Axial fan, particularly for motor vehicles for agricultural use.

Priority: 21.12.90 IT 6805290

Date of publication of application: 01.07.92 Bulletin 92/27

Publication of the grant of the patent: 12.04.95 Bulletin 95/15

Designated Contracting States: DE ES FR GB

References cited:
EP-A- 0 373 322  DE-U- 8 903 903
US-A- 4 684 324

Proprietor: NEW HOLLAND FIAT S.p.A.
Viale delle Nazioni 55
I-41100 Modena (IT)

Inventor: Lorea, Angelo
Via I. Calvino 17
I-10043 Orbassano, Torino (IT)
Inventor: Cezolini, Alfredo
Via Buozzi 67
I-41100 Modena (IT)
Inventor: Boretti, Alberto Andrea
Via dei Gerani 11
I-50047 Prato, Firenze (IT)

Representative: Quinhterno, Giuseppe et al
C/o JACOBACCI & PERANI S.p.A.
Corso Regio Parco, 27
I-10152 Torino (IT)

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid (Art. 99(1) European patent convention).
Description

The present invention relates to an axial fan, particularly for use in motor vehicles for agricultural use, intended to provide particularly silent operation.

More specifically, the invention relates to an axial fan comprising a central hub, a plurality of blades which extend from the hub to the periphery and which are curved forwardly in the direction of rotation of the fan and an outer ring coaxial with the hub, to which the peripheral ends of the blades are connected.

An axial fan of the said type is described, for example, in the patent USA No. 4358245. The said fan according to the prior art is constructed in one single piece from moulded plastics material and has blades which have a very marked forwards curvature. In the axial projection of the said fan the median line through each blade always has a positive angle of curvature, increasing steadily from the hub to the outer ring.

In the said US patent it is furthermore stipulated that the angular extension of the median line of each blade must be greater than half of the distance between two adjacent blades.

It follows that, in the case of the fan according to US patent No. 4358245, the length of the blades is fairly considerable and this has repercussions on the amount of material needed to produce the blades and therefore the weight of the fan. Furthermore, the considerable length of the blades results in a lessening of the vibration frequencies of the said blades, and this may lead to a certain instability and a reduction in performance and in the silent running of the fan.

To overcome these drawbacks, it has been proposed to produce axial fans in which, proceeding from the hub towards the outer ring, each blade is firstly curved rearwardly in respect of the direction of rotation of the fan and therefore in its peripheral portion it is forwardly incurvate. Solutions of this type, which make it possible already to achieve a certain reduction in the length of the blades, are described, for example, in US patents Nos. 4569631 and 4684324.

The fans disclosed by the said documents are intended to be produced in one single piece in moulded plastics material and are intended to be used in conjunction with the radiator of a motor vehicle.

An object of the invention is to produce an axial fan which is silent in operation and which has blades which are furthermore of reduced length, with consequent benefits in terms of weight and stability of operation, as well as in fairly high speeds of rotation.

The interest in achieving this object is felt all the more in the case of fans intended for motor vehicles for agricultural and earth-moving applications, such as tractors, excavators etc. In fact, for use on such motor vehicles, it is appropriate that the fans should be made from a metallic material rather than from a plastics material which means that generally they are intrinsically heavier than those which are intended for use on motor cars.

The fans according to US patents Nos. 4569631 and 4684324 comprise blades of a fairly complex form which gives rise to no shortage of production problems. Thus, for example, US patent No. 4569631 prescribes particular patterns of the angle of curvature of the leading and trailing edges of the blades; furthermore, the chord between the leading edge and the trailing edge of each blade must decrease from the hub to the outer ring.

According to US patent No. 4684324, on the other hand, the blades have a progressively increasing chord from the hub to the outer ring.

A further object of the invention is therefore to provide an axial fan which operates silently and which comprises blades of simplified and more easily produced form.

With a view to achieving the aforesaid objects, the present invention relates to an axial fan of the above-specified type, characterised in that
- the angle of curvature of the median line through each blade in axial projection is substantially nil at the hub and for about one third of the radial extension of the blade from the hub;
- the angle of incidence (blade angle) of each blade is substantially constant between the hub and the outer ring;
- each blade is of constant thickness and
- the chord between the leading edge and the trailing edge of each blade is substantially constant between the hub and the outer ring.

Preferably, according to a further aspect of the invention, each blade is produced in such a way that it has a substantially constant angle of deflection (camber angle) between the hub and the outer ring.

Further characteristic features and advantages of the invention will become apparent from the following detailed description which is given with reference to the attached drawings which are provided purely by way of non-limitative example and in which:
Figure 1 is a perspective view of an axial fan according to the invention, Figure 2 is a partial frontal elevation of a fan according to Figure 1 and Figure 3 is a partial sectional view taken on the line III-III in Figure 2.

In drawings, reference numeral 1 generally designates a fan unit comprising a central hub 2, a plurality of blades 3 and an outer ring 4.

In the embodiment shown, the hub 2 is of a metallic material such as aluminium, its alloys or other alloys and it has a central annular portion 5 from which six arms 6 extend radially outwardly. The arms 6 are twisted so that they are not co-planar with the annular portion 5 of the hub but instead they are all rotated through the same angle (blade angle) which is between 20° and 30° and which is preferably about 25°.

In view of the use of the fan on a motor vehicle for agricultural use, the blades 3 are also ideally made from a metallic material, preferably aluminium or its alloys or other metallic alloys, and have the respective inner ends connected in an ordered way to the arms 6 of the hub 2, and the peripheral ends welded to the inner surface of the ring 4. For use in the agricultural field, too, the said ring is suitably constructed from a metallic material such as aluminium or its alloys.

Each blade 3 extends from its inner end, disposed at a radial distance \( R_1 \) from the axis of the hub 2, as far as its junction with the outer ring 4, situated at a radial distance \( R_2 \) from the axis of the hub.

With reference to the front view of Figure 2, \( M \) indicates the median line (in axial projection) of a blade. \( C \) denotes a generic circumference with the centre on the axis of the fan, and with a radius \( r \) of between \( R_1 \) and \( R_2 \). \( S \) denotes the circular thickness of a blade 3 at the circumference \( C \). The circular thickness \( S \) is therefore defined as the arc on the circumference \( C \) which is between the points at which the said circumference intersects the projections \( A \) and \( B \) of the leading and trailing edges of the blade respectively.

The median line \( M \), which is shown as a broken line, starts at a point \( m_1 \) which represents the hub and ends at a point \( m_0 \) which corresponds to the ring 4.

In Figure 2, \( P \) and \( Q \) indicate the radial directions which pass through the points \( m_1 \) and \( m_0 \). The angle \( \alpha \) between the said directions represents the total or final angle of curvature (skew angle) of each individual blade. The said angle, as will be more clearly apparent hereinafter, is preferably equal to about +25°.

Still the reference to Figure 2, \( \alpha \), indicates the angle of curvature of the median line \( M \) of the blade at the generic circumference \( C \).

In the fan according to invention, as Figure 2 shows, the angle of curvature \( \alpha \), of the median line \( M \) of each blade (in axial projection) is nil at the hub. In other words, the radial direction \( P \) is a tangent on the line \( M \) corresponding to the inner end of the blade; furthermore, beginning from the hub, the median line \( M \) is maintained for a certain distance which is substantially coincident with the radial direction \( P \); in other words, the angle of curvature \( \alpha \), of the median line \( M \) remains substantially nil over the initial portion of the blade, proceeding from the hub towards the outer ring. As will become apparent from the numerical example described hereinafter, the portion of the blade in which the median line shows a rectilinear pattern extends over about one third of the radial extension \( R_2 - R_1 \) of each blade.

In Figure 3, \( \beta \) indicates the blade angle in the generic section corresponding to the circumference \( C \) in Figure 2. The angle \( \beta \) is between 20° and 30° and is preferably equal to approximately 25° and is furthermore constant from the hub 2 to the outer ring 4.

In Figure 3, \( d \) denotes the chord between the leading edge A and the trailing edge B of the blade. The said chord, like the circular thickness \( S \) of the blade, is substantially constant along the entire blade from the hub 2 to the outer ring 4.

The effective thickness of each blade, indicated as \( S \) in Figure 3, is also preferably constant and is between 1 and 3%, preferably approximately 2%, of the chord \( d \).

In Figure 3 \( \gamma \) denotes the angle of deflection (camber angle) of the general blade. The said angle is defined between the straight lines \( t_1 \) and \( t_2 \) which are tangents on the section of blade corresponding to the leading edge A and trailing edge B respectively. The angle \( \gamma \) is also constant along the blade and is between 45° and 55°, preferably 50°.

As is apparent from Figure 2, the edges from the end of each blade which is inclined towards the hub 2 have a rounded profile.

**EXAMPLE**

An axial fan intended for use in conjunction with the radiator of a motor vehicle and produced according to the invention has the following characteristic features:
outer radius of the blades: 280 mm
inner radius: 80 mm
number of blades: 6
blade angle: 25°
ratio of s/d: 0.019
angle of deflection of the blades: 50°
angle of curvature $\alpha_r$ of the median line M:

TABLE

<table>
<thead>
<tr>
<th>r (mm)</th>
<th>$\alpha_r$ (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>102</td>
<td>0</td>
</tr>
<tr>
<td>124</td>
<td>0</td>
</tr>
<tr>
<td>147</td>
<td>0</td>
</tr>
<tr>
<td>169</td>
<td>+0.8</td>
</tr>
<tr>
<td>191</td>
<td>+5.9</td>
</tr>
<tr>
<td>213</td>
<td>+11</td>
</tr>
<tr>
<td>236</td>
<td>+16</td>
</tr>
<tr>
<td>258</td>
<td>+21</td>
</tr>
<tr>
<td>280</td>
<td>+25</td>
</tr>
</tbody>
</table>

Naturally, while the principle underlying the invention remains the same, the embodiments and details of production may be varied widely compared with what has been described and illustrated purely by way of a non-limitative example, without thereby departing from the scope of the present invention which is defined in the claims.

Claims

1. An axial fan, particularly for motor vehicles for agricultural use and for earth-moving machines, comprising a central hub (2), a plurality of blades (3) which extend from the hub (2) to the periphery and which are forwardly curved in the direction of rotation of the fan (1) and an outer ring (4) coaxial with the hub (2) and to which the peripheral ends of the blades (3) are connected; characterised in that
   - the angle of curvature ($\alpha_r$) of the median line (M) of the blade (3) in axial projection is nil at the hub (2) and for about one third of the radial extension ($R_o - R$) of the blade from the hub (2);
   - the blade angle ($\beta$) of each blade (3) is substantially constant along the blade between the hub (2) and the outer ring (4);
   - each blade (3) has a constant thickness (s) and
   - the chord (d) between the leading edge (A) and the trailing edge (B) of each blade (3) is substantially constant along the blade (2) between the hub (2) and the outer ring (4).
EP 0 493 342 B1

2. A fan according to Claim 1, characterised in that the angle of deflection (\(\gamma\)) of each blade (3) is substantially constant along the blade between the hub (2) and the outer ring (4).

3. A fan according to Claim 1 or 2, characterised in that the blade angle (\(\beta\)) of the blades (3) is between 20° and 30° and is preferably equal to 25°.

4. A fan according to any one of the preceding claims, characterised in that the thickness (t) of each blade (3) is between 1 and 3% and is preferably equal to 2% of the chord (d) between the leading edge (A) and the trailing edge (B) of the blade (3).

5. A fan according to any one of the preceding claims, characterised in that the angle of deflection (\(\gamma\)) of the blades (3) is between 45° and 55° and is preferably equal to 50°.

6. A fan according to any one of the preceding claims, characterised in that the hub (2), the blades (3) and the outer ring (4) are of metallic material.

7. A fan according to Claim 6, characterised in that the peripheral ends of the blades (3) are welded to the outer ring (4).

8. A fan according to Claim 6 or 7, characterised in that the hub (2) has a star-like configuration with a plurality of virtually radial arms (6) to each of which is connected the inner end of a respective blade (3).

9. A fan according to Claim 8, characterised in that the inner end of each blade (3) is connected to an arm (6) of the hub (2) by bolts or riveting.

10. A fan according to Claim 8 or 9, characterised in that the edges of the inner end of each blade (3) have a rounded profile.

11. A fan according to any one of Claims 6 to 10, characterised in that it is of aluminium or one of its alloys.

Patentansprüche

1. Axiallüfter, insbesondere für Kraftfahrzeuge für Landwirtschaftsgebrauch und Erdbewegungsmaschinen, mit
   - einer zentralen Nabe (2),
   - mehreren Schaufeln (3), die von der Nabe (2) bis zur Peripherie reichen und in Drehrichtung des Lüfters (1) nach vorn gekrümmt sind, sowie
   - einem zur Nabe (2) koaxialen Außenring (4), mit dem die äußeren Enden der Schaufeln (3) verbunden sind,
   - durch gekennzeichnet,
   - der Krümmungswinkel (\(\alpha\)) der Mittellinie (M) der Schaufel (3) in axialer Projektion an der Nabe (2) und auf etwa einem Drittel der radialen Ausdehnung (R0 - R1) der Schaufel ab der Nabe (2) gleich Null ist,
   - der Schaufelwinkel (\(\beta\)) jeder Schaufel (3) entlang der Schaufel zwischen der Nabe (2) und dem Außenring (4) im wesentlichen konstant ist,
   - jedes Schaufel (3) eine konstante Dicke (s) aufweist und
   - die Sehne (d) zwischen der Vorderkante (A) und der Hinterkante (B) jeder Schaufel (3) entlang der Schaufel (2) zwischen der Nabe (2) und dem Außenring (4) im wesentlichen konstant ist.

2. Lüfter nach Anspruch 1, dadurch gekennzeichnet, daß der Ablenkungswinkel (\(\gamma\)) jeder Schaufel (3) entlang der Schaufel zwischen der Nabe (2) und dem Außenring (4) im wesentlichen konstant ist.

3. Lüfter nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Schaufelwinkel (\(\beta\)) der Schaufeln (3) zwischen 20° und 30° und vorzugsweise 25° beträgt.
4. Lüfter nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Dicke (s) jeder Schaufel (3) zwischen 1% und 3% und vorzugsweise 2% der Sehne (d) zwischen der Vorderkante (A) und der Hinterkante (B) der Schaufel (3) beträgt.

5. Lüfter nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der Ablenkungswinkel (γ) der Schaufeln (3) zwischen 45° und 55° und vorzugsweise 50° beträgt.

6. Lüfter nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Nabe (2), die Schaufeln (3) und der Außenring (4) aus einem metallischen Werkstoff hergestellt sind.

7. Lüfter nach Anspruch 6, dadurch gekennzeichnet, daß die äußeren Enden der Schaufeln (3) an den Außenring (4) angeschweißt sind.

8. Lüfter nach Anspruch 6 oder 7, dadurch gekennzeichnet, daß die Nabe (2) sternförmig ist und mehrere im wesentlichen radiale Arme (6) aufweist, an denen das innere Ende einer zugehörigen Schaufel (3) angebracht ist.

9. Lüfter nach Anspruch 8, dadurch gekennzeichnet, daß das innere Ende jeder Schaufel (3) mittels Schrauben oder Nieten an einem Arm (6) der Nabe (2) angebracht ist.

10. Lüfter nach Anspruch 8 oder 9, dadurch gekennzeichnet, daß die Ränder des inneren Endes jeder Schaufel (3) ein abgerundetes Profil aufweisen.

11. Lüfter nach einem der Ansprüche 6 bis 10, dadurch gekennzeichnet, daß er aus Aluminium oder einer Aluminiumlegierung hergestellt ist.

Revendications

1. Ventilateur axial, en particulier pour véhicules à moteur destinés à une utilisation agricole et pour des machines déplaçant de la terre, comportant
   un moyeu central (2),
   plusiers pales (3) qui s'étendent à partir du moyeu (2) vers la périphérie et qui sont incurvées
   vers l'avant dans la direction de rotation du ventilateur (1) et un anneau extérieur (4) coaxial au moyeu
   (2) et auquel les extrémités périphériques des pales (3) sont reliées;
   caractérisé en ce que
   - l'angle de courbure (αₙ) de la ligne médiane (M) de la pale (3) en projection axiale est nul au
     niveau du moyeu (2) et sur environ un tiers de l'extension radiale (Rₙ - R₀) de la pale à partir du
     moyeu (2).
   - l'angle de pale (β) de chaque pale (3) est à peu près constant le long de la pale entre le moyeu
     (2) et l'anneau extérieur (4);
   - chaque pale (3) a une épaisseur constante (s) et
   - la corde (d) existant entre le bord avant (A) et le bord arrière (B) de chaque pale (3) est à peu
     près constante le long de la pale (2) entre le moyeu (2) et l'anneau extérieur (4).

2. Ventilateur selon la revendication 1, caractérisé en ce que l'angle de déflexion (γ) de chaque pale (3) est à peu près constante le long de la pale entre le moyeu (2) et l'anneau extérieur (4).

3. Ventilateur selon la revendication 1 ou 2, caractérisé en ce que l'angle de pale (β) des pales (3) est compris entre 20° et 30° et de manière préférentielle est égal à 25°.

4. Ventilateur selon l'une quelconque des revendications précédentes, caractérisé en ce que l'épaisseur (s) de chaque pale (3) est comprise entre 1 et 3% et de manière préférentielle est égale à 2% de la
   corde (d) entre le bord avant (A) et le bord arrière (B) de la pale (3).

5. Ventilateur selon l'une quelconque des revendications précédentes, caractérisé en ce que l'angle de
   déflexion (γ) des pales (3) est compris entre 45° et 55° et de manière préférentielle est égal à 50°.
6. Ventilateur selon l'une quelconque des revendications précédentes, caractérisé en ce que le moyeu (2), les pales (3) et l'anneau extérieur (4) sont constitués de matériau métallique.

7. Ventilateur selon la revendication 6, caractérisé en ce que les extrémités périphériques des pales (3) sont soudées sur l'anneau extérieur (4).

8. Ventilateur selon la revendication 6 ou 7, caractérisé en ce que le moyeu (2) a une configuration analogue à une étoile ayant plusieurs bras (6) virtuellement radiaux dont chacun est relié à l'extrémité intérieure d'une paie respective (3).

9. Ventilateur selon la revendication 8, caractérisé en ce que l'extrémité intérieure de chaque pale (3) est reliée à un bras (6) du moyeu (2) à l'aide de boulons ou de rivets.

10. Ventilateur selon la revendication 8 ou 9, caractérisé en ce que les bords de l'extrémité intérieure de chaque paie (3) a un profil arrondi.

11. Ventilateur selon l'une quelconque des revendications 6 à 10, caractérisé en ce qu'il est constitué d'aluminium ou d'un de ses alliages.