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(54) **FAN WHEEL**

(57) Fan wheel (1) comprising a first (2) and second (3) end plate, and blades (5) arranged between the first (2) and the second (3) end plate and joined to the first and the second end plate. In order to obtain an efficient fan wheel the outer surfaces (31) of the blades (5) are inclined in relation to the rotation axis (9) of the fan wheel (1), the first (2) and second (3) end plate have outer portions which protrude radially outward beyond the outer edges (8) of the blades, the outer portion of the first end plate (2) is generally curved or inclined towards the second end plate (3) and the outer portion (12) of the second end plate (3) is generally curved or inclined away from the first end plate (2), and the blades (5) are profiled to have a profile where the thickness of the blades vary between the outer edges (8) of the blades (5) and the inner edges (14) of the blades.

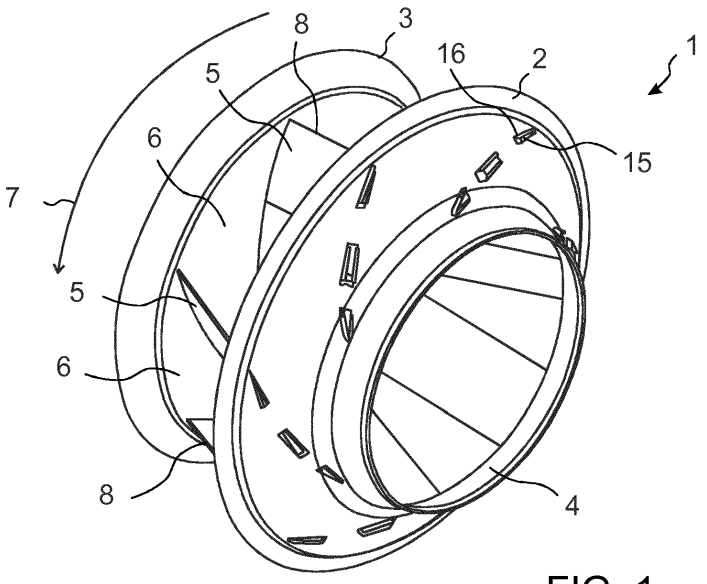

FIG. 1

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] This invention relates to a fan wheel which may be utilized in an air handling box of a building, for instance, in order to generate an air flow in the ventilation system of the building, for instance.

DESCRIPTION OF PRIOR ART

[0002] Previously there is known a fan wheel having a first and second end plate arranged at a distance from each other and blades which are attached between the end plates. An opening in the first end plate allows inflow into the fan wheel, and the first and second end plates together with outer edges of the blades delimit openings allowing outflow from the fan wheel.

[0003] A problem relating to a fan wheel of this kind is that the performance is far from optimal once the fan wheel is mounted in an air handling box. In practice the air flowing out from the fan wheel in a radial direction needs to be redirected in the axial direction, which has turned out to be problematic.

[0004] Attempts have been made to minimize the problems relating to the redirection of the air flow by increasing the size of the air handling box in order to reserve more space for redirecting the air flow in an efficient way, or by using flow guiding plates inside the box. However, such attempts have caused other problems as the space available for an air handling box is in practice limited. Therefore the air handling box should preferably be as small as possible.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to provide solution improving the performance and properties of a fan wheel. This and other objects of the invention can be achieved with the solution defined in independent claims 1 and 13.

[0006] The possibility of providing the fan wheel with end plates having an outer portion providing a diffusion space and which direct the outflow in an optimal direction from the fan wheel in combination with profiled blades that are inclined in relation to the rotation axis leads to a construction which in practical tests has turned out to have excellent properties.

[0007] Preferred embodiments of the invention are disclosed in the dependent claims.

BRIEF DESCRIPTION OF DRAWINGS

[0008] In the following the present invention will be described in closer detail by way of example and with reference to the attached drawings, in which

Figures 1 to 3 and 4a to 4e illustrate a first embodiment of a fan wheel,

Figures 5 and 6 illustrate a blade suitable for the fan wheel in Figures 1 to 3 and 4a to 4e,

Figure 7 illustrates an air handling box utilizing a fan wheel according to Figures 1 to 3 and 4a to 4e, and

Figure 8 illustrates a second embodiment of a fan wheel.

DESCRIPTION OF AT LEAST ONE EMBODIMENT

[0009] Figures 1 to 3 and 4a to 4e illustrate a first embodiment of a fan wheel 1. Figures 1 to 3 show front and side views of the fan wheel 1. Figure 4 is a partial cross section of the fan wheel along line IV - IV in Figure 3.

[0010] The illustrated fan wheel 1 is a mixed-flow fan wheel comprising a first end plate 2 and a second end plate 3 arranged at a mutual distance from each other. A mixed-flow fan wheel refers to a fan wheel, where the air flowing out from the fan wheel is not entirely radially directed and not entirely axially directed but instead somewhere between the radial and axial direction. The angle of direction to the rotation axis of the air flowing out from the fan wheel is typically 20° to 70°. The first end plate 2 has an opening 4 which allows inflow into the fan wheel. Blades 5 are arranged between the first 2 and the second 3 end plate. The blades 5 are joined to the first and the second end plate in such a way that the blades 5 together with the first 2 and second 3 end plate limit openings 6 allowing outflow from the fan wheel while the fan wheel is rotated as illustrated by arrow 7 around the rotation axis 9.

[0011] The outer (trailing) edges 8 of the blades 5 are inclined in relation to the rotation axis 9 such that the distance between the outer edges 8 and the rotation axis 9 is bigger at the first end plate 2 than at the second end plate 3. As illustrated in Figure 4, also the inner (leading) edges 14 of the blades 5 are inclined in relation to the rotation axis 9. The angle of direction α of the locus of the blade leading edge 14 intersection points with meridian plane may be 15° to 20° or most preferably about 19°. Figure 4a illustrates the upper part of the fan wheel 1 in cross-section along the meridian plane, in other words a plane along the rotation axis 9.

[0012] Figures 4b to 4e illustrate in more detail the inclination of the blade. The above mentioned angle of direction α is accomplished by inclining the blade 5 as illustrated in Figures 4b to 4e. In Figures 4b to 4e the center line 32 of the blade outer surface 31 is parallel with both the inner (leading) edge 14 of the blade 5 and the outer (trailing) edge 8 of the blade 5. The tangent 33 of the center line 32 is perpendicular to the center line. To accomplish the angle of direction α the blade 5 has firstly been inclined with an angle δ outwards to the direction of the normal of the center line 32 as illustrated in Figures 4b to 4e. This angle δ may be 15° to 21°, most preferably 18°. Secondly, the blade 5 has been inclined outwards (to the outer diameter of the fan wheel 1) with

an angle γ to the direction of the tangent line 33 as illustrated in Figures 4b to 4e. This angle γ may be 8° to 14°, most preferably 11°.

[0013] The first 2 and second 3 end plate have outer portions 11 and 12 which protrude radially outward beyond the outer edges 8 of the blades 5 such that an outwardly open diffusion space is delimited by the outer portions 11 and 12 and the blades 5. As can be seen from the figures, the outer portions 11 and 12 need not to be exactly radially oriented, in which case they would extend perpendicularly outwards from the rotation axis 9, but instead they may be inclined in relation to the rotation axis. However, when measured perpendicularly from the rotation axis, the outermost parts of the outer portions 11 and 12 are located at a greater distance from the rotation axis than the outermost parts of the blades. In praxis the diffusion space has a generally annular shape. This diffusion space may have a width W which increases outwardly. One alternative is to utilize end plates having straight outer portions 11 and 12 which are inclined in relation to each other with an angle β. This angle β may be 16° to 22°, most preferably 19°. Alternatively the outer portions 11 and 12 may be curved instead of being straight. Additionally, it should be observed that an outwardly widening diffusion space may not be necessary in all embodiments.

[0014] As best seen in Figure 4a, the portion 11 of the first end plate 2 as well as the portion 12 of the second end plate 3 protrude radially outward beyond the outer (trailing) edges 8 of the blades 5 in a direction, which is inclined to the rotation axis 9 of the fan wheel 1, with a distance d. In Figure 4a the outer diameter of the first end plate 2 is indicated with D. The distance d, in other words the depth of the diffusion space, may be such that d is 5 to 10% of D, most preferably about 7% of D.

[0015] The pressure range for which the fan wheel in the embodiment of Figures 1 to 3 and 4a to 4e is suitable is about 200 to 2000 Pa when the specific speed n_s is about 323 to 423, most preferably about 373. The specific speed n_s is defined as follows:

$$n_s = 1000 \times \frac{n \times \sqrt{q_v}}{(g \times H)^{3/4}}$$

$$H = \frac{\Delta p}{\rho \times g}$$

where

n_s is the specific speed (dimensionless)
n is the rotation speed (r/s)
q_v is the airflow (m^3/s)
p is the air density (kg/m^3)
g is the gravitational acceleration (9,81 m/s^2)
H is the pressure head for the fan (m), and
Δp is the pressure increase for the fan (Pa).

[0016] The values given above have been specified by way of example based on practical tests which have indicated that a 4% increase in efficiency for a fan wheel in an air handling box may be achieved, while the sound power level of the fan can be kept low. Therefore, also combinations of these values with other values are possible.

[0017] Figures 5 and 6 illustrate a blade 5 suitable for the fan wheel in Figures 1 to 3 and 4a to 4e. Figure 5 illustrates the blade 5 as viewed from above and Figure 6 as seen from the side in Figure 5.

[0018] The illustrated blade 5 is profiled to have a constant cross-sectional shape along the profile where the thickness 13 of the blade 5 varies between the outer edge 8 of the blade and the inner edge 14 of the blade. As can be seen from Figures 5 and 6, the thickness 13 of the cross-section of the profiled blades 5 is constant in the width direction of the blades along a line 28 which is parallel with the inner (leading) edges 14 of the blades (and located anywhere between the inner 8 and outer 14 edges of the blades). Figure 6 also illustrates that in this embodiment, the outer 31 and inner 30 surfaces of the blade are straight in the width direction of the blade and consequently, the blade is not twisted. As compared to a traditional non-profiled blade, which in practice is as flat (thin) as a metal plate, an aerodynamically more optimal shape can be obtained with the profiling.

[0019] In the illustrated example, the outer edge 8 of the blade 5 is parallel with the inner edge 14 of the blade over the entire width of the blade.

[0020] In Figures 1 to 6 it has by way of example been illustrated that the sides of the blades 5 are provided with protrusions 15 and the first 2 and second 3 end plate with corresponding holes 16 through which the protrusions 15 may be threaded when the fan wheel 1 is assembled. After this, the final attachment may be carried out by welding, for instance. Assembly of the fan wheel such that the blades are exactly correctly located may be simplified due to use of such protrusions 15 and holes 16. However, it is not necessary to utilize such protrusions 15 and holes 16 in all embodiments, because there exists other suitable ways of ensuring that the blades are exactly correctly positioned to the first 2 and second 3 end plate before these parts are attached to each other.

[0021] The fan wheel and the blades as illustrated in Figures 1 to 6 may be entirely manufactured of a suitable metal material, such as aluminum, for instance. When compared to other materials such as plastic materials, for instance, metal materials have advantages when considering how the properties of the material changes over time while used in the environment of a fan wheel. However, it is also possible to manufacture the fan wheel of other materials such as of plastic, for instance.

[0022] One alternative to manufacture the fan wheel is to manufacture the first end plate 2 and the second end plate 3 by cutting from an aluminum plate, for in-

stance. The opening 4 may be cut through the material of the first end plate 2, and after this the first and second end plate may be bent to have their correct shapes by deep drawing, for instance.

[0023] The blade 5 may be manufactured by extrusion of aluminum in order to obtain an elongated profile bar having the thickness varying as illustrated in Figure 6. This elongated profile bar is then cut into profiled blades 5 by cuts along the sides 25 of the blade as illustrated in Figure 5. One elongated profile bar may therefore be cut into several blades 5.

[0024] Once the blades 5 have been manufactured (and possibly slightly machined, if necessary) the profiled blades 5 are arranged in a position as illustrated in Figures 1 to 3 and 4a to 4e such that the outer surfaces 31 of the blades are inclined in relation to a rotation axis 9 of the fan wheel 1 and a distance between the outer surfaces 31 and the rotation axis 9 is bigger at the first end plate 2 than at the second end plate 3, and in a position where the first 2 and second 3 end plate have outer portions 11 and 12 protruding radially outward beyond the outer (trailing) edges 8 of the blades 5, in other words to a larger radius. In this position the blades are attached to the first and second end plates by welding, for instance.

[0025] The above solution for producing a fan wheel results in a fan wheel with a very good performance, without any need for twisting the blades. Instead the profiled shape of the blades illustrated in Figures 5 and 6 is sufficient to obtain a fan wheel with excellent properties.

[0026] Figure 7 illustrates an air handling box 17 utilizing a fan wheel 1 according to Figures 1 to 4 with blades 5 as illustrated in Figures 5 and 6. A motor, such as an electric motor 22 is connected to the second end plate 3 of the fan wheel for causing the fan wheel to rotate.

[0027] The walls 18 of the air handling box 17, which are air tight, separate the fan wheel 1 from the surrounding environment. An inlet opening 19 in a front wall of the air handling box allows air to enter an inlet cone 21 which is arranged to conduct air 20 from the inlet opening 19 to the opening 4 in the first end plate 2 of the fan wheel 1.

[0028] In Figure 7 the air flowing out from the openings 6 of the fan wheel is illustrated with arrows 23. Due to the shape and dimensioning of the fan wheel 1, the air flowing out from the fan wheel is from the beginning slightly axially directed such that direction of the air flow 23 can efficiently be directed towards an outlet opening 24 in the air handling box 17, which is arranged on an opposite side (opposite wall) of the fan wheel 1 as compared to the inlet opening 19.

[0029] In practice the efficiency of the fan wheel depends at least partially on how heavily the air flow 23 collides with the side walls of the air handing box, which causes disturbance in the flow. The illustrated construction, as explained in connection with the previous embodiments, minimizes losses by efficiently directing the air flow 23 as illustrated in Figure 7 without any significant collisions occurring between the air flow 23 and the side walls. Redirection of the air flow 23 towards the opening 24 is in fact so efficient that it is possible to minimize the size of the air handling box 17. No additional flow guiding plates or other additional constructions are needed in the air handling box in order to re-direct the air flow.

[0030] Figure 8 illustrates a second embodiment of a fan wheel 1'. The embodiment of Figure 8 is very similar to the embodiment explained in connection with Figures 1 to 7. Therefore the embodiment of Figure 8 will be mainly explained by pointing out the differences between these embodiments.

[0031] In Figure 8 the blades 5' have a different shape than the blades illustrated in the other Figures. The blades 5' in Figure 8 are also profiled to have a thickness varying between the outer (trailing) edges 8' of the blades and the inner (leading) edges of the blades. However, the outer edges 8' are not straight along their entire length, but they have a step at a section 29' such that the diameter to which they protrude in the radial direction diminishes stepwise.

[0032] In the illustrated example the outer (trailing) edges 8' include three sections 26', 27' and 29'. Figure 8 illustrates a first straight section 26' closest to the first end plate 2 and a second straight section 27' closest to the second end plate 3 where the outer edges 8' of the blades are straight and parallel with each other, and additionally parallel with the inner edges of the blades.

[0033] At a location between the first straight section 26' and the second straight section 27' there is a third section 29', where the outer edges extend in a different direction, such that they are not parallel with the edges of the first section 26', the second section 27' or the inner edges of the blades.

[0034] An advantage obtained with the illustrated step is that speed of the air exiting the fan wheel 1' at different distances as measured from the first end plate 2 (for instance) along the rotation axis 9 can be efficiently controlled.

[0035] It is to be understood that the above description and the accompanying figures are only intended to illustrate the present invention. It will be obvious to a person skilled in the art that the invention can be varied and modified without departing from the scope of the invention.

Claims

1. A fan wheel (1, 1') comprising:

a first (2) and second (3) end plate arranged at a mutual distance from each other, the first end plate (2) having an opening (4) which allows inflow (20) to the fan wheel, and

blades (5, 5') arranged between the first (2) and the second (3) end plate and joined to the first and the second end plate, whereby outer edges (8, 8') of the blades (5, 5') together with the first and second end plate delimit openings (6) al-

lowing outflow from the fan wheel, and wherein outer surfaces (31) of the blades (5, 5') are inclined in relation to a rotation axis (9) of the fan wheel (1, 1') such that the distance between the outer surfaces (31) and the rotation axis (9) is bigger at the first end plate (2) than at the second end plate (3), **characterized in that**
the first (2) and second (3) end plates have outer portions (11, 12) which protrude radially outward beyond the outer edges (8, 8') of the blades such that an outwardly open diffusion space is delimited by the outer portions (11, 12) of the first (2) and second (3) end plates and the blades (5, 5'), the outer portion (11) of the first end plate (2) is generally curved or inclined towards the second end plate (3) and the outer portion (12) of the second end plate (3) is generally curved or inclined away from the first end plate (2), and
the blades (5, 5') are profiled to have a profile where the thickness (13) of the blades varies between the outer edges (8, 8') of the blades (5, 5') and the inner edges (14) of the blades while the thickness of the blades remains constant in a width direction of the blades.

2. The fan wheel according to claim 1, wherein the width (W) of the diffusion space increases outwardly.

3. The fan wheel according to claim 1 or 2, wherein the fan wheel (1, 1') is entirely manufactured of metal.

4. The fan wheel according to one of claims 1 to 3, wherein the diffusion space does not contain additional plates, guides or elements between the outer portions (11, 12) of the first (2) and second (3) end plate.

5. The fan wheel according to one of claims 1 to 4, wherein the diameter (D) of the first end plate (2) is larger than the diameter of the second end plate (3).

6. The fan wheel according to one of claims 1 to 5, wherein the inner edges (14) of the blades (5, 5') are inclined in relation to the rotation axis (9) of the fan wheel (1, 1') such that an angle of direction (α) of the locus of the blade leading edge (14) intersection points with a meridian plane is 15° to 20°, most preferably about 19°.

7. The fan wheel according to one of claims 1 to 6, wherein the width (W) of the diffusion space increases outwardly with an angle (β) of 16° to 22°, most preferably about 19°.

8. The fan wheel according to one of claims 1 to 7, wherein the outer portion (11) of the first end plate (2) protrudes radially outward beyond the outer edges (8, 8') of the blades (5, 5') with a distance (d) that is at least 5 to 10%, most preferably 7%, of a diameter (D) of the first end plate (2).

9. The fan wheel according to one of claims 1 to 8, wherein the thickness of the cross-section of the profiled blades (5) is constant in the width direction of the blades between the first end plate (2) and the second end plate (3) along a line (28) which is parallel with the inner edges (14) of the blades (5).

10. The fan wheel according to one of claims 1 to 9, wherein the blades (5) have outer edges (8) and inner edges (14), and at least a part of the outer edges (8) are parallel with the inner edges (14).

11. The fan wheel according to one of claims 1 to 10, wherein the outer edges (8') of the blades (5') protrude in the radial direction to a diameter which diminishes stepwise from the first end plate (2) towards the second end plate (3) such that at the first end plate (2) and at the second end plate (3) the outer edges (8') of the blades (5') have a first straight section (26') and a second (27') straight section where the outer edges (8') are parallel and between the first straight section (26') and the second straight section (27') the outer edges (8') of the blades (5') have a third section (29'), where the outer edges (8') of the blades (5') extend in a different direction than at the first straight section (26') and at the second straight section (27').

12. Use of a fan wheel according to one of claims 1 to 10, **characterized in that**
the fan wheel (1, 1') is arranged in an air handling box (17) having walls (18) separating the fan wheel from a surrounding environment,
an inlet opening (19) of the air handling box (17) is connected to the opening (4) allowing inflow into the fan wheel (1, 1') via an inlet cone (21), and
an outlet opening (24) for conducting air from the air handling box (17) is arranged on an opposite side of the fan wheel (1, 1') as compared to the inlet opening (19) of the air handling box (17).

13. A method for manufacturing a fan wheel (1, 1'), **characterized in that** the method comprises
manufacturing a first end plate (2) with a center opening (4) of a metal material,
manufacturing a second end plate (3) of a metal material,
extrusion of a metal material to an elongated profile bar having a thickness (13) varying over the width of the elongated profile bar,
cutting the extruded elongated profile bar into profiled blades (5, 5'), arranging the profiled blades (5, 5') between the first (2) and second (3) end plate in a position where outer surfaces (31) of the blades are inclined in relation to a rotation axis (9) of the fan

wheel and a distance between the outer surfaces (31) of the blades and the rotation axis (9) is bigger at the first end plate (2) than at the second end plate (3), and arranging the profiled blades (5, 5') in a position where the first (2) and second (3) end plate have outer portions (11, 12) protruding radially outward beyond the outer edges (8, 8') of the blades and form an an outwardly open diffusion space, and attaching the profiled blades (5, 5') to the first (2) and second (3) end plate to obtain a fan wheel (1, 1') having an inflow opening consisting of the center opening (4) of the first end plate (2) and outflow openings (6) delimited by the first (2) and second (3) end plate and outer edges (8, 8') of the blades.

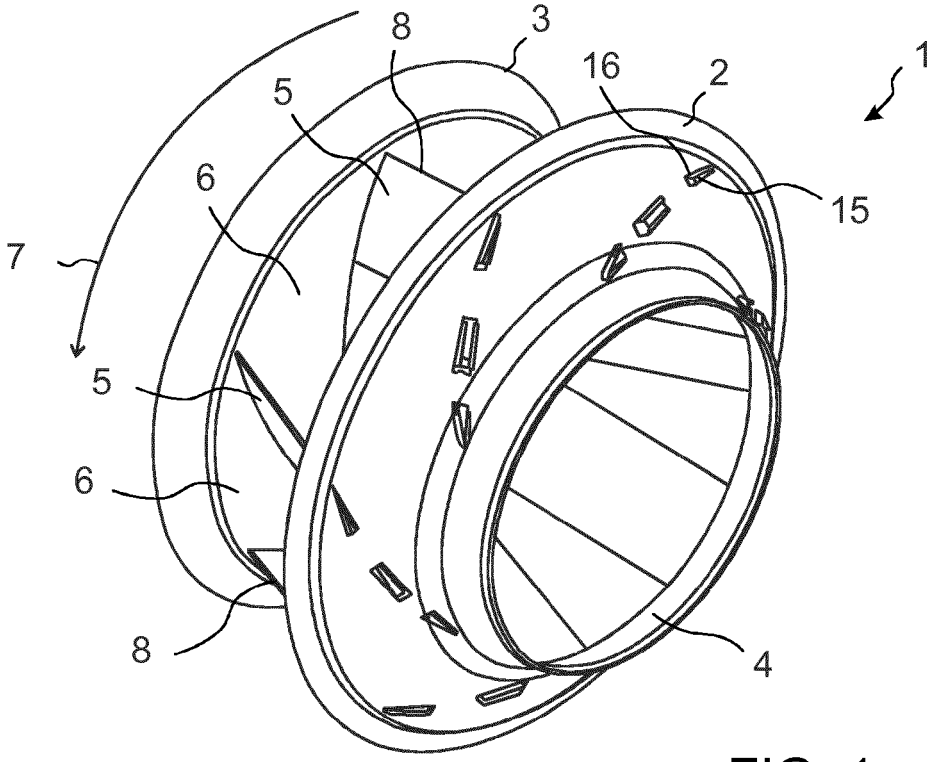

FIG. 1

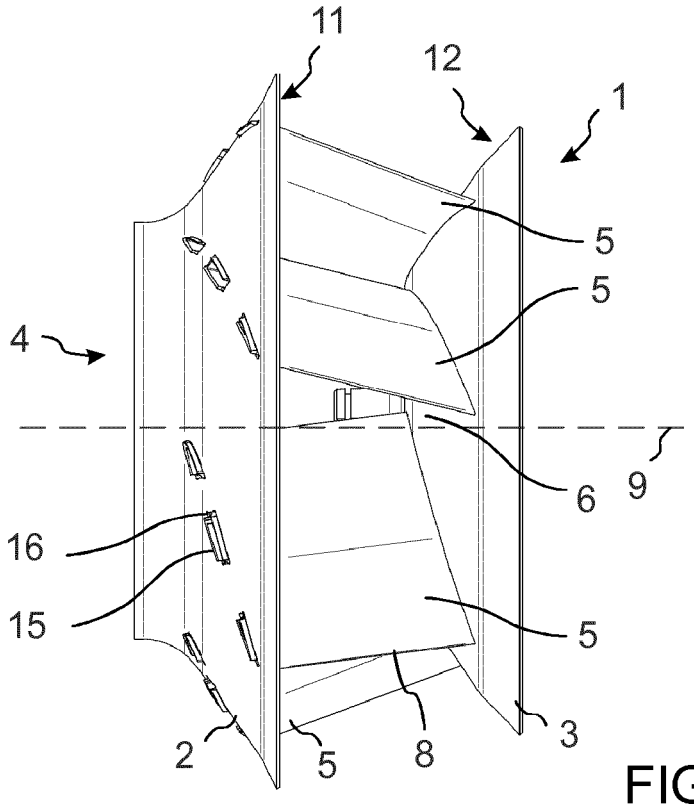

FIG. 2

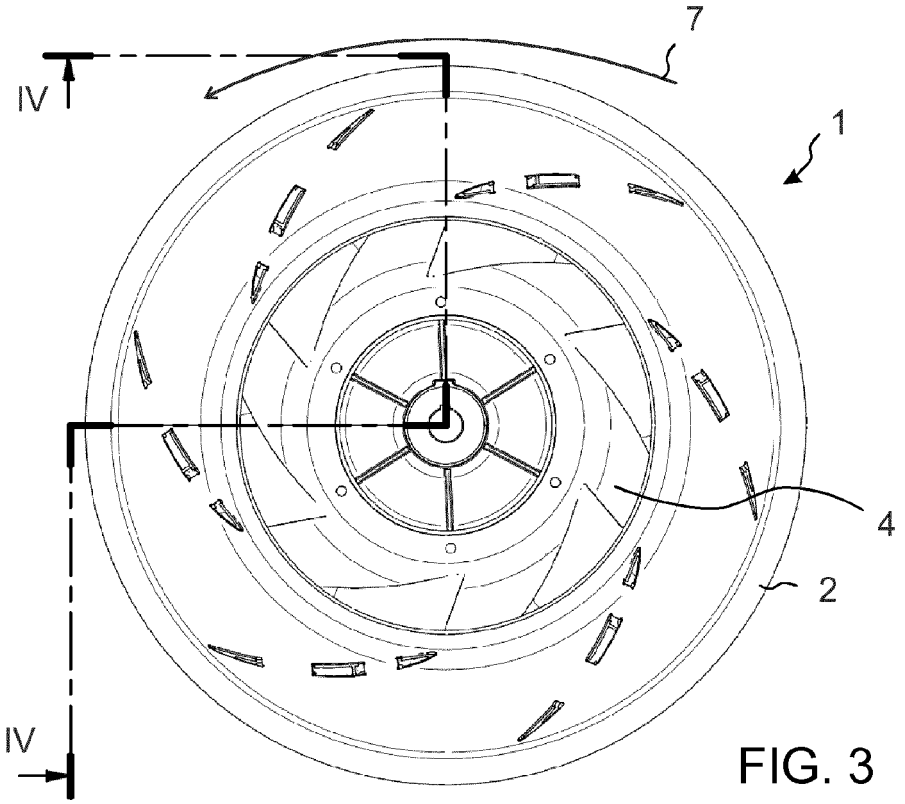

FIG. 3

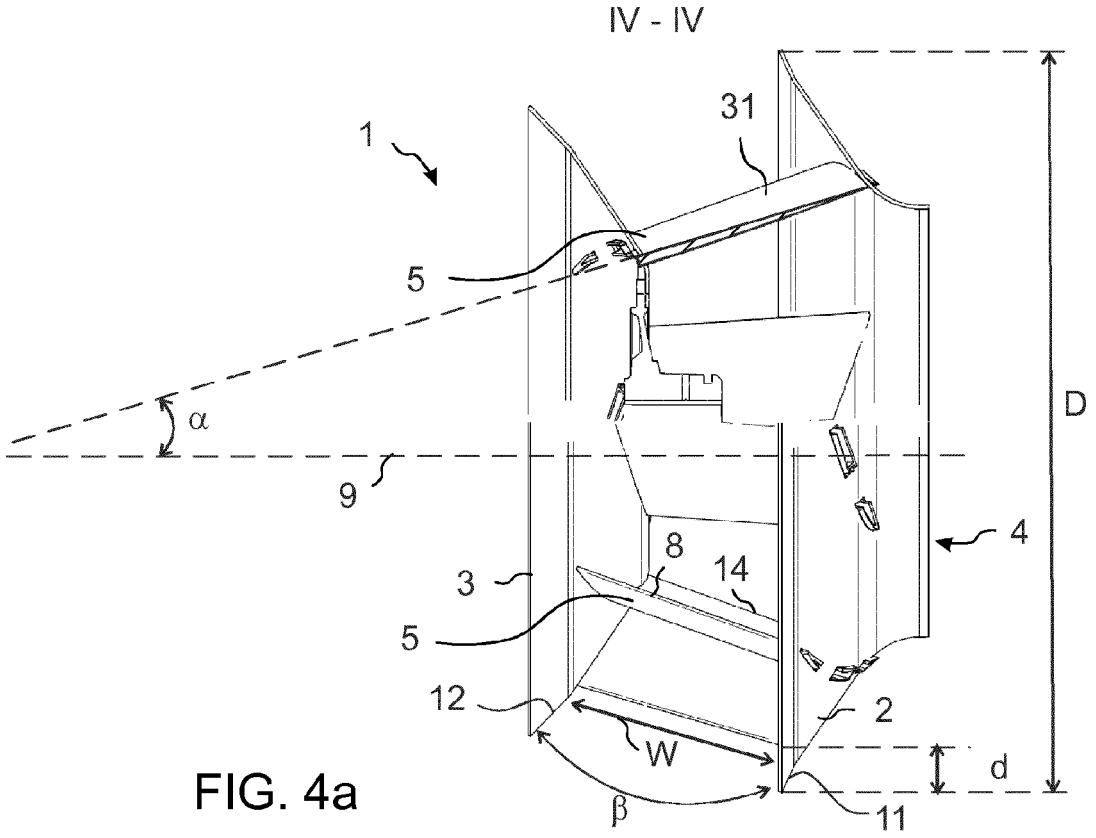

FIG. 4a

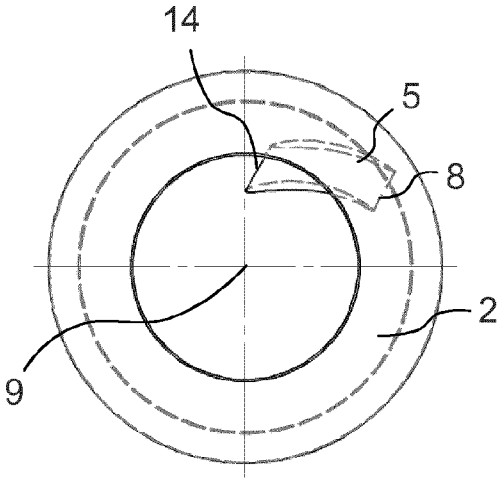

FIG. 4b

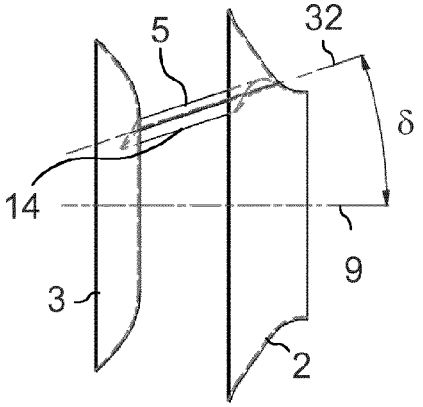

FIG. 4c

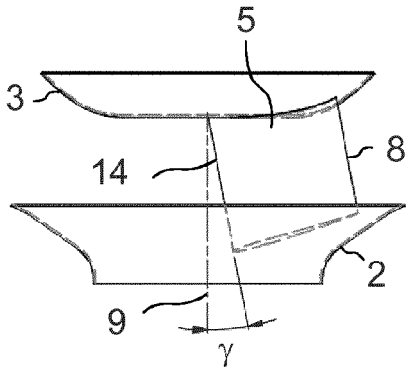

FIG. 4d

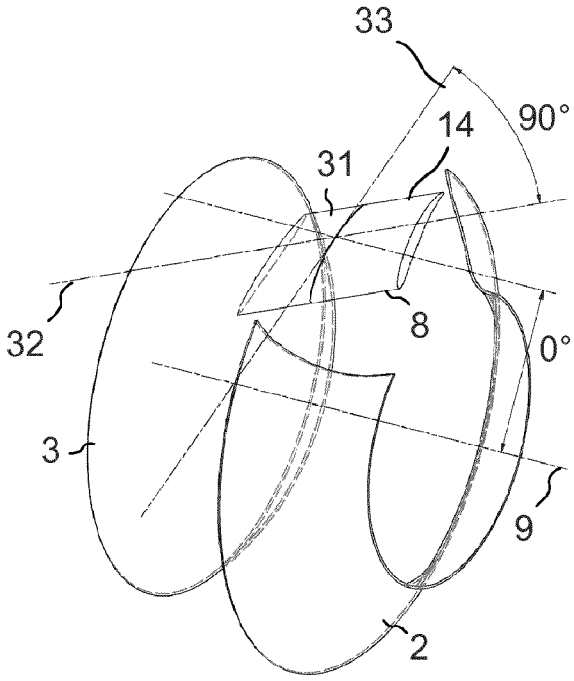

FIG. 4e

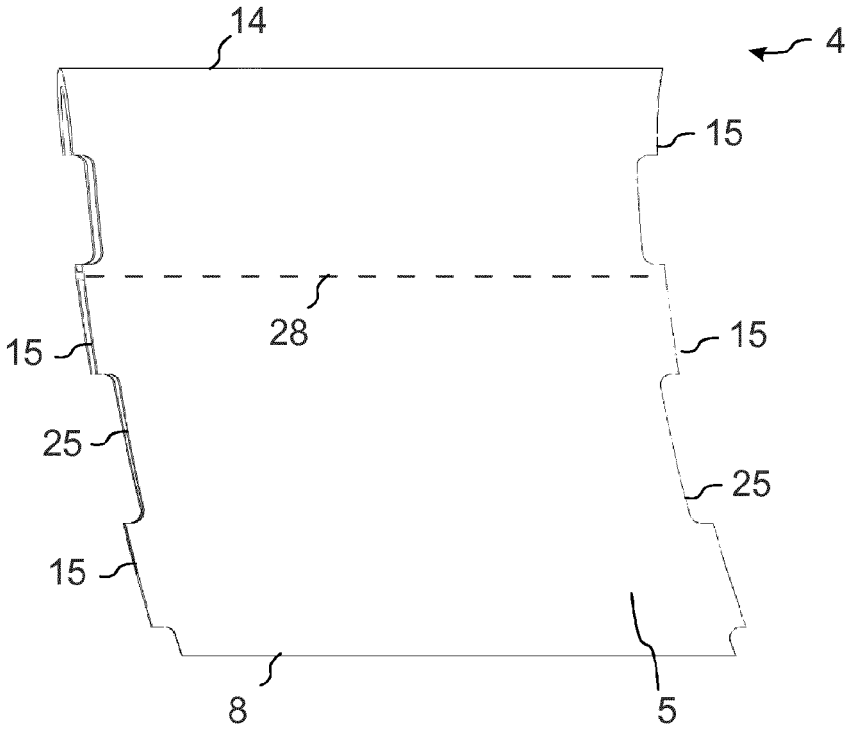

FIG. 5

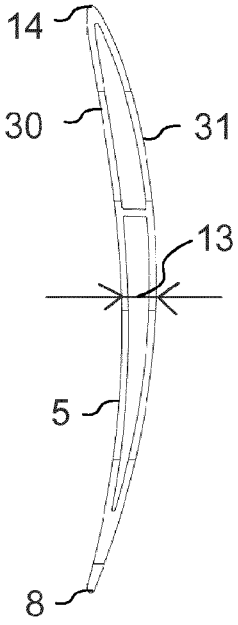

FIG. 6

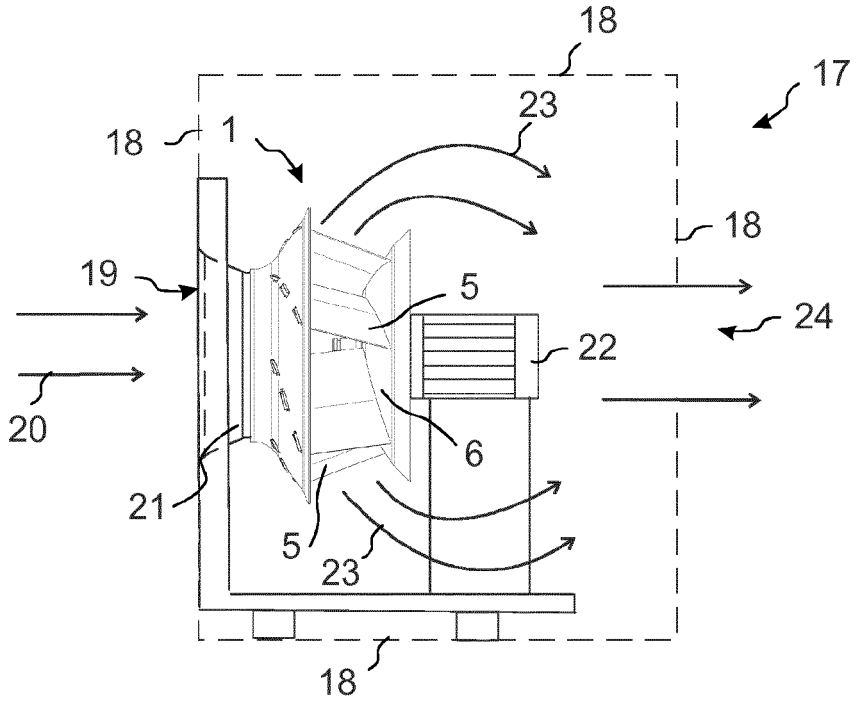

FIG. 7

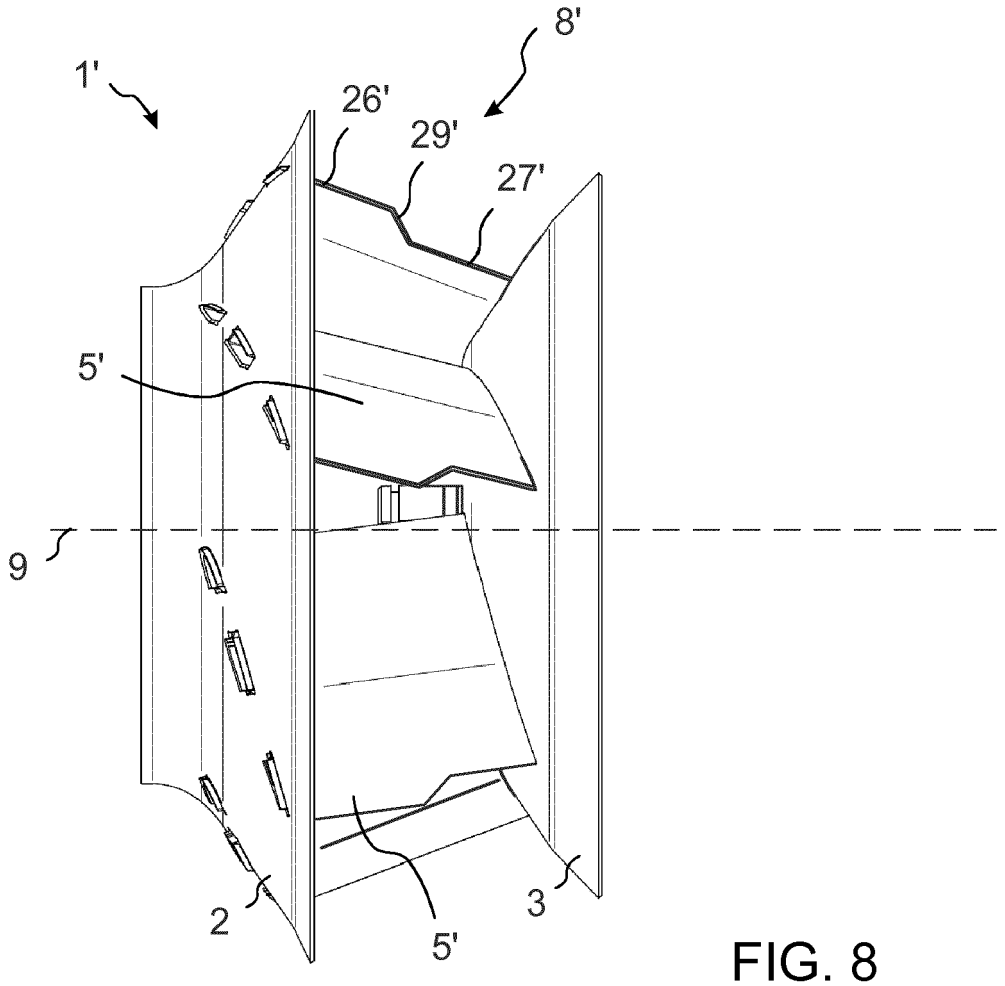

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 15 17 2115

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 3 584 968 A (KEITH MOWRY W) 15 June 1971 (1971-06-15) * column 2, lines 55-56; figures 2,3 *	1-13	INV. F04D29/28
X	WO 01/96745 A1 (GREENHECK FAN CORP [US]; MATHSON TIMOTHY R [US]; KUSKI TIMOTHY D [US]) 20 December 2001 (2001-12-20) * sentences 2-3, paragraph 56; figures 1-3 *	1-13	
X	US 1 447 916 A (WATKINS JAMES A) 6 March 1923 (1923-03-06) * claim 1; figure 4 *	1-13	
X	DE 195 00 994 A1 (BRAUN AG [DE]) 18 July 1996 (1996-07-18) * abstract; figure 3 *	1-13	
A	WO 97/09535 A1 (PM LUFT [SE]; BERG GUNNAR [SE]) 13 March 1997 (1997-03-13) * abstract; figures 2,3 *	1,13	TECHNICAL FIELDS SEARCHED (IPC)
A	GB 1 196 488 A (LICENTIA GMBH [DE]) 24 June 1970 (1970-06-24) * claim 1; figure 1 *	1,13	F04D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 October 2015	de Martino, Marcello

CATEGORY OF CITED DOCUMENTS

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