

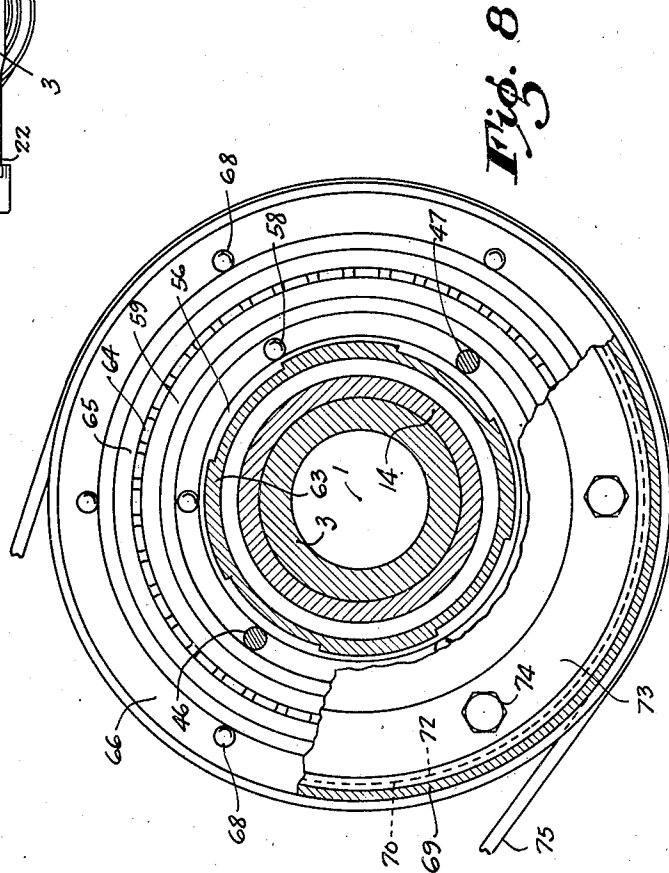
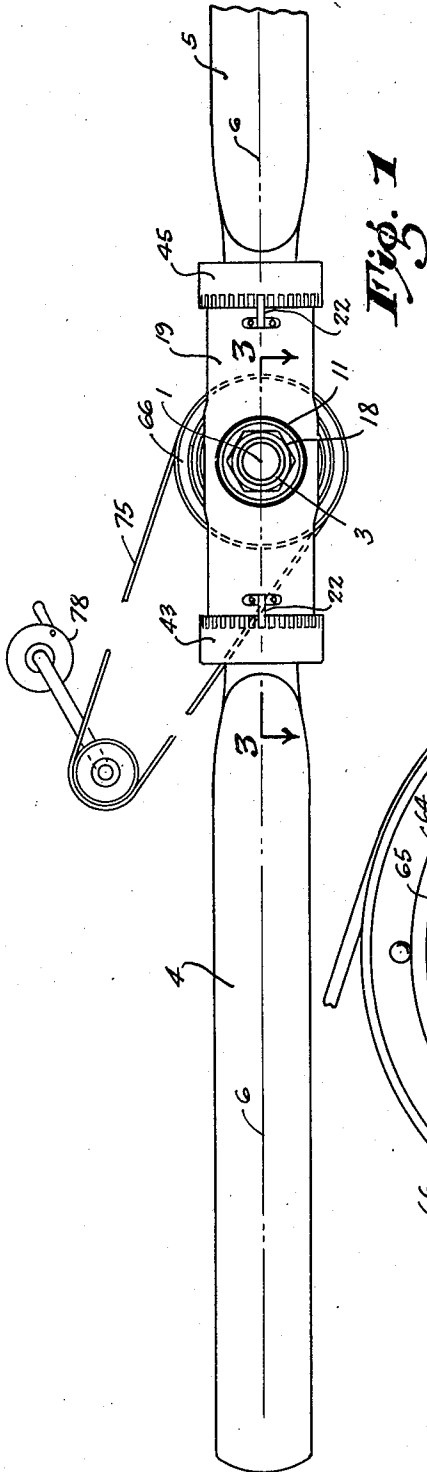
June 15, 1948.

W. E. GREENWOOD
CONTROLLABLE PITCH PROPELLER

2,443,239

Filed Jan. 31, 1944

3 Sheets-Sheet 1



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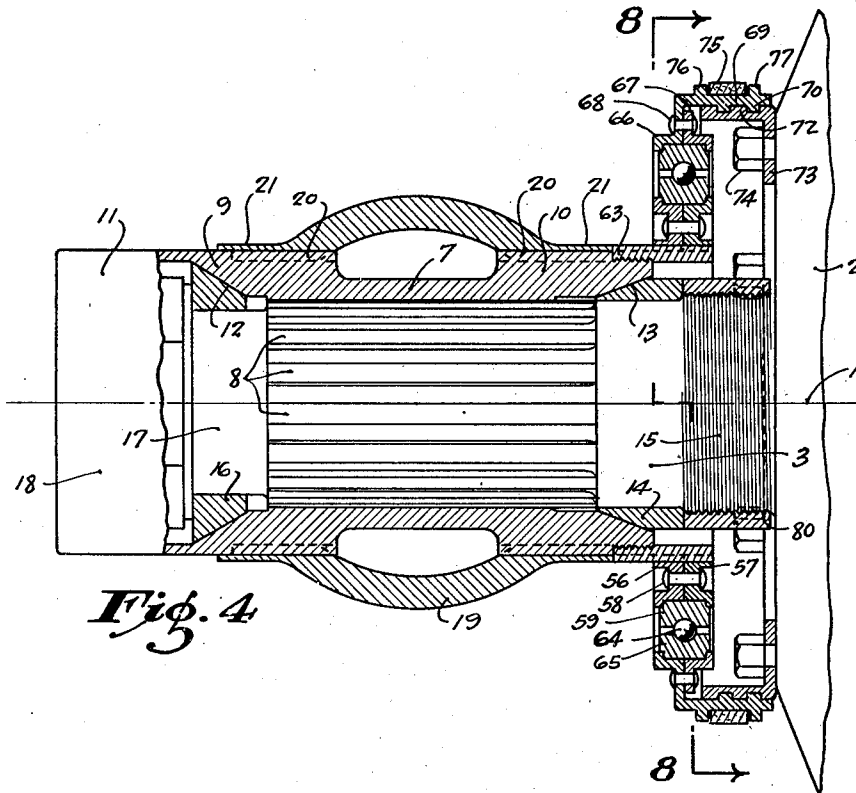


Fig. 4

Fig. 5

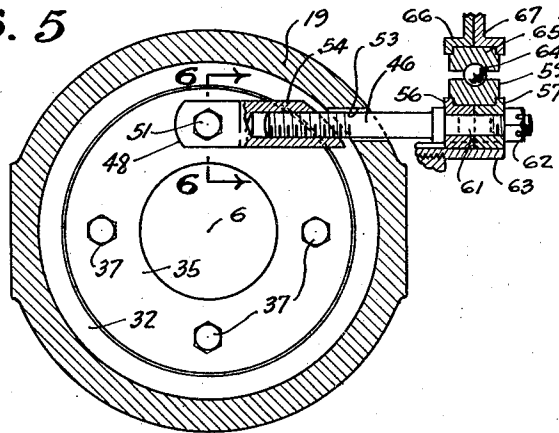


Fig. 6

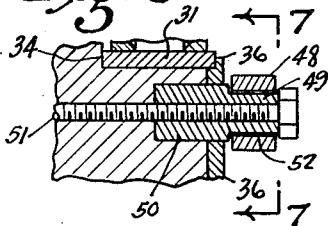
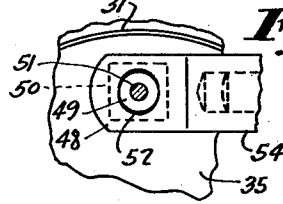


Fig. 7



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2,443,239

CONTROLLABLE PITCH PROPELLER

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Application January 31, 1944, Serial No. 520,476

2 Claims. (Cl. 170-162)

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This invention relates to propellers and especially to propellers having blades that may be adjusted for varying the pitch thereof.

Propellers of this general class are in common use on aircraft. They are generally arranged so that the pitch is adjusted on the ground or controlled by the pilot as the conditions of the flight may require. The adjustment of the blades is an angular movement about the center lines of the blades, and which center lines are radial to the axis of rotation of the propeller.

It is one of the objects of this invention to provide a simple and efficient controllable pitch propeller which may be so inexpensively constructed that it may be used on relatively small airplanes.

In many instances, the blades of such propellers are made of laminated wood, such as birch or maple, and the laminations may be impregnated with a phenolic condensation product to provide a compact structure. The butt of the blades may be fastened into metal sockets disposed radially of a propeller hub. If such wood blades be utilized in a metal propeller hub, there is difficulty in firmly attaching the blade in the socket. If a metal ferrule is placed upon the butt end, the wood dries out and shrinks; and this causes intolerable looseness in the ferrule. This is extremely objectionable, due to the stresses caused by the intensive vibrating forces imposed upon the propellers. These disadvantages of the wood propeller blades occur even when the propeller is of fixed pitch.

However, for controllable pitch propellers, the wood blade supporting means presents additional important problems. The blades must be quite freely rotatable in their sockets; and the rotatable supports must be such as to be operative even against the effect of centrifugal forces tending to move the butts out of the sockets. The latter requirement is especially difficult in connection with high speed propellers.

It is another object of this invention to make it possible to comply with these requirements by the aid of a relatively simple mechanism.

In order to accomplish these results, it is important that the butt of the blade retains a truly cylindrical shape under all of the stresses imposed thereon. Since laminated wood notoriously is incapable of retaining this shape under these conditions, a metal sleeve is preferably placed over the butt to form the exterior surface. It is another object of this invention to ensure that the butt will not become loosened in the sleeve even upon the continued exertion of strong centrifugal forces.

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This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of one embodiment of the invention. For this purpose there is shown a form in the drawings accompanying and forming part of the present specification. The form will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of this invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a front view, partly broken away, of a two-bladed propeller incorporating the invention;

Fig. 2 is a vertical sectional view, on an enlarged scale, of the hub portion of the propeller illustrated in Fig. 1;

Fig. 3 is a horizontal sectional view, taken along plane 3-3 of Fig. 1;

Fig. 4 is a vertical sectional view, taken along plane 4-4 of Fig. 2;

Fig. 5 is a fragmentary sectional view, taken generally along plane 5-5 of Fig. 2;

Fig. 6 is an enlarged detail sectional view, taken along plane 6-6 of Fig. 5;

Fig. 7 is a fragmentary sectional view, taken along plane 7-7 of Fig. 6; and

Fig. 8 is a fragmentary sectional view, taken generally along plane 8-8 of Fig. 4.

The propeller structure is shown as rotatable about an axis 1 that corresponds to the axis of rotation of an airplane engine. The housing 2 for the engine is shown diagrammatically in Figs. 3 and 4. Extending from the housing 2 is the hollow engine shaft 3.

This engine shaft 3 serves to support the radial propeller blades 4 and 5 (Figs. 1, 2, and 3). These propeller blades are shown as having longitudinal axes 6 that are radial to the axis 1 of the shaft 3. The inner ends of these propeller blades, formed as hereafter described, are arranged to be supported in a hub structure mounted on the shaft 3.

The hub structure for the blades includes a sleeve 7 into which the shaft 3 is splined, as indicated by the splines 8 formed on the shaft (Figs. 2 and 4). This sleeve 7 has enlarged opposed ends 9 and 10. It is held in fixed position on shaft 3 by a structure now to be described. The end 9 is shown as terminating in a hollow cylindrical extension 11. Tapered or conical surfaces 12 and 13 are provided in the ends 9 and 10 (Fig. 4). These surfaces 9 and 10 provide appropriate

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clamping surfaces. For this purpose nut structures are provided. Thus, co-operating with the tapered surface 13 is a tapered collar or cone 14 placed over the engine shaft. This cone is restrained by the thrust nut 80 threaded on the threaded portion 15 of shaft 3. At the left hand end of the shaft 3, a tapered collar or cone 16, conforming with the tapered surface 13, is shown as telescoping over the cylindrical portion 17 of the shaft 3. This collar 16 is urged against the surface 12 by the aid of a nut 18 threaded on a threaded extension of the shaft 3 (Figs. 1 and 4).

The sleeve 7 forms the main support of the propeller hub, and serves to support a cylindrical socket forming member 19 (Figs. 1, 2, 3, 4, and 5). The member 19 is of general cylindrical form, having an axis coincident with the axis 6 of blades 4 and 5. It is joined to the sleeve 7, as by the splines 20 formed between the sleeve 7 and the cylindrical extensions 21 of the member 19 (Figs. 2, 3, and 4).

The opposed ends of the tubular member 19 form sockets in which the butt ends of the blades 4 and 5 may be accommodated and supported. The manner in which this is accomplished may be explained in connection with Figs. 2 and 3.

The blades 4 and 5 are of laminated wood, such as birch or maple, natural or impregnated with phenol formaldehyde, and compressed. The butt ends 23 of these blades are shown as tapering outwardly toward the root end of the blade. Since the structure is identical for both blades, only that associated with blade 4 need be described.

A sleeve 24 of relatively rigid metal encompasses the tapered end 23. In order to hold the butt end 23 within the sleeve 24, use is made of a wedge structure 30 interposed between the tapered exterior surface of the butt end 23 and the sleeve 24. This wedge structure may be split into semi-circular segments having tapered inner surfaces 25 conformed with the butt end 23, and cylindrical surface of sleeve 24. Each of the segments includes a flange 27 adjacent the outer end of the socket. This flange 27 is shown as having a tapered surface 28 conforming with the corresponding tapered surface 29 at the end of the socket in which the butt end 23 is arranged.

The process of forming the assembled structure at the butt end may be here described in greater detail. The wood laminations of the blade are first glued together to form a block; then the blade is carved and finished with the round tapered butt 23. This butt is then assembled with the split wedge structure 30. Then the sleeve 24, which may be of steel, is placed over the wedge. An axial force urging the wedge tightly in place is then exerted. This axial force is at least twice that which would be exerted by the centrifugal effect occurring during operation of the propeller.

In compressing the wood in the butt end by forcing the sleeve 24 thereover, the wood laminations offer greater resistance to compression in a direction parallel to the laminations than in the direction transverse to the laminations. Accordingly, the sleeve 24 will be urged slightly out of round in this process of assembling. Thereafter, the assembled blade 4, with wedge structure 30, and the ferrule, or sleeve, 24, is then put in a lathe and the sleeve 24 is turned to a true cylindrical shape. In this way, the sleeve 24 can be inserted in the socket formed by the member 19 to provide a good running fit therein.

Angular motion of the blade butt in its socket is permitted by the aid of bearing structures

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supporting the assembled blade within the member 19. At the inner end of the butt 23, the butt end is turned down to a cylindrical form over which the inner race 31 for rolling bearings is disposed. The outer race 32 is pressed into the member 19. The rolling elements 33 may be needle bearings, located between the inner and outer races. The inner race 31 may be held against the shoulder 34 at the end of the tapered portion of the butt by the aid of a ring 35 (Figs. 2 and 6). This ring 35 is shown as having a flange 36 overlying the right hand edge of the race 31. The ring 35 may be fastened to the inner surface of the butt end 23 as by a plurality of lag screws 37 (see also Fig. 5).

A ball thrust bearing having angular contact is provided for the butt end 23 adjacent the outer end of the socket in member 19. One race 38 of this bearing structure is shown as supported upon the extension 39 of the wedge structure 30. Furthermore, this race 38 abuts against the left hand surface 40 of flange 27. The co-operating race 41 is shown as urged axially toward the right by the flange 42 of nut 43. The nut 43 is shown as threaded over the exterior threaded portion 44 of the member 19 (see also Figs. 1 and 3). It may be locked in place by any conventional means, such as a key 22, indicated in Fig. 1.

By turning the nut 43, the assembled cylindrical butt is urged into the socket member 19, and the butt assembly is furthermore held against axial movement with respect to its socket by the nut 43. The sleeve 24 is thus freely movable within the socket.

Although the butt end of blade 4 has been described, it is understood that a similar structure is provided for the butt end 23 of the other blade 5. It also includes a nut 45 (Fig. 1) corresponding to nut 43 to hold the blade 5 against axial movement with respect to its socket.

In order to rotate the blades 4 and 5 simultaneously about the axis 6, as desired by the pilot to vary the pitch of the propeller, use is made of the connecting rods 46 and 47 (Figs. 3 and 5), that are joined to crank pin structures carried by the inner ends of the blades. These connecting rods and their associated structures will now be described.

Since the connecting rod mechanisms are substantially identical for both of the blades, only one need be described in detail. The connecting rod 46 for blade 4 is shown as threaded into the clevis 54. This clevis 54 (Figs. 2 to 7 inclusive) is shown as provided with an ear 48 that is disposed over the crank pin 49. The pin 49 is shown as formed integrally with a square insert 50 disposed within a recess in the butt end 23. It is held in place in the recess by a lag screw 51 threaded through the insert 50 and into its butt. As shown most clearly in Fig. 7, the aperture 52 in the ear 48 is slightly larger than the pin 49. In this way, a pull or push on rod 46, as viewed on Fig. 5, will be permitted without bending the rod 46.

As shown most clearly in Fig. 5, the rod 46 passes through a clearance aperture 53 in the member 19. Rod 47 is identical in structure with rod 46. However, it is disposed diametrically opposite the rod 46 with relation to the axis 6. This is indicated most clearly in Fig. 2, where the clevis 55, corresponding to clevis 54, is shown below the axis 6. Accordingly, as both connecting rods are urged toward the left, as viewed in Fig. 5, the blade 4 will be moved

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in a counter-clockwise direction, and blade 5 will be moved in a clockwise direction. This opposite angular motion is necessary, for the advancing edges of the two blades are on opposite sides of the axis 6. As the blades are rotated, rods 46 and 47, connected to the blades, are also moved about the axis 1. Mechanism is provided for nevertheless imparting longitudinal motion to these rods even during such rotation.

For this purpose, use is made of a rotating ring structure formed of the half members 56 and 57 (Figs. 4 and 8). To this ring structure are fastened the right hand ends of connecting rods 46 and 47. This is illustrated most clearly in Fig. 5. Thus, rod 46 has a reduced portion 61 extending through an aperture in the members 56 and 57. The member 61 is held in engagement with the ring structure by the aid of the nut 62.

The ring members 56 and 57 are held together as, for example, by the aid of the rivets 59 (Figs. 4 and 8). Furthermore, this ring structure 56 and 57 is capable of movement in a direction corresponding to the axis 1 of the engine shaft 3. For this purpose, the inner edge of the ring structure is shown as slidably splined to a ring support 63. This ring support 63 forms an extension of the end 10 of sleeve 7, as by being threaded to the enlarged end.

Axial movement of the ring structure 56 and 57 is accomplished through a thrust bearing structure, whereby the axial adjustment of the structure can be made even while it is rotating. For this purpose, the ring 56—57 serves to support the inner race 59 of a ball bearing structure including the balls 64. The outer race 65 of the ball bearing structure is arranged to be moved in an appropriate axial direction from a remote point, as, for example, by a pilot in the fuselage. The outer race 65 is held in a band formed by the members 66 and 67. These members 66—67 may be fastened together by the aid of the rivets 68. The member 66 is shown as having a flange extension provided with square threads 70 engaging corresponding square helical threads on the flange 72 of a support 73. This support 73 is shown as bolted to the housing 2, as by the bolts 74.

Thus, to move the outer race 66 in an axial direction, the flange 69 may be angularly rotated about the axis 1 to cause axial movement thereof with respect to flange 72. The controlling movement can be accomplished even while the entire hub structure of the blades 4 and 5 are rotated about axis 1. This is due to the interposition of the balls 64, providing a thrust bearing between the rotary inner race 59 and the angularly adjustable outer race 66.

Angular movement of flange 69 may be accomplished by appropriate gearing belting, or the like. In the present instance, a belt 75 (Figs. 1, 2, 3, 4, and 8) is provided for this purpose, and is restrained against axial movement with respect to the flange 69 by the annular abutments 76 and 77. Movement of the belt may be accomplished by the aid of the hand wheel 78, or the like, illustrated diagrammatically in Fig. 1. Furthermore, the belt 75 may

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be so arranged over appropriate idlers as to locate the controlling hand wheel 78 in the desired place.

The inventor claims:

1. In a controllable pitch propeller, a plurality of wood blades having butt ends; each of said butt ends having a continuous tapered surface of revolution; a propeller hub having sockets for accommodating said ends; a sleeve having a continuous exterior cylindrical surface carried by the butt end of each blade, and having an axial length substantially coextensive with the butt end; wedge means, separate from the sleeve, for maintaining the butt end in said sleeve and interposed between the butt end and the sleeve; a rolling thrust bearing structure supported on the hub socket and cooperating with the outer edge of the said assembled sleeve, butt end and wedge means, said bearing structure restraining the blade against outward movement; and a rolling bearing structure between the socket and the inner end of the butt end.

2. In a controllable pitch propeller, one or more wood blades having a butt end that tapers continuously outwardly toward the inner end of the blade, a sleeve surrounding the butt end, a wedge structure between the sleeve and the butt end for compressing the butt end in the sleeve, a propeller hub having sockets for accommodating said ends, a rolling radial bearing structure interposed between the inner end of the blade and the socket, a thrust bearing structure at the outer end of the wedge structure, and means for urging the thrust bearing structure inwardly of the socket, said wedge structure, sleeve, and butt end being in such relation that the resistance against outward motion of the blade with respect to the structure is greater than the centrifugal force acting upon the blade in normal operation.

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