Dec. 29, 1970 D. Z. GLUCKSMAN 3,551,070

AXIAL FAN

Filed May 8, 1968 5 Sheets-Sheet 1

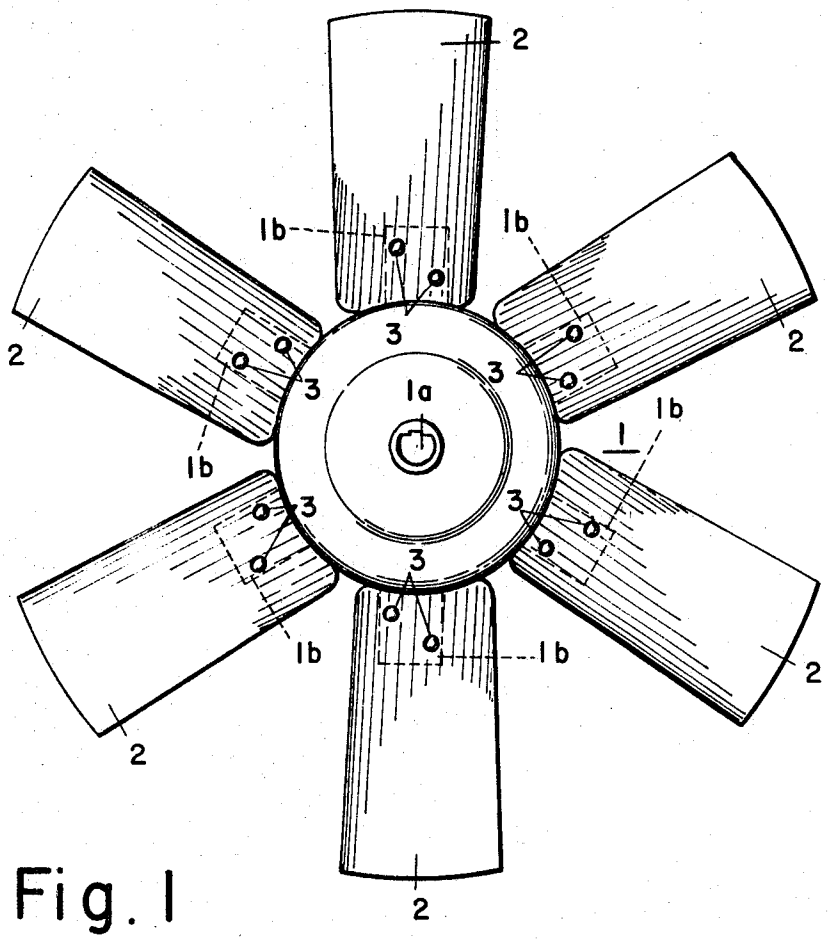


Fig. 1

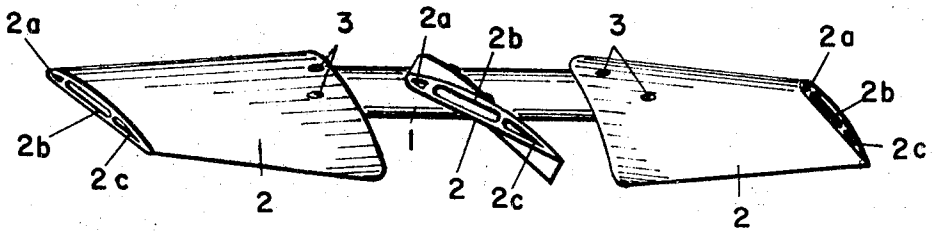


Fig. 2

INVENTOR.

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Dec. 29, 1970 D. Z. GLUCKSMAN 3,551,070

AXIAL FAN

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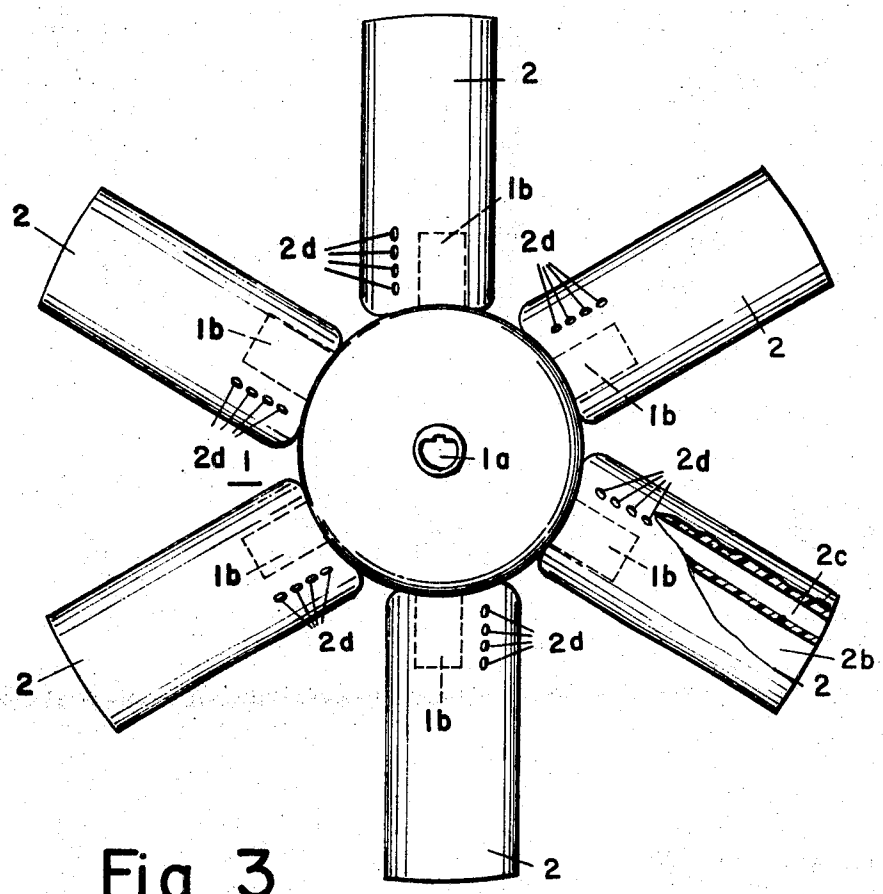


Fig. 3

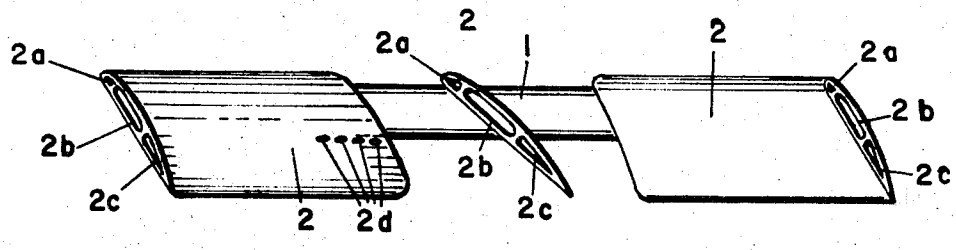


Fig. 4

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Dec. 29, 1970 D. Z. GLUCKSMAN 3,551,070

AXIAL FAN

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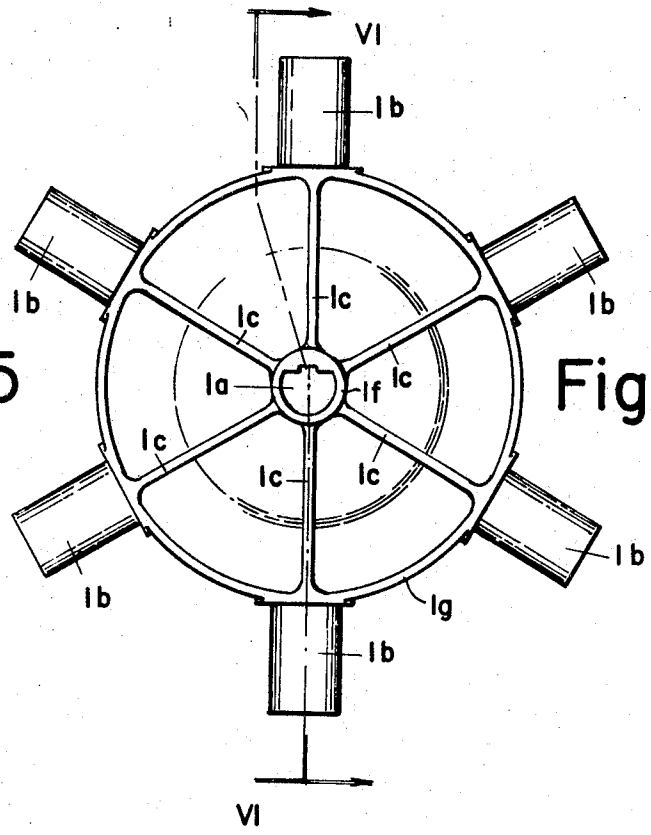


Fig.5

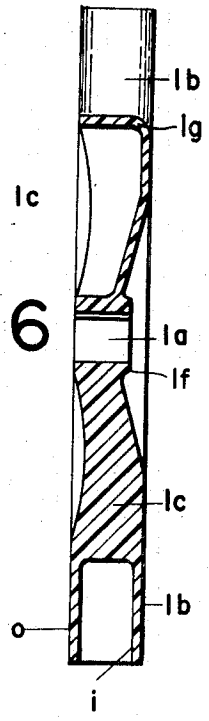


Fig.6

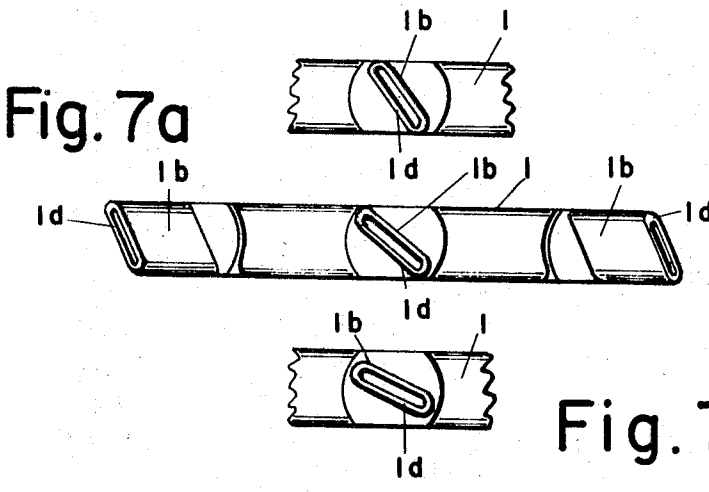


Fig.7a

Fig.7b

Fig.7c

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AXIAL FAN

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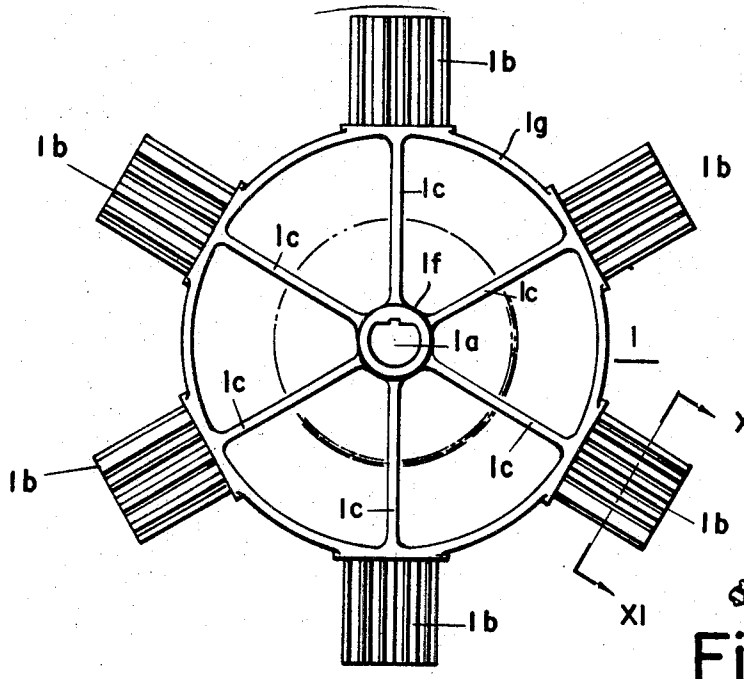


Fig. 8

Fig. 9

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AXIAL FAN

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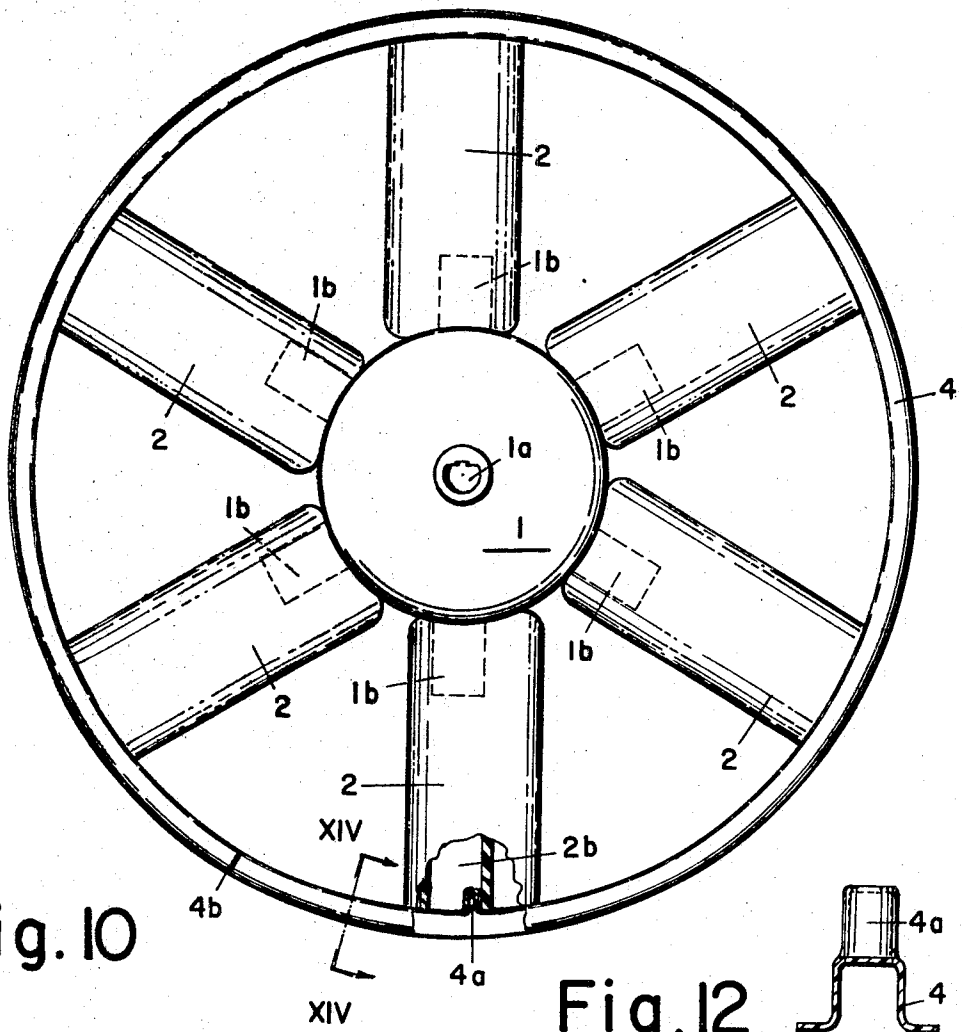


Fig. 10

Fig. 12

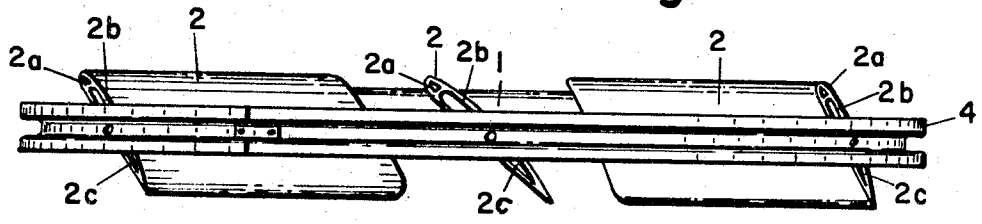


Fig. 11

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United States Patent Office 3,551,070 Patented Dec. 29, 1970

3,551,070

AXIAL FAN

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Filed May 8, 1968, Ser. No. 727,452
Int. Cl. B64c 11/26
U.S. Cl. 416—91 6 Claims

ABSTRACT OF THE DISCLOSURE

A composite axial fan including a hub member and a plurality of separate blades in the form of tubular airfoils. The hub member has substantially radially outwardly extending projections engaging the tubular airfoils, and supporting the latter. The tubular airfoils are extrusions or, in other words, all cross-sections of the airfoils taken along any cylindrical surface coaxial with the hub member of the fan between the radially inner ends and the radially outer ends of the airfoils are congruent.

BACKGROUND OF INVENTION

Most axial fans presently on the market are manufactured out of sheet metal. Blades are made by curving a stamped sheet of aluminum or steel and attaching it to a spider which is provided with a hub for mounting on a driving shaft. The sheet metal impellers suffer from low efficiency, high sound levels, uneven flow distribution, and unstable operation. The invention relates to a fan or, more generally, to a family of fans where blades are extruded airfoil sections which are very efficient means for imparting energy to the air. In addition noise levels and unstable operation are improved because the flow around airfoil sections is steady, very few vortices are shed and thus noise levels are low and stability of operation retained. In addition to the performance advantages the invention bears on the economics of fan manufacturing.

Engineering practice calls for the design of various types and sizes of axial fans since different applications require such diversity. As a result, manufacturers of axial fans must make a large number of types and sizes of axial fans, depending upon the specific application for which any particular axial fan is intended. This greatly increases the cost of production of axial fans.

This invention relates to a fan structure of the kit-type which makes it possible to produce a great number of different types and different sizes of axial fans with a relatively limited number of basic parts. Each of the basic parts which go into the fabricated kit-type axial fan is, in turn, designed in such a way as to allow production thereof with a minimum of cost.

SUMMARY OF INVENTION

Axial fans embodying this invention include a hub member having projections extending substantially radially outwardly therefrom. Such axial fans further include a plurality of separate tubular airfoils each having a radially inner end and a radially outer end, the former being engaged by one of the projections of the hub member. The cross-sections of each of said plurality of airfoils are substantially congruent at any point between the radially inner end and the radially outer end thereof.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a front view of an axial fan embodying the present invention;

FIG. 2 is a top-plan view of the structure of FIG. 1;

FIG. 3 is a front view of a modification of the structure of FIG. 1;

FIG. 4 is a top-plan view of the structure of FIG. 3;

FIG. 5 is a front view of a hub member for the structure of FIGS. 1 or 3 molded of a plastic material;

FIG. 6 is a section along VI—VI of FIG. 5;

FIGS. 7*a*, 7*b* and 7*c* are top plan views of the structure of FIG. 5 and show several possible modifications thereof;

FIG. 8 is a front view of another hub member for the structure of FIGS. 1 to 4;

FIG. 9 is a section along XI—XI of FIG. 10;

FIG. 10 is a front elevation of another axial fan embodying the present invention;

FIG. 11 is a top plan view of the structure of FIG. 12; and

FIG. 12 is a section taken along XIV—XIV of FIG. 12.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

In the drawings reference numeral **1** has been applied to generally designate a hub member having a bore **1***a* for receiving a fan-supporting shaft (not shown). Hub member **1** is provided with a plurality of angularly displaced projections **1***b* extending substantially radially therefrom. Projections **1***b* enclose equal angles. The number of projections **1***b* may vary. In FIGS. 1–4 and FIG. 5 hub member **1** is shown as being provided with six integral, substantially radially extending projections **1***b*. The blades of the fan are formed by a plurality of tubular airfoils **2**. The number of airfoils **2** is equal to the number of projections **1***b* of hub member **1**. Airfoils **2** are extrusions. Hence their cross-sections are substantially congruent at any point thereof. Airfoils **2** are preferably of a plastic material, and more particularly of a synthetic resin. Where it is desired to use metal blades rather than blades of an organic material, airfoils **2** may be extrusions of aluminum. Each airfoil **2** defines one or more internal passageways. In the embodiment of the invention shown in FIGS. 1 to 4 each airfoil **2** defines three internal passageways to which reference characters **2***a*, **2***b* and **2***c* have been applied. Each airfoil **2** has a radially inner end, and a radially outer end. Projections **1***b* engage the radially inner ends of tubular airfoils **2**, and thus support the latter on the hub member **1**. Each projection **1***b* may be shaped to enter into but one of the passageways **2***a*, **2***b* and **2***c*, namely the largest passageway **2***b*, or projections **1***b* may be in the form of three prongs each entering into one of passageways **2***a*, **2***b*, **2***c*. Fasteners **3**, e.g. rivets, project transversely across airfoils **2** and projections **1***b*, and thus secure the former to hub member **1**.

The hub member **1** shown in FIG. 5 and FIG. 6 defines a shaft-receiving bore **1***a* and is provided with six reinforcing ribs **1***c* each extending radially outwardly toward one of the radial extensions **1***b* of hub member **1**. As clearly shown in FIG. 6 each radial projection **1***b* is tubular and has an inner surface *i* and outer surface *o*. The latter engages the inner surface of airfoils **2**, i.e. enters into the internal passageway, or passageways, which are defined by airfoils **2**. As shown in FIGS. 5 and 6 the shaft-receiving bore **1***a* is provided in a radially inner tubular shaft receiving portion **1***f* of hub member **1**. Hub member **1** further includes a coaxial radially outer cylindrical airfoil-supporting portion **1***g*. The projections **1***b* for supporting the air foils extend radially outwardly from the periphery of airfoil-supporting portion **1***g*. Ribs **1***c* which are angularly displaced 60 degrees extend radially outwardly from shaft-receiving portion **1***f* of hub member **1** to the airfoil-supporting portion **1***g* of hub member **1**. The projections **1***b* of the cylindrical radially outer hub-member portion **1***g* are also angularly displaced 60 degrees. Each rib **1***c* and each projection **1***b* are arranged along a common radius of parts **1***f* and **1***g*. The purpose of this particular geometry is to cause ribs **1***c* to receive directly the stresses to which projections **1***b* are subjected.

As shown in FIGS. 7*a*, 7*b* and 7*c* tubular projections **1***b* may have different inclinations relative to the axis of

hub member 1, and the same basic mold may be used for producing hub members whose radial airfoil-supporting extensions 1*b* have different inclinations in regard to the axis of the hub member. This can be achieved by using side pulls in combination with the same basic mold which can be positioned at different angles. It will be apparent from FIGS. 7*a*, 7*b* and 7*c* that each of the radial projections 1*b* of hub member 1 has a radially outer end surface 1*d* whose axis is inclined relative to the central axis of the hub member 1.

The structure of FIGS. 1 and 2 differs from that of FIGS. 3 and 4 in that the former has twisted airfoils 2, while the latter has straight airfoils 2. If airfoils 2 are made of a thermoplastic synthetic resin they may be twisted before curing thereof, and thus the shape shown in FIGS. 1 and 2 may be readily imparted to airfoils 2. Since airfoils 2 are extrusions in the structure of FIGS. 1 and 2 as well as in the structure of FIGS. 3 and 4, all cross-sections of airfoils 2 taken along any cylindrical surface coaxial with hub member 1 are congruent. The twisting of the airfoils in the structure of FIGS. 1 and 2 results in that the cross-sections of each airfoil are angularly displaced in regard to the axis of the respective airfoil from the inner end of each airfoil 2 to the outer end thereof. This has been clearly shown in FIG. 2.

In FIGS. 1 to 4 the radially outer ends of passageways 2*a*, 2*b* and 2*c* have been shown to be open. If desired for reasons of better appearance the radially outer ends of passageways 2*a*, 2*b*, 2*c* may be plugged by streamlined plug means.

It will be noted that while the structure of FIGS. 1 and 2 includes fasteners 3 for securing airfoils 2 to projections 1*b* of hub member 1, such fasteners have been deleted in the structure of FIGS. 3 and 4. If both the hub member 1 and the airfoils 2 are made of a thermoplastic material these parts may be bonded together by ultrasonic welding or by the use of an adhesive, thus dispensing with additional fasteners 3.

In the structure of FIGS. 3 and 4 the radially inner ends of airfoils 2 are provided with perforations 2*d* whose inner ends are coextensive with passageway 2*c*. These perforations are suction holes for drawing the boundary layer from the outer surface of the airfoils 2 into airfoils 2 and to thus relieve stall. The perforations can perform as suction holes because of a difference between the pressure at the tips of the blades and that at the area of the suction holes. This difference can be explained by the centrifugal field created by the rotation of the impeller.

The hub member shown in FIG. 8 and FIG. 9 is of a synthetic resin. Each of the radial projections 1*b* of hub member 1 has ribs 1*b'* which are intended to engage the inner surfaces of tubular airfoils 2. In other words, each of projections 1*b* has an undulatory outer surface including peak regions and valley regions of which the former engage the inner surfaces of tubular air foils 2, and of which the latter are spaced from the inner surface of airfoils 2.

The ribbed projections provide for good mechanical strength while minimizing the amount of material required, thus allowing for short molding cycles. The ribs also serve as energy-directors for best result when airfoils 2 and projections 1*b* are welded together ultrasonically. In FIG. 8 the same reference characters as in FIGS. 5 and 6 have been applied to indicate the shaft-receiving portion, airfoil-supporting portion and their interconnecting ribs to designate like parts as in FIGS. 5 and 6 and for this reason a more detailed description of FIG. 8 is not deemed necessary.

The axial fan shown in FIGS. 10 to 12 is substantially the same as that shown in FIGS. 3 and 4 but includes a slinger ring 4 for condensate removal. As clearly shown in FIG. 12, slinger ring 4 is substantially U-shaped in cross-section and includes equidistantly spaced projections 4*a*. The latter enter the internal passageways of tubular airfoils 2, and are attached to them, thus securing the slinger ring 4 to the airfoils 2. The slinger ring forms a gap 4*b* where it is spliced by any appropriate splice means. Slinger ring 4 consists preferably of a thermoplastic material and is vacuum formed to the desired U cross-section shape.

Axial fans embodying this invention are not only easier to manufacture than conventional fans but, in addition thereto, their aerodynamic performance is superior to that of conventional axial fans. The weight-to-strength ratio of blades formed according to the present invention by air foils 2 is superior to the weight-to-strength ratio of conventional metal blades of axial fans.

Though several embodiments of the invention have been illustrated and described in detail, the invention in not limited thereto. It will be understood that the structures illustrated may be modifield without departing from the spirit and scope of the invention as set forth in the accompanying claims.

I claim as my invention:

1. An axial fan including in combination:
   (a) a hub member including a radially inner tubular shaft-receiving portion, a coaxial radially outer cylindrical airfoil-supporting portion having a plurality of angularly displaced projections extending radially outwardly from the periphery thereof, and a plurality of angularly displaced ribs each extending radially outwardly from said shaft-receiving portion to said airfoil supporting portion, each of said plurality of projections and each of said plurality of ribs being arranged along a common radius of said shaft-receiving portion and said airfoil supporting portion, said shaft-receiving portion, said airfoil-supporting portion, said plurality of projections thereof and said plurality of ribs being formed by an integral molded workpiece; and
   (b) a plurality of separate tubular airfoils secured to said hub member, each of said plurality of airfoils having a hollow radially inner end engaged on the inside thereof by one of said plurality of projections of said hub member and a radially outer end, the cross-sections of each of said plurality of airfoils being substantially congruent at any point between said radially inner end and said radially outer end thereof.

2. An axial fan as specified in claim 1 wherein each of said plurality of projections of said hub member is tubular and engages with the outer surface thereof the inner surface of one of said plurality of tubular airfoils.

3. An axial fan as specified in claim 1 wherein said molded workpiece is of a synthetic resin and wherein said molded workpiece has corrugations co-extensive with the outer surface of each of said plurality of projections, the peak regions of said corrugations engaging the inner surfaces of said plurality of tubular airfoils and the valley regions of said corrugations being spaced from the inner surfaces of said plurality of airfoils.

4. An axial fan as specified in claim 1 wherein said plurality of airfoils are of a thermoplastic synthetic resin and wherein cross-sections of each of said plurality of airfoils are angularly displaced about the axis thereof from said radially inner end to said radially outer ends of each of said plurality of airfoils.

5. An axial fan as specified in claim 1 wherein said plurality of airfoils are provided with transverse perforations to draw in the boundary layer of the surrounding medium and to thus relieve stall.

6. An axial air fan including in combination:
   (a) a hub member including a radially inner tubular shaft-receiving portion, a coaxial radially outer cylindrical airfoil-supporting portion having a plurality of angularly displaced projections extending radially outwardly from the periphery thereof, and a plurality of angularly displaced ribs each extending

radially outwardly from said shaft-receiving portion to said airfoil-supporting portion, each of said plurality of projections and each of said plurality of ribs being arranged along a common radius of said shaft-receiving portion and said airfoil-supporting portion, said shaft-receiving portion, said airfoil-supporting portion, said plurality of projections thereof and said plurality of ribs being formed by an integral molded workpiece; and

(b) a plurality of airfoils formed by a plurality of tubular extrusions of a thermoplastic synthetic resin, each of said plurality of airfoils having a radially inner end engaged at the inside thereof by one of said plurality of projections of said hub member and a radially outer end, the cross-sections of each of said plurality of airfoils being substantially congruent at any point thereof between said radially inner end and said radially outer end thereof, and each of said plurality of airfoils being twisted so that said cross-sections of each of said plurality of airfoils are angularly displaced about the axis of

each of said plurality of airfoils from said radially inner end to said radially outer end thereof.

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U.S. Cl. X.R.

416—210, 229, 233