70. Now it will be understood that as the wheel 70 is turned the resultant upward or downward motion will be transmitted by the rods 76 to the collar 60 to cause the variation in pitch of the lift blades 76 and 77 as described.

The housing has an annular extended flange or cam race 78 some distance above the collar 60 and same has three (or more) equally spaced

apertures 79 through which cam pins 80 are slidably mounted in a vertical direction parallel to the axis of the housing 1. At their upper ends these pins 80 have cam heads 81 rounded on their upper faces as at 82.

A control lever fork or yoke 83 of substantially U-shaped form is set astraddle the housing 1 and is pivotally mounted by its bight 84 on a pin extended outwardly from the housing. This yoke 83 has upwardly extended ears 85 between which a control handle 86 is pivotally mounted as at 87 and the yoke has guide wings 88 depended and extended rearwardly between which the handle 86 may rest. The free ends of the yoke 83 are connected by ball and socket joints 89 to the lower ends of a pair of the cam pins 80 while the upper end of the handle 86 has an arm 90 turned inwardly toward the housing 1 to which the other pin 80 is connected also by a ball and socket joint 91.

These parts are so located that the handle 86 is disposed at the rear of the housing 1 thus convenient to the pilot's seat B and the handle is connected to a cam head 81 which is likewise located at the rear of the housing. Then the other heads 81 are located forwardly around the flange 78 in the manner shown.

Push pins 92 are slidably mounted through the hub 14 and down through a flange 93 turned outwardly from the bearing 19 and at their upper ends one pin is eccentrically and pivotally engaged with each of the drums 58 on which the lift control cables 57 are wound. Normally the lower ends of these pins 92 hang down to a point which will just clear the cam heads 81 as the rotor turns and carries the pins around above the flange 78.

In operation the hub 14 and attached blades 26, 27 and 43, 44 are set in rotation under influence of the engine C and the pilot by manipulation of the control wheel 70 adjusts the pitch of the lifting blades 26 and 27 to the point where they exert enough lift to raise the airplane from the ground. Then when the ascent has been made and assuming it is the aim to proceed in flight forwardly the pilot pulls back on the control handle 86 raising the rear cam head 81 and now each time one of the push pins 92 passes this cam head it will engage and be raised thereby. The resulting upward thrusts on the push pins will then cause a periodic partial rotation of the drums 58 exerting a pull each time on the cable 57 sufficient to operate the bell crank levers 53 and force the lift panels 47 downward at their centers. Thus the lift is increased each time one of the stub blades 43 and 44 pass around the rear of the housing 1 and as a result the airplane will tilt upward lightly at the rear and will glide forwardly meanwhile being sustained in the air by the lift of the whirling blades 26 and 27. By swinging the control handles 86 to either side the yoke 83 may be rocked on its bearing 85 to raise either of the other cam heads 81 and cause flight or turning to either side as will be understood.

The separation of functions of lift control and horizontal flight control to separate sets of blades results in a more compact, practical and convenient assembly especially where the flight control is embodied in short stub blades as is the case herein. This for the reason the lift control panels being set to travel in an orbital path of smaller diameter than the longer variable pitch blades afford a better balance and nicety of control.

As in both my hereinbefore mentioned co-pending applications provision is made for safe

descent in case of engine failure while in the air. This is done herein by the following means. Should the engine fail the clutch 5 will allow the rotor to turn free and the pilot allows the plane to drop vertically a short distance meanwhile reversing the pitch of the blades 26 and 27 by manipulation of the control wheel 70. Thus the drop will set the rotor into rapid rotation and is allowed to continue until the plane is near the ground after which the pitch is again reversed and the resultant upward thrust before the rotor stalls is sufficient to arrest the descent and cause the plane to settle lightly to the ground.

Since the whole lift afforded by the rotor is transmitted to the shaft 3 it is important that this shaft be strengthened against longitudinal strain. A particularly advantageous form of shaft is shown at 3a in Figure 14 in which it has a longitudinal bore 94 through which a number of steel or bronze cables 95 are passed. The ends of the cables are leaded as at 96 into tapering sockets at the ends of the bore 94 and thus the cables reinforce the shaft against lengthwise stress.

The meeting ends 33 of all the blade segments have rubber bumpers 97 which limit the relative upward movement of the segments and absorb all shocks and jars.

While I have herein set forth a certain preferred embodiment of my invention it is understood that I may vary from the same in minor structural details so as best to provide a practical device for the purposes intended, not departing from the spirit of the invention and within the scope of the appended claims.

I claim:

1. In an airplane, a rotor, articulated lift producing blades extended from the rotor, and relatively short fixed stub blades extended between the lift producing blades and having means for periodically causing a lift to be exerted by these stub blades.

2. In an airplane, a rotor, articulated lift producing blades extended from the rotor, relatively short fixed stub blades extended between the lift producing blades and having means for periodically causing a lift to be exerted by these stub blades at different points around their orbital path.

3. In an airplane, a rotor, a plurality of articulated lifting blades extended from the rotor, means for varying and reversing the pitch of the said blades, shorter intermediate stub blades extended from the rotor, and means on these stub blades for controlling the direction of horizontal flight.

4. In an airplane, a rotor, a plurality of articulated lifting blades extended from the rotor, means for varying and reversing the pitch of the said blades, shorter intermediate stub blades extended from the rotor, means on these stub blades for controlling the direction of horizontal flight, and cables extended lengthwise through the lifting blades to hold the same in alignment.

5. In an airplane, a rotor, a plurality of articulated lifting blades extended from the rotor and pivotally joined thereto, means for varying or reversing the pitch of the said blades, shorter stub blades extended from the intermediate the lifting blades, lift panels in the stub blades, and means for selectively actuating the lift panels at different points around the orbital path of the blades whereby the lift may be increased to cause gliding flight in any direction.

6. In an airplane, a rotor, a plurality of articu-

lated lifting blades extended from the rotor and pivotally joined thereto, means for varying or reversing the pitch of the said blades, shorter stub blades extended from the intermediate the lifting blades, lift panels in the stub blades, means
5 for selectively actuating the lift panels at differ-

ent points around the orbital path of the blades whereby the lift may be increased to cause gliding flight in any direction, the said stub blades being set at a level so that they have no lift except through action of the lift panels.

WALTER W. ROTHENHOEFER.