Jan. 24, 1933. E. MACALUSO 1,895,043

PROPELLER

Filed Nov. 13, 1931 2 Sheets-Sheet 1

Fig. 1

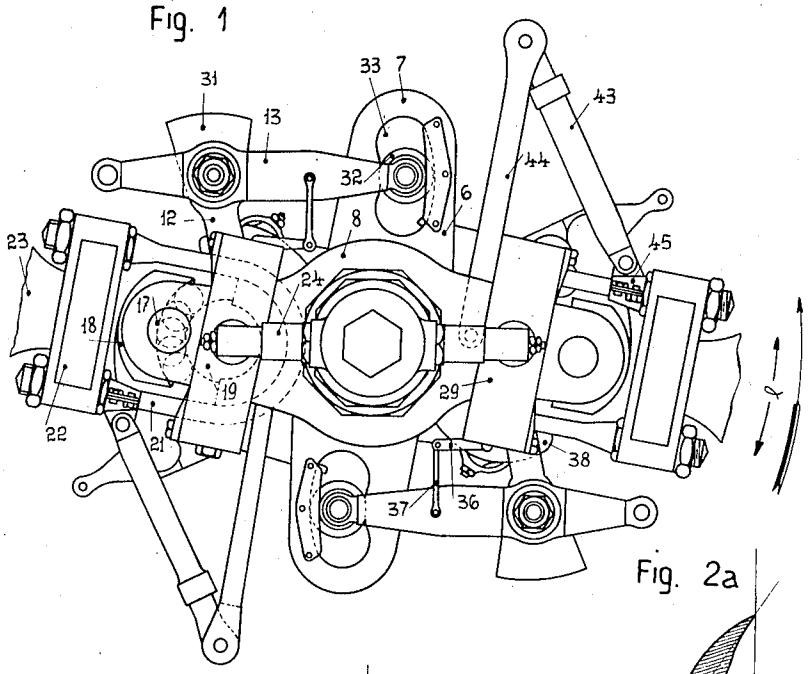


Fig. 2a

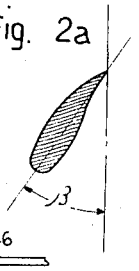


Fig. 2

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Fig. 3

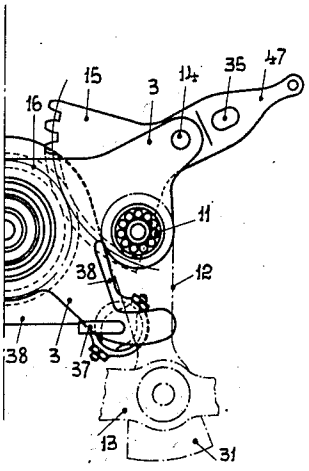
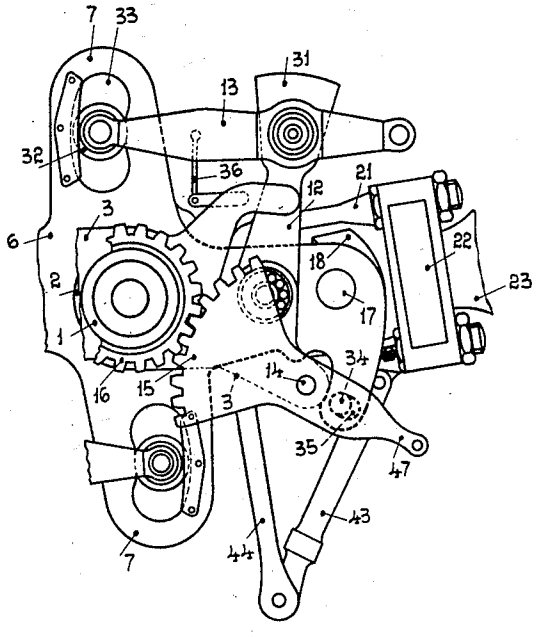


Fig. 4



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UNITED STATES PATENT OFFICE

EUGENIO MACALUSO, OF TURIN, ITALY

PROPELLER

Application filed November 13, 1931, Serial No. 574,819, and in Italy November 14, 1930.

This invention relates to a mechanism for airscrews (pulling, pushing or sustaining screws) with adjustable pitch, adapted to produce automatically the pitch variation in such manner that the pitch is at any time the best suited for obtaining the highest efficiency from the engine and propeller, independently of the speed of the aircraft or other vehicle on which the propeller is mounted.

According to this invention the engine working follows therefore substantially a constant curve of utilization, with any variation in the conditions of flight (relative axial speed of the propeller and density of the medium). The said curve of utilization may be chosen at will by the pilot through a suitable device and is maintained automatically constant under any conditions of flight, as long as the pilot's action does not modify it even during flight.

According to this invention the blades are not rigidly secured to the hub, but are capable of a rotary movement β on the axis on which they are keyed for varying the propeller pitch, as well as of an angular movement α on a pivot, of which the axis is parallel to the axis of the propeller shaft. The two movements are inter-dependent so that to an angular displacement α of the blade on the said pivot corresponds a given angular rotation β of the blade about its axis, i. e. a given variation in the propeller pitch in the desired direction. It will be understood that the rotation α instead of being performed directly by the blade can be effected by a blade carrier loosely mounted on the propeller shaft, in which case the angle α is equal to the relative angular displacement of the blade carrier and hub.

This inter-dependence of movements is obtained automatically according to this invention, the blade or the blade-carrier being subjected simultaneously to two forces both proportional to the square of the speed of rotation, but opposed to each other, i.-e. being subjected on one side to the action of the centrifugal force acting; (*a*) on the mass of the blade; (*b*) on an auxiliary mass not rigidly connected to the blade; (*c*) on both masses and on the other side to the resistance of the medium in which the propeller moves.

If a change in the speed of flight or in the density of air disturbs the above said balance of rotation between the centrifugal force and the aerodynamic force, a displacement of the blade (or of the blade-carrier) is generated, and this displacement, through the cynematic connection referred to above, causes in turn a rotation of the blade through a certain angle β in the direction which re-establishes the balance.

In other words, the variations of the angles α and β are so inter-dependent that to any increase (or reduction) in the angle α corresponds a reduction (or increase) in the angle β, and therefore in the pitch, until the cause which has produced the increase (or reduction) in the former is annulled.

A further object of this invention is to provide means for preventing the aerodynamic forces from objectionably affecting the working of the mechanism.

A further object of this invention is to provide a device of simple construction placed within reach of the pilot for going over from one to another curve of utilization of the engine by which the propeller is moved, without acting on the engine controls.

The accompanying drawings show a construction of the object of this invention. In this construction the centrifugal force coming into action through the automatic mechanism acts as specified above under (*b*).

Figure 1 is a front view of the propeller hub portion, in which the arrows referred to by α denote the angular displacements in the two directions of the blade-carrier with respect to the hub which carries along in rotation the said carrier through members subjected to the centrifugal force.

Figure 2 is a plan view of Fig. 1 with the mechanism for adjusting the pitch partly in side view and partly in axial section.

Figure 2*a* is a cross section of the blade showing the angle β under which it is keyed.

Figure 3 shows the mechanism, the propeller and its carrier being removed.

Figure 4 is a rear view of the propeller shown in Fig. 1.

Referring to the drawings, 1 denotes a hub rigidly keyed on the engine shaft, 2 is a blade-carrier loosely fitted on the hub 1 and axially held thereon by the flange 3 of the hub 1 and by the thrust bearing 4 clamped by the screw-threaded ring 5. The blade-carrier 2 is provided with a flange 6 of special form, comprising two arms 7, and a second flange 8 is fixedly connected to the blade-carrier by means of keys 9 and nuts 10.

The flange 3 carries by means of bearings 11 the pivots of the swing arms 12 connected by the rods 13 to the arms 7 of the blade carrier 2, in the manner more fully specified hereinafter. The flange 3 carries also (Figure 3) the pivot 14 of the quadrant 15 meshing with the pinion 16 loosely mounted on the hub 1. The blade-carrier 2 carries by means of the flange 6 and flange 8 on trunnions 17 a bearing 18 with a spherical seat for a ball 19 lodged therein with the interposition of rolling balls and carried by means of a cradle 20 by the strap 21. The strap member 21 presses the ball 19 against the bearing 18 holding against this latter the root 22 of the blade 23 to which the strap 21 is fastened; the resulting ball joint 18—19 enables the blade 23 to take any position and adjustment relative to the centre of the ball 19, whilst it follows the blade carrier 2, loosely mounted on the hub 1 on rotation through an angle β (Figure 2*a*) corresponding to a rotation through an angle α of the blade-carrier 2. The blade-carrier 2 is connected to the stationary hub 1 by means of the cross bar 24 fitted on the end of the hub 1 and connected to the blades by means of the forks 25 carrying a pair of bearings in diametrically opposed positions. The forks 25 are carried by the cross bar 24 by means of a short arm 26 fixed to the cross bar 24 and carrying a slidable seat 27 for a spherical joint 28 of the yoke 29 of the forks 25. The members 24, 26 are clamped together by tightening the nut 30. The blade-carrier 2 is carried along in rotation by the hub 1 through the toggle 12—13, having a weight 31 hinged by the arm 12 to the flange 3 of the hub 1 and by the arm 13 to the arms 7 of the flange 6 of the sleeve 2. The pivot of this latter joint, consisting of the roller 32, can be displaced by the pilot in an arcuated slot 33 of the arm 7, even during flight, so as to vary at will the arm of the couple of forces due to the centrifugal force of the members 12—13—31.

In a given position of the roller 32 in the slot 33, to a given angular aperture of the toggle corresponds a variation of the angle α between the hub 1 and the blade-carrier 2 and, consequently, of the angle β under which the blade 23 is keyed, i. e. a variation in the propeller pitch.

The position of the roller 32, namely of the articulated joint of the double rod 13 and of the arm 7 is determined by the arm 37 (Figs. 1 and 2) to which is articulated a rod 36 carrying a spindle 39 provided with a steep-pitched thread engaging in a nut 40 carried by the plate 38 loosely and slidably mounted in the hub 1. The variation of the position of the hinge of the rod 13 causes a change in the curve of utilization of the engine.

The pilot can vary the angular displacement of the rod 36, i. e. the curve of utilization, even during rotation of the propeller. by producing an angular displacement of the spindle 39 through the axial displacement of the plate 38, obtained by means of a forked lever 41 through the thrust bearing 42.

In any case the pilot needs not act upon the engine controls as long as he does not intend to increase or reduce the engine power.

The aerodynamic forces acting on the blade produce further variations in moments which may objectionably affect the general working of the device. This drawback is obviated by connecting with the linkage-blade group an auxiliary weight arranged in front of the leading edge of the blade. The auxiliary weight comprising the rods 43 and 44 and any other weight fixed thereto is attached to the root of the blade by means of a sleeve 45 fixed to the strap 21, while the double rod 44 is fixed to the cradle 20. As said above, the cross bar 24 with the short arm 26 is clamped by tightening the nut 30. If the centre of gravity of the blade by virtue of the shape of the blade or of the supplementary weights 43 and 44 is displaced towards the leading edge by an extent such that the direction of the variations in the moments of the aerodynamic forces is reversed with respect to the axis on which the blade is keyed, so that the said forces assist in a certain way the working of the device, and if the nut 30 is left loosened, the blades (if geometrically equal to each other) will automatically tend to take equal angles of incidence. This will eliminate any original asymmetry of keying in the mounting of the blades. When it is not deemed convenient to utilize this method, the nut 30 is tightened, but greater care should then be taken in mounting the blades. It will be appreciated that the auxiliary weights 43—44 can be incorporated in the blade in manufacture.

The unevenness of the propelling couple of forces, especially when explosion engines are used, more particularly engines with a small number of cylinders, gives rise to tangential inertia forces which disturb the normal working of the mechanism.

The action of said forces on the working of the mechanism is eliminated by loosely mounting on the hub 1 (or on the engine shaft) a suitably proportioned beam 46, said beam being carried along in rotation by its pinion 16 meshing with the quadrants 15 carried by the flange 3 of the hub 1. The quadrants are subjected to the variations of the angle α be-

tween the hub 1 and the blade-carrier 2 through a knob 34 (Fig. 4) provided on the flange 6 and engaging in a slot 35 of the extension 47 of the quadrants 15. The beam 46 receives therefore the relative rotary motion α reversed and amplified through the ratio between the gears 16—15, thus allowing for the tangential inertia forces. The beam 46 may be provided with additional weights connected thereto either rigidly or by an articulated joint, as required.

The constructional details of the automatic pitch adjusting device, and the solution of secondary problems may be varied from what has been described and illustrated by way of example without departing from the object of this invention.

What I claim is:

1. Airscrew propeller comprising, in combination with a propeller shaft, a hub fixed on said propeller shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges in diametrally opposed positions, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles connecting adjacent arms on said hub and blade-carrier, centrifugal weights carried by said toggles, a cross bar secured to the hub and forks pivoted to the universal supports and connected by a telescopic and spherical joint to the ends of said cross bar.

2. Airscrew comprising, in combination with a propeller shaft, a hub secured on said propeller shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges in diametrally opposite positions, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles pivoted to the arms on the hub, a pin and slot joint for connecting said toggles to the arms on the blade-carrier so that the pin can be adjusted at will in the slot, centrifugal weight carried by said toggles, a cross bar secured to the hub and forks pivoted to the universal supports and connected by a spherical and telescopic joint to the ends of said bar.

3. Airscrew comprising, in combination with a propeller shaft, a hub fixed on said propeller shaft, a blade-carrier loosely mounted on said hub, blades mounted on said blade-carrier capable of swinging about their axis and in the plane of rotation, a toggle connecting said hub to said blade-carrier, a centrifugal weight carried by said toggle and means carried by said hub for rotating said blades about their axis according to the action of the centrifugal force on said toggle, a beam for compensating tangential inertia forces loosely mounted on said hub, a pinion fixedly connected to said beam, quadrants meshing with said pinion and pivoted on said hub and a pin and slot joint between said quadrants and said blade-carrier.

4. Airscrew propeller, comprising in combination with a propeller shaft, a hub fixed on said propeller shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges in diametrally opposed positions, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles connecting adjacent arms on said hub and blade-carrier, centrifugal weights carried by said toggles, a cross bar secured to the hub and forks pivoted to the universal supports and connected by a telescopic and spherical joint to the ends of said cross bar, a beam for compensating tangential inertia forces loosely mounted on said hub, a pinion fixedly connected to said beam, quadrants meshing with said pinion and pivoted to the arms on said hub and a pin and slot joint between said quadrants and the arms on the blade-carrier.

5. Airscrew comprising, in combination, a hub, blades mounted on said hub capable of swinging about their axis and in the plane of rotation and means responding to the centrifugal force through which the blades are automatically set, during rotation, in their balanced position under the combined action of the centrifugal and aerodynamic forces, and means for compensating tangential inertia forces.

6. Airscrew comprising, in combination with a propeller shaft, a hub secured on said propeller shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges in diametrally opposite positions, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles pivoted to the arms on the hub, a pin and slot joint for connecting said toggles to the arms on the blade-carrier so that the pin can be adjusted at will in the slot, centrifugal weights carried by said toggles, a cross bar secured to the hub, forks pivoted to the universal supports and connected by a spherical and telescopic joint to the ends of said bar, a beam for compensating tangential inertia forces loosely mounted on said hub, a pinion fixedly connected to said beam, quadrants meshing with said pinion and pivoted to the arms on said hub and a pin and slot joint between said quadrants and the arms on the blade-carrier.

7. Airscrew comprising, in combination

with a propeller shaft, a hub fixed on said shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges at diametrally opposite points, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles pivoted to the arms on the hub, a pin and slot joint for connecting said toggles to the arms on the blade-carrier, centrifugal weights carried by said toggles, an arm pivoted to a member of each of said toggles, a plate slidably keyed on said hub, a link hinged to said arm and having a screw-threaded spindle engaging in a nut on said plate, a hand-operated lever for displacing said plate in order to rotate said link and to adjust said spindle in its slot, a cross bar fixed to the hub and forks pivoted to the universal supports and connected by a spherical and telescopic joint to the ends of said cross bar.

8. Airscrew comprising, in combination with a propeller shaft, a hub fixed on said shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges at diametrally opposite points, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles pivoted to the arms on the hub, a pin and slot joint for connecting said toggles to the arms on the blade-carrier, centrifugal weights carried by said toggles, an arm pivoted to a member of each of said toggles, a plate slidably keyed on said hub, a link hinged to said arm and having a screw-threaded spindle engaging in a nut on said plate, a hand-operated lever for displacing said plate in order to rotate said link and to adjust said spindle in its slot, a cross bar fixed to the hub and forks pivoted to the universal supports and connected by a spherical and telescopic joint to the ends of said cross bar, a beam for compensating tangential inertia forces loosely mounted on said hub, a pinion fixedly connected to said beam, quadrants meshing with said pinion and pivoted to the arms on said hub and a pin and slot joint between said quadrants and the arms on the blade-carrier.

9. Airscrew comprising, in combination with a propeller shaft, a hub fixed on said propeller shaft, a blade-carrier loosely mounted on said hub, blades mounted on said blade-carrier, capable of swinging about their axis and in the plane of rotation, toggles connecting said hub to said blade-carrier, centrifugal weights carried by said toggles, means carried by said hub for rotating said blades about their axes according to the action of the centrifugal force on said toggles, a beam for compensating tangential inertia forces loosely mounted on said hub, a pinion fixedly connected to said beam, quadrants meshing with said pinion and pivoted to said hub, a pin and slot joint between said quadrants and said blade-carrier and auxiliary centrifugal weights fixed to the attachment of the blades in front of the leading edge to prevent variations in the moments of rotation due to the aerodynamical forces.

10. Airscrew comprising, in combination with a propeller shaft, a hub secured on said propeller shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges in diametrally opposite positions, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles pivoted to the arms on the hub, a pin and slot joint for connecting said toggles to the arms on the blade-carrier so that the pin can be adjusted at will in the slot, centrifugal weights carried by said toggles, a cross bar secured to the hub, forks pivoted to the universal supports and connected by a spherical and telescopic joint to the ends of said bar, a beam for compensating tangential inertia forces loosely mounted on said hub, a pinion fixedly connected to said beam, quadrants meshing with said pinion and pivoted to the arms on said hub and a pin and slot joint between said quadrants and the arms on the blade-carrier, and auxiliary centrifugal weights fixed to the attachment of the blades in front of the leading edge for preventing variations in the moments of rotation due to the aerodynamical forces.

11. Airscrew comprising, in combination with a propeller shaft, a hub secured on said propeller shaft, a blade-carrier loosely mounted on said hub and having a pair of opposite flanges, universal supports mounted between said flanges in diametrally opposite positions, blades carried by said universal supports, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier substantially at right angles to the arms on the hub, toggles pivoted to the arms on the hub, a pin and slot joint for connecting said toggles to the arms on the blade-carrier so that the pin can be adjusted at will in the slot, centrifugal weights carried by said toggles, a cross bar secured to the hub, forks pivoted to the universal supports and connected by a spherical and telescopic joint to the ends of said bar, a beam for compensating tangential inertia forces loosely mounted on said hub, a pinion fixedly connected to said beam, quadrants meshing with said pinion and pivoted to the arms on said hub, a pin and slot joint between said quadrants and the arms on the blade-carrier and

auxiliary centrifugal weights consisting of rods hinged together and attached to the root of each blade and to its respective universal support for preventing variations in the moments of rotation due to the aerodynamical forces.

12. An airscrew comprising, in combination with a propeller shaft, a hub fixed on said propeller shaft, a blade-carrier loosely mounted on said hub, blades mounted on said blade-carrier capable of swinging and thereby causing a variation of the pitch inclination, means carried by the fixed hub for interdependently connecting said blade oscillations for varying the pitch inclination and the oscillation of the blade-carrier loosely mounted on the hub; means to cause said oscillating blade-carrier to turn with the hub, a toggle connecting said hub to said blade-carrier and balancing, through the centrifugal action of its mass, the aerodynamical moment opposing the rotation of the propeller, being applied to said loosely mounted blade-carrier.

13. An airscrew comprising, in combination with a propeller shaft, a hub fixed on said propeller shaft, a blade-carrier loosely mounted on said propeller shaft hub and having a pair of opposite flanges, spherical supports mounted between said flanges in diametrally opposed positions, blades carried by said spherical supports in such a way as to be capable of oscillating in the three spatial directions, diametrally opposite arms on said hub, diametrally opposite arms on said blade-carrier, toggles connecting adjacent arms on said hub and said blade-carrier, centrifugal weights constituted and carried by said toggles and means carried by said hub for rotating said blades about their axis for varying the pitch according to the differential balancing action of the centrifugal force acting on said toggles and aerodynamical forces transmitted from the blades to said spherical supports and from these latter to the blade-carrier oscillating about and connected to said hub.

In testimony whereof, I hereunto affix my signature.

EUGENIO MACALUSO.