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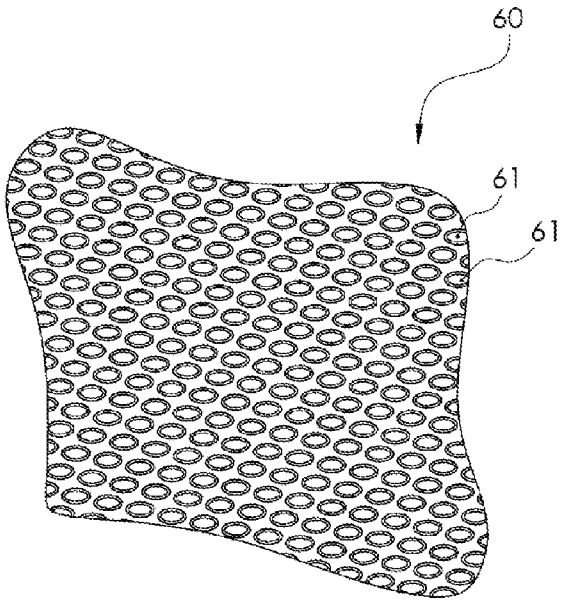

Fig. 4A

(57) Abstract: The invention relates to a device for converting wind energy to at least mechanical energy, comprising a rotor drivable rotatably about a rotation axis by wind and a duct disposed round the rotor, wherein a central axis of the duct substantially coincides with the rotation axis of the rotor, wherein an inner surface of the duct and/or rotor blades of the rotor is/are provided with a structure, which structure has a pattern of recesses for receiving substantially stationary air.

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DEVICE FOR CONVERTING WIND ENERGY INTO AT LEAST MECHANICAL ENERGY

The invention relates to a device for converting wind energy to at least mechanical energy, comprising a rotor drivable rotatably about a rotation axis by wind and a duct disposed round the rotor, wherein a central axis of the duct substantially coincides with the rotation axis of the rotor.

Such a device for converting wind energy to at least mechanical energy is per se known and also referred to as a wind turbine or windmill. The invention can relate particularly to a relatively small wind turbine, also referred to as a microturbine or urban wind turbine, which wind turbine can be set up in an urban environment, and in particular optionally on a building. The invention can relate more particularly to a so-called horizontal wind turbine, wherein in use of the wind turbine the rotation axis of the rotor and the central axis of the duct are disposed substantially horizontally.

It is an object of the invention to improve the per se known device of the type stated in the preamble. A particular object of the invention can be to increase the efficiency of the per se known device.

This object is achieved with a device of the type stated in the preamble which is characterized according to the invention in that an inner surface of the duct and/or rotor blades of the rotor is/are provided with a structure, which structure has a pattern of recesses for receiving substantially stationary air.

An advantage of the pattern of recesses according to the invention, which serve to receive substantially stationary air, is that the surface of the duct and/or the rotor blades in contact with the airflow flowing in the duct consists partially of the stationary air present in the recesses. For the part where the airflow is in contact with the stationary air present in the recesses air-to-air friction will occur, which provides for a lower friction than the parts where the airflow is in contact with the duct and/or the rotor blades. The efficiency of the device can increase as a result of the reduction in the air friction, and thereby the increase in the flow section, of the airflow.

In an embodiment of the device according to the invention the characteristic dimensions of the structure lie in the order of magnitude of several μm to several mm.

Applicant has found that, when the recesses have a determined form and/or geometry and/or are disposed in a suitable manner, the recesses can provide the intended effect of receiving stationary air in effective manner. The recesses according to the invention are characterized for this purpose by one of the following features or a random combination thereof:

- a depth of each recess is between 0.1 x - 2 x the length of each recess;
- a width of each recess is between 0.8 x - 3.5 x the length of each recess;
- the recesses have an elliptical shape, a longitudinal axis of which is disposed at an angle relative to the central axis, wherein the angle lies for instance between 0° and 45°;

- the peripheral wall of each recess extends at an angle to the inner surface of the duct, wherein the angle lies for instance between 90 and 100°;

- the peripheral wall of each recess is connected at a rounded angle to the bottom of each recess, wherein the rounded angle has for instance a radius of between 0 x - 1 x the length of each recess;

- the recesses are disposed adjacently of each other in a number of substantially straight lines, wherein the straight line extends at an angle relative to the central axis, wherein the angle lies for instance between 0° and 90°, wherein a centre-to-centre distance between two recesses disposed adjacently of each other in one line lies for instance between 1 x - 4 x the width of each recess, and wherein the recesses of two mutually adjacently disposed lines of recesses are for instance arranged offset relative to each other, wherein the offsetting is for instance greater than 0 x the length of each recess and a maximum of 2 x the length of each recess.

In an embodiment the device according to the invention is provided with guide means disposed upstream of the rotor for guiding the wind in a substantially helical movement round the central axis during use of the device such that the wind is supplied in the substantially helical movement round the central axis to the rotor, which guide means comprise a number of stator blades disposed in the duct, which stator blades extend radially outward from the central axis, and wherein the stator blades are provided with a structure, which structure has a pattern of recesses for receiving substantially stationary air. The structure can comprise one or more of the above stated features.

In another embodiment the device according to the invention is provided with guide means disposed downstream of the rotor for guiding the wind away in a substantially downstream direction, which guide means comprise a number of rear stator blades disposed in the duct, which rear stator blades extend radially outward from the central axis, and wherein the rear stator blades are provided with a structure, which structure has a pattern of recesses for receiving substantially stationary air. The structure can comprise one or more of the above stated features.

The invention will be further elucidated with reference to the figures shown in a drawing, in which

- figures 1A-1D show schematically the wind turbine according to a first embodiment of the invention, wherein figure 1A is a perspective view from a wind inlet side, figure 1B is a side view, figure 1C is a perspective view from a wind outlet side, and figure 1D is a longitudinal vertical cross-section;

- figure 2 shows schematically a perspective view of rotor and guide blades disposed in a duct of the wind turbine of figure 1;

- figures 3A and 3B show schematically in detail the valves on the wind outlet opening, wherein figure 3A shows the valves in an open state and figure 3B shows the valves in a closing

state;

- figures 4A-4C show schematically a nanostructure which can be arranged on a number of surfaces of the wind turbine, wherein figure 4A is a top view of the nanostructure, figure 4B shows a detail of figure 4A and figure 4C shows a cross-section through the nanostructure.

- figures 5A-5E show schematically a rotor of the wind turbine of figure 1, wherein figure 5A is a perspective front view, figure 5B is a front view, figure 5C is a section in the longitudinal direction of the rotor of figure 5B; figure 5D shows a pressure side of a rotor blade and figure 5E is a rear view of the rotor blade; and

- figures 6A and 6B show schematically the wind turbine according to a second embodiment of the invention, wherein figure 6A is a perspective view from a wind inlet side and figure 6B is a front view.

The various aspects of the invention will be elucidated with reference to the figures. The same elements will be designated here with the same reference numerals. The different aspects of the invention can be applied individually or in any random combination.

Figures 1A-1D show a wind turbine 1 according to a first embodiment of the invention. Wind turbine 1 comprises a duct 2 with a central axis 3. A rotor 4 is disposed in duct 2, wherein the central axis 3 of duct 2 substantially coincides with a rotation axis of rotor 4. Duct 2 has a wind inlet opening 5 and a wind outlet opening 6. In this first embodiment wind inlet opening 5 and wind outlet opening 6 are circular.

According to an aspect of the invention, duct 2 is provided on its outer side close to wind inlet opening 5 with a number of wind capture elements 7, in this example three, extending radially outward. Each wind capture element 7 is provided with a channel 8 extending to the inner side of duct 2. The three wind capture elements 7 are arranged distributed at an equal mutual angular distance over the outer surface of duct 2. Each channel 8 extends over substantially its full length in helical form in flow direction round the central axis through duct 2, and debouches with an outlet opening 9 on the inner surface of duct 2. Wind capture elements 7 capture wind flowing on the outer side of duct 2 and feed this wind in helical form to the inner surface of duct 2 via outlet openings 9.

According to another aspect of the invention, see also figure 2, wind turbine 2 comprises a number of stator blades 10, in this example six, which are disposed upstream of rotor 4 in duct 2 and which extend radially outward from the central axis 3. Stator blades 10 have a main plane which extends radially from central axis 3 and which is disposed at an oblique angle relative to central axis 3. Because of the oblique angle of the main plane of stator blades 10 the wind flow flowing in duct 2 is guided in an oblique direction relative to central axis 3 so that the wind flow is guided in a substantially helical movement round the central axis 3. Each stator blade 10, in particular the main plane thereof, is provided with a number of upright ribs 11, in this example

three. The upright ribs 11 extend from the pressure side of each stator blade 10 from an upstream wind entry side of blade 10 to a downstream wind exit side of stator blade 10. Ribs 11 extend obliquely outward as seen in radial direction over the wind guiding surface so that on the wind exit side each rib 11 is located at a greater radial distance from the central axis than on the wind entry side. The ribs support the change in the flow direction of the airflow to said helical movement round central axis 3. The desired angle of the helical movement of the wind round central axis 3 is preferably adjustable. Stator blades 10 are connected for this purpose to a connecting shaft 12 extending radially from central axis 3, which connecting shafts 12 are each connected at their radial outer end to duct 2. Stator blade 10 is pivotable about or with connecting shaft 12 for the purpose of adjusting the oblique angle of stator blade 10 relative to central axis 3. Each stator blade 10 is provided with a number of openings 13, in this example three. On the wind exit side each stator blade 10 is provided with a substantially sine-shaped end edge 14, the second derivative of which changes sign more than once.

According to another aspect of the invention, see figure 1D, the inner side of duct 2 takes the form, from wind inlet opening 5 up to for instance the location where connecting shaft 12 is disposed, of a Venturi narrowing in flow direction. In a part of duct 2 where rotor 4 is disposed the inner side of duct 2 is substantially cylindrical. Particularly the combination of the Venturi form of the inner side of duct 2 and the stator blades 10 ensures that the wind flows in helical form with a radially outward component upstream of the stator blades 10, so that the diameter of the wind flow supplied to wind turbine 2 upstream of wind inlet opening 5 increases in upstream direction, see also figure 1A.

According to another aspect of the invention, see figure 1D and figure 2, wind turbine 2 comprises a number of rear stator blades 20, in this example six, disposed in duct 2 downstream of rotor 4 and substantially connecting thereto for guiding the wind away from rotor 4 in a substantially downstream direction. Rear stator blades 20 extend radially outward from central axis 3. Each rear stator blade 20 is provided with a number of upright ribs 21, in this example three. Upright ribs 21 extend from the pressure side of each rear stator blade 20 from an upstream wind entry side of blade 20 to a downstream wind exit side of rear stator blade 20. Ribs 21 extend obliquely outward as seen in radial direction with a determined curvature over the wind guiding surface so that on the wind exit side each rib 21 is located at a greater radial distance from central axis 3 than on the wind entry side. Ribs 21 substantially convert a possible helical airflow coming from rotor 4 to a radially outward expanding airflow flowing substantially parallel to central axis 3. The angle of rear stator blades 20 to the central axis is preferably adjustable. Rear stator blades 20 are connected for this purpose to a connecting shaft 22 extending radially from central axis 3, which connecting shafts 22 are each connected at their radial outer end to duct 2. Rear stator blade 20 is pivotable about or with connecting shaft 22 for the purpose of adjusting the angle of rear

stator blade 20 relative to central axis 3. On the wind exit side each rear stator blade 20 is provided with a substantially sine-shaped end edge 24, the second derivative of which changes sign more than once. Each rear stator blade 20 has substantially two blade parts 25, 26 disposed at an angle α4 relative to each other, wherein blade part 25 substantially connects to rotor 4 and blade part 26 is disposed downstream of blade part 25. Depending on the adjusted angle of rear stator blade 20, blade part 25 can extend substantially at an angle to central axis 3 and blade part 26 can extend substantially parallel to central axis 3. The angle α1 between blade parts 25, 26 is in this example around 130°. Blade part 26 has an increasing height so that the wind is guided substantially radially outward, and thereby expands. The increasing height of blade part 26 is optionally adapted to the form of the inner side of that part of duct 2 where blade part 26 is disposed, as will be further elucidated below.

According to another aspect of the invention, see figure 1D, a part of duct 2 extending from rotor 4 to wind outlet opening 6 widens in flow direction, particularly in the form of a Venturi. Duct 2 widens in Venturi form particularly on both its inner side and its outer side. Due to the Venturi form of the outer side of duct 2 the airflow flowing on the outer side of duct 2 is guided radially outward to some extent, whereby an underpressure is created in the area of outlet opening 6. An outlet angle α11 of wind outlet opening 6 to central axis 3 is in this example about 60°.

As elucidated above with reference to rear stator blades 20 and as shown in figure 1D and figure 2, the height of blade part 26 can be adapted here to the inner side of duct 2 widening in the form of a Venturi. A tangent of an upper edge 27 of each rear stator blade 20, and in particular of blade part 26 thereof, can make an angle α2 with central axis 3 which is adapted to the inner side of duct 2 widening in the form of a Venturi, and thereby increases in this example along its length in downstream direction from about 20° to about 80°.

According to another aspect of the invention, duct 2 has a thickness and/or form such that the flow distance of the wind through duct 2 is smaller than the flow distance round the outer side of duct 2, and that because of the form the flow direction round the outer side of duct 2 changes direction at the position of wind outlet opening 6. An underpressure is hereby created in the area of outlet opening 6.

According to another aspect of the invention, the diameter of wind outlet opening 6 of the duct is greater than an outer diameter of wind inlet opening 5 of duct 2.

According to another aspect of the invention, the outer periphery of duct 2 is provided with a helical upright rib 30. This lengthens the flow distance of the wind on the outer side of duct 2 compared to the flow distance of the wind through the inner side of duct 2, and it changes the flow direction round the outer side of duct 2. An underpressure is hereby created in the area of outlet opening 6.

According to another aspect of the invention, see also figures 3A, 3B, wind turbine 1 is

provided in the area of wind outlet opening 6 of duct 2 with a number of annular elements 40, in this case two, disposed concentrically with outlet opening 6. Annular elements 40 each have a different diameter which are both smaller than the diameter of outlet opening 6. Annular elements 40 each comprise a cylindrical peripheral surface which extends obliquely outward in downstream direction at an angle to central axis 3. Annular elements 40 are therefore substantially conically widening annular elements. Due to the outward tapering form of annular elements 40 the wind flowing out of outlet opening 6 is guided radially outward. Arranged on duct 2 extending over the periphery of outlet opening 6 is a flexible valve 41 which is connected with one end zone to duct 2. Arranged on the outer annular element 40 is a flexible valve 41 which extends over the periphery thereof and which is connected with one end zone to annular element 40. In figure 3A valves 41 are shown in their open state, in which they leave outlet opening 6 substantially clear. The wind flowing out of wind outlet opening 6 moves the valves automatically into this open state. When the wind turns and threatens to flow into duct 2 via outlet opening 6, the wind pushes valves 41 automatically to their closing state as shown in figure 3B. In the closing state the valve 41 connected to duct 2 lies with its free end zone against the outer annular element 40, and the valve connected to the outer annular element 40 lies against the inner annular element 40 so that valves 41 substantially close at least the peripheral zone of wind outlet opening 6. Particularly the valve 41 connected to outlet opening 6 substantially closes the space between outlet opening 6 and the outer annular element 40. Particularly the valve 41 connected to outer annular element 40 substantially closes the space between outer annular element 40 and inner annular element 40. Bounding elements in the form of rods 42 extend between the peripheral end zone of outlet opening 6 of duct 2 and outer annular element 40 and between outer annular element 40 and inner annular element 40. These rods 42 prevent the flexible valves 41 blowing the valves 41 further inward from their closing state by the wind threatening to flow into outlet opening 6. In this example the inner annular element 40 is not provided with a valve, so that a central part of outlet opening 6 cannot be closed. This inner annular element 40 can if desired also be provided with a valve so that the central part of outlet opening 6 can be closed and outlet opening 6 can be substantially completely closed.

Wind turbine 1 according to the invention can particularly be a relatively small wind turbine, also referred to as a microturbine or urban wind turbine, which wind turbine can be set up in an urban environment, and in particular optionally on a building. Wind turbine 2 can for this purpose comprise a leg 50, using which the wind turbine can be set up. As shown in the figures, wind turbine 1 is particularly a so-called horizontal wind turbine, wherein the rotation axis of the rotor and the central axis 3 of duct 2 are disposed substantially horizontally during use of wind turbine 1.

An inner surface of the duct and/or rotor blades of the rotor is/are provided with a

structure, which structure has a pattern of recesses for receiving substantially stationary air.

Figures 4A-4C show a nanostructure 60 which can for instance be arranged on the inner surface of duct 2 and/or on stator blades 10 and/or on rear stator blades 20. Nanostructure 60 has a pattern of recesses 61 for receiving substantially stationary air. The dimensions of recesses 61 lie in the order of magnitude of several μm to several mm. In this example the dimensions are substantially oval, but can take any desired form. In this example the length 62 of each recess is about 4.2 mm. The width 63 of each recess in this example is about 2.3 mm. In this example the depth 64 of each recess is about 0.7 mm. The peripheral wall of each recess 61 extends in this example at an angle α3 to the inner surface of the duct and/or the surface of stator blade 10 and/or rear stator blade 20, wherein the angle α8 is in this example about 95°. The peripheral wall of each recess 61 is connected in this example at a rounded angle 65 to the bottom of each recess, wherein the rounded angle 65 in this example has a radius of about 0.6 mm. In this example the recesses 61 are disposed adjacently of each other in a number of substantially straight lines 69, wherein the straight line extends at an angle α4 relative to the central axis 3, wherein the angle α4 in this example is about 41°. In this example a centre-to-centre distance 66 between two recesses 61 disposed in one line adjacency of each other is about 3.8 mm. In this example recesses 61 of two mutually adjacent lines 69 of recesses 61 are disposed offset relative to each other, wherein the offsetting 67 in a direction perpendicularly of the longitudinal direction of duct 2 is in this example about 1.1 mm. A centre-to-centre distance 68 between two adjacent recesses 61 of adjacent lines 69 is in this example about 5.2 mm.

Figures 5A-5E show a rotor according to an aspect of the invention. The rotor comprises a number of rotor blades 70, in this example six, which are connected with a peripheral edge to a rotor body 71 of a generator, see also figure 1D. Rotor 4 is driven rotatingly by a wind flow flowing in duct 2, whereby rotor body 71 co-rotates. A stator body 77 of the generator disposed in duct 2 is arranged round rotor body 71, see figure 1D. As shown in figure 5C, rotor blades 70 are disposed at an angle α5 to rotation axis 3, this angle α5 being about 53° in this example. As shown in, among others, figures 5A, 5B and 5D, the rotor blades have a wind entry side with a front end edge 72 and a wind exit side with an end edge 73. End edge 73 is substantially sine-shaped over a curved main line 74. An angle α6 of main line 74 close to an inner end of end edge 73, which is disposed close to the rotation axis coinciding with central axis 3, relative to a straight line 75 between the inner end and the outer end of end edge 73, which is disposed close to rotor body 71, is in this example about 38°. An angle α7 of the main line 74 close to the outer end of end edge 73 relative to the straight line 75 between the inner end and the outer end is in this example about 17°. The front end edge 72 is substantially arcuate. An angle α8 of front end edge 72 close to an inner end of front end edge 72, which is disposed close to the rotation axis coinciding with central axis 3, relative to a straight line 76 between the inner end and the outer end of front end edge 72, which is

disposed close to rotor body 71, is in this example about 28°. An angle α14 of front end edge 72 close to the outer end of front end edge 72 relative to the straight line 76 between the inner end and the outer end is in this example about 48°. As can be seen in, among others, figures 5C and 5E, rotor blades 70 are twisted in a direction between an inner end zone and the peripheral edge connected to generator body 71, in this example through an angle α15 of about 5°.

Figures 6A and 6B show a wind turbine 1 according to a second embodiment of the invention. Only the differences from the wind turbine of figures 1-5 will be elucidated here, and for a further specification of figures 6A and 6B reference is made to the figure description associated with figures 1-5.

Wind turbine 1 according to the second embodiment of the invention differs from the wind turbine according to the first embodiment in that inlet opening 5 and outlet opening 6 are substantially oval-shaped instead of circular. Duct 2 transposes gradually from its oval end zones or openings 5, 6 to a round cross-sectional form so that the part of duct 2 where rotor 4 is disposed is substantially cylindrical, just as in the wind turbine according to the first embodiment.

It is noted that the invention is not limited to the shown embodiments but also extends to variants within the scope of the appended claims.

The stated values for dimensions, angles and the like are thus given only by way of example. Applicant has found that said values are particularly suitable, but the invention is thus not limited thereto.

It will also be apparent that the form of the inlet opening and/or outlet opening is not limited to the shown circular shape or oval shape, but that it can have any suitable shape. The part where the rotor is disposed is however preferably of circular cross-section, and thereby cylindrical, wherein in the case of a non-circular inlet opening or non-circular outlet opening a gradual transition to this cylindrical part will take place.

Claims

1. Device for converting wind energy to at least mechanical energy, comprising a rotor drivable rotatably about a rotation axis by wind and a duct disposed round the rotor, wherein a central axis of the duct substantially coincides with the rotation axis of the rotor, **characterized in that** an inner surface of the duct and/or rotor blades of the rotor is/are provided with a structure, which structure has a pattern of recesses for receiving substantially stationary air.

2. Device as claimed in claim 1, wherein the characteristic dimensions of the structure lie in the order of magnitude of several μm to several mm.

3. Device as claimed in claim 1 or 2, wherein a depth of each recess is between 0.1 x - 2 x the length of each recess.

4. Device as claimed in any of the foregoing claims, wherein a width of each recess is between 0.8 x - 3.5 x the length of each recess.

5. Device as claimed in any of the foregoing claims, wherein the recesses have an elliptical shape, a longitudinal axis of which is disposed at an angle relative to the central axis.

6. Device as claimed in claim 5, wherein the angle lies between 0° and 45°.

7. Device as claimed in any of the foregoing claims, wherein the peripheral wall of each recess extends at an angle to the inner surface of the duct.

8. Device as claimed in claim 7, wherein said angle lies between 90 and 100°.

9. Device as claimed in any of the foregoing claims, wherein the peripheral wall of each recess is connected at a rounded angle to the bottom of each recess.

10. Device as claimed in claim 9, wherein the rounded angle has a radius of between 0 x - 1 x the length of each recess.

11. Device as claimed in any of the foregoing claims, wherein the recesses are disposed adjacently of each other in a number of substantially straight lines, wherein the straight line extends at an angle relative to the central axis.

12. Device as claimed in claim 11, wherein the angle lies between 0° and 90°.

13. Device as claimed in claim 11 or 12, wherein a centre-to-centre distance between two recesses disposed adjacently of each other in one line lies between 1 x - 4 x the width of each recess.

14. Device as claimed in any of the claims 11-13, wherein the recesses of two mutually adjacently disposed lines of recesses are arranged offset relative to each other, wherein the offsetting is greater than 0 x the length of each recess and a maximum of 2 x the length of each recess.

15. Device as claimed in any of the claims 1-14, wherein the device is provided with guide means disposed upstream of the rotor for guiding the wind in a substantially helical movement round the central axis during use of the device such that the wind is supplied in the substantially helical movement round the central axis to the rotor, which guide means comprise a number of stator blades disposed in the duct, which stator blades extend radially outward from the central axis, and wherein the stator blades are provided with a structure, which structure has a pattern of recesses for receiving substantially stationary air.

16. Device as claimed in any of the claims 1-15, wherein the device is provided with guide means disposed downstream of the rotor for guiding the wind away in a substantially downstream direction, which guide means comprise a number of rear stator blades disposed in the duct, which rear stator blades extend radially outward from the central axis, and wherein the rear stator blades are provided with a structure, which structure has a pattern of recesses for receiving substantially stationary air.

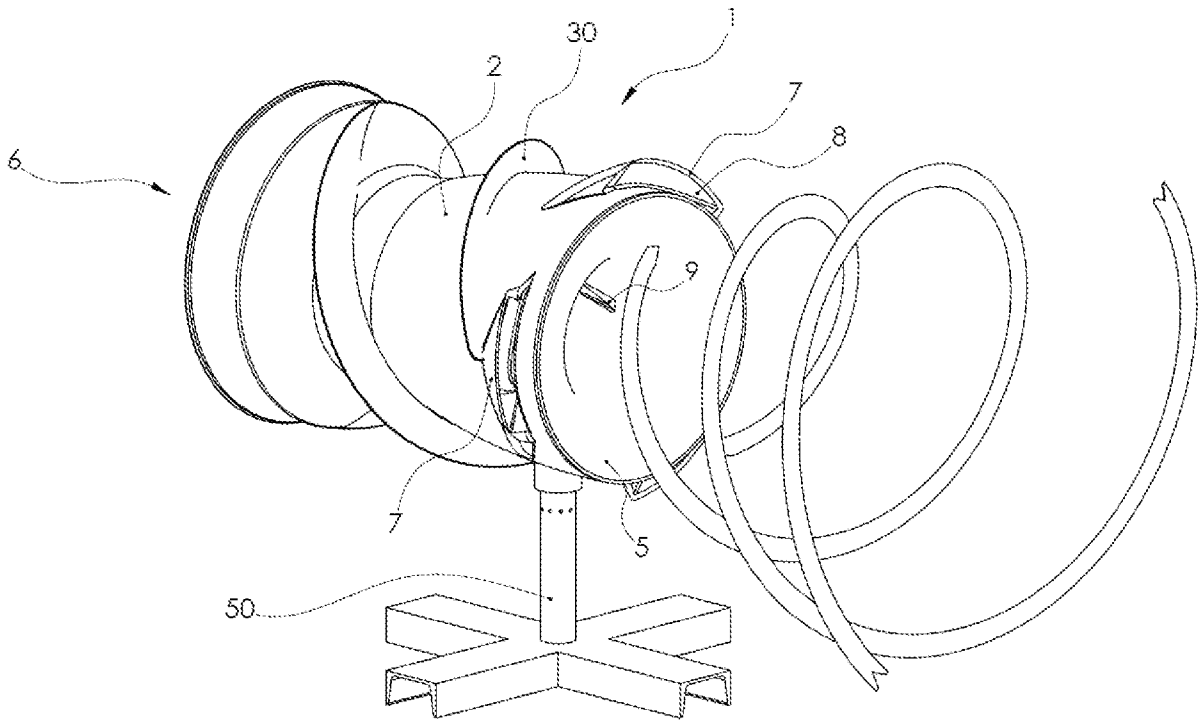

Fig. 1A

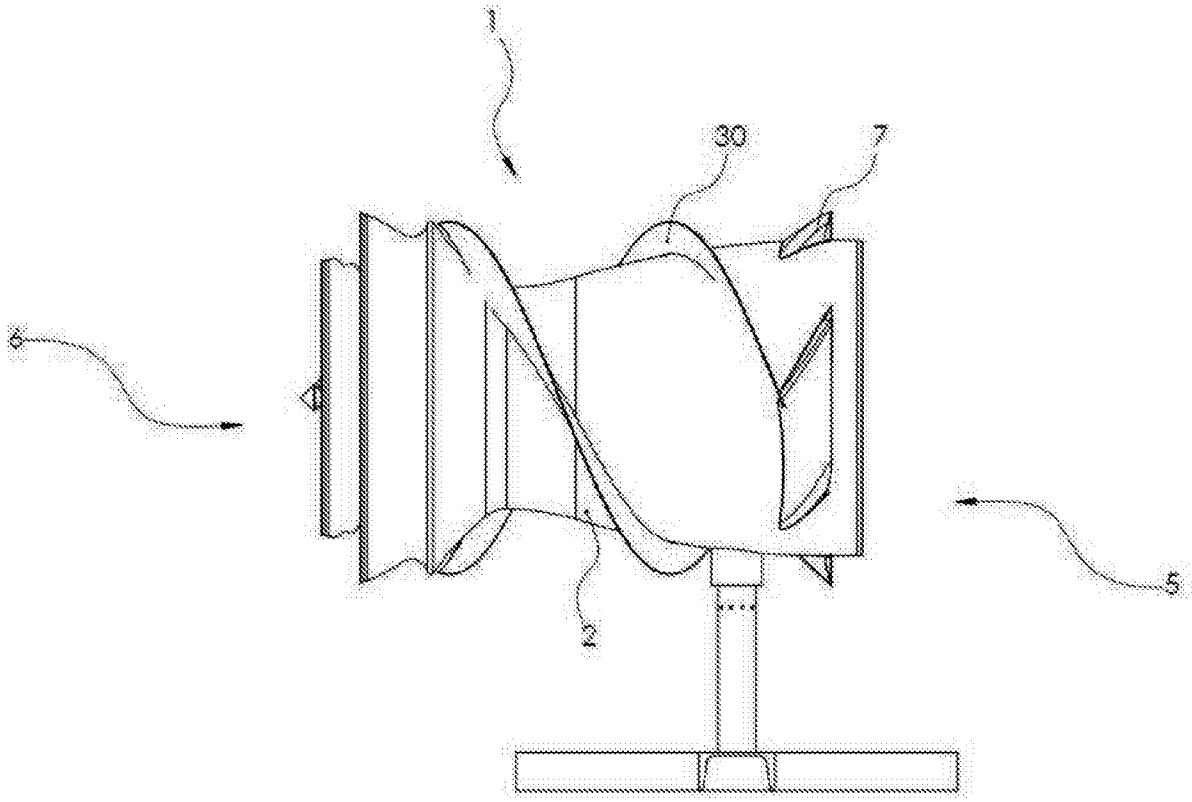

Fig. 1B

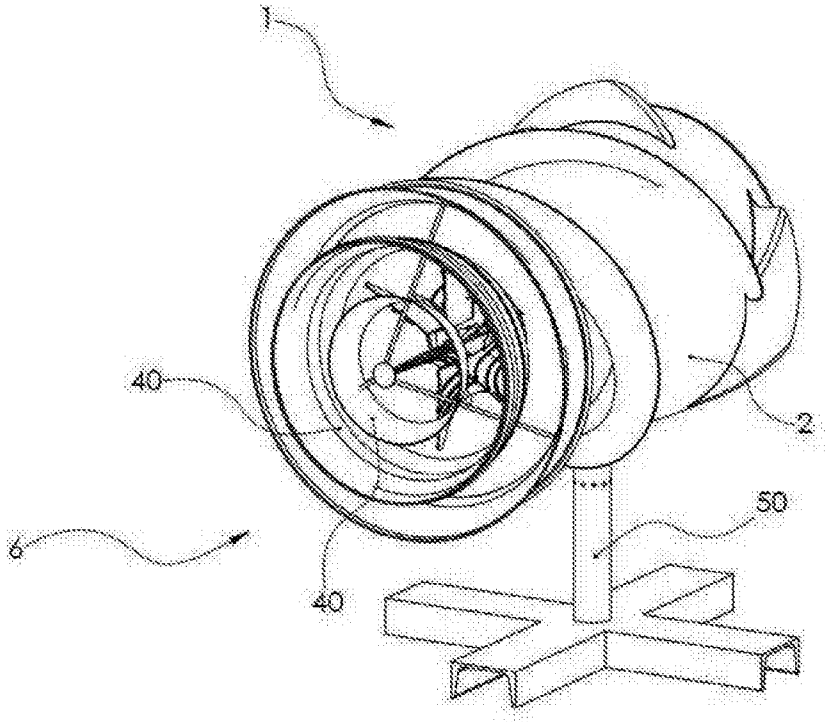

Fig. 1C

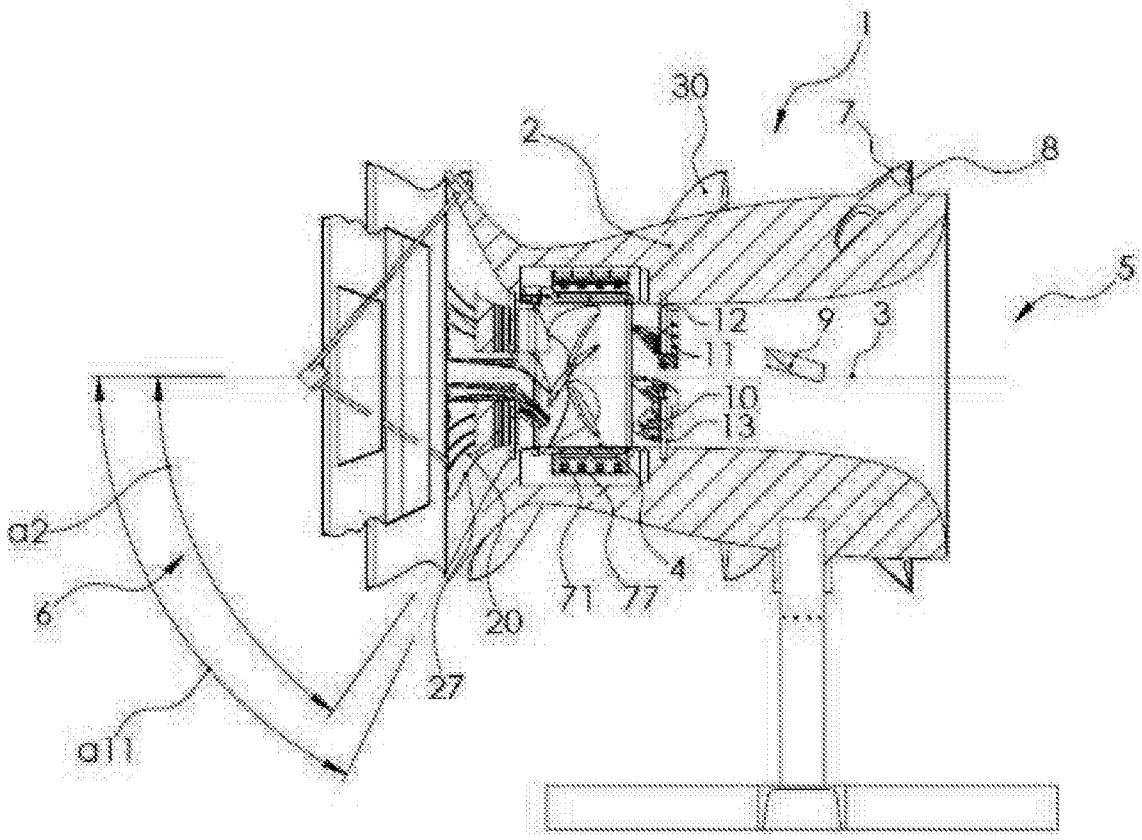

Fig. 1D

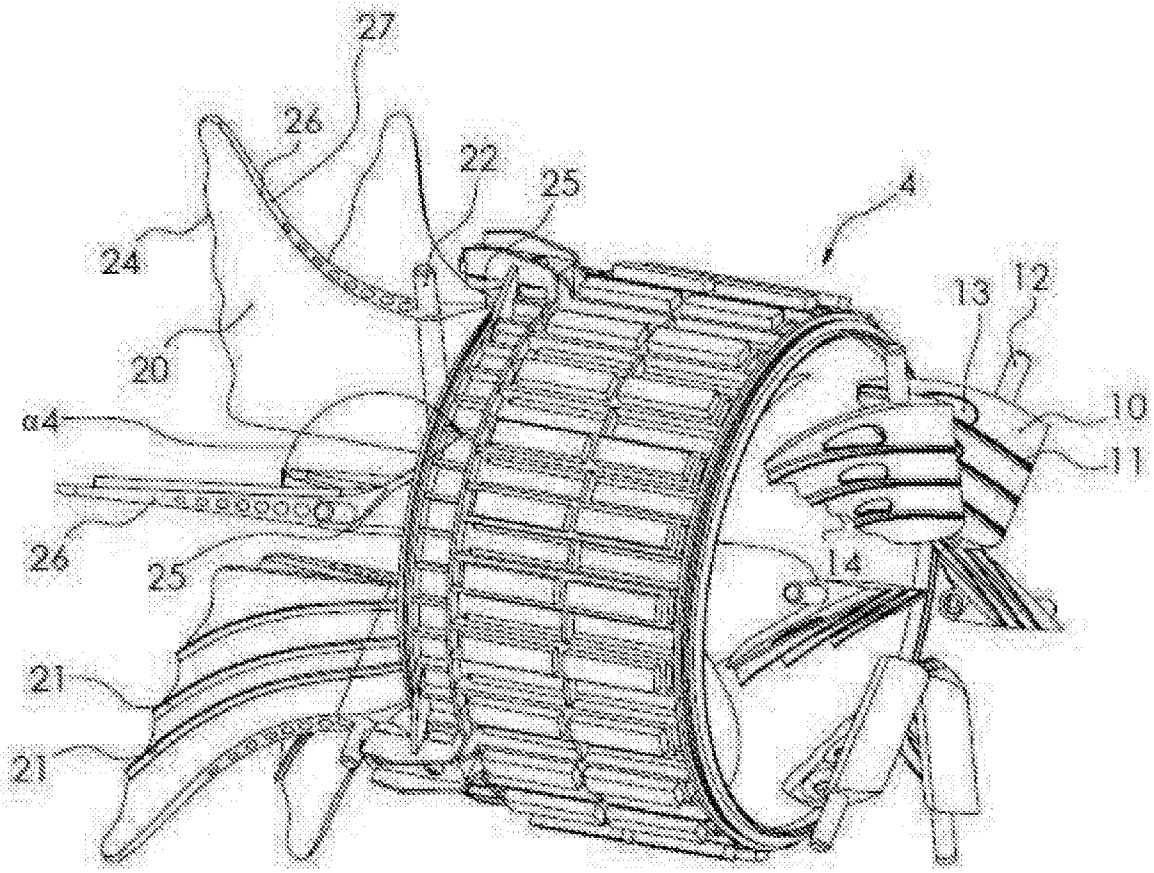

Fig. 2

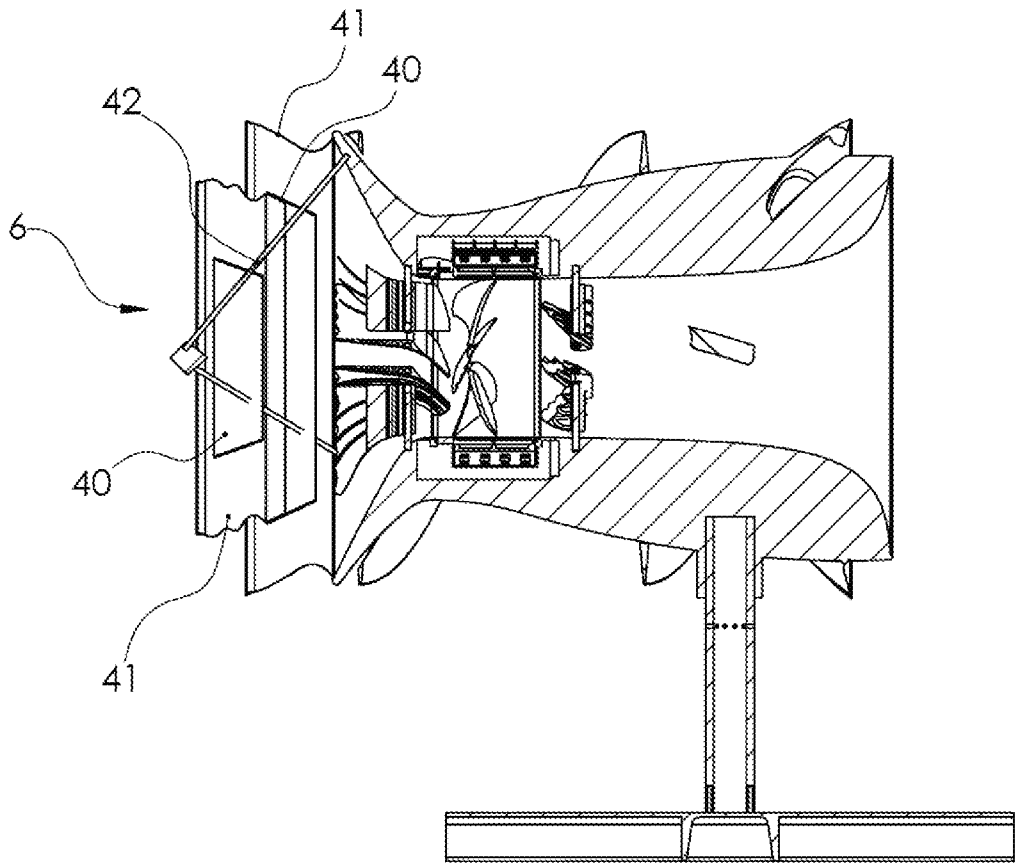

Fig. 3A

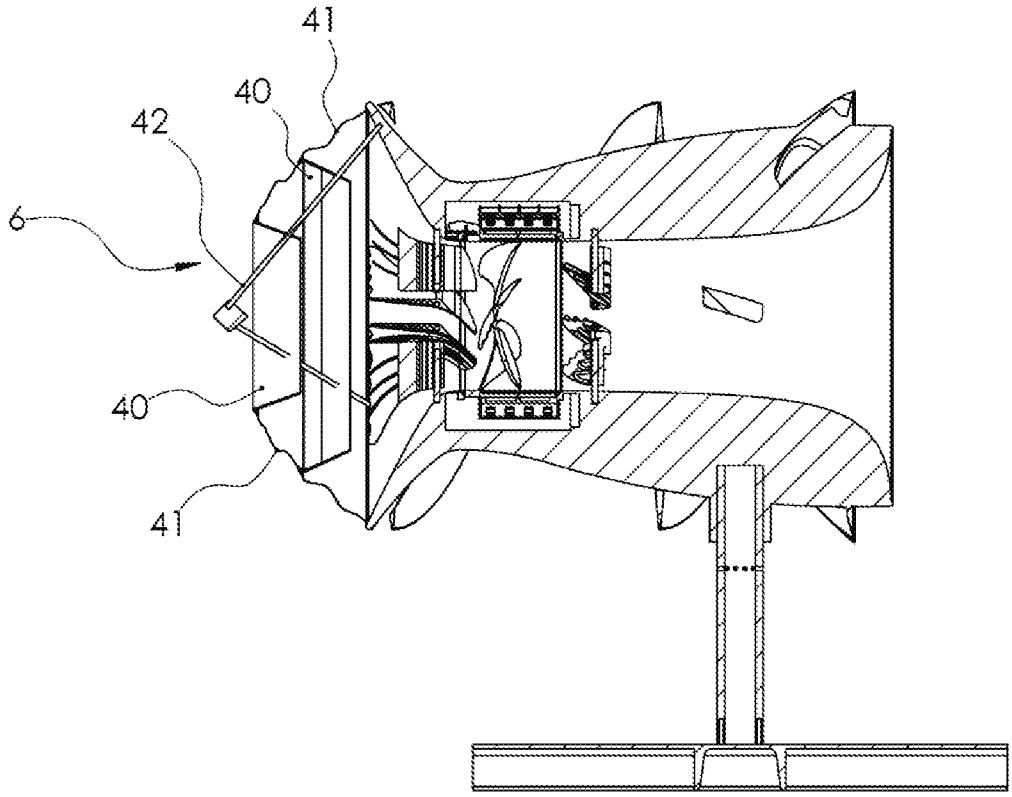

Fig. 3B

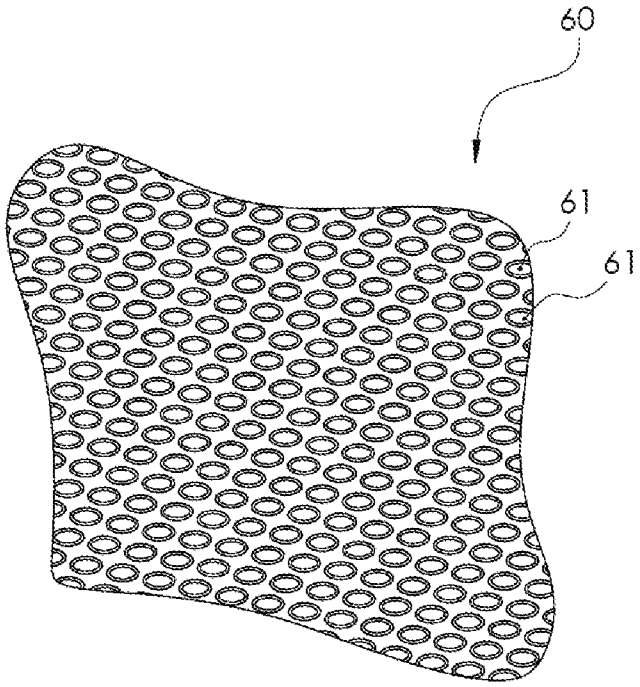

Fig. 4A

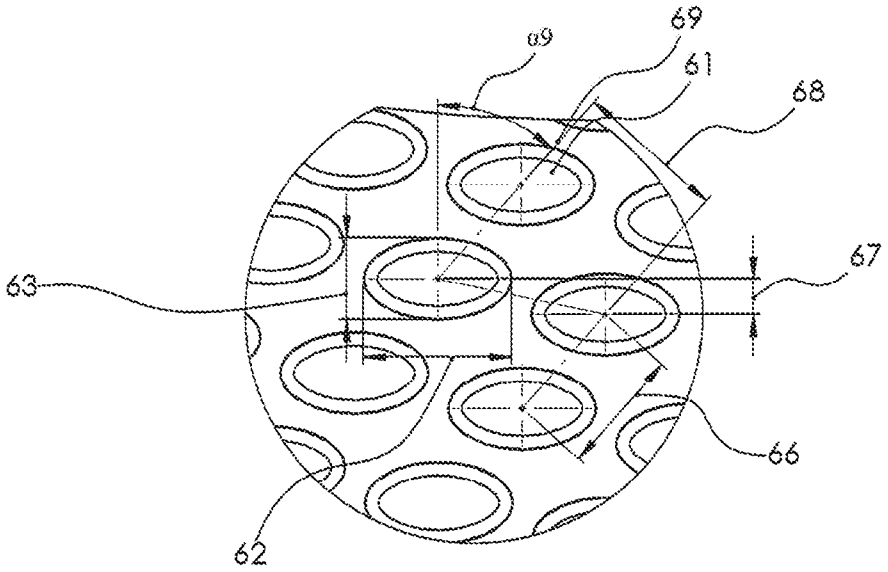

Fig. 4B

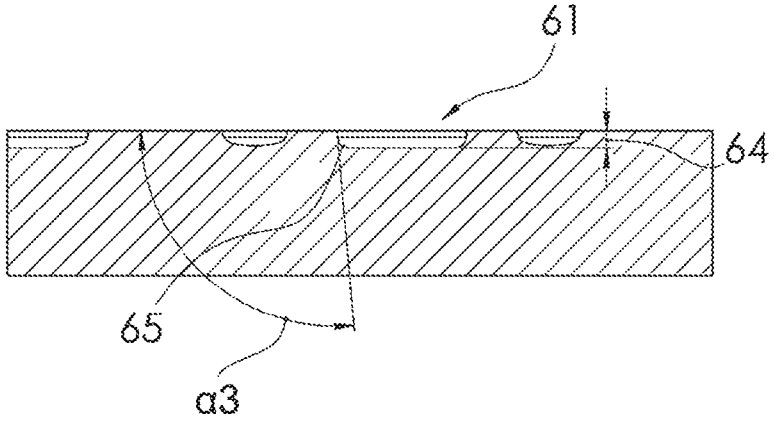

Fig. 4C

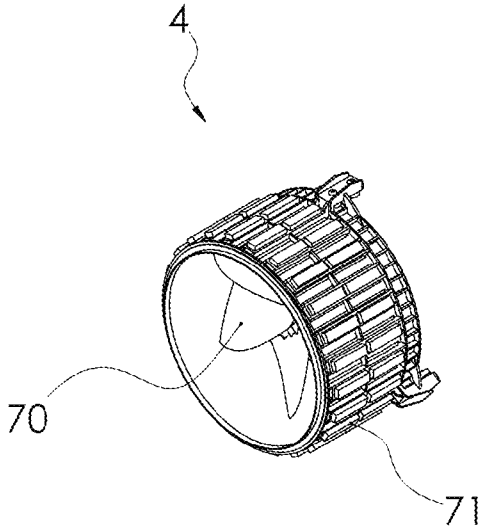

Fig. 5A

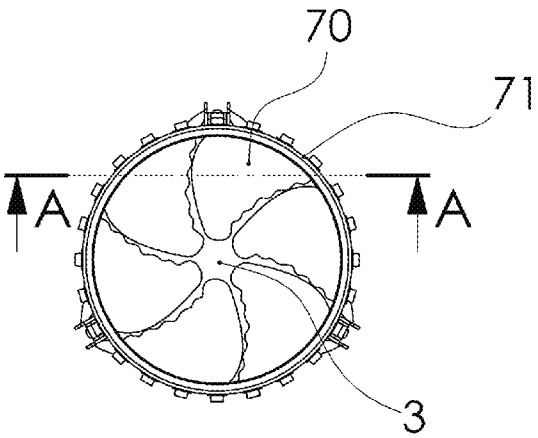

Fig. 5B

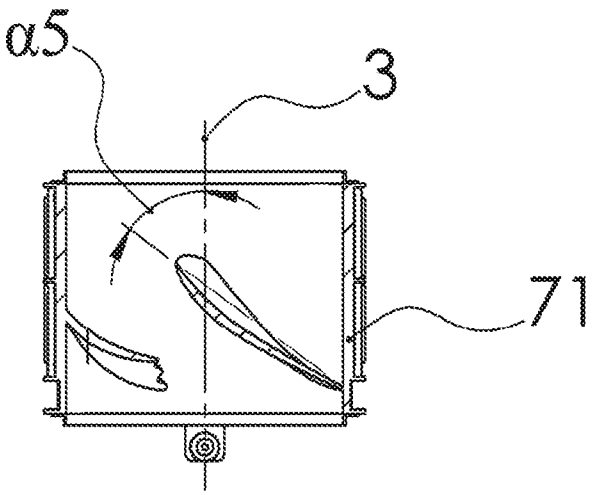

Fig. 5C

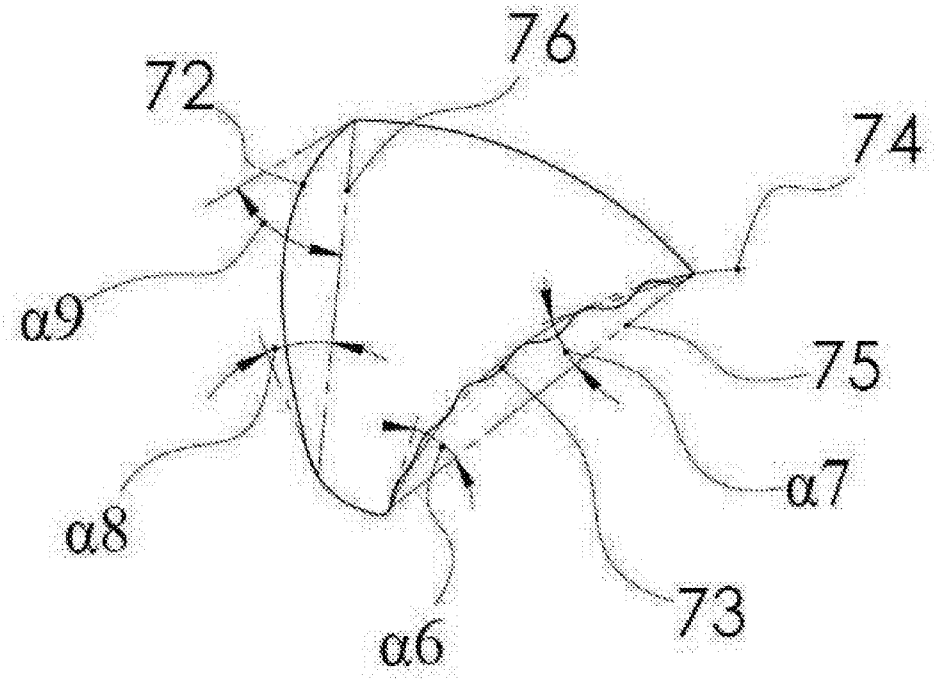

Fig. 5D

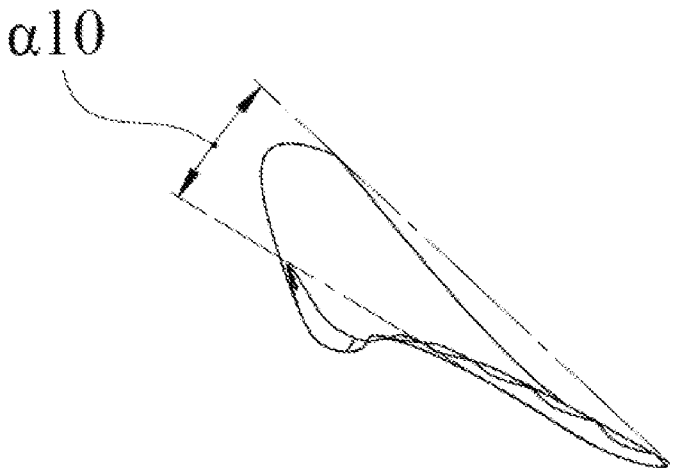

Fig. 5E

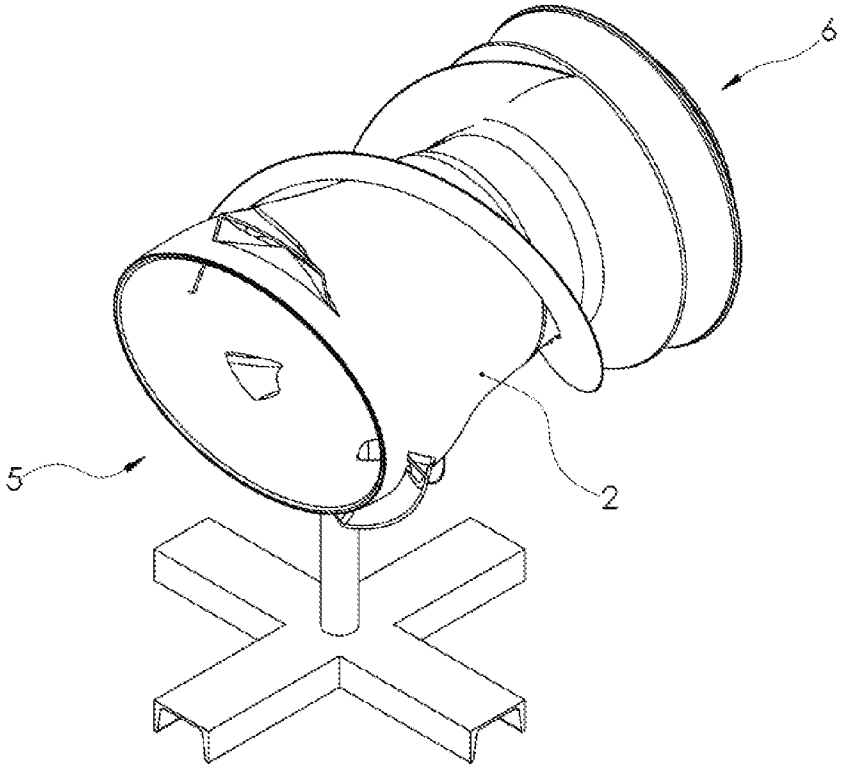

Fig. 6A

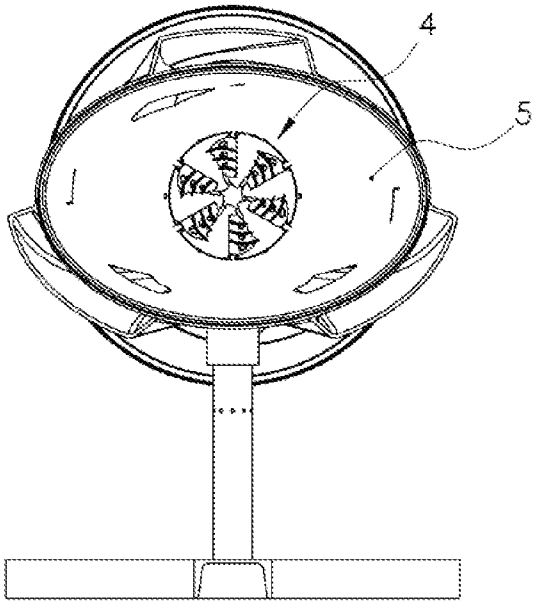

Fig. 6B

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2016/050653

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D3/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/256424 A1 (MARIN ED [US]) 11 October 2012 (2012-10-11)	1-4,7-14
Y	paragraph [0067]	15,16

Y	DE 32 26 470 A1 (SCHREIBER AUGUST [DE]) 19 January 1984 (1984-01-19) figure 1	15

Y	US 2011/037268 A1 (SAMMY JOHANN QUINCY [US]) 17 February 2011 (2011-02-17) figure 1	16

A	EP 2 412 971 A1 (UNIV KYUSHU NAT UNIV CORP [JP]) 1 February 2012 (2012-02-01) paragraph [0167]; figure 31	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 January 2017	02/02/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Biloen, David

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INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2016/050653

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/044552 A1 (SMYTH JAMES [IE] ET AL) 13 February 2014 (2014-02-13) the whole document	1
A	WO 2013/026127 A1 (CASTANON SEOANE DIEGO [CA]) 28 February 2013 (2013-02-28) the whole document	1
A	WO 2012/028890 A1 (TOULAS THEODOROS [GR]; MICHALIS EMMANUEL [GR]) 8 March 2012 (2012-03-08) the whole document	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2016/050653

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012256424 A1	11-10-2012	US 2012256424 A1	11-10-2012
		WO 2011090729 A2	28-07-2011
DE 3226470 A1	19-01-1984	NONE	
US 2011037268 A1	17-02-2011	NONE	
EP 2412971 A1	01-02-2012	CN 102365452 A	29-02-2012
		EP 2412971 A1	01-02-2012
		JP 5030122 B2	19-09-2012
		US 2012086216 A1	12-04-2012
		WO 2010109800 A1	30-09-2010
US 2014044552 A1	13-02-2014	IE S86162 B2	27-03-2013
		IE S86367 B2	26-03-2014
		US 2014044552 A1	13-02-2014
		WO 2014023739 A1	13-02-2014
WO 2013026127 A1	28-02-2013	NONE	
WO 2012028890 A1	08-03-2012	CN 102918263 A	06-02-2013
		GR 20100100474 A	30-04-2012
		WO 2012028890 A1	08-03-2012