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(71) Applicant: **GLOBAL LIGHTNING PROTECTION SERVICES A/S** [DK/DK]; HI Park 445, DK-7400 Herning (DK).

(72) Inventors: **OLSEN, Flemming Bjørn**; Skoleparken 84, DK-8330 Beder (DK). **MIERITZ, Casper Falkenstrøm**; Gråstensgade 3, 1. th., DK-1677 København V (DK). **BERTELSEN, Kim**; Kronhedevej 8, DK-6990 Ulfborg (DK). **KROGH, Thomas Holm**; Skadevej 20, DK-8765 Klovborg (DK). **MADSEN, Søren Find**; Ørnevej 15, DK-4330 Hvalsø (DK).

(74) Agent: **CARLSEN, Bjarne**; Patender ApS, Birk Centerpark 40, 7400 Herning (DK).

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(54) **Title**: SIDE RECEPTOR FOR LIGHTNING PROTECTION SYSTEM

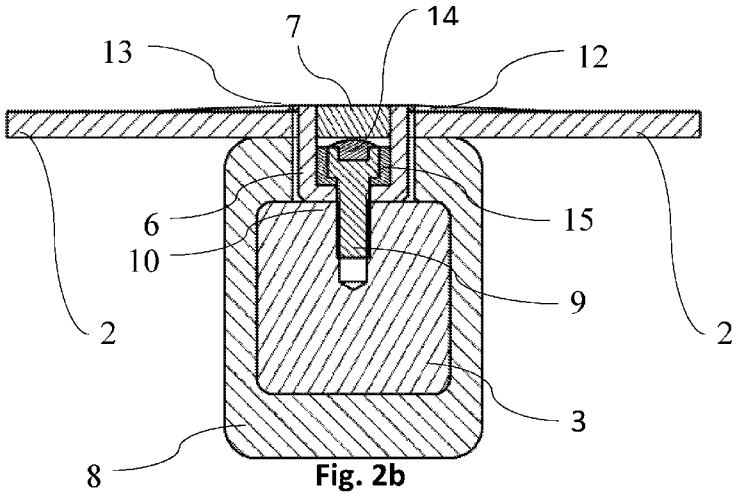

Fig. 2b

(57) **Abstract**: A side receptor (1) for a lightning protection system for a wind turbine blade (2) is disclosed, comprising a receptor cylinder (6), a mounting bolt (9) and a receptor plug (7), wherein the receptor cylinder is a tubular metallic part with one partly closed end penetrated by a centred hole, the diameter of which centred hole is slightly larger than the diameter of the thread part of the mounting bolt, wherein the inner diameter of the receptor cylinder is larger than the diameter of the head of the mounting bolt and the internal length of the receptor cylinder is larger than the height of the head of the bolt, and wherein the receptor plug is dimensioned to fit into the end of the receptor cylinder opposite the partly closed end to cover the head of the mounting bolt concealed therein.

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SIDE RECEPTOR FOR LIGHTNING PROTECTION SYSTEM

The present invention relates to a side receptor for a lightning protection system for a wind turbine blade.

Background of the invention

Most known lightning protection systems for wind turbine blades comprise one or more internally arranged down conductors and a number of lightning receptors arranged on the external surface of the blade. Typically, there is a tip receptor arranged at the tip of the wind turbine blade and a number of side receptors distributed on the surface of the wind turbine blade along at least a part of the length thereof.

It is a well-known problem that such external lightning receptors can be damaged by lightning impacts and that, therefore, the lifetime of such receptors is limited, depending on the number of lightning impacts to which they are subjected.

A typical side receptor as known in the art simply consists of a metal bolt, the head of which is aligned with the external surface of the wind turbine blade and the thread part of which is screwed into a side receptor base arranged within the wind turbine blade. The electrically conducting side receptor base is electrically grounded so that the current from lightning strikes impacting the head of the side receptor passes through the thread part thereof to the side receptor base and further through the wind turbine blade and the wind turbine tower to the ground.

A number of problems are related to the use of such typical side receptors. For instance, the head of the side receptor is often damaged by the impacts of lightning strikes. This means that any recesses (slots) or other structural elements in the head meant for engagement by tools may have at least partly disappeared after a number of lightning impacts. Therefore, it is often more or less impossible to unscrew the

side receptor, for instance in order to replace it. Ironically, the more a replacement of a side receptor is needed, the more difficult it may be to remove it.

Another problem is that, because the lightning current must pass through the threads of the side receptor, manufacturers are often reluctant to use threadlockers or other adhesives for securing the side receptor because it may reduce the conductivity between the side receptor and the side receptor base.

Brief description of the invention

It is an object of the present invention to provide a side receptor for at lightning protection system, which overcomes at least partly the above-mentioned disadvantages of side receptors known in the art.

The present invention relates to a side receptor for a lightning protection system for a wind turbine blade, which side receptor comprises a receptor cylinder, a mounting bolt and a receptor plug, wherein the receptor cylinder is a tubular metallic part with one partly closed end penetrated by a centred hole, at least a part of the external surface of which partly closed end is arranged to be a contact surface for mechanical and electrical contact to a side receptor base when the side receptor is mounted within a wind turbine blade, and the diameter of which centred hole is slightly larger than the diameter of the thread part of the mounting bolt, wherein the inner diameter of the receptor cylinder is larger than the diameter of the head of the mounting bolt and the internal length of the receptor cylinder is larger than the height of the head of the bolt so that the mounting bolt can be arranged with its head concealed within the receptor cylinder and its thread part protruding through the centred hole in the partly closed end thereof, and wherein the receptor plug is dimensioned to fit into the end of the receptor cylinder opposite the partly closed end to cover the head of the mounting bolt concealed therein.

A side receptor configured this way is advantageous, for instance, in that the head of the mounting bolt are protected from being damaged by lightning strikes and, therefore, stays intact so that the side receptor can be removed for replacement whenever needed.

Another advantage is that the lightning current passes through the contact surface rather than through the threads of the mounting bolt and that, therefore, there are no problems related to using threadlockers or other adhesives for securing the mounting bolt and thereby the side receptor.

In an embodiment of the invention, the receptor plug is made from a solid material, such as a metal, a plastic material or fibreglass.

In this case, the solid plug may be drilled out, when the side receptor has to be replaced and access to the mounting bolt is needed.

In an embodiment of the invention, the receptor plug consists of a heat resistant paste, such as silicone.

In an embodiment of the invention, a screw cap, made for instance by High-density polyethylene (HDPE), is arranged within the slot of the mounting bolt.

Placing a screw cap within the slot of the mounting bolt protects the slot and ensures that it is not filled by paste, from which the receptor plug may be formed, which could be troublesome when a tool has to engage with this slot for loosening and removal of the mounting bolt.

In an embodiment of the invention, the side receptor further comprises a washer to be arranged between the head of the mounting bolt and the internal surface of the partly closed end of the receptor cylinder.

In an embodiment of the invention, the side receptor further comprises around the head of the mounting bolt a bolt insulator, made for instance from polymers or insulating composites (fibreglass or Bakelite), for insulating the mounting bolt electrically from the receptor cylinder.

The use of such a bolt insulator ensures that the lightning current does not pass through the mounting bolt.

In an embodiment of the invention, the thread diameter of the mounting bolt is between 8 mm and 15 mm, preferably between 10 mm and 12 mm.

In an embodiment of the invention, the outer edge of the receptor cylinder at the partly closed end thereof is bevelled so that at least a part of the contact surface is slanted.

In an embodiment of the invention, the angle between the bevelled part of the contact surface and the longitudinal axis of the receptor cylinder is between 30° and 70°, preferably between 55° and 65°, most preferred 59°.

The use of an at least partly slanted contact surface ensures a better mechanical contact and results in a larger contact surface for passage of the lightning current from the side receptor to the side receptor base. An angle of 59° corresponds to the shape of the end of a standard drill.

In an embodiment of the invention, the side receptor further comprises at its end opposite the partly closed end a receptor ruff protruding outwards substantially perpendicularly to the longitudinal axis of the receptor cylinder.

A receptor ruff helps ensuring a tight connection between the side receptor and the surrounding surface of the wind turbine blade and ensures more material for the arc root erosion due to lightning impacts.

In an embodiment of the invention, the receptor cylinder consists at least partly of copper or a copper alloy.

The use of copper ensures a very high electric conductivity and a high thermal conductivity of the receptor cylinder.

In an embodiment of the invention, the receptor cylinder consists at least partly of steel.

The use of steel ensures a very high mechanical strength and reduces the risk of corrosion-related problems at a relatively low cost.

In an embodiment of the invention, the receptor cylinder consists at least partly of aluminium.

The use of aluminium allows easy mechanical processing at a relatively low cost.

In an embodiment of the invention, the receptor cylinder at its end opposite the partly closed end is covered with a protective layer of a temperature-resistant material, such as tungsten carbide.

In an embodiment of the invention, the receptor cylinder consists at least partly of tungsten carbide.

The use of tungsten carbide ensures a high electric conductivity, a high thermal conductivity and a very high melting temperature of the surface of the receptor cylinder and, hence, low susceptance to charge erosion from lightning strikes. Particularly, coatings of tungsten carbide applied on other materials have a proven high performance to the so-called long stroke components of lightning strikes. The

chemical stability of tungsten carbide is high, meaning that the risk of corrosion-related problems is greatly reduced.

In an embodiment of the invention, the inner diameter of the receptor cylinder is between 10 mm and 40 mm, preferably between 15 mm and 30 mm.

In an embodiment of the invention, the wall thickness of the receptor cylinder is between 2 mm and 10 mm, preferably between 4 mm and 8 mm.

In an embodiment of the invention, the length of the receptor cylinder is between 15 mm and 150 mm, preferably between 20 mm and 50 mm.

In an embodiment of the invention, the side receptor further comprises a blade surface protection surrounding the receptor cylinder and extending outwards therefrom in a plane substantially perpendicular to the longitudinal axis thereof being substantially aligned with the end of the receptor cylinder opposite the partly closed end and, if present, with the receptor ruff.

In an embodiment of the invention, the blade surface protection is made from a circular sheet of a heat-resistant plastic material, such as a polyester or polyamide film, fibreglass composite materials or high temperature ceramic compounds, which is fastened to the surface of the wind turbine blade by means of an adhesive.

In an aspect of the invention, it relates to a lightning protection system for a wind turbine blade comprising one or more side receptors as described above.

In an aspect of the invention, it relates to a wind turbine comprising a lightning protection system as described above.

The drawing

In the following, a few embodiments of the invention are described in more detail with reference to the drawing, of which

Fig. 1 illustrates schematically a wind turbine blade with a lightning protection system including a side receptor as known in the art,

Fig. 2a is a perspective view of a side receptor according to an embodiment of the invention mounted within the surface of a wind turbine blade,

Fig. 2b is a cross-sectional view of the side receptor shown in Fig. 2a,

Fig. 3a is a cross-sectional view of a side receptor according to an embodiment of the invention,

Fig. 3b is a cross-sectional view of a side receptor according to another embodiment of the invention, and

Fig. 4 is an explosive view of a side receptor according to a third embodiment of the invention mounted within the surface of a wind turbine blade.

Detailed description of the invention

Fig. 1 illustrates schematically a wind turbine blade 2 with a lightning protection system including a side receptor 1 as known in the art. The side receptor 1 is mounted within the surface of the wind turbine blade 2, preferably aligned therewith, and mechanically and electrically connected with a side receptor base 3 arranged within the wind turbine blade 2 and covered by an insulation 8. The side receptor 1 being typically formed as a bolt, the connection to the side receptor base 3 consists simply in a threaded connection.

A down conductor 4 extending along the longitudinal axis of the wind turbine blade 2 ensures that the side receptor base 3 (and thereby the side receptor 1) and a tip receptor 5 of the wind turbine blade 2 are electrically connected to earth through the wind turbine nacelle and tower (not shown).

Figs. 2a and 2b are a perspective view and a cross-sectional view, respectively, of a side receptor 1 according to an embodiment of the invention mounted within the surface of a wind turbine blade 2. A receptor cylinder 6 constitutes the electrically conducting part of the side receptor 1. Its upper circular end forms the external part of the side receptor 1 being substantially aligned with the surface of the wind turbine blade 2 when the side receptor 1 is mounted therein. This is the part being impacted by lightning strikes.

The opposite end of the receptor cylinder 6 forms a contact surface 10 through which the lightning current passes from the side receptor 1 into the side receptor base 3 to which the side receptor 1 is connected. The receptor cylinder 6 is mechanically connected to the side receptor base 3 by means of a mounting bolt 9, the head of which is concealed within the receptor cylinder 6 and the thread part of which protrudes through a centred hole in the contact surface 10 of the receptor cylinder 6.

In the embodiment illustrated in these figures, the contact surface 10 is plane and perpendicular to the longitudinal axis of the receptor cylinder 6. In other embodiments, as for instance illustrated in Fig. 3b, the contact surface 10 or at least a part thereof can be slanted.

Fig. 2b shows how the insulation 8 covers the side receptor base 3 as well as the side receptor 1 connected thereto. This is very important for ensuring that the lightning strikes do, in fact, pass through the side receptor 1 rather than bypassing it by penetrating the shell of the wind turbine blade 2 next to the side receptor 1 on its path to the side receptor base 3 and the down conductor inside the wind turbine blade 2.

A washer can be arranged between the head of the mounting bolt 9 and the internal surface of the receptor cylinder 6 for securing the mounting bolt 9.

In the illustrated embodiment, the side receptor 2 comprises an optional blade surface protection 12 in the form of a circular sheet of a heat resistant material arranged around the receptor cylinder 6 for protecting the surface of the wind turbine blade 2 against being damaged from the excessive heat energy following lightning strikes impacting the side receptor 1. Advantageously, this blade surface protection 12 is adhered to the surface of the wind turbine blade 2 during the mounting of the side receptor 1 therein.

A sealant 13 ensures a tight connection between the side receptor 1 and the surrounding surface of the wind turbine blade 2.

The open end of the receptor cylinder 6 is closed by a receptor plug 7, which may either be made from a solid electrically conducting or insulating material or consist of a heat-resistant paste. This receptor plug 7 covers and protects the head of the mounting bolt 9 from being damaged from impacting lightning strikes. A screw cap 14 protects the slot of the mounting bolt 9, for instance against entrance of paste, if the receptor plug 7 consists of such a paste.

Furthermore, this embodiment of the side receptor 1 comprises a bolt insulator 15 arranged around the head of the mounting bolt 9 for ensuring electrical insulation between the mounting bolt 9 and the receptor cylinder 6 so that the lightning current is forced to pass through the contact surface 10 rather than through the threads of the mounting bolt 9 on its path from the side receptor 1 to the side receptor base 3.

Fig. 3a is an enlarged cross-sectional view of the side receptor 1 of the two previous figures, whereas Fig. 3b is a cross-sectional view of a side receptor 1 according to another embodiment of the invention.

One difference from the embodiment shown in Fig. 3a is that in the embodiment shown in Fig. 3b, the receptor cylinder 6 is provided with a receptor ruff 11 extending outwards from the upper circular end of the receptor cylinder 6. Such a receptor ruff 11 is useful for ensuring a tight and weather-resistant connection between the side receptor 1 and the surrounding surface of the wind turbine blade 2 and provides additional material for the arc root erosion and, hence, the natural wear of the side receptor 1.

Furthermore, the edge of the receptor cylinder 6 is bevelled in such a way that at least a part of the contact surface 10 is slanted. This increases the area of the contact surface 10 and thereby improves the electrical connection to the side receptor base 3. Furthermore, it ensures a better mechanical stability of the connection between the side receptor 1 and the side receptor base 3.

Fig. 4 is an explosive view of the side receptor 1 mounted within the wind turbine blade 2 as shown in Figs. 2a and 2b (but without the insulation 8 of the side receptor base). Again, the receptor plug 7 may either be made from a solid material or consist of a heat-resistant paste.

List of reference numbers

1. Side receptor
2. Wind turbine blade
3. Side receptor base
4. Down conductor
5. Tip receptor
6. Receptor cylinder
7. Receptor plug
8. Insulation of side receptor base
9. Mounting bolt
10. Contact surface
11. Receptor ruff
12. Blade surface protection
13. Sealant
14. Screw cap
15. Bolt insulator

Claims

1. A side receptor (1) for a lightning protection system for a wind turbine blade (2), which side receptor comprises a receptor cylinder (6), a mounting bolt (9) and a receptor plug (7),

wherein the receptor cylinder is a tubular metallic part with one partly closed end penetrated by a centred hole, at least a part of the external surface of which partly closed end is arranged to be a contact surface (10) for mechanical and electrical contact to a side receptor base (3) when the side receptor is mounted within a wind turbine blade, and the diameter of which centred hole is slightly larger than the diameter of the thread part of the mounting bolt,

wherein the inner diameter of the receptor cylinder is larger than the diameter of the head of the mounting bolt and the internal length of the receptor cylinder is larger than the height of the head of the bolt so that the mounting bolt can be arranged with its head concealed within the receptor cylinder and its thread part protruding through the centred hole in the partly closed end thereof, and

wherein the receptor plug is dimensioned to fit into the end of the receptor cylinder opposite the partly closed end to cover the head of the mounting bolt concealed therein.

2. The side receptor according to claim 1, wherein the receptor plug is made from a solid material, such as a metal, a plastic material or fibreglass.

3. The side receptor according to claim 1, wherein the receptor plug consists of a heat resistant paste, such as silicone.

4. The side receptor according to claim 3, wherein a screw cap (14), made for instance by High-density polyethylene (HDPE), is arranged within the slot of the mounting bolt.

5. The side receptor according to any of the preceding claims, further comprising a washer to be arranged between the head of the mounting bolt and the internal surface of the partly closed end of the receptor cylinder.

6. The side receptor according to any of the preceding claims, further comprising around the head of the mounting bolt a bolt insulator (15), made for instance from polymers or insulating composites (fibreglass or Bakelite), for insulating the mounting bolt electrically from the receptor cylinder.

7. The side receptor according to any of the preceding claims, wherein the thread diameter of the mounting bolt is between 8 mm and 15 mm, preferably between 10 mm and 12 mm.

8. The side receptor according to any of the preceding claims, wherein the outer edge of the receptor cylinder at the partly closed end thereof is bevelled so that at least a part of the contact surface is slanted.

9. The side receptor according to claim 8, wherein the angle between the bevelled part of the contact surface and the longitudinal axis of the receptor cylinder is between 30° and 70°, preferably between 55° and 65°, most preferred 59°.

10. The side receptor according to any of the preceding claims, further comprising at its end opposite the partly closed end a receptor ruff (11) protruding outwards substantially perpendicularly to the longitudinal axis of the receptor cylinder.

11. The side receptor according to any of the preceding claims, wherein the receptor cylinder consists at least partly of copper or a copper alloy.

13. The side receptor according to any of the preceding claims, wherein the receptor cylinder consists at least partly of steel.

14. The side receptor according to any of the preceding claims, wherein the receptor cylinder consists at least partly of aluminium.

15. The side receptor according to any of the preceding claims, wherein the receptor cylinder at its end opposite the partly closed end is covered with a protective layer of a temperature-resistant material, such as tungsten carbide.

16. The side receptor according to any of the preceding claims, wherein the receptor cylinder consists at least partly of tungsten carbide.

17. The side receptor according to any of the preceding claims, wherein the inner diameter of the receptor cylinder is between 10 mm and 40 mm, preferably between 15 mm and 30 mm.

18. The side receptor according to any of the preceding claims, wherein the wall thickness of the receptor cylinder is between 2 mm and 10 mm, preferably between 4 mm and 8 mm.

19. The side receptor according to any of the preceding claims, wherein the length of the receptor cylinder is between 15 mm and 150 mm, preferably between 20 mm and 50 mm.

20. The side receptor according to any of the preceding claims, further comprising a blade surface protection (12) surrounding the receptor cylinder and extending outwards therefrom in a plane substantially perpendicular to the longitudinal axis thereof being substantially aligned with the end of the receptor cylinder opposite the partly closed end and, if present, with the receptor ruff.

21. The side receptor according to claim 20, wherein the blade surface protection is made from a circular sheet of a heat-resistant plastic material, such as a polyester or polyamide film, fibreglass composite materials or high temperature ceramic compounds, which is fastened to the surface of the wind turbine blade by means of an adhesive.

22. A lightning protection system for a wind turbine blade (2) comprising one or more side receptors (1) according to any of the preceding claims.

23. A wind turbine comprising a lightning protection system according to claim 22.

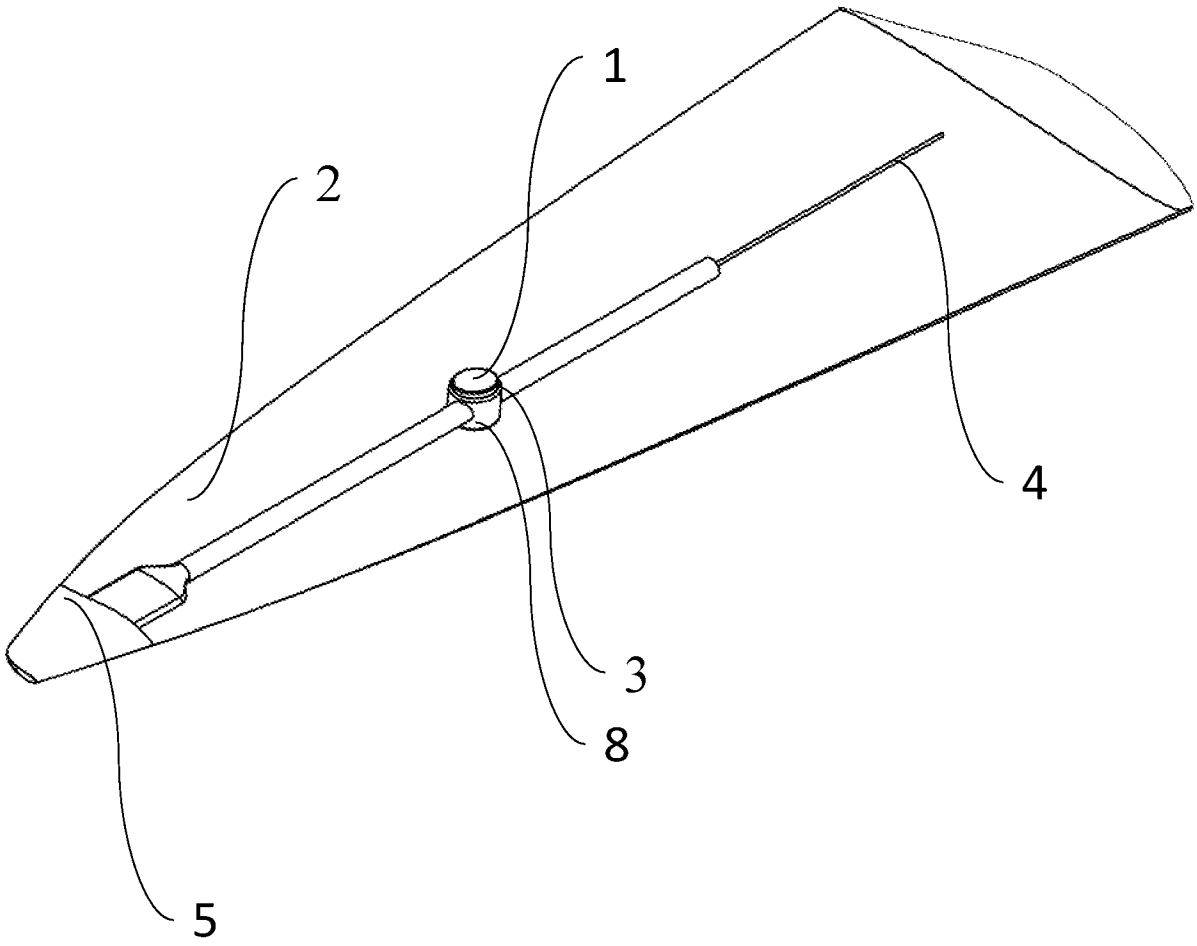

Fig. 1

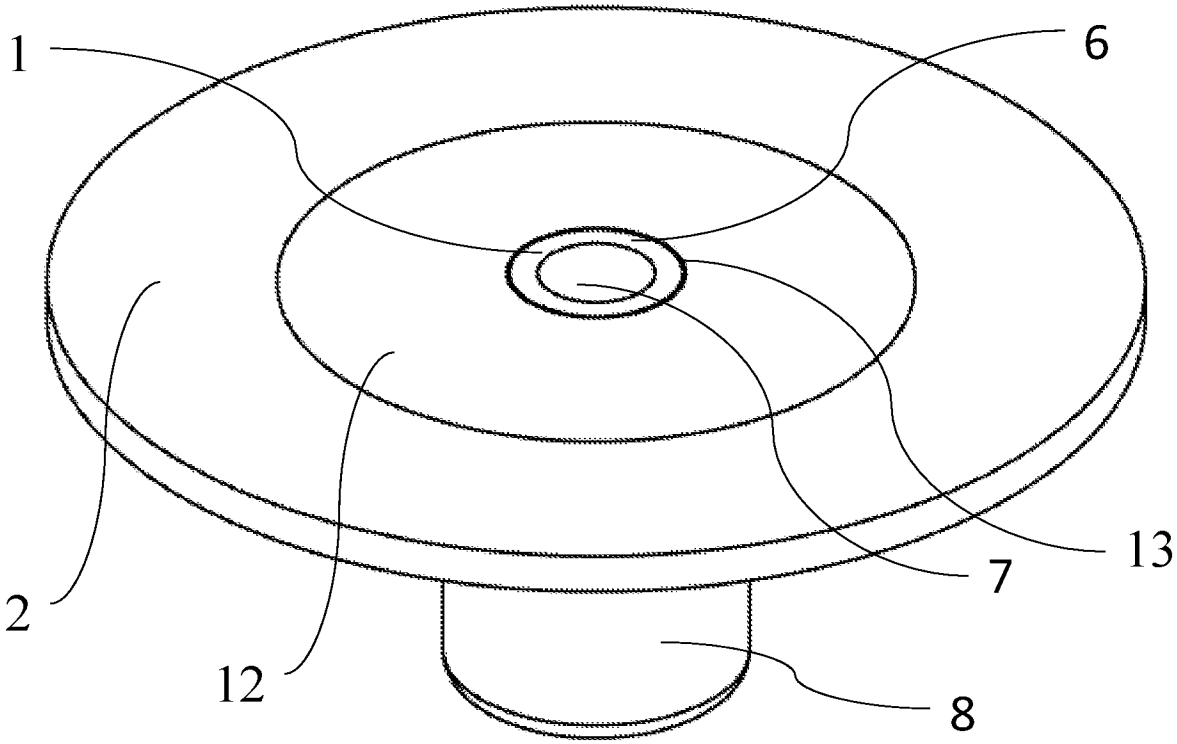

Fig. 2a

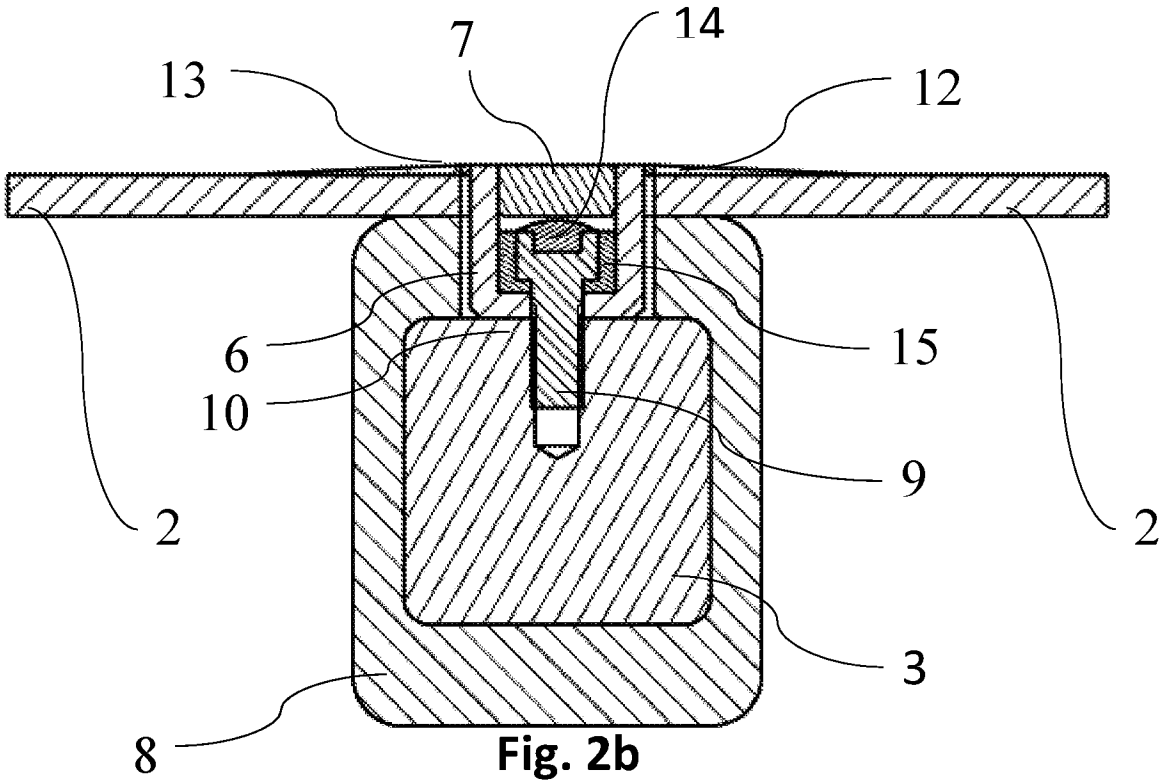

Fig. 2b

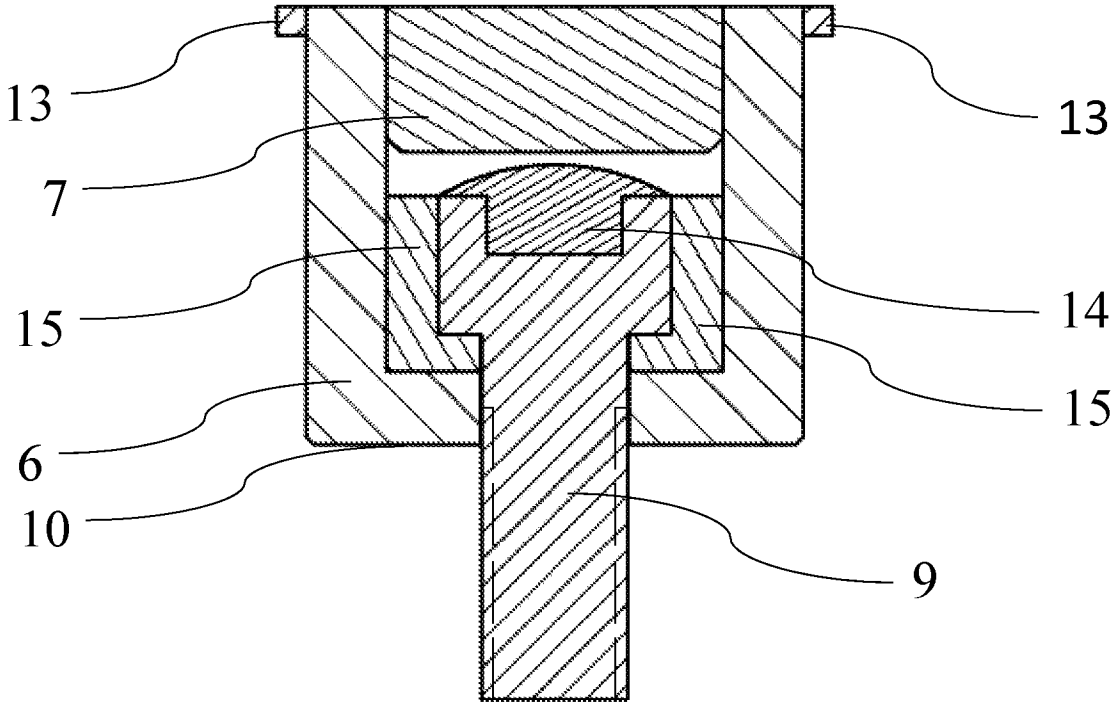

Fig. 3a

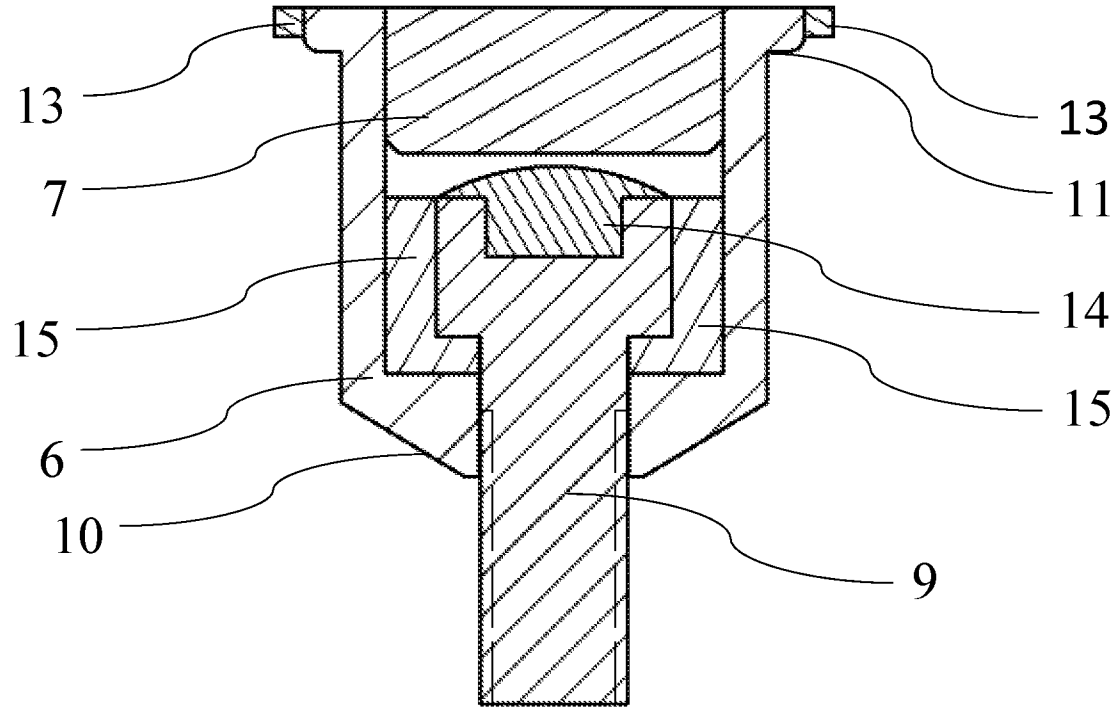

Fig. 3b

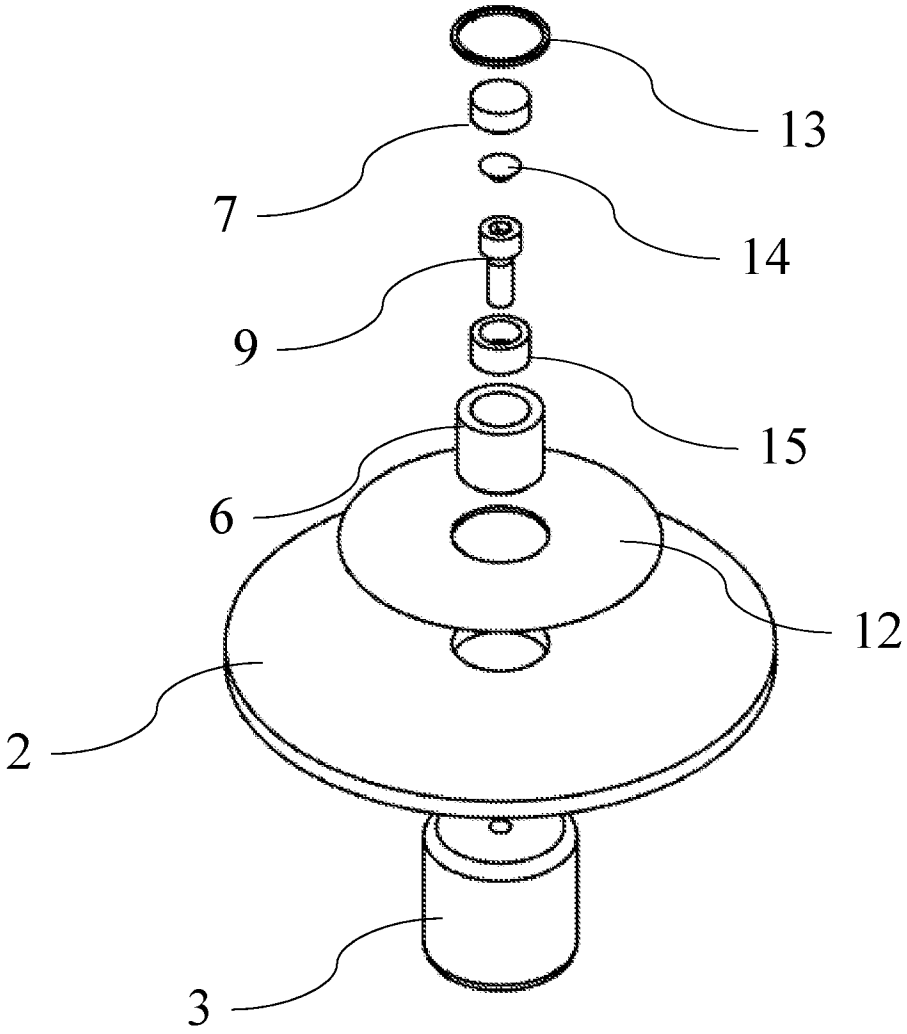

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2015/050100

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D11/00
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 B64D F16B

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

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A	page 4, paragraph 42 - paragraph 44; figure 3	6

A	WO 2005/031158 A2 (VESTAS WIND SYS AS [DK]; HIBBARD PAUL [DK]; CHRISTIANSEN CLAUS [DK]) 7 April 2005 (2005-04-07) page 16, line 20 - line 30	1-4

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	column 1, line 1 - line 59; figure 5 column 4, line 42 - line 68	

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[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

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"P" document published prior to the international filing date but later than the priority date claimed

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 2015	14/12/2015

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	Tack, Gaël

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2015/050100

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2013/084370 A1 (MITSUBISHI HEAVY IND LTD [JP]; FUJIOKA HIDEYASU [JP]) 13 June 2013 (2013-06-13) page 11, paragraph 52 - paragraph 54; figures 4,15 -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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