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

(11) EP 2 642 130 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.09.2013 Bulletin 2013/39

(51) Int Cl.:
F04D 29/38 *(2006.01)*

(21) Application number: **13160281.5**

(22) Date of filing: **21.03.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **22.03.2012 IT MI20120451**

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(54) Impeller for axially conveying fluids, particularly for refrigeration systems

(57) An axial impeller (1) for conveying fluids comprises a hub (3) and a plurality of blades (2) and, when seen in a projection on a plane normal to a rotation axis (R) of the impeller:
- a leading edge (8) of the blades is substantially rectilinear and extends in a direction radial to the rotation axis (R),
- an apical edge (7) of the blades is shaped like an arc of circle concentric to the rotation axis (R),
- a trailing edge (9) of the blades has a curved and concave shape with a wrap angle (28) that increases from the intermediate radius (25) up to close to the outer radius (13).

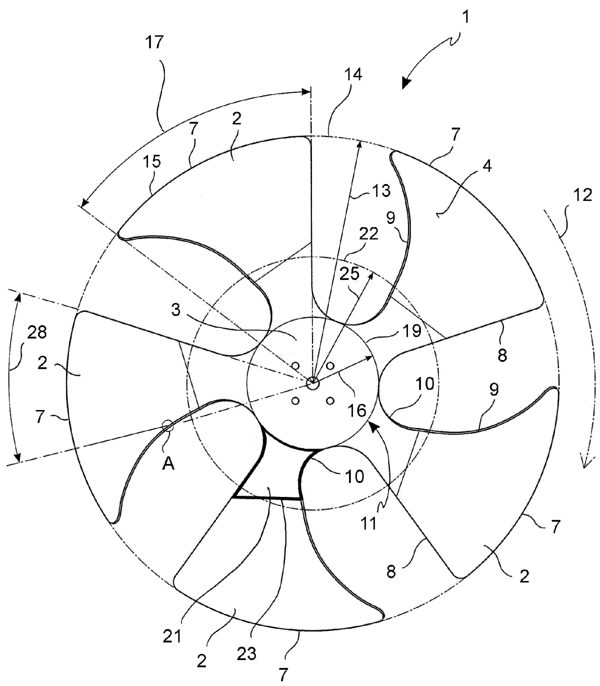

FIG. 1

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Description

[0001] It is the object of the present invention an impeller for axially conveying aeriform fluids, particularly for processing cooling flows, in refrigeration systems.

[0002] The impellers of the type indicated above have to meet needs of reduced bulk, reduced weights, manufacturing easiness, and cost effectiveness. From a performance point of view, higher and higher levels of fluido-dynamic efficiency and noiselessness are required.

[0003] Therefore, the object of the present invention is to propose an axial impeller having such characteristics as to better meet the above- mentioned needs and to reconcile them to one another.

[0004] These and other objects are achieved by an impeller according to claim 1. The dependent claims relate to advantageous embodiments.

[0005] In order to better understand the invention and appreciate the advantages thereof, an exemplary, non-limiting embodiment and some variations thereof will be described below, with reference to the appended Figures, in which:

- Fig. 1 is a front view - blade face side - of an impeller according to an embodiment of the invention;
- Figs. 2 and 3 are perspective views of the impeller in Fig. 1;
- Fig. 4 is a side view of the impeller in Fig. 1;
- Fig. 5 shows the trend of angles of the impeller blades according to an embodiment and in relation to the Table 1 in the following detailed description;
- Fig. 6 illustrates a blade section with the indication of the chord and the blade angles at the leading edge and at the trailing edge of the blade section.

[0006] With reference to the Figures, an axial impeller is generally indicated with the reference 1. The impeller 1 has a plurality of, preferably five, blades 2 symmetrically connected to a hub 3 suitable for the connection of the impeller 1 to a shaft, the longitudinal axis of which forms the rotation axis R of the impeller 1.

[0007] Preferably, the blades 2 of the impeller 1 are equal to one another, and it is therefore sufficient to determine the geometry of a single blade 2 and the hub 3 of the impeller 1, since the other blades 2 are obtained by rotation about the axis R of the reference blade by the angular pitch [360°/ (number of blades)] of the blades.

[0008] With reference to the Figures, the blade 2 of the impeller 1 is rigidly secured to the hub 3 that connects the blades 2 together and that can be, in turn, connected to a shaft suitable to rotate the impeller 1. Each blade 2 forms a front surface 4 and an opposite back surface 5 connected together along a profile edge 6 made up of a radially outer apical edge 7, a side leading edge 8 that is the first to meet the flow F, a side trailing edge 9 opposite the leading edge 8, and joining edges 10 in the connection area of the blade 2 with the hub 3 (referred to as blade root).

[0009] During a rotation of the impeller 1 in the "forward" direction of rotation (arrow 12), an overpressure is generated on the front surface 4, while a fluido-dynamic depression is generated on the back surface 5.

[0010] The outer radius 13 of the impeller 1 is the radius of a circular circumference 14 circumscribing the impeller and tangent to the radially outermost points, referred to as shrouds 15, of the blades 2. The inner radius 16 of the impeller 1 is the radius of an inner circular circumference 19 circumscribing the hub 3 and tangent to the connection points between the hub 3 and the blades 2 (referred to as blade roots 11). The difference between the outer radius 13 and the inner radius 16 defines the blade length.

[0011] By intersecting the blade 2 of the impeller 1 with a cylinder co-axial to the rotation axis R, a blade section is obtained for a given radius of the co-axial intersection cylinder. The rectilinear segment joining the circumferentially extreme points of the blade section is referred to as the chord 29 of the section. The length of the blade section, measured along the chord, is referred to as a length of chord at the radius at issue. The angle of incidence 24 defines the angle formed by the chord of an impeller blade with the plane perpendicular to the rotation axis R. The maximum axial dimension of the blade section denotes the maximum thickness of the section at the same radius.

[0012] The skew of the blade 2 indicates a displacement of each blade section along the helicoidal intersection line with the coaxial cylinder, measured by the generator at the section reference point. A positive skew is oriented in a direction opposite the "forward" direction of rotation R of the impeller or, in other terms, going radially outwardly, the barycenter of the area of circumferential section of the blade moves to the direction opposite the "forward" direction of rotation R of the impeller 1.

[0013] Further parameters for the blade 2 shape are the angle of inclination 27 of the blade 2 at the leading edge 8 thereof (leading angle) and at the trailing edge 9 thereof (trailing angle), as well as the wrap angle 28 along the blade profile 6.

[0014] Within the scope of the present description, the angle of inclination 27 (Beta), also referred to as a relative angle of flow, denotes the angle between the direction of the flow (axial R) and the tangent to the blade surface in a point of a curve, defined by the intersection of a cylinder co-axial to the rotation axis R and the blade surface (Figures 4, 6).

[0015] The wrap angle 28 (Theta) denotes, when seen in a projection axial on a plane normal to the rotation axis R, the angular width or the circumferential extension expressed in terms of the angle defined between two planes radial to the rotation axis R and tangent at the leading edge and at the trailing edge of the blade for the same radius. In other terms, the wrap angle 28 (Theta) defines the width of the blades in the circumferential direction, at a given radius R, particularly in the area comprised between the outer radius 13 and the intermediate radius 25 (Fig. 1).

Detailed description of the geometry when seen in a projection on a plane normal to the rotation axis

[0016] In accordance with an aspect of the invention, when seen in a projection on a plane normal to the rotation axis R of the impeller 1 (Fig. 1), the leading edge 8 of the blade 2 is substantially rectilinear and extends in a direction radial to the rotation axis R, except for a rounded or beveled transition length between the leading edge 8 and the apical edge 7. Such a beveled transition length has a very reduced extension of a few millimeters, both in the radial direction and in the circumferential direction relative to the rotation axis R.

[0017] Expressed as a ratio with the overall dimension of the impeller 1, the beveled length may have an extension from about 0.016*R1 to 0.063*R1, preferably from 0.031*R1 to 0.047*R1, even more preferably about 0.039*R1, both in the radial direction and in the direction circumferential relative to the rotation axis R, in which R1 is the outer radius of the impeller 1.

[0018] In accordance with a further aspect of the invention, again when seen in a projection on a plane normal to the rotation axis R of the impeller 1, the apical edge 7 of the blade 2 is shaped like an arc of circle concentric to the rotation axis R, except for the above-mentioned rounded or beveled transition length between the leading edge 8 and the apical edge 7.

[0019] In accordance with a further aspect of the invention, again when seen in a projection on a plane normal to the rotation axis R of the impeller 1, the trailing edge 9 of the blade 2 has a curved and concave shape, imparting to the blade 2 a positive skew and a continuous increase, approximately exponential, of the circumferential extension (axial projection of the length of chord) of the blade 2, as the radial distance relative to the rotation axis R increases.

[0020] Between the trailing edge 9 and the apical edge 7, a rounded or beveled transition length is formed, which may have a very reduced extension of a few millimeters both in the radial direction and in the circumferential direction relative to the rotation axis R.

[0021] As expressed as a function of the overall dimension of the impeller 1, the beveled length has an extension from about 0.016*R1 to 0.063*R1, preferably from 0.031*R1 to 0.047*R1, even more preferably about 0.039*R1, both in the radial direction and in the circumferential direction relative to the rotation axis R, in which R1 is the outer radius 13 of the impeller 1.

[0022] In an embodiment, the joining edge 10 extends in the root area 11 of the blades 2 continuously and stepless from the trailing edge 9 of a blade 2 to the leading edge 8 of the adjacent blade 2. When seen in a projection on a plane normal to the rotation axis R of the impeller 1 (Fig. 1), such a joining edge 10 preferably has an arc of circle shape, having a radius of between 0.12*R1 and 0.18*R1, preferably between 0.14*R1 and 0.16*R1, even more preferably about 0.15*R1, in which R1 is the outer radius 13 of the impeller 1, as well as an angular extension of between 160° and 180°, preferably between 170° and 175°.

[0023] Advantageously, the inner radius 16 of the impeller is within the range from 0.2*R1 to 0.3*R1, preferably from 0.25*R1 to 0.28*R1, even more preferably about 0.27*R1, in which R1 is the outer radius 13 of the impeller 1.

[0024] Again when seen in a projection on a plane normal to the rotation axis R of the impeller 1, the blade 2 has a maximum circumferential extension (axial projection of the length of chord) at the apical edge 7 with an apical angle 17 (the angle defined between two planes radial to the rotation axis R that include together the total circumferential bulk of the apical edge 7 of the blade 2 on the leading side and on the trailing side) selected approximately within the range from 50° to 55°, preferably about 53°.

[0025] The total number of blades 2 is preferably 5, with a consequent angular pitch of 72°.

Detailed description of the axial bulk

[0026] In accordance with a further aspect of the invention, the blade 2 has a maximum axial bulk 18 (Fig. 4) at the apical edge 7, or more precisely, at the transition lengths from the apical edge 7 to the leading 8 and trailing 9 edges. Such a maximum axial bulk 18 can be selected within the range from 0.35*R1 to 0.40*R1, preferably from 0.37*R1 to 0.38*R1, even more preferably about 0.376*R1, in which R1 is the outer radius 13 of the impeller 1. By way of example, for an impeller with an outer radius 13 of R1=127mm, the maximum axial bulk 18 can be of about 47.8 mm.

[0027] In accordance with an embodiment, the blade thickness is substantially constant over the entire extension of the blade 2. In this manner, the impeller 1 can be manufactured in metal sheet by cutting and cold deformation by a press or, alternatively, in synthetic material by injection molding with homogeneous thicknesses, promoting the control of the material shrinkage during the cooling thereof. Advantageously, the hub 3 and the blades 2 are formed in a single piece and with a wall thickness that is substantially equal and uniform.

[0028] In accordance with an embodiment, the hub 3 (or a hub 3 portion of the sheet or wall forming the impeller 1) may have the shape of a disc that is substantially planar and perpendicular to the rotation axis R. Advantageously, the roots 11 of the blades 2 connect to the hub 2 along the inner circumference 19 in a single plane normal to the rotation axis R and, with further advantage, the hub 3 is substantially plane and lies in such a normal plane 20.

[0029] Preferably, the blade 2 has a twisted portion 21 extending radially from the root 11 (inner circumference 19) up to a retroflection area or line 23 formed in the blade 2 at an intermediate circumference 22, and characterized by an extreme (maximum) angle of incidence 24 and an extreme local curvature (minimum radius of curvature) in the opposite direction to the torsion direction of the twisted portion 21, particularly at the leading 8 and trailing 9 edges. Such a retroflection line 23 implements a reinforcement rib for the blade 2.

[0030] The twisted portion 21 has a twisted shape ("twisted" in the meaning of a twisting deformation) about an axis radial to the rotation axis R, obtaining a transition of the blade 2 shape and orientation from the root 11 (inner circumference 19) up to the retroflection area or line 23 (intermediate circumference 22).

[0031] In accordance with an embodiment, the intermediate radius 25, i.e., the average radial distance between the rotation axis R and the retroflection line 23 of the blade 2, is preferably selected within the range from 0.42*R1 to 0.52*R1, preferably between 0.460*R1 and 0.480*R1, even more preferably about 0.472*R1, in which R1 is the outer radius 13 of the impeller 1. For an outer radius R1=127mm, the intermediate radius 25 has preferably a length of 60mm.

[0032] In accordance with a further embodiment, the axial bulk 26 of the blade 2 at the retroflection line 23 (intermediate circumference 22) is selected within the range from 0.6*Z1 to 0.65*Z1, preferably from 0.62*Z1 to 0.63*Z1, even more preferably about 0.628*Z1, wherein Z1 is the maximum axial bulk of the blade 2 at the apical edge 7. By way of example, for an impeller with a maximum axial bulk Z1=47.8mm, the axial bulk 26 at the retroflection line 23 may be of about 30 mm.

[0033] Expressed as a function of the outer radius 13 of the impeller 1, the axial bulk 26 at the retroflection line can be selected within the range from 0.21*R1 to 0.26*R1, preferably from 0.23*R1 to 0.24*R1, even more preferably about 0.236*R1, in which R1 is the outer radius 13 of the impeller 1. By way of example, for an impeller with an outer radius 13 of length R1=127mm, the axial bulk 26 at the retroflection line 23 can be of 30 mm.

<u>Detailed description of the inclination angles (leading and trailing angles)</u>

[0034] In accordance with a further development of the invention, the angle of inclination 27 at the leading edge 8 [Beta_LE] gradually increases starting from the retroflection line 23 and going radially outwardly up to the shroud 15 of the blade 2. Furthermore, starting from the retroflection line 23 and going radially outwardly up to the shroud 15 of the blade 2, the gradient of the angle of inclination 27 at the leading edge 8 [ΔBeta_LE/ΔR] decreases.
Advantageously, the trend of the angle of inclination 27 at the leading edge 8 follows a polynomial function starting from an initial value (at the intermediate radius 25) within the range between 55° and 58°, preferably about 56.4° and up to a final value (outer radius 13) within the range between 74° and 78°, preferably about 76.0°.

[0035] The angle of inclination 27 at the trailing edge 9 [Beta_TE] gradually increases starting from the retroflection line 23 and going radially outwardly up to close to the shroud 15 of the blade 2. Furthermore, starting from the retroflection line 23 and going radially outwardly up to the shroud 15 of the blade 2, also the gradient of the angle of inclination 27 at the trailing edge 9 [ΔBeta_TE/ΔR] decreases and, close to the shroud 15, such a gradient changes sign, since the angle of inclination 27 at the trailing edge 9 locally decreases close to the apical edge 7. Advantageously, the trend 15 of the angle of inclination 27 at the leading edge 8 follows a polynomial function starting from an initial value (at the intermediate radius 25) within the range between 16.0° and 18.0°, preferably about 17.4°, and up to a final value (outer radius 13) within the range between 44° and 47°, preferably about 45.3°.

[0036] The difference between the angle of inclination 27 at the leading edge 8 and that at the trailing edge 9 for the same radius of the impeller [Beta_ LE- Beta_ TE] gradually decreases starting from the retroflection line 23 and going radially outwardly up to close to the shroud 15 of the blade 2. Furthermore, starting from the retroflection line 23 and going radially outwardly up to close to the shroud 15 of the blade 2, also the absolute value of the gradient of the difference in the angle of inclination 27 at the leading 8 and trailing 9 edges [Δ (Beta_ LE- Beta_ TE) / ΔR] decreases. Close to the shroud, such a gradient changes sign and becomes positive at the apical edge 7.

[0037] Advantageously, the trend of the difference in the angle of inclination 27 at the leading 8 and trailing 9 edges [Beta_ LE- Beta_ TE] follows a polynomial function starting from an initial value (at the intermediate radius 25) within the range between 38.0° and 40.0°, preferably about 39.0°, and up to a final value (outer radius 13) within the range between 29° and 32°, preferably about 30.7°.

[0038] <u>Detailed description of the wrap angles</u>

[0039] In accordance with a further development of the invention, the wrap angle 28 to the leading edge 8 [Theta_LE] is substantially zero from the retroflection line 23 up to the shroud 15 of the blade 2. The wrap angle 28 at the trailing edge 9 [Theta_TE] gradually increases starting from the retroflection line 23 and going radially outwardly up to close to the shroud 15 of the blade 2. Furthermore, starting from the retroflection line 23 and going radially outwardly up to the shroud 15 of the blade 2, the gradient of the wrap angle 28 at the trailing edge 9 [ΔTheta_TE/ΔR] increases continuously.

[0040] Advantageously, the trend of the wrap angle 28 at the trailing edge 9 follows a polynomial function starting from an initial value (at the intermediate radius 25) within the range between 29.0° and 32.0°, preferably about 30.6°, and up to a final value (outer radius 13) within the range between 55° and 57°, preferably about 56.1°.

Table 1

Radi us [mm]	Beta_ LE [°]	Beta_ TE [°]	Theta_ LE [°]	Theta_ TE [°]	Delta_Be ta [°]	Delta_Th eta [°]
60	56,43	17,44	0,00	30,57	39,00	30,57
65	58,52	22,22	0,00	31,84	36,30	31,84
75	62,23	27,93	0,00	34,12	34,30	34,12
85	65,42	32,51	0,00	36,95	32,90	36,95
95	68,33	36,53	0,00	40,43	31,80	40,43
105	70,94	40,14	0,00	44,65	30,80	44,65
115	73,33	43,42	0,00	49,23	29,90	49,23
120	74,36	44,74	0,00	52,01	29,62	52,01
125	75,42	45,85	0,00	54,92	29,57	54,92
127	76,01	45,31	0,00	56,07	30,70	56,07

[0041] By way of non-limiting example, the table 1 indicates the trend of the angles of inclination Beta_LE and Theta_ LE at the leading and trailing edges and the relationships thereof. A graphical representation of such values is provided in Fig. 5.

[0042] The impeller 1 according to the invention has a number of advantages. It is particularly noiseless, it has a high degree of fluido-dynamic efficiency, can be easily manufactured, has a reduced overall weight and overall dimensions while keeping the energization of the processed flow constant. The axial impeller 1 according to the invention is particularly suitable for conveying cooling flows in refrigeration systems.

[0043] It shall be apparent that to the axial impeller 1 according to the present invention, one of ordinary skill in the art, with the aim of meeting specific, contingent needs, will be able to make further modifications and variations, all of which actually falling within the protection scope of the invention, as defined by the following claims.

Claims

1. Axial impeller (1) for conveying fluids, said impeller (1) defining a rotation axis (R) and comprising a hub (3) for the connection of the impeller (1) to a rotary shaft and a plurality of identically- shaped blades (2) connected to the hub (3) with constant angular pitch,
wherein the radius of an outer circumference (14) circumscribing the impeller (1) and tangent to the radially outermost points of the blades (2) defines an outer radius (13) of the impeller (1),
wherein the radius of an inner circumference (19) circumscribing the hub (3) and tangent to the connection points between the hub (3) and the blades (2) defines an inner radius (16) of the impeller (1), wherein the radius of an intermediate circumference (22) at a blade section with extreme angle of incidence (24) defines an intermediate radius (25) of the impeller (1), said intermediate radius (25) being greater than the inner radius (16) and less than the outer radius (13),
wherein the blades (2) have a profile edge (6) made up of a radially outer apical edge (7), a leading edge (8) that is the first to meet the flow (F), a trailing edge (9) opposite the leading edge (8) and joining edges (10) in the connection area of the blade (2) with the hub (3),
wherein, when seen in a projection on a plane normal to the rotation axis (R) :

- the leading edge (8) is substantially rectilinear and extends in a direction radial to the rotation axis (R),
- the apical edge (7) is shaped like an arc of circle concentric to the rotation axis (R),
- the trailing edge (9) has a curved and concave shape with a wrap angle (28) that increases from the intermediate radius (25) up to close to the outer radius (13).

2. Axial impeller (1) according to claim 1, wherein the blades (2) form a twisted portion (21) extending radially from the inner circumference (19) up to a retroflection line (23), said retroflection line (23) being formed at the intermediate circumference (22) and having an extreme local curvature in the opposite direction to the direction of twisting of the twisted portion (21), wherein the retroflection line (23) forms a reinforcement rib for the blade (2).

3. Axial impeller (1) according to one of the previous claims, wherein the joining edge (10) extends continuously from the trailing edge (9) of a blade (2) to the leading edge (8) of the adjacent blade (2) and has, when seen in a projection on a plane normal to the rotation axis (R), a substantially arc of circle shape having an angular extension of between 170° and 175° and a radius of between 0.12*R1 and 0.18*R1, in which R1 is the outer radius (13) of the impeller (1).

4. Axial impeller (1) according to one of the previous claims, wherein the inner radius (16) is within the range from 0.2*R1 to 0.3*R1, preferably from 0.25*R1 to 0.28*R1, even more preferably about 0.27*R1, in which R1 is the outer radius (13) of the impeller (1).

5. Axial impeller (1) according to one of the previous claims, wherein the total number of blades (2) is five and, when seen in a projection on a plane normal to the rotation axis (R), the blade (2) has a maximum circumferential extension at the apical edge (7) with an apical angle (17) from 50° to 55°, preferably about 53°.

6. Axial impeller (1) according to one of the previous claims, wherein the blade (2) has a maximum axial bulk (18) at the apical edge (7), said maximum axial bulk (18) being selected within the range from 0.35*R1 to 0.40*R1, preferably from 0.37*R1 to 0.38*R1, even more preferably about 0.376*R1, in which R1 is the outer radius (13) of the impeller (1).

7. Axial impeller (1) according to one of the previous claims, wherein the blade thickness is substantially uniform over the entire extension of the blade (2).

8. Axial impeller (1) according to one of the previous claims, wherein the intermediate radius (25) is selected within the range from 0.42*R1 to 0.52*R1, preferably between 0.460*R1 and 0.480*R1, even more preferably about 0.472*R1, in which R1 is the outer radius (13) of the impeller (1).

9. Axial impeller (1) according to one of the previous claims, wherein the axial bulk (26) of the blade (2) at the intermediate radius is selected within the range from 0.6*Z1 to 0.65*Z1, preferably from 0.62*Z1 to 0.63*Z1, even more preferably about 0.628*Z1, wherein Z1 is the maximum axial bulk of the blade (2) at the apical edge (7).

10. Axial impeller (1) according to one of the previous claims, wherein the axial bulk (26) at the intermediate radius is selected within the range from 0.21*R1 to 0.26*R1, preferably from 0.23*R1 to 0.24*R1, even more preferably about 0.236*R1, in which R1 is the outer radius (13).

11. Axial impeller (1) according to one of the previous claims, wherein, from the intermediate radius (25) up to the outer radius (13), the angle of inclination (27) at the leading edge (8) gradually increases and the gradient of the angle of inclination (27) at the leading edge (8) decreases, wherein at the intermediate radius (25) the angle of inclination (27) at the leading edge (8) is within the range between 55° and 58°, preferably about 56.4°,
wherein at the outer radius (13) the angle of inclination (27) at the leading edge (8) is within the range between 74° and 78°, preferably about 76.0°.

12. Axial impeller (1) according to one of the previous claims, wherein the angle of inclination (27) at the trailing edge (9) gradually increases from the intermediate radius (25) up to close to the outer radius (13) and decreases locally at the apical edge (7),
wherein the gradient of the angle of inclination (27) at the trailing edge (9) decreases from the intermediate radius (25) up to the outer radius (13) and changes sign at the apical edge (7),
wherein at the intermediate radius (25) the angle of inclination (27) at the leading edge (8) is within the range between 16.0° and 18.0°, preferably about 17.4°, wherein at the outer radius (13) the angle of inclination (27) at the leading edge (8) is within the range between 44° and 47°, preferably about 45.3°.

13. Axial impeller (1) according to one of the previous claims, wherein the difference between the angle of inclination (27) at the leading edge (8) and at the trailing edge (9) for the same radius of the impeller decreases from the intermediate radius (25) up to close to the outer radius (13),
wherein, at the intermediate radius (25), the difference in the angle of inclination (27) at the leading edge (8) and trailing edge (9) is within the range between 38.0° and 40.0°, preferably 39.0°, wherein, at the outer radius (13), the

difference in the angle of inclination (27) at the leading edge (8) and the trailing edge (9) is within the range between 29° and 32°, preferably 30.7°.

14. Axial impeller (1) according to one of the previous claims, wherein, from the intermediate radius (25) up to close to the outer radius (13), the gradient of the wrap angle (28) at the trailing edge (9) increases, wherein, at the intermediate radius (25), the wrap angle (28) at the trailing edge (9) is within the range between 29.0° and 32.0°, preferably 30.6°, wherein, at the outer radius (13), the wrap angle (28) at the trailing edge (9) is within the range between 55° and 57°, preferably 56.1°.

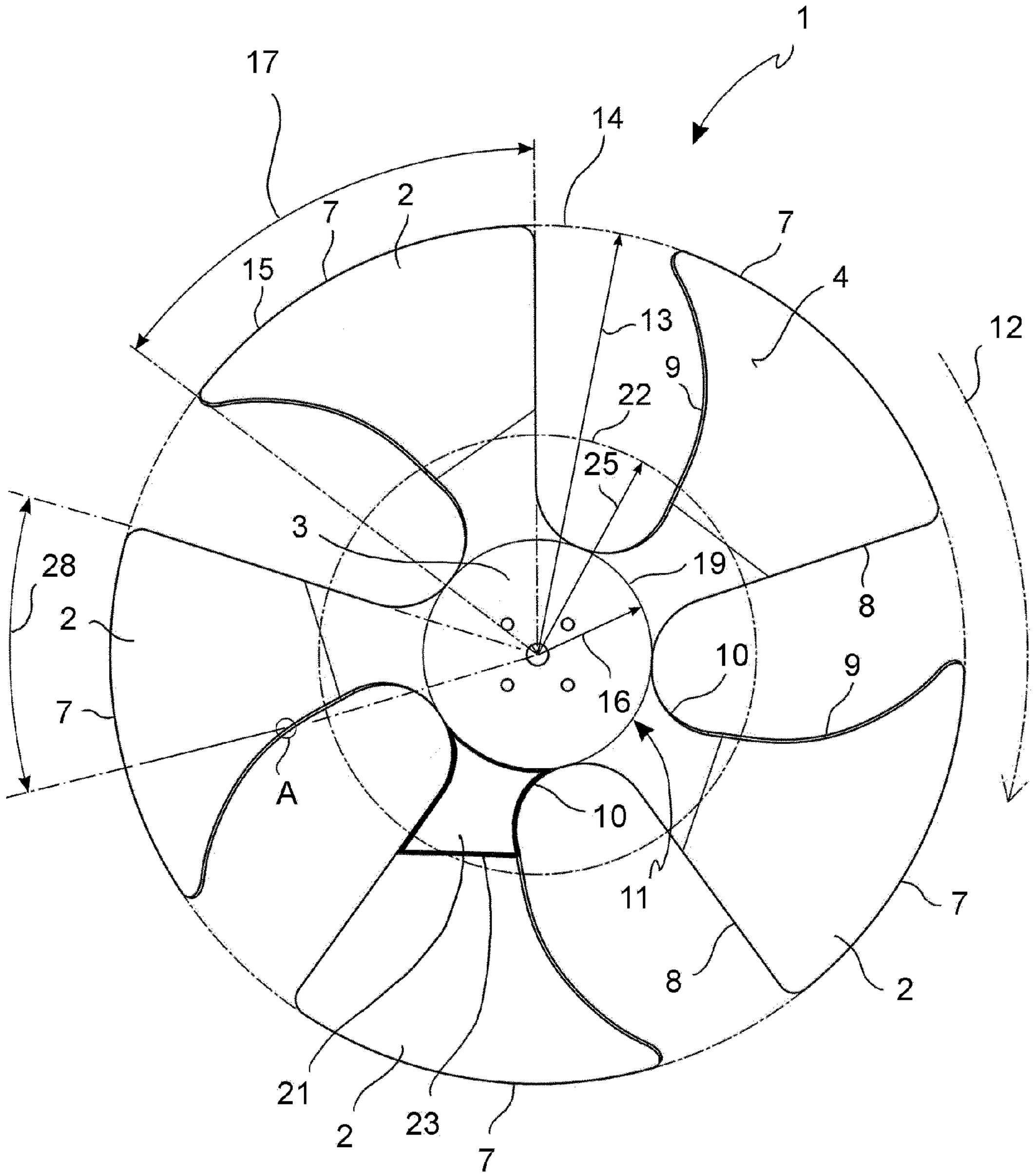

FIG. 1

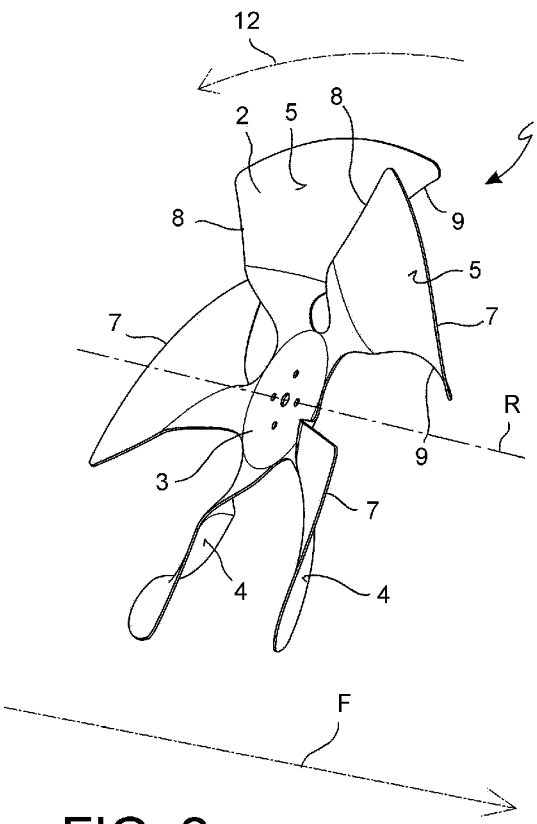

FIG. 2

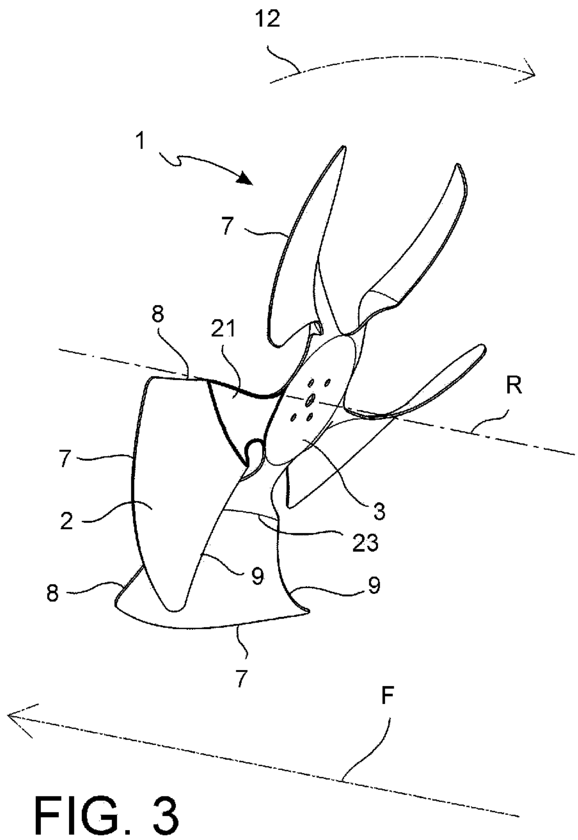

FIG. 3

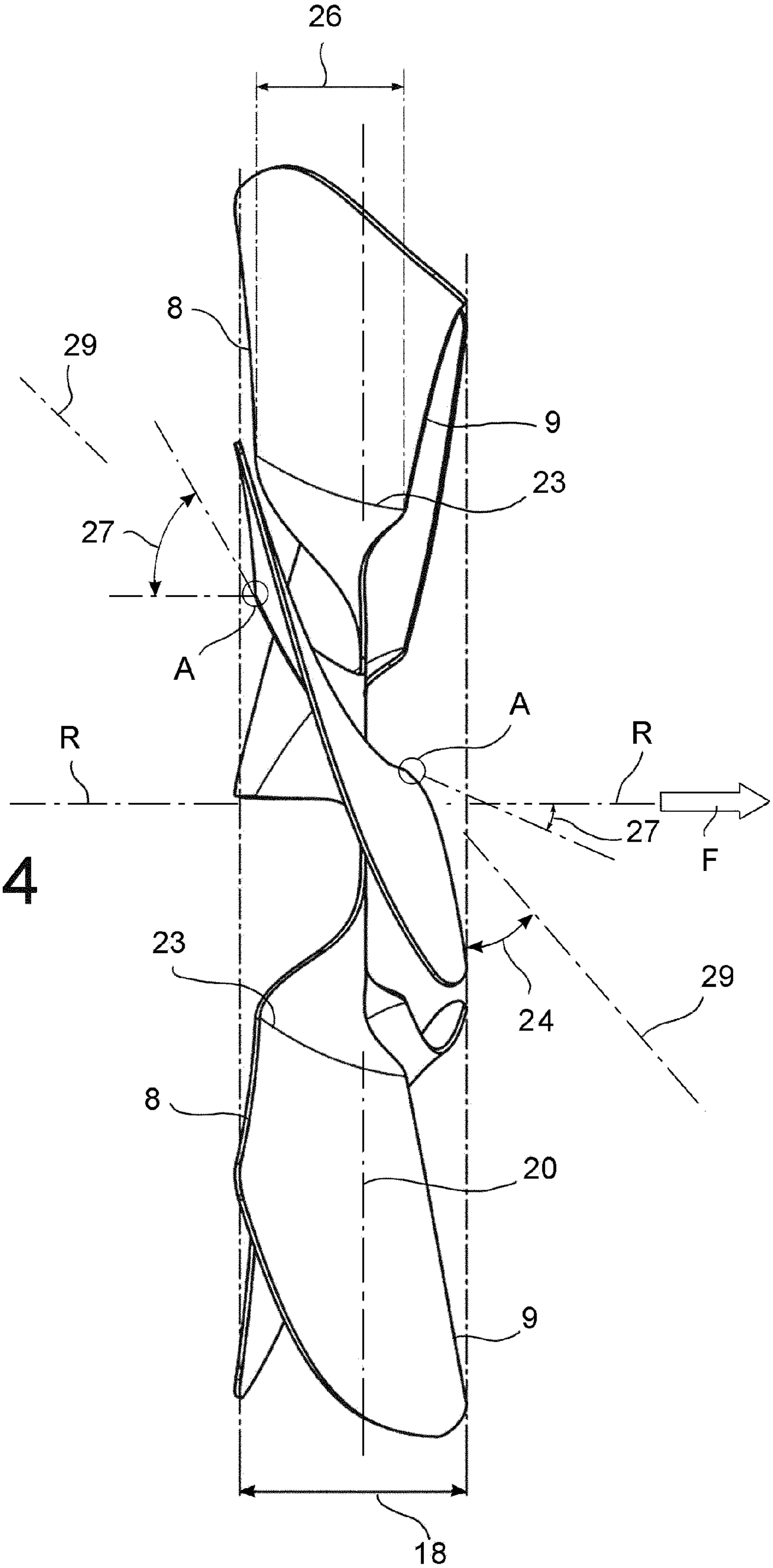

FIG. 4

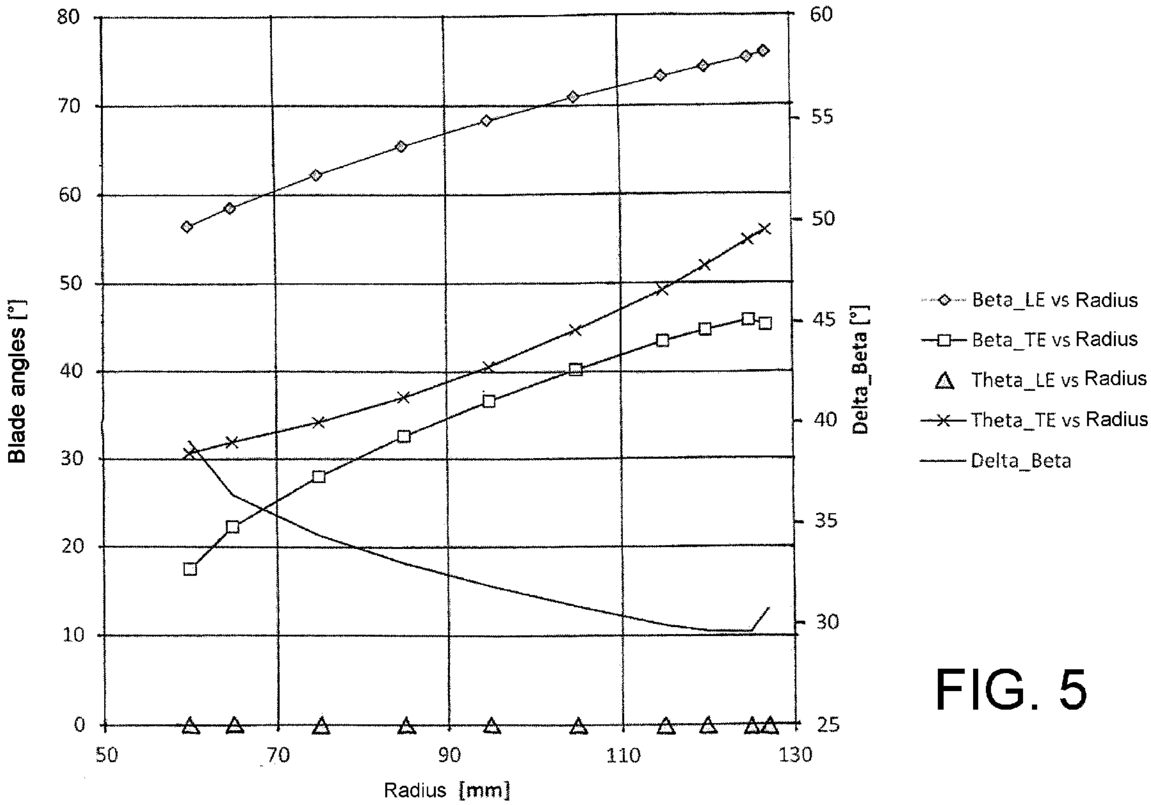
Blade angles [°]
Delta_Beta [°]
Radius [mm]
Beta_LE vs Radius
Beta_TE vs Radius
Theta_LE vs Radius
Theta_TE vs Radius
Delta_Beta
80
70
60
50
40
30
20
10
0
60
55
50
45
40
35
30
25
50
70
90
110
130

FIG. 5

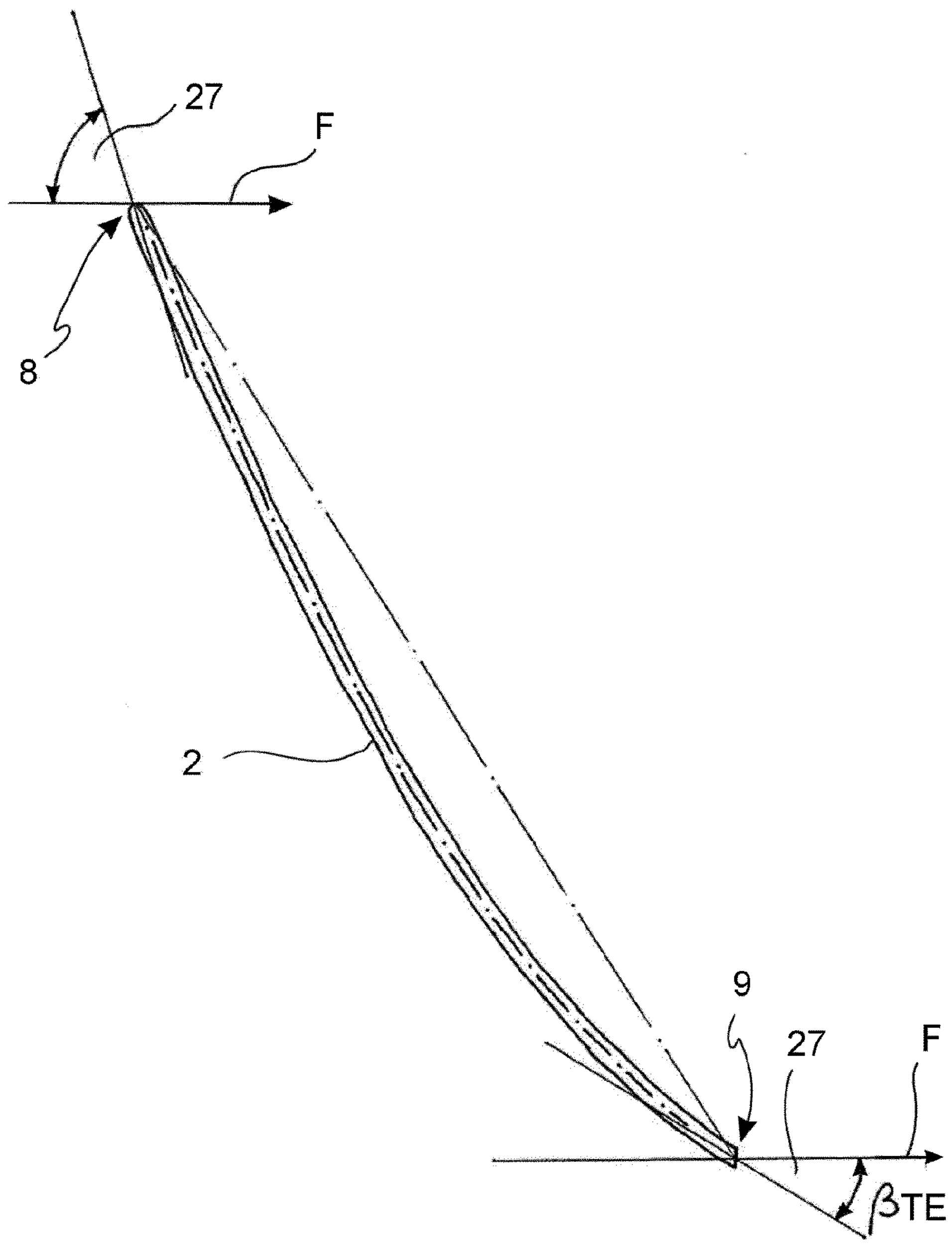

FIG. 6

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 13 16 0281

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	EP 0 259 061 A2 (SEIKO ELECTRONIC COMPONENTS [JP]) 9 March 1988 (1988-03-09) * column 3, line 12 - line 28; figures 4,5 * * column 4, line 9 - line 55 *	1,5,7	INV. F04D29/38
A	GB 401 625 A (BRITISH THOMSON HOUSTON CO LTD) 16 November 1933 (1933-11-16) * page 2, line 36 - line 90; figure 1 * * page 4, line 25 - line 32; figure 3 *	1	
A	FR 1 399 313 A (ROTRON MFG COMPANY) 14 May 1965 (1965-05-14) * page 2, last paragraph - page 3, paragraph 2; figures 1,3 *	1	
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F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 June 2013	Di Giorgio, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons
& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 16 0281

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82