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BARREL-SHAPED BEARING

This invention relates to a pivoting bearing of a servo-actuator.

An objective of the invention is to provide such a bearing for a blade of a wind turbine rotor hub.

5 In general, bearings capable of withstanding significant stresses already exist and include:

- at least one first and one second bearing ring extending at two different radial distances with respect to the axis of the blade, and rotatably mounted with respect to
10 one another, about said axis,

- at least one series of roller bearings arranged, in a radial plane with respect to said axis, between the first and second rings,

- first means for attaching the first ring to the rotor
15 hub,

- second means for attaching the second ring to the blade.

In particular the wind turbine blades are exposed not only to significant stresses in the axis of the/each blade (axial stresses), but also to very significant stresses
20 exerted radially with respect to the axis of the blade and the rotor hub (radial or centrifugal stresses).

The rotation speeds, the ever-increasing sizes of wind turbines, the stresses imposed by the wind, as well as the stresses associated with the blade angle require an ever-
25 increasing strength of the bearings.

In this regard, it is commonplace for the blades to be capable of pivoting about ten degrees about their axis of extension so as to enhance their efficiency according to the direction of wind.

30 Although hereinafter, for simplicity, reference is only made to blade(s) and rotor hub(s), the invention can be

applied to other apparatuses having the same problems (cranes, large items of construction equipment ... etc).

In this context, an objective of the invention is to improve the mechanical strength of the bearings, by enhancing their resistance, in particular to radial stresses, and their overall performance, in particular for this application in large wind turbines.

In a proposed solution according to claim 1, the roller bearings used are barrel-shaped roller bearings each having an axis of rotation, which axes are slanted with respect to the axis of the blade and arranged in a radial plane with respect to the latter, between the first and second rings, with at least one of these rings being separated into at least two parts, along a transverse surface with respect to the axis of the blade, for the assembly and/or disassembly of the roller bearings.

To combine strength, reliability, efficacy and effective production and maintenance conditions, it is recommended that, in a direction parallel to the axis of the blade, the bearing include at least two series of such barrel-shaped roller bearings arranged at two different levels in this direction, and of which the axes of rotation intersect between the levels.

In this case, it is also recommended, for the same reasons, and in directions parallel to the axis of the blade:

- that the separation between (the) two parts of the corresponding ring be located between (the) two levels of the series of roller bearings,

- that the ring in at least two parts has, respectively on one and the other of these parts, first and second radial support shoulders for the two corresponding series of roller bearings, which shoulders each have, in a cross-section containing the axis of the blade and passing through one of said roller bearings at each level, a concave bearing surface complementary to a convex surface of these roller bearings or

rollers, which first and second shoulders are connected at a thinned central portion where the ring is separated into two parts, between the two levels of said series of roller bearings,

5 - and that the other ring has, between (the) two levels of the roller bearing series, a third intermediate radial shoulder having, in said through-cross-section, two concave bearing surfaces complementary to said convex surface of the roller bearings, so as to contribute to the support thereof.

10 The intersecting rotation axes of the roller bearings intersect in a zone of the intermediate portion of lower thickness of said ring separated into at least two parts, for the reasons indicated above.

Particularly for optimised stress transfer and a secure
15 attachment, it is also preferable for the bearing to include:

- a connection portion inserted between the blade and said additional ring and second ring and extending, radially with respect to the axis of the blade, opposite them, with at least one of said rings being attached to the connection part
20 without being attached to the blade to which it will nevertheless be connected by means of said connection part, and

- an additional bearing ring located, radially with respect to the axis of the blade, inside or around the first
25 and second rings and attached to the blade.

Under these conditions, it is preferable for said additional ring and second ring and the blade to be connected together by a single connection through which at least some of the stresses (preferably all) exerted simultaneously on said
30 other and second rings pass. This connection is therefore not specific to any of the rings.

In particular for the radial strength under stress, it is also recommended for a holding element or portion to be mechanically connected to the connection part or to the rotor

hub, by being held at least radially with respect to the axis of the blade by one or the other. These holding means will border the peripheral surface of said ring that is radially farthest from the axis of the blade.

5 It is noted that this solution relates to an embodiment in which the aforementioned "connection part" is a separate part and not an element or a portion of another part. In EP-A-158 015, the part 13 of figures 1 to 7 integrates at least one "connection portion" that extends, in a radial direction with
10 respect to the general rotation axis, until it is opposite the ring that is radially farthest from this central axis.

 The use of such a "connection portion" is envisaged here. In this case, it is recommended for the external ring mentioned above to radially have a thickness that is greater
15 toward its end closest to the blade than toward its end closest to the rotor hub, which ring consequently has an external peripheral surface with a generator that is not parallel or not continuously parallel to the axis of the blade.

 The means for attachment with said first ring and
20 external ring will then be arranged, together, on this connection portion.

 While formulated according to different features, the two solutions presented above, respectively with the connection part and with the connection portion, closely connected to the
25 rotor hub or attached thereto, provide the same solution to the problem stated above, of improving the strength under stress of the bearings, in particular radially with respect to the rotation axis of the/each blade, on increasingly powerful wind turbines, which are therefore placed under increasing
30 mechanical stress.

 The features mentioned above, and even those in the following more detailed description, improve the reliability of the corresponding wind turbines, as well as the ergonomics

of assembly/disassembly, by providing a technically and financially effective solution.

In this regard, the following recommendations are made:

- the blade should be attached exclusively to the intermediate ring and should therefore not be attached directly to the outer rings,

- or at least one of said additional ring and second ring should be attached to the connection part without being attached to the blade to which it will, however, be connected by means of the aforementioned connection part.

In the examples shown in the appended drawings:

- figure 1 is a front diagram of a wind turbine according to the invention,

- figure 2 is a side view,

- figure 3 shows the cross-section III-III, along a plane perpendicular to the axes, in this case coincident, of the corresponding rotor hub and the blade,

- figure 4 shows a simplified alternative of figure 3,

- figure 5 shows a diagram, according to the same cross-section, of a solution with three rings and two double series of barrel-shaped roller bearings,

- figure 6 shows a diagram of the three rings alone of figure 5, in a preferred alternative,

- figure 7 shows a diagram of the same rings, according to the arrow VII,

- figures 8, 9 and 10 show, according to the same cross-section, three alternatives with a connection part inserted between the outer rings and the blade, with a support.

Figures 1 and 2 show a wind turbine 1 including a head mast 3 on which three blades 5a, 5b, 5c rotate about the horizontal axis 7a of a central hub 7.

Typically, the hub 7 is itself mounted so as to rotate about a vertical axis 7b with respect to the mast 3, so as to be best oriented with respect to the wind.

Each blade, and in particular blade 5c of figure 2, can pivot several to several dozen degrees about its axis of extension 50c, with respect to the rotor hub 7, so as to be best catch the wind.

5 Figure 3 shows the axis 50c of the blade 5c and the rotor hub 7.

The preferred angular orientation of each blade, such as blade 5c, generates in particular significant radial stresses, as well as high bending moments.

10 The bearing 9 shown in figure 3 includes two series of barrel-shaped roller bearings 11a, 11b, distributed along two rings arranged so as to be parallel to the axis 50c and inserted between an external ring 13 and an internal ring 15.

We use the term "barrel-shaped roller bearing" as it is used as in documents FR-A-2 774 315 or FR-A-2 263 416. It can refer to needle bearings.

The roller bearings have, according to their axis of rotation, respectively 112a, 112b, a length L between their two planar ends that can be greater than their maximum diameter D in the centre, at the apex of their dished external surface. This external bearing surface is typically circular, with a cross-section as shown in figure 3. It can however have a plurality of adjusted radii. The mean radius of this external bearing surface is typically greater than 10, and even 20 times greater than the diameter D.

The external ring 13 is made of a single piece. The internal ring 15 includes at least two parts. These rings 15a, 15b are separated along a junction line 4 located where the ring 15 with the smallest diameter (radially, the internal ring) has a thinned central portion 6a located, parallel to the axis 50c, between a first and a second radial support shoulder 6b, 6c for the roller bearings 11a, 11b.

Correspondingly, the external ring 13 has, between the two levels of these roller bearings, a third intermediate radial shoulder 8a.

To support the barrel-shaped roller bearings, both the third shoulder 8a and the first and second shoulders 6b, 6c each have, in the plane of the cross-section 10 of this figure (which is the same as in the other figures with a cross-section view) concave bearing surfaces, such as 80a, 80b for the third shoulder; see also concave bearing surfaces 60b, 60c for the first and second radial shoulders 6b, 6c.

These concave bearing surfaces of the bearing tracks for the barrel-shaped rollers are toroids or toroidal, or also referred to as "aspherical".

All of these surfaces are complementary with the convex bearing surfaces of the two series 11a, 11b.

They will therefore advantageously define the tracks on the spherical or barrel-shaped bearing surface. In figure 3, as in the other figures showing the cross-section view, the bearing surfaces have a constant curvature in contact with the roller bearings and define, with the latter, sphere portions (see 80a, 80b; 60b, 60c).

The axes of rotation, respectively 112a and 112b, of the two barrel-shaped roller bearings shown in figure 3, which therefore define a permanent slanted rotation orientation of the rollers, with respect to the axis 50c, intersect in the location of the intermediate portion 6a of lower thickness of the internal ring 15, which is favourable for assembly, disassembly and strength under stress, in particular radial, inasmuch as it is the internal ring 15 that consists of a plurality of parts, with the zone of convergence 112c of the two rotation axes being located in the immediate vicinity of the junction surface 4. In this figure, as in the others, the common tilt angle $\underline{i}$ of the rotation axes is in this case

between 15° and 70° with respect to a parallel to the axis 50c, and preferably 20° to 45° .

On either side of the roller bearings, the rings 13, 15 are attached respectively to the rotor hub 7 and to the blade 5c.

The bolts, with or without a head, 27 and 25 respectively, provide the aforementioned attachments, parallel to the axis 50c, at two radial distances different from this axis, in the direction 21.

The threaded clamping rod of each attachment means 27 cooperates with a nut 27a; similarly, for the clamping nut 25a of the attachment means 25, unless the other threaded end 25a is screwed directly into the body of the root of the blade 5c.

Thus, the nuts 25b, 27b are accessible by the hollow interior 31 of the rotor hub 7.

Figure 4 shows a solution that is in principle mechanically less favourable, in which the internal ring 151 consists of a single piece, whereas the external ring 131 consist of two parts 131a, 131b, with the radial separation 131c between the two levels of barrel-shaped roller bearings 11a, 11b of which the rotation axes 110a, 110b now intersect toward the outside, on the side of the ring 13, substantially at the level of said contact surface 131c.

As for the rest, it is essentially the features discussed in relation to figure 3 that are presented.

In figure 5, the bearing includes an external ring 131 consisting of two parts, an internal ring 15 also consisting of two parts and an intermediate ring 19. The three rings are concentric with respect to the axis 50c; see figure 7. In this figure (as also on the following) there is therefore an additional ring compared to the preceding solutions.

For the same reasons as above, with regard to the ring 13 consisting of a plurality of parts, the solution of figure 6 is preferred.

The wind turbine blade 5c has a diameter slightly larger than in the case of figures 3 and 4.

The diameters, with respect to the axis 50c, where said rings are attached, are different from one another; see d12, d13 and d14 of figure 7, where these attachments are shown: in each pitch P, there is, for each ring, an attachment either to the blade or to the hub, with the same diameter. This principle applies to other cases, in particular figure 8 and those following. In figure 7, the roller bearings are not shown.

In figure 5, the intermediate ring 19 is screwed into the root of the blade 5c, whereas the two outer rings 15, 131 are attached directly to the connection portion 51 closely connected to the rotor hub 70, all in this case parallel to the axis of extension 50c of the blade 5c.

This connection portion 51 is integrated, in a single piece, with the rotor hub 70 that it extends, in a cross-section, in the shape of a T of which the stem axially (parallel to the axis 50c) extends the body of the rotor hub and of which the bar receives, on one side 51a, the clamped attachment of the attachment means 27 and, on the other side 51b, the clamped attachment of the attachment bolts 49, which therefore lead on one side into the hollow internal volume 310 of the rotor hub 70 and, at the opposite axial end, opposite the internal volume 500d of the blade 5c of which the internal diameter is slightly greater than that of the blade of figures 3 and 4.

Opposite the attachment means (in this case bolts) 53 with which the intermediate ring 19 is attached in the root of the blade 5c, the connection portion 51 has a concave surface 510. Thus, the clamping head 55 of each threaded rod is housed in a closed chamber.

The barrel-shaped roller bearings are in this case are divided into two series of double roller bearing levels with,

at a first mean diameter d15, two levels 111a, 111b separated axially and, at a second mean diameter d16, two other levels 110a, 110b, axially separated by the same distance.

At each diameter d15 or d16, these barrel-shaped roller bearings have their rotation axes, which intersect in a zone of the outer rings 15, 131, near the intermediate contact surfaces, 4 and 131c respectively.

The solution of figure 6 is preferred in that, in particular, the rotation axes of the same barrel-shaped roller bearings 110a, 110b; 111a, 111b all converge, preferably in groups of two as shown, toward a central zone, in this case at (or near) the intermediate contact surface 190c where the two constituent parts 190a, 190b of the intermediate ring 190 come together, and the radially outer rings 13, 151 then consist of a single piece. This "X"-shaped arrangement of the rotation axes is shown in figures 8 and 10 and can advantageously be seen in figure 9.

In said figure 6, the attachments to the rotor hub and to the blade can be as shown in figure 5; however, it is preferable for them to be produced as in figures 8, 9 or 10.

In figure 6, it is also noted that the external ring 13 farthest from the axis of the blade can radially have a thickness that is greater, such as e1, toward its end 13a closest to the blade (see reference 5c), while toward its end 13b closest to the rotor hub (see reference 7), this thickness would be reduced to e2.

Thus, this ring 13 can have an external peripheral surface 13c with a generator that is not parallel or not continuously parallel to the axis of the blade. The wall 13c slanted with respect to the axis of the blade is shown with dotted lines. It can consist of a step or a shoulder close to the end 130a and increasing the thickness from e2 to e1. This added radial thickness is preferably at least 20 %.

In figures 8, 9 and 10, the constituent parts 190a, 190b of the intermediate ring 190 are attached directly to the rotor hub 7, whereas the external 13 and internal 151 rings, consisting of a single piece, are attached to the rotor blade 5c, by means of a connection part 23.

In a generally parallel direction with respect to the axis 50c, the connection part 23 ensures, in this case with respect to the blade 5c, the direct attachment of said blade of the internal ring 151, via the attachment means 25, whereas the attachment of the external ring 13 to the blade is only indirect, since it is attached to the connection part 23 (and not to the blade), by the attachment means 27. These attachments therefore ensure, via the part 23, at least one passage of stress common to the two rings 13, 151.

Radially (direction 21), the first ring 13 is located beyond the blade. Thus, its axial attachment means 27, in this case bolts, lead outwardly, at two opposite axial ends of the ring, and are in this case easily accessible, either by the clamping head 27a, or by the nut.

The attachment means 25, which are therefore located at a smaller diameter, also each include a threaded rod accessible from its clamping end, which in this case has a nut 25b and which ends opposite the hollow internal volume 31 of the rotor hub 7.

It is noted that this volume 31 communicates axially with the hollow internal volume 500c of the blade shown here, via the internal intermediate volumes successively of the internal ring 151 and the connection part 23 inserted, parallel to the axis 50c, between the rings 13, 151 and the blade with which said part comes into contact.

At its other axial end, the threaded rod 25 is screwed into the body of the blade.

Between these ends, the rod 25, on its non-threaded part, passes through the second ring 151 and the connection part 23.

As regards the attachment means 29 of the first ring 190, they lead, at one end, into the volume 31 (nut 29b) and, at the other end (rod head 29a), into an internal chamber 33 limited radially by the cylindrical external and internal walls, respectively, of the two rings 13, 151 and axially, at one end, by the planar wall of the ring part 190b where the head 29a is supported, and, at the other end, by a concave surface 230 of the connection part 23.

The clamping end of the bolt 29, which leads to 33, is locked in rotation by holding protuberances 35 attached to part 190a or to the connection part 23.

Thus, the ring 190 is attached to the hub 7 and its clamping, in this case parallel to the axis 50c, can take place from the internal volume 31.

In figures 8 to 10, it is also noted that the external peripheral surface 13a of the external ring 13 is held at least radially with respect to the axis 50c by a holding element 231 mechanically connected to the connection part 23, so as to oppose a radial stress F tending to separate at least some of said rings from one another and/or deflect in particular the ring 13, when the blade rotates or, more generally, when the wind turbine is operating.

In this case, the holding portion 231 is closely connected to the connection part 23 with which it is integrated and that it extends as a shoulder on which the peripheral surface 13a is radially supported.

As a possible alternative, it can also be imagined, in a simplified solution, that the rotor hub 7 has a radial protuberance 71 provided with a shoulder 700, coming into radial contact with said external surface 13a, toward its end closest to the hub.

Optionally, this shoulder 700 may even be part of a connection part 800 (dotted lines in figure 8) inserted

between the hub 7 and the ring 190 and through which the means 29 would pass in order to be attached in the hub.

Between the intermediate ring 190 and the outer rings 13, 151, respectively, are the aforementioned series of barrel-shaped roller bearings. Only their receiving sites can be seen.

Given that it is in figure 9 that the blade diameter is smallest, an arrangement has been provided as in figure 5 of the four roller bearings shown, while, otherwise, the more heavy-duty solution of figure 6 is preferred.

In figure 9, the connection part 23, for its connection with the blade, has, opposite the internal volume 150 of the ring 151, a solid portion 233 provided with apertures 41 located at a radial distance from the axis 50c that is smaller than all of the aforementioned distances. These apertures are each passed through by one of a plurality of fourth attachment means 43 attaching, alone, the annular connection part 23 directly to the blade 5c, while the external ring 13 and the second ring 151 are each attached only to this connection part 23, at two different radial distances.

These attachment means 43, in this case, again, screws, end on one side opposite the volume 150 and are screwed on the other side into the root of the blade.

Thus, the stresses passing through the two outer rings 13, 151 will pass into the connection part 23 and be transmitted to the blade 5c by these means 43.

In figure 10, in a version in which the diameter of the blades, and in particular blade 5c, is greater than in figure 8, the attachment to this blade through the connection part 23 is achieved with the external ring 13, replacing the internal ring 151.

For an attachment parallel to the axis 50c, the attachment means 25 and 27 are thus in some way switched.

In the preferred versions of figures 8 to 10, the part 23 and the rings 13, 151 are not threaded.

These solutions with three concentric rings are perfectly suitable for large wind turbines.

Possible applications of all or some of the solutions proposed here can also be envisaged in particular for large
5 cranes. Other applications on large installations, such as tunnel borers or installations with large turrets exposed to significant stress can be envisaged.

TØNDEFORMET LEJE

Krav

- 5 **1.** Pinolleje til en servomotor til et blad til et nav i en rotor i en vindgenerator, hvor bladet danner en akse, og lejet omfatter:
- en første og anden lejering (13, 15, 19, 131, 151, 190), der
10 strækker sig i to forskellige radiale afstande væk fra bladets akse (50c), så de roterer i forhold til hinanden omkring aksen,
 - mindst to rækker rullelejer (11a, 11b, 110a, 110b, 111a,
15 111b) med konvekse leje-flader, der samarbejder med de konkave leje-flader på løbe-fladerne (60b, 60c, 80a, 80b), der rummer disse rullelejer, der er trindelt i to forskellige niveauer i en retning parallelt med aksen (50c), hvis rullelejer for hver række rullelejer, som er arrangeret i et plan aksialt på
20 bladets akse (50c) mellem den første og anden ring,
 - første fastgørelsesmetode (27) for første ring (13, 131) til rotornavet,
 - anden fastgørelsesmetode (25) for anden ring (15, 151) til
25 bladet (5c),
 - mindst én af ringene er opdelt i mindst to dele (15a, 15b, 131a, 131b) lang en overflade, der går på tvær af bladets akse, så rullelejerne kan monteres og/eller fjernes,
- kendetegnet ved, at** de nævnte mindst to rækker af rullelejer
30 er rækker af tøndeformede rullelejer (11a, 11b, 110a, 110b, 111a, 111b), og rotationsakserne (112a, 112b) for mindst to rækker af rullelejer er sammenløbende mellem faserne, hvorved rullelejerne hver har:

- en rotationsakse (112a, 112b...), der er permanent orienteret i en vinkel (i) i forhold til bladets akse (50c),

- og, langs denne rotationsakse, en længde (L) mellem to
5 planender af nævnte rulleleje.

2. Leje i henhold til krav 1, **kendetegnet ved, at** den fælles hældningsvinkel (i) af rotationsakserne af de nævnte rullelejer i forhold til en parallel med bladets akse (50c) er
10 mellem 15° og 70°.

3. Leje i henhold til krav 1 eller 2, **kendetegnet ved, at** de konkave lejeflader af løbefladerne er torusformede, asfæriske.

15 4. Leje i henhold til ét af de foregående krav, **kendetegnet ved, at** de nævnte konkave overflader, der rummer de tøndeformede rullelejer, er torusformede.

5. Leje i henhold til krav 1, **kendetegnet ved, at** , i
20 retninger parallelt med bladets akse:

- opdelingen mellem de to dele (15a, 15b, 131a, 131b) af den relevante skål er placeret mellem de to faser af rækkerne af rullelejer,

25 - skålen (15), fremstillet i mindst to dele, har, på henholdsvis én af disse dele (15a, 15b, 131a, 131b), første og anden radiale fremspring (6b, 6c) til at holde de modsvarende to rækker rullelejer, hvor disse fremspring hver i et
30 tværsnit, der indeholder bladaksen og passerer gennem én af de nævnte rullelejer i hver fase, har en nævnt konkav leje flade (60b, 60c), der virker sammen med nævnte konvekse flade af disse rullelejer, og hvor disse første og andet fremspring forbinder til en tyndere central del (6a), hvor opdelingen (4)

af skålen i to dele befinder sig mellem de to faser af nævnte rækker af rullelejer,

– og den anden ring (13) har, mellem (de) to faser af rækkerne af rullelejer (110a, 110b, 111a, 111b), et tredje mellemliggende radialt fremspring (8a), der i nævnte gennemgående sektion har to nævnte konkave lejeblade (80a, 80b), der virker sammen med den nævnte konvekse flade på disse rullelejer til fuldførelse af fastholdelse af disse.

10

6. Leje i henhold til krav 1 og krav 5, **kendetegnet ved, at** nævnte samtidige rotationsakser krydser i et område på den mindre tykke mellemliggende del (8a) af nævnte ring, der er opdelt i mindst to dele (15a, 15b, 131a, 131b).

15

7. Leje i henhold til ethvert af de foregående krav, **kendetegnet ved, at** én af de første og anden ringe er fastgjort direkte på eller i rotornavet, og den anden er fastgjort direkte på eller i bladet.

20

8. Leje i henhold til ethvert af de foregående krav, **kendetegnet ved, at:**

– radialt på bladets akse (50c) har den anden ring en udvendig diameter, der er mindre end den indvendige diameter af den første ring,

25

– den nævnte anden ring (15) er den, der er opdelt i mindst to dele (15a, 15b),

30

– denne anden ring er fastgjort på bladet (5c) via anden fastgørelsesmetode (25), der passerer gennem de nævnte mindst to dele af ringen,

- den første ring (13) er fastgjort til navnet ved første fastgørelsesmetode (27), der er placeret i en radial afstand fra bladaksen, som er større end den for den nævnte anden fastgørelsesmetode,

5

- og rotationsakserne for de to rækker tøndeformede rullelejer er samløbende mod den anden ring (15).

9. Leje i henhold til ethvert af de foregående krav,

10 **kendetegnet ved, at** det desuden omfatter:

- en yderligere lejering (15, 151; 13, 131), der er placeret radialt på bladaksen inden i eller omkring den første og anden lejering, hvor denne yderligere lejering er fastgjort til

15 motornavet (70),

- og en forbindelsesdel (23), der er placeret mellem rotornavet (70), hvortil denne forbindelsesdel er tilsluttet, og både denne anden ring og den nævnte første ring (13, 131 eller 15, 151) er arrangeret og strækker sig radialt på
20 bladaksen i retning af disse ringe, hvorved nævnte yderligere ring og første ring er fastgjort sammen på denne forbindelsesdel (23).

25 **10. Leje i henhold til krav 9, kendetegnet ved, at:**

- den nævnte første ring (13, 131 or 15, 151) og yderligere ring er fastgjort sammen på den forbindende del (51) vha. henholdsvis første fastgørelsesmetode (27, 49) og tredje

30 fastgørelsesmetode (49, 27), og

- den første og anden fastgørelsesmetode (27, 53) er arrangeret sammen på henholdsvis første og anden ring (13, 131, 19, 190) i en radial afstand i forhold til bladaksen, der

er anderledes end den, der adskiller nævnte tredje fastgørelsesmetode (49, 27) fra denne akse.

11. Leje i henhold til krav 9 eller 10, **kendetegnet ved, at:**

5 - rotornavet (70) har en akse parallelt med bladets,

- og, i en radial sektion parallel med navaksen, definerer nævnte forbindelsesdel (51) en T-formet forlængelse, der er integreret i rotornavet og tværstangen (51a, 51b), hvori
10 fastgørelserne mellem denne forbindende del og på den ene side den første ring (13, 190) og på den anden side den nævnte yderligere lejering (15, 131, 151) optages.

12. Leje i henhold til ethvert af kravene 1 til 8, **kendetegnet ved, at** det desuden omfatter:

- en yderligere lejering (151 eller 13), der er placeret radialt på bladaksen inden i eller omkring den første og anden lejering, hvor denne yderligere lejering er fastgjort til
20 bladet (5c), og

- et forbindelsesstykke (23) placeret mellem bladet og nævnte yderligere ring og anden ring (13, 151) og, strækkende sig i en retning radialt på bladaksen, vendt mod denne yderligere
25 ring og denne anden ring, hvor mindst én af dem er fastgjort til dette forbindelsesstykke (23) uden at være fastgjort til bladet (5c), hvortil det på trods af det er tilsluttet via dette forbindelsesstykke.

30 **13.** Leje i henhold til krav 12, **kendetegnet ved, at** i et plan radialt på bladaksen er nævnte yderligere ring og anden ring (13, 151) og bladet (5c) forbundet med hinanden med en enkelt forbindelse (25, 43), og hvorigennem i det mindste noget af belastningen, der er anvendt på både denne yderligere ring og

den anden ring, passerer, og som derfor ikke er specifik for nogen af disse ringe.

14. Leje i henhold til et af kravene 9 og 12, **kendetegnet ved,**
5 **at** det desuden omfatter et holdeelement eller -del (231, 700),
der er mekanisk forbundet med forbindelsesstykket (23, 800)
eller med rotornavet (7, 70), mens det holdes som minimum
radialt på bladaksen med den ene eller anden, og hvilket i en
retning radialt på bladaksen grænser op til en udvendig
10 perifer flade (13a) på den ene af de nævnte ringe, der er
radialt længst væk fra bladaksen, for at modvirke en radial
kraft, der har tendens til at bevæge i det mindste nogle af de
nævnte ringe fra hinanden og/eller afbøje denne ring (13,
131), der er radialt længst væk fra bladaksen, i takt med at
15 bladet roterer.

15. Leje i henhold til et af kravene 1 til 13, **kendetegnet**
ved, at den ene af de nævnte ringe (13, 131), der radialt
længst væk fra bladaksen har en radial tykkelse (e1), der er
20 større mod dens ende, der er nærmest på bladet, end mod dens
ende, der er nærmest på rotornavet, hvorved denne ring derfor
har en udvendig perifer flade (13c), der har en frembringer,
der ikke er parallel med eller ikke er kontinuerligt parallel
med bladaksen.

25

16. Vindgenerator bestående af mindst ét leje i henhold til
ethvert af de foregående krav, indsat mellem og forbundet med
et blad og et rotornav i denne vindgenerator.

30

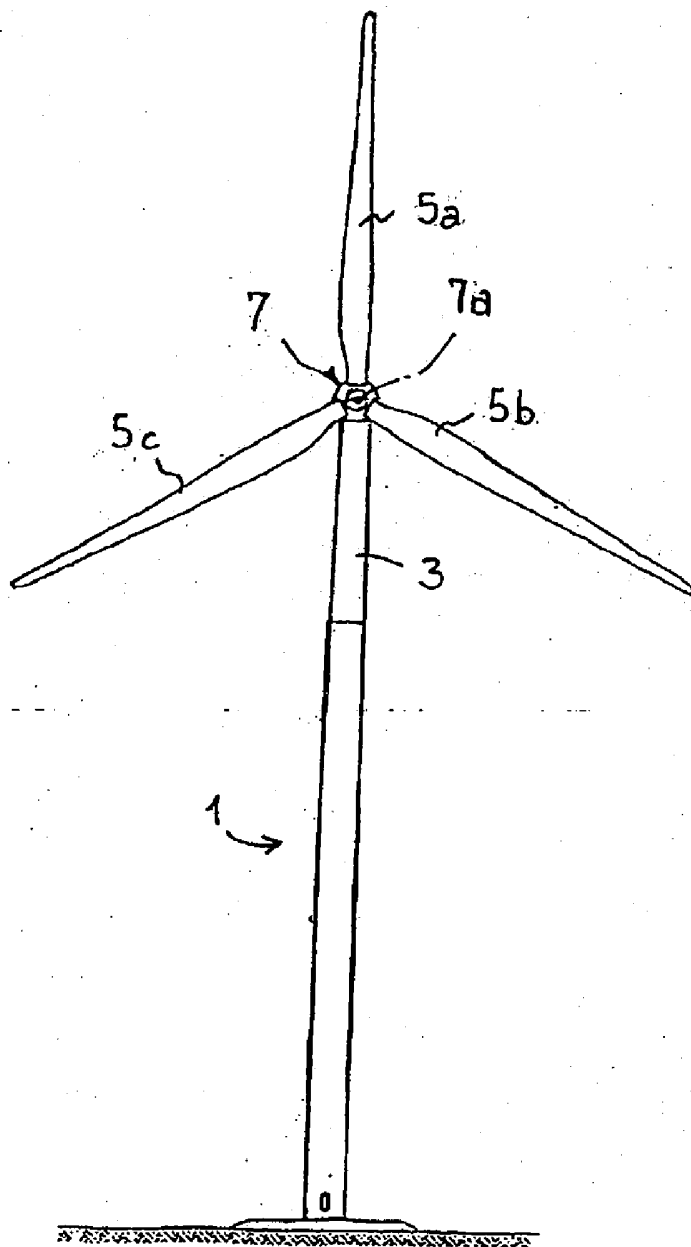


FIG. 1

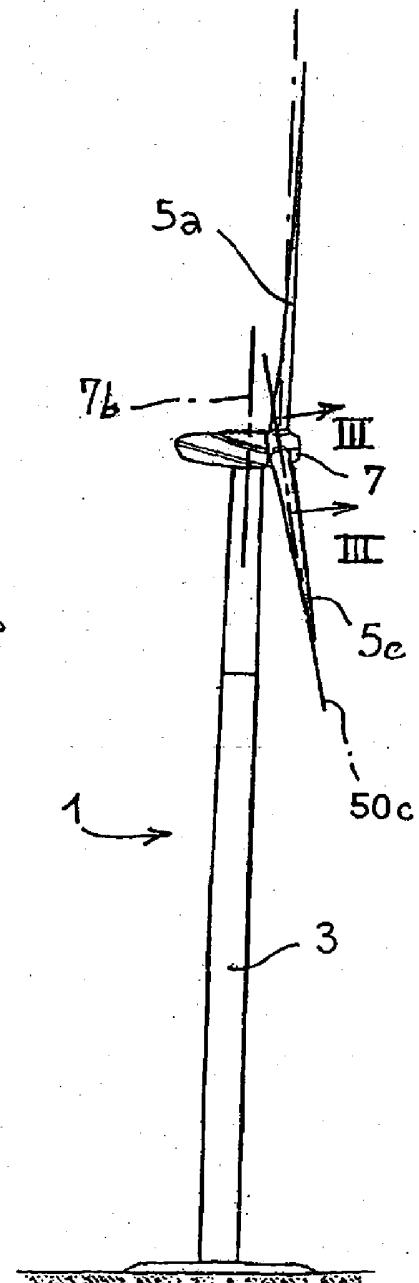
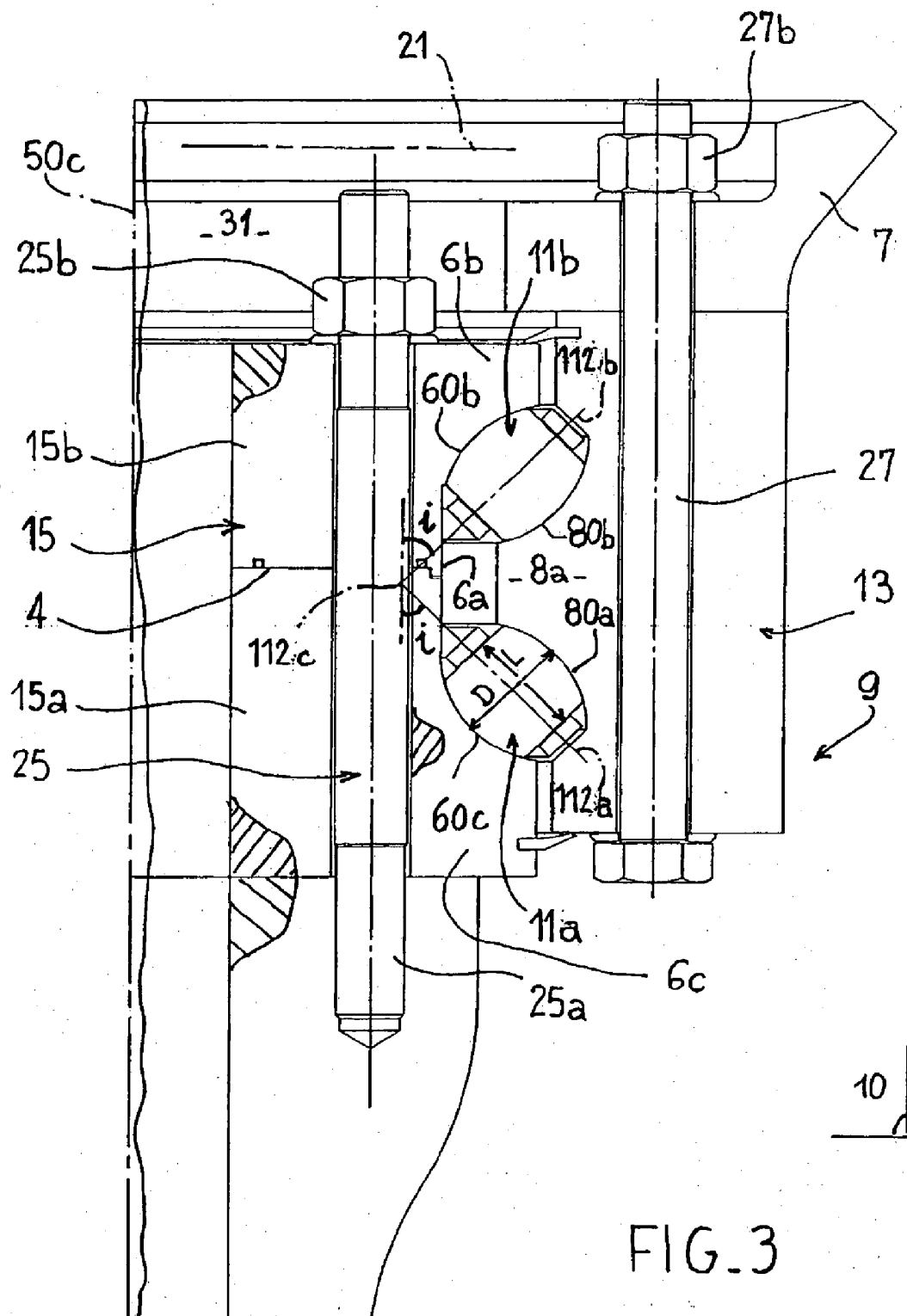
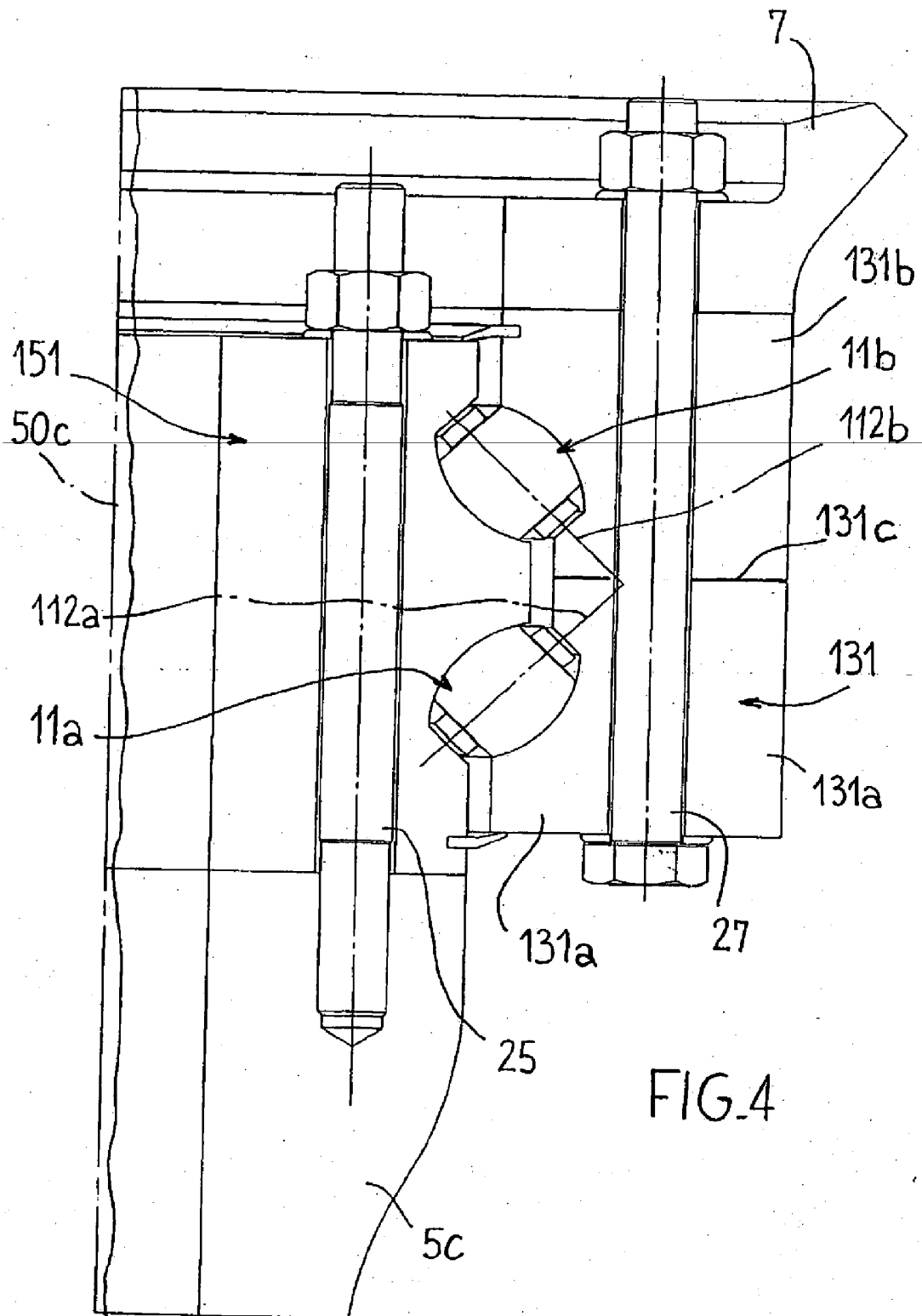


FIG. 2





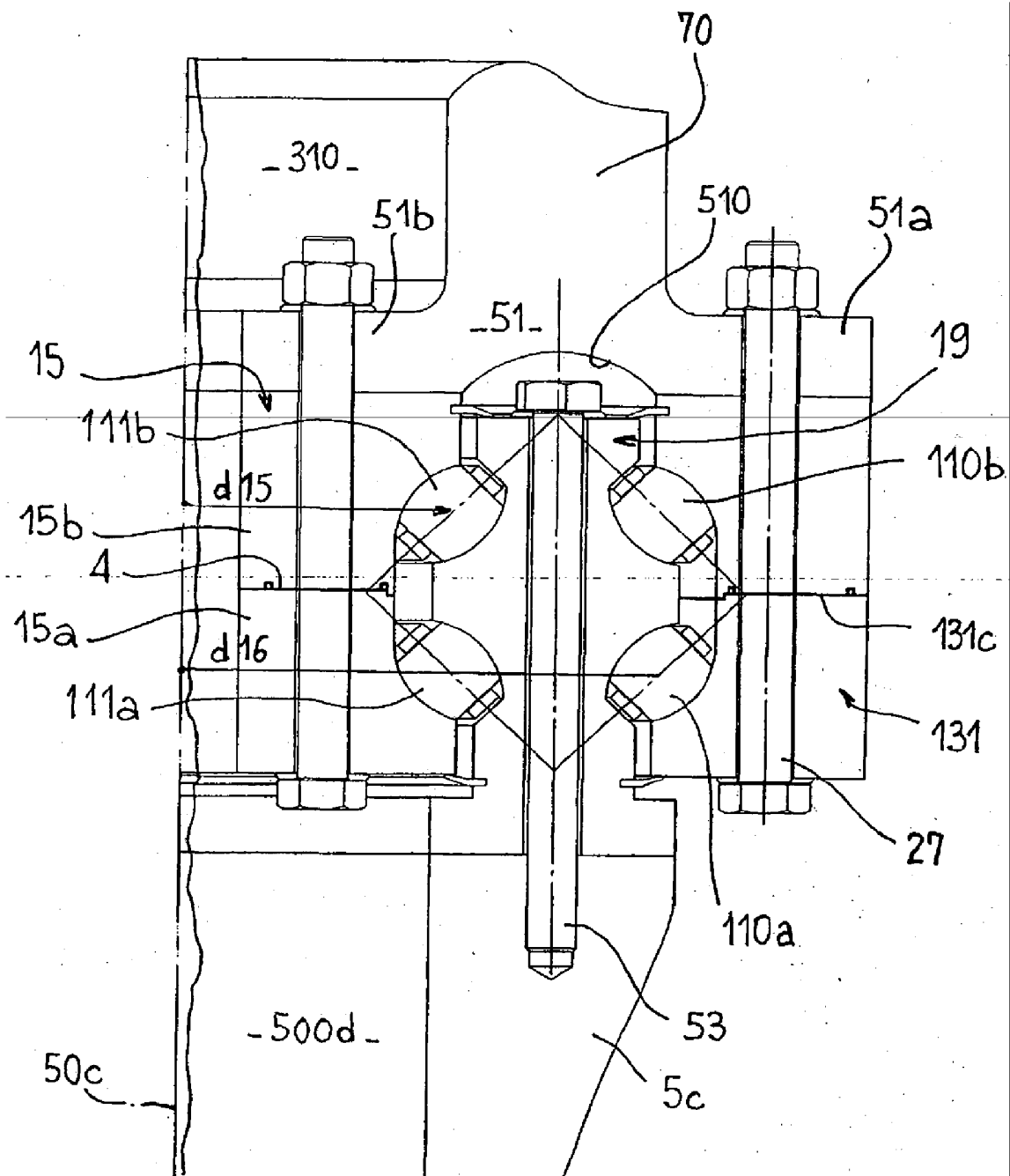


FIG. 5

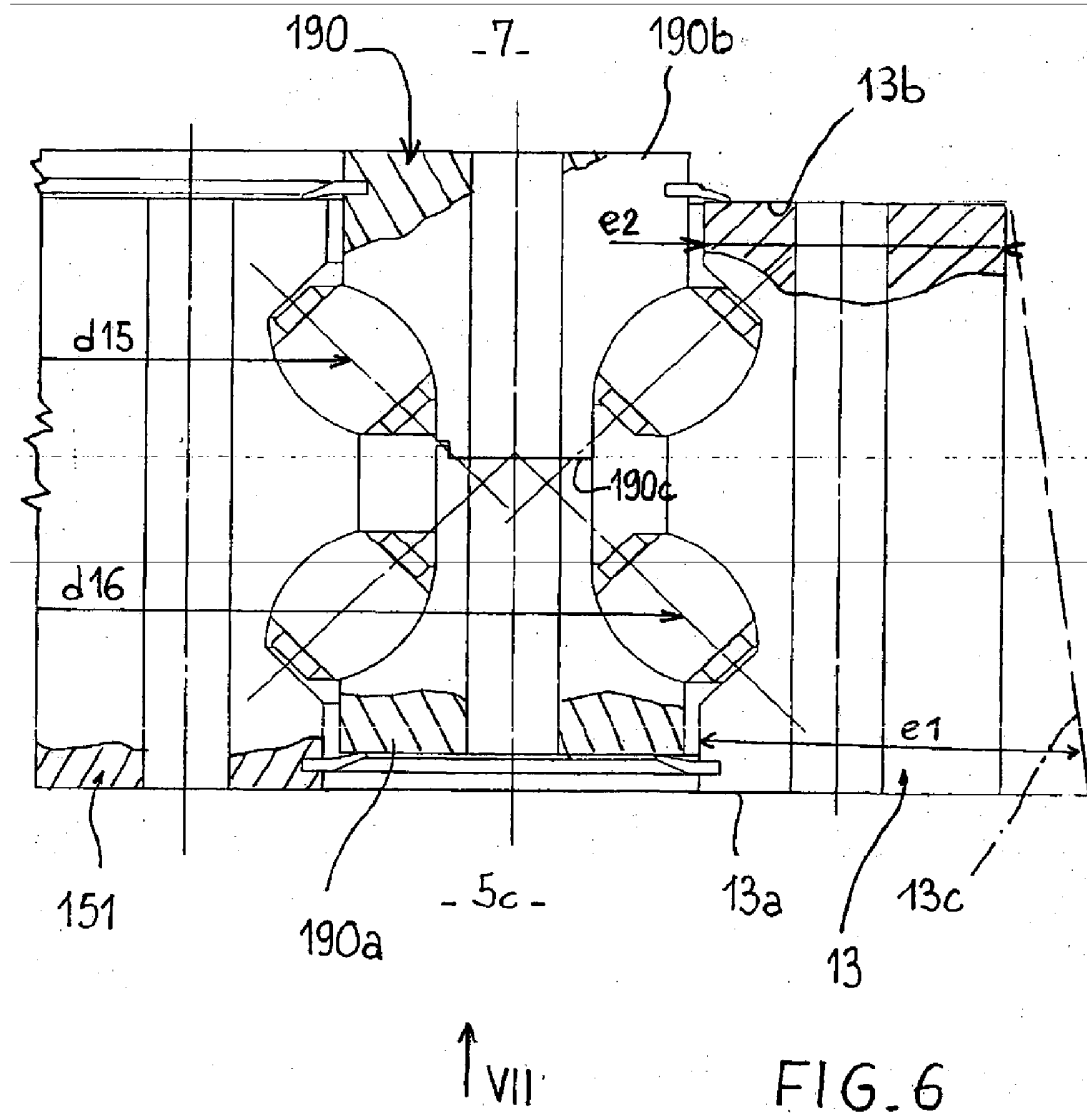


FIG. 7

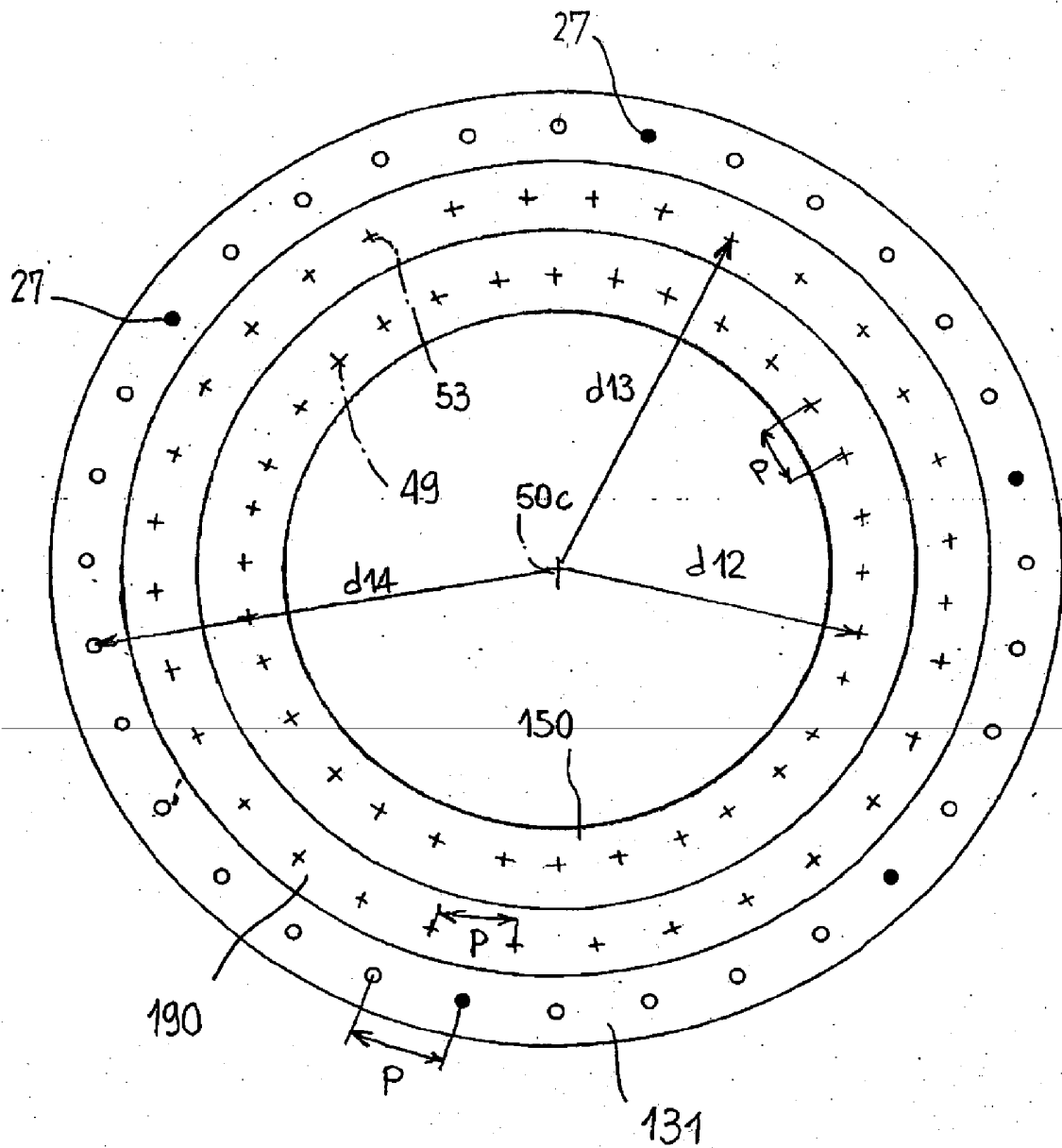
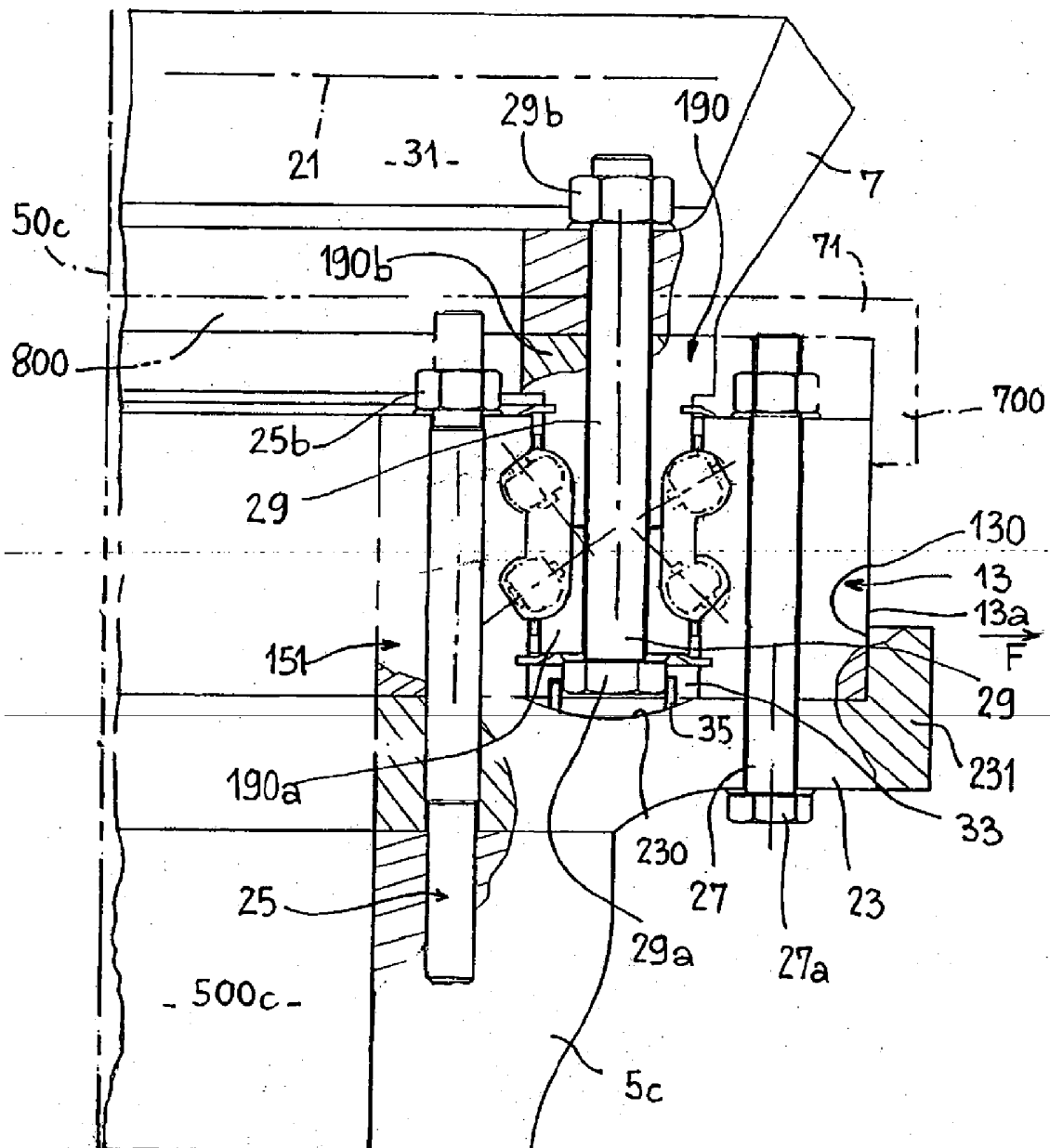


FIG. 8



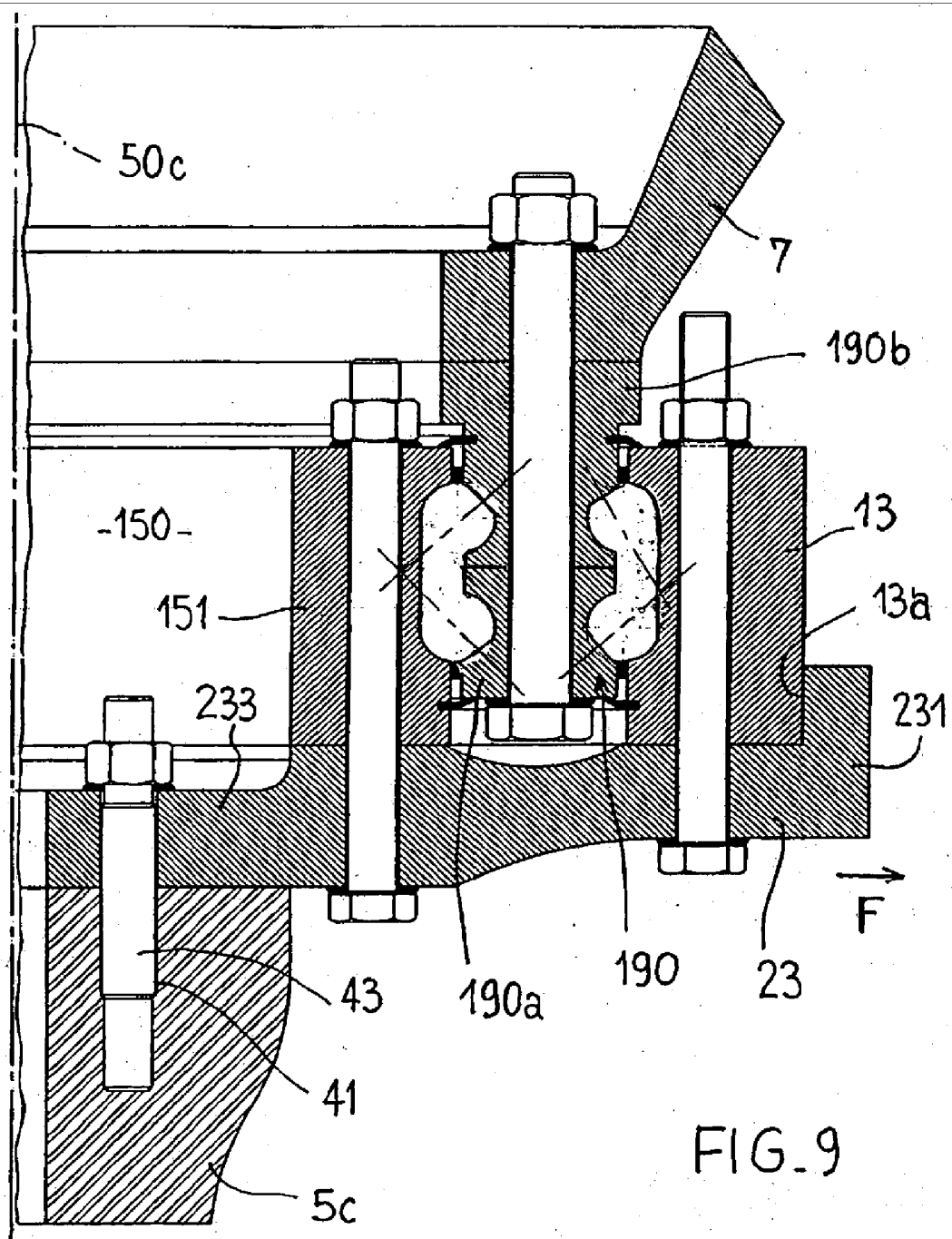


FIG. 10

