(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 May 2019 (23.05.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/096360 A1

(51) International Patent Classification:
F03D 80/80 (2016.01) *F03D 80/60* (2016.01)

(21) International Application Number:
PCT/DK20 18/050302

(22) International Filing Date:
20 November 2018 (20. 11.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA 2017 70871 20 November 2017 (20. 11.2017) DK
PA 2017 70919 06 December 2017 (06. 12.2017) DK

(71) Applicant: **ENVISION ENERGY (DENMARK) APS** [DK/DK]; Randersvej 2a, 8600 Silkeborg (DK).

(72) Inventor: **KILIAN, Allan;** Gormsvej 37, 8600 Silkeborg (DK).

(74) Agent: **PATRADE A/S;** Ceresbyen 75, 8000 Aarhus C (DK).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) Title: NACELLE, WIND TURBINE, WIND TURBINE AIR FILTRATION SYSTEM AND A METHOD FOR FILTRATION OF AIR IN THE NACELLE OF A WIND TURBINE

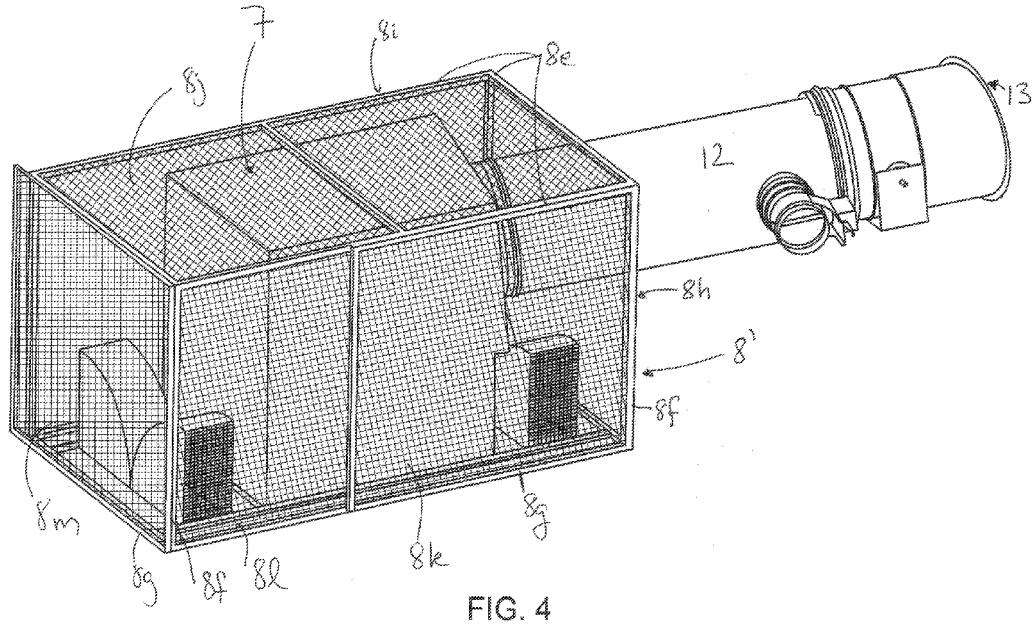

FIG. 4

(57) Abstract: A wind turbine **(1)** and a wind turbine nacelle (3) comprising an interior room, where- in the interior room in the nacelle (3) is divided into a clean section (9) and a dirty section (10). The clean section and the dirty section of the room are separated by a filter wall (8). One or more blower means are arranged in the nacelle (3) for drawing air into the nacelle' dirty section (9), through the filter wall (8), and into the clean section (10). A generator (7) is arranged in the clean section of the nacelle room. Cooling air for cooling of the generator is drawn in directly from surrounding air in the clean section. The invention significantly increases filtration area manifold and reduces risk of clogged filters. A method for purifying air in the nacelle is also disclosed.

WO 2019/096360 A1

[Continued on next page]

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Nacelle, wind turbine, wind turbine air filtration system and a method for filtration of air in the nacelle of a wind turbine

Field of the Invention

The present invention relates to a wind turbine nacelle.

The present invention also relates to a wind turbine comprising a tower, a nacelle and a wind turbine hub with rotor blades, where the wind turbine hub is arranged rotatably on the nacelle.

The present invention also relates to a method for cleaning air in a wind turbine nacelle.

The present invention also relates to a wind turbine air filtering system.

Background of the Invention

The increasing size of modern wind turbines has led to a growing awareness and focus on the thermal control of heat emitting components in the wind turbine's nacelle. The need for thermal control is caused by the increasing frictional heat emitted by main components such as gearbox, generator, converters and/or control/supervisory electronics. The increasing size of such main components also increases the risk of having large thermal stresses, caused by temperature differences across main components, e.g. a generator.

Further, in recent years there has been an increased focus on reducing production costs, installation costs as well as costs related to maintenance and/or repair.

In connection with direct cooling of the generator in the nacelle of a wind turbine, it is necessary that the cooling air is sufficiently pure in order to avoid deposits inside the generator. Such deposits inside the generator may cause a built-up layer on internal surfaces. This provides an unintended insulating layer that reduces the ability to effectively transfer heat generated in the generator to the surroundings.

Particle laden air from the surrounding air may lead to such built-up layers unless these particles are removed from the cooling air prior to entering the generator via the air generator cooling system.

Such built-up layers inside the generator cause clogging and may result in damages in the generator and increased repair costs. In addition, such build-ups inside the generator are often very difficult to remove in, for example, narrow channels or voids or otherwise inaccessible areas/space inside the generator unit leading to increased maintenance costs or, in worse cases, even to a wrecked generator and thus increased repair costs.

Air borne particles that may result in such build-ups may e.g. be fine and/or coarse particles, such as pollen, sand, dirt, dust, etc. or coarser particles such as airborne catkins, airborne plant seeds, in particular fluffy seeds with a woolly or fibrous layer on the surface of the seed, or the like. The concentration of air borne particles may thus vary greatly depending on the surroundings, weather conditions (rainy/dry periods in combination with wind conditions), time of year, e.g. is it spring where pollen are released or summer/fall where various airborne seeds appear, etc.

It is quite common to provide filtration systems for filtering air that enters the nacelle interior, the gear box cooling system and/or the generator cooling system. Prior art direct systems are e.g. disclosed in CN 202034685 U or WO2017/0888846 A. These systems disclose different types of particle filters that filter the ambient air prior to entering a cooling system in a direct cooling system or in systems where the ambient air absorbs heat from a second circulating cooling fluid. CN 204253286 U does not disclose a direct cooling system, but provides a solution using an air filter for filtering air that cools the generator using a second circulating cooling fluid

With a traditional air system, e.g. as discussed in the preceding paragraph, the filter area, e.g. as provided in an inlet of a generator's direct cooling system, is not large enough. This results in that the filter gets clogged very quickly causing a large pressure drop across the filter. This may further reduce the flow of cooling air and subsequently resulting in insufficient cooling effect. The latter two documents provide dif-

ferent solutions where the filter screen is cleaned or exchanged in order to ensure that the filter screen does not clog.

In particular WO20 17/0888846 A provides a large and heavy filtration unit installed in the nacelle. This solution thus also occupies space inside the nacelle and increases the load and potential stress on the nacelle body by increasing the overall weight of the nacelle including the equipment inside the nacelle.

Another solution is to provide an air/water system, where a cooling air provided to the generator is initially cooled in exchange with circulating water and where a cooling tower is arranged on the exterior roof part of the nacelle for cooling of the circulating water.

This solution is very expensive, and it provides a system where additional possible errors with leaks in the water system and clogged cooling elements may occur leading to increased maintenance and/or repair costs. Further, the exteriorly mounted cooling tower transported separately to the erection site and is attached to the nacelle on-site in connection with erection of the wind turbine resulting in increased costs and overall installation time.

Further, the exteriorly mounted cooling tower is sensitive to strong wind, e.g. wind speed over 18 m/s and may increase stress on the nacelle unit caused by strong wind. Thus, the nacelle walls must be dimensioned to carry the additional load of the cooling tower and to withstand the stress during such strong wind situations, which further increases the overall costs of the wind turbine. In addition, the cooling tower provides insufficient cooling in low to middle wind situations, such as wind speed up to 11-18 m/s.

Object of the Invention

Thus, it is an object of the present invention to provide a solution for providing cooling air to the generator, irrespective of the type of generator, which does not suffer from the above mentioned drawbacks of prior art systems.

Further, it is an object of the present invention to provide a solution which reduces overall costs of wind turbines.

It is also an object of the present invention to provide a solution which reduces installation time and/or installation costs of wind turbines.

It is also an object of the present invention to provide a solution which reduces maintenance time and/or maintenance costs of wind turbines.

It is also an object of the present invention to provide a solution which increases effectiveness, installation time, weight, costs and reduces maintenance of air filtration systems in wind turbine nacelles.

It is also an object of the present invention to provide a simplified air filtration system in a wind turbine that drastically increases the filter capacity, is low in cost, low maintenance and low installation time, that is low weight and thus lower influence on dimensioning, e.g. thickness of walls, floor and/or top, of the nacelle body.

Description of the Invention

These objects are obtained by means of a wind turbine nacelle comprising an interior room, wherein the interior room is divided into a clean section and a dirty section, , wherein the clean section and the dirty section of the room are separated by a filtration wall arranged to surround or enclose the generator and the clean section of the nacelle interior.

Thus, the filtration wall is arranged to surround the generator and creating a cage-like structure that encloses the generator and the surrounding clean section in filter wall subsections.

By interior room is meant the room inside of the nacelle extending between the inner walls, inner floor and inner ceiling of the nacelle. By clean section is meant that the concentration of airborne particles is lowered significantly or preferably substantially removed from the air in the part of the nacelle's interior room that is defined as the

clean section. In the dirty section, the air corresponds to the surrounding air in respect of content of airborne particles and may contain significant amount of airborne particles.

This enables that the generator is installed in the clean section which enables that cooling air can be provided to the generator cooling system directly from the surrounding clean air in the clean section of the nacelle interior room. This provides a very simple and low cost system for providing clean generator cooling air, in particular in connection with direct air cooling of the generator arranged in the clean section of the nacelle.

This solution also avoids complex and/or heavy solutions, such as systems including cooling towers arranged on top of the nacelle.

Further, by providing a clean section in the nacelle interior room where the air is substantially free from particulate matter, deposits can also be avoided on other sensitive equipment, such as electronics, PLC's, converters, controllers etc. This also leads to fewer damages to the electronic equipment and less maintenance and/or repair thereof and thus further reduced costs.

The clean section and the dirty section of the room are separated by a filtration wall. The filtration area of the filter wall is many times larger than a traditional filter arranged in the air ducts of the generator cooling system leading to a huge increase in filter area and filtration capacity compared to prior art techniques. The large increase in the filter area also greatly reduces the risk of clogged filters.

Further, the filter wall is very easy to access which makes change of filter material or similar maintenance work on the filter very easy and very fast.

The filter provided in the filter wall is preferably exchangeable.

The type of filter material is not important as long as the filter is able to remove the above-mentioned types of particles that are unwanted in the clean section of the nacelle interior.

It is also possible to use two or more layers of filter screens, e.g. a first coarse filter or filter screen layer that catches coarser particles such as seeds, catkins, sand, etc. followed by a fine filter that separates fine particles such as dust, pollen, and the like. The skilled person will know how to select pore size of the filter screen or screens of the filter wall so as to remove the unwanted particles from the air that passes through the filter wall.

Thus, the filter as such may e.g. be made of filter material that is supported by the filter wall construction as described further below. A filter that needs support may e.g. be made from one or more flat or pleated sheets of paper, textiles, such as woven or non-woven filter cloth.

The filter of the filter wall may also be self-supporting and may comprise one or more rigid filter plates or may comprise one or more separate filter modules such as filter cassettes that can be installed in or supported by the filter wall construction as described further below.

Thus, the cooling system for the generator is greatly simplified leading also to overall reduced costs when providing the air filter in the filter wall inside the nacelle.

The filtration wall may in principle also extend across the entire cross section of the interior room in a direction perpendicular or substantially perpendicular to the longitudinal axis of the nacelle. This result in that air from the dirty section cannot pass from the dirty section to the clean section unless passing through the filter wall resulting in that particles are caught in the filter and are thus not carried into the clean section.

The nacelle is special in that the filtration wall is arranged between the gearbox and the generator that are arranged in the nacelle's interior room. The gearbox is usually cooled using a liquid coolant, e.g. water. Thus, the gearbox is not as such sensitive to deposits of airborne particles. Therefore, the gearbox can be positioned in the dirty section.

As mentioned above, the filtration wall comprises a filtration wall or filtration wall subsections which are arranged to surround or enclose the generator and the clean section of the nacelle interior. Thus, the filtration wall optionally further comprises filtration wall subsections arranged to surround the generator and creating a cage-like structure that encloses the generator in filter wall subsections.

The cage-like enclosure may optionally further comprise a roof subsection arranged to provide a filter element extending between and connecting the upper ends of the wall subsections resulting in a box-shaped filter surface that encloses the generator in filtration surfaces on all sides thereof. This further maximises the filtration surface.

The inlet that provides air into the nacelle may be positioned so that air is provided into the dirty section. The dirty section is preferably provided in the front end, i.e. the hub end of the nacelle. Thus the air inlet is preferably provided in the front end of the nacelle, e.g. in combination with an air intake provided in the hub that provides a cooling air flow to cool the hub bearing and then subsequently directs the cooling air into the nacelle interior. Alternatively, the air inlet may be arranged in the floor area, to provide an air flow without any risk of ingress of water or rain.

The air flow is then directed from the dirty section, through the filter wall to the clean section.

In the clean section, the generator cooling system draws cooling air from the surrounding air in the clean section of the nacelle interior room, by means of a fan or a blower. The fan or blower may e.g. be arranged on the generator rotary shaft. Thus, the fan or blower of the generator cooling system may also ensure sufficient air circulation inside the nacelle interior room to ensure that air is drawn through the filter wall and filtered when entering the clean section. The cooling air is expelled from the generator through an air duct that directs the heated cooling air to the air outlet.

The air outlet is preferably provided in the rear end wall or floor area of the nacelle. The air outlet arranged in the rear end wall or the rear end floor part are protected from ingress of water or e.g. rain, snow, etc.

The fan or blower may alternatively be a separate device arranged in the nacelle, such as in connection with the air inlet or the air outlet. When a separate fan or blower is used, the air outlet may be the same air outlet as from the generator cooling system or a separate second outlet.

The filter wall may be a single plane wall that extends across the nacelle's interior room if the interior layout and position of the equipment in the nacelle, in particular the gearbox and the generator, allow so. The filter wall may be divided into one or more subsections. Alternatively, the filtration wall may be adapted to the position or arrangement of the equipment in the nacelle, in particular the position of the gearbox and the generator. Thus, the filter wall may comprise one or more subsections that are positioned in angles to other subsections, e.g. perpendicularly to one or two other neighbouring sub sections and thereby extend across the nacelle's interior room. This may result in that one or some subsections are offset to in relation to other subsections across the nacelle room.

The filtration wall comprises a frame and a filter screen that is arranged in the frame. The frame is preferably built from standard profiles, such as T, U or H profiles. The profiles are made in dimensions and of a material suitable for carrying the load of the filter screen. The profiles are e.g. made of metal or alloys, such as steel or aluminium.

The filter wall may comprise one or more frame members that are attached to the inner wall of the nacelle or to one or more ribs, protrusions or ledges in the inner nacelle wall. The frame member(s) are adapted to conform to the greatest possible extent to the cross section of the nacelle in order to maximise the filtration area. In order to make production of the filter wall easy and to easily adapt the filter wall to the cross section of the nacelle interior, the outermost area between the frame and the inner wall of the nacelle of the filter wall is covered by cover plates.

The frame may thus comprise a single frame or two or more subframes or modules that are built together to form the filter wall frame. Each frame module or subframe preferably has a polygonal shape, such as square, rectangular, triangular, or with five or more edges that ensures that the subframes are easily connected to the cross section

of the nacelle interior room. This makes the filter wall easy to transport and easy to install inside the nacelle.

The filter screen may be attached to the frame or the grid/netting by conventional means such as by screwing the filter screen to the frame member, e.g. by using bolts and nuts e.g. winged bolts and/or nuts, or by means of snap lock connections. This ensures that the filter screen may be easily detached and reattached on the frame when the filter screen is mounted or changed during maintenance. Alternatively, the filter screen may be attached to the frame using tracks integrated in the frame, or by clips that readily clip the filter screen between spring biased clips and the frame. Such clips may be separate and attached to the frame by means of the spring force or the clips may be integrated into the frame. Further possible attachment members may also include hooks, rings, or similar conventional filter cloth attachment means.

In order to support the filter screen and/or improve stability of the filter wall, the filter wall frame may preferably comprise filter support means, preferably a rigid grid or netting member, on at least one side or on both sides of the filter screen.

If the filter wall comprises netting on both sides of the filter screen, the grid or net on at least one side is provided with hinges or attached to the frames using latches, pins, bolts, winged screws and/or winged nuts or by means of snap lock connections to allow access to the void between the grids/netting to allow the exchange of filter screen.

It is also possible to attach each side of netting/grid to separate frames. The frames may then be joined together to form the filter wall frame with dual netting/grids to support the filter screen. The filter screen can then simply be arranged in the filter wall by squeezing the filter screen between the two frames and/or between the two faces of grid/netting, thus holding the filter screen in position between the frames.

Thus, the filter screen is easily arranged in the frame and may be provided rolled-up in standard width that corresponds to the distance between frame members of the frame or sub section frames in the filter wall. The filter screen may thus be simply cut in the required length and attached to the filter wall frame using the attachment means as

described above. In case a single large filter surface is provided, the filter screen may be cut in shape using a template that corresponds to the shape of the filter wall.

Preferably, the filter area of the filter wall covers at least two thirds of the entire cross section area of the nacelle, or more preferred at least 75% or at least 80% or at least 90% of the entire cross section area of the nacelle which maximizes the filter capacity and reduces the risk of clogged filters to a minimum.

The filter wall may further comprise a shielding plate member surrounding the generator rotary shaft. Thus, the shielding plate comprises a through-going hole through which the generator rotary shaft can extend into the dirty section. The shielding plate member preferably comprises one or more sealing members arranged between the shielding plate and the generator shaft. The sealing member(s) provide a particle tight or dust tight connection around the generator rotary shaft. The generator rotary shaft is connected to the gear box and, thus, extends through the filtration wall. The shielding plate may be a separate plate member attached to the floor and/or a wall of the nacelle's interior room. Alternatively, the shielding plate may be integrated into the nacelle body, e.g. by forming the shielding plate as a rib extending from the floor and/or wall of the nacelle body interior. The shielding plate floor may, for example, be cast together with the nacelle body, e.g. in glass fibre.

The filtration wall frame may alternatively comprise a filter screen comprising one or more self-supported filter elements.

Self-supported filters may be a self-supported plate member, e.g. cardboard like filter elements, or cassettes with filter screens that can be arranged in the frame, e.g. in tracks on the frame.

The filtration wall may also comprise a door. The door member is preferably arranged in conventional manner using hinges in the filter wall, or in a subsection of the filter wall to ensure access between the clean section and the dirty section during service, maintenance, or repair. The door may e.g. be attached to the frame of the filter wall, see further below, via hinges.

Alternatively, the door may be a sliding door, e.g. using wheels arranged in a track. A sliding door is advantageous if a hinged door cannot be applied because of limited free area. An entire subsection of the filtration wall may thus be a sliding door, or a sliding door may be arranged in a subsection of the filtration wall.

The door area may also form a filtration surface. If necessary, the door and/or the door frame surrounding the door may comprise sealing strip members for sealing between the door frame and the door and, thus, prevent escape of dust from the dirty section to the clean section if there is a gap between the door and the door frame.

The door member is preferably also made of a frame member with a filter screen, so as to further increase the filter area and thus optimize air filtration capacity of the filter wall.

The present invention also relates to a wind turbine comprising a tower, a nacelle and a wind turbine hub with rotor blades, where the wind turbine hub is arranged rotatably on the nacelle, and wherein the wind turbine nacelle is as defined in any of the claims 1-9 or as described above.

The above-mentioned drawbacks are further solved by providing a method for cleaning air in a wind turbine nacelle. The method comprises the steps of introducing surrounding air into a dirty section of an interior room of the nacelle, filtering the air through a filter wall arranged between the dirty section and a clean section and where said filter wall is arranged to surround or enclose the generator arranged in the clean section, and thereby providing clean filtered air into the clean section of the nacelle interior room.

As discussed above, clean room air in clean section is suitable for direct use as cooling air to generator and, thus, eliminating need for complex/heavy solutions, e.g. eliminates need for cooling tower arranged on top of the nacelle. This method and the nacelle/wind turbine as discussed above also greatly simplifies the nacelle construction, and hereby obtaining a lower weight, an easier transport and an easier installation of the nacelle.

The method further comprises that cooling air is provided to the generator arranged in the clean section from the surrounding air in the clean section of the interior room. Hereby, the above-mentioned advantages of low cost, simplified system etc. are further improved.

As noted above in relation to the nacelle construction/wind turbine, the method further comprises the step of drawing air into the interior room of the nacelle in the hub end of the nacelle and that air is expelled to the surroundings in the rear end or the rear end bottom of the nacelle.

The above-mentioned drawbacks are further solved by providing a wind turbine air filtering system arranged in the nacelle and for filtering air in the nacelle comprising air introduction means for introducing surrounding air into an interior room of the nacelle, and further comprising a filter wall dividing the interior room of the nacelle into a dirty section and a clean section, and where said filter wall is arranged to surround or enclose the generator arranged in the clean section, and where one or more blower means are arranged in the nacelle for drawing air into the nacelle, through the filter wall, and wherein a generator is arranged in the clean section of the nacelle.

Preferably, the wind turbine air filtering system further comprises blower means, where the generator cooling system comprises blower means for drawing air from the surrounding clean section of the nacelle to the generator cooling system.

The wind turbine air filtering system is further greatly simplified by means of using a single blower arranged to force air through the filter wall as well as to provide cooling air to the generator cooling system.

As mentioned above, the wind turbine air filtering inlet is arranged in the hub end of the nacelle and that the air outlet from the nacelle is arranged in the rear end or the rear end bottom of the nacelle.

The filter in the wind turbine air filtering system is a filter wall as defined and as described above.

Description of the Drawing

The present invention will in the following be described in detail with reference to the drawings in which:

Fig. 1 shows the exterior of a wind turbine according to the present invention

Fig. 2 shows a wind turbine nacelle in perspective view with part of the nacelle wall being removed for displaying the interior room,

Fig. 3 shows details from the nacelle interior and the position of the filter wall relative to the wind turbine generator, and

Fig. 4 shows details from the nacelle interior and a variant of arranging the filter wall relative to the wind turbine generator.

Detailed Description of the Invention

Fig. 1 shows a wind turbine 1 comprising a tower 2, a nacelle 3 and a wind turbine hub 4 supporting blades 5. The hub 4 is rotatably arranged on the nacelle 3.

Figs. 2-3 show the interior room inside the nacelle 3. A gearbox 6 is arranged in the hub end of the nacelle 3 interior room, and a generator 7 is arranged nearer to the rear end of the nacelle 3.

A filter wall 8 is arranged to extend across the interior room in the nacelle 3. The filtration wall extends from one side wall to the other side wall and from the floor to the ceiling in the nacelle interior room.

The filter wall 8 comprises a frame 8e, 8f. The filter wall 8 may comprise a single frame plane frame. Or the filter wall may comprise two or more subsections 8a-8d that are attached to each other to form the filter wall 8. The filter wall 8 or each subsection 8a-8d comprises horizontal cross beams 8e in the top and the bottom and two or more vertical pillars 8f arranged to extend between the cross beams 8e.

A filter screen (not shown) is arranged on the frame or frames so that the frame 8e-8f supports the filter screen.

The filtration wall is preferably arranged between the gearbox 7 and the generator 8 that are arranged in the nacelle's 3 interior room.

The inlet (not shown in figs.) that provides air into the nacelle 3 interior may be positioned so that air is provided into the dirty section, such as in or near the hub end of the nacelle 3 e.g. in the front end or the floor in the dirty section.

The air flow is as illustrated by the arrows 11 a, l lb, l lc, and is directed from the dirty section 10, through the filter wall 8 to the clean section 9.

In the clean section 9, the generator 7 cooling system draws cooling air from the surrounding air in the clean section 9 of the nacelle interior room and into the generator body by means of a fan or a blower (not shown) that is integrated into the generator 7. The fan or blower may e.g. be arranged on the generator rotary shaft. Thus, the fan or blower of the generator cooling system may also ensure sufficient air circulation inside the nacelle interior room to ensure that air is drawn through the filter wall and filtered when entering the clean section. The cooling air is expelled from the generator 7 through an air duct 12 that directs the heated cooling air to the air outlet 13.

The air outlet 13 is preferably provided in the rear end wall or floor area of the nacelle 3.

The fan or blower may alternatively be a separate device arranged in the nacelle 3 interior room, such as in connection with the air inlet or the air outlet 13.

The filter wall 8 may be a single plane wall that extends across the nacelle's interior room if the interior layout and position of the equipment in the nacelle, in particular the gearbox and the generator, allow so.

In figs. 2-3, the filter wall 8 is shown in a variant where the filter wall 8 is divided into one or more subsections 8a-8d. The filter wall 8 may comprise one or more subsections 8d that are positioned in angles to other subsections, e.g. perpendicularly to one or two other neighbouring sub sections 8c, 8e. This may result in that one or some subsections 8e are offset to in relation to other subsections 8a-8c across the nacelle room.

The filter wall 8 can be attached to the inner wall of the nacelle 3 or to one or more ribs, protrusions or ledges (not shown) in the inner nacelle wall. The frame member(s) are adapted to conform to the greatest possible extent to the cross section of the nacelle in order to maximise the filtration area. In order to make production of the filter wall easy and to easily adapt the filter wall to the cross section of the nacelle interior, the outermost area between the frame and the inner wall of the nacelle of the filter wall is covered by cover plates.

The filter screen is mounted to the filter wall frame across the frame 8e, 8f. Details on filter screens and/or mounting thereof are described in the preceding paragraphs. The netting 8g on figs. 2-3 can illustrate both the filter screen as well as a supporting net or grid 8g as described above.

The filter wall 8 may preferably comprise filter support means, preferably a rigid grid or netting member 8g, on at least one side or on both sides of the filter screen, as also discussed above.

The filter area of the filter wall 8 covers at least two thirds of the entire cross section area of the nacelle 3, or more preferred at least 75% or at least 80% or at least 90% of the entire cross section area of the nacelle 3.

The remaining part of the filter wall may further comprise cover plates (not shown) and/or ribs on the nacelle inner wall, floor and/or ceiling extending between the frame 8e-8f and the inner surfaces of the nacelle 3 room to provide a particle tight or dust tight connection between the filter wall frame 8e-8f and the inner surfaces of the nacelle 3.

A shielding plate member 15 is preferably also arranged to surround the generator rotary shaft 14. Thus, the shielding plate 15 comprises a through-going hole through which the generator rotary shaft 14 can extend from the clean section 9 and into the dirty section 10. The shielding plate member preferably comprises one or more sealing members (not shown) arranged between the shielding plate and the generator shaft. The shielding plate 15 may be a separate plate member attached to the floor

and/or a wall of the nacelle's interior room or may be integrated into the nacelle body 3, e.g. by forming the shielding plate 15 as a rib extending from the floor and/or wall of the nacelle body interior.

According to the present invention, the filter wall 8 is arranged to surround the generator 7 e.g. in box-like manner as shown in fig. 4. Fig. 4 shows the same generator 7 but from another angle.

In fig. 4, the filtration wall 8 is arranged to enclose the clean section 9 and a generator 7 arranged in the clean section. Preferably, the filter wall 8 comprises wall subsections 8h, 8i, 8k, 81, 8m which are arranged to surround the generator and the clean section of the nacelle interior.

The cage-like enclosure may optionally further comprise a roof subsection 8j arranged to provide a filter element extending between and connecting the upper ends of the wall subsections 8h, 8i, 8k, 81, 8m resulting in a box-shaped filter surface that encloses the generator in filtration surfaces on all sides thereof. This maximises the filtration surface.

In a not shown variant, the filtration wall 8 optionally further comprises filtration wall subsections 8h, 8i, 8k, 81, 8m arranged to surround the generator but omitting the roof filter element 8j. This will result in a cage-like structure that encloses the generator in filter wall subsections. In this variant, the filtration wall subsections may be arranged to extend between the floor and the ceiling of the nacelle interior room as described above.

The filtration wall may also comprise a door (not shown). The door member is preferably arranged in the filter wall 8 in conventional manner using hinges or is arranged in a subsection 8a-8e of the filter wall to ensure access between the clean section and the dirty section during service, maintenance, or repair.

Alternatively, the door may be a sliding door, e.g. using wheels arranged in a track. A sliding door is advantageous if a hinged door cannot be applied because of limited free

area. A subsection of the filtration wall may thus be a sliding door, or a sliding door may be arranged in a subsection of the filtration wall.

If necessary, the door and/or the door frame surrounding the door may comprise sealing strip members for sealing between the door frame and the door and, thus, prevent escape of dust from the dirty section to the clean section if there is a gap between the door and the door frame.

The door member is preferably also made of a frame member with a filter screen, so as to further increase the filter area and, thus, optimize air filtration capacity of the filter wall.

The method for cleaning air in a wind turbine nacelle 3 comprises the steps of introducing surrounding air into a dirty section 10 of an interior room of the nacelle 10, filtering the air through a filter wall 8 arranged between the dirty section and a clean section 9, and thereby providing clean filtered air into the clean section of the nacelle interior room. Air is drawn into the interior room of the nacelle 3 in the hub 4 end of the nacelle. Air is expelled to the surroundings via an air outlet 15 in the rear end or the rear end bottom of the nacelle 3.

The room air in the clean section 9 is suitable for direct use as cooling air e.g. in direct cooling of the generator 7.

Cooling air is provided to the generator 7 arranged in the clean section 9 and from the surrounding air in the clean section 9 of the interior room.

The wind turbine air filtering system is arranged in the nacelle and for filtering air in the nacelle 3, in particular to provide substantially particle free air to a direct cooling arrangement of the generator.

Preferably, the wind turbine air filtering system further comprises blower means, where the generator cooling system comprises blower means for drawing air from the surrounding clean section 9 of the nacelle 3 and into to the generator cooling system

as illustrated by arrow 1lb. The heated air is expelled from the generator 7 via an outlet duct 12 to the air outlet 15 as illustrated by arrow 1lc.

5

Reference numbers

1. Wind turbine
2. Tower
3. Nacelle
4. Hub
5. Rotor blades
6. Gear Box
7. Generator
8. Filter wall; 8'. Filter wall, box shape

   a-d: Filter wall subsections

   e-f: Filter wall frame

   g : Filter screen /grid or netting

   h-m: Filter wall subsections in box version
9. Clean section
10. Dirty section
11. Arrows illustrating air flow inside nacelle
12. Air outlet duct from generator
13. Air outlet from nacelle
14. Generator rotary shaft
15. Plate section of filter wall

CLAIMS

1. A wind turbine nacelle comprising an interior room, wherein the interior room is divided into a clean section and a dirty section, wherein the clean section and the dirty section of the room are separated by a filtration wall arranged to surround or enclose a generator and the clean section,

2. A wind turbine nacelle according to claim 1 or 2, **characterised in** the filtration wall comprises wall subsections.

3. A wind turbine nacelle according to claim 1 or 2, **characterised in** that the filtration wall optionally further comprises a roof subsection arranged to provide a filter element extending between and connecting the upper ends of the wall subsections.

4. A wind turbine nacelle according to any of the preceding claims 1-3, **characterised in** that the filtration wall comprises a shielding plate member surrounding the generator shaft, and where the shielding plate member comprises one or more sealing members arranged between the shielding plate and the generator shaft.

5. A wind turbine nacelle according to any of the preceding claims 1-4, **characterised in** that the filtration wall comprises a frame and a filter screen that is arranged in the frame.

6. A wind turbine nacelle according to any of the preceding claims, **characterised in** that the filtration wall frame comprises filter support means, preferably a grid or netting member, on at least one side or on both sides of the filter screen.

7. A wind turbine nacelle according to any of the preceding claims, **characterised in** that the filtration wall frame comprises a filter screen of one or more self-supported filter elements.

8. A wind turbine nacelle according to any of the preceding claims, **characterised in** that the filter wall comprises a door.

9. A wind turbine comprising a tower, a nacelle, and a wind turbine hub with rotor blades, where the wind turbine hub is arranged rotatably on the nacelle, and wherein the wind turbine nacelle is as defined in any of the preceding claims 1-10.

10. A method for purifying air in a wind turbine nacelle comprising the steps of:

- introducing surrounding air into a dirty section of an interior room of the nacelle,
- filtering the air through a filter wall arranged between the dirty section and a clean section, and where said filter wall is arranged to surround a generator arranged in the clean section,
- -thereby providing clean filtered air into the clean section of the nacelle interior room.

11. A method according to claim 10, **characterised in** that cooling air is provided to the generator arranged in the clean section from the surrounding air in the clean section of the interior room.

12. A method according to claim 10 or 11, **characterised in** that air is drawn into the interior room of the nacelle in the hub end of the nacelle and that air is expelled to the surroundings in the rear end or the rear end bottom of the nacelle.

13. A wind turbine air filtering system arranged in the nacelle and for filtering air in the nacelle comprising air introduction means for introducing surrounding air into an interior room of the nacelle, and further comprising a filter wall dividing the interior room of the nacelle into a dirty section and a clean section, and where said filter wall is arranged to surround a generator arranged in the clean section, and where one or more blower means are arranged in the nacelle for drawing air into the nacelle and through the filter wall.

14. A wind turbine air filtering system according to claim 13, **characterised in** that the generator cooling system comprises blower means for drawing air from the surrounding clean section of the nacelle to the generator cooling system.

15. A wind turbine air filtering system according to claim 13 or 14, **characterised in** that a single blower means is arranged to force air through the filter wall as well as to provide cooling air to the generator cooling system.

16. A wind turbine air filtering system according to any of the claims 13-15, **characterised in** that the air inlet is arranged in the hub end of the nacelle and that the air outlet from the nacelle is arranged in the rear end or the rear end bottom of the nacelle.

17. A wind turbine air filtering system according to any of the claims 13-16, **characterised in** that the filter wall is as defined in any of claims 1-8.

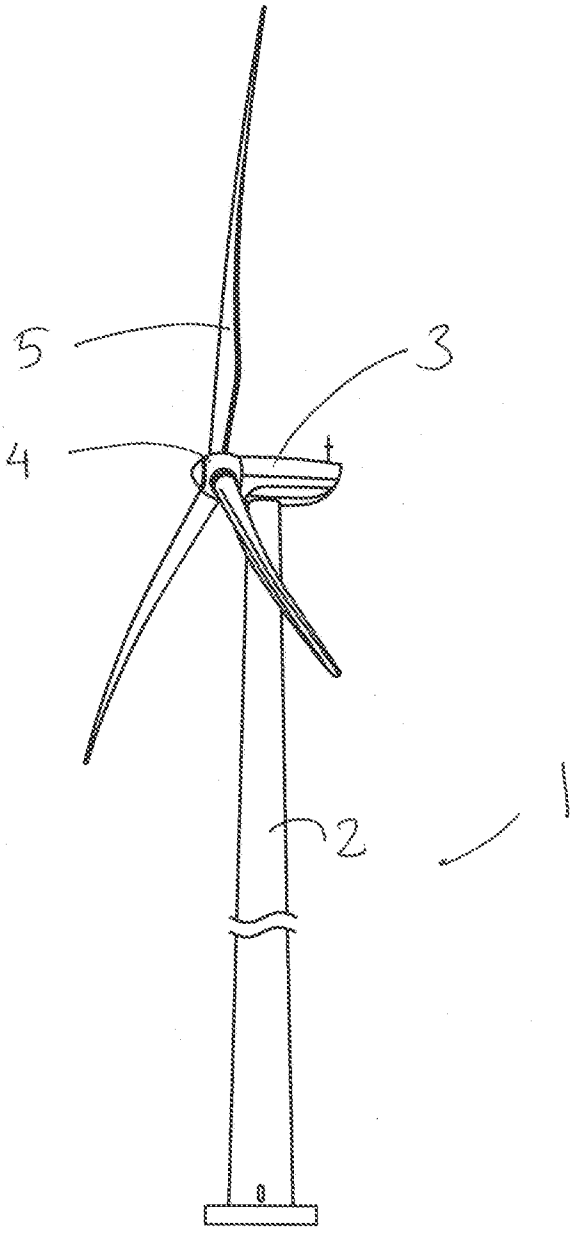

FIG. 1

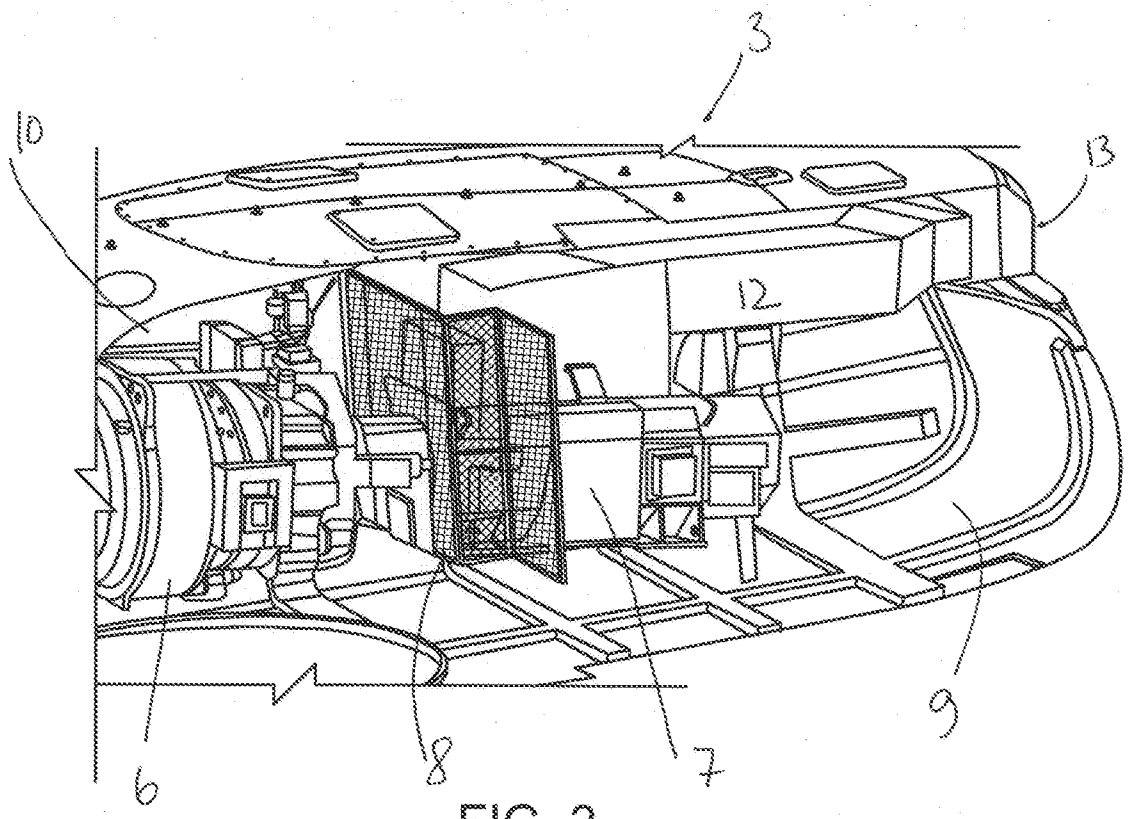

FIG. 2

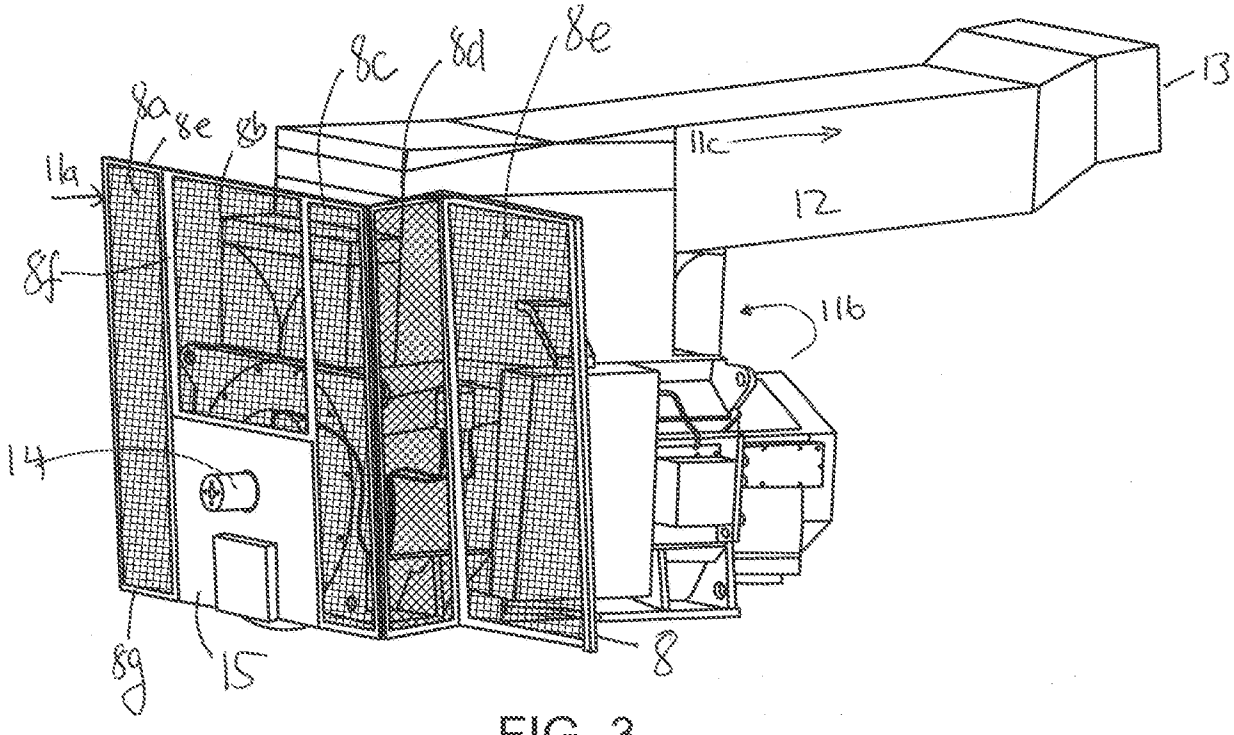

FIG. 3

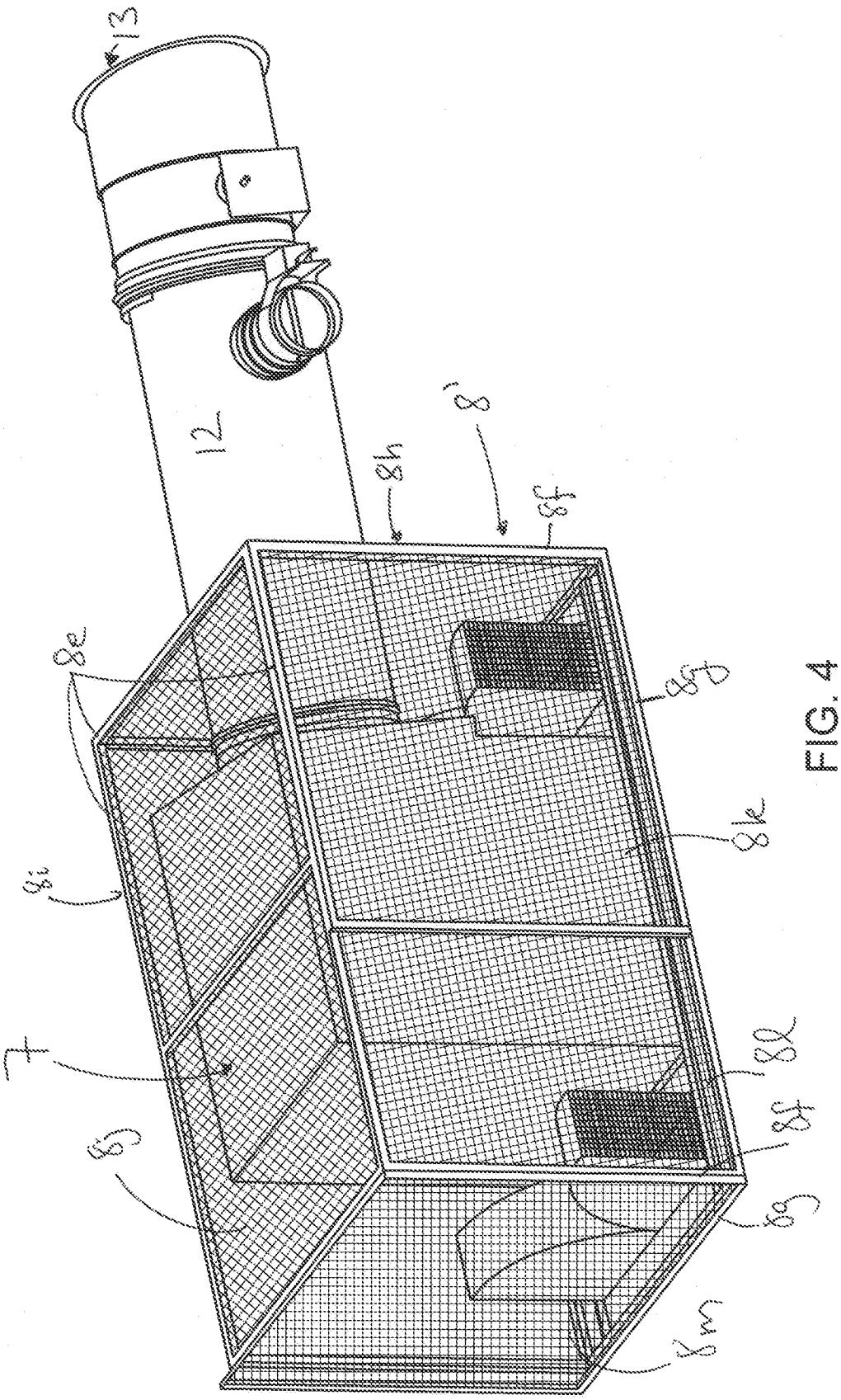

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2018/050302

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D80/80 F03D80/60
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.
A	EP 2 589 805 A1 (MITSUBISHI HEAVY IND LTD [JP]) 8 May 2013 (2013-05-08) paragraphs [0001], [0029], [0030], [0031], [0033], [0034], [0038] figures 1,2	1,4, 8-13,16
A	EP 2 123 139 A1 (VESTAS WIND SYS AS [DK]) 25 November 2009 (2009-11-25) paragraphs [0001], [0006], [0007], [0010], [0014], [0022]	1,9,11, 13,14
A	EP 2 500 563 A2 (SINOVEL WIND GROUP CO LTD [CN]) 19 September 2012 (2012-09-19) paragraphs [0001], [0030] figures 1,2	1,9,13, 17

-/--

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

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) orwhich 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 international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and 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

Date of the actual completion of the international search	Date of mailing of the international search report
15 February 2019	25/02/2019

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	Pasquet, Pierre

1

Form PCT/ISA/210 (second sheet) (April 2005)

International application No
PCT/DK2018/050302

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2018/059974 A1 (SIEMENS AG [DE]) 5 April 2018 (2018-04-05) page 1, lines 9-13 page 11, lines 13-30 figure 1 -----	1,2,5-7, 9-11,13, 14,17

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/DK2018/050302

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2589805 A1	08-05-2013	EP 2589805 A1	08-05-2013
		JP 5463218 B2	09-04-2014
		JP 2012013003 A	19-01-2012
		US 2012025541 A1	02-02-2012
		WO 2012002466 A1	05-01-2012
EP 2123139 A1	25-11-2009	AT 476863 T	15-08-2010
		CN 101669411 A	10-03-2010
		EP 2123139 A1	25-11-2009
		ES 2350271 T3	20-01-2011
		US 2010118492 A1	13-05-2010
		WO 2008098573 A1	21-08-2008
EP 2500563 A2	19-09-2012	AU 2012201587 A1	04-10-2012
		BR 102012006175 A2	05-11-2013
		CA 2771494 A1	18-09-2012
		CN 102678472 A	19-09-2012
		EP 2500563 A2	19-09-2012
		US 2012235419 A1	20-09-2012
WO 2018059974 A1	05-04-2018	NONE	