April 21, 1931. D. G. LILLEY 1,801,511

PROPELLER HUB

Filed May 24, 1929 2 Sheets-Sheet 1

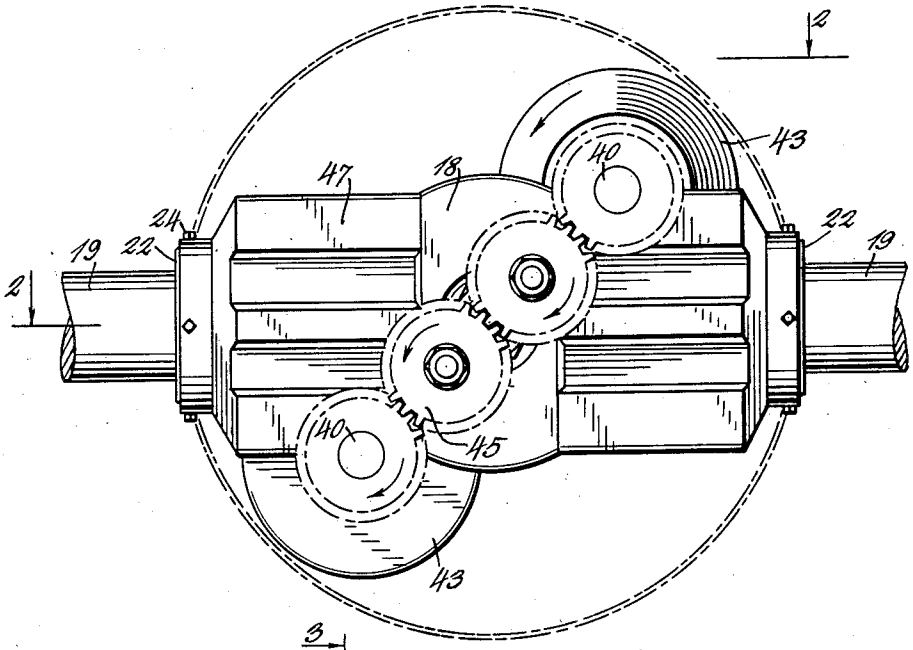


Fig. 1.

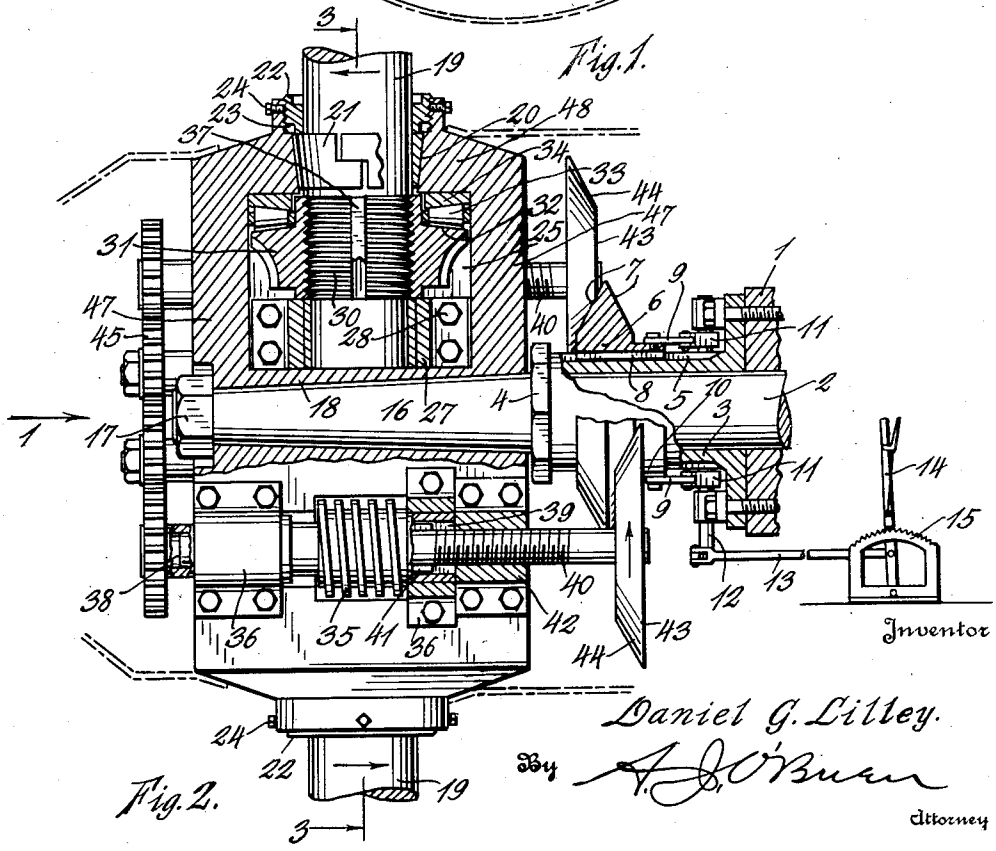


Fig. 2.

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Filed May 24, 1929 2 Sheets-Sheet 2

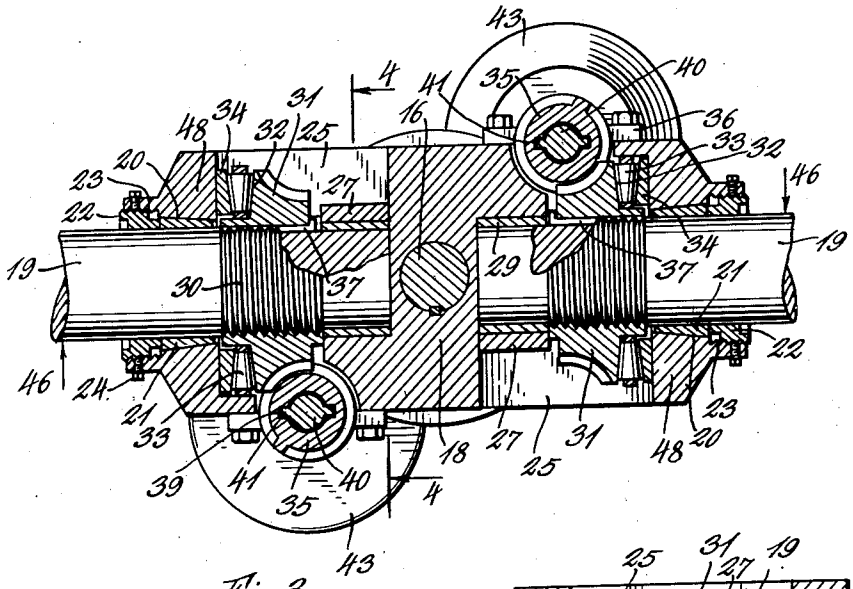


Fig. 3.

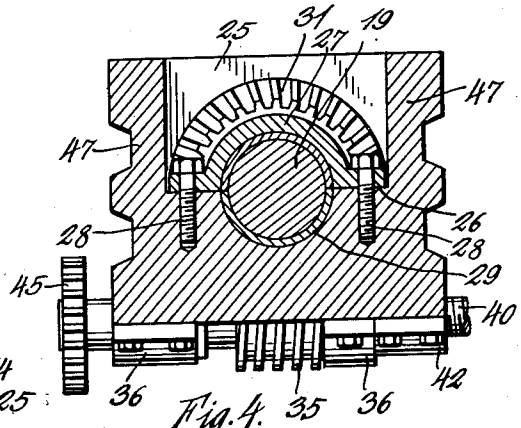


Fig. 4.

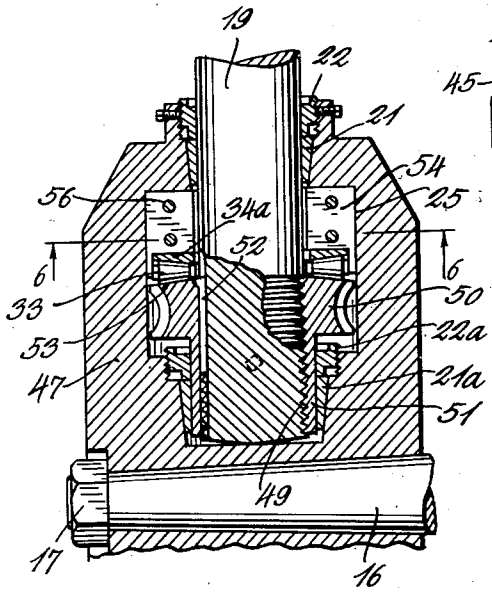


Fig. 5.

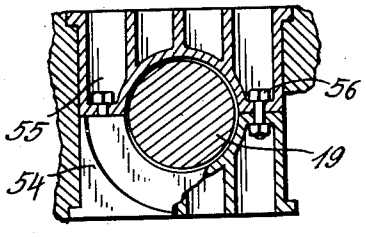


Fig. 6.

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UNITED STATES PATENT OFFICE

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PROPELLER HUB

Application filed May 24, 1929. Serial No. 365,703.

This invention relates to improvements in the construction of propellers for aeroplanes and has reference more particularly to an improved hub construction which is especially adapted for use with variable pitch propellers of the type described and claimed in U. S. Letters Patent 1,712,708, dated May 14, 1929.

It is well known among those having experience with the operation of aeroplanes and airships that much better operation would be obtained if it were possible to change the pitch of the propellers while the ship is in operation. The question of constructing a practical variable pitch propeller has been found to involve some very difficult mechanical problems and problems of design which apparently has so far not been solved in a satisfactory manner.

It is the object of this invention to produce a hub construction which shall be adapted to be employed in connection with the mechanism described and claimed in the patent above identified for rotating the blades and changing their pitch while in operation.

It is evident that propellers of the type to which this invention relates, are subjected to very severe strains, some of which are due to centrifugal force and others of which are due to the bending strains resulting from the resistance offered by the air to the rotation of the propellers. A propeller hub construction must, of course, be of a very strong construction so as to enable it to successfully resist the severe strains and when, as in this case, the pitch of the blades are to be varied while the propeller is rotating suitable thrust bearings must be provided which must be so designed that they will resist the powerful forces due to centrifugal action and which will at the same time permit the propeller blades to be rotated.

The above and other objects which may become apparent as the description proceeds are attained by means of a construction and an arrangement of parts that will now be described in detail, reference for this purpose being had to the accompanying drawings in which the preferred embodiment of my invention has been illustrated, and in which:

Fig. 1 is an end view of the propeller hub looking in the direction of arrow 1 in Fig. 2;

Fig. 2 is a section taken on line 2—2, Fig. 1;

Fig. 3 is a section taken on line 3—3, Fig. 2;

Fig. 4 is a section taken on line 4—4, Fig. 3.

Fig. 5 is a section showing a slightly modified form of construction; and

Fig. 6 is a section taken on line 6—6, Fig. 5.

In the drawings numeral 1 represents one of the main bearings of the engine and 2 the propeller drive shaft which may be a prolongation of the engine crank shaft. Secured to the outer end of bearing 1 is a bearing sleeve 3, whose outer end is threaded for the reception of a nut 4. This sleeve is provided with one or more grooves 5 and carries a friction gear 6 which has two friction surfaces 7. This gear is provided with a spline 8 that engages the groove 5 and holds the gear against rotation. Links 9 connect the hub 10 and gear 6 with cranks 11 which are secured to the shaft 12. This shaft can be rotated by means of a link 13 that is connected with the control lever 14. This lever is held in adjusted position by means of a quadrant 15. The mechanism which is employed for varying the pitch of the propellers and which has partly been described forms the subject matter of the patent above identified and will therefore not be described in this application with any greater detail than necessary for the purpose of explaining the invention. The propeller drive shaft is provided with a tapered end portion 16, whose outer end is threaded for the reception of a nut 17. Secured to the tapered end of the shaft is the hub of the propeller. This hub is formed from a single unitary steel casting having a central portion 18, which is provided with a tapered opening for the reception of the shaft. Two or more radial arms extend outwardly from the central portion. These arms are integral with the central portion and are provided with radial openings through which the cylindrical root portions 19 of the propeller blades extend. These radial openings

have their outer ends tapered as indicated by reference numeral 20 and located within the tapered portion of each radial opening is a split bearing ring 21, whose outer surface is tapered to conform with the taper of the openings in the arm. A ring 22 has a threaded engagement with the inner threaded surface 23 and serves to move the rings 20 inwardly and to hold them in adjusted position. Set screws 24 hold the rings 22 against rotation so that the parts will remain in adjusted position. Each arm has a rectangular recess or opening 25 extending inwardly from the following side of the hub and this opening communicates with the radial openings above referred to. At the innermost ends of the radial openings the recesses 25 terminate in planes 26 that coincide with the axes of these openings, all as shown in Fig. 4. A removable bearing cap 27 is held in place by means of bolts 28 and serves to enclose the inner end of each root portion. Split bushings 29 may be interposed between the inner ends of the root portions 19 and the adjacent surfaces of the hub and the bearing caps. These bushings may be made of a suitable metallic alloy or may be of fiber or some nonmetallic composition whichever may be found to be most desirable. The cylindrical root portions 19 are provided with threaded sections 30 with which the worm gears 31 are threadedly connected. The worm gears have one side provided with conical surfaces 32 which cooperate with the tapered rollers 33 and with the annular roller races 34 to form thrust bearings which resist the centrifugal force that is generated during the rotation of the propellers and which also serve as part of the means for rotating the propeller for the purpose of varying its pitch. The outer end of each recess 25 extends entirely through the arm and forms an opening in which the worm 35 is located. These worms rotate in bearings that are formed in part by the caps 36 and cooperate with the worm gears 31 for the purpose of controlling the rotation of the propeller blades. The worm gears 31 are held against rotation by means of keys 37 that are of such length that they can be inserted after the root portions 19 have been put into place as shown in Fig. 3. For the purpose of inserting and removing these keys the bearing caps 27 must be removed. Referring now more particularly to Fig. 2, it will be seen that worms 35 are provided with longitudinal openings 38 whose sides are provided with diametrically located slots or grooves 39. Screws 40 extend into the openings 38 and are provided with outwardly extending fins 41 that engage the grooves 39. So that the screws may move longitudinally within the worms without having any relatively rotary movement therewith. The screws 40 extend through bearings whose inner surfaces are threaded. These bearings are formed in part by caps 42, and the outer end of each screw is provided with a friction gear 43 having a bevelled surface 44. One of these gears are located on each side of the gear 6 and the latter can therefore be moved into contact with either gear 43. In Fig. 1 I have shown how the two worms 35 are interconnected by means of a train of gears comprising a plurality of gear wheels 45.

Let us now assume that the hub shown in Fig. 3 is rotated in a counterclockwise direction. The resistance due to the movement of the fan blades through the air produces a force, one component of which has been designated by arrow 46. This force tends to move the inner ends of the root portions downwardly against the bottom of the opening which is formed in the integral portion of the hub. By means of the adjusting nut 22 the split ring 20 can be moved inwardly so as to produce the desired fit between it and the surface of the corresponding root portion. The centrifugal forces are resisted by the thrust bearing which has been described herein. The side walls 47 which extend from the central portion of the hub to the integral end portions 48 of the arms may have as great depth as may be necessary to resist the strains produced by the operation of the propeller and may have sufficient thickness to give them the desired strength to withstand all the strains to which they will be subjected.

Attention is called to the fact that the bearing caps 27 are not called upon to resist any severe strains as the forces due to the air resistance are in the opposite direction, and therefore the function of these caps consists in holding the inner ends of the root portions against movement away from the bottoms of the bearings.

The openings 25 are provided for the purpose of inserting and removing the worm gear wheel 50 and the thrust bearing. In order to obtain the maximum strength and rigidity, the hub has been formed from a single piece of steel with a central opening for the reception of the end 16 of the drive shaft and with radial arms. Each arm comprises two walls 47 that are spaced the width of opening 25 and whose outer ends are joined by an integral transverse wall 48. The bottom of the opening 25 is on the leading side of the rotating arms and is therefore subjected to tension when the propeller operates. It is, of course, also subjected to flexure due to the tractive effort of the blades.

By making the hub from a single piece of metal, it will have the maximum strength and rigidity and therefore it will not be distorted to any appreciable extent during the operation. Since the end wall 48 is integral with the side walls and the bottom of the opening 25, it will withstand the centrifugal forces produced at high speed and therefore the bearings will not bind, but will function

freely. If the hub were made of several pieces bolted or riveted together, it would be more liable to become distorted and its operation would be less satisfactory. The fact that the open side of opening 25 is on the following side is of importance for by this means the maximum strength and rigidity is obtained and it is also possible to resist the force exerted by the inner end of the blade roots on a bearing that is integral with the hub.

The construction above described gives to all intents and purposes a one-piece hub whose integral parts may be made of any suitable metal and so designed as to have sufficient strength to take care of the various forces and strains to which it is subjected during operation.

Attention is called to the fact that the worms 35 are located substantially midway of the radial arms and that the forces which are necessary for rotating the propeller blade are resisted by the central portion of the propeller, thereby obviating the production of severe tortional strains which, if applied to the outer ends of the arms, might tend to distort them to a dangerous extent.

In Figs. 5 and 6 I have shown a slightly modified form of construction in which the cylindrical root portions 19 are provided at their inner ends with threaded sections that have been designated by reference numeral 49. The worm wheels 50 are somewhat different in shape than the corresponding wheels 31 and are each provided with a long threaded hub 51. These worm wheels are held against rotation by means of keys 52. The outer surfaces of the hubs 51 serve as bearings and these extend into conical split rings 21*a*. These rings are held in adjusted position by means of nuts 22*a*. The outer surfaces of the worm wheels have conical bearing surfaces 53 with which the rollers 33 cooperate. The annular raceway 34*a* rests against the inner side of the two spacing blocks 54 and 55. These blocks are made removable for the purpose of permitting the worm wheels 50 to be inserted into the openings, and are held in place by means of bolts 56. This construction brings the rotating mechanism closer to the center and therefore diminishes to a still greater extent the torque which tends to distort the radial arms when the propeller blades are adjusted.

Attention is called to the fact that with the construction illustrated, it is possible to adjust the bearings so as to prevent any relative movement between the propeller blades and the hub except the rotary movement necessary for adjustment. The conical split rings maintain the axes of the propeller blades in exactly the same position after each adjustment for wear. The removable bushings 29 can be removed and replaced if they should wear to any appreciable extent and it is therefore possible to maintain the entire assembly in proper adjustment at all times.

In the above description the hub construction has been explained in connection with the propeller blade rotating mechanism described and claimed in the patent above identified, but I want it understood that this particular mechanism has been employed as an example of such means only and that the hub construction can be employed in connection with any other means for rotating the blades.

Having described my invention what I claim as new is:

1. A propeller hub having radial arms each formed from two parallel walls joined rigidly together by integral transverse walls, one wall connecting the inner ends of the radial walls and a separate wall connecting the outer ends of each pair of parallel walls whereby a box-like opening is formed in each parallel wall, the transverse end walls having openings through which the root portion of a propeller blade can extend and the wall connecting the inner ends of the radial walls having a bearing for the inner end of the root portion of the propeller blade.

2. A propeller hub formed from a single piece of metal, said hub having a plurality of radial arms, each arm having a radial opening for the reception of the root portion of a propeller blade, each of the radial arms having an opening extending into the same from the following side, and a smaller opening extending into the radial opening from the leading side, the inner end of the radial opening forming a bearing.

3. A propeller hub for use with variable patch propellers, said hub comprising a single piece of steel having a central opening for the reception of a propeller shaft and a plurality of radial arms, each formed from two parallel, spaced walls lying in planes perpendicular to the axis of rotation, the outer ends of the walls being integrally joined by a transverse wall which has an opening adapted to receive the root portion of a propeller blade, the leading edges of the spaced parallel walls being connected by an integral wall member which forms the bottom of a recess whose other side is open, the end of the recess nearest the center of the hub having a bearing for the reception of the inner portion of a propeller root portion.

4. A propeller hub formed from a single piece of steel, said hub having a solid central portion provided with an opening for the reception of a propeller shaft, said hub having a plurality of radial arms, each arm having a radial opening for the reception of the root portion of a propeller blade, each radial arm having an opening extending thereinto in the plane of rotation, and the inner end of the radial opening of each arm having a bearing that is formed in the central portion and which is adapted to receive the

inner end of the root portion of a propeller blade.

5. A propeller hub having radial arms each formed from two parallel walls lying in spaced planes and joined rigidly together by integral transverse walls, one wall connecting the inner ends of the radial arms and a separate wall connecting the outer ends of each pair of parallel walls whereby a box-like opening is formed between each pair of parallel walls, the transverse end wall having an opening through which the root portion of a propeller blade can extend and the wall connecting the inner ends of the radial arms having a bearing for the inner end of the root portion of the propeller blade.

In testimony whereof I affix my signature.

DANIEL G. LILLEY.