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**WO-A1-2012/052521**



# DESCRIPTION

**[0001]** The invention relates to a bearing for a wind turbine, the use of the bearing and a method to control the temperature of the bearing.

**[0002]** A wind turbine comprises a rotor with a hub and rotor blades. During the operation of the wind turbine the wind interacts with the rotor blades and rotates the rotor. The rotation of the rotor is transferred to an electric generator to generate electric power.

**[0003]** In a direct driven wind turbine the rotor and the generator are directly coupled, without a gearbox between the rotor and the generator. Thus the rotor of the wind turbine is directly coupled to the rotor of the electric generator.

**[0004]** The rotor of the wind turbine and the rotor of the electric generator belong to the rotational part of the wind turbine. The rotational part of the wind turbine is supported by a bearing.

**[0005]** The bearing comprises a stationary ring and a rotatable ring. The stationary ring is attached to the stationary part of the wind turbine, and the rotatable ring is connected to the rotatable part of the wind turbine.

**[0006]** The bearing is often called the main bearing of the wind turbine. The main bearing is a rolling element bearing or a sliding bearing.

**[0007]** The lifetime of the bearing, and the width of the air gap in the generator, depend on the clearance in the bearing. Thus it is important to control the clearance in the bearing.

**[0008]** During the start up of the wind turbine and during operation the bearing warms up due to friction in the bearing. Due to the warming the parts of the bearing expand. This expansion influences the clearing of the bearing.

**[0009]** The clearance stays mainly the same, as long as the stationary ring and the rotatable ring of the bearing expand mainly equally. This is the case, when they show mainly the same temperature.

**[0010]** During the start up of the wind turbine or changes in the load in the rotating part of the wind turbine the temperature in the bearing changes. Due to the different mass of the rotatable ring and the stationary ring of the bearing, the rings might warm up or cool down in a different time.

**[0011]** This leads to a difference in the temperature of the bearing rings. Thus the clearance of the bearing is changing. A changing clearance has a negative effect on the lifetime of the bearing and/or the width of the air gap of the generator.

**[0012]** It is therefore known to cool the bearing with an integrated oil lubrication system, where the oil is cooled and is pumped through the bearing. This shows the problem, that the exchange rate of the oil in the bearing is too low to cool the whole bearing with the lubrication oil.

**[0013]** WO 2011082836 A1 describes a cooling system of a bearing of a direct driven wind turbine, whereby the cooling system comprises at least one heat sink being in thermal contact to the inner ring of the bearing and a heat dissipater being in thermal communication with the heat sink.

**[0014]** The system shows the disadvantage that a cooling liquid is circulating though the heat sink at the bearing and the heat dissipater. Thus the installation of ducts for the cooling fluid is necessary that guide the cooling liquid, and there is a certain risk that the liquid might leak from the system.

**[0015]** WO 2012/052521 A1 discloses an arrangement in the form of a bearing, large rolling bearing, pivoting drive or rotational connection, comprising components and which are rotatable in relation to one another and devices for the integrated heating or cooling of the rolling body raceways or of the components which are rotatable in relation to one another, characterized in that the heating or cooling effect is respectively undertaken and can be controlled in a defined manner by direct entry of heat into the component or direct removal of heat from the component and is formed by the cooperation of cold- or heat- generating elements or functions or devices, and whereby it is possible to switch between a heating effect and cooling effect.

**[0016]** The aim of the invention is therefore to provide an improved arrangement to cool the bearing.

**[0017]** The object of the invention is achieved by the independent claims. Further features of the invention are disclosed in the dependant claims.

**[0018]** A bearing for a wind turbine comprises an inner ring and an outer ring. The inner ring and the outer ring are prepared and arranged in a way to rotate in respect to each other. The inner ring comprises at least one channel. The channel is prepared and arranged in a way that air flows along inside the channel so that excess heat of the inner ring is removed by the airflow in the channel.

**[0019]** The bearing comprises an inner ring and an outer ring. The bearing can be either a rolling element bearing or a sliding bearing.

**[0020]** When the bearing is used in a wind turbine, one of the bearing rings is connected to the stationary part of the wind turbine and the other bearing ring is connected to the rotating part of the wind turbine. The stationary part of the wind turbine comprises the stator of the

electrical generator and the rotatable part of the wind turbine comprises the rotor of the electrical generator and the hub of the wind turbine.

**[0021]** The inner ring of the bearing can either be connected to the stationary part of the wind turbine or to the rotatable part of the wind turbine.

**[0022]** The inner ring comprises a channel, whereby the channel is in thermal communication with the inner ring. Thus, heat of the inner ring is transferred to the channel. Air flows along inside the channel so that excess heat of the inner ring is removed by the airflow in the channel.

**[0023]** During the operation of the bearing excess heat is generated due to friction in the bearing. The excess heat is transferred from the inner ring of the bearing to the channel and is removed by the airflow in the channel.

**[0024]** Thus the air flowing through the channel cools the channel and the inner ring of the bearing. Thus excess heat is removed from the inner ring of the bearing. Thus the inner ring of the bearing is cooled and the temperature of the inner ring of the bearing can be influenced.

**[0025]** Thus the thermal expansion of the inner ring of the bearing can be influenced. Thus the clearance of the bearing can be influenced and controlled by cooling the inner ring of the bearing.

**[0026]** In the case of the use of the bearing in a wind turbine, especially in a direct driven wind turbine, the air gap of the electrical generator depends on the clearance of the main bearing.

**[0027]** Thus by controlling the clearance of the main bearing the width of the air gap can be controlled. The clearance of the bearing is important for the lifetime of the bearing. To achieve a long lifetime of the bearing, the clearance of the bearing has to be kept within a certain range.

**[0028]** The clearance of the bearing can be influenced by cooling the bearing. By influencing the temperature of the inner ring of the bearing the clearance of the bearing can be kept within a certain range.

**[0029]** Thus the lifetime of the bearing can be enlarged by controlling the temperature of the inner ring of the bearing. Thus the lifetime of the bearing can be increased. Thus the necessity to exchange the bearing is reduced. Thus the costs for exchanging the bearing can be saved.

**[0030]** The channel is at least partially covered by a lid.

**[0031]** Thus the channel is a closed channel. Thus the air flow is guided along inside the channel. The air inside the covered channel can not mix with the air outside of the covered channel.

**[0032]** The air is forced to flow along inside the channel. Thus the cooling effect is improved.

**[0033]** The channel comprises at least two openings that are used as an air inlet opening and as an air outlet opening to allow the air to flow through the channel.

**[0034]** The channel comprises one opening that allows the air to flow into the channel and one opening that allows the air to flow out of the channel. Thus the air can flow along inside the channel.

**[0035]** The opening is an open end of the channel, a hole in the wall of the channel or a slot in the wall of the channel.

**[0036]** Thus the air can enter the channel at one open end of the channel flow along inside the channel and leave the channel at another open end.

**[0037]** The channel can comprise the hole in the wall of the channel so that the air can enter the channel through the hole, flow along inside the channel and leave the channel at an open end.

**[0038]** The opening in the channel can also be a slot in the wall of the channel to achieve a larger area for the air to enter the channel.

**[0039]** A ventilator is arranged at least at one opening of the channel in a way that a ventilator moves air through the opening of the channel and through the channel.

**[0040]** Thus the air is forced through the channel by the ventilator.

**[0041]** Thus the amount of air moving through the channel can be influenced by the ventilator. Thus the amount of cooling of the inner ring can be influenced by controlling the ventilator at the channel.

**[0042]** The inner ring comprises a plurality of channels.

**[0043]** Thus, the air flows through a plurality of channels. The channels can be arranged in parallel to each other. Thus the air is guided through parallel channels along the inner ring.

**[0044]** The individual channels can be designed with a different diameter thus the amount of air flowing through the channels is varying from one channel to the next.

**[0045]** Thus the local efficiency of the cooling can be influenced by the design of the channels.

**[0046]** The single channels might be equipped with individual ventilators to control the amount of air moving through the channel. Thus the amount of cooling effected by the individual

channel can be influenced.

**[0047]** The ventilator is arranged at a plurality of channels in a way that the ventilator overlaps the channels at the openings of the channels so that the ventilator moves air through the channels.

**[0048]** The inner ring comprises a plurality of channels. The channels comprise an opening to allow the air to enter or exit the channel.

**[0049]** A ventilator is arranged at the channels overlapping the channels at their openings so that the ventilator can move the air through the openings of the channels and through the channels.

**[0050]** Thus one ventilator is needed for a plurality of channels.

**[0051]** The inner ring comprises a radially inner surface and at least one channel is arranged at the radially inner surface of the inner ring of the bearing.

**[0052]** The bearing comprises an inner ring and an outer ring. The inner ring is arranged radially inwardly of the outer ring. The inner ring comprises a radially inner surface. At least one channel of the inner ring is arranged at a radially inner surface of the inner ring.

**[0053]** Thus the inner ring is cooled from the side of the radially inner surface.

**[0054]** The channel is formed by an extruded aluminum profile that is at least partially covered by a lid and it is arranged at the surface of the inner ring.

**[0055]** An extruded aluminum profile forms one or more open tranches or channels. The extruded aluminum profile can be closed by a lid that is connected to the extruded aluminum profile.

**[0056]** Thus the open channels or tranches of the extruded aluminum profile are closed to form a channel to allow the air to flow along inside the channel.

**[0057]** The extruded aluminum profile that is covered by a lid is arranged along the surface of the inner ring. The air moves to the covered tranches or channels in the extruded aluminum profile and cools the aluminum profile.

**[0058]** The aluminum profile is in thermal communication with the inner ring. Thus the inner ring of the bearing is cooled by the air moving through the extruded aluminum profile.

**[0059]** The ventilator is arranged at an air inlet opening at the channel so that the ventilator blows the air through the channel.

**[0060]** The opening of the channel used as an air inlet opening can be an open end of the channel, a hole in the wall of the channel or a slot in the wall of the channel. The ventilator is arranged at the air inlet opening and forces the air through the air inlet opening into the channel.

**[0061]** The air flows along inside the channel and exits the channel at a second opening. Thus the air is forced through the channels by the ventilator. The air flows along inside the channels and cools the inner ring of the bearing.

**[0062]** The ventilator is arranged at an air outlet opening at the channel so that the ventilator sucks the air through the channel.

**[0063]** The opening used as an air outlet opening of the channel can be an open end of the channel, a hole in the wall of the channel or a slot in the wall of the channel. The ventilator is arranged at the air outlet opening in a way that it sucks the air through the opening out of the channel.

**[0064]** The air enters the channel through an air inlet opening. It flows along inside the channel and is forced by the ventilator to exit the channel at the air outlet opening.

**[0065]** The air flows along inside the channel and cools the channel and thus cools the inner ring of the bearing.

**[0066]** The channels of the plurality of channels have at least two different lengths, so the different local amounts of excess heat are removed from the inner ring by the air flowing along inside the channels.

**[0067]** A plurality of channels is arranged along the surface of the inner ring. Several channels of the plurality of channels can be of a different length. Thus the cooling effect of the channels is different.

**[0068]** The amount of excess heat present in the inner ring of the bearing can vary. Channels of different length can be used to remove different amounts of excess heat present in the inner ring.

**[0069]** Thus the length of the channels can be designed in a way to remove different amounts of energy. Thus the cooling of the inner ring of the bearing is optimized. Thus temperature differences in the inner ring can be leveled out.

**[0070]** The bearing comprises at least one temperature measurement device and a control device for controlling the air flow in the channel of the bearing.

**[0071]** The temperature of the inner ring can be measured with a temperature measurement device. The temperature measurement device can be arranged at the outer ring or at the inner

ring of the bearing.

**[0072]** A control device can control the amount of air flow through the channels. Thus the amount of cooling of the bearing can be controlled. Thus the overall temperature of the bearing can be controlled.

**[0073]** A bearing according to the invention is used as a main bearing in a direct driven wind turbine.

**[0074]** In the direct driven wind turbine the rotatable part of the wind turbine is connected to the stationary part of the wind turbine by a bearing.

**[0075]** The rotatable part of the wind turbine comprises the rotor of the wind turbine and the rotor of the electrical generator.

**[0076]** The stationary part of the wind turbine comprises the stator of the electrical generator. A bearing is used to connect the rotatable part and the stationary part of the wind turbine.

**[0077]** The bearing can be a rolling element bearing or a sliding bearing. The main bearing of the wind turbine is used to transfer radial forces, axial forces and tilting moments from the rotor of the wind turbine to the stationary part of the wind turbine.

**[0078]** In addition, a second bearing can be used.

**[0079]** The main bearing of a wind turbine experiences high forces when the wind turbine is in operation. Thus the main bearing of a wind turbine experiences a high friction and thus a high amount of excess heat is generated in the main bearing of a wind turbine.

**[0080]** Thus the main bearing of the wind turbine needs to be cooled to keep the temperature of the bearing stable.

**[0081]** By cooling the main bearing of a wind turbine the thermal expansion of the bearing rings and thus the clearance of the main bearing can be influenced. In a direct driven wind turbine the air gap of the electrical generator depends on the clearance of the bearing.

**[0082]** By controlling the temperature of the bearing, the clearance of the bearing and thus the air gap of the electrical generator can be kept within a certain range.

**[0083]** The arrangement as described in this invention provides an easy and simple way to cool the inner ring of the bearing. Air is used as a cooling medium, thus leakage in the cooling system does not affect electrical equipment or mechanical equipment as it would when water or oil is used as a cooling liquid.

**[0084]** In addition, the cooling circuit can be built as an open cooling circuit as air is available

everywhere in the nacelle of a wind turbine.

A method for controlling the temperature of a bearing described in this invention comprises the step of guiding an airflow through at least one channel of the inner ring of the bearing.

The invention is shown in more detail by the help of figures. The figures show a preferred configuration and do not limit the scope of the invention.

FIG 1 shows a bearing system for a wind turbine,

FIG 2 shows a detail of the channels,

FIG 3 shows another detail of the bearing,

FIG 4 shows a bearing in a direct driven wind turbine,

FIG 5 shows a detail of the channels,

FIG 6 shows another embodiment of the bearing.

FIG 1 shows a bearing system for a wind turbine.

**[0085]** FIG 1 shows a bearing 1 for a wind turbine. The bearing 1 comprises an inner ring 2 and an outer ring 3. The inner ring 2 and the outer ring 3 are prepared and arranged in a way to rotate in respect to each other. The bearing 1 can be a rolling element bearing or a sliding bearing.

Channels 4 are arranged at a radially inner surface of the inner ring 2 of the bearing 1. The channels 4 are in thermal communication with the inner ring 2 of the bearing 1.

**[0086]** A ventilator 5 is arranged at openings or holes in the channels 4 to move air through the channels 4, to cool the inner ring 2 of the bearing 1. The ventilator 5 forces air through the channels 4 that are attached to the inner ring 2. The air moves through the channels 4 and removes the excess heat from the inner ring 2 and cools the inner ring 2 of the bearing 1. The air exits the channels 4 at the open end of the channels 4.

**[0087]** FIG 2 shows a detail of the channels.

Fig 2 shows a part of the channels 4. Channels 4 are arranged along the inner ring of the bearing.

**[0088]** The channels 4 comprise openings 6. A ventilator 5 is arranged on top of the openings 6 to force air through the openings 6 into the channels 4. The air enters the channels 4 through the openings 6, it flows along inside the channels 4 and exits the channels 4 at their open ends.

**[0089]** The air moving through the channels 4 picks up the excess heat of the inner ring 2 of the bearing 1 that is generated during the operation of the bearing 1.

**[0090]** The channels in FIG 2 are formed by an extruded aluminum profile. The profile comprises a plurality of tranches that are covered by a common lid. Thus channels 4 are formed that can be used to force air through them.

**[0091]** The openings in the channels 4, to allow the air to enter the channels 4, are formed by an area without an lid on top of the extruded aluminum profile.

**[0092]** FIG 3 shows another detail of the bearing 1. The bearing 1 shows an inner ring 2 and an outer ring 3. The inner ring 2 and the outer ring 3 are arranged in a way that they can rotate in respect to each other.

**[0093]** Channels 4 are connected to the inner ring 2 of the bearing 1.

**[0094]** The channels 4 comprise openings or holes 6. A ventilator 5 is arranged at the holes 4 to suck air out of the channels 4 through the openings or holes 6. The air moves along inside the channels 4 and picks up the excess heat that is generated in the bearing 1 during the operation.

**[0095]** The channels 4 are formed by an extruded aluminum profile that is at least partially covered by a lid. The opening 6 is formed by an area where no lid is present on top of the extruded aluminum profile.

**[0096]** FIG 4 shows a bearing in a direct driven wind turbine.

FIG 4 shows a bearing 1 in a direct driven wind turbine. The bearing 1 comprises an inner ring and an outer ring. The inner ring 2 is connected to the stationary part 14 of the wind turbine. The outer ring is connected to the rotatable part 15 of the wind turbine. The stationary part 14 of the wind turbine comprises the stator 10 of the electrical generator 8. The rotatable part 15 of the wind turbine comprises the rotor 11 of the electrical generator 8 and the hub 7 of the wind turbine.

**[0097]** Channels 4 are arranged along the inner circumferential surface of the inner ring 2 of the bearing 1. A ventilator 5 is arranged at the channels 4 to force air through holes 6 in the channels 4. The air moves along inside the channels 4 to cool the inner ring of the bearing 1.

**[0098]** FIG 5 shows a detail of the channels 4.

FIG 5 shows a cut through the channels 4.

The channels 4 are made of an extruded aluminum profile 13. The profile 13 is covered by a lid 12.

**[0099]** The channels 4 comprise an opening 6 to allow air to enter or exit the channels 4. The opening or hole 6 is achieved by a gap in the lid 12. A ventilator is later arranged to the opening 6, the gap in the lid 12, to force air into the channels 4 or to suck air out of the channels 4.

**[0100]** The channels 4 can also be casted together with the inner ring 2 to form an integral part of the inner ring 2 of the bearing 1.

**[0101]** FIG 6 shows another embodiment of the bearing.

FIG 6 shows a bearing 1 for a wind turbine. The bearing 1 comprises an inner ring 2 and an outer ring 3. The inner ring 2 and the outer ring 3 are prepared and arranged in a way to rotate in respect to each other. The bearing 1 can be a rolling element bearing or a sliding bearing.

**[0102]** Channels 4 are arranged at a radially inner surface of the inner ring 2 of the bearing 1. The channels 4 are in thermal communication with the inner ring 2 of the bearing 1.

**[0103]** The channels 4 show a different length along the inner ring 2, that depends of the amount of heat that needs to be removes from the inner ring 2.

**[0104]** The channels 4 are attached to the inner ring 2 of the bearing 1 by bars 9 that are screwed to the inner ring 2.

**[0105]** A ventilator 5 is arranged at openings or holes in the channels 4 to move air through the channels 4, to cool the inner ring 2 of the bearing 1.

**[0106]** The ventilator 5 forces air through the channels 4 that are attached to the inner ring 2. The air moves through the channels 4 and removes the excess heat from the inner ring 2 and cools the inner ring 2 of the bearing 1.

**[0107]** The air exits the channels 4 at the open end of the channels 4.

**[0108]** The illustration in the drawings is in schematic form. It is noted that in different figures, similar or identical elements are provided with the same reference signs.

**[0109]** Although the present invention has been described in detail with reference to the preferred embodiment, it is to be understood that the present invention is not limited by the disclosed examples, and that numerous additional modifications and variations could be made thereto by a person skilled in the art without departing from the scope of the invention.

**[0110]** It should be noted that the use of "a" or "an" throughout this application does not exclude a plurality, and "comprising" does not exclude other steps or elements. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

## **REFERENCES CITED IN THE DESCRIPTION**

This list of references cited by the applicant is for the reader's convenience only. It does not

form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

**Patent documents cited in the description**

- WO2011082836A1 [0013]
- WO2012052521A1 [0015]

## Patentkrav

### 1. Lejesystem til en vindmølle omfattende

- et leje (1) med en indvendig ring (2) og en udvendig ring (3),

5 - en ventilator (5)

- hvor den indvendige ring (2) og den udvendige ring (3) er udformet og anbragt på en sådan måde, at de roterer i forhold til hinanden,

- den indvendige ring (2) omfatter mindst en kanal (4),

- hvor kanalen (4) er i det mindste delvist dækket af en afdækning (12),

10 - hvor kanalen (4) omfatter mindst to åbninger (6), der anvendes som en luftindløbsåbning og som en luftudløbsåbning for at gøre det muligt for luften at strømme gennem kanalen (4),

- hvor kanalen (4) er udformet og anbragt på en sådan måde, at der strømmer luft langs det indre af kanalen (4), således at overskydende varme af den indvendige ring (2) fjernes ved hjælp af luftstrømmen i kanalen (4),

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- hvor ventilatoren (5) er anbragt ved mindst en åbning (6) af kanalen (4) på en sådan måde, at ventilatoren (5) bevæger luften gennem åbningen (6) af kanalen (4) og gennem kanalen (4).

**kendetegnet ved, at** ventilatoren (5) er anbragt ved flerheden af kanaler (4) på en sådan måde, at ventilatoren overlapper kanalerne (4) ved åbningerne af kanalerne (4), således at ventilatoren (5) bevæger luften gennem kanalerne (4).

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**2. Leje (1) til en vindmølle ifølge et af de foregående krav, kendetegnet ved, at** åbningen (6) er en åben ende af kanalen (4), et hul i væggen af kanalen (4) eller en slids i væggen af kanalen (4).

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**3. Leje (1) til en vindmølle ifølge et af de foregående krav, kendetegnet ved, at** den indvendige ring (2) omfatter en flerhed af kanaler (4)

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**4. Leje (1) til en vindmølle ifølge et af de foregående krav, kendetegnet ved, at** den indvendige ring (2) omfatter en radially indvendig overflade, og at mindst en kanal (4) er anbragt på den radially indvendige overflade af den indvendige ring (2) af lejet (1).

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5. Leje (1) til en vindmølle ifølge et af de foregående krav, **kendetegnet ved, at** kanalen (4) er dannet af en ekstruderet aluminiumsprofil (13), som er i det mindste delvist dækket af en afdækning (12), og som er anbragt på overfladen af den indvendige ring (2).

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6. Leje (1) til en vindmølle ifølge krav 1, **kendetegnet ved, at** ventilatoren (5) er anbragt ved en luftindløbsåbning (6) ved kanalen (4), således at ventilatoren blæser luften gennem kanalen (4).

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7. Leje (1) til en vindmølle ifølge krav 1, **kendetegnet ved, at** ventilatoren (5) er anbragt ved en luftudløbsåbning (6) ved kanalen (4). således at ventilatoren (5) suger luften gennem kanalen (4).

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8. Leje (1) til en vindmølle ifølge krav 3, **kendetegnet ved, at** kanalerne (4) af flerheden af kanaler har mindst to forskellige længder, således at forskellige lokale mængder af overskydende varme fjernes fra den indvendige ring (2) ved hjælp af luften, der strømmer langs det indre af kanalerne (4).

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9. Leje (1) til en vindmølle ifølge et af de foregående krav, **kendetegnet ved, at** lejet omfatter mindst en temperaturmåleindretning og en styreindretning til styring af luftstrømmen i kanalen (4) af lejet (1).

10. Anvendelse af et lejesystem ifølge et af kravene 1 til 9 med et hovedleje i en direkte drevet vindmølle.

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11. Fremgangsmåde til styring af temperaturen i et lejesystem ifølge krav 1 til 9, omfattende trinnet:

- at føre en luftstrøm gennem mindst en kanal (4) af den indvendige ring (2) af lejet (1).

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# DRAWINGS

FIG 1

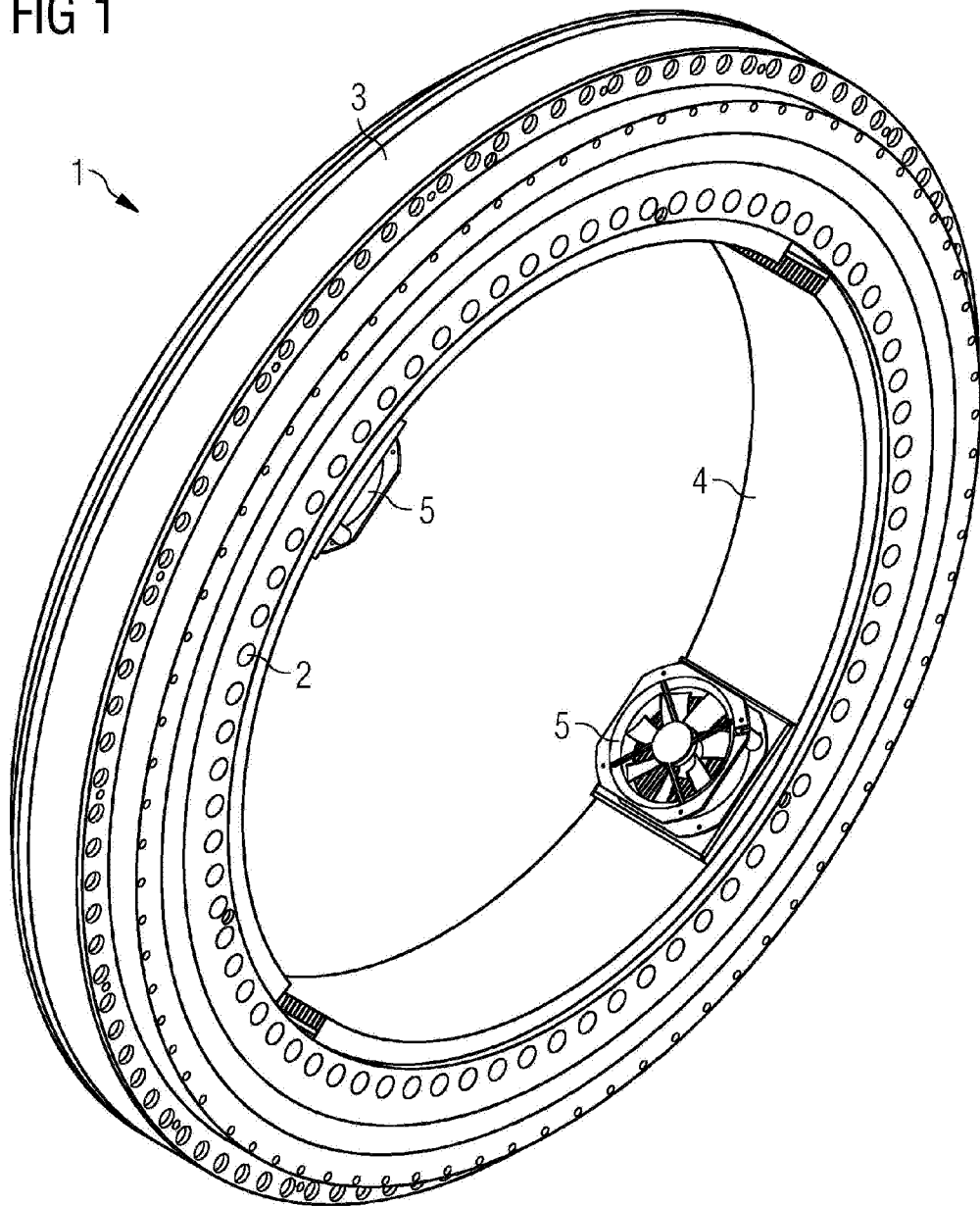


FIG 2

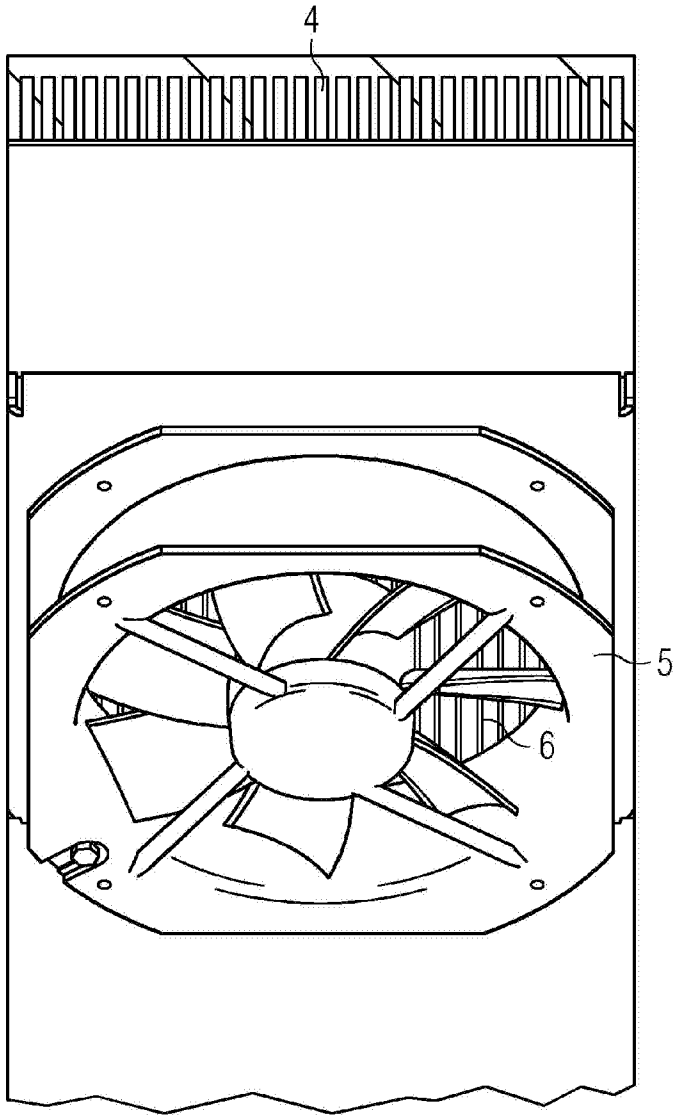
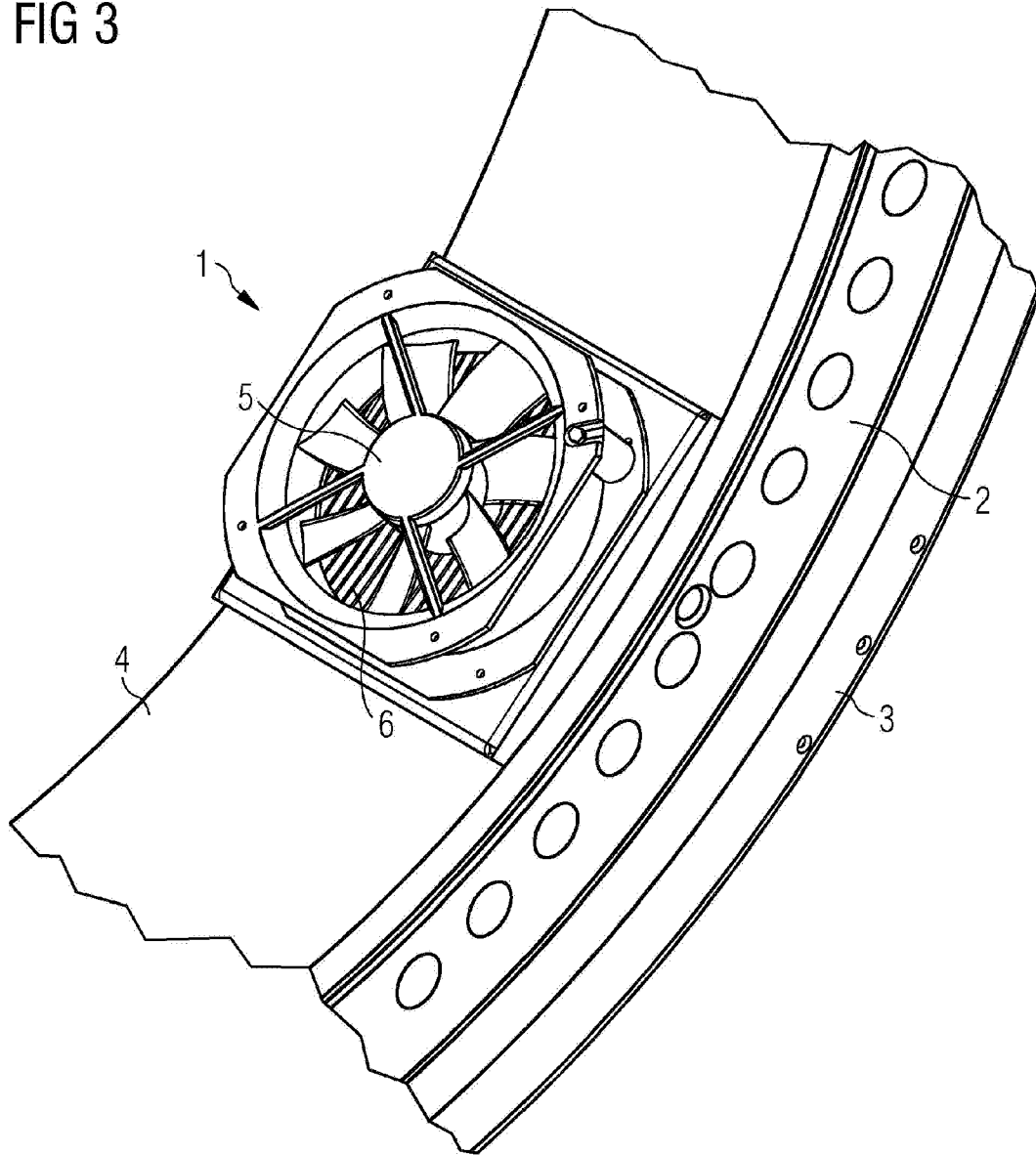


FIG 3



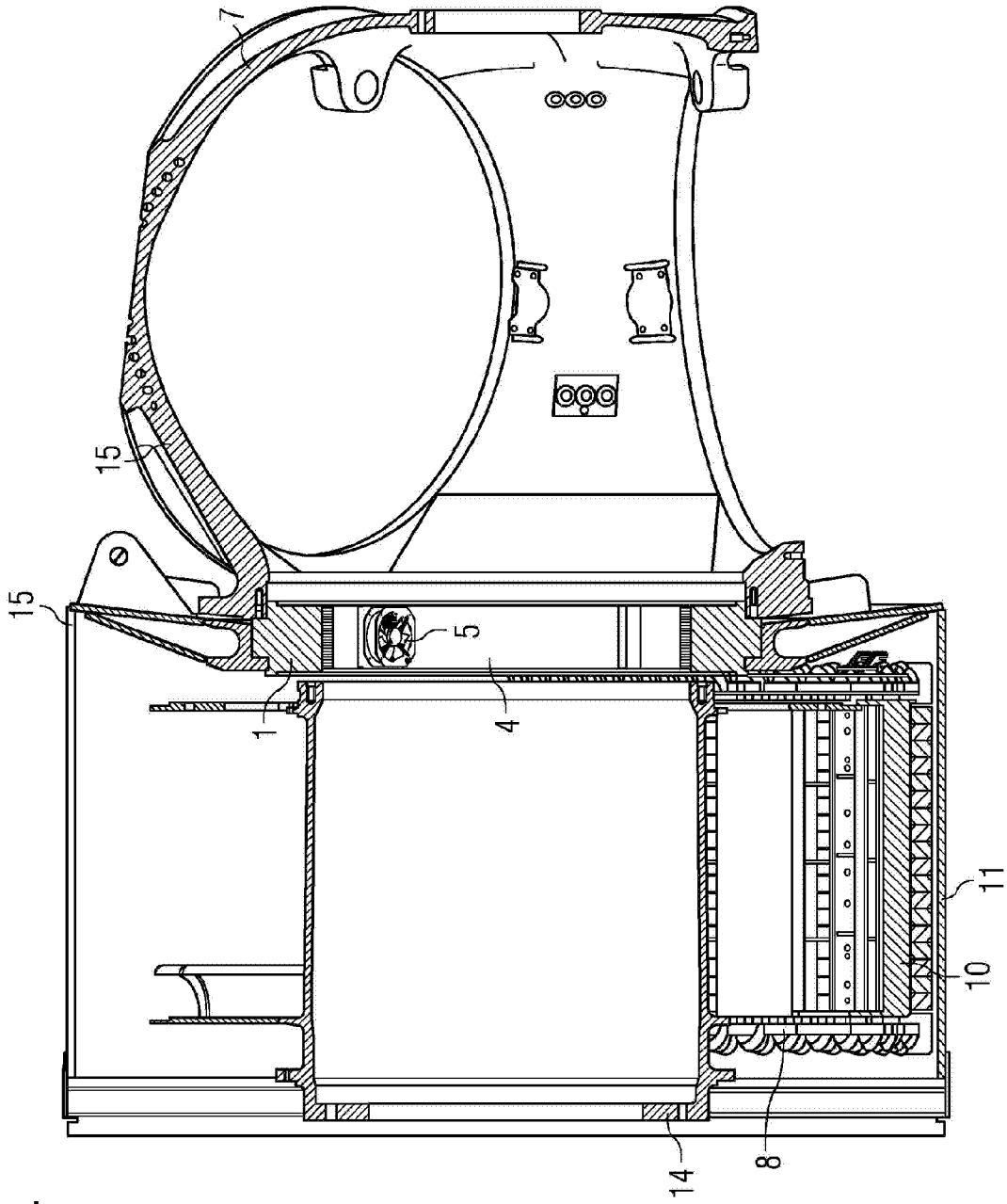


FIG 4

FIG 5

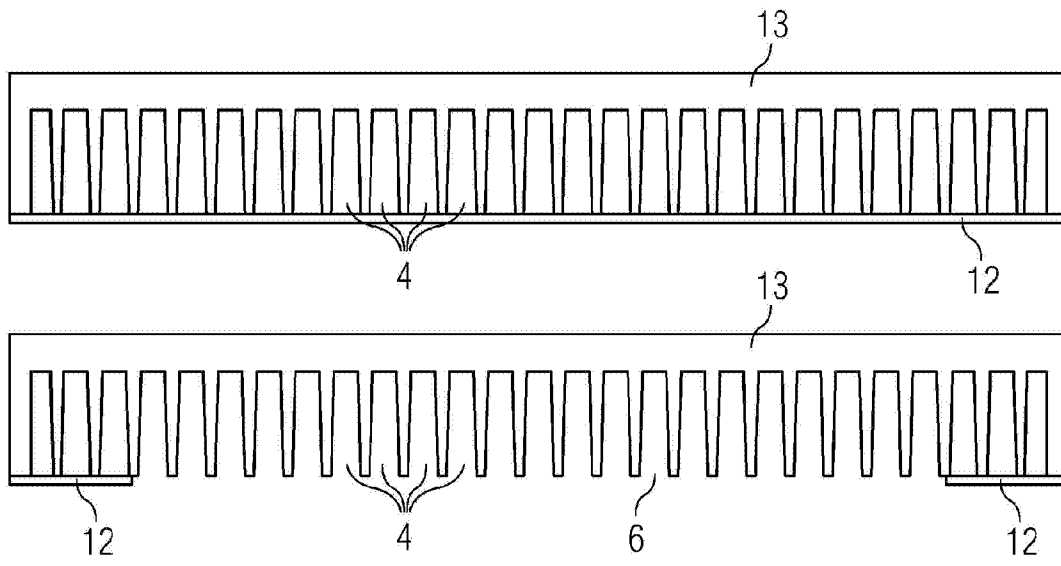


FIG 6

