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ADJUSTABLE PITCH PROPELLER

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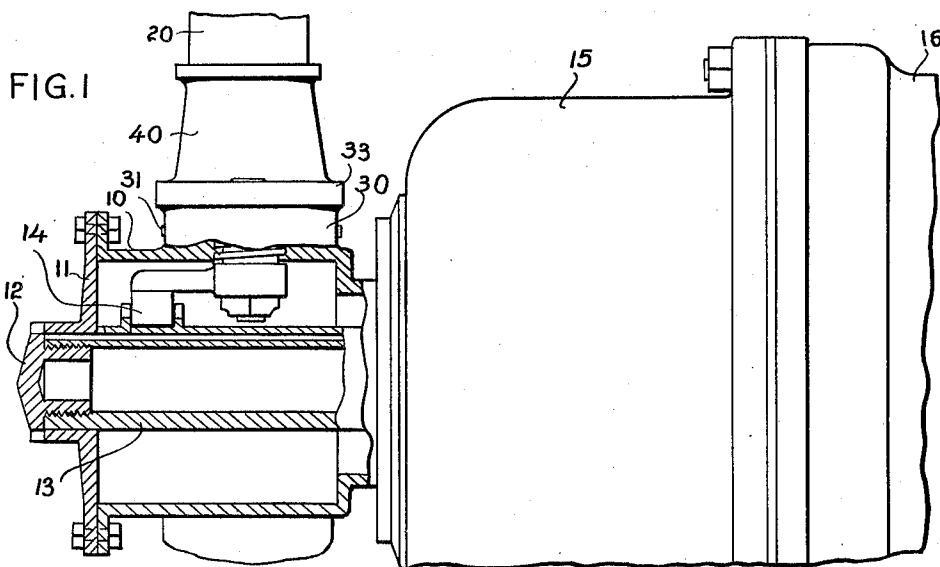


FIG. 2

FIG. 3

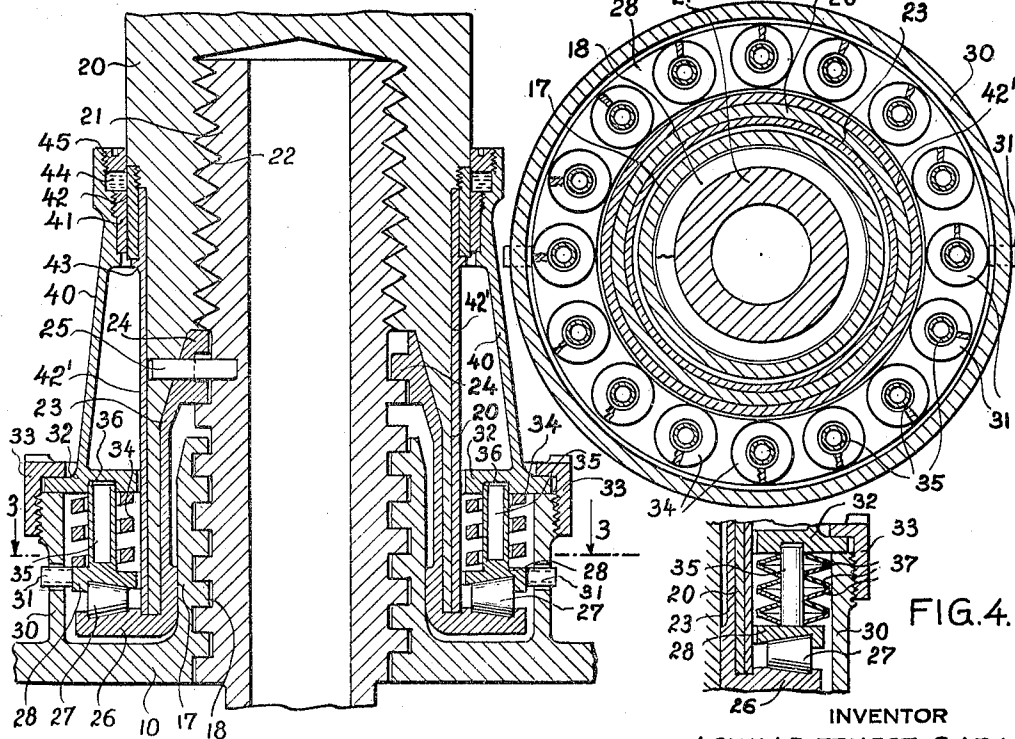


FIG. 4

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ADJUSTABLE PITCH PROPELLER

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10 Claims. (Cl. 170—173)

This invention relates to adjustable pitch propellers and has for its principal object the provision of improved apparatus for connecting the blade of an adjustable pitch propeller to a rotatable propeller hub. The present application is a continuation in part of my copending application Serial No. 757,536, filed December 14, 1934, which issued on September 22, 1936, as United States Patent No. 2,054,810.

In my above-mentioned copending application, an adjustable pitch propeller is described in which propeller blades are received within cylindrical stub branches extending outwardly from a rotatable propeller hub and are secured to the hub by means of a core comprising a pair of interconnected helically threaded cylinders and a stud. The threads of one of the cylinders of the core engages corresponding threads provided in the foot of the propeller blade and the threads of the other cylinder of the core engages threads provided upon a cylindrical member disposed within the stub branch and extending outwardly from the hub. The stud engages a second set of threads formed in a recess in the propeller blade and is secured to the core.

In the structure described above, the centrifugal force tending to tear the blades from the hub when the assembly is rotating is resisted wholly by the threaded cylindrical member whose threads engage the threads of the core. The present invention provides improved apparatus for connecting the blades to the rotatable hub in such a manner that a centripetal force is applied to the propeller blades to offset in part the centrifugal force of the rotating blades and thereby to provide an improved distribution of the forces acting while the propeller assembly is rotating.

In the apparatus of the invention, a substantially cylindrical blade-support member having an outwardly extending flange adjacent its lower end is rigidly associated with a propeller blade adjacent the foot of the blade, and appropriate means are provided for exerting a force upon the flange of the blade-support member to aid in holding the blade in operative relation with the hub.

The structure of the invention includes a main connecting element for connecting the blade to the hub which comprises a threaded stud engaging the propeller blade adjacent the foot thereof and also engaging a threaded inner core secured to and extending outwardly from the hub. The blade-support member is rigidly connected to the stud and to the blade. An outer cylin-

dric core extending outwardly from the hub and surrounding the blade-support member is provided with an annular cap extending substantially radially inwardly. The relation of the annular cap with respect to the flange of the blade support member is such that the cap is positioned substantially directly over the flange. A ball or roller bearing is seated against the flange, and spring means seated against the underside of the cap exert a force on the ball or roller bearing assembly and through it to the flange of the blade-support member, thereby applying a centripetal force to the blade when the propeller assembly is rotating to aid in holding the propeller blade in operative relation with respect to the hub.

A substantially cylindrical housing member associated with the cap surrounds the foot of the blade. A bushing member associated with the upper end portion of the housing member is adapted to provide a bearing surface against the foot of the blade. A relatively hard ring member associated with the blade advantageously is provided to furnish a bearing surface upon which the bushing acts.

The invention will be better understood from the following description considered in conjunction with the accompanying drawing, in which

Fig. 1 is an elevation, partially in section, showing the relation of the apparatus of the invention to an adjustable pitch propeller assembly;

Fig. 2 is a longitudinal cross section through a structure according to the invention by which a propeller blade is connected to a rotatable hub;

Fig. 3 is a transverse cross section taken substantially along the line 3—3 of Fig. 2; and

Fig. 4 is a cross section through a modified spring assembly.

A propeller hub 10 is mounted by means of a plate 11 and a cap screw 12 on a propeller shaft 13. Mechanism 14 for adjusting the pitch of propeller blades is housed within the annular space between the hub and the propeller shaft and in a casing 15, and the entire assembly is connected to the crank shaft of a motor 16.

An outwardly extending cylindrical inner core 17 is secured to the hub (preferably it is formed integrally therewith) and is provided with helical threads 18 formed on its inner surface. A propeller blade 20, the foot of which is suitably recessed, is positioned adjacent the cylindrical inner core 17.

A stud 21 provides means for connecting the propeller blade to the hub through the cylindrical

core 17, and this stud constitutes the main connecting element between the propeller blade and the hub. The stud 21 is threaded adjacent its upper end portion to engage threads 22 formed in the propeller blade 20 and adjacent its lower end to engage the helical threads 18 of the core 17. The assembly is such that if a turning moment is applied to the stud 21, the propeller blade will be turned about its longitudinal axis to adjust the pitch of the blade.

A substantially cylindrical blade-support member 23 is rigidly secured to the blade. The connection between the blade-support member and the blade is effected principally through the intermediary of the stud. The upper portion of the blade-support member 23 extends radially inwardly and is provided with threads 24 engaging a section of the helical threads formed on the stud 21 adjacent the point at which the stud enters into engagement with the propeller blade. The blade support member thus in effect becomes a lock-nut on the stud to hold it rigidly in engagement with the blade, the blade, stud, and blade-support member becoming thereby a solidary structure. A pin 25 extending through the blade, the blade-support member, and the stud locks these three elements in position.

The lower portion of the blade-support member 23 is provided with an annular flange 26 extending radially outwardly beyond the periphery of the foot of the blade 20. A ball or roller bearing 27 is seated against the flange 26, which advantageously constitutes the lower face thereof. An annular ring 28 forms the upper face of the bearing.

An outer cylindrical core 30 extending outwardly from the hub 10 surrounds the flange 26 of the blade support member and extends to a point substantially above the flange. Suitable stops 31 engaging the outer cylindrical core 30 and the upper face 28 of ball or roller bearing hold the latter in non-rotatable relation with respect to the outer core 30.

An annular cap 32 extending radially inwardly is secured to the outer cylindrical core 30 by a threaded clamping ring 33 engaging threads suitably formed on the outer cylindrical core. The annular cap 32 is positioned substantially directly over the flange 26 of the blade-support member.

A series of compression springs 34, seated against the undersurface of the annular cap 32, are mounted within the space between the cylindrical core 30 and the outer surface of the blade 20 to exert a force upon the upper face of the ball or roller bearing and through it upon the flange 26 of the blade-support member to aid in holding the blade in operative relation with respect to the hub. The springs 34 are guided by shafts 35 mounted on the upper face 28 of the ball or roller bearing and extending upwardly into suitably formed recesses 36 in the annular cap 32. The recesses 36 are sufficiently deep to allow slight movement of the guide shafts 35 into and out of them.

In place of the compression springs 34 described above, other means for applying force to the flange 26 of the blade-support member 23 may be adopted. For example, as shown in Fig. 4, a series of dished washers 37 mounted one over the other on the guide shafts 35 to act in the manner of springs may be employed if desired.

A substantially cylindrical housing member 40 extends upwardly from the annular cap 32 and surrounds the foot of the blade 20. A bushing 41

is associated with the upper end portion of the housing member 40 and is adapted to provide a bearing surface engaging the propeller blade. A corresponding ring member 42 is associated with the blade to provide a bearing surface in engagement with the bushing 41. The bushing 41 and the ring member 42 are advantageously formed of very hard steel and are accurately machined to reduce to a minimum the frictional resistance to turning the blade about its longitudinal axis. A cylindrical hoop 42' provided with a flange 43 surrounding the blade foot aids in retaining the ring member 42 in position and in preventing lateral distortion of the blade foot.

An oil-seal 44 is provided adjacent the bushing 41 to lubricate it and to keep dirt and grit from gaining access to the mechanism. The oil-seal is closed by a ring 45 in threaded engagement with the upper end portion of the cylindrical housing member 40.

The apparatus of the invention is such that an improved distribution of the forces exerted at the foot of the blade, when the propeller assembly is in operation is attained. A considerable portion of the centrifugal force tending to throw the blade from the hub is taken by the stud 21 and the inner cylindrical core 17, but these members are relieved from taking the full magnitude of such forces by virtue of the pressure exerted by the springs 34 on the flange 26 of the blade-support member. The pressure of the springs constitutes a centripetal force acting in opposition to the centrifugal force of the rotating blade.

Suppose the centrifugal force of the blade has a value F and the counter-force exerted by the springs 34 on the blade-supporting member 23 has a value f . The resultant pressure on the screw-thread of the inner core 17 will be $F-f$. The arrangement of the invention thus provides for a better distribution of the stresses encountered in retaining the blade in position, since the threaded inner core 17 participates in these stresses only to the extent of the value of $F-f$, the outer cylindrical core 30 participating therein to the extent of the value of f .

Due to the fact that the coefficient of the friction on the ball or roller bearing is much lower than the coefficient of the friction of the screw-thread, the frictional resistance to be overcome in order to cause the blade to turn in adjusting the pitch thereof during flight is made less. If $\tan \psi$ equals the coefficient of friction of the screw threads, and $\tan \epsilon$ the coefficient of friction of the bearing roller, then for a centrifugal force F the frictional resistance F_c on the screw threads is, as pointed out in my above-mentioned copending patent,

$$F_c = (F) \cos \alpha \tan \psi$$

(where α is the pitch of the screw threads) whereas with the compensating device of the invention, exerting a centripetal force f , I will have a frictional resistance F_c' due to the screw threads amounting only to

$$F_c' = (F-f) \cos \alpha \tan \psi$$

and on the ball bearing a frictional resistance f_c of

$$f_c = (f) \tan \epsilon$$

By suitably proportioning the centripetal thrust of the springs 34 the sum $F_c' + f_c$ can be made much less than F_c .

I claim:

1. In an adjustable pitch propeller assembly

comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising a main connecting element, and means for relieving the stress imposed on the main connecting element during operation of the propeller assembly comprising an outwardly extending flange associated with the blade adjacent the lower end thereof and means exerting a downwardly acting force on the flange.

2. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising a main connecting element, and means for relieving the stress imposed on the main connecting element during operation of the propeller assembly comprising an outwardly extending flange associated with the blade adjacent the lower end thereof and spring means exerting a downwardly acting force on the flange.

3. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising a stud secured in the lower end portion of the blade, means connecting the stud to the hub, an outwardly extending flange associated with the blade adjacent the lower end thereof, and means exerting a downwardly acting force on the flange to relieve the stress imposed on the stud during operation of the propeller assembly.

4. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising a stud secured in the lower end portion of the blade, means connecting the stud to the hub, an outwardly extending flange associated with the blade adjacent the lower end thereof, and a plurality of springs exerting a downwardly acting force on the flange to relieve the stress imposed on the stud during operation of the propeller assembly.

5. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising a stud secured in the lower end portion of the blade and engaging with the hub to secure the blade to the hub and resist the centrifugal force tending to tear the blade from the hub during rotation of the hub, an outwardly extending flange associated with the blade adjacent the foot thereof, and means for exerting a centripetal force on the flange during rotation of the hub to relieve the stress imposed by the centrifugal force of the blade on the stud.

6. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising an inner core extending outwardly from the hub, a stud secured in the lower end portion of the blade and engaging with

the inner core, an outwardly extending flange associated with the blade adjacent the lower end thereof, an outer core extending outwardly from the hub and surrounding the flange, and means associated with the outer core exerting a downwardly acting force on the flange.

7. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising an inner internally threaded core extending outwardly from the hub, a stud secured in the lower end portion of the blade and engaging with the threads of inner core, an outwardly extending flange associated with the blade adjacent the lower end thereof, an outer core extending outwardly from the hub and surrounding the flange, an annular cap secured to the outer core, and means bearing against the annular cap and exerting a downwardly acting force on the flange.

8. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising an inner internally threaded core extending outwardly from the hub, a stud secured in the lower end portion of the blade and engaging with the threads of inner core, an outwardly extending flange associated with the blade adjacent the lower end thereof, an outer core extending outwardly from the hub and surrounding the flange, an annular cap secured to the outer core, and spring means seated against the annular cap and exerting a downwardly acting force on the flange.

9. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, apparatus for connecting the blade to the hub comprising an inner internally threaded core extending outwardly from the hub, a stud secured in the lower end portion of the blade and engaging with the threads of inner core, an outwardly extending flange associated with the blade adjacent the lower end thereof, an anti-friction bearing seated on the flange, an outer core extending outwardly from the hub and surrounding the flange, an annular cap secured to the outer core, and a plurality of springs bearing against the annular cap and exerting a downwardly acting force on the anti-friction bearing.

10. In an adjustable pitch propeller assembly comprising a propeller blade, a rotatable propeller hub, and means for adjusting the pitch of the blade, an outer core extending outwardly from the hub and surrounding the lower end of the blade, an annular cap secured to the outer core, a substantially cylindrical housing member extending upwardly from the annular cap and surrounding the lower end portion of blade, and a bushing associated with the upper end of the housing and providing a bearing surface for the blade.

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