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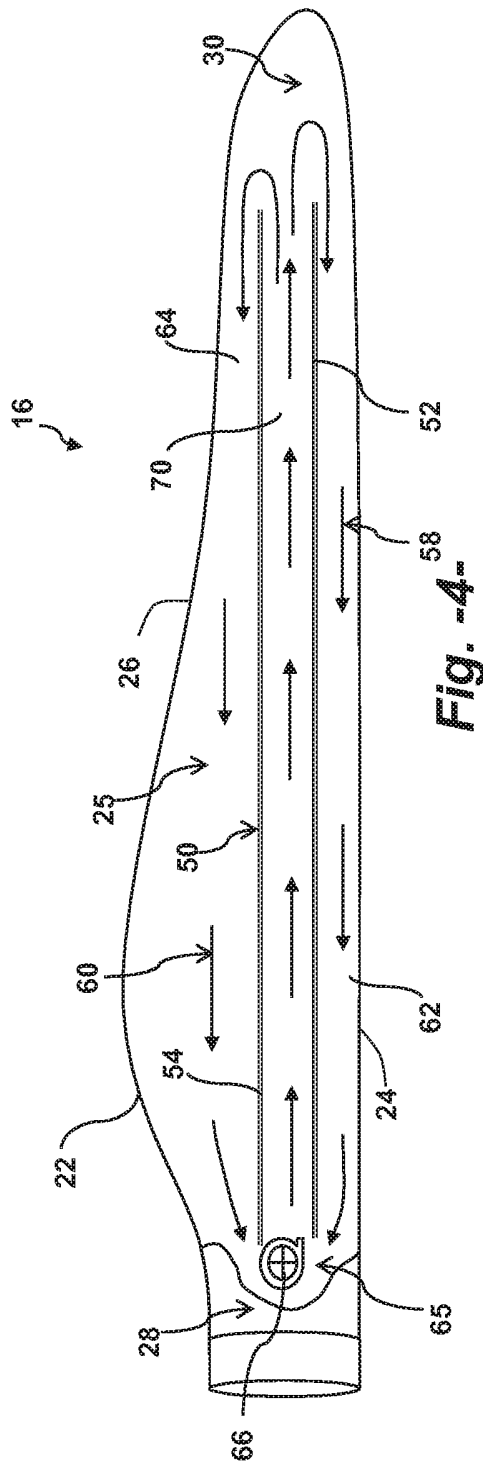
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The present invention relates to a system and a method for deicing a wind turbine rotor blade (16) which includes simultaneously directing heated air through an internal leading edge circulation loop (58) and a separate internal trailing edge circulation loop (16) within the rotor blade (16).

Fortsættes ...



SYSTEM AND METHOD FOR DEICING WIND TURBINE ROTOR BLADES

Field of the invention

5 [0001] The present invention relates generally to the field of wind turbines, and more particularly to a system and method for deicing of the rotor blades, thereby increasing the overall operational efficiency of the wind turbine.

10 Background of the invention

[0002] Wind turbines have gained increased acceptance as an environmentally safe and relatively inexpensive alternative energy source. With this growing interest, considerable efforts have been made to develop
15 wind turbines that are reliable and efficient.

[0003] Generally, a wind turbine includes a rotor having one or more blades. The rotor is mounted on a housing or nacelle, which is positioned on top of a truss or tubular tower. The turbine's blades transform wind energy into a
20 rotational torque or force that drives one or more generators that are rotationally coupled to the rotor through a gearbox. The gearbox steps up the inherently low rotational speed of the turbine rotor for the generator to efficiently convert mechanical energy to electrical energy, which is fed into a utility grid. Gearless direct drive turbines also exist.

25 [0004] Under certain combinations of atmospheric conditions, the rotor blades can become covered with ice. For an operational wind turbine, ice buildup typically occurs on the leading edge of the blade, resulting in a modified airfoil shape and reduced lifting capability. As the ice layer becomes
30 increasingly thick, weight is added to the airfoil, further reducing the lifting capability and the aerodynamic performance of the rotor blade. Ice shedding

(the throwing off of ice as the blades rotate) can also be a safety issue, particularly for wind turbines located near residential areas. For wind turbines that are stopped or idling, ice will generally form uniformly over the entire surface of the blades, thereby necessitating deicing of the entire blade before
5 the wind turbine can be placed back in operation.

[0005] Methods and devices are known and practiced for deicing rotor blades, which also encompasses preventing icing on the rotor blades when atmospheric conditions are favorable for ice formation. For example,
10 installing resistive heating wires or other electrical conductors onto the leading edge or other surfaces of the rotor blade is known. This system, however, can provide a conduit for lightning, and a lightning strike can render the rotor blade useless. In another known technique for reducing icing, an inflatable air bladder is bonded to the leading edge of the blades. However,
15 inflation of the air bladder alters the aerodynamics of the rotor blade, and the air bladder itself may be or become subject to fatigue and failure in certain environments.

[0006] The Canadian patent CA 2228145(counterpart to EP 0842360 B1)
20 describes a system for deicing wind turbine rotor blades wherein a heated medium, which may be the air within the blade cavity, is channeled to internal cavities within the blade. The heated medium is directed from the blade root area into a cavity behind the leading edge of the blade, and then diverted at the blade tip into a cavity along the trailing edge of the blade and back to the
25 root area. A fan with integrated heating elements is provided in the blade root to generate and maintain circulation of the heated medium. The chambers or cavities may be defined by reinforcement ribs that run parallel to the longitudinal axis of the blade.

30 [0007] A drawback to the system and method of the CA 2228145 patent is that the warmest air is not directed to the tip of the blade first, which may be

the area of the blade most susceptible to icing, but along the entire length of the leading edge before reaching the blade tip. In addition, a thermal imbalance is created within the rotor blade as a result of the unidirectional flow path of the heated medium. The leading edge cavity is heated to a far greater extent than the trailing edge cavity, and the trailing edge cavity is heated to a greater extent than the remaining internal space between the trailing and leading edge cavities. Thus, the deicing capability of the system is focused primarily on the leading edge, which may not be beneficial in certain situations, such as when atmospheric conditions become harsh enough to cause ice formation on the pressure and/or suction side surfaces, or trailing edge.

[0008] WO 2013/107457 discloses a rotor blade comprising a blade root, a blade tip, a leading edge and a trailing edge extending between the blade tip and blade root, structural members disposed within an internal volume of the rotor blade, the structural members defining a leading edge fluid circulation loop and a trailing edge fluid circulation loop, and a fluid handling system disposed within the internal volume of the rotor blade and configured with the structural members so as to direct a heated fluid medium through the leading edge and trailing edge fluid circulation loops. The present invention provides an improved rotor blade deicing system and method that addresses at least certain of the drawbacks of conventional systems, including the type of system described in the CA 2228145 patent.

Summary of the invention

[0009] Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0010] In accordance with aspects of the invention as defined in independent claims 1 and 9, a rotor blade for a wind turbine is provided with an integrated deicing capability with an improved fluid circulation wherein leading edge and trailing edge fluid circulation loops are separate. Thus, airflow through the
5 respective loops may be individually controlled by, for example, separate respective fan heaters disposed within the blade root for each of the loops. It should be appreciated that the term "deicing" is used herein to encompass removal or minimizing ice that has formed on the rotor blade, as well as preventing formation of ice on the rotor blade. The rotor blade includes a
10 blade root, a blade tip, and a leading edge and a trailing edge extending between the blade tip and blade root. Any manner of structural members, such as webs, walls, ducts, baffles, dampers, and so forth, are disposed within an internal volume of the rotor blade, with these members defining a leading edge fluid circulation loop and a separate trailing edge fluid
15 circulation loop. A fluid handling system is disposed within the internal volume of the rotor blade and is configured with the structural members so as to direct a heated fluid medium through the leading edge and trailing edge fluid circulation loops. These heated fluid medium streams may be directed simultaneously through the leading edge and trailing edge fluid circulation
20 loops, or may be directed through one of the loops while the other loop is idle or isolated. The loops may be independently controlled so that the heated fluid medium streams have a different flow rate or temperature.

[0011] In a particular embodiment, the heated fluid medium is the air within
25 the internal volume of the rotor blade, and the fluid handling system includes any combination of air handling components, such a one or more fans, heater elements, dampers, ducts, and the like. The term "fan heater" is used herein to encompass and combination of a fan and heating element within the same or separate housings. In alternate embodiments, the heated fluid
30 medium may be, for example, an inert gas that is circulated through the

respective fluid circulation loops by any combination of fluid handling components.

5 [0012] The structural members may define a span-wise extending middle circulation channel that is common to the leading edge and the trailing edge fluid circulation loops in that a portion of each of the circulation loops simultaneously flows through the middle circulation channel. This middle channel can be defined by any combination of structural or non-structural webs, ducts, and so forth.

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[0013] In one embodiment, the structural members comprise a first web disposed proximate to the leading edge and defining a leading edge channel, and a second web disposed proximate to the trailing edge and defining a trailing edge channel. The first and second webs may be shear web components of the blades internal support system. With this embodiment, the middle circulation channel is defined between the first and second webs. In alternate embodiments, any manner of ducting may be used to define the middle circulation channel. For example, the blade may include only a single shear web and an internal duct may serve the function as the middle circulation channel. The fluid handling system may include at least one fan heater disposed within the blade root so as to direct a heated outflow airstream through the leading edge and trailing edge fluid circulation loops, including the middle circulation channel.

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25 [0014] It should be appreciated that the system is not limited to a single flow direction through the leading and trailing edge circulation loops. For example, the fan heater may be disposed so as to direct the heated outflow airstream along the middle circulation channel to adjacent the blade tip where the outflow airstream is directed into separate return airstreams that flow through the leading edge and the trailing edge channels, respectively, back to the blade root. In an alternate embodiment, one or more fan heaters may be

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disposed so as to direct the outflow airstream as separate streams through the leading edge and trailing edge channels, wherein the separate streams combine adjacent the blade tip into a single return airstream through the middle circulation channel and back to the blade root.

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[0015] The present invention also encompasses various method embodiments for deicing a wind turbine rotor blade in accordance with the concepts discussed above, including directing heated air through an internal leading edge circulation loop and a separate internal trailing edge circulation loop within the rotor blade. The air may be directed alternately or simultaneously through the leading edge and trailing edge circulation loops, independently controlled. This method embodiment may include directing the heated air through a middle circulation channel that is common to the leading edge and the trailing edge circulation loops.

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[0016] In a particular method, the heated air is directed as an outflow airstream from one or more fan heaters disposed in a root area of the rotor blade through the middle circulation channel towards a tip area of the rotor blade, wherein the outflow airstream is directed at the tip area into separate return airstreams through respective leading and trailing edge channels within the rotor blade.

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[0017] In an alternate method embodiment, the outflow airstream is maintained as separate airstreams through the middle circulation channel and are diverted into the respective leading and trailing edge channels at the tip area of the rotor blade. In this embodiment, airflow through the respective leading edge and trailing edge circulation loops may be independently controlled.

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[0018] In still another method embodiment, the heated air is directed as separate outflow airstreams from one or more fan heaters disposed in a root area of the rotor blade through respective leading and trailing edge channels within the rotor blade towards a tip area of the blade. At the tip area, the outflow airstreams are directed through a middle circulation channel back to the root area of the blade. The separate outflow airstreams may be combined into a single return airstream in the middle circulation channel, or maintained as separate streams.

[0019] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Brief description of the drawings

[0020] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

[0021] Figure 1 is a perspective view of a conventional wind turbine;
[0022] Figure 2 is top view of a conventional wind turbine rotor blade;
[0023] Figure 3 is cross-sectional view of a conventional wind turbine rotor blade;
[0024] Figure 4 is a top cut-away view of an embodiment of a wind turbine blade in accordance with aspects of the invention;

[0025] Figure 5 is a top cut-away view of an alternate embodiment of a wind turbine blade in accordance with aspects of the invention;'

[0026] Figure 6 is a top cut-away view of still another embodiment of a wind turbine blade in accordance with aspects of the invention;

5 [0027] Figure 7 is a top cut-away view of a different embodiment of a wind turbine blade in accordance with aspects of the invention;

[0028] Figure 8 is a top cut-away view of yet another embodiment of a wind turbine blade in accordance with aspects of the invention;

10 [0029] Figure 9 is a top cut-away view of an alternate embodiment of a wind turbine blade in accordance with aspects of the invention; and

[0030] Figure 10 is a top cut-away view of still another embodiment of a wind turbine blade in accordance with aspects of the invention.

15 **Detailed description of the invention**

[0031] Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the
20 invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the
25 present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0032] Fig. 1 illustrates a wind turbine 10 of conventional construction. The wind turbine 10 includes a tower 12 with a nacelle 14 mounted thereon. A
30 plurality of turbine blades 16 are mounted to a rotor hub 18, which is in turn connected to a main flange that turns a main rotor shaft. The wind turbine

power generation and control components are housed within the nacelle 14. The view of Fig. 1 is provided for illustrative purposes only to place the present invention in an exemplary field of use. It should be appreciated that the invention is not limited to any particular type of wind turbine configuration.

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[0033] Figs. 2 and 3 are more detailed views of a conventional wind turbine blade 16. The blade 16 includes an upper shell member 20 and a lower shell member 22. The upper shell member 20 may be configured as the suction side surface of the blade 16, while the lower shell member 22 may be configured as the pressure side surface of the blade. The blade 16 includes a leading edge 24 and a trailing edge 26, as well as a root portion 28, and a tip portion 30. The blade 16 extends in a longitudinal, span-wise direction 34. As is well known in the art, the upper shell member 20, and lower shell member 22 are joined together at the leading edge 24 and trailing edge 26. The blade 16 includes an internal cavity 25 in which various structural members, such as spar caps 32 and shear webs 33, are configured. The construction and function of the internal structural components of the blade 16, such as the spar caps 32 and shear webs 33 are well known to those skilled in the art and need not be described in detail herein for an understanding and appreciation of the present invention.

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[0034] Fig. 4 depicts an embodiment of a wind turbine rotor blade 16 incorporating an integrated deicing capability in accordance with aspects of the invention. Any manner of structural members 50, such as webs, walls, ducts, baffles, dampers, and so forth, are disposed within the internal volume 25 of the rotor blade 16 and define a leading edge fluid circulation loop 58 and a separate trailing edge fluid circulation loop 60. These loops 58 and 60 may include any configuration of structural members 50 that establish separate flow paths along the leading edge 24 and trailing edge 26, as compared to a single, continuous flow path wherein the leading and trailing edge flows would be serial (one-after-the-other) within the single loop. For

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example, as depicted in Fig. 4, the separate fluid circulation loops 58 and 60 may be counter-rotating flow paths. These flow paths may be simultaneous, as depicted in Fig. 4, or may be independently established and controlled, as discussed in greater detail below.

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[0035] A fluid handling system, generally denoted as 65, is disposed within the internal volume 25 of the rotor blade 16 and is configured with the structural members 50 so as to direct a heated fluid medium simultaneously through the leading edge and trailing edge fluid circulation loops 58, 60, respectively, as indicated by the arrows in Fig. 4 denoting the circulation loops 58, 60. In the illustrated embodiment, the heated fluid medium is the air within the internal volume 25 that is heated and recirculated by an air handling system 65. This system may include any combination of air handling components, such a one or more fans, heater elements, dampers, ducts, and the like. In the embodiments depicted in the various figures, the air handling system 65 includes a fan heater 66, which is intended to encompass any configuration of a fan and heating elements. For example, the fan heater 66 may include a fan, one or more diffusers/ducts, and heating element within the same housing or separate housings. The heating elements may be resistive elements, and any other suitable heating element or system. The fan heater 66 (and any other components of the handling system 65) are desirably selected to have sufficient capacity to generate a desired flow rate through the circulation loops 58, 70, while minimizing weight, power consumption, and the time needed to deice the blades.

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[0036] In particular embodiments illustrated in the figures, the structural members 50 may define a span-wise extending middle circulation channel 70 that is common to the leading edge and the trailing edge fluid circulation loops 58, 60. For example, referring to Fig. 4, the fluid circulation loops 58, 60 include respective portions that flow through the middle circulation channel 70, which may be simultaneous in certain embodiments.

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[0037] In various depicted embodiments (e.g., Figs. 4 and 6), the structural members 50 include a first web 52 that is disposed proximate to the leading edge 24 such that a leading edge channel 62 is defined, and a second web 54 disposed proximate to the trailing edge and defining a trailing edge channel 64. It should be appreciated that these channels 62, 64 may be considered as any manner of physically defined flow structure and may have a varying cross-sectional profile. The channels 62, 64 are not limited to any particular shape or dimension. The first and second webs 52, 54 may correspond to the shear webs 33 described above with respect to the conventional blade of Figs. 2 and 3, or any other component of the blades internal support system. With this embodiment, the middle circulation channel 70 is defined between the first and second webs 52, 54 and corresponds to the space between the shear webs 33 (Figs. 2 and 3).

[0038] In an alternate embodiment depicted in Fig. 5, the blade 16 has a single internal shear web 52. A duct 55 is attached to the shear web 52 (or may be supported by any other structure) and functions as the middle circulation channel 70.

[0039] As mentioned above, it should be appreciated that the deicing system is not limited to a single flow direction through the leading and trailing edge circulation loops 58, 60. For example, in the embodiment of Fig. 4, the fan heater 66 is disposed so as to direct a heated outflow airstream along the middle circulation channel 70 to an area adjacent the blade tip 30. From there, the outflow airstream is directed into separate return airstreams or legs of the respective circulation loops 58, 60 that flow through the leading edge and the trailing edge channels 62, 64 and back to the blade root, thereby establishing the counter-rotating flow path loops depicted in the figure. However, in alternate embodiments as depicted for example in Fig. 8, one or more fan heaters 66 may be disposed so as to direct the outflow airstream as

separate streams that flow initially through the leading edge and trailing edge channels 62, 64, wherein the separate streams combine adjacent the blade tip 30 into a single return airstream through the middle circulation channel 70 and back to the blade root. Any manner of ducting 67 or other diverting structure may be used to split the single output of the fan heater 66 into separate outflow streams.

[0040] Figs. 4, 5, and 6 depict embodiments wherein a single combined outflow stream from the fan heater 66 is directed through the middle circulation channel 70 such that the leading edge and the trailing edge fluid circulation loops 58, 60 share a combined (co-mingled) outflow portion through the middle fluid circulation channel 70. A single fan heater 66 may be used in this embodiment having sufficient airflow capacity to maintain a desired minimum airflow through the leading and trailing edge fluid circulation loops 58, 60. Referring to Fig. 6, separating structure, such as a middle web 56, may be provided at least partially within the middle circulation channel 70 such that the leading edge and the trailing edge fluid circulation loops 58, 60 have separate (not co-mingled) flow portions along at least a portion of the middle circulation channel 70. For example, the separating structure 56 may be a wall, web, or baffle that extends from the blade tip 30 partially into the middle circulation channel 70 and serves to separate the single outflow airstream into separate streams in the area adjacent to the blade tip 30.

[0041] The embodiments of Figs. 4 through 6 may be particularly advantageous in that the heated air is initially directed to the blade tip area 30 through the middle channel 70, which is flow channel most insulated from atmospheric conditions. The core materials of the webs 52, 54 (e.g., shear webs 33) insulate the channel 70 and minimizes heat loss along the channel. Thus, heating is maximized at the critical blade tip 30 area that is most prone to icing conditions.

[0042] In the embodiment depicted in Fig. 7, the middle web separating structure 56 extends essentially completely through the middle circulation channel 70 and divides the middle circulation channel 70 into separate flow channels of the respective flow circulation loops 58, 60. Thus, with this
5 embodiment, the leading and trailing edge fluid circulation loops 58, 60 are not combined or co-mingled through the middle circulation channel 70. Separate fan heaters 66 may be configured in the blade root area for the respective fluid circulation loops 58, 60 such that airflow through the loops may be individually controlled and adjusted for different icing conditions along
10 the leading and trailing edges 24, 26 of the blade 16.

[0043] The embodiment of Fig. 9 is similar in structure to the embodiment of Fig. 7, with the difference being that the separate fan heaters 66 are configured to direct their respective outflow streams into the leading edge
15 and trailing edge channels 62, 64. The outflow streams are maintained separate in their return flow path within the middle circulation channel 70 by the middle web 56 that extends completely through the channel 70.

[0044] With the embodiments of Figs. 7 and 9, separate fan heaters 66 are
20 utilized to separately supply the leading edge and trailing edge channels 62, 64. These fan heaters 66 may have different capacities and outputs, and may be separately controlled. For example, the system may be designed with an overall power rating of 20 KW, with this power divided differently between the channels 62, 64. The fan heater 66 assigned to the leading edge channel 62
25 may have a 12 KW rating, while the fan heater 66 assigned to the trailing edge channel 64 may have a 8 KW rating, and so forth. In an alternate embodiment, the fan heaters 66 may have the same rating, but are cycled and not operated at the same time. In another embodiment, the system may have a total capacity rating of 20KW between the fan heaters 66. The fan 66
30 assigned to the leading edge channel 62 may have multiple settings, for example 10 KW and 20 KW settings, while the fan assigned to the trailing

edge channel 64 has a setting of 10 KW. With this configuration, all 20 KW may be used for heating the leading edge channel 62 when icing conditions so dictate (with the fan assigned to the trailing edge channel 62 turned off). With the fan assigned to the leading edge channel 62 at the lower setting (e.g., the 10 KW setting), the fan assigned to the trailing edge channel 64 can be energized.

[0045] The embodiment of Fig. 10 is similar in structure and function to the embodiment of Fig. 4, with the difference being that one or more airflow passages 68 are defined through the webs 52, 54 along a portion thereof adjacent to the blade tip 30. Thus, air is directed out of the middle circulation channel 70 through these airflow passages 68, as well as at the end of the channel 70 wherein the remaining stream is divided by the middle web 56. It should be appreciated that the airflow passages may be defined at any location along the webs 52, 54. It will also be appreciated that airflow passages 68 as described in this paragraph may be applied to the embodiments described above and below.

[0046] The present invention also encompasses various method embodiments for deicing a wind turbine rotor blade 16 in accordance with the concepts discussed above with respect to Figs. 4 through 10. For example, an exemplary method embodiment includes simultaneously directing heated air through an internal leading edge circulation loop 58 and a separate internal trailing edge circulation loop 60 within the rotor blade 16. This method embodiment may include directing the heated air through a middle circulation channel 70 that is common to the leading edge and the trailing edge circulation loops 58, 60.

[0047] In a particular method, the heated air is directed as an outflow airstream from one or more fan heaters 66 disposed in the blade root area 28 through the middle circulation channel 70 towards a blade tip area 30,

wherein the outflow airstream is diverted at the tip area into separate return airstreams through respective leading and trailing edge channels 62, 64 within the rotor blade. The method may include maintaining the outflow airstream as a single combined airstream through the middle circulation channel 70, and dividing the combined airstream into separate return airstreams at the blade tip area 30.

[0048] In an alternate method embodiment, the method may include maintaining the outflow airstream from one or more fan heaters 66 as separate airstreams through the middle circulation channel 70, and diverting these separate airstreams into the respective leading and trailing edge channels 62, 64 at the tip area of the rotor blade. In this embodiment, the method may include independently controlling airflow through the respective leading edge and trailing edge circulation loops 58, 60.

[0049] In still another method embodiment, the heated air is directed as separate outflow airstreams from one or more fan heaters 66 disposed in a root area 28 of the rotor blade through respective leading and trailing edge channels 62, 64 towards the blade tip area 30. At the tip area, the outflow airstreams are directed through the middle circulation channel 70 back to the blade root area 28. The separate outflow airstreams may be combined into a single return airstream in the middle circulation channel 70, or maintained as separate streams.

[0050] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not

differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

5 [0051]

Reference Character	Component
10	Wind Turbine
12	Tower
14	Nacelle
16	Blades
18	Rotor Hub
20	Upper Shell Member
22	Lower Shell Member
24	Leading Edge
25	Internal Cavity/Volume
26	Trailing Edge
28	Blade Root
30	Blade Tip
32	Spar Caps
33	Shear Webs
34	Span-Wise Aspect
50	Structural Member
52	First Web
54	Second Web
55	Middle Duct
56	Middle Web (separating structure)
58	Leading Edge Fluid Circulation Loop
60	Trailing Edge Fluid Circulation Loop
62	Leading Edge Channel

64	Trailing Edge Channel
65	Fluid Handling System
66	Fan Heater
67	Ducting
68	Air Flow Passages
70	Middle Circulation Channel

PATENTKRAV

1. Rotorvinge (16) til en vindmølle (10) med en integreret afisningsfunktion, hvilken rotorvinge (16) omfatter:

- 5 – en vingerod (28);
- en vingspids (30);
- en forkant (24) og en bagkant (26), der strækker sig mellem vingspidsen (30) og vingeroden (28);
- konstruktionselementer, der er anbragt i en indre volumen (25) af rotorvingen (16);
- 10 – hvor konstruktionselementerne (50) fastlægger et forkantfluidcirkulationsloop (58) og et bagkantfluidcirkulationsloop (60); og
- et fluidhåndteringssystem (65), som er anbragt i den indre volumen (25) af rotorvingen (16) og udstyret med konstruktionselementerne (50), således at der ledes et opvarmet fluidmedium gennem forkant- og bagkantfluidcirkulationsloopet (58, 60),
- 15 – **kendetegnet ved, at**
- forkantfluidcirkulationsloopet (58) og bagkantfluidcirkulationsloopet (60) er adskilt;
- 20 – konstruktionselementerne (50) fastlægger en spændvis sig strækkende midtercirkulationskanal (70),
- desuden omfattende en separerende konstruktion i midtercirkulationskanalen (70), således at forkant- og bagkantfluidcirkulationsloopet (58, 60) har separate flowdele, og
- 25 – hvor den separerende konstruktion strækker sig helt gennem midtercirkulationskanalen (70) og opdeler midtercirkulationskanalen (70) i separate flowkanaler, således at luftflowet gennem forkant- og bagkantfluidcirkulationsloopet kan styres uafhængigt.

2. Rotorvinge (16) ifølge krav 1, hvor konstruktionselementerne (50) omfatter en første web (52), som er anbragt i nærheden af forkanten (24) og fastlægger en forkantkanal (62) af forkantfluidcirkulationsloopet (58), og en anden web (54), som er anbragt i nærheden af bagkanten (26) og fastlægger en bagkantkanal (64) af bagkantfluidcirkulationsloopet (60), hvilken midtercirkulationskanal (70) er fastlagt mellem den første og anden web (52, 54).
3. Rotorvinge (16) ifølge et hvilket som helst af kravene 1-2, hvor fluidhåndteringssystemet (65) omfatter mindst en varmeblæser (66), som er anbragt i vingeroden (28), således at der ledes en opvarmet outflow-luftstrøm gennem forkant- og bagkantfluidcirkulationsloopet (58, 60).
4. Rotorvinge (16) ifølge krav 3, hvor den i det mindste ene varmeblæser (66) er anbragt således, at outflow-luftstrømmen ledes langs med midtercirkulationskanalen (70) til ved vingespidsen (30), hvor den opvarmede outflow-luftstrøm deler sig i separate tilbageføringsluftstrømme, som strømmer gennem hhv. forkant- og bagkantkanalen (62, 64) tilbage til vingeroden (28).
5. Rotorvinge (16) ifølge krav 3, hvor den mindst ene varmeblæser (66) er anbragt således, at outflow-luftstrømmen ledes som separate strømme gennem forkant- og bagkantkanalen (62, 64), hvor de separate strømme ved vingespidsen (30) forenes til en enkelt tilbageføringsluftstrøm gennem midtercirkulationskanalen (70) og tilbage til vingeroden (28).
6. Rotorvinge (16) ifølge krav 1, hvor den separerende konstruktion strækker sig fra vingespidsen (30) ind i midtercirkulationskanalen (70).
7. Rotorvinge (16) ifølge krav 1, yderligere omfattende en separat respektiv varmeblæser, som er anbragt i vingeroden (28), for hver af de separate

flowkanaler, hvor luftstrømmen gennem forkant- og bagkantfluidcirkulationsloopet (58, 60) kan styres uafhængigt.

5 8. Rotorvinge (16) ifølge et hvilket som helst af kravene 3-7, hvor webs'ene (52, 54) omfatter luftstrømspasser (68) fastlagt derigennem langs med en spændvis del af webs'ene (52, 54) ved vingespidsen (30).

9. Fremgangsmåde til afisning af en vindmøllerotorvinge (16), **kendetegnet ved**, at fremgangsmåden omfatter at lede opvarmet luft gennem et indre
10 forkantcirkulationsloop (58) og et separat indre bagkantcirkulationsloop (60) i rotorvingen (16), og hvor luftstrømmen gennem det respektive forkant- og bagkantfluidcirkulationsloop bibeholdes separat og styres uafhængigt.

10. Fremgangsmåde ifølge krav 9, hvilken fremgangsmåde yderligere
15 omfatter at lede den opvarmede luft gennem en midtercirkulationskanal (70), som er fælles for forkant- og bagkantcirkulationsloopet (58, 60).

11. Fremgangsmåde ifølge krav 10, hvorved den opvarmede luft ledes som en outflow-luftstrøm fra en eller flere varmeblæsere (66), som er anbragt i et
20 rodområde (28) af rotorvingen (16), gennem midtercirkulationskanalen (70) til et spidsområde (30) af rotorvingen (16), hvor outflow-luftstrømmen i spidsområdet (30) ledes ind i separate tilbageføringsluftstrømme gennem den respektive for- og bagkantkanal (62, 64) i rotorvingen (16).

25 12. Fremgangsmåde ifølge krav 10, hvorved den opvarmede luft ledes som separate outflow-luftstrømme fra en eller flere varmeblæsere (66), der er anbragt i et rodområde (28) af rotorvingen (16), gennem den respektive for- og bagkantkanal (62, 64) i rotorvingen (16) til et spidsområde (30), hvor outflow-luftstrømmene i spidsområdet (30) ledes gennem
30 midtercirkulationskanalen (70) tilbage til rodområdet (28) af vingen (16).

13. Fremgangsmåde ifølge krav 9, hvilken fremgangsmåde yderligere omfatter at lede den opvarmede luft gennem en midtercirkulationskanal (70), som er fælles for forkant- og bagkantcirkulationsloopet (58, 60), og anvende en separerende konstruktion, der strækker sig fra vingespidsen (30) mindst delvist ind i midtercirkulationskanalen (70) med henblik på at opdele den opvarmede luft i separate luftstrømme.

14. Fremgangsmåde ifølge krav 9, hvorved en spændvis sig strækkende midtercirkulationskanal (70) er fælles for forkant- og bagkantfluidcirkulationsloopet (58, 60), hvilken midtercirkulationskanal (70) er fastlagt af en første web (50), som er anbragt i nærheden af forkanten (24), og en anden web (52), som er anbragt i nærheden af bagkanten (26), hvilken fremgangsmåde yderligere omfatter at lede den opvarmede luft gennem luftflowpassager (68) fastlagt i den første og anden web langs med en spændvis del af webs'ene ved vingespidsen.

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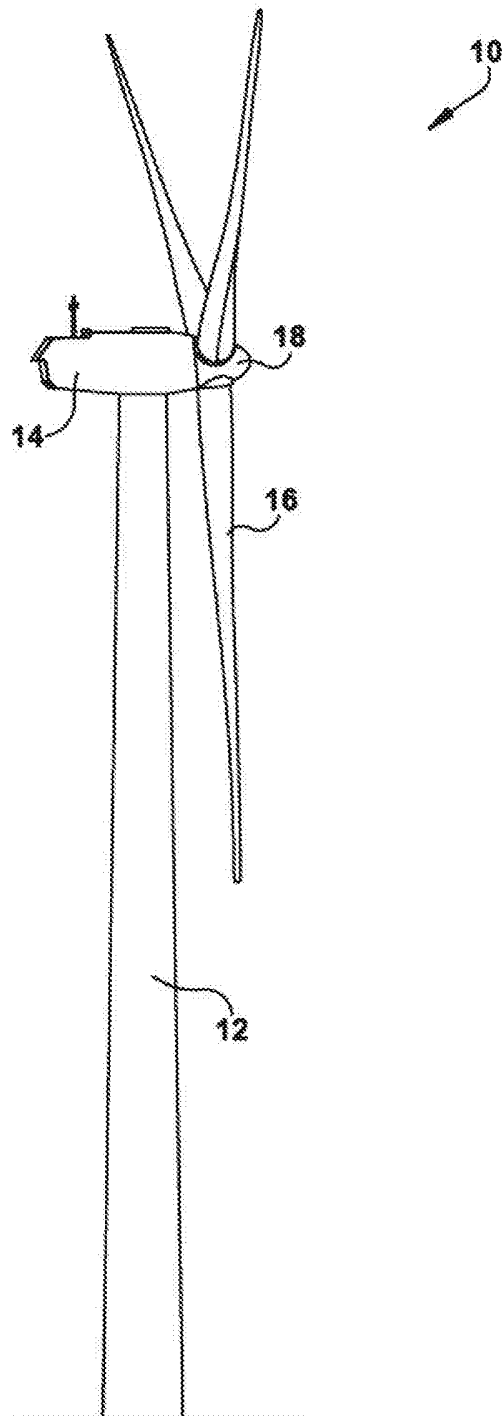


Fig. -1-
-Prior Art-

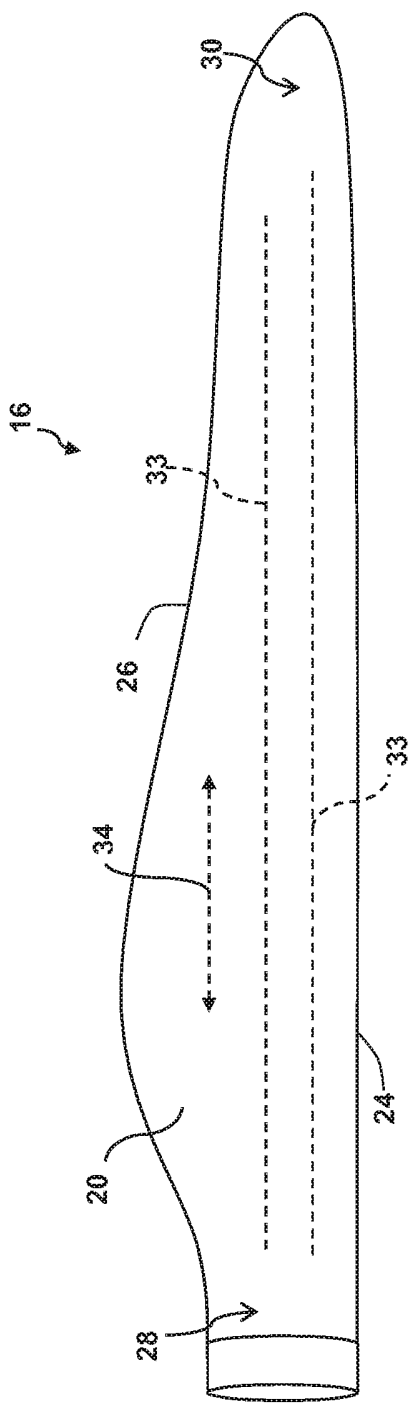


Fig. -2-
-Prior Art-

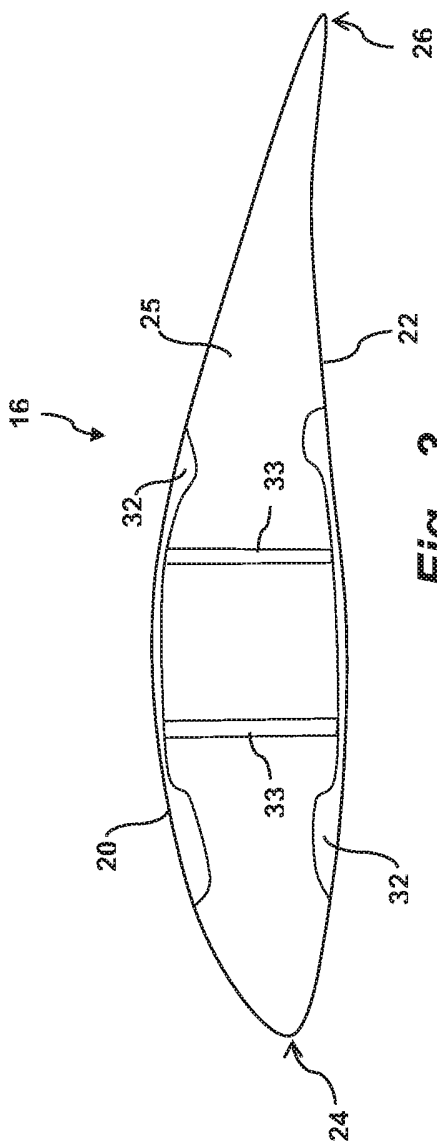
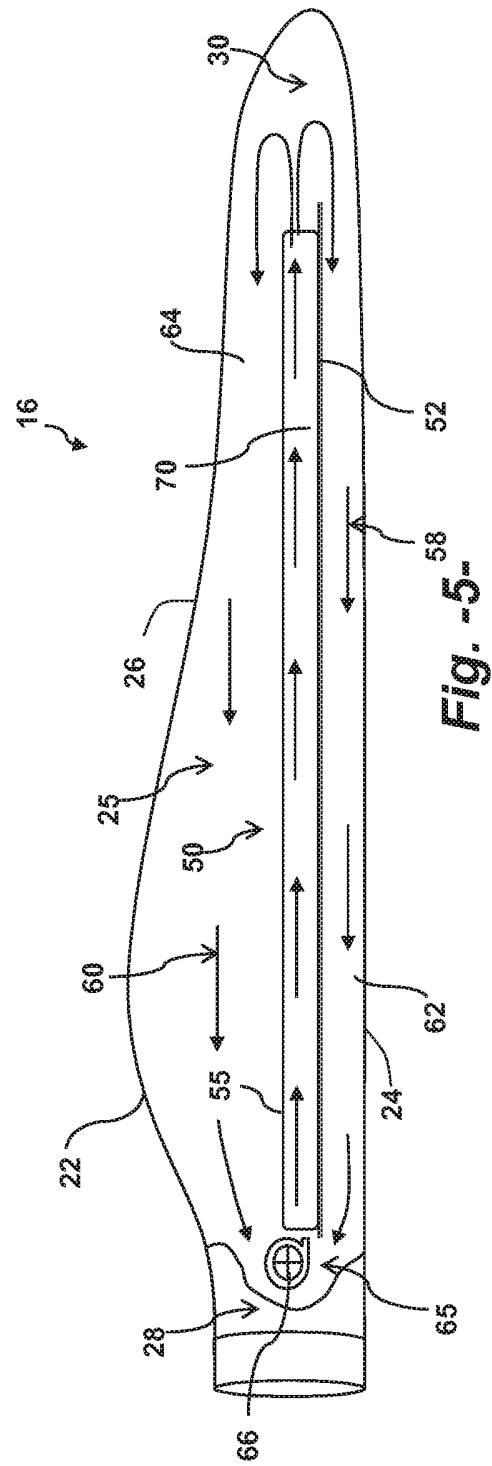
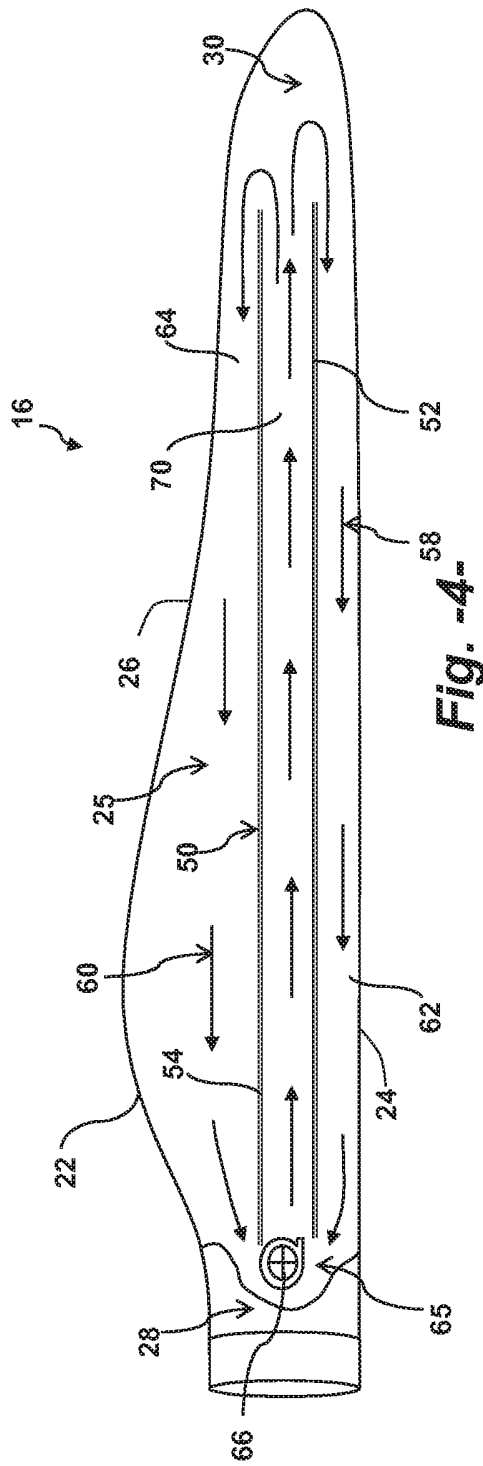
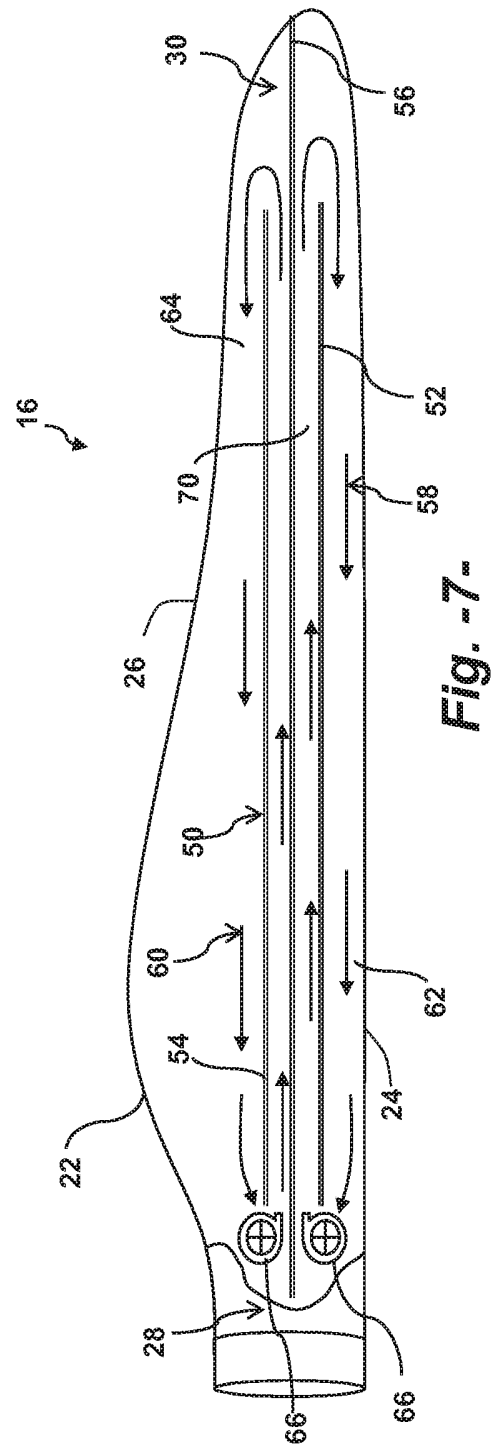
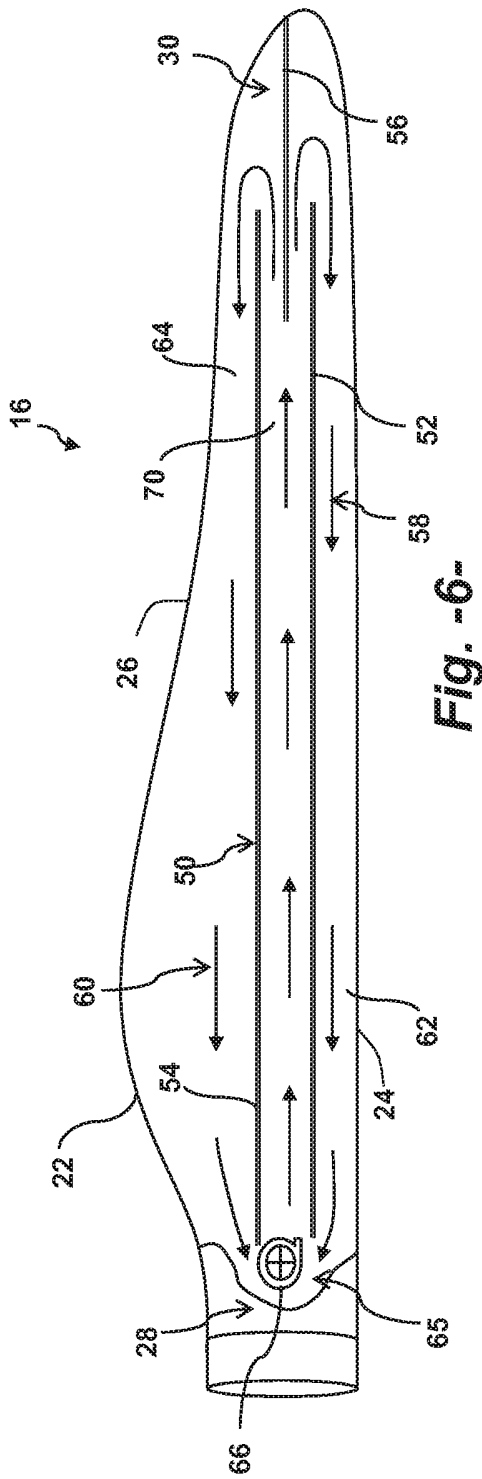
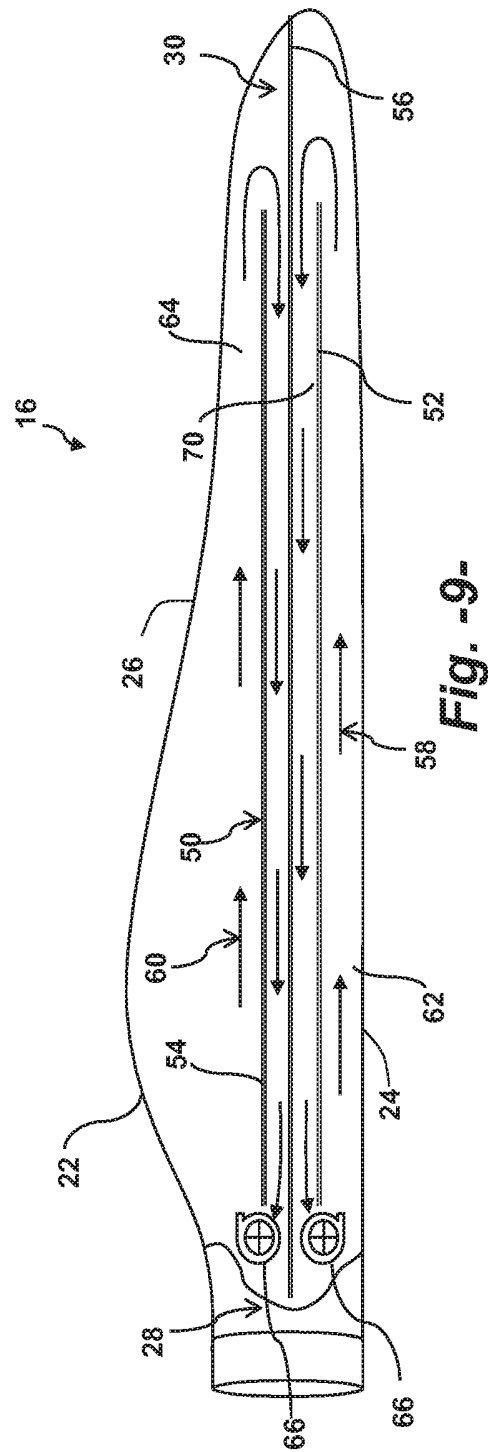
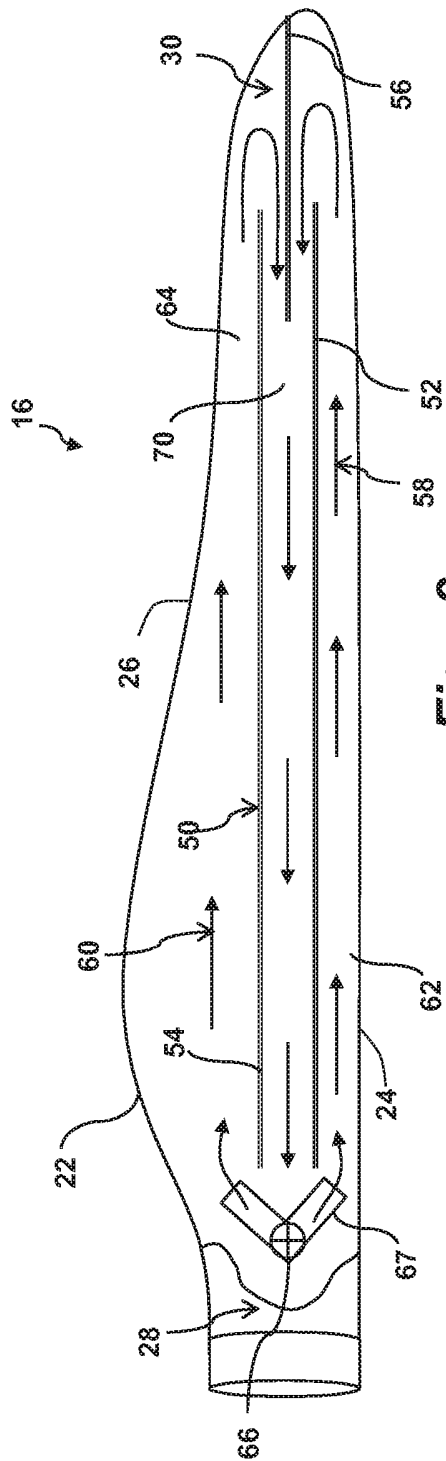
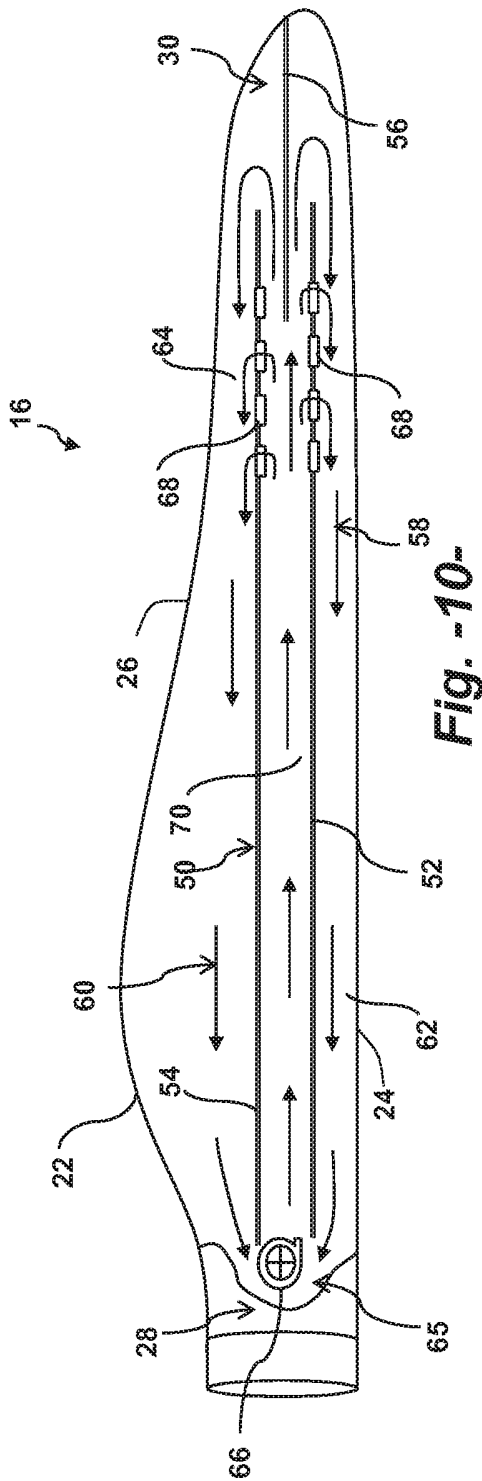


Fig. -3-
-Prior Art-









SEARCH REPORT - PATENT		Application No. PA 2014 70503
1. ☐ Certain claims were found unsearchable (See Box No. I). 2. ☐ Unity of invention is lacking prior to search (See Box No. II).		
A. CLASSIFICATION OF SUBJECT MATTER F 03 D 11/00 (2006.01); F 03 D 1/06 (2006.01) 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) IPC, CPC: F03D Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: IPC-classes as above. Electronic database consulted during the search (name of database and, where practicable, search terms used) EPODOC, WPI, FULL TEXT: ENGLISH		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
X	WO 2013/107457 A1 (VESTAS WIND SYSTEMS) 25.07.2013 See page 9, line 13-22 and line 30-36; from page 11, line 21 to page 12, line 13; page 18, line 3-7; from page 19, line 19 to page 20, line 5; Fig. 1-5	1-20
A	US 2011/0142623 A1 16.06.2011 See full document	1-20
A	DE 19644355 A1 (DRAYER) 30.04.1998 See full document	1-20
☒ Further documents are listed in the continuation of Box C.		
* Special categories of cited documents: "A" Document defining the general state of the art which is not considered to be of particular relevance. "D" Document cited in the application. "E" Earlier application or patent but published on or after the filing date. "L" Document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified). "O" Document referring to an oral disclosure, use, exhibition or other means.	"P" Document published prior to the filing date but later than the priority date claimed. "T" Document not in conflict with the application but cited to understand the principle or theory underlying the invention. "X" Document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone. "Y" Document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" Document member of the same patent family.	
Danish Patent and Trademark Office Helgeshøj Allé 81 DK-2630 Taastrup Denmark Telephone No. +45 4350 8000 Facsimile No. +45 4350 8001	Date of completion of the search report 17 March 2015 Authorized officer René Sørensen Telephone No. +45 4350 8155	

SEARCH REPORT - PATENT		Application No. PA 2014 70503
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
A	DE 102010051297 A1 (NORDEX ENERGY GMBH) 16.05.2012 See full document	1-20
A	US 2004/0041408 A1 (CASAZZA) 04.03.2004 See full document	1-20

SEARCH REPORT - PATENT	Application No. PA 2014 70503
Box No. I Observations where certain claims were found unsearchable	
This search report has not been established in respect of certain claims for the following reasons: 1. ☐ Claims Nos.: because they relate to subject matter not required to be searched, namely: 2. ☐ Claims Nos.: because they relate to parts of the patent application that do not comply with the prescribed requirements to such an extent that no meaningful search can be carried out, specifically: 3. ☐ Claims Nos.: because of other matters.	
Box No. II Observations where unity of invention is lacking prior to the search	
The Danish Patent and Trademark Office found multiple inventions in this patent application, as follows:	

SEARCH REPORT - PATENT	Application No. PA 2014 70503
SUPPLEMENTAL BOX	
Continuation of Box [.]	