July 23, 1946. S. P. NEMETH 2,404,522

PITCH CONTROL MEANS FOR SUSTAINING ROTORS

Filed Aug. 20, 1943

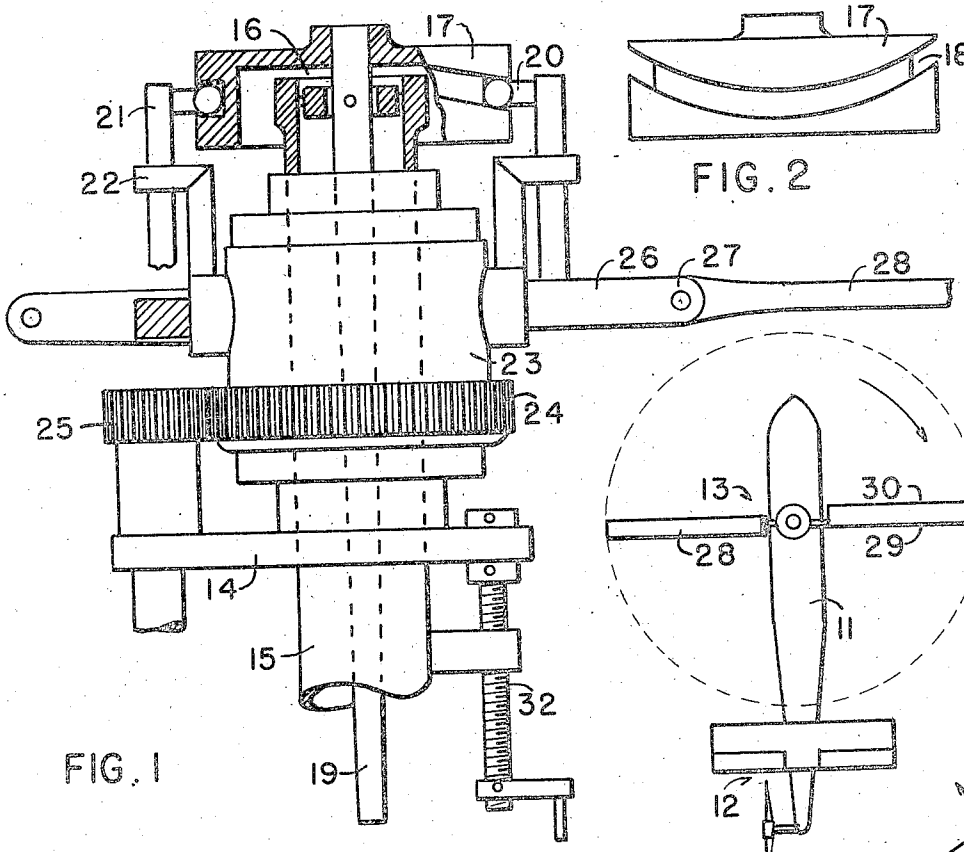


FIG. 1

FIG. 2

FIG. 3

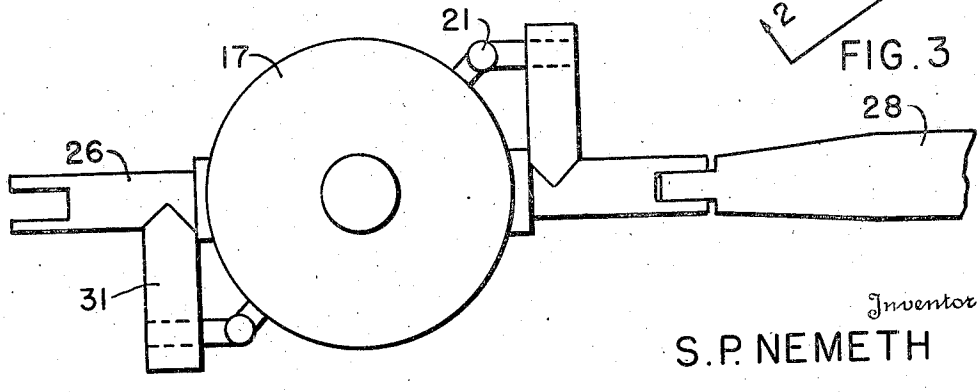


FIG. 4

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Patented July 23, 1946 2,404,522

UNITED STATES PATENT OFFICE

2,404,522

PITCH CONTROL MEANS FOR SUSTAINING ROTORS

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Application August 20, 1943, Serial No. 499,340

4 Claims. (Cl. 244—17)

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This invention relates to aircraft principally sustained by a rotor or rotors adapted to be either positively driven or aerodynamically rotated. The invention is applicable to such rotors regardless of the number of blades incorporated therein.

The invention relates more particularly to rotors the blades of which are arranged for composite motion relative to their hub. They are free to swing up and down. In addition, their pitch angle is variable, this variation being partly automatic, and the characteristics of the automatic pitch variation being likewise partly under the control of the pilot.

The pitch angle variation features under the control of the pilot are intended to reduce the flapping angle and to provide pitch and roll control of the aircraft in a known manner. The flapping is principally relied on for stabilizing the rotor and for preventing excessive centrifugal loads and stresses. A periodic pitch angle variation of a period equal to that of the rotor rotation having an amplitude under the control of the pilot is used for providing an approximate balance between the left side and the right side of the rotor, that is to say for an approximate equalization of the lift of the advancing blade and of the retreating blade. A variation of the average blade pitch angle under the control of the pilot is provided for governing the mode of flying, whether the aircraft is predominantly flying forwardly with its best speed or whether it shall predominantly climb or hover at a lesser or no speed.

The inner portions of rotating blades do not produce lift commensurate with the lift produced by their outer portions, because the velocity of rotation of the inner blade portions is much smaller than the velocity of rotation of the outer blade portions. The lift production is therefore practically concentrated within an outer ring portion of the circular "disc" area through which the blades rotate. In consequence, there is produced on the left side and on the right side of the aircraft more lift, and at the center portion of the disc circle, near the fuselage path, less lift than would be desirable for best efficiency. It is a first object of my invention to provide a sustaining rotor producing a more advantageous lift distribution crosswise the aircraft, favoring the portion near the flight path of the fuselage to a larger extent than present rotors do.

The retreating blade has a very small lift capacity by virtue of its small velocity relative to the air. The advancing blade has basically a much larger lift capacity by virtue of its large velocity relative to the air. But this larger capacity cannot be fully utilized because the lift of the advancing blade must balance and not overbalance the lift of the retreating blade. Thus, the lift capacity of the advancing blade is partly wasted, to the detriment of its efficiency. This particular shortcoming is also inherent in the presently described improved rotor. But furthermore, with conventional rotors, the blade when pointing forwardly into the direction of flight, or rearwardly into a tailwise direction, is arranged to produce a lift half way between the lift corresponding to the true lift capacity of the advancing blade and the true lift capacity of the retreating blade. In other words, the effective pitch angle of the blade in forward and in rearward position is substantially the arithmetic mean of the pitch angles of the blade when in advancing or in retreating relation. This arrangement utilizes the lift capacity of the blades in their fore-aft positions below full capacity, thereby further reducing the efficiency of the rotor. There is no compelling reason for this additional lift capacity reduction. The lift production fore and aft is substantially equal, and balance is provided at a lift production at full capacity as well as at a lift production at part capacity. It is a further object of my invention to provide a sustaining rotor utilizing the lift capacity of the blades in their fore and aft position fullest without regard to the lateral balance requirement.

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The blades of conventional rotors change their effective angle of incidence relative to the moving air periodically, once during each revolution of the blade. I have found that a more frequent change of the incidence angle, at least twice during each blade revolution, and one with an amplitude of the angle variation beyond that necessary for the lateral control greatly benefits the aerodynamic action of the blades, reducing the blade resistance and increasing the blade lift capacity. It is a third object of my invention to provide a sustaining rotor having blades arranged to change their effective incidence angle periodically at least twice during each revolution of the blades with considerable amplitude variation.

These and other desirable objects and advantages of the present invention will be illustrated in the accompanying drawing and described in the specification, a certain preferred embodiment being disclosed by way of illustration only, for, since the underlying principles may be incorporated in other specific devices, it is not intended to be limited to the one here shown, except as

such limitations are clearly imposed by the appended claims.

In the drawing like numerals refer to similar parts throughout the several views, of which:

Fig. 1 represents an elevational view, partly in section, of a rotor hub assembly,

Fig. 2 represents an elevational view of the cam track drum of said hub assembly, seen from a direction indicated by the arrows 2—2 of Fig. 3.

Fig. 3 represents a diagrammatic plan view of the aircraft having said rotor hub assembly incorporated, and

Fig. 4 represents a plan view of the rotor hub assembly shown in Fig. 1.

The hub assembly broadly designated by 13 comprises a housing 14 fastened to the fuselage structure 11. A sleeve 15 is mounted in said housing adapted to slide up and down and held in vertical position relative to the housing by screw means 32 under the control of the pilot. A cam track drum 17 is tiltably mounted on top of sleeve 15 by means of a universal joint 16, its tilting position being controlled by means of control lever 19 extending downwardly through the housing 14 and having its end adapted to be manipulated or controlled by the pilot. Rotor hub 23 is mounted rotatably about a substantially vertical axis on and around housing 14. At its lower end it forms a gear wheel 24 in mesh with the gear wheel 25 mounted on casing 14 and adapted to be driven by an engine.

Blade roots 26 are mounted on the hub 23 rotatable about substantially horizontal axes in substantially radial relation to the hub. Blades 28 are hinged to the roots 26 at the hinge joints 27, the hinge axes being substantially at right angles to the rotor hub axis and to the blade roots 26. The blades have a leading edge 29 and a trailing edge 30. They rotate in clockwise direction when seen from above. The tail unit of the aircraft is broadly designated by 12.

Blade roots 26 have lever arms 31 projecting therefrom in trailing relation to the blade motion. Connecting rods 21 are hinged to said levers and guided by rod guides 22 for up and down motion. At their upper ends they are provided with cam followers 20 in operative contact with the cam track 18 of cam track drum 17. Cam track 18 is sinuous having two valleys and two peaks, as shown in Fig. 2. As the blades rotate, their pitch angle is periodically changed in consequence of a tilting angle of the drum 17, as it may be maintained by means of the lever 19. This partial or component periodic pitch angle variation has a period equal to the period of the blade rotation. Moving sleeve 15 by means of screw 32 changes the average pitch angle of the blades.

Superposed to these known control and adjustment variations of the pitch angle is a periodic variation comprising two pitch angle increases and two pitch angle decreases during each blade rotation. The amplitude of this variation is governed by the amplitude of the sinuosity of the cam track 18. I obtained excellent results by varying the pitch angle during each half revolution by plus and minus 3½ degrees.

It is essential for this invention that the blade produce its largest lift near its most forward position and near its most rearward position relative to the aircraft, and that it produce its smallest lift near its lateral position relative to the aircraft. This does not necessitate the largest pitch angle at the fore and aft positions nor the smallest pitch angle at the left and right positions. For the blades are mounted free to flap about hinges 27, and this introduces a phase difference between the variation of their pitch angle and the variation of the effective incidence angle relative to the air. The latter determines the production of the lift, the former does not. The flapping motion is the outcome of an added up effect of the lift produced and tends to counteract or neutralize the pitch. This counteracting takes place with time delay by virtue of the mass effects of the blades. Hence, in order to obtain the largest effective incidence angle at the forward and rearward positions of the blades, it is necessary that the pitch angles have their maximum at angular positions assumed after these forward and rearward positions have been passed by the blades. I have obtained excellent results by arranging the maximum pitch angles to take place at the 10° and 190° azimuth position of the blades, with the forward position of the blade being considered at zero azimuth. That is to say, the blade assumes the maximum pitch angle as far as traceable to the sinuosity of the cam track while occupying the front quadrant and the rear quadrant of the blade rotation circle, more particularly while occupying the second half of these quadrants, the first half of these quadrants having already been passed through by the blade.

This is represented in the drawing. Since the levers 31 trail the roots 26, contact of follower 20 with the lowest point of track 18 will produce the highest pitch angle. The contact points trail the root positions by 45°. Hence, the lowest point of track 18 must be at or near the azimuth positions 325° and 145°. As indicated in Fig. 3, track 18 of Fig. 2 is represented as seen by an observer looking in the direction of a radius forming an angle of about 145° with the forward direction of the aircraft.

I have thus provided a sustaining rotor combining frequent and pronounced periodic changes of the blade incidence with a lift unequality favoring the portion of the blade course nearer the fuselage axis.

I claim:

1. In an aircraft sustained by a bladed rotor having blades mounted with freedom for flapping movement, and having controllable mechanism for shifting the line of action of the rotor force to maneuver the aircraft, automatic mechanism operative in different positions of adjustment of said controllable mechanism to periodically vary the geometric pitch angle of the blades, said automatic mechanism being constructed and arranged so as to impart maximum increment of pitch angle to the blades while they are passing through the quadrants of the circle of rotation in forward and in rearward relation to the aircraft.

2. In an aircraft sustained by a bladed rotor having blades mounted with freedom for flapping movement, and having controllable mechanism for shifting the line of action of the rotor force to maneuver the aircraft, automatic mechanism operative in different positions of adjustment of said controllable mechanism to periodically vary the geometric pitch angle of the blades, said automatic mechanism being constructed and arranged so as to impart maximum increment of pitch angle to the blades while they are passing through the quadrants of the circle of rotation in forward and in rearward relation to the aircraft and after they have passed through their fore-aft position.

3. In an aircraft, a sustaining rotor comprising a hub rotatable about a substantially verti-

cal axis, a blade root projecting substantially radially from said hub and mounted rotatably for variation of its geometric pitch angle, a blade hinged to said root, a slidable and universally tiltable drum mounted in said aircraft centrally to said rotor, a sinuous cam track in said drum, a cam follower in operative contact with said cam track and in operative linkage with said root, the cam track and the linkage being so dimensioned, arranged, and adjusted so as to impart to the blade a maximum increment of geometric pitch angle while it is passing through the quadrants of the circle of rotation in forward and in rearward relation to the aircraft.

4. In a rotary aircraft, a sustaining rotor having radial variable-pitch blades, a circuitous sinuous cam track with two valley portions and two peak portions, and mechanism linking the cam track to the blades constructed and arranged so as to cause automatically periodic variations of the geometric pitch angle of the blades, so as to associate a predetermined value of the increment of geometric pitch angle with each angular station of the blade, and so as to associate the maximum increment of geometric pitch angle of the blades with blade stations within the two quadrants of the blade rotation circle in forward relation and in rear relation to the aircraft.

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