(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 843 102 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.05.1998 Bulletin 1998/21

(51) Int. Cl.[6]: **F04D 29/32**

(21) Application number: **97119447.7**

(22) Date of filing: **06.11.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **13.11.1996 US 748587**

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(54) Fan assembly having increased fan blade area

(57) A fan assembly (11) is adapted to be driven by an input drive (V), and comprises an annular hub (15) fixed to rotate with the input drive, the fan assembly further comprising a plurality of fan blades. The plurality of fan blades includes a plurality of inner fan blades (17) fixed relative to the annular hub (15) and extending radially outward therefrom, and an annular ring member (23) disposed about the plurality of inner fan blades (17) and fixed to the radially outer extent thereof. A plurality of outer fan blades (25) is fixed relative to the annular ring member (23) and extends radially outward. There is a greater number of outer fan blades (25) than inner fan blades (17), thus increasing the air flow capability of the fan, as well as the efficiency thereof.

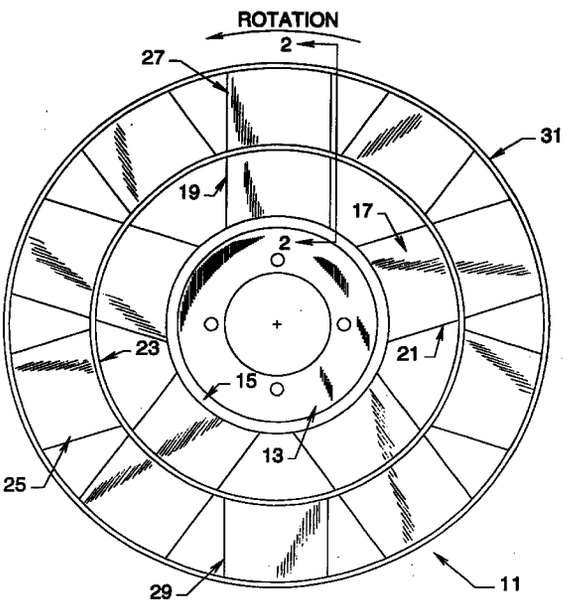

FIG. I

EP 0 843 102 A2

Description

BACKGROUND OF THE DISCLOSURE

The present invention relates to fan assemblies of the type used for moving air for purposes of cooling, and more particularly, to fan assemblies of the type including annular hubs.

Although the present invention may be utilized in connection with fan assemblies of various types, it is especially advantageous for use with radiator cooling fans, for moving cooling air through the radiators of vehicle internal combustion engines, and will be described in connection therewith.

Furthermore, although the present invention is adapted for use with fan assemblies of various construction types (e.g., including stamped steel blades, etc.), it is especially adapted for use with plastic fans in which the entire fan assembly is formed (e.g., by injection molding) as a single, integral part, and will be described in connection therewith. Such a fan assembly is illustrated and described in U.S. Patent No. 5,226,783, incorporated herein by reference.

As is well known to those skilled in the art, for any given fan diameter, there is a maximum possible blade "solidity", which may be thought of as the ratio of the actual blade area to the maximum "potential" blade area. As the solidity increases, so does the amount of air flow generated, as well as the fan efficiency, i.e., the amount of air flow per unit of input horsepower.

In recent years, those skilled in the art have attempted to improve fan air flow and efficiency in a number of ways, one of which is to surround the fan blades with a cylindrical ring or band, in an attempt to reduce the air flow losses which would otherwise typically occur toward the radially outer extent of the fan blades. A typical "ring fan" of the type noted above is illustrated and described in U.S. Patent No. 4,569,631, incorporated herein by reference.

Although many such attempts have resulted in increased fan air flow and efficiency, there is a need within the industry to continually improve the solidity, and therefore, the air flow and the efficiency for a fan of a given diameter.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved cooling fan assembly which, for a given fan diameter, will have increased solidity and air flow capability, and increased fan efficiency.

It is a related object of the present invention to provide an improved fan assembly having an increased air flow capability, such that it is possible to reduce the fan speed and the associated noise of operation, while still achieving the same volumetric air flow.

The above and other objects of the invention are accomplished by the provision of a fan assembly adapted to be driven by an input drive, the fan assembly comprising an annular hub adapted to be fixed to rotate with the input drive. The fan assembly further comprises a plurality of fan blades.

The improved fan assembly is characterized by the plurality of fan blades comprising a plurality of inner fan blades fixed relative to the annular hub and extending radially outward therefrom. An annular ring member is disposed about the plurality of inner fan blades and is fixed to the radially outer extent thereof. The plurality of fan blades further comprises a plurality of outer fan blades fixed relative to the annular ring member and extending radially outward therefrom. The plurality of inner fan blades is less in number than the plurality of outer fan blades.

In accordance with a further aspect of the present invention, the annular ring member comprises an inner ring member, and the fan assembly further comprises an annular outer ring member disposed about the plurality of outer fan blades and fixed to the radially outer extent thereof.

In accordance with an additional aspect of the present invention, the plurality of outer fan blades is equal to twice the number of the plurality of inner fan blades.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front plan view of the fan assembly of the present invention.

FIG. 2 is a transverse cross-section taken on line 2-2 of FIG. 1, including a schematic representation of a typical input drive.

FIG. 3 is a transverse cross-section, similar to FIG. 2, illustrating an alternative embodiment of the invention.

FIG. 4 is a cross section through one of the inner blades of the present invention, looking radially inward.

FIG. 5 is a cross section through one of the outer blades of the present invention, looking radially inward.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, which are not intended to limit the invention, FIG. 1 illustrates a front plan view of a fan assembly, generally designated 11, made in accordance with the present invention.

In the subject embodiment, the fan assembly includes a stamped sheet metal spider 13, of the type which is now well known to those skilled in the art, forms no part of the present invention, and will not be described further herein. As is also well known to those skilled in the art, the metal spider 13 is typically attached, as by a plurality of bolts (not shown) to an input drive, such as the output or body B of a viscous fan drive, generally designated V, whereby input drive torque is transmitted from a vehicle engine (not shown),

by means of a shaft S, through the viscous fan drive V to the spider 13 of the fan assembly 11.

Although the fan assembly 11 of the present invention is illustrated in conjunction with a stamped metal spider, the invention is not so limited, and the input drive could be transmitted to the fan assembly 11 by a variety of other arrangements. For example, in accordance with the teachings of U.S. Patent No. 5,358,382, assigned to the assignee of the present invention and incorporated herein by reference, the viscous fan drive V could include a portion formed integrally with either the body B or the cover (not identified herein), and extending radially outward beyond the nominal diameter of the viscous fan drive V, with the fan assembly 11 being directly formed (such as by molding) about the outer extent of this radial portion.

Referring again primarily to FIGS. 1 and 2, the fan assembly 11 includes an annular hub 15 which, in the subject embodiment, is molded with the radially outer extent of the spider 13 disposed in the mold cavity, as is now conventional.

Extending radially outward from the annular hub 15 is a plurality of inner fan blades 17, with five of the inner blades 17 being included in the subject embodiment. As is well known to those skilled in the art, the blades 17 may be spaced uniformly about the circumference of the hub 15, or may be disposed at different circumferential spacings, in order to "break up" the repetitive pattern of the fan blades, and reduce the noise generated by the fan assembly. As may best be seen in FIG. 2, each of the inner blades 17 includes a leading edge 19 and a trailing edge 21.

In accordance with one important aspect of the invention, an annular ring member 23 is disposed to be concentric with the annular hub 15, and each of the inner blades 17 terminates at the inside diameter of the ring member 23. In the embodiment of FIGS. 1 and 2, the annular ring member 23 is simply a cylindrical, relatively thin (in the radial direction) member. It is preferred that the entire fan assembly 11 be formed as a single, molded part, with the radially outer extent of the inner blades 17 merely "flowing" or blending into the inside diameter of the annular ring member 23. It will be understood by those skilled in the art that, although various manufacturing methods may be used, other than molding the fan assembly as a single, molded part, such other manufacturing methods will likely involve some assembly, which adds to the total cost of the fan assembly. For certain applications, the fan assembly 11 could comprise steel stampings, in which case it would be necessary to braze or solder or weld the fan blades to the annular hub and to the middle and outer ring members 23 and 31. However, those skilled in the art will understand that the essence of the present invention is the configuration of the fan, rather than the materials involved or the method of fabrication.

Attached to the outside diameter of the annular ring member 23 is a plurality of outer fan blades 25, and in the subject embodiment, there are ten of the outer blades 25, i.e., twice the number of inner fan blades 17. However, it should be understood that it is not an essential feature of the present invention for the number of outer blades 25 to be twice the number of inner blades 17. What is essential to the present invention is simply that there be more of the outer blades 25 than there are of the inner blades 17, thereby increasing the blade area (and air flow, cooling efficiency, etc.), compared to the blade area which would exist if the five inner blades 17 merely extended to the full diameter of the fan assembly 11, as in the prior art. Each of the outer fan blades 25 includes a leading edge 27 and a trailing edge 29.

Disposed about the outer fan blades 25, and attached to the radially outer extent thereof, is an annular outer ring member 31, the construction and function of which are now generally well known in the art. It should be understood that the outer ring member 31 is not an essential feature of the present invention, but is included in the subject embodiment for the same reasons (e.g., airflow efficiency) that such rings are included in many fans in commercial production now .

Referring now to FIGS. 4 and 5, in conjunction with FIG. 1, it may be seen that the inner fan blades 17 and the outer fan blades 25 have the same blade profile and blade pitch, although the present invention is not so limited. There may be various applications where it would be desirable to provide one particular blade profile and/or pitch for the inner blades 17, and a substantially different blade profile and/or pitch for the outer blades 25, and it is an important aspect of the present invention that this sort of "tailoring" of the blades can now be accomplished with the present invention.

In the embodiment shown in FIGS. 1, 4 and 5, each of the inner fan blades 17 is "aligned" with one of the outer fan blades 25, such that it appears to be one continuous fan blade. If the fan assembly were to be fabricated from metal stampings, it is quite possible that each of the inner blades and its corresponding outer blade would comprise a single blade passing through an opening in the middle ring member, thus reducing the total number of parts and the amount of brazing, etc. However, the invention is not limited to each of the inner blades being aligned with one of the outer blades, especially if the number of outer blades 25 is something other than twice the number of inner blades 17. Also, in FIG. 1 it appears that the middle ring 23 is about halfway between the hub 15 and the outer ring 31, such that the radial lengths of the inner blades 17 and the outer blades 25 is about equal. Such a dimensional relationship is not essential to the invention, however, and those skilled in the art will recognize that the radial location of the middle ring 23, and the relative numbers of inner and outer blades 17 and 25, may be selected to maximize the fan performance, for a given fan outside diameter.

Referring now to FIG. 3, there is illustrated an alter-

native embodiment of the present invention in which the middle ring member is not simply a relatively thin, cylindrical member. Instead, in the embodiment of FIG. 3, at the outer periphery of the inner blades 17 is an annular ring member 33, which is generally cylindrical, and adjacent thereto is a conical ring member 35. In the embodiment of FIG. 3, the outer fan blades 25 extend radially from the conical ring member 35, and terminate at the outer ring member 31 in the same manner as described in connection with FIG. 2. Disposed between the ring members 33 and 35 there are preferably a plurality of reinforcing ribs 37.

The invention has been described in connection with an embodiment in which there are inner and outer blades, i.e., there are two sets of blades. Those skilled in the art will recognize that, especially in larger fans, the teachings of the present invention may be used to provide three, or even more, sets of blades, with each radially adjacent set of blades being separated by an annular ring member, similar to the ring member 23. In that case, each set of blades will include more blades than the set of blades disposed immediately radially inward therefrom. In an assembly having three or more sets of blades, each set of blades can have a different pitch and profile than the blades in any of the other sets.

The invention has been described in great detail in the foregoing specification, and it is believed that various alterations and modifications of the invention will become apparent to those skilled in the art from a reading and understanding of the specification. It is intended that all such alterations and modifications are included in the invention, insofar as they come within the scope of the appended claims.

Claims

1. A fan assembly (11) adapted to be driven by an input drive (V), the fan assembly comprising an annular hub (15) adapted to be fixed to rotate with the input drive, the fan assembly further comprising a plurality of fan blades; characterized by:

   (a) said plurality of fan blades comprising a plurality of inner fan blades (17) fixed relative to said annular hub (15) and extending radially outward therefrom;
   (b) an annular ring member (23) disposed about said plurality of inner fan blades (17) and fixed to the radially outer extent thereof; and
   (c) said plurality of fan blades further comprising a plurality of outer fan blades (25) fixed relative to said annular ring member (23) and extending radially outward therefrom, said plurality of inner fan blades (17) being less in number than said plurality of outer fan blades (25).

2. A fan assembly (11) as claimed in claim 1 characterized by said annular ring member comprises an inner ring member (23), and said fan assembly further comprises an annular outer ring member (31) disposed about said plurality of said outer fan blades (25), and fixed to the radially outer extent thereof.

3. A fan assembly (11) as claimed in claim 1 characterized by said plurality of outer fan blades (25) being equal to twice the number of said plurality of inner fan blades (17).

4. A fan assembly (11) as claimed in claim 3 characterized by one of said plurality of outer fan blades (25) is aligned, circumferentially, with each of said plurality of inner fan blades (17).

5. A fan assembly (11) as claimed in claim 1 characterized by each of said plurality of outer fan blades (25) has a blade profile which is substantially the same as the blade profile of each of said plurality of inner fan blades (17).

6. A fan assembly (11) as claimed in claim 1 characterized by each of said plurality of outer fan blades (25) has a blade pitch which is substantially the same as the blade pitch of each of said plurality of inner fan blades (17).

7. A fan assembly (11) as claimed in claim 1 characterized by said annular ring member (23) is substantially cylindrical.

8. A fan assembly (11) as claimed in claim 1 characterized by said annular ring member (35) is generally conical, increasing in diameter from a leading edge (19) toward a trailing edge (21).

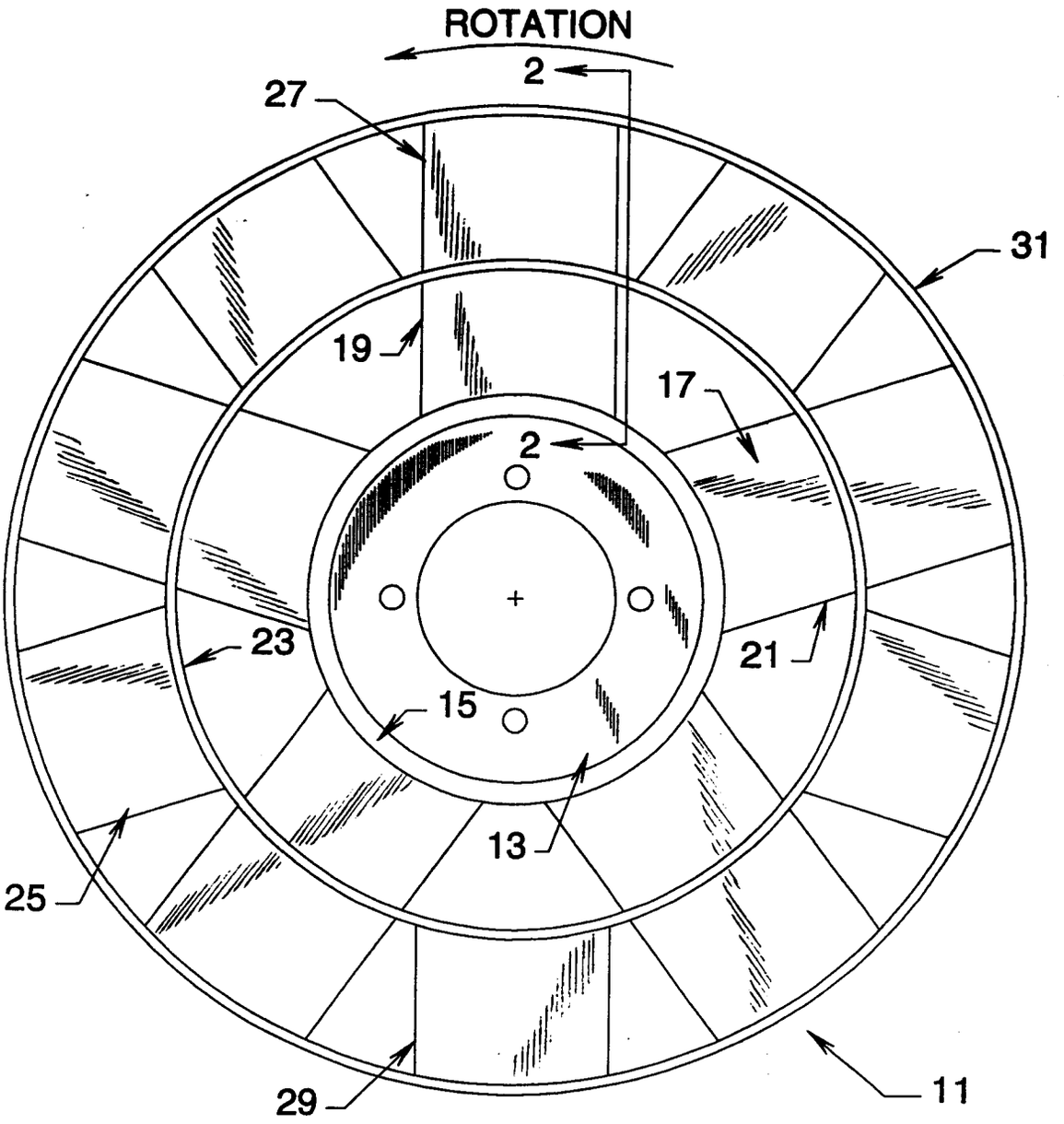

FIG. I

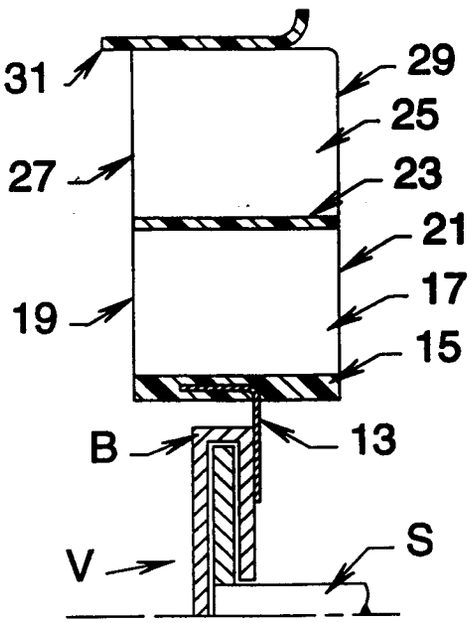

FIG. 2

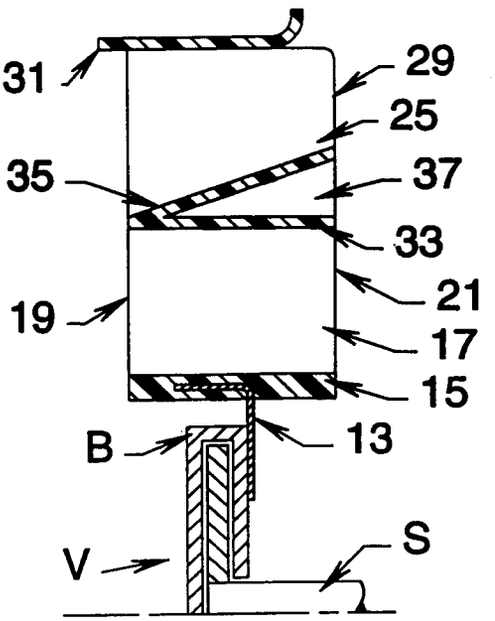

FIG. 3

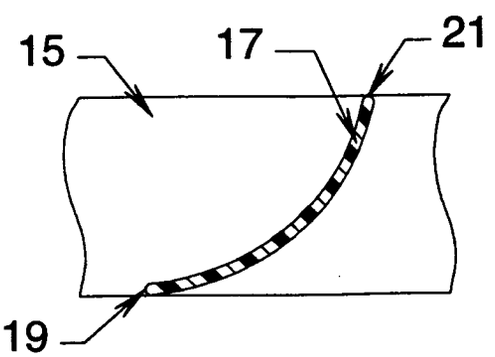

FIG. 4

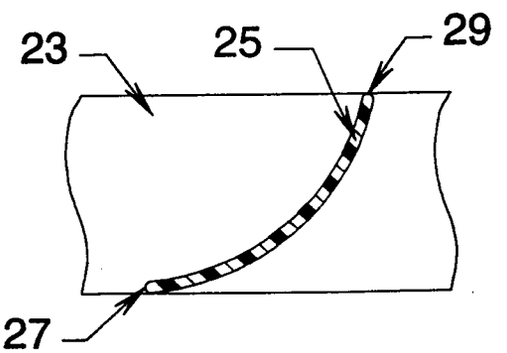

FIG. 5