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DeJong

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[54] **CONTROLLED DEFLECTION FLEXIBLE BLADED FAN**

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[52] **U.S. Cl.** **416/132,** 416/240
[51] **Int. Cl.** **F04d 29/38**
[58] **Field of Search** 416/132, 240

[56] **References Cited**

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Primary Examiner—Everette A. Powell, Jr.

[57] **ABSTRACT**

A flexible bladed fan having radially extending blades transversely curved from upstream to downstream and having a support member on the upstream side of each blade, curved in the same direction as said blade, said support member having a larger radius than that of said blade, the leading portions of the blade and support member being tangent, the trailing portion of said support member radially discontinuous and spaced from said blade.

9 Claims, 3 Drawing Figures

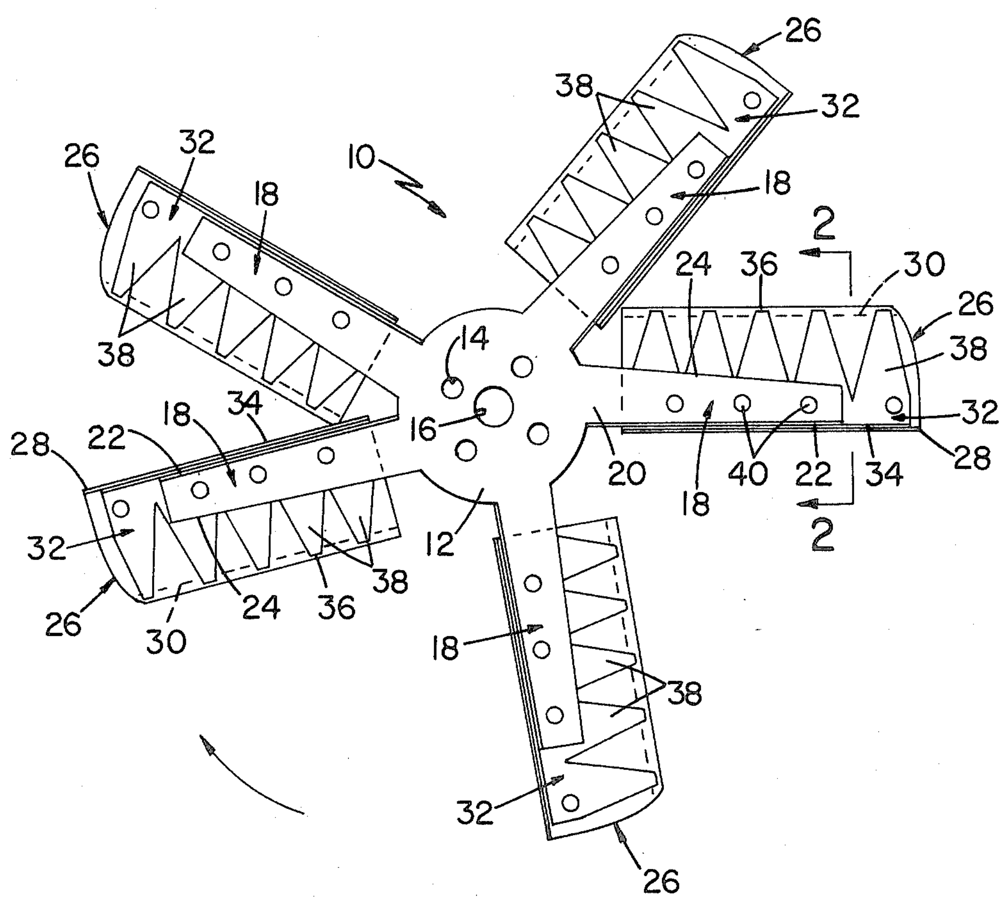
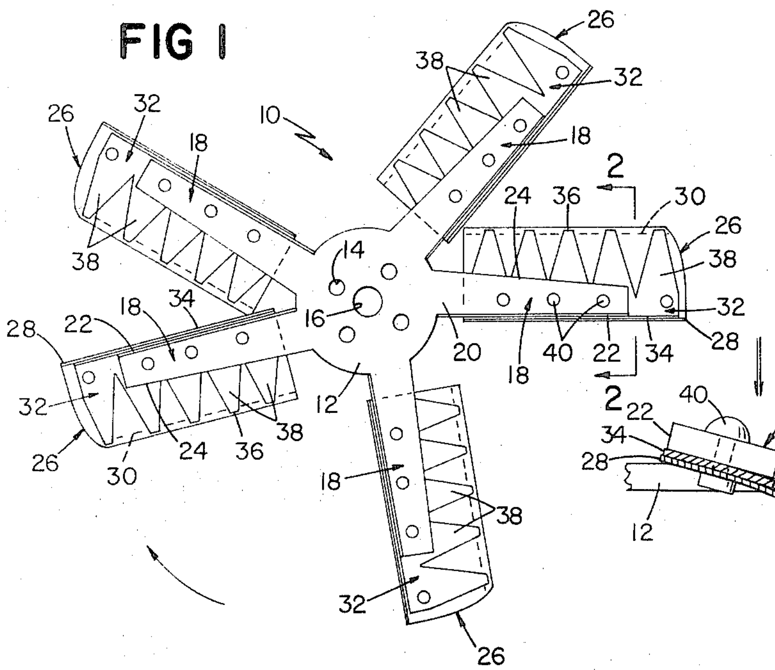


FIG 1



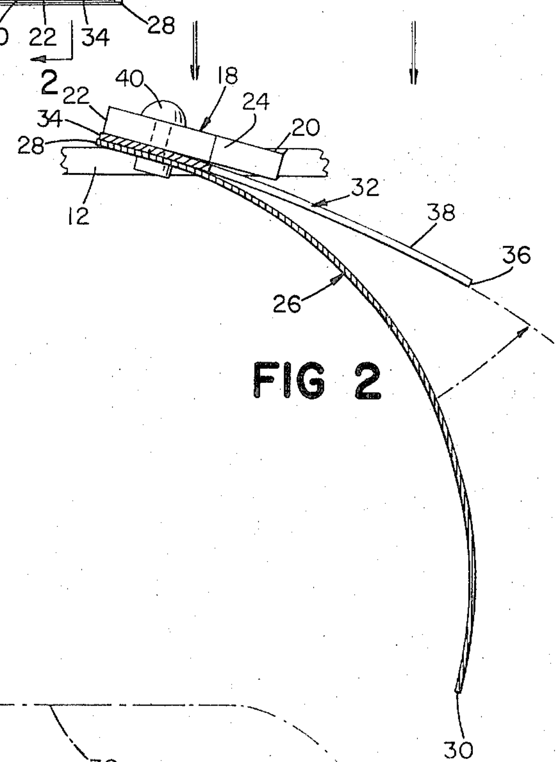
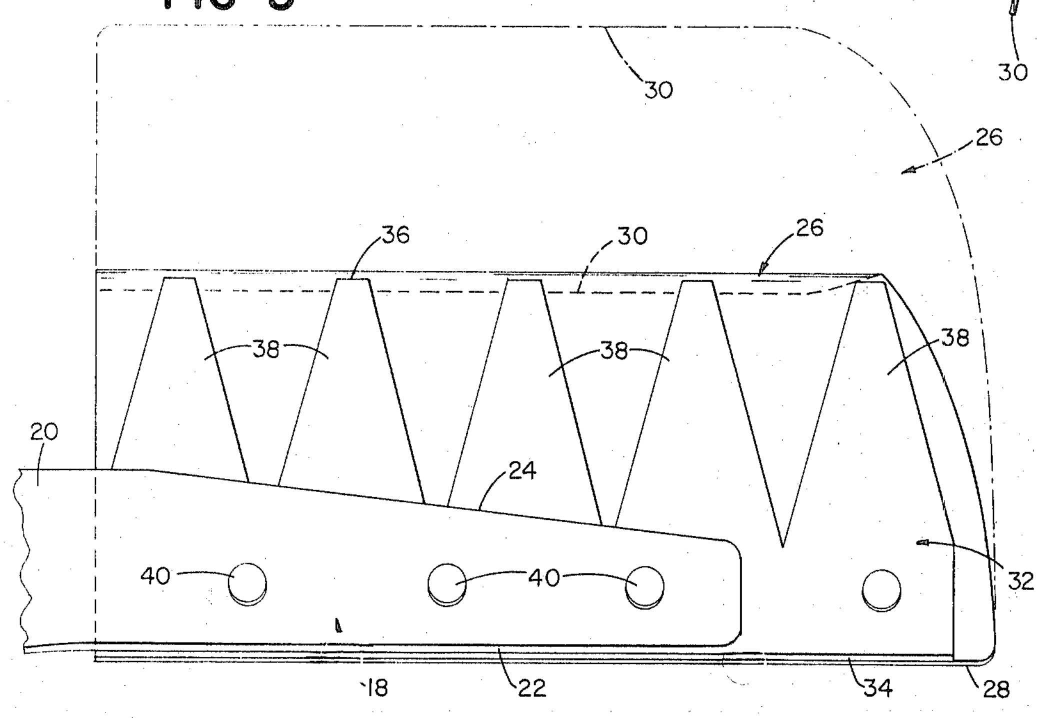


FIG 2

FIG 3



CONTROLLED DEFLECTION FLEXIBLE BLADED FAN

This invention relates to flexible-bladed automotive cooling fans and more particularly to such a fan having an improved high speed blade profile.

It is a principal object of this invention to control the high speed blade profile of a flexible bladed fan to improve its high speed air moving capacity and at the same time reduce or eliminate the S-shaped reverse curvature typically assumed by the blades of such fans at high speeds. It is a further object of this invention to provide a design permitting the use of wider blades than heretofore customarily employed in flexible bladed fans. It is still another object of this invention to provide such a fan without adversely affecting noise characteristics thereof.

In general the invention features a fan having flexible blades which decamber as rotational speeds increase. The fan blades are curved from upstream adjacent the blade leading edges to downstream adjacent their trailing edges thereby presenting convex surfaces on the upstream sides thereof. On the upstream side of each blade is positioned a support member curved in the same direction as the blade and connected thereto at their respective leading portions. The support member is curved on a larger radius than the blade. Thus, the trailing portion of the support member is progressively more spaced from the blade toward the trailing position of the support member. The trailing portion of the support member is, additionally, radially discontinuous, defining a plurality of support fingers and slots therebetween.

In a preferred embodiment, the leading portion of the support member is radially continuous. The support fingers have generally triangular shape with their apices at the trailing position of the support member and with their bases integrally connected to the leading portion thereof. The blades and support members are supported on radially extending fan arms with the width of the support members behind the arms comprising about 30–50 percent of the width of the blades behind the arms.

Other objects, features and advantages of this invention will be apparent to those skilled in the art from the following detailed description thereof taken together with the accompanying drawings, in which:

FIG. 1 is a plan view of the upstream side of an automotive cooling fan embodying the invention;

FIG. 2 is an enlarged sectional view taken along the line 2—2 of FIG. 1; and

FIG. 3 is an enlarged plan view of an arm, blade and associated structure of the fan shown in FIG. 1.

Referring now to the drawings, and more particularly to FIGS. 1 and 3 thereof, it will be seen that the fan 10 comprises a hub 12 having conventional mounting holes 14 and pilot hole 16 provided therein. A plurality of arms 18 extend generally radially from hub 12 and are integral therewith. The hub and arms are made of relatively heavy rigid material, SAE 950 steel, about 0.190 inch thick, in the preferred embodiment.

Arms 18 are twisted at their roots 20, in the preferred embodiment, to an angle of about 15° relative to the plane of fan rotation. The arms 18 each have spaced leading 22 and trailing 24 edges defined by the direction of fan rotation, indicated by the arrow in FIG. 1. The trailing edges 24 of the arms 18, due to the twist at roots 20, extend toward the downstream side of the fan, defined by the direction of air flow.

Fastened to each arm 18, on the downstream side thereof, relative to the direction of airflow indicated by arrows in FIG. 2, is a blade 26 of resilient material, AISI 301 stainless steel, about 0.022 inch thick, in the preferred embodiment. Blade 26 extends transversely from its leading edge 28, adjacent leading edge 22 of arm 18, to a trailing edge 30, parallel to its leading edge 28 and substantially behind the trailing edge 24 of arm 18, e.g., in the preferred embodiment, blade 26 is about 5 inches in width whereas arm 18 has an average width of about 1 inch. Blade 26 is curved toward the downstream side of the fan behind arm 18, presenting a transversely extending convex surface on the upstream side of blade 26. Blade 26 extends radially along arm 18 and beyond the end thereof.

Sandwiched between arm 18 and blade 26, and extending radially along the length of blade 26, is a deflection control support member 32. Support member 32 extends transversely from its leading edge 34, adjacent leading edges 22 and 28, respectively, of arm 18 and blade 26, to a trailing position 36, parallel to its leading edge 34 and intermediate the trailing edges 24, 30 of arm 18 and blade 26. Support member 32 preferably has a width behind trailing edge 24 of arm 18 of about 30–50 percent of the width of blade 26 behind trailing edge 24 of arm 18, member 32 having an overall width of about 2.75 inches in the illustrated embodiment.

Support member 32 is resilient but is heavier than blade 26 to provide greater resistance to bending, in the preferred embodiment, being made from SAE 950 steel about 0.045 inch thick. Support member 32 is curved toward the downstream side of the fan behind arm 18, presenting a convex surface on the upstream side of member 32 and a concave surface facing the convex surface of blade 26. The radius of curvature of support member 32, however, is substantially larger than that of blade 28 and is selected to approximately correspond to the dynamic blade curvature, indicated by broken lines in FIGS. 2 and 3, at a predetermined rotational speed, usually what is known in the automotive industry as either the second or the third grade-load cooling point. In the illustrated embodiment member 32 is curved on an 8 inch radius adjacent arm 18 and a 12 inch radius behind arm 18, whereas blade 26 is curved on a 3 inch radius. Thus, the blade 26 and member 32 are tangent at their leading portions adjacent the trailing edge 24 of arm 18 and are separated at their trailing portions behind arm 18 to a progressively greater degree from trailing edge 24 of arm 18 to the trailing position 36 of member 32.

Support member 32 is radially continuous at its leading portion along arm 18 and the leading portion of blade 26. From adjacent the trailing edge 24 of arm 18 to trailing position 36, however, member 32 is radially discontinuous, comprising a plurality of equally radially spaced, transversely extending, resilient, generally triangular shaped support fingers 38 extending from bases integral with the leading portion of member 32, adjacent the trailing edge of arm 18, to apices at trailing position 36. A plurality of slots are provided along member 32, defined between fingers 38.

Blade 26 and member 32 are secured to each other and to arm 18 by rivets 40.

In operation, as the fan is rotated in the direction of the arrow in FIG. 1, air is moved as indicated by arrows in FIG. 2. Air is admitted at lower rotational speeds through the slots between support fingers **38** to the space between the facing surfaces of blade **26** and member **32**. As rotational speed increases, blade **26** gradually decambers to the position shown in broken lines in FIGS. **2** and **3** conforming to the configuration of member **32**. As rotational speed increases even further, blade **26** continues to conform generally to the configuration of member **32** but is permitted to decamber to limited and controlled extent by the resilient support provided by triangular support fingers **38**.

Advantageously, member **32** controls the high speed configuration of blade **26** maintaining an improved air foil shape for moving air and substantially reducing or eliminating the tendency of the blade to take on a reverse curvature at high speed. In turn, this enhances the air moving capacity of the fan and reduces high speed air turbulence, consequently further improving high speed cooling performance. With the reduced tendency of the blades to assume a reverse curvature, blade stress levels are lowered permitting use of wider blades in flexible bladed fans than had heretofore been customary, enhancing both low speed and high speed cooling. The triangular shape of fingers **38** provides a relatively ideal spring shape permitting and controlling blade deflection after blade **26** contacts member **32** and, significantly, the slotting between fingers **38** minimizes low and medium speed air turbulence between member **32** and blade **26**. The resultant fan design has low noise characteristics.

Though this invention has been described with reference to a preferred embodiment thereof, other embodiments of this invention will occur to those skilled in the art which are within the scope of the following claims.

What is claimed is:

1. In an automotive cooling fan comprising a hub, a plurality of resilient blades which decamber as rotational speed increases extending radially relative to said hub, each said blade having spaced leading and trailing edges defined by the direction of fan rotation, and, respectively thereadjacent, leading and trailing portions, said blade extending transversely between said leading and trailing edges thereof and curved from an upstream position, defined by the direction of airflow, adjacent said leading edge to a downstream position adjacent said trailing edge presenting a transversely extending convex surface on the upstream side of said blade, and a resilient support member on the upstream side of said blade extending along and connected to said leading portion of said blade and extending transversely to a trailing position intermediate said leading and trailing edges of said blade, said support member also curved between its leading edge and trailing position in the same direction as said blade presenting a transversely extending convex surface on the upstream side of said support member and a concave surface facing the convex surface of said blade, that improvement in which:

said support member is curved on a larger radius than that of said blade and said support member comprises a radially extending leading portion, tangent to said leading portion of said blade and progressively more spaced from said blade transversely toward said trailing position of said support member, and, between said leading portion and said trailing position of said support member, a radially discontinuous trailing portion thereof defining a plurality of radially spaced transversely extending, resilient, support fingers and a plurality of slots defined between said support fingers,

wherein said blade decambers to the curved configuration of said support member at a predetermined rotational speed, limited resilient decambering of said blade and support member is permitted at rotational speeds higher than said predetermined rotational speed while generally conforming said blade to said support member curved configuration, and at rotational speeds below said predetermined rotational speed air is admitted between said blade and said support member through said slots.

2. The fan claimed in claim **1** in which said leading portion of said support member is radially continuous.

3. The fan claimed in claim **2** in which said support fingers have a generally triangular shape integrally connected at their bases to said leading portion of said support member and having their apices at said trailing position of said support member.

4. The fan claimed in claim **1** in which a plurality of arms, integral with said hub extend radially from said hub, one said blade and support member is connected to each said arm on the downstream side thereof with said support member leading portion sandwiched between said arm and said blade leading portion, said arm having a trailing edge, said support member leading portion substantially tangent with said blade adjacent said arm trailing edge, said blade trailing edge positioned behind said arm trailing edge, and the trailing position of said support member positioned intermediate said arm and blade trailing edges.

5. The fan claimed in claim **4** in which said support fingers have a generally triangular shape integrally connected at their bases to said leading portion of said support member and having their apices at said trailing position of said support member.

6. The fan claimed in claim **4** in which the width of said support member behind said arm trailing edge is on the order of 30–50 percent of the width of said blade behind said arm trailing edge.

7. The fan claimed in claim **6** in which said leading portion of said support member is radially continuous.

8. The fan claimed in claim **7** in which said support fingers have a generally triangular shape integrally connected at their bases to said leading portion of said support member and having their apices at said trailing position of said support member.

9. The fan claimed in claim **8** in which said bases are positioned adjacent said arm trailing edge.

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