March 5, 1946. P. F. HACKETHAL 2,395,867

PROPELLER

Filed May 3, 1940 3 Sheets-Sheet 1

FIG. 1.

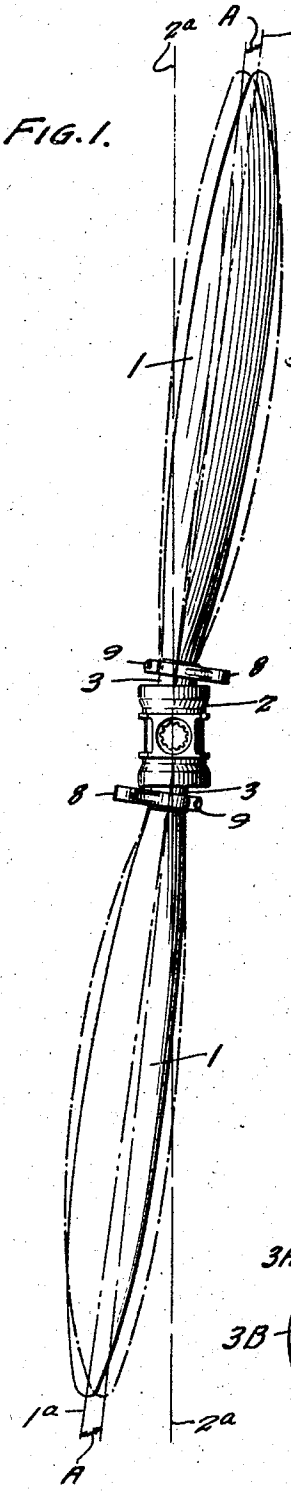


FIG. 3.

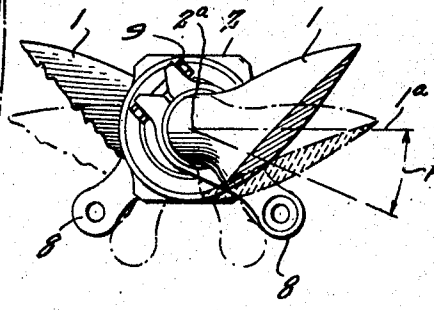


FIG. 2.

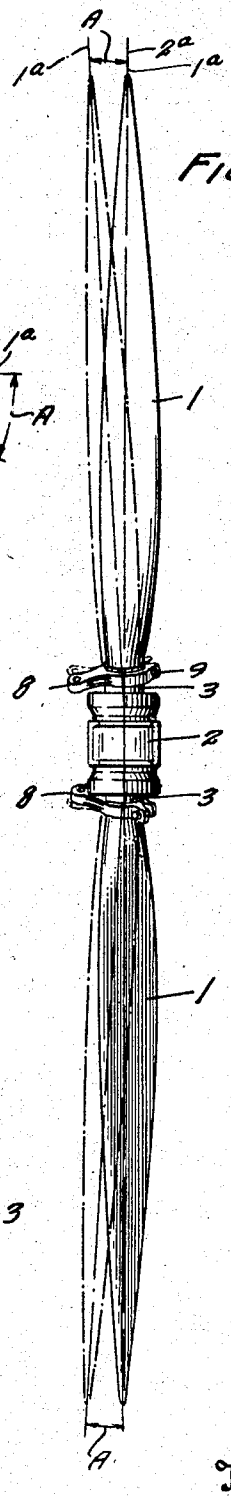
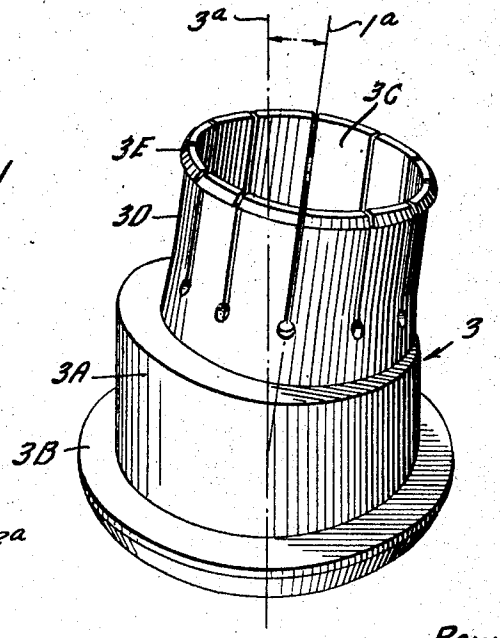


FIG. 9.



Inventor

PAUL F. HACKETHAL

By Semmes, Keegin & Semmes

Attorneys

March 5, 1946. P. F. HACKETHAL 2,395,867

PROPELLER

Filed May 3, 1940 3 Sheets-Sheet 2

FIG. 4.

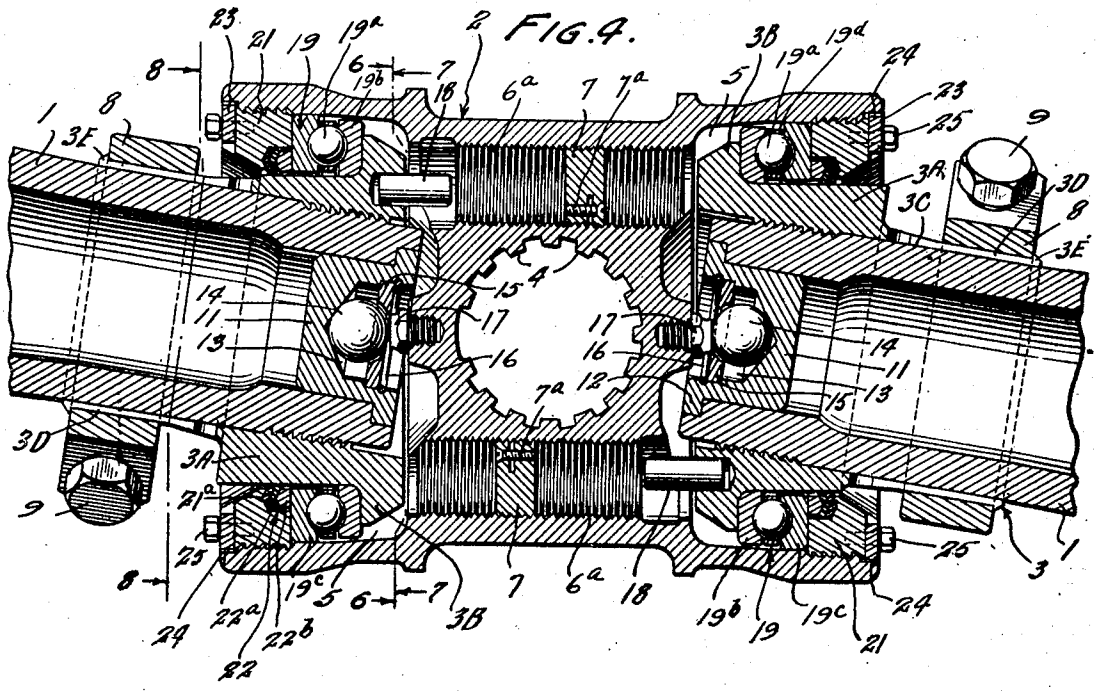
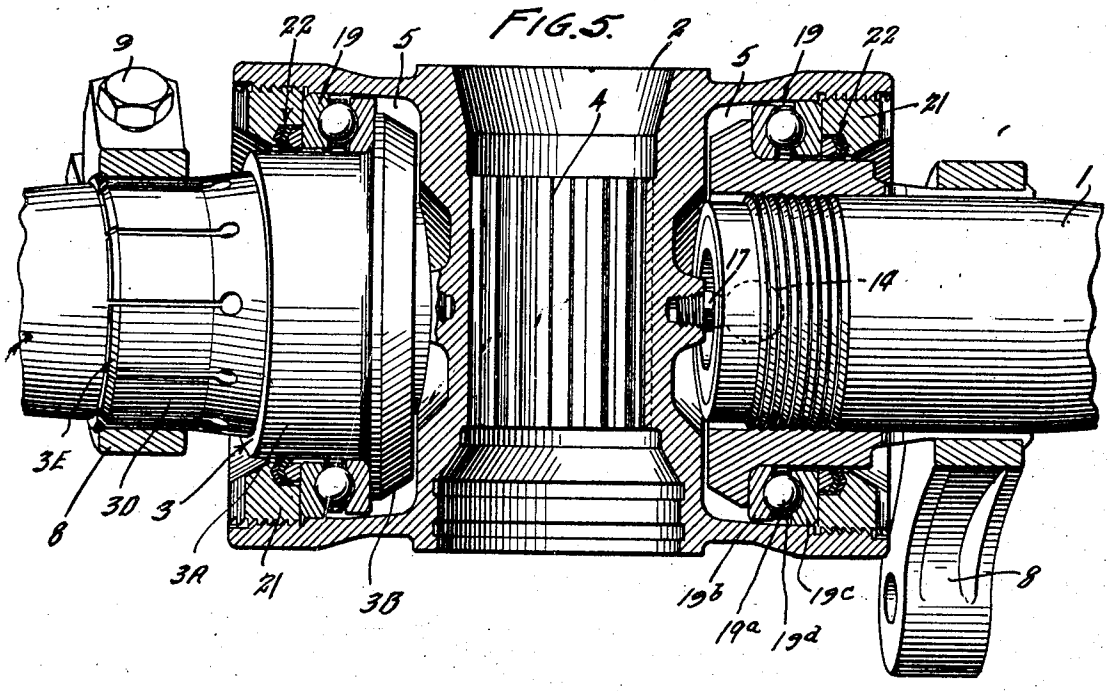


FIG. 5.



Inventor

PAUL F. HACKETHAL

By

Semmes, Keegin & Semmes

Attorneys

March 5, 1946. P. F. HACKETHAL 2,395,867

PROPELLER

Filed May 3, 1940 3 Sheets-Sheet 3

FIG. 6.

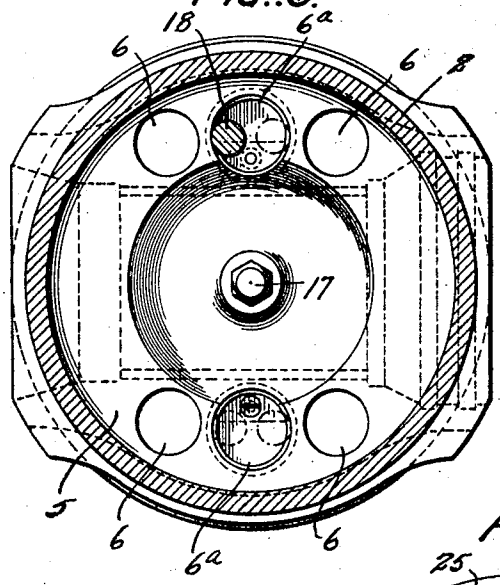


FIG. 7.

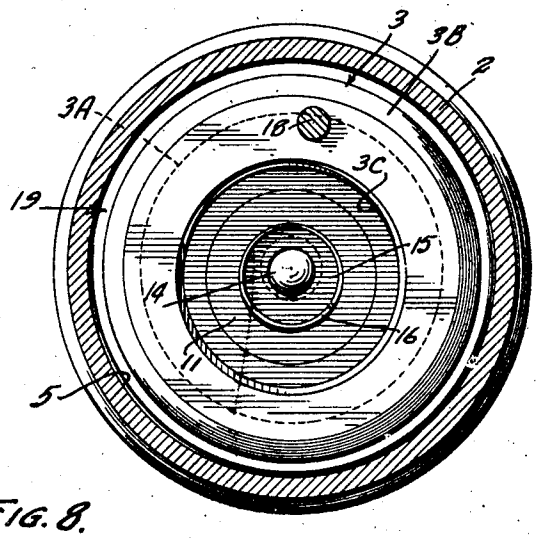


FIG. 8.

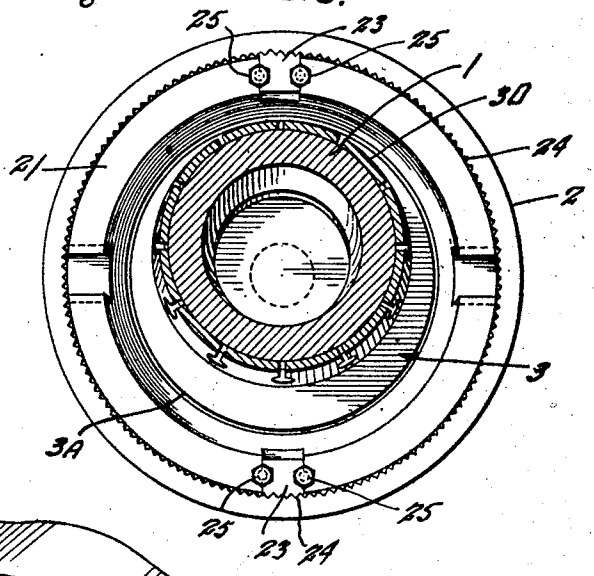
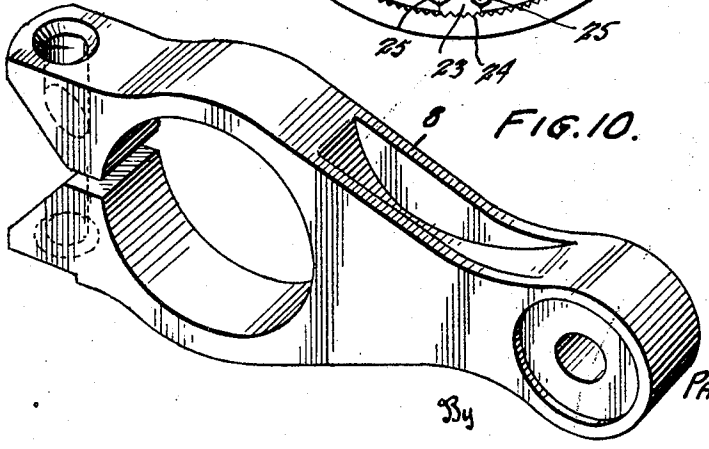


FIG. 10.



Inventor

PAUL F. HACKETHAL

By

Semmes, Keegin & Semmes

Attorneys

Patented Mar. 5, 1946 2,395,867

UNITED STATES PATENT OFFICE

2,395,867

PROPELLER

Paul F. Hackethal, Baltimore, Md., assignor to Everel Propeller Corporation, Baltimore, Md., a corporation of Maryland

Application May 3, 1940, Serial No. 333,239

11 Claims. (Cl. 170—162)

This invention relates to propellers, and more particularly has reference to an automatic variable pitch propeller.

Most automatic variable pitch propellers are predicated upon the concept of permitting the blade to move along the arc of a cone. This movement of course is in addition to the rotation of the propeller.

Movement along the cone arc effects a change in the pitch of the propeller, and, in general, the propeller is so designed and constructed that the pitch varies inversely with the density of the medium in which the propeller operates. For instance, in the case of an airplane propeller, the blades will have the minimum pitch at sea level, but as the plane operates at higher altitudes the pitch will be increased.

It is of course essential that there be a high sensitivity of the propeller, insofar as its conically arcuate movement is concerned, and it is therefore obvious that frictional resistance of the moving parts should be maintained at a minimum.

Therefore, one of the principal objects of the present invention is to provide an automatic variable pitch propeller capable of moving about the arc of a cone, and so constructed as to have a low frictional resistance.

Another object of my invention is to provide an automatic variable pitch propeller adapted to readily respond to changed conditions of operation which render desirable a variation in the pitch of the propeller.

Yet another object of this invention is to provide an automatic variable pitch propeller of strong, but relatively light, construction which is dependable and efficient in operation.

To accomplish the above, and other important objects as will more fully appear hereinafter, my invention in general embraces the concept of mounting a blade upon a rotative support and permitting movement of the blade with respect to the support to thereby vary the pitch of the blade. The mounting is of such construction that the blade is confined to a definite and precise path of movement, and the frictional resistance to such movement is maintained at a minimum. In the preferred form, the mounting comprises a single precision, anti-friction bearing.

In the accompanying drawings, there is disclosed one specific embodiment of my inventive concept, but it will be appreciated that various modifications may be made therein without departing from the spirit of my invention. In these drawings, in which corresponding numerals refer to the same parts:

Figure 1 is a front elevation of a propeller constructed in accordance with my invention, the solid outline indicating the position of the propeller at maximum pitch, while the broken line indicates the position of the propeller for minimum pitch.

Figure 2 is a side elevation of the propeller, with the solid line indicating maximum pitch and the broken line indicating minimum pitch.

Figure 3 is a view, partly in plan and partly in section, which indicates the conically arcuate movement to effect a variation in the pitch of the blade.

Figure 4 is a vertical, longitudinal sectional view through the hub of the propeller, showing in detail the mounting for the blade.

Figure 5 is a sectional view, horizontally and longitudinally of the hub, and with various portions of the blade mounting in elevation.

Figure 6 is a sectional view taken along the line 6—6 of Figure 4 looking in the direction of the arrows.

Figure 7 is a view taken along the line 7—7 of Figure 4 looking in the direction of the arrows.

Figure 8 is a view taken along the line 8—8 of Figure 4 looking in the direction of the arrows.

Figure 9 is a view in perspective of the sleeve, in which the blade is mounted.

Figure 10 is a view in perspective of a counterweight arm which may be used if necessary, and which is also designed to secure the blade against rotation in the sleeve.

As indicated in Figures 1, 2 and 3, the blades 1 are mounted in a hub designated generally 2 in such a manner that the blades may oscillate about the longitudinal axis 2a of the hub to describe the arc A of a cone which has its apex in the hub adjacent the end of the blades. As most clearly shown in Figure 3, this movement results in a change in the pitch of the blade. For instance, in the most forward position, indicated by the broken lines in Figures 2 and 3, the blade is at minimum pitch, whereas in the rearward-most position, as indicated by the solid lines in these figures, the blade is at maximum pitch.

The conico-arcuate movement of the blade is attained by mounting the shank of the blade in a rotatable sleeve 3 so that the longitudinal axis of the blade is angularly disposed to the axis of oscillation of the sleeve. The resulting conico-arcuate movement of the blade can be readily visualized by observing Figure 9 and assuming

that the sleeve 3 is oscillated about the axis 3a. It will then be appreciated that the longitudinal axis 1a of the blade will describe the arc of a cone which has its apex at the intersection of 3a and 1a.

Referring to the mechanical construction of the hub and mounting, it will be observed that the hub is centrally bored and provided with splines 4 to register with corresponding splines upon the usual crank shaft or drive shaft.

Opposite ends of the hub are recessed as indicated by the numerals 5, in which recesses the sleeves 3 are fitted, so that the axis 3a of the sleeve 3 will coincide with the axis 2a of the hub 2. As shown in Figure 6, channels 6 may be drilled between the recesses 5 in order to decrease the weight of the hub, and two of the channels 6 may be screw threaded, as 6a, for the purpose of receiving balance weights. Such balance weights may be in the form of plugs 7 which, upon proper positioning in the threaded channel, may be anchored in such positions by means of a slot and screw 7a, as best shown in Figure 4.

Referring more particularly to Figure 9, the sleeve 3 is made up of a cylindrical body section 3A and a flange 3B at the inner end thereof. As best shown in Figure 4, the sections 3A and 3B of the sleeve are concentric with the recess 5. The sleeve 3 is bored, as at 3C, at an angle to the oscillation axis 3a of the sleeve to receive the shank of the blade 1. The outer end of the sleeve 3 is reduced and slotted longitudinally to form a flexible cuff 3D concentric with the bore 3C.

The bore 3C in the sleeve 3 is threaded and is adapted to receive corersponding threads on the blade shank. In assembling the blade and sleeve, the blade is screwed into the sleeve and adjusted therein so that the blade has the desired pitch. The blade is then clamped in this position by means of a suitable clamp encircling the slotted cuff 3D. When counterweights are employed, such counterweights may serve as the clamp as disclosed herein. The counterweight 8 may be of the desired size and shape, and split to permit clamping upon the slotted cuff 3D, as best shown in Figure 10. A bolt and nut 9, or any other suitable means, may be employed for securely clamping the counterweight to the slotted cuff 3D. A flange 3E is formed upon the free end of the cuff 3D to prevent any slipping of the counterweight or clamp therefrom. It will be appreciated of course that the clamp or counterweight will bind the cuff 3D so tightly that rotation of the blade with respect to the sleeve 3 is prevented.

The shank of the blade 1 is hollow and is adapted to receive a ball cage 11. The ball cage 11 is provided with a flange 12 which is adapted to fit into a corresponding recess at the end of the blade. The cage 11 is provided with a central recess 13 in which the ball 14 rests. It will be noted that the bottom of the recess 13 is conical to assist in the centering of the ball. The recess 13 is shouldered and provided with an annular groove, in order to receive a ball retaining member 15 and a compressible retaining ring 16, respectively. It will be noted that the ball retaining member 15 is centrally apertured to permit the projection of a portion of the perimeter of the ball 14 therethrough.

A post 17 is screwed into a threaded aperture centrally located in the base of the recess 5 so that it is adapted to contact the ball 14 when the propeller is assembled. This post and ball, in association with the other securing means, serve to eliminate all looseness or slack of the blade assembly.

The inner surface of the sleeve 3 is provided with a pin 18 which extends into one of the bores 6, or preferably 6a, and thereby limits the extent of oscillation of the blade with respect to the hub. It will of course be appreciated that it may be necessary to vary the shape of the particular bore in which the pin projects in order to vary the limits of movement of the blade.

A single combined radial and thrust bearing 19 is composed of balls 19a, inner race 19b, outer race 19c, and bearing cage 19d. The inner race 19b is in frictional engagement with the cylindrical portion 3A of the sleeve 3 and bears against the flange 3B while the outer race 19c is in frictional engagement with the wall of the recess 5.

The various elements are held in assembled position by means of a nut 21, which is threaded in recess 5, and which is provided with an annular groove 21a to hold a packing element 22 and thereby retain lubricant within the recess.

The packing element 22 is of a type to reduce friction between the hub and sleeve to a minimum and consists of a plurality of flexible, chevron shaped rings 22a which fit the annular groove 21a and a pressure ring 22b positioned between the rings 22a and the outer ball race 19c. Only the inner peripheries of the rings 22a contact the sleeve 3 so that the amount of seal is proportional with the amount of centrifugal force acting on the blade.

Other types of lubricating packing may be employed as conditions may dictate.

When screwed into final position, the nut 21 is held against rotation by means of clips 23 which fit within grooves on its face. These clips have serrations adapted to fit into corresponding serrations 24 on the interior of the hub. The clips 23 may be locked in position by means of bolts 25 and, when so locked in mesh with the serrations of the hub, movement of the nut 21 is of course impossible.

While I have described my invention with reference to a propeller, particularly an aircraft propeller, it is of course obvious that the underlying principle is applicable to other types of device, such as, for instance, ship propellers, fans, autogiro rotors, etc. I desire particularly to point out that where I use the word "propeller" in the claims, such expression is to cover any type of blade adapted to rotate in a fluid and where it may be desired to change the pitch of the blade.

While I have described a propeller which varies its pitch by virtue of forces acting directly on it, it will be appreciated that supplementary devices may be employed to facilitate the variation of the pitch.

While I have shown and described the preferred embodiment of my invention, I wish it to be understood that I do not confine myself to the precise details of construction herein set forth by way of illustration, as it is apparent that many changes and variations may be made therein, by those skilled in the art, without departing from the spirit of the invention, or exceeding the scope of the appended claims.

I claim:

1. An adjustable variable pitch propeller comprising a hub mounted upon a drive shaft, said hub being provided with a radial recess, a propeller blade mounted in a sleeve, said sleeve being freely rotatably mounted in said recess, and bearing means adapted to determine the innermost position of the sleeve and eliminate slack in the

propeller assembly, said bearing means comprising an adjustable element mounted in the bottom of said radial recess, said element being provided with a bearing surface adjacent the sleeve, and an anti-friction bearing disposed within said sleeve and cooperating with said bearing surface.

2. An adjustable variable pitch propeller as set forth in claim 1 wherein the bearing means lies in the axis of rotation of the sleeve.

3. An adjustable variable pitch propeller as set forth in claim 1 wherein the propeller blade shank has a conical recess disposed within said shank, the axis of said conical recess lying within the propeller blade axis, and said anti-friction bearing being detachably disposed within said recess.

4. An adjustable variable pitch propeller comprising a hub for mounting upon a drive shaft, said hub being provided with a radial recess, a propeller blade, a sleeve for said propeller blade having a cylindrical external surface and a peripheral outwardly extending flange at the inner end thereof concentric with the external surface of the sleeve, bearing means cooperating with the external surface of the sleeve and the flange and with the wall of the recess for mounting the sleeve in the recess, said sleeve having a cylindrical blade-shank-receiving socket formed therein, the axis of which is inclined to that of the sleeve and recess, an axial cuff-like flange extending from the outer end of the sleeve coaxially of the blade-shank-receiving socket and having a bore forming a continuation of the socket bore, said propeller blade having a shank mounted in said socket and cuff-like flange with its axis aligned with the axis of said socket, and additional bearing means adapted to determine the innermost position of the sleeve and eliminate slack in the propeller assembly, said additional bearing means comprising an adjustable element mounted in the bottom of said radial recess, said element being provided with a bearing surface adjacent the sleeve, and an anti-friction bearing disposed within said sleeve and cooperating with said bearing surface.

5. An adjustable variable pitch propeller comprising a hub for mounting upon a drive shaft, said hub being provided with a radial recess, a propeller blade, a sleeve for said propeller blade having a cylindrical external surface and a peripheral outwardly extending flange at the inner end thereof concentric with the external surface of the sleeve, bearing means cooperating with the external surface of the sleeve and the flange and with the wall of the recess for mounting the sleeve in the recess, said sleeve having a cylindrical blade-shank-receiving socket formed therein, the axis of which is inclined to that of the sleeve and recess, an axial cuff-like flange extending from the outer end of the sleeve coaxially of the blade-shank-receiving socket and having a bore forming a continuation of the socket bore, said propeller blade having a shank mounted in said socket and cuff-like flange with its axis aligned with the axis of said socket, and additional bearing means adapted to determine the innermost position of the sleeve and eliminate slack in the propeller assembly, said additional bearing means comprising an adjustable element mounted in the bottom of said radial recess, said element being provided with a bearing surface adjacent the sleeve, and an anti-friction bearing disposed within said sleeve and cooperating with said bearing surface, said additional bearing means lying in the axis of rotation of the sleeve.

6. An adjustable variable pitch propeller comprising a hub for mounting upon a drive shaft, said hub being provided with a radial recess, a propeller blade, a sleeve for said propeller blade having a cylindrical external surface and a peripheral outwardly extending flange at the inner end thereof concentric with the external surface of the sleeve, bearing means cooperating with the external surface of the sleeve and the flange and with the wall of the recess for mounting the sleeve in the recess, said sleeve having a cylindrical blade-shank-receiving socket formed therein, the axis of which is inclined to that of the sleeve and recess, an axial cuff-like flange extending from the outer end of the sleeve coaxially of the blade-shank-receiving socket and having a bore forming a continuation of the socket bore, said propeller blade having a shank mounted in said socket and cuff-like flange with its axis aligned with the axis of said socket, and additional bearing means adapted to determine the innermost position of the sleeve and eliminate slack in the propeller assembly, said additional bearing means comprising an adjustable element mounted in the bottom of said radial recess, said element being provided with a bearing surface adjacent the sleeve, and an anti-friction bearing disposed within said sleeve and cooperating with said bearing surface, said propeller blade shank having a conical recess disposed within said shank, the axis of said conical recess lying within the propeller blade axis and said anti-friction bearing being detachably disposed within said conical recess.

7. A propeller assembly comprising a hub for mounting upon a drive shaft, said hub having a radial recess therein, a propeller blade, a sleeve for the blade, support means to mount the sleeve for coaxial free rotational movement within the recess, said sleeve having a blade shank receiving bore, the axis of which is angularly disposed with respect to the axis of the sleeve and recess whereby the pitch of the blade is changed upon rotation of said sleeve, the base of said recess having an aperture therein arranged eccentrically with respect to the axis of the recess, and a pin projecting longitudinally from the inner end of said sleeve and selectively engageable with opposite walls of said aperture for determining maximum and minimum pitch positions of the blade.

8. A propeller assembly comprising a hub for mounting upon a drive shaft, said hub having a radial recess therein and a channel forming a longitudinal extension of said recess but disposed eccentrically with respect to the axis thereof, a propeller blade, a sleeve positioned about the shank of the blade, support means for mounting the sleeve in the recess for coaxial free rotational movement with respect thereto, said sleeve being provided with a blade shank receiving bore disposed at an angle to the axis of the sleeve and recess thereby to effect a change in the pitch of the blade upon rotation of said sleeve, a pin projecting from the inner end of the sleeve and selectively engageable with opposite walls of said channel for determining maximum and minimum pitch positions of the blade, a weight member positioned in said channel and capable of longitudinal adjustment with respect thereto for balancing the propeller assembly, and means for frictionally engaging the weight member with the wall of said channel thereby to maintain an adjusted position of said weight member.

9. An airscrew adapted to change its pitch in accordance with the aerodynamic and centrifugal

forces to which it is subjected comprising a hub mounted upon a shaft for rotation therewith, a recess formed in the hub, a sleeve pivotally mounted in the recess with its pivot axis radial to the axis of rotation of the hub, said sleeve being provided with a split cuff angularly disposed with respect to the pivoting axis of the sleeve, a blade shank adjustably mounted in said sleeve and cuff and likewise disposed at an angle to the pivoting axis of the sleeve so that upon pivoting of the sleeve the gravity axis of the blade describes the arc of a cone whose axis coincides with the pivoting axis of the sleeve, a counterweight clamped upon the cuff to fix the blade, the cuff and the counterweight with respect to each other, said counterweight being adjustable upon the cuff to vary the effect of the counterweight.

10. An adjustable variable pitch air screw comprising a hub provided with means for mounting it upon a drive shaft for rotation about the axis of the drive shaft, said hub being provided with a radial recess, a blade receiving sleeve pivotally mounted in said recess, a blade having its shank mounted in said sleeve, cooperating means on said sleeve and hub for limiting outward movement of said sleeve in said recess, and means for determining the innermost position of the sleeve in said recess and to eliminate axial movement of the sleeve in said recess, said last mentioned means including an adjustable element mounted in the recess and aligned with the pivoting axis of the sleeve, a bearing engaging surface upon said element, and an anti-friction bearing interposed between said surface and a surface of said sleeve.

11. An adjustable variable pitch air screw comprising a hub provided with means for mounting it upon a drive shaft for rotation about the axis of the drive shaft, said hub being provided with a radial recess, a blade receiving sleeve pivotally mounted in said recess, a blade having its shank mounted in said sleeve, cooperating means on said sleeve and hub for limiting outward movement of said sleeve in said recess, and means for determining the innermost position of the sleeve in said recess and to eliminate axial movement of the sleeve in said recess, said last mentioned means including an adjustable element mounted in the recess upon the drive shaft mounting means, and aligned with the pivoting axis of the sleeve, a bearing engaging surface upon said adjustable element, and an anti-friction bearing interposed between said surface and a surface carried by the inner portion of said sleeve.

PAUL F. HACKETHAL.