Sept. 2, 1952 C. I. PLACE 2,609,058

PROPELLER FAN CONSTRUCTION

Filed March 26, 1949 2 SHEETS—SHEET 1

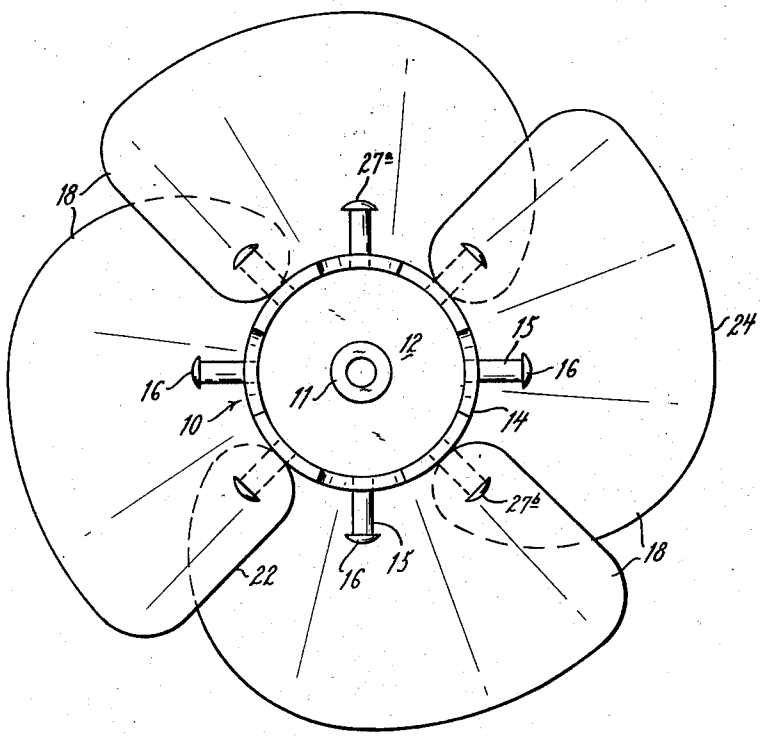


FIG. 1.

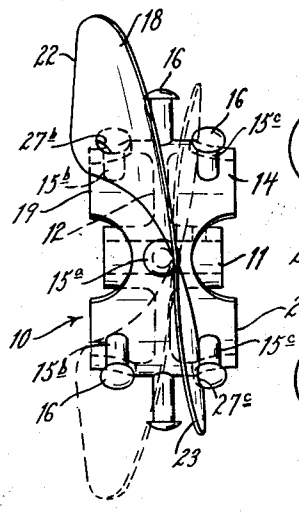


FIG. 2.

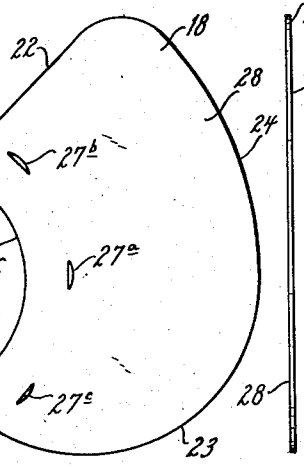


FIG. 3.

FIG. 4.

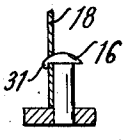


FIG. 5.

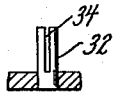


FIG. 6.

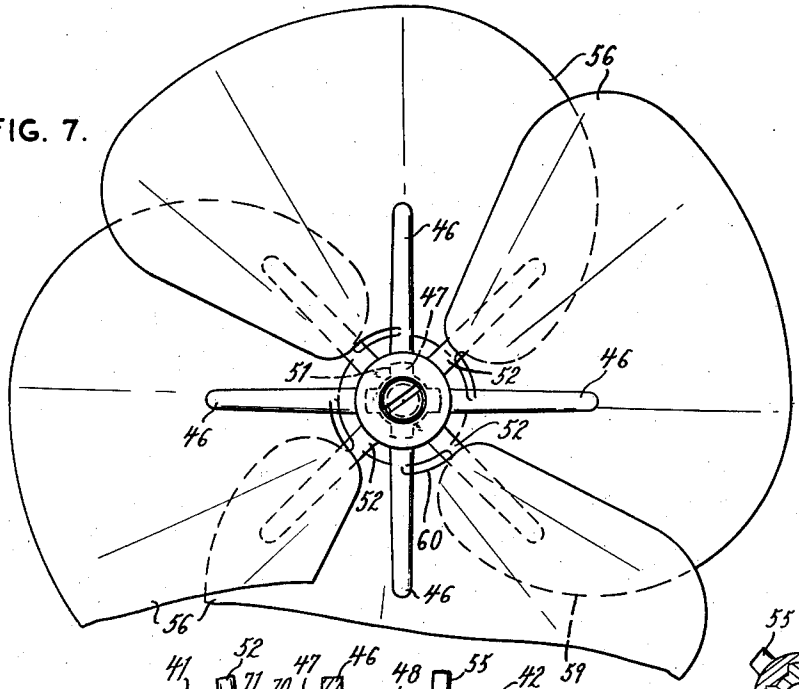
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PROPELLER FAN CONSTRUCTION

Filed March 26, 1949 2 SHEETS—SHEET 2

FIG. 7.



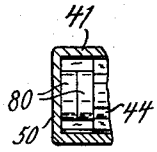


FIG. 11.

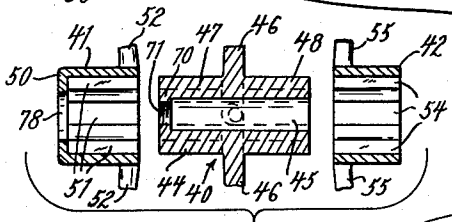


FIG. 10.

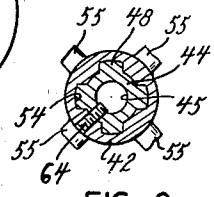


FIG. 9.

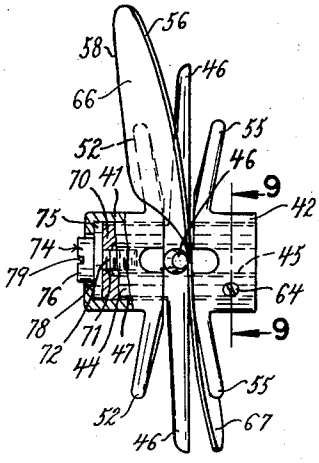


FIG. 8.

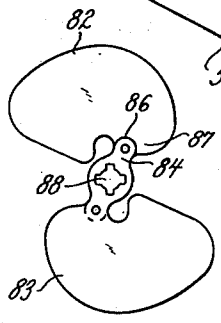


FIG. 13.

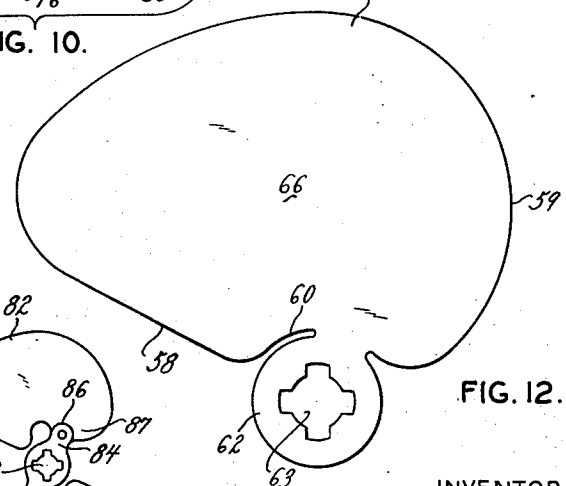


FIG. 12.

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2,609,058

PROPELLER FAN CONSTRUCTION

Charles I. Place, Norfolk, Conn.

Application March 26, 1949, Serial No. 83,702

6 Claims. (Cl. 170—173)

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This invention relates to axial flow or propeller type fans, and has reference more particularly, to improvements in the construction and manner of assembly of such fans.

The principal object of the present invention is to provide an axial flow type fan blade and hub structure which is characterized by a relatively simple construction affording economical manufacture of the blade and hub parts, and wherein the parts are adapted for ready and quick assembly without requiring blade-shaping and other special assembling tools.

Another object is to provide a propeller blade and hub structure of simple and sturdy construction, which may be readily shipped or transported in dis-assembled or so-called "knocked-down" condition such as to afford marked savings in packaging and shipping costs, and which thereafter may be assembled in the field readily and easily by any one possessed of ordinary skill.

A further object is to provide a fan blade and hub structure of the character indicated, wherein the hub and blade parts are formed and adapted for assembly selectively such as to condition the fan for either clockwise or counter-clockwise operation, and further, in which the blades may be readily reversed in assembly to the hub such that the normal leading edges thereof become the trailing edges in fan operation.

These and numerous other objects and advantages of the present invention will appear from the following description of presently preferred embodiments thereof, as such are illustrated in the accompanying drawings, wherein:

Fig. 1 is a view in front elevation, of an axial flow fan constructed in accordance with the present invention;

Fig. 2 is an on-edge view of the fan, showing one blade in assembly position, and indicating in broken lines an alternate position of the blade;

Fig. 3 is a plan view of a blade before assembly;

Fig. 4 is an edge view of the blade of Fig. 3;

Fig. 5 is a detail view of one of the blade supporting and shaping elements or studs, showing a modification in the manner of blade support thereby;

Fig. 6 illustrates a modified form of blade-supporting stud;

Fig. 7 illustrates in front elevation, an axial flow fan of a modified construction within the scope of the present invention;

Fig. 8 is an on-edge view of the fan according to Fig. 7, showing but one blade assembled to the hub;

Fig. 9 is a fragmentary sectional view transversely of the hub, as taken from line 9—9 in Fig. 8;

Fig. 10 is an exploded view of the three-part

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hub, with each part shown in longitudinal section;

Fig. 11 is a fragmentary longitudinal section of the hub in the embodiment of Fig. 8, showing one form of blade pitch adjustment device;

Fig. 12 illustrates in plan, a fan blade before assembly thereof in the structure of Fig. 7, and

Fig. 13 shows in plan greatly reduced, a pair of interconnected blades suitable for application to the fan embodiment of Fig. 7.

With reference now to the form of the invention shown by Figs. 1 to 4, a blade-mounting hub 10 is provided of suitable rigid material, and is cast, pressed or otherwise formed such as to present a central or axial shaft-hub portion 11, an annular flange or web 12 on portion 11, and a cylindrical wall or rim portion 14. Extending from the periphery of rim 14 are a plurality of equal length projections, studs or finger-like elements 15 each having a head 16, the studs or finger elements affording supports for the fan blades 18 and serving to determine the pitch and shape of the blades, as will appear presently. The studs according to the present example, are directed substantially radially (Fig. 1), and are secured to the rim 14 in any suitable manner, as by threading or press-fitting in rim openings, or by welding to the rim. In the instance of a die-cast hub, these studs may be provided as integral portions, if desired. According to the present example, four blades 18 are shown, each by preference and for greater aerodynamic efficiency, being of a width approximating or greater than its radial dimension, such as to afford blade-overlap as appears in Fig. 1. The invention is applicable, however, to fans of a greater or lesser number of blades, with or without blade-overlap.

In accordance with the present invention, the least number of studs or finger elements necessary for effecting the desired blade pitch and shape, is three studs for each blade, or a total of twelve for the present four-blade fan. These are relatively arranged about rim 14 such that in respect to each blade (Fig. 2), one stud 15*a* is centered longitudinally on the rim, while a second stud 15*b* is near the end margin 19 of the rim and angularly spaced from stud 15*a* by approximately 45 degrees (circularly of the rim), and a third stud 15*c* is similarly spaced from stud 15*a* but on the opposite side thereof and near the opposite end margin 20 of the hub. Thus there are four sets of studs each comprised of studs 15*a*, 15*b* and 15*c*, wherein the center studs 15*a* are relatively spaced about the rim 14 by ninety degrees or a right angle. Consequently, since in each set the studs 15*b* and 15*c* are spaced angularly by forty-five degrees from and on opposite sides of the center stud 15*a*, it will appear that the stud 15*b* of each set will be in alignment longitudinally of the rim, with the stud 15*c* of

the next adjacent set (Fig. 2). Moreover, in each set the studs 15b and 15c preferably project at least at a slight angle to the radial, outwardly in the direction of the adjacent end of the hub rim 14.

The blades 18 are provided preferably in flat or planar form as illustrated by Figs. 3 and 4, and are stamped, cut or otherwise produced from suitable sheet material characterized by flexibility and a degree of resiliency affording in the blade, an appreciable spring-back tendency when the blade is flexed out of its planar form. Preferably, each blade has a relatively straight or rectilinear trailing edge or margin 22, and an arcuate or curved leading edge or margin 23 continuing smoothly into the blade peripheral edge 24. The inner ends of the trailing and leading edges are rounded to mergence with the root edge 26 of the blade, the latter being arcuate or curved on a radius which may correspond substantially to the radius of the peripheral surface of hub rim 14. In the root region of the blade and spaced from the blade root edge 26 a distance equivalent to the height of the studs 15 on the rim 14, are a plurality of similar shaped openings or notches 27a, 27b and 27c. Notch 27a is located substantially centrally intermediate the blade trailing and leading margins, while notch 27b is located relatively adjacent the blade trailing edge 22, and notch 27c relatively near the nose portion of the blade leading edge 23. The shape of the notch in each instance is such as to accommodate and snugly receive therein a projecting portion of the head 16 on the associated stud in blade assembly to the hub. The blade as thus formed, presents opposite faces 28 and 30, one of which is the leading or fluid impelling face of the blade depending on the position of the blade in assembly, as will hereinafter appear.

In assembling the blades to the hub 10, each blade is flexed and disposed to seat its root margin 26 in edge-abutment with the surface of hub rim 14 in an angular course thereover as shown in Fig. 2, and such as to engage the blade in its root area, against the studs 15a, 15b and 15c in the alternate manner indicated. More particularly, blade-mounting is such as to locate root areas of the blade on its face 30, against the studs 15b and 15c, with portions of the heads 16 of the latter received in and through the blade notches 27b and 27c respectively, while a root portion of the blade on its opposite face 28, is engaged with the center stud 15a, with a portion of the head 16 thereof through the center notch 27a of the blade. The blades as thus positioned, present the faces 28 thereof for fluid displacement. Hence, blade faces 28 are the leading faces, while the faces 30 constitute the trailing faces. Each blade being flexed into alternately opposed engagement with the studs as now described, is retained against the studs through the spring-back tension obtaining in the flexed condition of the blade. Further, the blade is held against shifting over the surface of rim 14 and also, against displacement outwardly or away from rim 14 as under the action of centrifugal force, by the stud heads 16 engaged through the blade notches. Thus the blades are supported and shaped by the studs for effective fluid displacement in fan operation.

In stud-shaping of the blades, the pitch angle of each blade is determined in consequence of the extent of axial off-set of the studs 15b and 15c relative to the center stud 15a. For example, in the present embodiment the studs of each set are positioned such that a curved line intersecting the axes of the studs 15b, 15a and 15c, intersects a transverse plane of the hub 10 containing the radial axis of stud 15a, at an angle approximating 30 degrees. Accordingly, the studs as so positioned, pitch the blade at about the same angle. From the foregoing, it will appear then that the pitch angle and shaping of each blade may be determined as desired, by axially off-setting the studs 15b and 15c to a greater or less extent relative to the center stud 15a. It is to be noted additionally, that various blade shapes and pitch angles may be obtained by constructing the hub to have the studs of each set, particularly the studs 15b and 15c thereof, variously inclined from the radial in the same or opposite directions therefrom. Further, while blade mounting is here shown on a cylindrical surface (rim 14), it will be appreciated that the manner of blade mounting according to the present invention, may be applied effectively to hub surfaces of other forms, as full or semispherical surfaces, conical surfaces, arcuate or curved surfaces, and the like.

Although resilient blades having an appreciable spring-back force when flexed from the normal unstressed conditions thereof, will remain in stud-effected assembly to the hub under normal fan usage, a more positive stud connection of the blades may be effected in the manner illustrated in Fig. 5. As there shown, the stud head 16 may have the free terminal 31 of the portion projecting through a notch of the associated blade, turned or peened-over against the blade such as to clamp the blade against the stud. Thus, any one or more of the studs 15a, 15b and 15c in each blade set, may be so treated. Moreover and importantly to the present improvements, peening-over of the blade-engaging portions of the stud heads 16 affords a means for retaining pre-formed blades in assembly to the hub. Thus, in place of the flat blades stressed by flexure into position against the studs and held thereagainst by the spring-back force of the flexed blades, blades pre-formed to have a set pitch and shape in a normal unstressed condition, may be applied and held by peening over the stud heads.

Fig. 6 illustrates a modification of the center stud 15a of each set in the hub structure according to Figs. 1 and 2. Instead of the headed stud 15a, there may be employed a stud 32 having a center slot 34 to receive the blade. By use of the slotted stud, the center notch, as 27a may be eliminated in each of the blades.

The fan as now described, affords a greatly improved and simplified structure, having parts which may be readily and economically manufactured, and assembled easily and quickly without any necessity for blade shaping and other special assembling tools, the latter because the blades are pitched and shaped in consequence of their mounting on the hub against the studs. Further, by reason of the present improvements in the form and manner of assembly of the fan parts, these parts may be transported or shipped in so-called "knocked-down" condition, thereby permitting marked savings in packaging and shipping costs. Moreover, it will appear now that by reason of the regular order of stud disposition about the hub rim 14, and the manner of blade assembly by blade-flexure into supporting and shaping engagement with the studs, the blades may be disposed selectively for clockwise or counterclockwise rotation, or such as to secure various displacement characteristics. The blades as shown by Figs. 1 and 2, are arranged for clock-

wise rotation. To adapt the fan for the reverse or counterclockwise rotation, it is only necessary to turn each blade end-for-end, as from the blade position shown in Fig. 2, and then apply each such that it will appear according to the blade shown in broken lines in Fig. 2. Again, the normal leading edge of each blade may be made the trailing edge in fan rotation. For example and considering the blade shown in solid lines in Fig. 2, this may be accomplished by end-for-end reversal of the blade shown, and then applying it to the same studs, so that the blade slot or notch 27c (at the normal leading end of the blade) receives the head of stud 15b, while the blade notch 27b receives the head of stud 15c, and the center notch 27a receives the head of center stud 15a exactly as before. In clockwise rotation of the fan then, the normal trailing edge of the blade becomes the leading edge, with consequent alteration of the fan displacement characteristic. Still other dispositions of the blades are apparent, so that it will be now appreciated that the present fan structure is readily and easily adaptable to different assembly relationships of the hub and blades, using the same parts in each case.

Another embodiment of the present invention is illustrated by Figs. 7 through 12. As therein appears, the fan structure includes a three-part hub assembly comprising a center section 40 and opposite end sections 41 and 42. The center section 40 is constituted by a tubular, shaft mounting portion 44 having an axial bore 45 to receive the fan drive shaft (not shown), and providing centrally intermediate the ends of the portion 44, a plurality of radially outstanding fingers 46 which are the counter-parts of the center fingers or studs 15a in the first described embodiment of Fig. 1. The present example is in respect to a four-blade fan, hence the fingers 46 are four in number, equally spaced about the section 40. Portion 44 is formed further, to provide splines 47 externally over one end, and similar splines 48 externally over the other end on the opposite side of fingers 46.

Hub end section 41 is of cup-shape generally, providing an end wall 50 and having internal splines 51 for relative engagement with splines 47 of the central section, in reception of the section 41 thereon. The section further, has four fingers 52 equally spaced and inclined in outward projection therefrom, substantially as shown in Fig. 8. In the splined mounting of the section on the center section, it is so disposed as to locate its fingers 52 intermediate the fingers 46 (Fig. 7), as at approximately 45 degrees to the latter. Fingers 52 are the counterparts of the studs 15b in the structure of Fig. 1.

The remaining hub end section 42 is tubular in form, and like section 41 has internal splines 54 engaging the splines 48 on the center section 40, the end section further providing four equally spaced fingers 55 inclined in outward projection therefrom. Fingers 55 have an inclination opposite to that of the fingers 52, and in assembly of this section to the center section, are disposed intermediate the fingers 46 and such that they are in registry longitudinally of the hub, with the fingers 52. Fingers 55 are the counterparts of the studs 15c in the embodiment of Fig. 1.

The four blades 56 are identical, and are provided preferably in flat or planar form, each in accordance with the simple blade shown in plan view in Fig. 12, and in general outline, similar to the blade of Fig. 4, the blades further being produced from flexible, resilient sheet stock having a spring-back characteristic as before described in connection with the blades of Figs. 1 and 3. The blade shown has a relatively straight trailing margin 58, an arcuate or curved leading margin 59 and a relatively short arcuate root area 60, the latter having formed integrally therewith a hub mounting projection 62 providing a splined opening 63 for reception of the splined end 48 of the center hub section 40 in blade-hub assembly.

Assembly of the hub and blade parts of the modified structure, is readily accomplished in the following manner: The hub end section 41 is engaged on the splined end 47 of the center section 40 such as to locate the fingers 52 intermediate the fingers 46. Then a blade 56 is applied with its splined opening over the splined end 48 of the center section 40, and such that the blade centrally abuts a finger 46 and engages near its trailing end, against a finger 52 on the side of the latter facing the cup end 50 of the end section 41 (Fig. 8). Each of the remaining blades is applied in the same manner, in equally spaced relation about the hub. Whereupon, the other hub end section 42 is applied on the splined end 48 of the center section, and is pushed against the stacked blade hub elements or projections 62, with the fingers 55 in axial alignment with fingers 52 and individually engaging the blades near the leading edges thereof (Fig. 8). In final assembly, the end section 42 is secured to the center section 40 as by a pin or set screw 64, it being noted that the set screw may project through the wall of the tubular portion 44 (Fig. 9) for fan securement contact with the drive shaft (not shown) when the latter is received in the hub bore 45.

In fan assembly as thus described, each blade has a finger 46 against its central portion on the leading face 66 of the blade (as appears in Fig. 8), a finger 52 against the trailing blade face 67 near the trailing edge 58, and a finger 55 against the trailing blade face 67 near the leading edge 59. The blade and fingers therefore, bear the same relationship as obtains with the blade and studs shown in Fig. 2. Accordingly, the blades are stressed into shape by the fingers, such as to have the desired pitch angle, determined by the relative axial spacing of the three fingers engaging each blade.

Provision is here made as shown in Fig. 8, for permitting adjustment of blade form and pitch after assembly of the parts. The splined end 47 of the center hub section 40 is formed to provide an end wall 70 having a threaded axial opening 71 therein. Threaded through opening 71 is the threaded end 72 of a stud 74, the stud presenting a washer-like flange 75 located between the end wall 70 and the end wall 50 of the hub section 41. The head end 76 of the stud is exposed through an opening 78 in end wall 50, and is provided with a slot 79 therein to receive a screwdriver or similar tool, for turning the stud. Rotation of the stud in one direction will produce relative separating displacement of the hub sections 40 and 41, this because the sections are splined together and hence, cannot have relative rotation. Such displacement in the separating direction thus increases the axial offset relation of the fingers 46 and 52, which thereby increases the curvature and pitch of the blades. On the other hand, reverse rotation of the stud will have the opposite effect.

Although the above described provision for selective adjustment of blade shape and pitch is presently preferred, it will be appreciated that

adjustments may be made by the use of one or more spacer elements between the sections **40** and **41**, as the elements or discs **80** shown in Fig. 11.

Fig. 13 illustrates a pair of connected blades **82** and **83** which, with a like pair, may be employed in the modified embodiment instead of the four separate blades **56**. Each blade of the pair has a hub mounting extension **84** which is riveted or otherwise secured at its free end **86**, to a root portion **87** of the opposite blade, the extensions of both blades being in overlying contact as indicated, and having the splined openings **88** thereof in registry. Application of the paired blades to the hub structure is accomplished in the same manner as described for the single blades **56**. It is to be noted that one advantage possessed by the paired blades over the single blade, is that the interconnection thereof in the root region, materially strengthens the blades against torsional stresses attending hub drive of the blades.

The now described modified embodiment of the invention is subject to the selectivity of blade mounting and other advantages as hereinbefore expressed in connection with the embodiment of Fig. 1, it being noted further, that each of the three hub sections may be readily and economically produced, as by casting or pressing processes and the like.

Having now described and illustrated presently preferred embodiments of the invention, it is to be understood that various alterations and modifications in addition to those herein expressed, may be made without departing from the spirit and full intended scope of the invention as defined by the appended claims.

I claim:

1. In a propeller fan, shaft-mounting hub means, a plurality of fan blades each having leading and trailing margins, and blade-shaping elements for each blade, carried by and extending from said hub means, one of said elements engaging the blade on its trailing face adjacent the trailing margin thereof, another element engaging the blade on its trailing face adjacent the leading margin thereof, and a third element engaging the blade on its leading face intermediate the leading and trailing margins of the blade.

2. In a propeller fan, shaft-mounting hub means, a plurality of fan blades each having leading and trailing margins, and blade-shaping elements for each blade, projecting from the hub means and relatively off-set axially of the hub, one of said elements engaging the blade on its trailing face adjacent the trailing margin thereof, another element engaging the trailing face of the blade adjacent the leading margin thereof, and a third element engaging the blade on its leading face intermediate the leading and trailing margins of the blade.

3. In a propeller fan, shaft-mounting hub means, a plurality of fan blades each having leading and trailing margins, blade-shaping elements carried by and extending outwardly from said hub means, said elements being arranged in groups one for each blade, and the elements of each group being relatively off-set axially of the hub means such as to determine the pitch of the associated blade, one element of each group engaging its blade on the trailing face adjacent the trailing margin thereof, another element of each group engaging its blade on the trailing face adjacent the leading margin thereof, and a third element of each group engaging its blade on the leading face of the blade substantially centrally between the ends of the blade.

4. In a propeller fan, a hub assembly comprising hub-forming members in relative engagement, each having a plurality of blade-shaping finger elements projecting therefrom, and flexible blades arranged about the hub assembly in blade-shaping engagement with said finger elements such that the elements of one hub-forming member engage the blades near the trailing margins thereof, the elements of another of the hub-forming members engage the blades near the leading margins thereof, and the elements of a third one of the hub-forming members engage the blades substantially in the central portions thereof, the blades as so engaged by the shaping finger elements, being constrained by the elements to a curved configuration characterized by an effective pitch angle.

5. A propeller fan according to claim 4 wherein said flexible blades include hub portions integral therewith, in driven connection with at least one of the hub-forming members.

6. In a propeller fan, a hub assembly comprising coaxially related hub-forming members each having a plurality of blade-shaping finger elements projecting therefrom, said members being related in assembly such that one member thereof is capable of adjustment axially relative to the other members, flexible blades carried by the hub assembly and arranged thereabout for blade-shaping engagement with said finger elements such that the elements of one hub-forming member engage the trailing faces of the blades near the trailing margins thereof, the elements of another of the hub-forming members engage the trailing faces of the blades near the leading margins thereof, and the elements of a third hub-forming member engage the leading faces of the blades substantially in the central portions thereof, the blades as so engaged by the finger elements, being constrained by the elements to a curved configuration, and means disposed between and operatively interconnecting the said axially adjustable hub-forming member and one of the other said hub-forming members for effecting axial adjustment of said adjustable member relative to the other members, whereby to vary the curved configuration of the blades.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
157,742	Dowler	Dec. 15, 1874
559,775	French	May 5, 1896
705,046	Davidson	July 22, 1902
1,096,079	Viall	May 12, 1914
1,260,562	McIntosh	Mar. 26, 1918
1,307,106	Armstrong	June 17, 1919
1,411,644	Schmidt	Apr. 4, 1922
2,234,319	Preston	Mar. 11, 1941
2,270,575	Bahr	Jan. 20, 1942
2,292,115	Frisbie	Aug. 4, 1942
2,321,143	Horton	June 8, 1943

FOREIGN PATENTS

Number	Country	Date
823,447	France	Oct. 18, 1937