United States Patent

[11] **3,584,969**

[72] Inventors **Shigeo Aiki;**
Uichiro Kobashi; Masaharu Hayashi, all of
Kariya-shi, Japan

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[73] Assignee **Aisin Seiki Company Limited**
Kariya-shi, Aichi-ken, Japan

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[33] **Japan**
[31] **43/35594**

[54] **FLEXIBLE BLADE FAN**
1 Claim, 6 Drawing Figs.

[52] **U.S. Cl.** **416/132,**
416/230, 416/240, 416/241
[51] **Int. Cl.** **F01d 5/28**
[50] **Field of Search** 416/137,
134, 229, 230, 240, 241

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Primary Examiner—Everette A. Powell, Jr.
Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

ABSTRACT: A cooling fan assembly for powered vehicle, preferably adapted for automotive use, and having a boss and a plurality of radial fan blades made integral therewith of synthetic and resilient resin material, said assembly being characterized by the provision of a recess formed at the downstream area on each of said fan blades and in proximity of the root of the blade, thereby reducing the quantity of the delivery air with higher rotational speeds of the fan for avoiding an overcooling of the powering engine of said vehicle.

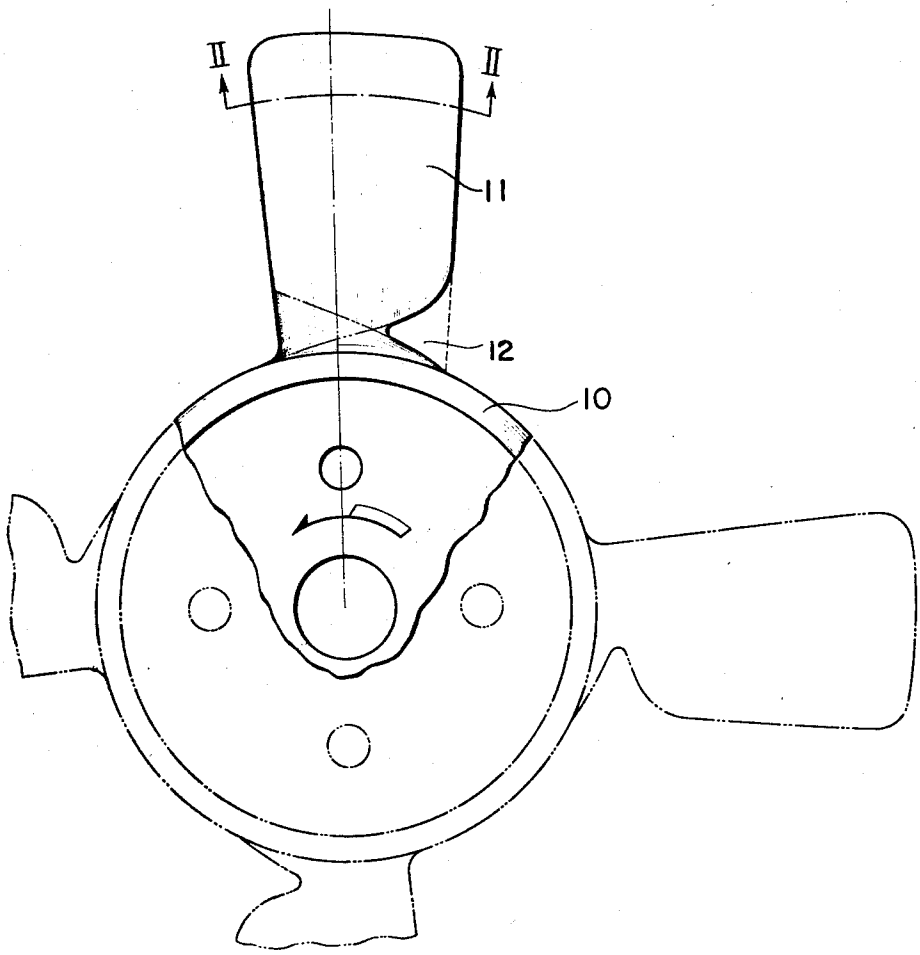


FIG. 1

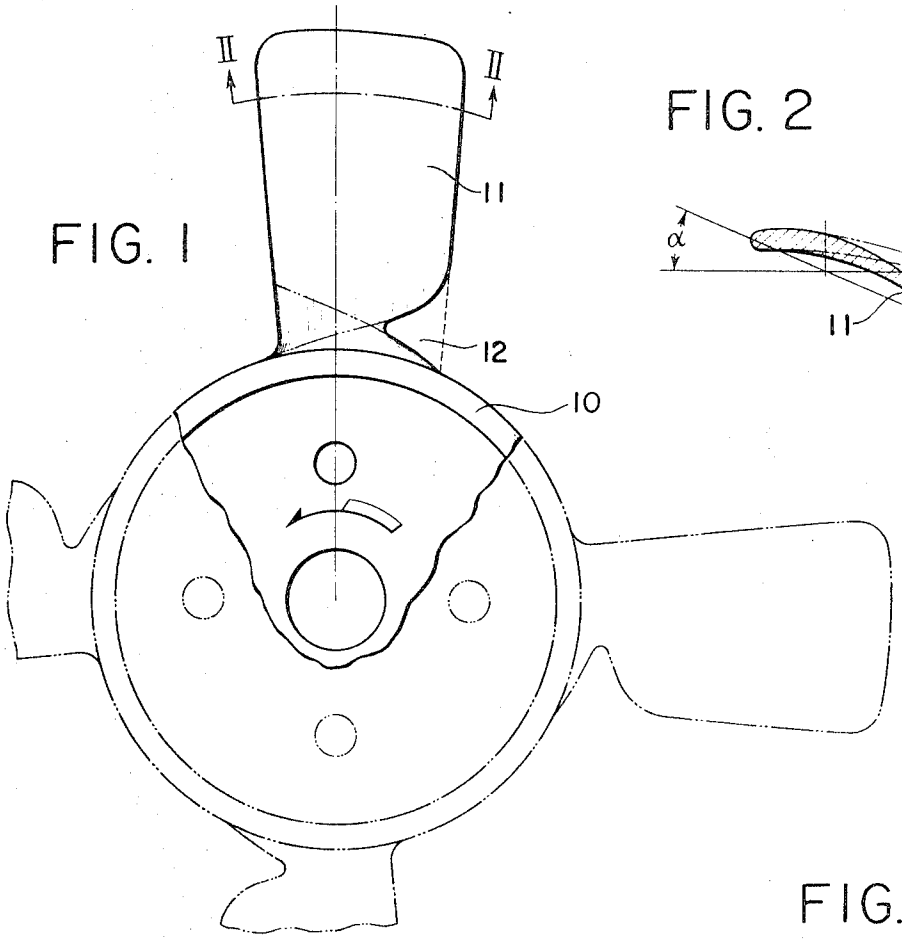


FIG. 2

FIG. 3

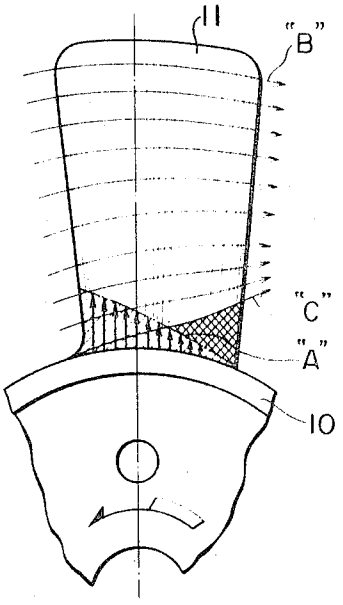


FIG. 4

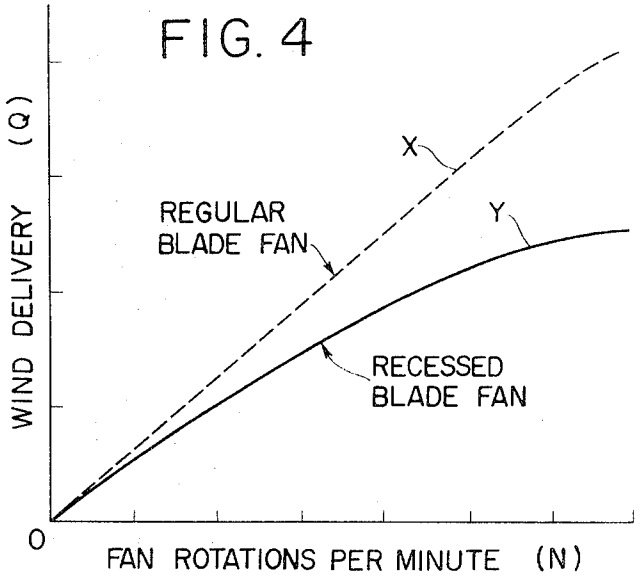


FIG. 5

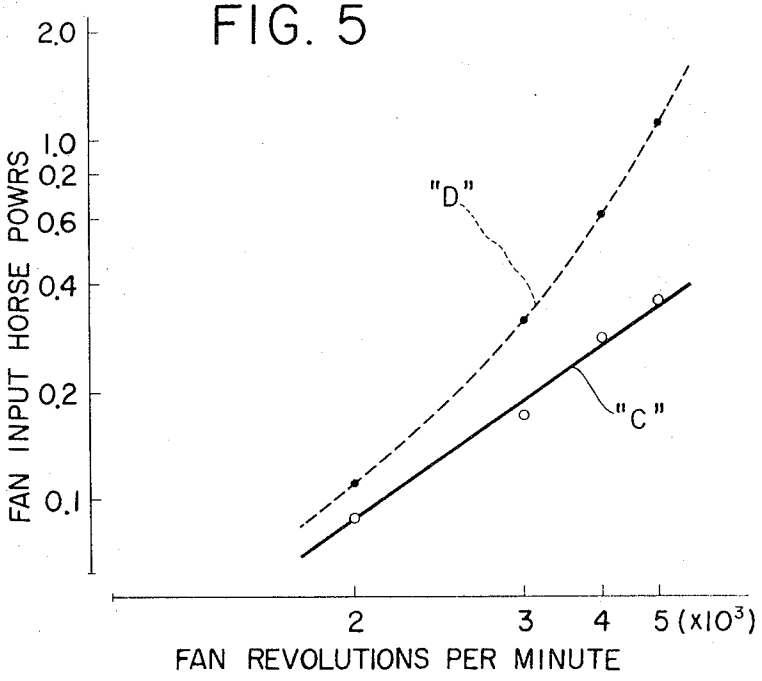
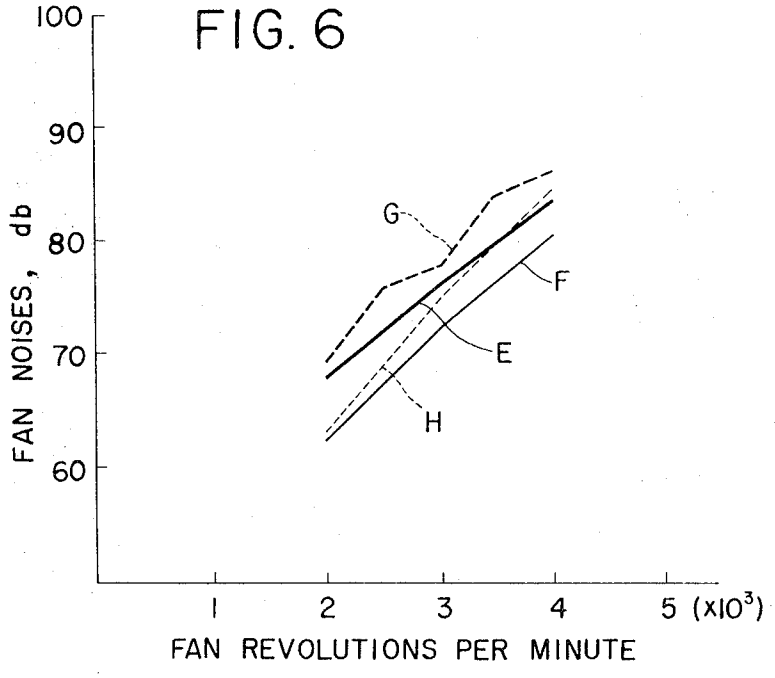

2.0
1.0
0.2
0.6
0.4
0.2
0.1
FAN INPUT HORSE POWRS
"D"
"C"
2
3
4
5 (x10³)
FAN REVOLUTIONS PER MINUTE

FIG. 6


100
90
80
70
60
FAN NOISES, db
G
F
E
H
1
2
3
4
5 (x10³)
FAN REVOLUTIONS PER MINUTE

FLEXIBLE BLADE FAN

This invention relates to improvements in and relating to a flexible blade fan.

The cooling fan assembly for powered vehicle, preferably for automotive use, is generally direct-coupled with the vehicle drive engine, thus the revolutional speed of the fan increasing with increase of the engine speed. At higher running speed of the engine, a correspondingly increased quantity of air is sucked through the radiator grill of the wheel by the cooling fan, and thus the engine may frequently be subjected to overcooling which results in a considerable reduction in the operating efficiency as well as the fuel consumption rate of the engine.

On the other hand, excess and unpleasant noises will develop with excessively higher rotational speed of the fan, not to speak of excess power consumption caused thereby.

It has been already proposed as a counter measure for above mentioned conventional drawbacks to manufacture the cooling fans from synthetic resin material which has an elastic characteristic to a larger or lesser degree. Difficulties were encountered in making the thickness of the fan blade to a desirous small value, which has a certain minimum limit considerably larger than the desirous one, on account of the resin moulding technique. The selection of elastic resin material for the manufacture of fans in the above sense has resulted in a favorable deformation of blade configuration at higher operational speeds of the fan, being unable however to attain the desirously optimal operational characteristics. On the other hand, it has been frequently encountered with adverse effects when there be a slight error in the design of the fan blades.

It is therefore the main object of the present invention to provide an efficient fan assembly capable of avoiding substantially the aforementioned conventional drawbacks, yet capable of deforming the blade configuration positively in the desire optimum sense at higher operational speeds of the fan, so as to provide a nearly ideal performance thereof, without loss of the necessary rigidity of the fan blades.

These and further objects, features and advantages of the invention will become more apparent when read the following detailed description of a preferred embodiment of the invention by reference to the accompanying drawing which constitutes a part of the present specification.

In the drawing:

FIG. 1 is a front view of a preferred embodiment of the invention, wherein however only a fan blade has been specifically represented and the remaining blades have been shown only in their whole or partial general configuration.

FIG. 2 is a cross section of a fan blade, in the section being taken substantially along the section line II–II in FIG. 1 and several explanatory symbols being additionally attached for better understanding of the working mode of the proposed fan.

FIG. 3 is substantially a reproduction of a part of FIG. 1, yet attached with several explanatory additives for the mechanical analysis of stresses developed during the rotational operation of the fan.

FIG. 4 is a comparative chart which illustrative of the performance of the fan according to this invention in comparison with that of a comparative conventional one.

FIGS. 5 and 6 show several comparative experimental curves of an inventive fan in comparison with a conventional comparative one.

Referring now to the accompanying drawing, the numeral 10 denotes the boss of a fan, having a plurality of radial blades 11 made of conventional synthetic resin material having a proper elasticity and made integral with the boss. The boss 10 is formed at its root portion with a recess or notch 12 positioned at the trailing area of said root when seen in the rotational movement of the fan. This recess or notch 12 has substantially triangular shape when seen from the front side of the fan and the apex of the triangle is positioned innermostly. As shown, this apex may advantageously rounded for avoiding

the otherwise encountered notch effect.

When a regular fan is rotated, the stress diagram at the blade root area must be such that those developing in the leading area are larger and those appearing in the trailing area may be smaller, thus forming substantially an elongated triangular shape distributed over the whole root portion of a blade as shown schematically in FIG. 3. When an envelope is drawn by connecting one after another the points of vectors representing the thus developed tensile stresses, a slightly curved line such as at "A" may be obtained.

On the other hand, when the fan is rotated, the relatively moving direction of air will become generally as follows:

The air will move substantially circumferentially in close proximity of the blade tip, as hinted by an arrow at "B." At the root area of the blade 11, the air will flow at first substantially circumferentially, but it deviates soon or later from the circumferential course of flow, as will be easily observed from an arrow at "C." This deviation is caused by the flow resistance provided by the outer peripheral surface of the boss 10. The provision of the recess or notch 12 is made upon full consultation of the both or more specifically the stress envelope curve "A" and the innermost air flowing course "C."

It will be easily understood that with the fan blade recessed or notched as above mentioned at the trailing area of the aerofoil, the latter will be liable to receive an elastic deformation in the region of that area so as to reduce the blade inclination angle"α" the more with higher rotational speed range of the fan can be substantially obviated.

Referring to FIG. 4, the dotted wind delivery curve at "X" represents a performance with regular blade fan, while the full line curve at "Y" shows a representative performance of the recessed blade fan as proposed by the invention. As seen, the wind delivery is considerably reduced at higher rotational speeds of the fan when compared with the regular or non-recessed blade fan.

In FIG. 4, comparative curves showing the air delivery rate for the inventive fan in comparison with a comparative conventional one are shown. In this figure, the full line curve "Y" shows the invention, while the dotted line "X" represents the conventional fan.

In these comparative experiments, the fan dimensions were:

O.D. of fan blades 410 mm.;
No. of fan blades 4;
Inclination angle of each blade 34°—24°;
Diameter of boss 87 mm.;
Max. length of notch as measured along blade edge 45 mm.;
Max. depth of notch 27 mm.

In FIG. 5, fan input horse powers are shown. Full line "C" denotes the invention, while dotted line "D" represents the conventional. Particular fan dimensions were same as above.

In FIG. 6, comparative noise curves are shown. The fan dimensions were as before. Curves "E" and "F" denote noises of the fan according to this invention as measured at a distance of 1 meter from the fan in the front and in the side, respectively. Curves "G" an "H" are those of the conventional fan and correspond to said curves "E" and "F," respectively.

What we claim is:

1. A fan assembly having a circular boss and a plurality of radially extending integral blades, said boss and blades being of one piece construction and made of synthetic resin material having a predetermined elasticity, said assembly being characterized in that each of said blades is formed with the lead and trailing edges thereof disposed substantially along radial lines and is formed at the root thereof in the region of the tailing area when seen in the direction of rotational movement of the blade with a substantially triangular recess for increasing the tendency of elastic deformation of the aerofoil section radially outward of said recess for reducing the wind delivery at high rotational speeds of the fan, said aerofoil section radially outwardly of said recess having a decreasing thickness from the radial centerline of the blade to the trailing edge to facilitate the elastic deformation of this portion of the blade.