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(71) Applicant: **VESTAS WIND SYSTEMS A/S** [DK/DK]; Hedeager 42, 8200 Aarhus N (DK).

(72) Inventor: **THOMSEN, Kristoffer Isbak**; Jens Baggesens Vej 98, 6. th, DK-8200 Århus N (DK).

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(54) Title: WIND TURBINE NACELLE STRUCTURE

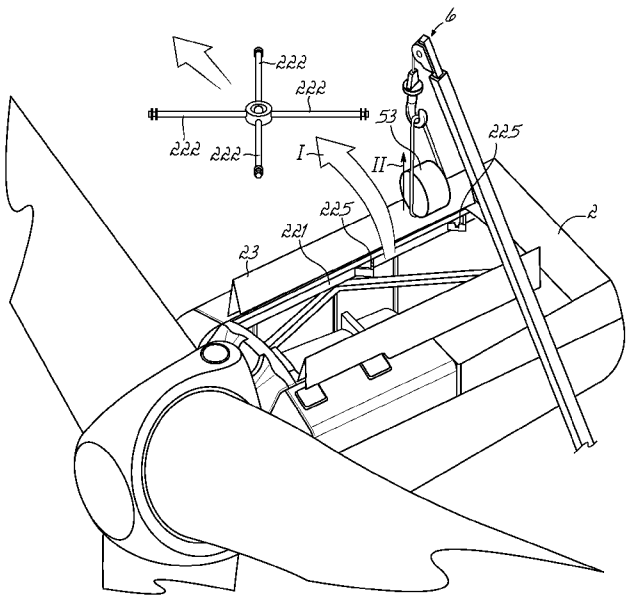


FIG. 9

(57) Abstract: A wind turbine is presented comprising a nacelle (2), mounted on a tower (3), the nacelle housing components including a generator (5) connected to a rotor (4), the nacelle comprising a cover (21) and a skeleton (22) to which the cover is attached, the skeleton comprising a plurality of connected elongated skeleton members, the skeleton members comprising a first skeleton member (221) and a second skeleton member (222) being non-parallel to the first skeleton member, a bolt (224) extending in parallel with the second skeleton member being provided for a connection between the second skeleton member and the first skeleton member. Also, a method is presented for removing a component (5) housed in a nacelle of a wind turbine, comprising disconnecting a second skeleton (222) member from first skeleton members (221), removing the second skeleton member from a path of removal of the component, and removing the component along said path.

WO 2015/149808 A1

WIND TURBINE NACELLE STRUCTURE

TECHNICAL FIELD

The invention relates to a wind turbine, in particular a horizontal axis wind turbine, comprising a nacelle, mounted on a tower, the nacelle housing components including a generator connected to a rotor, the nacelle comprising a cover and a skeleton, the skeleton comprising a plurality of connected elongated skeleton members. The invention also relates to a method for removing a component housed in a nacelle of a wind turbine.

BACKGROUND OF THE INVENTION

In the trend of wind turbine models growing in size, the design of the nacelles can creates challenges. In particular, the nacelle needs to be provided with a structure suited for carrying large loads, and also for facilitating service of parts in the nacelle.
WO2008000267A1 discloses a handling system for a wind turbine nacelle in connection with self-loading or self -unloading of the nacelle to or from a vehicle.

SUMMARY

It is an object of the invention to improve the structure of wind turbine nacelles. It is also an object of the invention to provide for a wind turbine nacelle to effectively carry loads, while also facilitating service of parts in the nacelle.

These objects are solved by a wind turbine comprising a nacelle, mounted on a tower, the nacelle housing components including a generator connected to a rotor of the wind turbine, the nacelle comprising a cover and a skeleton to which the cover is attached, the skeleton comprising a plurality of connected elongated skeleton members, the skeleton members comprising a first skeleton member and a second skeleton member being non-parallel to the first skeleton member, a bolt extending in parallel with the second skeleton member being provided for a connection between the second skeleton member and the first skeleton member. Preferably, the skeleton members are straight.

Thus, the second skeleton member can be connected to the first skeleton member with at least one bolt extending in parallel with the second skeleton member. The bolt connection provides for removal of the second skeleton member, e.g. for clearing the path for a component to be removed from the nacelle during a service operation. Also, the bolt extending in parallel with the skeleton member gives the possibility to provide pre-tension in the second skeleton member when mounting it to the first skeleton member, which is beneficial from a structural point of view.

Preferably, the bolt extends coaxially with the second skeleton member. Thereby, a pre-tension load provided by the bolt will be aligned with the second skeleton member, avoiding bending moments in the latter.

Preferably, the first skeleton member presents a contour with a concavity, the bolt, preferably the pin of the bolt, extending through the concavity. The contour with the concavity can for example be provided by a protruding ear of the first skeleton member. Thereby, the second skeleton member can be easily disassembled from the first skeleton member by loosening the bolt and moving the second skeleton member laterally so that the bolt pin leaves the concavity.

Preferably, the skeleton members comprise two parallel first skeleton members connected by at least one second skeleton member, the second skeleton member forming an angle to the first skeleton members which angle is larger than zero degrees and smaller than 90 degrees, preferably between 20 and 70 degrees, preferably between 30 and 60 degrees, preferably 45 degrees. Where the skeleton members comprise two parallel first skeleton members, these could be connected by at least two second skeleton members arranged in an X-shaped configuration. The two parallel first skeleton members could extend substantially in parallel to a rotational axis of the rotor, and preferably, as seen from above, on opposite sides of the rotational axis of the rotor.

The invention also provides a method for removing a component housed in a nacelle of a wind turbine, the nacelle being mounted on a tower, the nacelle comprising a cover and a skeleton to which the cover is attached, the skeleton comprising a plurality of connected elongated skeleton members, the skeleton members comprising a first skeleton member and a second skeleton member, the second skeleton member being connected to the first skeleton

member, the second skeleton member being in a path of removal of the component, the method comprising disconnecting the second skeleton member from the first skeleton members, removing the second skeleton member from said path, and removing the component along said path. Thereby, a high degree of optimisation of the load carrying capacity of the nacelle structure can be obtained, while at the same time providing for good service solutions in relation to components in the nacelle.

Where the second skeleton member is, before being removed from said path, located above the component, removing the component along said path may comprise lifting the component by means of a crane. The first skeleton members could extend in parallel to each other and substantially in parallel to a rotational axis of a rotor of the wind turbine, and, as seen from above, on opposite sides of the rotational axis of the rotor. Thereby the component could be removed along said path between the first skeleton members.

The method could further include, for example at the end of a service procedure, introducing the component or another component along said path, into the nacelle, and connecting the second skeleton member to the first skeleton members.

DESCRIPTION OF FIGURES

Below embodiments of the invention will be described with reference to the drawings, in which

- fig. 1 shows a perspective view of a wind turbine,
- fig. 2 shows a perspective view of a skeleton of a nacelle of the wind turbine in fig. 1, according to an embodiment of the invention,
- fig. 3 shows a top view of a part of the skeleton in fig. 2,
- fig. 4 shows a perspective view of a detail of the skeleton in fig. 2,
- fig. 5 shows a top view of the detail in fig. 4,
- fig. 6 and fig. 7 show respective top views of a part of a nacelle skeleton according to alternative embodiments of the invention,
- fig. 8 shows a partly sectioned side view of a part of the wind turbine in fig. 1, and
- fig. 9 shows a perspective view of a part of the wind turbine in fig. 1, illustrating steps in a method according to an embodiment of the invention.

DETAILED DESCRIPTION

Fig. 1 shows a horizontal axis wind turbine 1 comprising a nacelle 2, mounted on a tower 3. The nacelle 2 has a cover 21 and houses components including a generator connected to a rotor 4, which in this example comprises three blades 41.

Fig. 2 shows a skeleton 22 of the nacelle 2. The cover 21 in fig. 1 is mounted to the skeleton 22, which comprises a plurality of connected elongated straight skeleton members. The skeleton members comprise first skeleton members 221 and second skeleton members 222. The first skeleton members 221 are connected to each other, e.g. by bolting or welding.

Fig. 3 shows how four second skeleton members 222 are mounted to two parallel first skeleton members 221 such that the second skeleton members 222 are non-parallel to the first skeleton members 221. More particularly, the second skeleton members 222 form 45 degree angles A to the first skeleton members 221. The four second skeleton members 222 are at respective ends thereof mounted by bolting or welding to a central bracket 223. At opposite respective ends the second skeleton members 222 are mounted to the first skeleton members 221. Thereby, the second skeleton members 222 are arranged in an X-shaped configuration. The two first skeleton members 221 extend in parallel to, and on opposite sides of, a rotational axis B, (indicated with a broken line), of the rotor 4, (fig. 1), of the wind turbine.

Fig. 4 and fig. 5 show how each of the second skeleton members 222 are connected to one of the first skeleton members 221 with a bolt 224 extending in parallel with the respective second skeleton member 222. The bolt 224 extends coaxially with the second skeleton member 222. The first skeleton member 221 presents a protruding planar ear 225, which is supported at its distal end by a support element 226, such that the ear forms a 45 degree angle to the longitudinal direction of the first skeleton member 221. As can be seen in fig. 4, the ear 225 presents a contour with a concavity 227, and the pin of the bolt 224 extends through the concavity 227.

The head of the bolt rests against the ear 225 via an intermediate washer, and its threaded pin extends through the concavity 227 into a female thread in the second skeleton member 222. The second skeleton members 222 are slightly shorter than what is needed to extend between

the ears 225 of the first skeleton members 221. By turning the bolts 224, while holding the second skeleton members 222 with a suitable tool at flattened portions 2221 to prevent their rotation, the second skeleton members 222 can be pre-tensioned during their installation. This is beneficial from a structural point of view. Also, the fact that the bolts 224 extend coaxially with the second skeleton members 222, the pre-tension load provided by the bolts 224 will be aligned with the second skeleton members 222, avoiding bending moments in the latter.

Fig. 6 shows an alternative embodiment of the invention, in which two second skeleton members 222 are mounted to two parallel first skeleton members 221, thereby forming an X-shaped configuration. For this the ears 225 are arranged so that the two second skeleton members 222 are offset in a vertical direction.

Fig. 7 shows a further alternative embodiment of the invention, in which only one second skeleton member 222 is mounted between two parallel first skeleton members 221.

Fig. 8 and fig. 9 illustrate an embodiment of a method for removing a component housed in the nacelle 2 of the wind turbine described above with reference to fig. 1 to fig. 5. As can be seen in fig. 8, the rotor 4 is connected to components in the nacelle 2 in the form of a main shaft 51, a gear box 52, and a generator 53. It can be seen that the generator 53 is located under the second skeleton members 222. Thereby, the second skeleton members 222 are in a path of removal of the generator 53 for service purposes.

As illustrated in fig. 9, the method comprises opening a door 23 of a roof hatch of the nacelle, and disconnecting the second skeleton members 222 from the first skeleton members 221. This disconnection is done by loosening the bolts 224, (fig. 4 and fig. 5), and lifting them out of the concavities 227 of the ears 225 of the first skeleton members 221. Thereafter the second skeleton members 222 are removed with the central connecting bracket 223, as illustrated with the arrow I in fig. 9. Thereby said path is cleared for removing for service purposes the generator 53. The generator 53 is removed from the nacelle 2 along said path by lifting with the aid of a crane 6, as illustrated by the arrow II.

Thus, the connections with bolts 224 and ear concavities 227 provide for easy removal of the second skeleton members 222, for clearing the path for a component 53 to be removed from the nacelle during a service operation. Thereby, a good service solution for components in the

nacelle is provided by removing the second skeleton members, which nevertheless can form an essential part of the load carrying nacelle structure during normal wind turbine operation. At the end of a service procedure, the component 53 or a replacement component could be introduced along said path, back into the nacelle, and the second skeleton members 222 could be reconnected to the first skeleton members 221.

CLAIMS

1. A wind turbine (1) comprising a nacelle (2), mounted on a tower (3), the nacelle housing components including a generator connected to a rotor (4) of the wind turbine, the nacelle comprising a cover (21) and a skeleton (22) to which the cover is attached, the skeleton comprising a plurality of connected elongated skeleton members, the skeleton members comprising a first skeleton member (221) and a second skeleton member (222) being non-parallel to the first skeleton member, a bolt (224) extending in parallel with the second skeleton member being provided for a connection between the second skeleton member and the first skeleton member.

2. A wind turbine according to claim 1, wherein the bolt extends coaxially with the second skeleton member.

3. A wind turbine according to any one of the preceding claims, wherein the first skeleton member presents a contour with a concavity, the bolt extending through the concavity.

4. A wind turbine according to any one of the preceding claims, wherein the skeleton members comprise two parallel first skeleton members connected by at least one second skeleton member, the second skeleton member forming an angle to the first skeleton members which angle is larger than zero degrees and smaller than 90 degrees.

5. A wind turbine according to claim 4, wherein the angle is between 20 and 70 degrees, preferably between 30 and 60 degrees, preferably 45 degrees.

6. A wind turbine according to any one of the preceding claims, wherein the skeleton members comprise two parallel first skeleton members connected by at least two second skeleton members arranged in an X-shaped configuration.

7. A wind turbine according to any one of claims 4-6, wherein the two parallel first skeleton members extend substantially in parallel to a rotational axis of the rotor.

8. A wind turbine according to claim 7, wherein the two parallel first skeleton members extend, as seen from above, on opposite sides of the rotational axis of the rotor.

9. A method for removing a component housed in a nacelle (2) of a wind turbine (1), the nacelle being mounted on a tower (3), the nacelle comprising a cover (21) and a skeleton (22) to which the cover is attached, the skeleton comprising a plurality of connected elongated skeleton members, the skeleton members comprising two first skeleton members (221) connected by at least one second skeleton member (222), the method comprising disconnecting the second skeleton member from the first skeleton members, removing the second skeleton member from a path of removal of the component, and removing the component along said path.

10. A method according to claim 9, wherein the second skeleton member is, before being removed from said path, located above the component, and removing the component along said path comprises lifting the component by means of a crane.

11. A method according to claim 10, wherein the first skeleton members extend in parallel to each other and substantially in parallel to a rotational axis of a rotor of the wind turbine, and, as seen from above, on opposite sides of the rotational axis of the rotor.

12. A method according to any one of claims 9-11, comprising introducing the component or another component along said path, into the nacelle, and connecting the second skeleton member to the first skeleton members.

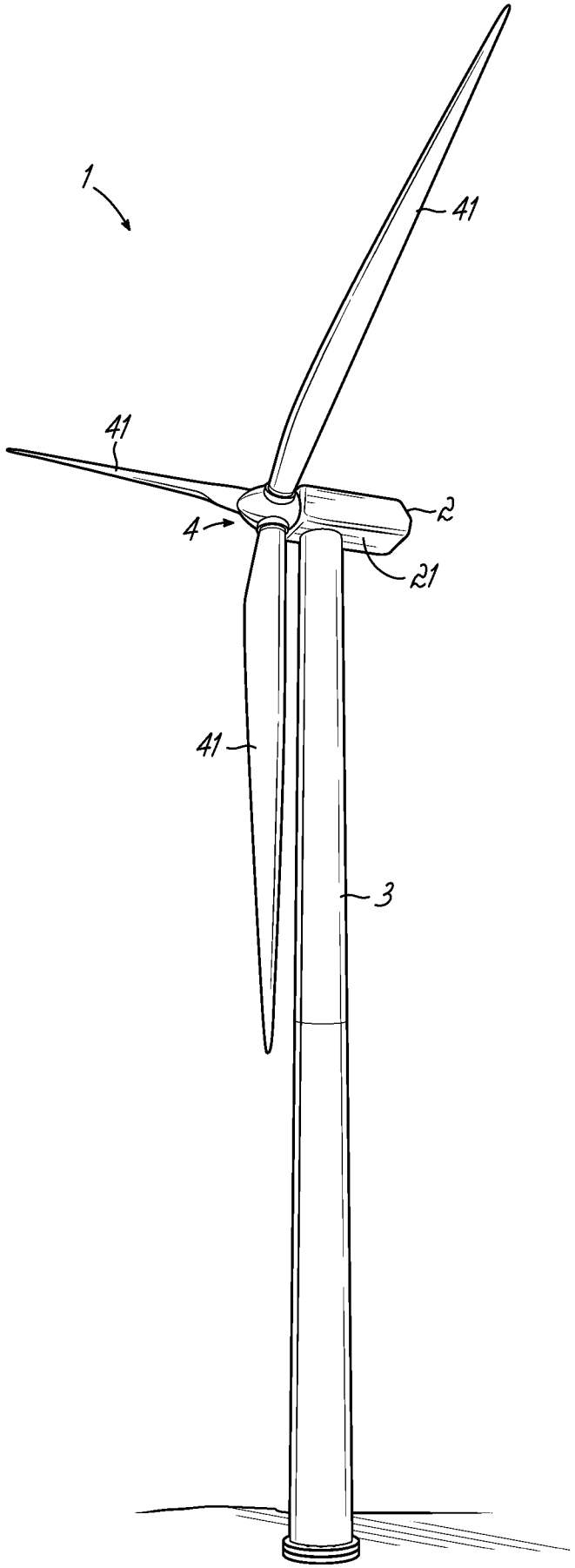


FIG. 1

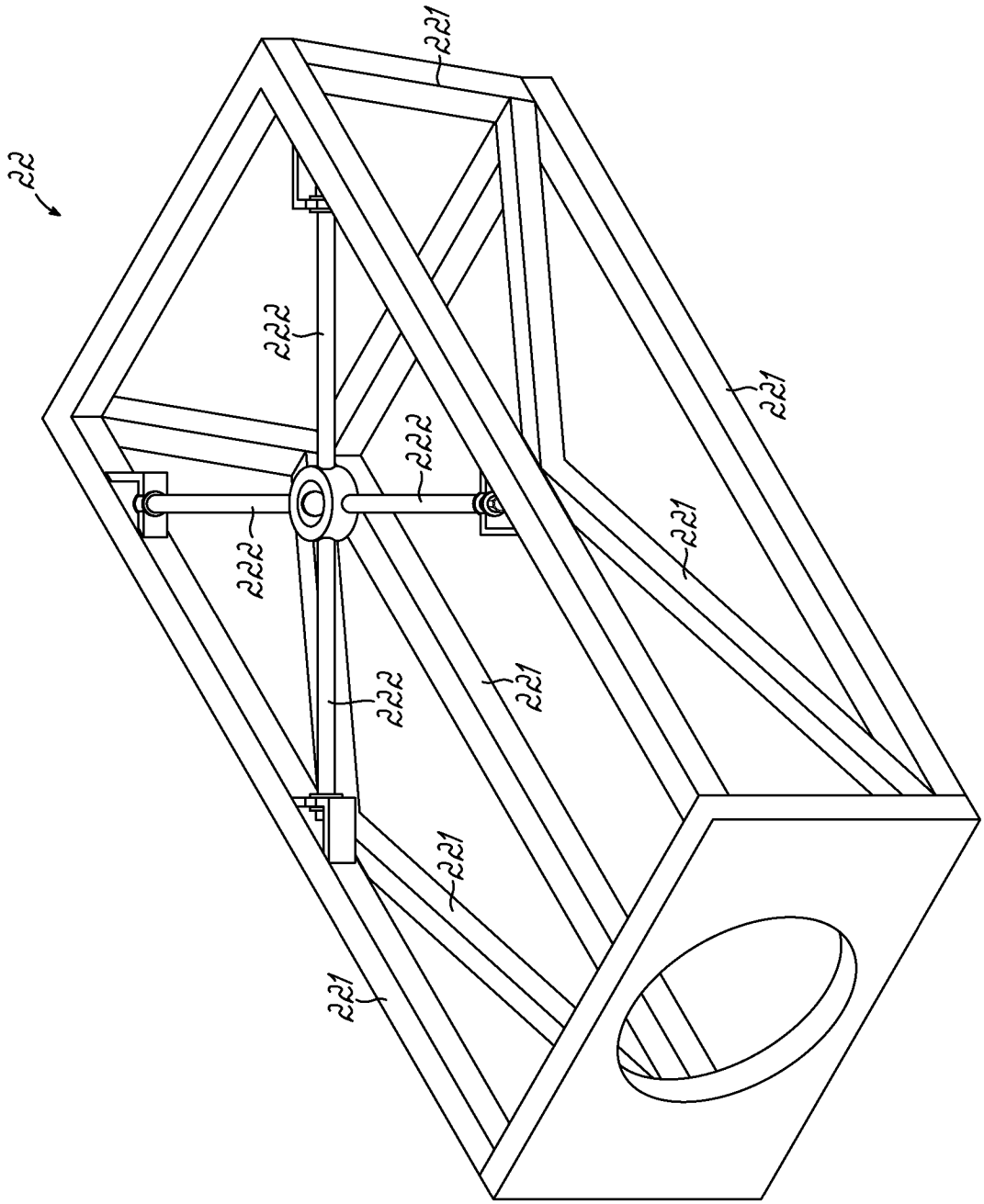


FIG. 2

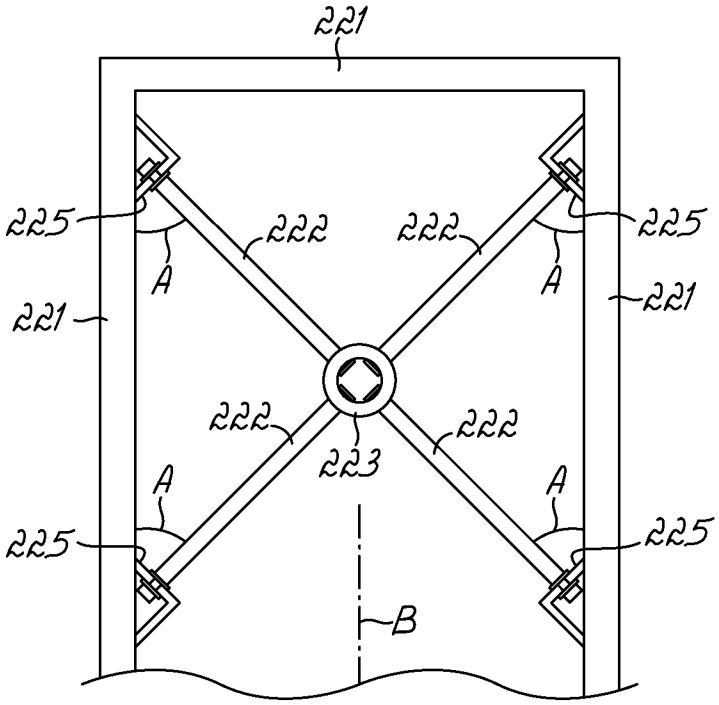

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FIG. 3

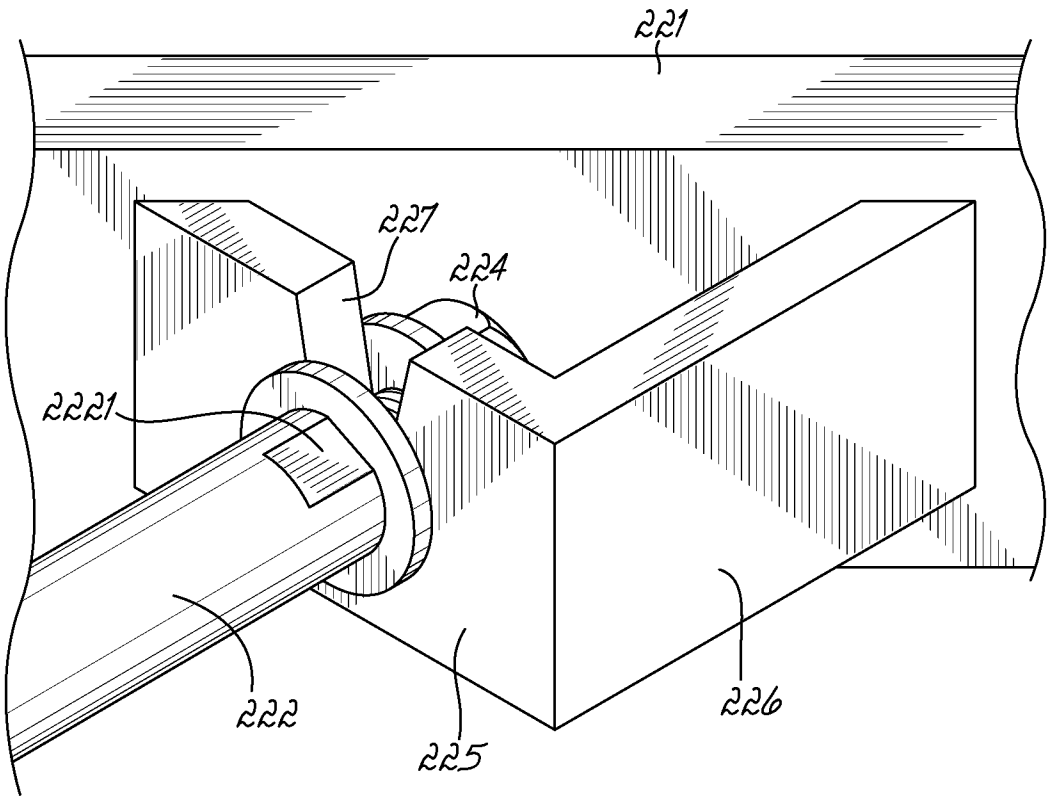

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FIG. 4

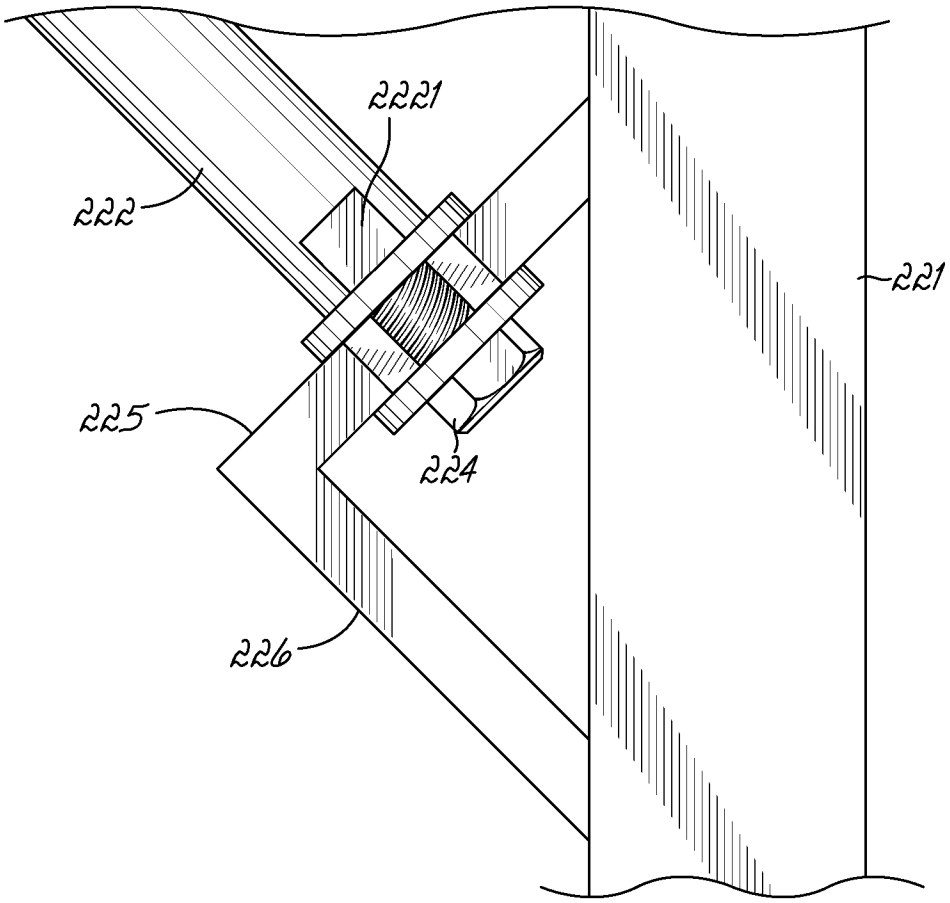

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FIG. 5

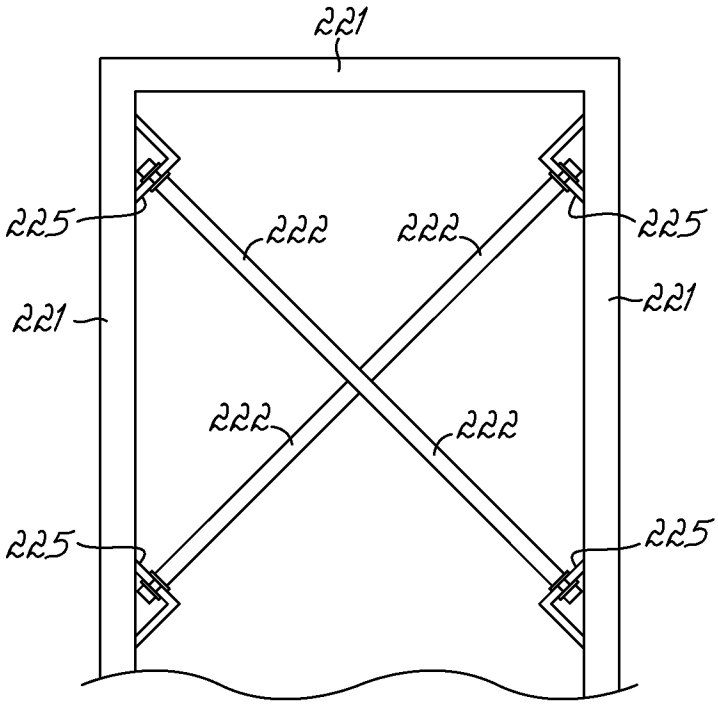

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FIG. 6

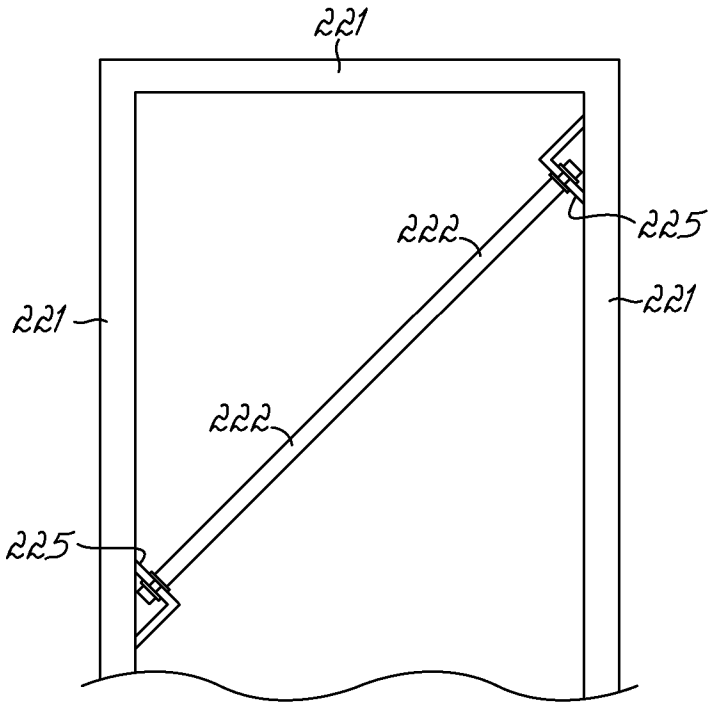


FIG. 7

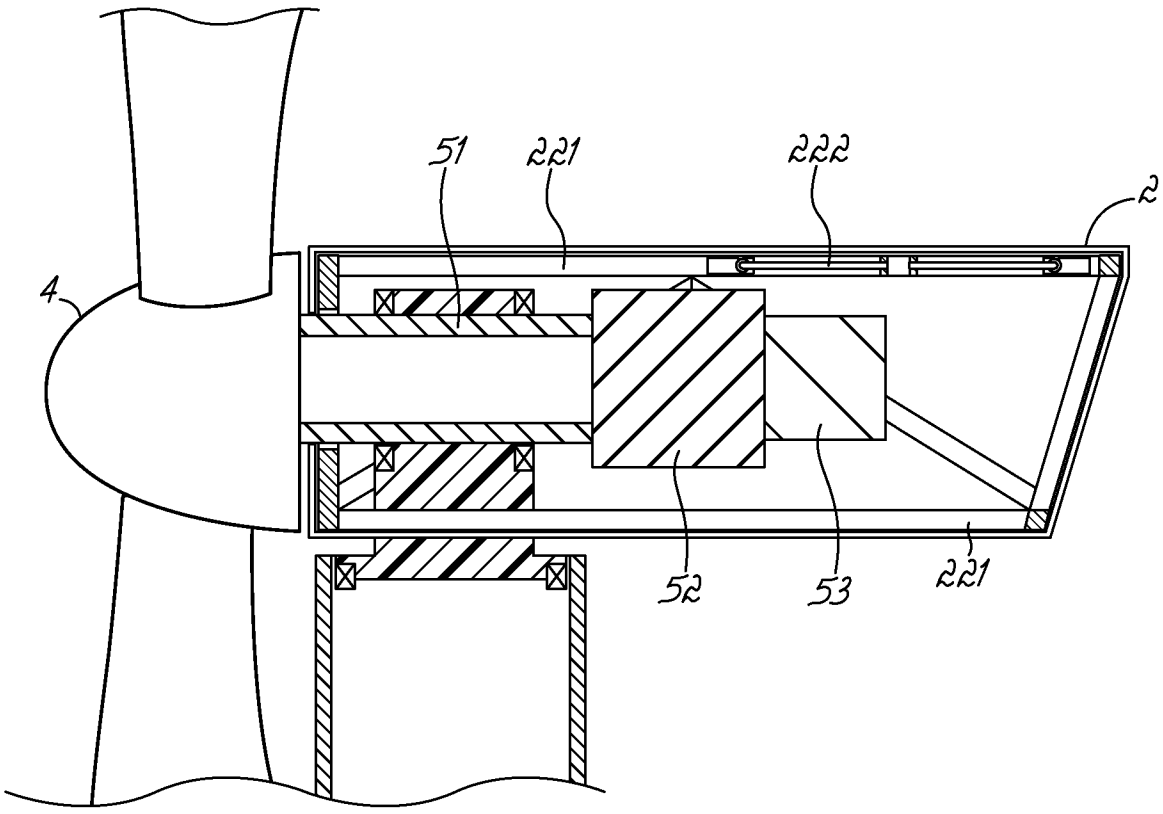


FIG. 8

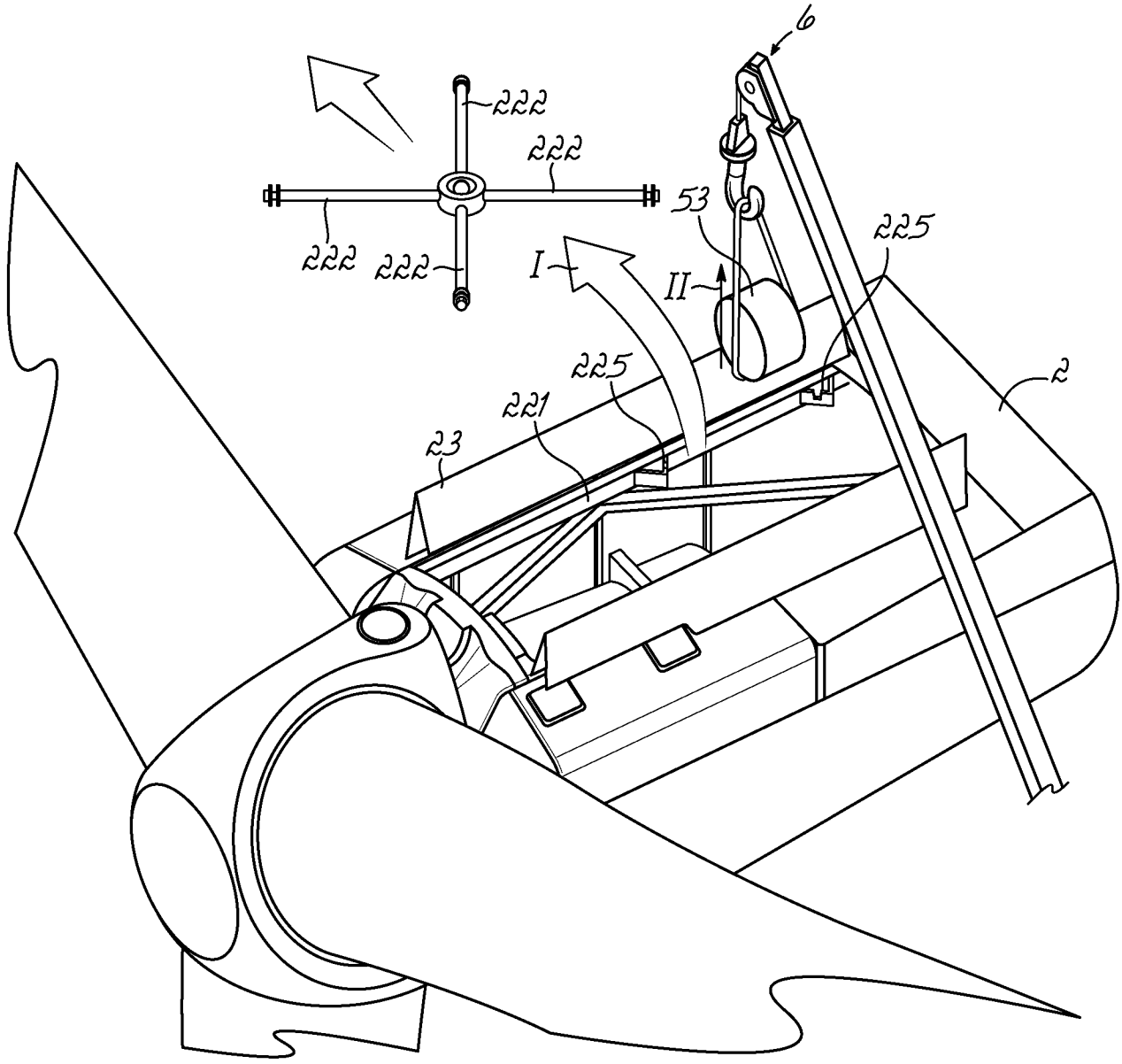


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2015/050064

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D11/00 F03D1/00
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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/003381 A1 (NEG MICON AS [DK]; MIKKELSEN PER SVEIGAARD [DK]) 8 January 2004 (2004-01-08)	9-12
A	abstract page 5, line 25 - page 7, line 29 figures	1-8

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Y	abstract	5,6
A	paragraph [0030] - paragraph [0054] figures	2,3,9-12

X	US 2011/309629 A1 (LARSEN GERNER [DK] ET AL) 22 December 2011 (2011-12-22)	1,4,7,8
A	abstract figures	9

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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 :

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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
8 June 2015	15/06/2015

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	Kolby, Lars

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INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2015/050064

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2011/117005 A2 (VESTAS WIND SYS AS [DK]; MORTENSEN HENNING [DK]; HANSEN FRANK MOELLER) 29 September 2011 (2011-09-29)	5,6
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1

INTERNATIONAL SEARCH REPORT

Information on patent family members

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