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(54) Title: A WIND TURBINE GENERATOR WITH A BACK SKEWED ROTOR

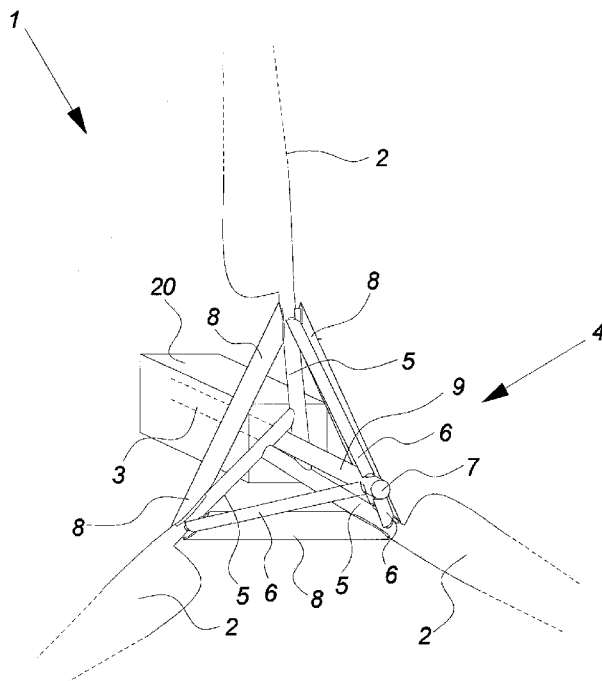


Fig. 1

(57) Abstract: The invention relates to a wind turbine generator with rotor blades being pitchably mounted, and a hub for connecting the rotor blades with the rotation shaft. The hub further comprises a plurality of radially extending support structures, a plurality of inclined support beams, one inclined support beam for each rotor blade, and/or at least a first peripheral support rod positioned in an exterior position on the hub, said first peripheral support rod connecting two of said radially extending support structures. The rotation axis for each pitchable rotor blade has a radial offset relative to the rotation shaft. The invention is thereby advantageous for obtaining a wind turbine where the resonances of the rotor blades may be controlled, i.e. shifted and/or reduced, by designing and dimensioning the plurality of inclined support beams and/or the first peripheral support rod accordingly.



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A WIND TURBINE GENERATOR WITH A BACK SKEWED ROTOR

FIELD OF THE INVENTION

- 5 The present invention relates to a wind turbine generator with a hub structure that provides extended rotor blades support in a back skewed rotor configuration. The invention also relates to a corresponding hub structure, and to a corresponding method for operating a wind turbine generator.

10 BACKGROUND OF THE INVENTION

- Normally, a wind turbine generator (WTG) has one or more rotor blades which are rotatable around a horizontal axis mounted in a nacelle. The nacelle is pivotable around a vertical axis in order to turn the rotor blade to a position which is
- 15 suitably aligned with the wind direction. The one or more rotor blades is rotated at a speed which is depending on the wind and the aerodynamics of the rotor blades in order to drive a generator for converting wind energy into electric energy. The typically three rotor blades are connected with a hub, which is in turn mechanically connected with a rotating shaft. The hub is accordingly a critical
- 20 mechanical part of a modern wind turbine generator. On one hand, the hub should be able to withstand a large mechanical load arising from the rotor blades, and on the other hand the hub, as a rotating part, should have a relatively low weight in order not to give rise to losses in the wind turbine generator. Moreover, the hub should preferably have a beneficial aerodynamical design in order not to increase
- 25 air resistance and/or create noise upon rotation.

- In operation, a modern wind turbine generator unfortunately often generates an unacceptably high level of audible noise. In particular, high noise may sound as each rotor blade enters plane downwind from the turbine's tower, where it
- 30 experiences a short decrease in wind speed. Moreover, the periodic force exerted between the tower and a rotor blade upon passage of the blade, the so-called 3P force generation, can be significant for a modern wind turbine generator.

- US patent application 2006/0067828 discloses a wind turbine including a rotor
- 35 having a hub and at least one blade having a torsionally rigid root, an inboard

section, and an outboard section. The inboard section has a forward sweep relative to an elastic axis of the blade and the outboard section has an aft sweep. This rotor design may reduce pitching moment at the blade roots resulting from sweep, and may facilitate a higher yield from the wind. However, this wind turbine generator does not provide any significant improvement in the hub structure itself. Moreover, noise reductions may also not be present.

Hence, an improved wind turbine generator would be advantageous, and in particular a more efficient and/or reliable wind turbine generator would be advantageous.

OBJECT OF THE INVENTION

It is a further object of the present invention to provide an alternative to the prior art.

In particular, it may be seen as an object of the present invention to provide a wind turbine generator that solves the above mentioned problems of the prior art with *inter alia* high loads on the hub of the wind turbine generator, and/or audible noise from the wind turbine generator.

SUMMARY OF THE INVENTION

Thus, the above described object and several other objects are intended to be obtained in a first aspect of the invention by providing a wind turbine generator comprising:

- a plurality of rotor blades, each rotor blade being pitchably mounted, thereby defining a corresponding rotation axis,
- a rotation shaft, and
- a hub for connecting the plurality of rotor blades with the rotation shaft,

wherein the hub further comprises

- a plurality of radially extending support structures, one radially extending support structure for each rotor blade, each support structure comprising at least a first blade support point for receiving and supporting a rotor blade, and
 - a plurality of inclined support beams, one inclined support beam for each rotor blade, the first end portion of each inclined support beam being connected to the corresponding radially extending support structure, the second end portion of each inclined support beam of the plurality of inclined support beams being collected in a common, connecting point in an exterior position on the hub,
 - and/or
 - at least a first peripheral support rod positioned in an exterior position on the hub, said first peripheral support rod connecting two of said radially extending support structures,
- wherein the rotation axis for each rotor blade has a radial offset relative to the rotation shaft.

The invention is particularly, but not exclusively, advantageous for obtaining a wind turbine generator where the resonances of the rotor blades may be controlled, i.e. shifted and/or reduced, by designing and dimensioning the plurality of inclined support beams and/or the first peripheral support rod accordingly.

This may facilitate the application of even longer rotor blades than the ones hitherto applied in the wind turbine generator technology. This is quite important because the covered wind area of a wind turbine generator scales with the square of the length of the rotor blades.

Another advantage of the present invention arises from the fact that the connecting hub, due to its pyramid-like structure, may be transported in smaller parts, e.g. the radially extending structure, the support beams, and/or the peripheral support rods may be transported and assembled on or near the site of the wind turbine generator. This may also facilitate even larger wind turbine generators to be manufactured, transported and assembled because currently wind turbine generators have reached a size where limitations imposed by the

transportation, both in terms of cost and physical limitations (e.g. width of roads and/or trucks), have reached a relatively high level.

As compared to many single-cast hubs currently applied, the mechanical properties of the present invention may be very attractive, even though the assembly of the hub near or on the site of the wind turbine generator may slightly complicate the final stage of the wind turbine generator assembly. It is however also envisioned that all, or alternatively, most of the various parts of the hub of the present invention may be assembled already during manufacturing.

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Furthermore, introduction of a radial offset of the rotor blades may result in the blade being tilted backwards in the rotor plane. Thus, the airflow across the blade will obtain an angle relative to the blade chord, resulting in an increased aerodynamic chord length of the airflow across the rotor blade. By increasing the aerodynamic chord length, the relative blade thickness will decrease leading to potentially reduced drag on the blade, and by this to a potential production increase on the blade.

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Alternatively, the present invention may enable increased thickness of the rotor blade without changing the chord/thickness ratio. Increasing the blade thickness may, in turn, allow for reductions in the material thickness, or use of less support material, e.g. highly expensive carbon fiber, in the inner part of the rotor blade, leading to reduced blade costs.

20

In particular, it may be mentioned that the present invention, by including a radial offset of the blade, facilitates that the time for a blade passage of the tower will be increased, leading to reduced 3P generation (and higher order; 6P, 9P, etc.) and reduced modulation of the noise emission.

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Summarizing, the present invention may give rise to easier manufacturing and/or transportation of hub parts, reduction of blade cost, minimization of noise emission, and maximization of power production.

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In the context of the present invention, it is to be understood that the radial offset of the rotation axes defines a displacement from a configuration where the

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rotation axes meet or substantially coincide near the rotation axis of the rotation shaft of the wind turbine generator. This will be further explained in connection with Figure 3 below.

- 5 In the context of the present invention, it is also to be understood that the inclined support beams and/or peripheral support rods may in principle have any appropriate shape (longitudinal and cross-sectional) suitable for fulfilling their purpose of supporting the rotor blade. Thus, the support beam need not be limited to having a substantially straight shape in the longitudinal direction but could
- 10 have various curved or bent shapes. Furthermore, the peripheral support rods could in particular have a curved shape in the longitudinal direction. In particular, for a wind turbine with only two rotor blades, the shape of the two intermediate peripheral support rods could be half-arcs connecting each rotor blade.
- 15 In one embodiment, the generator may further comprise a shaft having a substantially central position in the hub, the shaft extending substantially along the rotation shaft for supporting the plurality of inclined support beams in the common, connecting point. This may advantageously support the common connection point for the inclined beams.
- 20 The generator may preferably comprise a second peripheral support rod positioned in an exterior position on the hub, said second support rod connecting two of said radially extending support structures similarly to the first support rod. Typically all rotor blades are inter-connected with support rods, but it could be
- 25 sufficient for some wind turbines to just have two support rods to obtain e.g. blade edge vibration frequency shifting. Even more advantageously, each peripheral support rod directly connects two radially extending support structures, whereby the said support rod together with the two connected radially extending support structures have a substantially triangular shape. In one variant of the
- 30 invention, at least one of said peripheral support rods may connect two radially extending support structures at two different radial positions relative to the rotating shaft because this may be advantageous for shifting the frequency of edge vibrations in a different manner as compared to the same radial positions.

Typically, each radially extending support structure may comprise a first and a second rotor blade support point for receiving and supporting a rotor blade, said first and a second rotor blade support points being located at radially different positions relative to the rotation shaft. This has the advantage that the two radial bearings result in reduction of moment over the blade bearings. Preferably, the said first and the said second rotor blade support points may be located opposite each other in separate radial half parts of the radially extending support structure. Preferably, the said first and the said second rotor blade support points may be located with a radial distance being at least 5%, 10% or 15% of the total rotor blade length as measured from the rotational shaft.

Advantageously, each radially extending support structure may have a radial extension of at least 10%, preferably at least 15%, or more preferably at least 20%, of the total rotor blade length as measured from the rotational shaft.

In general, the longer radial support structure, the less amplitude there will be on the edge and/or the flap vibration of the blades.

Preferably, each radially extending support structure may comprise a hollow portion for receiving a corresponding end portion of the rotor blade. Typically, the rotor blades may be pitchably mounted, for example in the first and the second support point in a type of pitch bearing.

In one embodiment, the radially extending support structures may also have an airfoil shape providing aerodynamic lift upon wind engagement. Even further, these structures may be arranged so that these shapes may be pitchable, though sufficient support should also be provided to the rotor blades.

Preferably, each radially extending support structure may comprise a hollow portion for receiving a corresponding end portion of the rotor blade to provide easy and reliable mounting of the blade on the hub structure.

Typically, but not always, the radially extending support structures, the inclined support beams, and/or the peripheral support rods may have a substantially straight shape, e.g. a beam-like structure to provide a relatively strong structure of the hub.

Preferably, the radially extending support structure, the inclined support beams, and/or the peripheral support rods may have an airfoil shape providing aerodynamic lift upon wind engagement. The aspect ratio of the cross-sectional shape of these airfoils shapes, i.e. the chord length to maximum thickness, may preferably be in the interval from 2 to 10, more preferably in the interval from 4 to 8. Alternatively, the minimum aspect ratio may be at least 2, 3, 4, 5, 6, 7, 8, 9, or 10.

10 In other embodiment, which is particularly relevant for remote locations such as off-shore wind turbines, each rotor blade in the plurality of rotor blades may be adapted to be temporally fixated to the corresponding radially extending support structure in a manner different from the normal mounting, for instance to allow for exchange of the first and/or the second rotor blade support point in the
15 radially extending support structure, thereby enabling repair of bearings to be performed while the blade is for example clamped to hub without use of the bearings used during normal operation.

In other embodiment, the plurality of rotation axes for the blades may also be
20 angularly offset around an axis substantial parallel to the rotation shaft but different from the rotation shaft. Thus the level of rotation may be e.g. 5, 10, 15, 20 degrees. This has the result that each rotor blade may be even more "non-parallel" to the tower during the passage of the tower which may lower 3P, 6P, 9P, and up to $3n P$ (where n is an integer) type of noise.

25 Advantageously, each of the rotor blades in the plurality of rotor blades may comprise a bent or curved portion along the length of the blade. This may provide a conning structure of the blade or a bended shape in the plane of blade rotors, and other shapes and combinations thereof may be envisioned within the context
30 of the present invention.

In a second aspect, the present invention relates to a hub for use in a wind turbine generator comprising a plurality of rotor blades and a rotation shaft, the hub being arranged for connecting the plurality of rotor blades with the rotation
35 shaft, wherein the hub comprises:

- a plurality of radially extending support structures, one radially extending support structure for each rotor blade, each support structure comprising at least a first blade support point for receiving and supporting a rotor blade, and
 - a plurality of inclined support beams, one inclined support beam for each rotor blade, the first end portion of each inclined support beam being connected to the corresponding radially extending support structure, the second end portion of each inclined support beam of the plurality of inclined support beams being collected in a common, connecting point in an exterior position on the hub,
 - and/or
 - at least a first peripheral support rod positioned in an exterior position on the hub, said first peripheral support rod connecting two of said radially extending support structures,
- wherein the rotation axis for each rotor blade has a radial offset relative to the rotation shaft.

In a third aspect, the invention further relates to a method for operating a wind turbine generator, the method comprises:

- providing a plurality of rotor blades,
- providing a rotation shaft, and
- providing a hub for connecting the plurality of rotor blades with the rotation shaft,

wherein the hub comprises:

- a plurality of radially extending support structures, one radially extending support structure for each rotor blade, each support structure comprising at least a first blade support point for receiving and supporting a rotor blade, and
 - a plurality of inclined support beams, one inclined support beam for each rotor blade, the first end portion of each inclined support beam being connected to the corresponding radially extending support structure, the second end portion of each inclined support beam of the plurality of inclined support beams being collected in a common, connecting point in an exterior position on the hub,
- and/or

- at least a first peripheral support rod positioned in an exterior position on the hub, said first peripheral support rod connecting two of said radially extending support structures,

wherein the rotation axis for each rotor blade has a radial offset relative to the
5 rotation shaft.

This aspect of the invention is particularly, but not exclusively, advantageous in that the method according to the present invention may be implemented near or on the site of assembly of the wind turbine generator provided easier
10 transportation of at least the hub of the wind turbine generator.

The first, second and third aspect of the present invention may each be combined with any of the other aspects. These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described
15 hereinafter.

BRIEF DESCRIPTION OF THE FIGURES

The wind turbine generator according to the invention will now be described in
20 more detail with regard to the accompanying figures. The figures show one way of implementing the present invention and are not to be construed as being limiting to other possible embodiments falling within the scope of the attached claim set.

Figure 1 is a perspective drawing of a wind turbine generator according to the
25 present invention,

Figure 2 is a side view drawing of a wind turbine generator according to the present invention,

30 Figure 3 is a schematic drawing showing the concept of radial offset,

Figure 4 is a schematic drawing of selected part of a hub for a wind turbine generator according to the present invention,

Figure 5 is a schematic drawing of a peripheral support rod configuration according to the present invention,

Figures 6 and 7 are two schematic perspective drawings of three connected
5 radially extending support structures according to the present invention,

Figure 8 is a schematic plan view of three connected radially extending support structures with radial support points according to the present invention,

10 Figure 9 is a schematic perspective drawing of three connected radially extending support structures with airfoil shape according to the present invention, and

Figure 10 is a schematic plan view of three connected radially extending support structures with temporary fixation points according to the present invention.

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DETAILED DESCRIPTION OF AN EMBODIMENT

Figure 1 is a perspective drawing of a wind turbine generator 1 according to the present invention, the tower being omitted for clarity. The wind turbine generator
20 1 comprises a plurality of rotor blades 2, i.e. three blades in this embodiment. The blades 2 are mechanically connected to a rotation shaft 3 by the hub 4.

The hub 4 comprises three radially extending support structures 5, one radially extending support structure 5 for each rotor blade 2. Each support structure
25 comprises at least a first blade support point for receiving and supporting a rotor blade 2 (not shown in this Figure).

Furthermore, the hub 4 has three inclined support beams 6, one inclined support beam for each rotor blade 2. The first end portion of each inclined support beam 6
30 is connected to the corresponding radially extending support structure 5, and the second end portion of each inclined support beam 6 is collected in a common, connecting point 7 in an exterior position on the hub 4, which is in the front part of the hub 4.

Three peripheral support rods 8 are positioned in an exterior position on the hub 4, each of the three peripheral support rods 8 are connecting two of the radially extending support structures 5.

- 5 Though not clearly evident in this Figure, each rotor blade 2 is pitchably mounted around a longitudinal axis, i.e. each blade has an associated rotation axis and these axes have a radial offset relative to the rotating shaft 3.

The wind turbine generator 1 further comprises a shaft 9 having a substantially
10 central position in the hub 4. This shaft 9 is extending substantially along the rotation shaft 3 for supporting the plurality of inclined support beams in the common, connecting point 7.

Figure 2 is a side view drawing of a wind turbine generator similar to Figure 1,
15 where the pyramid-like open hub structure positioned in front of the nacelle 20 is apparent. The tower 21 is also indicated.

Figure 3a is a schematic drawing showing the concept of radial offset. With dotted lines are indicated the rotational axes 30a, 30b, and 30c of three rotor blades (not
20 shown for clarity) in a conventional configuration where the rotational axes 30a, 30b, and 30c meet in a common, central point near or substantially coinciding with the rotational axis of the rotation shaft 9 (not shown here). With the present invention, the rotation axes 31a, 31b, of 30b of the rotor blades are, however, displaced, as indicated by the three arrows, so that the rotational axes do not
25 meet in a common point near the rotation shaft. The radial offset thereby defined may constitute a significant distance as compared to the total rotor blade length (cf. definition in connection with Figure 8). In particular, the radial offset may be at least 1%, preferably at least 3%, or more preferably at least 5%, of the total blade length. Specifically, the radially offset may be at least 1 meter, preferably at
30 least 2 meter, more preferably at least 3 meter. In short, the larger the radial displacement, the more reduced 3P generation and/or reduced modulation in noise emission one may obtain, though of course other constructional constraints may be taken into account.

Figure 3b is a similar schematic drawing showing the concept of radial offset with the further addition that the rotation axes are also rotationally translated relative the configuration indicated with dotted lines. The rotational translation may be only slightly different from the configuration shown in Figure 3a, i.e. at least 1
5 degree, preferably at least 3 degrees, or more preferably at least 5 degrees. Alternatively, larger rotations are also considered advantageous, i.e. at least 10 degrees, preferably at least 15 degrees, or more preferably at least 20 degrees, in order to have more reduced 3P generation and/or reduced modulation in noise emission. Likewise, the larger the radial and/or angular offset, the larger the
10 increase in the aerodynamic chord length one may obtain, and thereby the relative blade thickness will decrease correspondingly.

Figure 4 is schematic drawing of selected part of a hub in a wind turbine generator according to the present invention. In particular, the each of three
15 peripheral support rods 8 connects two radially extending support structures 5 directly. Thus, one support rod 8 together with the two connected radially extending support structures 5 have a substantially triangular shape.

Figure 5 is a schematic drawing of a peripheral support rod configuration
20 according to the present invention, where a peripheral support rod 8 connects two radially extending support structures 5' and 5'' at two different radial positions relative to the rotating shaft. For clarity, the inclined support beams are omitted in this Figure. Thus, rod 8 is connected to structure 5' at a larger radial distance, as seen from the rotation centre of the rotor blades 2, than the radial position
25 where the rod 8 is connected or joined with the other structure 5''. This has advantages both with respect to shifting the frequencies of edge vibrations of the rotor blades 2, and with respect to obtained beneficial aero dynamical benefit of the air foil shape of the support rod 8.

30 Figure 6 is a schematic perspective drawing of three connected, radially extending support structures 5 comprised in the hub 4 according to the present invention. For clarity, the inclined support beams and the peripheral support rods are omitted in this Figure. As seen for the two lower structures 5, each radially extending support structure 5 comprises a hollow portion 5a for receiving a
35 corresponding end portion of the rotor blade 2. Preferably, the rotor blades are

pitchably mounted in a first and a second support point (not visible in this Figure) within the structure 5, e.g. in a pitch bearing.

Figure 7 is a similar schematic perspective drawing of three connected, radially
5 extending support structures 5 comprised in the hub 4 according to the present
invention. For clarity, the inclined support beams and the peripheral support rods
are also omitted in this Figure. As seen for one structure 5, each radially
extending support structure 5 comprises a shaft extension 5b for entering a
corresponding hollow portion (not shown in this view) of the rotor blade 2 for
10 assembly. Preferably, the rotor blades 2 are pitchably mounted in a first and a
second support point (not visible in this Figure) within the rotor blade 2, e.g. in a
pitch bearing. The shaft extension 5b can be made as one solid entity with the
radially extending structure 5, or the shaft extension or stub shaft 5b may be
mounted on the radially extending structure 5.

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Figure 8 is a schematic plan view of three connected radially extending support
structures 5 with two radial support points 60a and 60b according to the present
invention, the support point 60a and 60b may be bearings or similar means for
receiving the corresponding end part of a rotor blade 2. For clarity, the inclined
20 support beams and the peripheral support rods are omitted in this Figure. The
first 60a and a second 60b rotor blade support points are located at radially
different positions relative to the rotating shaft 3 connected to the hub 4.

The said first and the said second rotor blade support points 60a and 60a may be
25 located opposite each other in separate radial half parts of the radially extending
support structure 5. Thus, in the Figure, support points 60a are located in the
outer half part of the radial length RS of the radially extending support structure
5, whereas support points 60b are located in the inner half part of the radial
length RS of the radially extending support structure 5.

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More specifically, the first 60a and the second 60b rotor blade support points are
located with a radial distance r being at least 5%, 10% or 15% of the total rotor
blade length R as measured from the rotational shaft 4.

Advantageously, the radially extending support structure 5 may have a radial extension RS of at least 10%, preferably at least 15%, or more preferably at least 20%, of the total rotor blade length R as measured from the rotational shaft 3. Generally, the longer the radially extending support structure 5 is, the less amplitude there will be on the edge and flap vibration of the rotor blades 2. Also, improved control of vibration frequencies of rotor blades will be obtained.

Figure 9 is a schematic perspective drawing similar to Figure 8 of three connected, radially extending support structures 5 with airfoil shape according to the present invention. The radially extending support structures have an airfoil shape providing aerodynamic lift upon wind engagement. The structures 5 define a shape which, upon wind engagement, provides a significant lift. The cross-sectional shape may be symmetric or anti-symmetric, but preferably an anti-symmetric cross-sectional shape may be chosen. The aspect ratio of the cross-sectional shape, i.e. the chord length to maximum thickness, is preferably in the interval from 2 to 10, more preferably in the interval from 4 to 8. Alternatively, the minimum aspect ratio is at least 2, 3, 4, 5, 6, 7, 8, 9, or 10.

In one embodiment, it is possible to pitch the airfoil shape of one or more radially extending support structures 5, i.e. the angle of attack with the wind is variable upon appropriate actuation.

Similarly, the airfoil shape of the inclined support beams 6 and the peripheral support rods 8 can be pitchably mounted in order to provide a controllable lift, where the angle of attack can be changed. Preferably, the lift coefficient (C_L) can be at least 0.5, 0.7, 0.9, or at least 1.1 of any of the airfoil shaped hub parts according to the present invention.

Figure 10 is a schematic plan view of three connected, radially extending support structures with temporary fixation means 80a and 80b according to the present invention. The fixation means 80 has the functionality that the rotor blade 2 is adapted to be temporally fixated to the corresponding radially extending support structure 5 to allow for exchange of the first and the second rotor blade support 60a and 60b point within the radially extending support structure 5. Thus for instance repair or replacement of a bearing in the support points 60a or 60b can

be performed while the blade 2 is fixed to the hub 4. The fixation means 80a and 80b can be various mechanical fixation means, such as hydraulic jacks, screw jacks, etc. Moreover, the rotor blade 2 can have a receiving part 81a and 81b corresponding to the fixation means 80a and 80b, as indicated in Figure 10. Thus,
5 the fixation means 80 could for instance have a protruding part shaped to fit in a corresponding hollow part in the rotor blade 2. Preferably, the receiving part 81a and 81b and the fixation means 80a and 80b may, upon engagement, have a locking cooperation so as to firmly secure the rotor blade 2 during maintenance and service of the first and the second rotor blade support 60a and 60b points.

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Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is set out by the accompanying claim set. In the context of the claims, the terms "comprising" or
15 "comprises" do not exclude other possible elements or steps. Also, the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. Furthermore, individual features mentioned in different claims, may possibly be advantageously combined, and the mentioning of these features in different claims does not exclude that a combination of features is not possible
20 and advantageous.

CLAIMS

1. A wind turbine generator comprising:

- 5 - a plurality of rotor blades, each rotor blade being pitchably mounted
 thereby defining a corresponding rotation axis,
- a rotation shaft, and
- 10 - a hub for connecting the plurality of rotor blades with the rotating shaft,
- wherein the hub further comprises
- a plurality of radially extending support structures, one radially extending
- 15 support structure for each rotor blade, each support structure comprising at least
 a first blade support point for receiving and supporting a rotor blade, and
- a plurality of inclined support beams, one inclined support beam for each
- 20 rotor blade, the first end portion of each inclined support beam being
 connected to the corresponding radially extending support structure, the
 second end portion of each inclined support beam of the plurality of
 inclined support beams being collected in a common, connecting point in an
 exterior position on the hub,
- and/or
- 25 - at least a first peripheral support rod positioned in an exterior position on
 the hub, said first peripheral support rod connecting two of said radially
 extending support structures,

 wherein the rotation axis for each rotor blade has a radial offset relative to the

30 rotation shaft.

2. The generator according to claim 1, wherein the generator further comprises a
shaft having a substantially central position in the hub, the shaft extending
substantially along the rotation shaft for supporting the plurality of inclined

35 support beams in the common, connecting point.

3. The generator according to claim 1, wherein the generator further comprises a second peripheral support rod positioned in an exterior position on the hub, said second support rod connecting two of said radially extending support structures.
- 5 4. The generator according to claim 3, wherein each peripheral support rod connects two radially extending support structures directly, whereby the said support rod together with the two connected radially extending support structures have a substantially triangular shape.
- 10 5. The generator according to claim 3 or claim 4, wherein at least one of said peripheral support rods connects two radially extending support structures at two different radial positions relative to the rotation shaft.
6. The generator according to claim 1, wherein each radially extending support
15 structure further comprises a first and a second rotor blade support point for receiving and supporting a rotor blade, said first and a second rotor blade support points being located at radially different positions relative to the rotation shaft.
7. The generator according to claim 6, wherein the said first and the said second
20 rotor blade support points are located opposite each other in separate radial half parts of the radially extending support structure.
8. The generator according to claim 7, wherein the said first and the said second rotor blade support points are located with a radial distance being at least 5%,
25 10% or 15% of the total rotor blade length as measured from the rotational shaft.
9. The generator according to claim 1, wherein each radially extending support structure has a radial extension of at least 10%, preferably at least 15%, or more preferably at least 20%, of the total rotor blade length as measured from the
30 rotational shaft.
10. The generator according to claim 1, wherein each radially extending support structure comprises a hollow portion for receiving a corresponding end portion of the rotor blade.

11. The generator according to any of the preceding claims, wherein the radially extending support structures, the inclined support beams, and/or the peripheral support rods have a substantially straight shape.
- 5 12. The generator according to any of the preceding claims, wherein the radially extending support structure, the inclined support beams, and/or the peripheral support rods have an airfoil shape providing aerodynamic lift upon wind engagement.
- 10 13. The generator according to any of the preceding claims, wherein each rotor blade in the plurality of rotor blades are adapted to be temporally fixated to the corresponding radially extending support structure in a manner different from the normal mounting.
- 15 14. The generator according to claim 1, wherein the plurality of rotation axes are also angularly offset around a axis substantial parallel to the rotation shaft but different from the rotation shaft.
15. The generator according to any of the preceding claims, wherein each rotor
20 blade in the plurality of rotor blades comprises a bend or curved portion along the length of the blade.
16. A hub for use in a wind turbine generator comprising a plurality of rotor blades and a rotation shaft, the hub being arranged for connecting the plurality of
25 rotor blades with the rotation shaft, wherein the hub comprises:
- a plurality of radially extending support structures, one radially extending support structure for each rotor blade, each support structure comprising at least a first blade support point for receiving and supporting a rotor blade, and
30
 - a plurality of inclined support beams, one inclined support beam for each rotor blade, the first end portion of each inclined support beam being connected to the corresponding radially extending support structure, the second end portion of each inclined support beam of the plurality of

inclined support beams being collected in a common, connecting point in an exterior position on the hub,

and/or

- at least a first peripheral support rod positioned in an exterior position on the hub, said first peripheral support rod connecting two of said radially extending support structures,

wherein the rotation axis for each rotor blade has a radial offset relative to the rotation shaft.

10

17. A method for operating a wind turbine generator, the method comprises:

- providing a plurality of rotor blades,
- providing a rotation shaft, and
- providing a hub for connecting the plurality of rotor blades with the rotation shaft,

20 wherein the hub comprises:

- a plurality of radially extending support structures, one radially extending support structure for each rotor blade, each support structure comprising at least a first blade support point for receiving and supporting a rotor blade, and

25

- a plurality of inclined support beams, one inclined support beam for each rotor blade, the first end portion of each inclined support beam being connected to the corresponding radially extending support structure, the second end portion of each inclined support beam of the plurality of inclined support beams being collected in a common, connecting point in an exterior position on the hub,
- and/or
- at least a first peripheral support rod positioned in an exterior position on the hub, said first peripheral support rod connecting two of said radially extending support structures,

wherein the rotation axis for each rotor blade has a radial offset relative to the rotation shaft.

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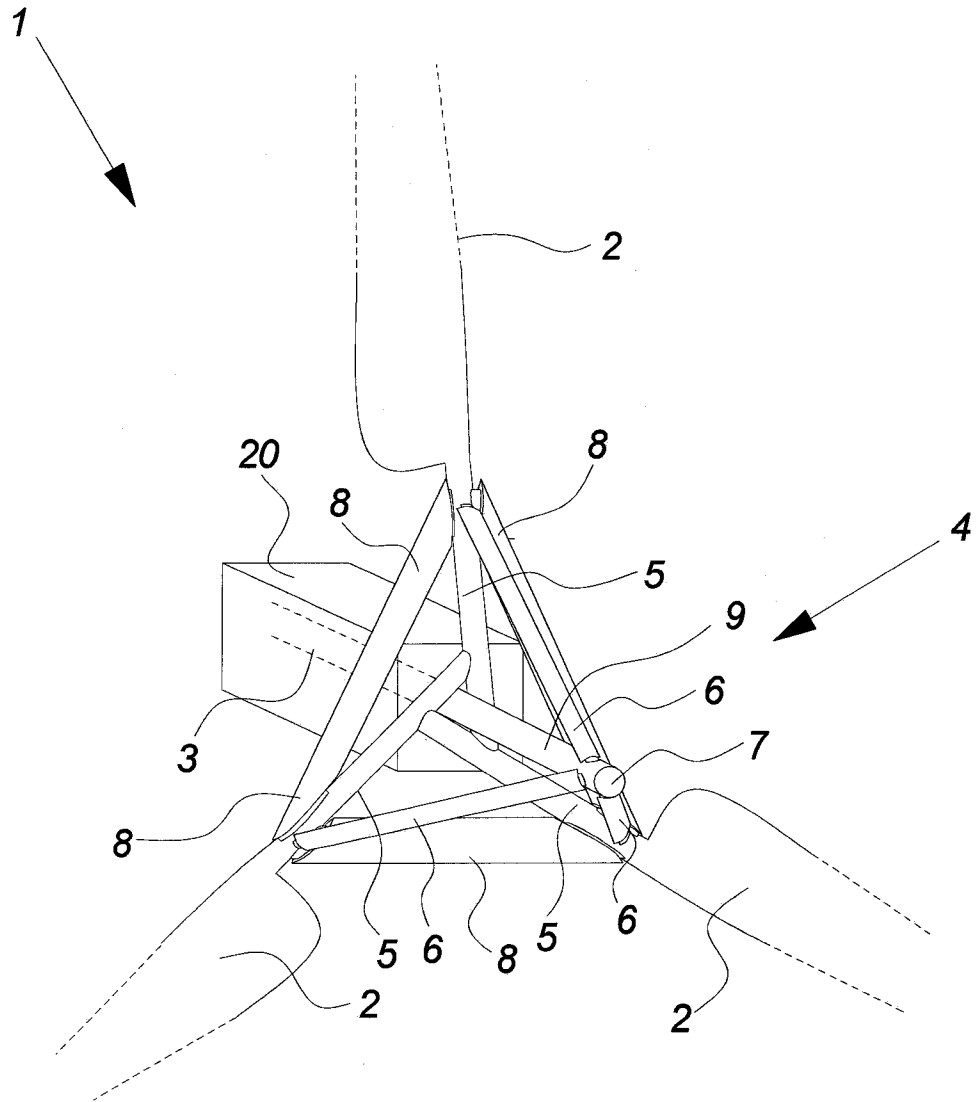


Fig. 1

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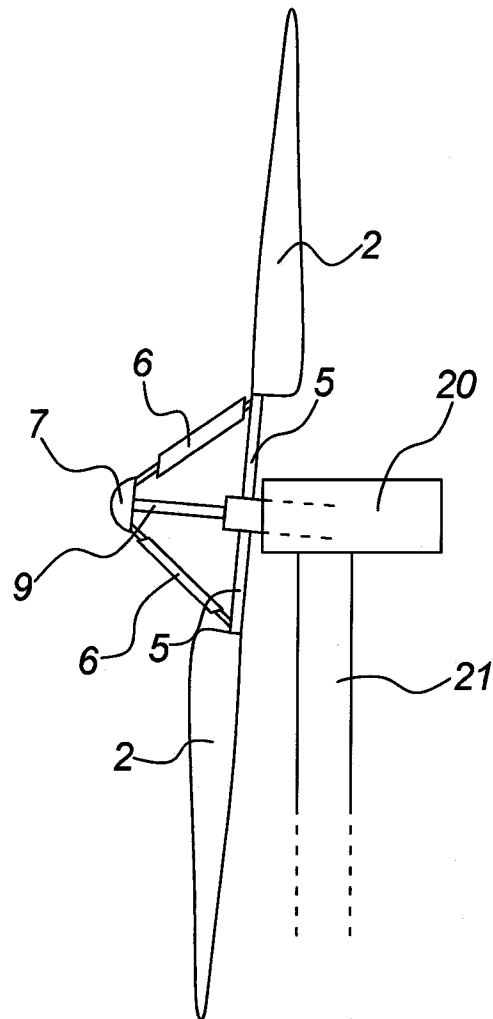


Fig. 2

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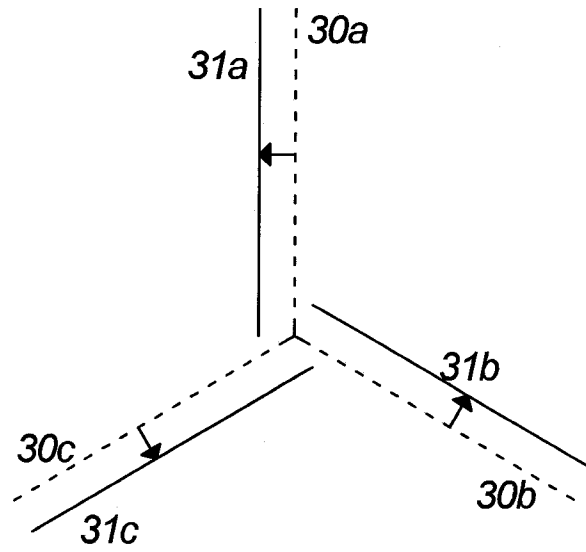


Fig. 3a

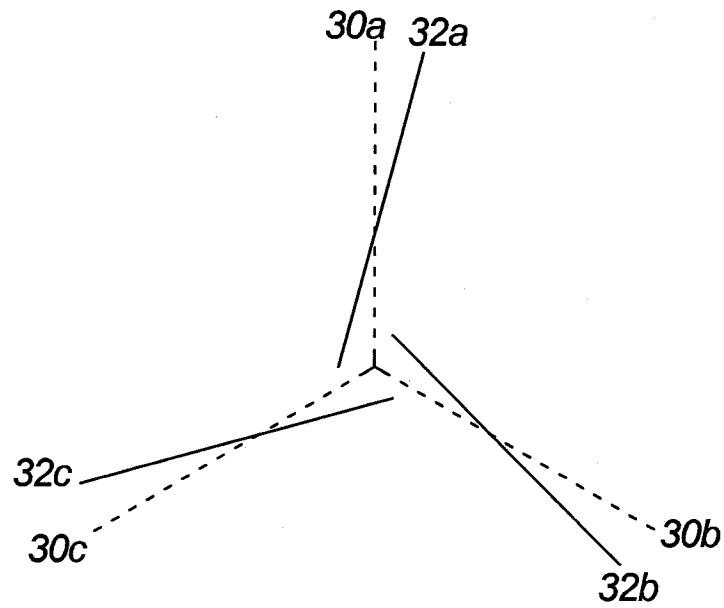
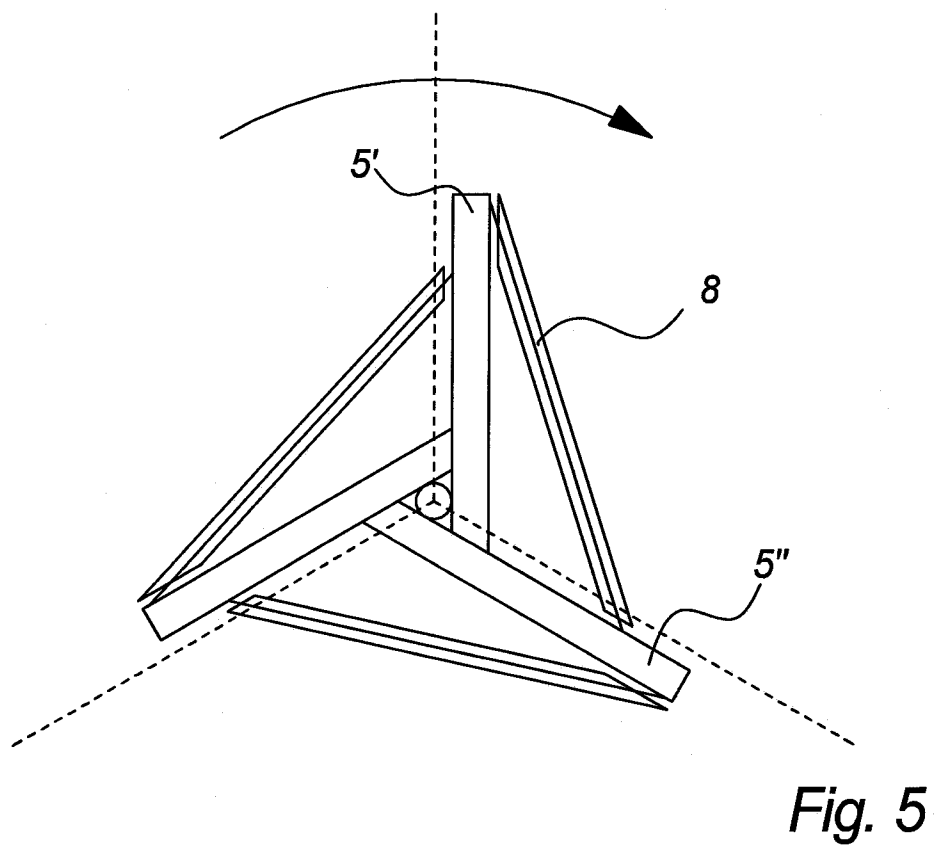
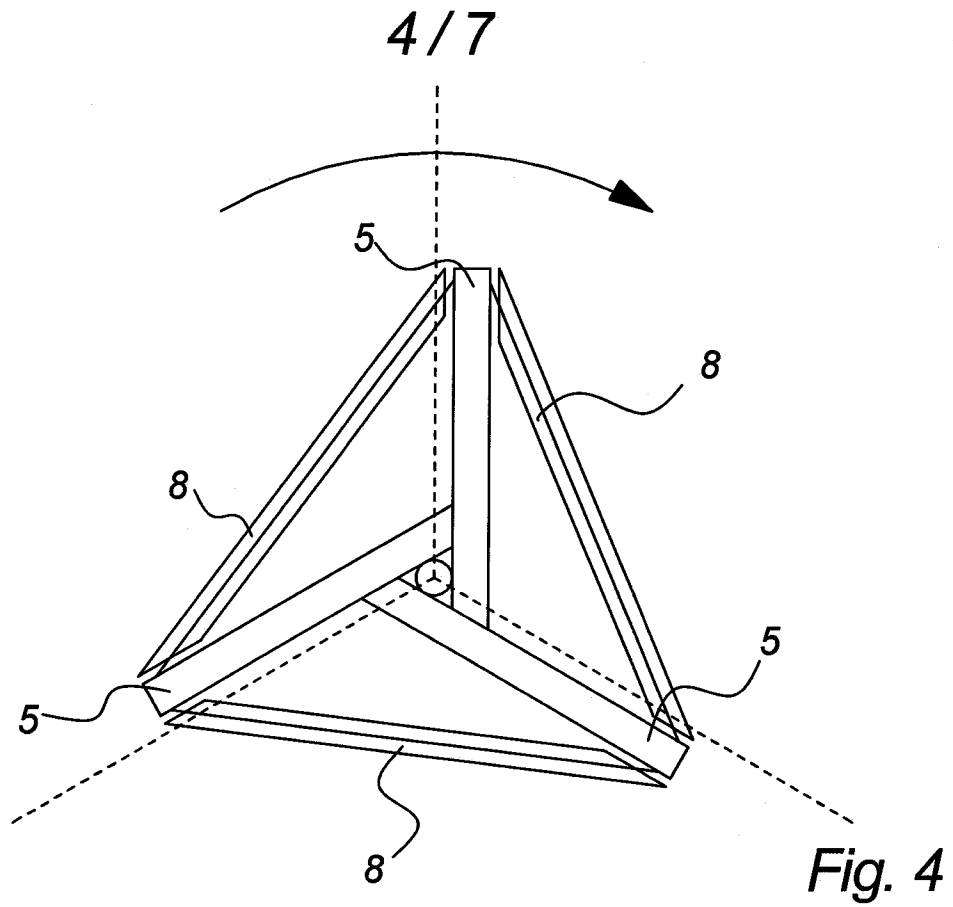


Fig. 3b



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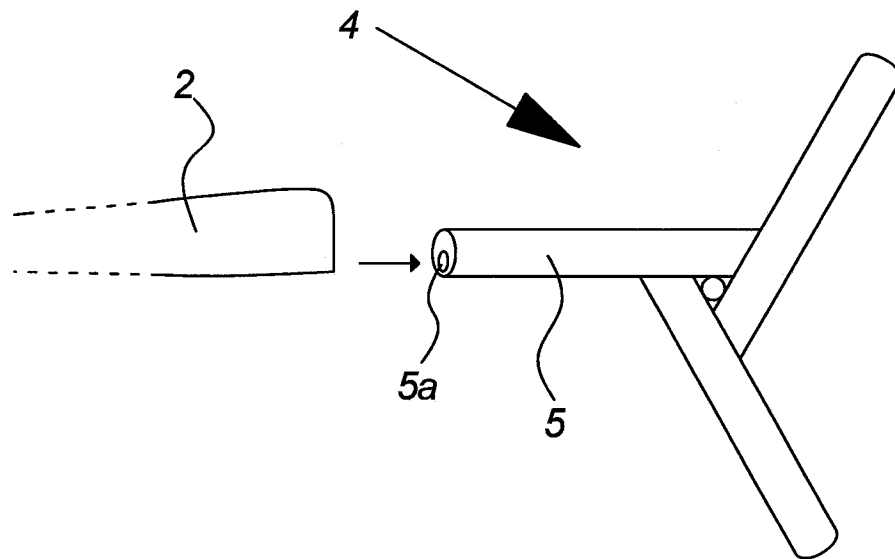


Fig. 6

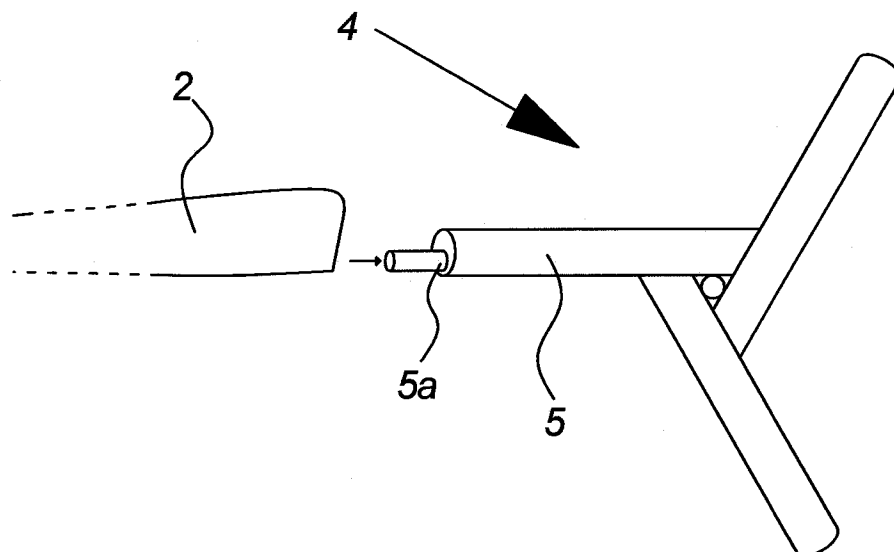


Fig. 7

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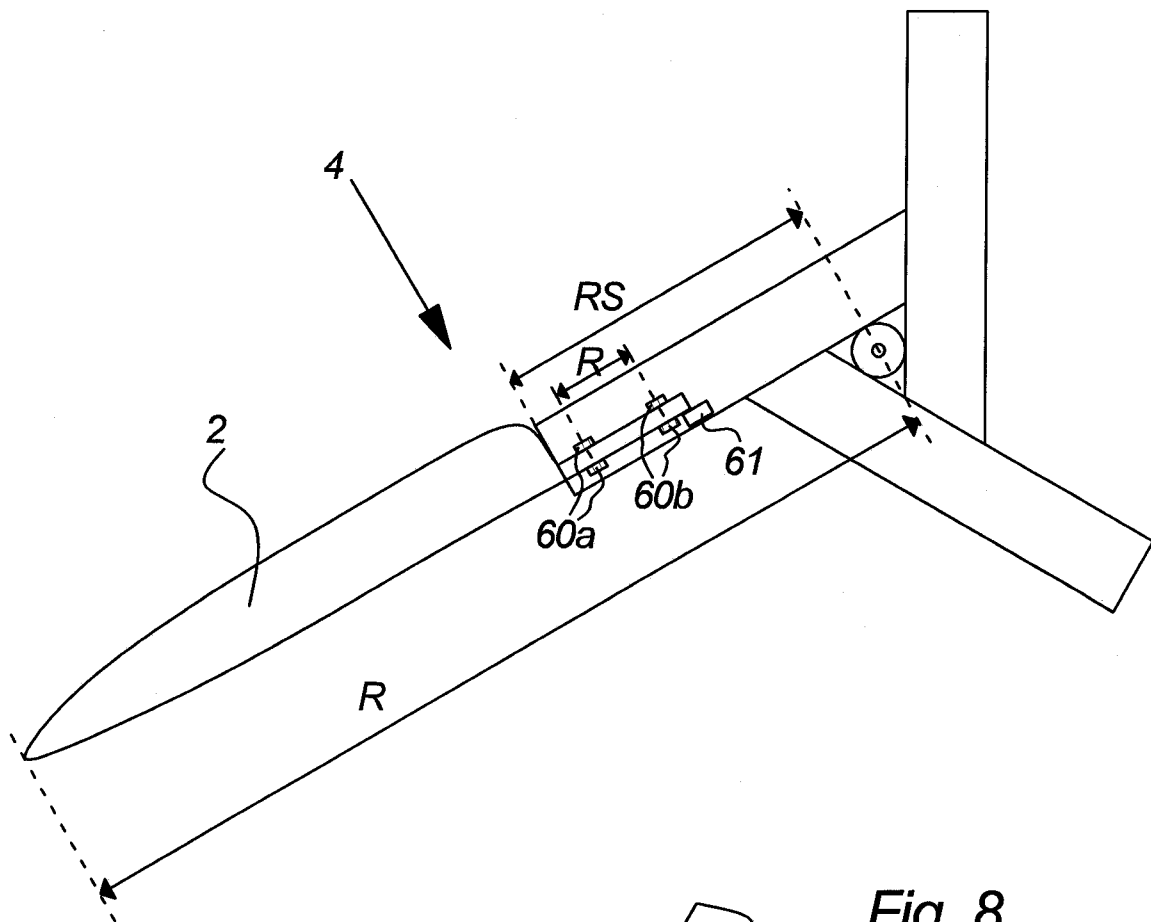


Fig. 8

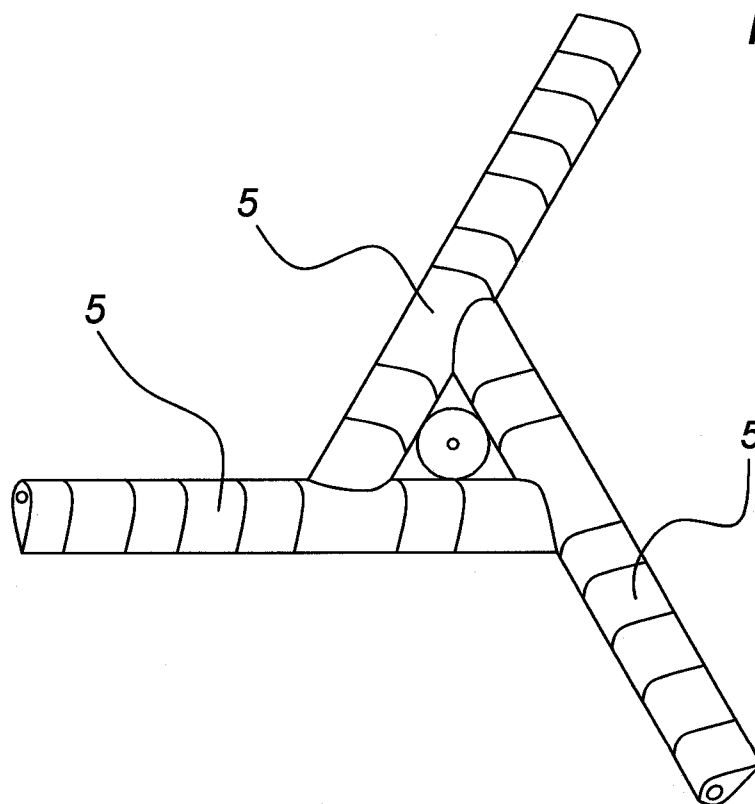


Fig. 9

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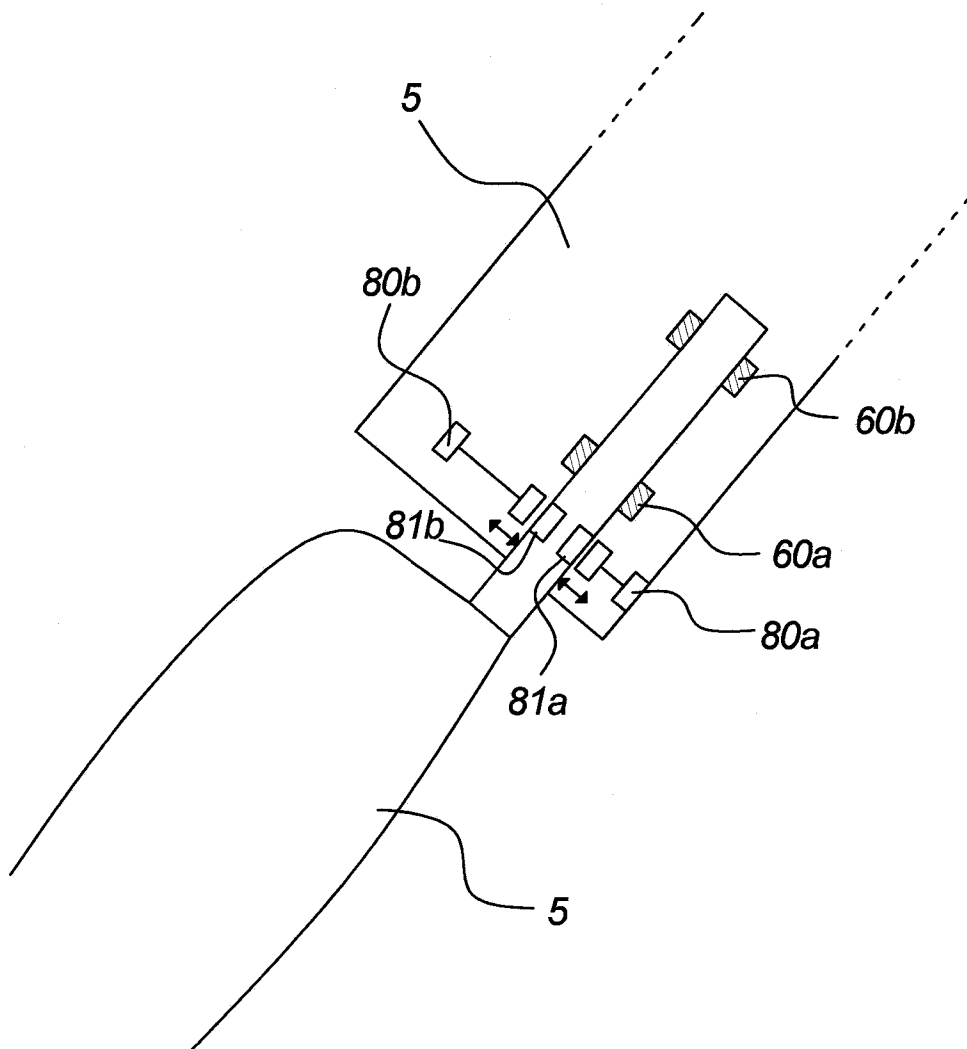


Fig. 10