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- (73) Patenthaver: **innogy SE, Opernplatz 1, 45128 Essen, Tyskland**
- (72) Opfinder: **FRANKE, Jan-Bernd, Bertholt-Brecht-Ring 21, 52336 Elmshorn, Tyskland**
- (74) Fuldmægtig i Danmark: **Dennemeyer & Associates S.A, P.O. Box 700425, DE-81304 Munich, Tyskland**
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WIND TURBINE WITH IMPROVED ROTOR BLADE SCREW CONNECTION

The present invention relates to a wind power plant having a rotor hub and at least one rotor blade, which is fastened to the rotor hub by means of a blade bearing arranged between the rotor hub and the rotor blade.

The prior art according to WO 2006/131301 discloses the fastening of a rotor blade to a rotor hub by means of a plurality of connecting bolts and mounting nuts. A blade bearing having an outer ring and an inner ring which can be rotated concentrically thereto is arranged between the rotor blade and the rotor hub. The rotor blade is connected by means of a plurality of fastening bolts to the inner ring, wherein end-side thread sections of the fastening bolts are screwed into threaded holes of the rotor blade, and wherein mounting nuts are screwed onto thread sections of the fastening bolts projecting out of the inner ring. The outer ring is connected by means of a plurality of fastening bolts to the rotor hub, wherein end-side thread sections of the fastening bolts are screwed into threaded holes of the rotor hub, and wherein mounting nuts are screwed onto thread sections of the fastening bolts projecting out of the outer ring. The rotor blade is therefore rotatably mounted with respect to the rotor hub about the longitudinal axis of the rotor blade.

Furthermore, wind power plants are known from the state of the art in which the outer rings of the blade bearings are each connected to the rotor blades and the inner rings of the blade bearings are each connected to the rotor hubs of the wind power plant.

The connecting bolts for connecting the rotor blades to the blade bearing are usually designed as expansion bolts.

In each case, an expansion region with a reduced outer diameter is arranged between end-side thread sections of the expansion bolts.

For reliable fastening of the rotor blade to the rotor hub, the mounting nuts must be tightened with predetermined torques or mounted with prestressing forces so that self-locking occurs between the thread sections and the mounting nuts and so that loosening of the mounting nuts from the respective thread sections is prevented.

Despite self-locking of the mounting nuts, they can become loosened from the second thread sections over time so that a reliable connection of the rotor blade to the rotor hub is no longer guaranteed. For example, because of the choice of material of the rotor blades, it may be necessary to tighten the mounting nuts with less torque so that the material of the rotor blade is not damaged. If, for example, carbon fibre-reinforced composite materials are used for the rotor blade, the mounting nuts can only be

tightened with a reduced torque.

Highly stressed screw connections can lead to self-loosening of nuts and bolts, as a result of which the entire screw connection can fail, which causes great material damage. Usually, a corresponding self-loosening process starts with the loosening of individual screws or individual mounting nuts, which can cause considerable damage to property and serious injury if they fall.

One cause of the self-loosening of screws and mounting nuts may be that the rotor hub, blade bearing and rotor blade are configured too elastically. One remedy might be to form a stiffer overall design, which, however, can only be implemented in the field with significant development, manufacturing, certification and logistics costs and would contribute to significant costs.

Another cause of the self-loosening of screws and mounting nuts may be slippage of the mutually contacting flanges of the rotor blade and the blade bearing or the blade hub and the rotor hub. It is known that the screw connections of rotor blades have not been configured properly in a larger number of established wind power plants. The mutually contacting flange surfaces were not cleaned, resulting in too low a friction coefficient in the joint between the flange surfaces. Owing to the low friction, it must be assumed that the mutually contacting flanges slip under extreme loads or higher operating loads. This would lead to inadmissible shear stresses of the screw connection elements. In addition, it is then assumed that the blade bearing of a displaced connection is braced and can no longer rotate.

This would mean that the wind power plant has to be shut down and the affected rotor blade removed, the mutually contacting flange surfaces would have to be cleaned, and then the rotor blade reassembled. A corresponding procedure would lead to considerable costs and, furthermore, to a considerable yield loss of the wind power plant.

US 2014/0377069 A1 describes a wind power plant having a rotor hub and a plurality of rotor blades, which are connected to the rotor hub via a ball bearing device. The ball bearing device has an inner ring and an outer ring, wherein each rotor blade is connected by means of fastening screws to the inner ring, and wherein the outer ring is connected via fastening screws to the rotor hub. A stiffening device, which can comprise a plurality of annular segments, has fastening openings in each case, through which the fastening bolts are guided so that the inner ring is arranged between the rotor blade and the stiffening device.

WO 2007/003866 A1 likewise shows a wind power plant having a rotor hub and a

plurality of rotor blades which are connected to the rotor hub via a ball bearing device having an inner ring and an outer ring. Further, the wind power plant has an outer plate and an inner plate, wherein the outer plate is connected to the outer ring such that the outer ring is arranged between the rotor hub and the outer plate, and wherein the inner plate is connected to the inner ring such that the inner ring is arranged between the inner plate and the rotor blade. Both the outer plate and the inner plate have a plurality of through holes, through which fastening screws project.

The EP 2045464 A2 also describes a wind power plant comprising a rotor hub, a blade bearing having an outer ring and an inner ring, and a plurality of rotor blades, which are connected via the blade bearings to the rotor hub.

The aim of the present invention is to provide a wind power plant with an improved rotor blade screw connection.

The aim of the present invention is achieved by a wind power plant having the features of claim 1. Advantageous embodiments of the wind power plant are described in the dependent claims.

More specifically, the aim of the present invention is achieved by a wind power plant comprising a rotor hub, at least one blade bearing and at least one rotor blade, wherein the blade bearing has a first ring and a second ring, which are concentrically rotatable with respect to each other. The first ring is connected to the rotor blade by means of at least one first connecting bolt which penetrates a first through hole of the first ring. The second ring is connected to the rotor hub by means of at least one second connecting bolt which penetrates a second through hole of the second ring. The wind power plant according to the invention is characterized in that it comprises at least one stiffening device having at least one through opening, through which the first connecting bolt and/or the second connecting bolt project/projects, wherein the stiffening device is subjected to force in the direction of the blade bearing by means of at least one mounting nut, which is screwed onto a thread section of the first connecting bolt and/or of the second connecting bolt projecting out of the stiffening device.

By providing the stiffening device, through which the first connecting bolt and/or the second connecting bolt project, the transverse forces and bending moments, which act on the connecting bolts when the rotor blades are loaded, are confronted with a greater moment of resistance. As a result, slippage of the rotor blade with respect to the first ring and/or slippage of the second ring with respect to the rotor hub is counteracted. Furthermore, it is possible to retrofit already existing and operating wind power plants with the stiffening device so as to allow the upgrading of a wind power plant with

significantly lower costs and shorter downtime.

The blade bearing can also be described as a bearing unit. The first ring and the second ring are thus arranged concentrically with respect to each other and can rotate relative to each other. Since the first ring is rotatable with respect to the second ring, the rotor blade is rotatable about its longitudinal axis with respect to the rotor hub.

Both the first connecting bolt and the second connecting bolt can each be designed as stud bolts and/or as expansion bolts.

The first connecting bolt has a thread section at each end. A second end-side thread section of the first connecting bolt can be screwed into a threaded hole of the rotor blade. A first end-side thread section of the first connecting bolt can project from the first ring and a mounting nut can be screwed onto the first thread section. Consequently, at least one first connecting bolt which penetrates the first through holes of the first ring in each case is connected by means of a second end-side thread section to the rotor blade, and a first mounting nut is screwed onto a first end-side thread section.

The second connecting bolt has a thread section at each of its ends. A second end-side thread section of the second connecting bolt can be screwed into a threaded hole of the rotor hub. A first end-side thread section of the second connecting bolt can project from the second ring, and a mounting nut can be screwed onto the first thread section. Consequently, at least one second connecting bolt which penetrates the second through holes of the second ring in each case is connected by means of a second end-side thread section to the rotor hub, and a second mounting nut is screwed onto a first end-side thread section.

Of course, the first ring is connected to the rotor blade by means of a plurality of first connecting bolts, which are each guided through first through holes of the first ring, which are arranged angularly offset from each other in the first ring and preferably extend over the entire circumference of the first ring.

Of course, the second ring is connected to the rotor hub by means of a plurality of second connecting bolts, each guided through second through holes of the second ring, which are arranged angularly offset from one another in the second ring and preferably extend over the entire circumference of the second ring.

The number of first through holes thus corresponds to the number of first connecting bolts.

The second connecting bolt is preferably connected to the rotor hub by means of the first thread section of the connecting bolt preferably in that the second thread section is screwed into a threaded hole of the rotor hub.

Preferably, the stiffening device has at least one first stiffening segment, and the first ring of the blade bearing is arranged between the first stiffening segment and the rotor blade, wherein the first stiffening segment is subjected to force in the direction of the first ring by means of a mounting nut.

Through a corresponding design of the wind power plant, slippage of the rotor blade with respect to the first ring is particularly effectively counteracted. Even when the stiffening device is designed accordingly, it is possible to retrofit already existing and operating wind power plants with the stiffening device so as to allow upgrading of a wind power plant with significantly lower costs and shorter downtime.

Preferably, the first stiffening segment is formed as a first partial ring segment having a radius of curvature corresponding to a radius of curvature of the first ring.

Designing the stiffening device accordingly has the advantage that a retrofitting of a wind power plant with the stiffening device is possible in a simplified way, since not all mounting nuts, by means of which the rotor blade is fastened to the first ring of the blade bearing, have to be loosened at the same time. This reduces the costs of upgrading a wind power plant.

Further preferably, the first stiffening segment comprises a plurality of through openings, which are each in alignment with first through holes of the first ring and are each penetrated by first connecting bolts.

By means of a stiffening segment designed accordingly with a plurality of through openings, the moment of resistance is further increased so that the construction deforms less elastically and the risk of loosening is thus reduced.

Further preferably, the first stiffening segment is formed as a first annular segment.

Even when the stiffening device is designed accordingly, the moment of resistance is further increased and it can form a positive connection between the bearing ring and the rotor blade so that slippage of the rotor blade with respect to the first ring of the blade bearing is even better counteracted.

Preferably, the first annular segment has a number of through openings which correspond to the number of through-holes in the first ring, are in alignment with first through holes of the first ring and are each penetrated by first connecting bolts.

The combination of designing the stiffening segment as an annular segment and the feature that the annular segment is penetrated by all the first fastening bolts further increases the moment of resistance so that the wind power plant can withstand increased loads without concern about the rotor blade slipping with respect to the inner bearing.

Preferably, the stiffening device has at least one clamp, which is connected to the first stiffening segment and to the rotor blade so that forces exerted on the rotor blade can be transmitted at least partially to the first stiffening element via the clamp.

A corresponding design of the wind power plant has the advantage that an additional load path between the rotor blade and the first ring is formed so that forces exerted on the rotor blade forces are transmitted not only by the first connecting bolt to the bearing ring, but also via the clamp/clamps from the rotor blade to the first ring of the blade bearing. As a result, the stability of the wind power plant is further increased. The first connecting bolts are relieved such that the loading of the mounting nuts, by means of which the rotor blade is fastened to the bearing ring, is reduced.

The retaining clamps can be fastened to the first stiffening segment, for example, by a screw connection. For this purpose, the first stiffening device preferably has a threaded hole and the clamps each have a through-opening, through which connecting bolts are guided, wherein the clamps are fastened by means of mounting nuts to the first stiffening segments. The connection between the clamps and the rotor blade can also be realised by a screw connection. Furthermore, it is also possible for the clamps to be connected to the rotor blade by means of adhesive bonding.

The stiffening device preferably has at least one second stiffening segment, the second ring of the blade bearing being arranged between the second stiffening segment and the rotor hub, and the second stiffening segment being subjected to force in the direction of the second ring (120) by means of a mounting nut.

By means of a corresponding design of the wind power plant, slippage of the blade bearing with respect to the rotor hub is particularly effectively counteracted. Even when the stiffening device is designed accordingly, it is possible to retrofit already existing and operating wind power plants with the stiffening device so as to allow upgrading of a wind power plant with significantly lower costs and shorter downtime.

Preferably, the second stiffening segment is formed as a second partial ring segment, which has a radius of curvature corresponding to a radius of curvature of the second ring.

A corresponding design of the stiffening device has the advantage that retrofitting of a wind power plant with the stiffening device is simplified since not all mounting nuts, by means of which the blade bearings are fastened to the rotor hub, have to be loosened at the same time. This reduces the costs of upgrading a wind power plant.

Further preferably, the second stiffening segment has a plurality of through openings, which are each in alignment with second through holes of the second ring and are each

penetrated by second connecting bolts.

By means of a stiffening segment designed accordingly with a plurality of through openings, the moment of resistance is further increased so that slippage of the blade bearing with respect to the rotor hub is further counteracted in an improved manner. Consequently, the wind power plant can be subjected to increased loads without the blade bearing slipping relative to the rotor hub.

Preferably, the second stiffening segment is designed as a second annular segment.

Even with a corresponding design of the stiffening device, the moment of resistance is further increased so that slippage of the blade bearing with respect to the rotor hub is further counteracted in an improved manner.

Further preferably, the second annular segment has a number of through openings which correspond to the number of second through holes in the second ring, are each in alignment with second through holes of the second ring and are each penetrated by second connecting bolts.

The combination of designing the stiffening segment as an annular segment and the feature that the annular segment is penetrated by all the second fastening bolts further increases the moment of resistance so that the wind power plant can withstand increased loads without concern about the blade bearing slipping with respect to the rotor hub.

Preferably, the first ring is designed as an inner ring and the second ring is designed as an outer ring of the blade bearing.

Further preferably, the first ring is designed as an outer ring and the second ring is designed as an inner ring of the blade bearing.

The outer ring can also be referred to as an outer connection ring or as a (first) connection element. The inner ring can also be referred to as an inner connection ring or as a (second) connection element.

Further advantages, details and features of the invention arise below from the explained exemplary embodiments. The following is shown:

Figure 1: shows a section through a rotor blade bearing unit of a wind power plant according to the invention.

A rotor blade 20 is usually formed from a fibre composite material and designed in the manner of a wing. To save weight, the rotor blade 20 is designed as a shell surface which encloses an inner cavity and merges at a rear end of the rotor blade 20 into a profile in the shape of cylinder shell having a diameter of usually 2 to 3 m. As a result, a plane of a rearward connection surface of the rotor blade 20 has a circular outline. In

this connection surface, which is also referred to as a connection flange, a plurality of annularly arranged threaded holes 21 are provided, by means of which the rotor blade 20 is fastened to a blade bearing 100.

In a rotor hub 10 of the wind power plant 1, a circular connection surface is formed, which is also referred to as a connection flange, enclosing a circular opening in the rotor hub 10. In the connection flange of the rotor hub 10, a plurality of annularly arranged threaded holes 11 is provided.

The blade bearing 100 is arranged between the connection flange of the rotor blade 20 and the connection flange of the rotor hub 10. The blade bearing 100 has two annular, mutually concentric and mutually rotatable ring elements 110, 120. A first ring 110, which is designed in the exemplary embodiment shown as an inner ring 110, of the blade bearing 100 is connected to the rotor blade 20 by means of a plurality of first connecting bolts 140 which penetrates first through holes 111 of the inner ring. The second thread sections 142 of the first connecting bolts 140 are screwed into the respective threaded holes 21 of the rotor blade 20. The rotor blade 20 is connected to the inner ring 110 in that first thread sections 141 of the first connecting bolts 140 projecting out of the inner ring 110 are fastened to the inner ring 110 by means of mounting nuts 143.

A second ring 110, which is designed in the exemplary embodiment shown as an outer ring 120, of the blade bearing 100 is connected to the rotor hub 10 by means of a plurality of second connecting bolts 150 which penetrates second through holes 121 of the outer ring 120. Second thread sections 152 of the second connecting bolts 150 are screwed into respective threaded holes 11 of the rotor hub 10. The outer ring 120 is connected to the rotor hub 10 in that thread sections 151 of the second connecting bolts 150 projecting out of the outer ring 120 are fastened to the outer ring 120 by means of mounting nuts 153.

The inner ring 110 is rotatable with respect to the outer ring 120, wherein a rolling body set 130 is arranged between the inner ring 110 and the outer ring 120. Since a longitudinal axis of the rotor blade 20 coincides with the longitudinal axes of the inner ring 110 and of the outer ring 120, the rotor blade 20 can be rotated with respect to the rotor hub 10 about the longitudinal axis of the rotor blade 20.

It can be seen from figure 1 that the wind power plant 1 comprises a stiffening device, which comprises, in the exemplary embodiment shown, a first stiffening segment 210 and a second stiffening segment 220.

The first stiffening segment 210 in this case has through openings 211, which are

aligned with the first through holes 111 of the inner ring 110. The respective first thread sections 141 of the first connecting bolts 140 protrude out of the first stiffening segment 210, and the first stiffening segment 210 is subjected to force in the direction of the inner ring 110 by means of mounting nuts 143. Consequently, the inner ring 110 of the blade bearing 100 is arranged between the first stiffening segment 210 and the rotor blade 20, more specifically the connection flange of the rotor blade 20.

Furthermore, figure 1 shows that the stiffening device 200 has at least one clamp 230, but preferably a plurality of clamps 230, which is connected both to the first stiffening segment 210 and to the rotor blade 20. The clamp 230 is connected to the first stiffening element 210 by means of a connecting bolt, which projects through a through hole in the clamp 230 and is screwed into a threaded hole provided therefor in the first stiffening segment. The clamp 230 and the first stiffening segment 210 are connected by means of a mounting nut. It can also be seen that the clamp 230 is in direct contact with the rotor blade 20. The connection between the clamp 230 and the rotor blade 20 can also be realised by a screw connection. In the exemplary embodiment shown, however, the connection between the clamp 230 and the rotor blade 20 is realised by adhesive bonding.

By connecting the rotor blade 20 to the first stiffening segment 210 by means of the clamp 230, a second load path is formed so that forces exerted on the rotor blade 20 are transferred to the inner ring 110 not only via the first connecting bolt 140, but also via the clamp 230. Furthermore, if the frictional engagement in the screw connection is impaired, for example by dirty flange surfaces, the additionally present positive connection of the clamp 230 can ensure load transfer.

The second stiffening segment 220 has through openings 221, which are aligned with the second through holes 121 of the outer ring 120. The respective first thread sections 151 of the second connecting bolts 150 project out of the second stiffening segment 220, and the second stiffening segment 220 is subjected to force in the direction of the outer ring 120 by means of mounting nuts 153. Consequently, the outer ring 120 of the blade bearing 100 is arranged between the second stiffening segment 220 and the rotor hub 10, more specifically the connection flange of the rotor hub 10.

It should be noted that the stiffening device may only be formed from the first stiffening element 210. Furthermore, it is possible for the stiffening device to be formed from the first stiffening segment 210 and the clamp 230. Furthermore, it is also possible for the stiffening device to be formed only from the second stiffening segment 220. However, an optimal effect of the stiffening device is achieved if this has the first stiffening

segment 210, the second stiffening segment 220 and a plurality of clamps 230 each connected to the first stiffening segment 210.

List of reference signs

- 1 Wind power plant
- 10 Rotor hub
- 11 Threaded hole (of the rotor hub)
- 20 Rotor blade
- 21 Threaded hole (of the rotor blade)
- 100 Blade bearing
- 110 First ring / inner ring (of the blade bearing)
- 111 First through hole (of the first ring)
- 120 Second ring / outer ring (of the blade bearing)
- 121 Second through hole (of the second ring)
- 130 Rolling body set / roller bearings / ball bearings (of the blade bearing)
- 140 First connecting bolt
- 141 (First) thread section (of the first connecting bolt)
- 142 (Second) thread section (of the first connecting bolt)
- 143 Mounting nut
- 150 Second connecting bolt
- 151 (First) thread section (of the second connecting bolt)
- 152 (Second) thread section (of the second connecting bolt)
- 153 Mounting nut
- 210 First stiffening segment / partial ring segment / annular segment (of the stiffening device)
- 211 Through opening (of the first stiffening segment)
- 220 Second stiffening segment / partial ring segment / annular segment (the stiffening device)
- 221 Through opening (of second stiffening segment)
- 230 Clamp (of the stiffening device)

Vindkraftanlæg med forbedret rotorbladsfastgørelse

PATENTKRAV

1. Vindkraftanlæg (1) med et rotornav (10), i det mindste et bladeje (100) og i det mindste et rotorblad (20), hvor vindkraftanlægget (1) har følgende kendetegn:

- Bladejet (100) omfatter en første ring (110) og en anden ring (120), som kan drejes koncentrisk i forhold til hinanden;
- den første ring (110) er forbundet med rotorbladet (20) ved hjælp af i det mindste en første forbindelsesbolt (140), som går igennem en respektiv første gennemgangsboring (111) i den første ring (110);
- den anden ring (120) er forbundet med rotornavet (10) ved hjælp af i det mindste en anden forbindelsesbolt (150), som går igennem en respektiv anden gennemgangsboring (121) i den anden ring (120);
- vindkraftanlægget (1) indeholder i det mindste en afstivningsanordning (210, 220) med i det mindste en gennemgangsåbning (211, 221), som den første forbindelsesbolt (140) og/eller den anden forbindelsesbolt (150) rager gennem;
- afstivningsanordningen (210, 220) er kraftpåvirket i retning mod bladejet (100) ved hjælp af i det mindste en fastgørelsesmøtrik (143, 153), der er skruet på et gevindafsnit (141, 151) af den første forbindelsesbolt (140) og/eller den anden forbindelsesbolt (150), der rager ud af afstivningsanordningen (210, 220);
- afstivningsanordningen (210, 220) omfatter i det mindste et første afstivningssegment (210);
- den første ring (110) i bladejet (100) er anbragt mellem det første afstivningssegment (210) og rotorbladet (20); og
- det første afstivningssegment (210) er kraftpåvirket i retning mod den første ring (110) ved hjælp af en fastgørelsesmøtrik (143),

hvor vindkraftanlægget (1) **er kendetegnet ved**, at afstivningsanordningen (210, 220) har i det mindste en bøjle (230), som er forbundet med det første afstivningssegment (210) og med rotorbladet (20), således at de kræfter, der udøves på rotorbladet (20) via bøjlen (230), kan overføres i det mindste delvist til det første afstivningselement (210).

2. Vindkraftanlæg ifølge krav 1, **kendetegnet ved**, at det første afstivningssegment

(210) er udformet som et første delringssegment (210), der har en krumningsradius, der svarer til den første rings (110) krumningsradius.

3. Vindkraftanlæg (1) ifølge et af de foregående krav, **kendetegnet ved**, at det første afstivningssegment (210) har en flerhed af gennemgangsåbninger (211), der hver især flugter med første gennemgangsboringer (111) i den første ring (110) og hver især gennemtrænges af første forbindelsesbolte (140).

4. Vindkraftanlæg (1) ifølge et af de foregående krav, **kendetegnet ved**, at det første afstivningssegment (210) er udformet som et første ringsegment (210).

5. Vindkraftanlæg (1) ifølge krav 4, **kendetegnet ved**, at det første ringsegment (210) har et antal gennemgangsåbninger (211) svarende til antallet af gennemgangsboringer (111) i den første ring (110), hvilke gennemgangsåbninger hver især flugter med første gennemgangsboringer (111) i den første ring (110) og hver især gennemtrænges af første forbindelsesbolte (140).

6. Vindkraftanlæg (1) ifølge et af de foregående krav, **kendetegnet ved**, at

- afstivningsanordningen (210, 220) omfatter i det mindste et andet afstivningssegment (220);
- den anden ring (120) i bladejet (100) er anbragt mellem det andet afstivningssegment (220) og rotorbladet (10); og
- det andet afstivningssegment (220) er kraftpåvirket i retning mod den anden ring (120) ved hjælp af en fastgørelsesmøtrik (153).

7. Vindkraftanlæg ifølge krav 6, **kendetegnet ved**, at det andet afstivningssegment (220) er udformet som et andet delringssegment (220), der har en krumningsradius, der svarer til den anden rings (120) krumningsradius.

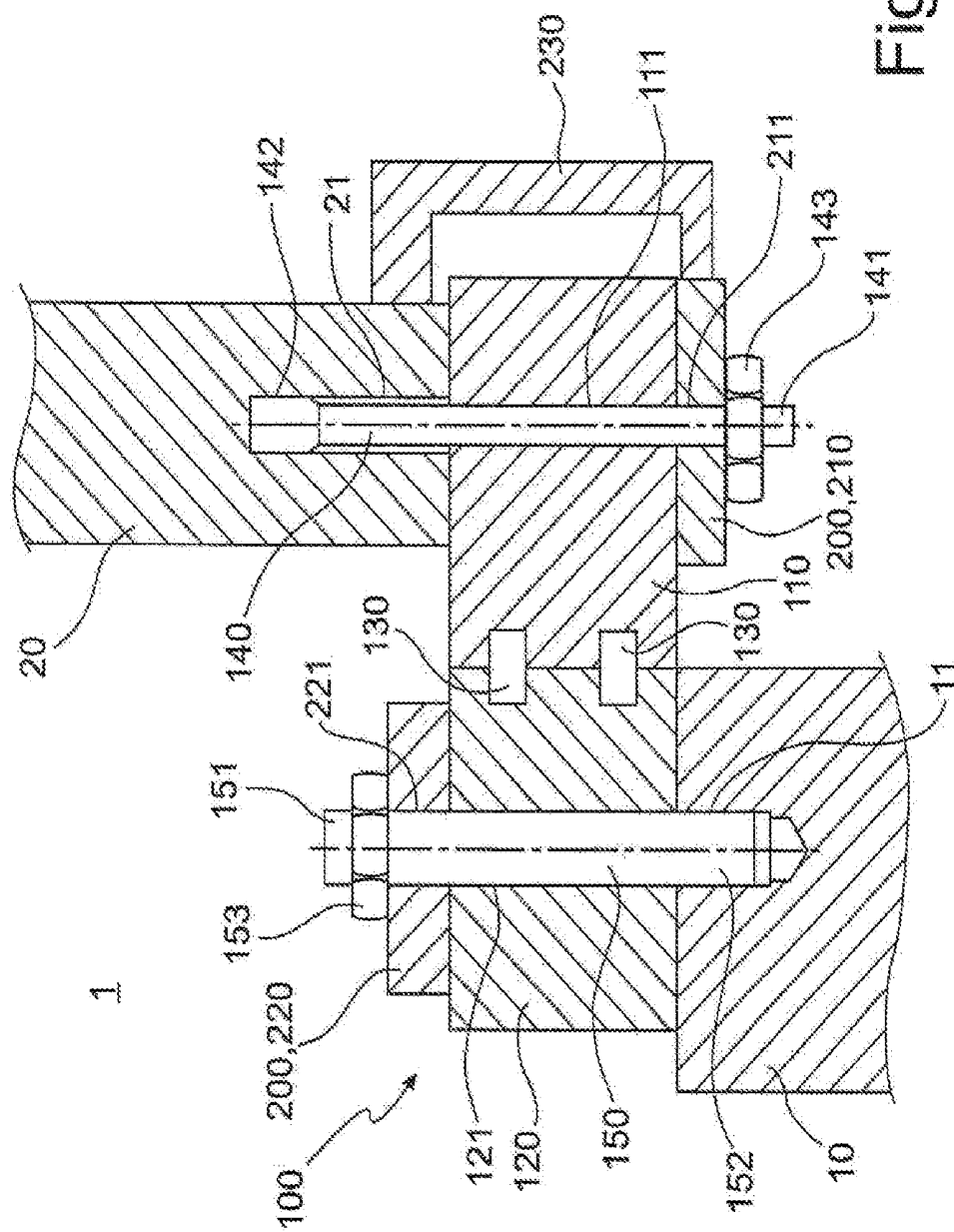
8. Vindkraftanlæg (1) ifølge et af kravene 6 til 7, **kendetegnet ved**, at det andet afstivningssegment (220) har en flerhed af gennemgangsåbninger (221), der hver især flugter med yderligere gennemgangsboringer (121) i den anden ring (120) og hver især gennemtrænges af yderligere forbindelsesbolte (150).

9. Vindkraftanlæg (1) ifølge et af kravene 6 til 8, **kendetegnet ved**, at det andet afstivningssegment (220) er udformet som et andet ringsegment (220).

10. Vindkraftanlæg (1) ifølge krav 9, **kendetegnet ved**, at det andet ringsegment (220) har et antal gennemgangsåbninger (221) svarende til antallet af yderligere gennemgangsboringer (121) i den anden ring (120), hvilke gennemgangsåbninger hver især flugter med yderligere gennemgangsboringer (121) i den anden ring (120) og hver især gennemtrænges af yderligere forbindelsesbolte (150).

11. Vindkraftanlæg (1) ifølge et af de foregående krav, **kendetegnet ved**, at den første ring (110) er udformet som inderring (110) og den anden ring (120) som yderring (120) i bladlejet (100).

12. Vindkraftanlæg (1) ifølge et af kravene 1 til 10, **kendetegnet ved**, at den første ring (110) er udformet som yderring (110) og den anden ring (120) som inderring (120) i bladlejet (100).



754