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(54) Titre : TOLE SEGMENTEE POUR UN EMPILAGE DE TOLES DE STATOR, EMPILAGE DE TOLES DE STATOR, AINSI QUE GENERATEUR ET EOLIENNE COMPRENANT CES DERNIERS
(54) Title: SEGMENT SHEET FOR A STATOR LAMINATION STACK, STATOR LAMINATION STACK, AND GENERATOR AND WIND TURBINE HAVING SAME

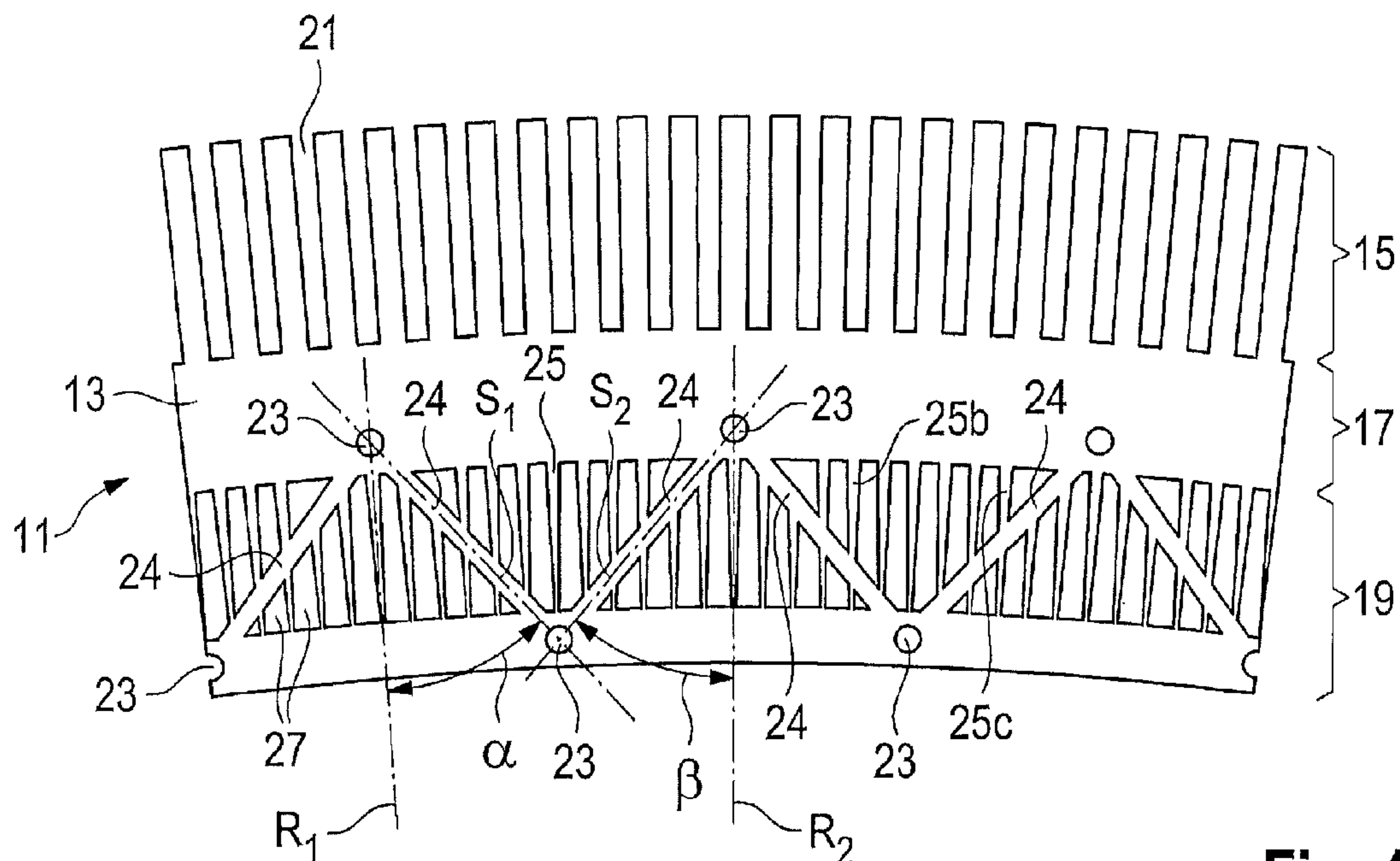


Fig. 4

(57) **Abrégé/Abstract:**

The invention relates to a segment sheet (11) for a stator lamination stack (10) of a generator (1) of a wind turbine (100), comprising a base sheet (13) in the form of a ring segment, wherein the segment sheet (11) has a first radial section (15) in which recesses (21) are provided for receiving a stator winding, and a second radial section (17), radially next to the first radial section (15), which forms a segment of a magnetic yolk of the generator (1). In particular, the segment sheet (11) has a third radial section (19) next to the second radial section (17), which forms a segment of a stator-carrier structure of the generator (1), and which is also configured, in particular, to form the stator-carrier structure of the generator together with the third radial sections of further segment sheets. The invention also relates to a stator lamination stack (10), a generator (1) and a wind turbine (100), each having segment sheets (11) of this type.

Abstract

The invention concerns a segment plate (11) for a stator lamination assembly (10) of a generator (1) of a wind turbine (100), comprising a
5 base plate (13) in the form of a ring segment, wherein the segment plate (11) has a first radial portion (15) in which recesses (21) are provided for receiving a stator winding and radially adjacent to the first radial portion (15) a second radial portion (17) forming a segment of a magnetic yoke of the generator (1). In particular adjacent to the second radial portion (17)
10 the segment plate (11) has a third radial portion (19) forming a segment of a stator carrier structure of the generator (1) and which in particular is adapted in conjunction with the third radial portions of further segment plates to form the stator carrier structure of the generator. The invention further concerns a stator lamination assembly (10), a generator (1) and a
15 wind turbine (100), each having such segment plates (11).

(Figure 4)

Segment sheet for a stator lamination stack, stator lamination stack, and generator and wind turbine having same

5 The invention concerns a segment plate for a stator lamination assembly of a generator of a wind turbine, comprising a base plate in the form of a ring segment, wherein the segment plate has a first radial portion in which recesses are provided for receiving a stator winding and radially adjacent to the first radial portion a second radial portion forming a
10 segment of a magnetic yoke of the generator. The invention further concerns a stator lamination assembly of a generator of a wind turbine, as well as a generator of a wind turbine, and a wind turbine.

 Wind turbines are generally known. They are used to convert energy in the wind into electric power by means of an electric generator. A core
15 component for that task is the generator in wind turbines. The generator has a generator stator and a generator rotor which rotates relative thereto, also referred to as the "rotor member". The invention concerns both wind turbines and generators have internal rotor members and also external rotor members, which is used to mean that, in the case of an internal rotor
20 member, the generator rotor rotates internally in an annular stator while in the case of an external rotor member the generator rotor rotates externally around the stator.

 The generator stator has a stator winding in which an electric voltage is induced by means of the rotating generator rotor. The stator winding is
25 accommodated in grooves provided in turn in the stator, for example in a stator ring.

 It is generally known for the component which accommodates the stator winding to be formed from one or more stator lamination assemblies. Those stator lamination assemblies are formed by segment plate which are
30 fitted together to constitute rings and are stacked one upon the other to form the lamination stack assembly.

 In that respect in the state of the art the mechanical instability of the individual plates could be only partially compensated by the plates being stacked to form stack assemblies and joined together. Hitherto to support

the stator lamination assemblies a support structure always had to be provided on the stator, generally a welded or cast unit which stiffens the stator lamination assemblies.

That circumstance necessitates a certain depth of manufacture on
5 the part of the wind turbine manufacturer, as well as comparatively high costs and a high level of manufacturing complication and expenditure. That was considered to be in need of improvement.

On the priority application from which priority is claimed for the present application the German Patent and Trade Mark Office searched the
10 following state of the art: DE 10 2008 063 783 A1 and EP 2 424 077 A2.

Consequently the object of the invention was to overcome the disadvantages previously encountered in the state of the art to the best possible extent. In particular the object of the invention was to find a possible way of reducing the manufacturing costs and complexity and
15 expenditure for wind turbines without compromising the mechanical integrity of the generator stator of the wind turbine.

The object of the invention is attained in that the invention proposes a second plate having the features of claim 1. In particular the invention proposes that adjacent to the second radial portion the segment plate has a
20 third radial portion forming a segment of a stator carrier structure of the generator. In particular the third radial portion is therefore adapted in conjunction with the third radial portions of further segment plates to form the stator carrier structure of the generator. In that respect the invention adopts the approach of making an additional external structure redundant
25 by providing that the stator lamination assemblies which are formed from the segment plates are self-supporting, that is to say do not require any external attachment components for ensuring mechanical integrity. For that purpose the segment plate is radially enlarged adjacent to the region which is to provide the magnetic yoke and it has a carrier structure which
30 enhances the stability of a plate ring formed from its segment plates.

An advantageous development of the segment plate of the present invention in regard to the stator carrier structure provides that in the third

radial portion are a plurality of reinforcing struts, wherein the reinforcing struts are adapted to carry compressive, tensile and shearing forces.

Further preferably provided in the third radial portion are a plurality of through openings which are adapted for the passage of corresponding
5 bracing elements. The through openings are preferably arranged along two or more mutually spaced circular arc lines, wherein the arc lines are preferably formed concentrically. Particularly preferably in an embodiment having a first arc line and a second arc line the through openings on a first arc line are arranged displaced in the peripheral direction relative to the
10 through openings on a second arc line. Further preferably the through openings are arranged in equidistantly spaced relationship on their respective arc lines. That arrangement has the following advantage: the segment plates can be stacked one upon the other in overlapping relationship so that the "seam locations" between the segment plates
15 adjoining each other in a ring plane are displaced relative to each other. At the same time the equidistant, in particular two-row or multi-row arrangement of the through openings, permits axial bracing of the overlapping segment plates. The friction adhesion produced thereby between the plates significantly enhances the load-carrying capacity of the
20 stator lamination assemblies and contributes to an improved damping characteristic in respect of acoustic vibrations which are emitted in operation of the wind turbine.

The bracing elements are adapted to fixedly connect stacked segment plates together. Preferably the bracing elements are in the form
25 of threaded rods, screws, tensioning cables or the like. Preferably, in the bracing context, arranged on the bracing elements at the ends are pressure distribution elements which are adapted to distribute the tensioning forces to the largest possible surface area of the segment plates. The pressure distribution elements are for example in the form of discs, rings, ring
30 segments, sleeves or the like. Further preferably arranged in the third radial portion are a plurality of material weakenings or recesses disposed between the reinforcing struts. The material weakenings or recesses preferably afford the effect of a reduction in weight.

Particularly preferably the reinforcing struts in the third radial portion are formed from the same thickness of material as the base plate in the first and/or second radial portion. The structure of the reinforcing struts is preferably obtained by means of laser cutting, water jet cutting, embossing
5 or – particularly preferably – stamping.

Particularly preferably the recesses in the first radial portion, the through openings and the reinforcing struts in the third radial portion are respectively formed by means of stamping of the base plate, wherein, in the case of the reinforcing struts, material regions adjacent to the struts to
10 be formed are embossed or stamped out.

In a preferred configuration of the segment plate the reinforcing struts have a plurality of first struts which are non-radially oriented. In that respect the term non-radially is used to mean that the segment plate is curved about a central axis and the first struts respectively define an
15 angle of >0 degree with a radius extending through the central axis. Preferably the first struts are respectively oriented non-radially with alternate angles and form a lattice-like structure.

Further preferably the reinforcing struts have a plurality of second struts which are oriented radially. In that respect the radial orientation is
20 with respect to the central axis of the segment plate.

In a particularly preferred embodiment respectively adjacent first struts are oriented in angular relationship with each other, and the through openings are respectively arranged at the point of intersection of the directions in which two adjacent first struts respectively extend. In other
25 words the through openings are disposed at the origin of the angle between adjacent first struts.

In a further preferred embodiment the second struts are of a tapered configuration in the direction of the central axis or in the direction of the radially inward side of the segment plate.

30 Preferably the first and second struts are such that at least some of the first and second struts open into each other or cross each other. That provides a mesh-like carrier structure which links low weight with high mechanical load-bearing capacity.

In particular in those embodiments in which recesses are provided between the struts the struts act at the same time as cooling ribs and the recesses as cooling passages. That provides for improved heat dissipation from the grooves accommodating the stator winding, in the direction of the machine carrier.

The invention has been described hereinbefore with reference to the segment plate. In a further aspect however the invention also concerns a stator lamination assembly for a generator of a wind turbine. The object of the invention is attained in relation to such a stator lamination assembly insofar as it has the features of claim 10. The invention proposes that the stator lamination assembly has a multiplicity of segment plate, wherein a plurality of segment plates are arranged at each other in a plane in such a way that they jointly form a plate ring, and a plurality of segment plates are stacked in the plate rings formed in such a way that they jointly form the stator lamination assembly, wherein the stator lamination assembly has a first radial portion in which there are provided a multiplicity of grooves for receiving a stator winding, wherein the grooves are formed by recesses provided in the segment plates, and adjacent to the first radial portion have a second radial portion forming a magnetic yoke of the generator. Adjacent to the second radial portion the stator lamination assembly has a third radial portion forming a stator carrier structure of the generator.

A further development of the invention provides that the segment plates are in accordance with one of the above-described preferred embodiments.

After the invention has been described hereinbefore with further reference to the stator lamination assembly a generator according to the invention is described in detail hereinafter.

The generator according to the present invention attains the object set forth in the opening part of this specification, insofar as it has the features of claim 12.

The invention therefore proposes a generator of a wind turbine, in particular a slowly rotating synchronous ring generator, which has a generator stator, a generator rotor mounted rotatably relative to the

generator stator, and a machine carrier for fixing the generator stator to the wind turbine, wherein the generator stator has at least one stator lamination assembly in which there are provided a multiplicity of grooves in which the stator winding is received. The generator stator has at least one
5 stator lamination assembly which is in accordance with one of the above-described preferred embodiments and correspondingly includes segment plates according to the invention. In accordance with the invention the term slowly rotating generator is used to denote a generator having a nominal rotary speed of 50 revolutions per minute or less.

10 Finally in a further aspect the invention concerns a wind turbine, in particular a gear-less wind turbine, comprising a pylon, a pod arranged rotatably on the pylon, a machine carrier arranged at the pod, a hub mounted rotatably on the pod and having a number of rotor blades, in particular three rotor blades, and a generator for producing electric power
15 which has a generator rotor connected to the hub and a generator stator connected to the machine carrier.

The wind turbine according to the invention attains the object of the invention by the generator being designed in accordance with one of the above-described preferred embodiments.

20 The generator is preferably alternatively in the form of an internal rotor generator or an external rotor generator. If the generator is an internal rotor generator the first radial portion of the stator lamination assembly or the stator plate represents the radially inward ring region while the third radial portion represents the radially outer ring portion. In the
25 case of an external rotor generator the situation is precisely the reverse.

The invention is described in greater detail hereinafter by means a preferred embodiment with reference to the accompanying Figures in which:

Figure 1 shows a diagrammatic perspective view of a wind turbine,
30 Figure 2 shows a partly sectioned diagrammatic view of a pod of the wind turbine of Figure 1,

Figure 3 shows a view on an enlarged scale of part of the view of Figure 2, and

Figure 4 shows a diagrammatic plan view of a segment plate for a stator lamination assembly of a generator of a wind turbine as shown in Figures 1 to 3.

Figure 1 shows a wind turbine 100 comprising a pylon 102 and a pod 104. Arranged at the pod 104 is a rotor 106 having three rotor blades 108 and a spinner 110. The rotor 106 is caused to rotate in operation by the wind and thereby drives a generator 1 (Figure 2) in the pod 104.

The pod 104 is shown in section in Figure 2. The pod 104 is mounted rotatably to the pylon 102 and is connected in driving relationship by means of an azimuth drive 112 in generally known manner. Arranged in the pod 104 also in generally known manner is a machine carrier 110 carrying a journal 114.

The generator 1 has a generator stator 5 fixed by means of the journal 114 to the machine carrier 110 in the pod 104. Other possible configurations which are not excluded by the invention provide for example that the generator stator 5 is joined directly to the machine carrier 110 or a corresponding component of the pod 104.

The generator 1 shown in Figure 2 has a generator rotor 3 which is designed in the form of an external rotor member. Alternative possible configurations which are not excluded from the invention also provide for example a generator rotor in the form of an internal rotor member.

The generator rotor 3 is non-rotatably connected to the hub 106. Closer details of the structure of the generator stator 5 are shown in Figure 3. The generator 5 has a stator ring 9. The generator rotor 3 runs outside the stator ring 9, spaced therefrom by an annular gap. The stator ring 9 is fixed to a stator mounting by means of two support rings 7. The stator mounting is in turn screwed to the journal 114. Other possible fixing arrangements for securing the stator 5 to the machine carrier are also within the scope of the invention.

The support rings 7 are comparatively thin-gauge plates which leave the load-carrying capability and mechanical stiffness of the stator ring 9 substantially uninfluenced. Instead the stator ring 9 is of a self-supporting nature.

The stator ring 9 is formed from a multiplicity of segment plates 11 which are fitted against each other to constitute plate rings 12 and are stacked one upon the other in such a way that at least one stator lamination assembly 10 is formed.

5 The structure of a segment plate according to the invention is shown in Figure 4.

The segment plate 11 shown in Figure 4 has a base plate 13. The segment plate 11 is of a configuration in the form of a ring segment, that is to say it is of a circular arcuate configuration curved around a central axis 10 (not shown). The segment plate 11, shown in Figure 4 in the form of a segment plate for an external rotor member, has a first radial portion 15 in which there are a multiplicity of recesses 21. The recesses 21 are adapted to receive the stator winding.

Adjacent to the first radial portion 15 the segment plate 11 has a 15 second radial portion 17 forming a segment of the magnetic yoke of the generator stator 5 (Figures 1 to 3).

The magnetic yoke is also referred to as a magnetic return member. Adjacent to the second radial portion 17 the structure of the segment plate 11 is enlarged by a third radial portion 19. The third radial portion 19 has 20 a multiplicity of through openings 23 for the passage of bracing means, like for example threaded rods, screws, tensioning cables and the like.

Arranged in the third radial portion 19 are a multiplicity of reinforcing struts 24, 25 which stiffen the segment plate 11 and are adapted, in the assembled condition, to stiffen the stator lamination assembly and the 25 stator ring 9 in order to make it capable of carry a load in itself. The reinforcing struts 24, 25 have a multiplicity of first struts 24 which are non-radially oriented. The first struts 24 respectively define an angle α β with the radii R_1 , R_2 . The angle α can be of the same value as the angle β .

Unlike the first struts 24 the second struts 25 are oriented radially. 30 Preferably the second struts 25 extend in a tapered configuration in the direction of the central axis (not shown). Among the first struts 25 there are at least some struts 25b which open into at least one first strut 24, and some struts 25c which respectively cross at least one first strut 24.

In a particularly preferred configuration the struts 24, 25 are formed by stamping out a plurality of recesses 27 from the base plate 13. Preferably both the recesses 21 and also the through openings 23 and the recesses 27 are produced from the base plate 13 by means of stamping.

5 The through openings 23 are preferably disposed at the origin of the angles α , β of the first struts 24 or are in alignment with the intersection points of the directions in which two respectively adjacent first struts 24 extend.

10 While the configuration shown in Figures 1 to 4 is explicitly directed to a generator 1 having an external rotor it is to be appreciated that in the spirit of the invention generators with an internal rotor are at any event also embraced, in which the same basic principles as described hereinbefore with reference to the external rotor also apply. The first radial
15 portion 15 having the recesses 21 for receiving the stator winding is then however arranged not radially outwardly but radially inwardly on the segment plate 11. A corresponding configuration applies for the second and third radial portions.

CLAIMS

1. A segment plate (11) for a stator lamination assembly (10) of a
5 generator (1) of a wind turbine (100), comprising
a base plate (13) in the form of a ring segment, wherein the
segment plate (11) has a first radial portion (15) in which recesses (21) are
provided for receiving a stator winding and radially adjacent to the first
radial portion (15) a second radial portion (17) forming a segment of a
10 magnetic yoke of the generator (1),
characterised in that adjacent to the second radial portion (17) the
segment plate (11) has a third radial portion (19) forming a segment of a
stator carrier structure of the generator (1).
- 15 2. A segment plate (11) according to claim 1
wherein provided in the third radial portion (19) are a plurality of
reinforcing struts (24, 25), wherein the reinforcing struts (19) are adapted
to carry compressive, tensile and shearing forces.
- 20 3. A segment plate (11) according to claim 1 or claim 2
wherein provided in the third radial portion (19) are a plurality of
through openings (23) which are adapted for the passage of corresponding
bracing elements.
- 25 4. A segment plate (11) according to one of the preceding claims
wherein a plurality of material weakenings or recesses (27) are
arranged in the third radial portion (19) between the reinforcing struts (24,
25).
- 30 5. A segment plate (11) according to one of claims 2 to 4
wherein the reinforcing struts have a plurality of first struts (24)
which are non-radially oriented.
6. A segment plate (11) according to one of claims 2 to 5

wherein the reinforcing struts have a plurality of second struts (25) which are radially oriented.

7. A segment plate (11) according to claim 5 or claim 6
5 wherein respectively adjacent first struts (24) are oriented in angular relationship with each other, and

wherein the through openings (23) are respectively arranged at the point of intersection of the direction in which two adjacent first struts (24) respectively extend.

10

8. A segment plate (11) according to claim 6 or claim 7
wherein the second struts (25) are of a tapered configuration in the direction of the radially inward side of the segment plate (11).

15

9. A segment plate (11) according to one of claims 6 to 8
wherein at least some of the first and second struts (24, 25) open into each other (25b) or cross each other (25c).

10. A stator lamination assembly (10) for a generator (1) of a wind
20 turbine (100) comprising a multiplicity of segment plate (11), wherein

a plurality of segment plates (11) are arranged at each other in a plane in such a way that they jointly form a plate ring, and

a plurality of segment plates (11) are stacked in the plate rings formed in such a way that they jointly form the stator lamination assembly

25

(10),

wherein the stator lamination assembly (10) has a first radial portion (15) in which there are provided a multiplicity of grooves for receiving a stator winding, wherein the grooves are formed by recesses (21) provided in the segment plates (11), and

30

adjacent to the first radial portion (15) have a second radial portion (17) forming a magnetic yoke of the generator (1),

12

characterised in that adjacent to the second radial portion (17) the stator lamination assembly (10) has a third radial portion (19) forming a stator carrier structure of the generator (1).

5 11. A stator lamination assembly according to claim 10
 wherein the segment plates (11) are in accordance with one of
 claims 1 to 9.

 12. A generator (1) of a wind turbine (100), in particular a slowly
10 rotating synchronous ring generator, comprising
 a generator stator (5) and a generator rotor (3) mounted rotatably
 relative to the generator stator (5),
 wherein the generator stator (5) has at least one stator lamination
 assembly (10) in which there are provided a multiplicity of grooves in which
15 the stator winding is received,
 characterised in that the generator stator has at least one stator
 lamination assembly according to claim 10 or claim 11.

 13. A wind turbine (100), in particular a gear-less wind turbine,
20 comprising
 a pylon (102),
 a pod (104) arranged rotatably on the pylon,
 a hub (106) mounted rotatably to the pod and having a number of
 rotor blades (108), and a generator (1) for providing electric power, which
25 has a generator rotor (3) connected to the hub and a generator stator (5)
 connected to the pod,
 characterised in that the generator is in accordance with claim 12.

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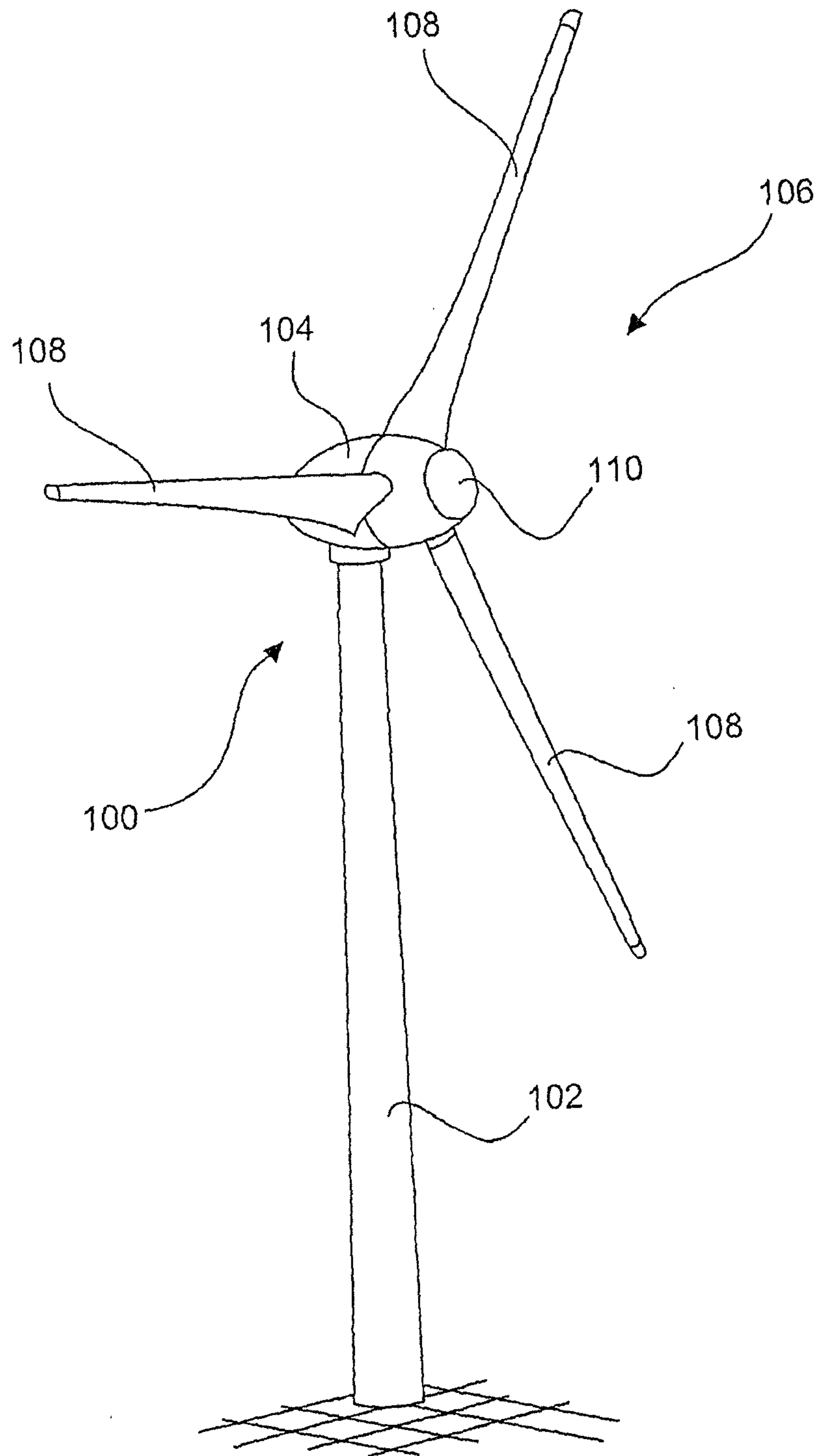


Fig. 1

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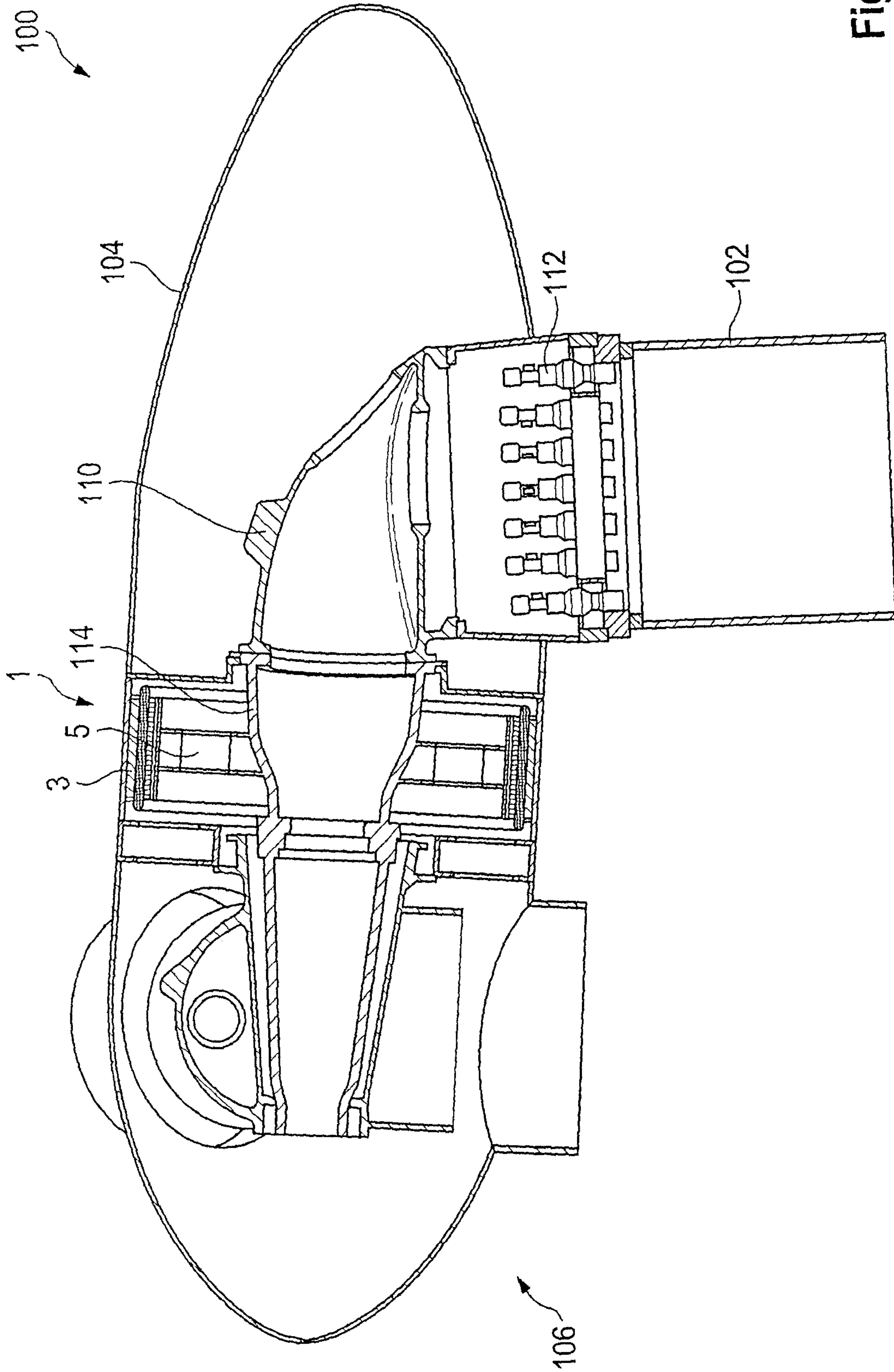


Fig. 2

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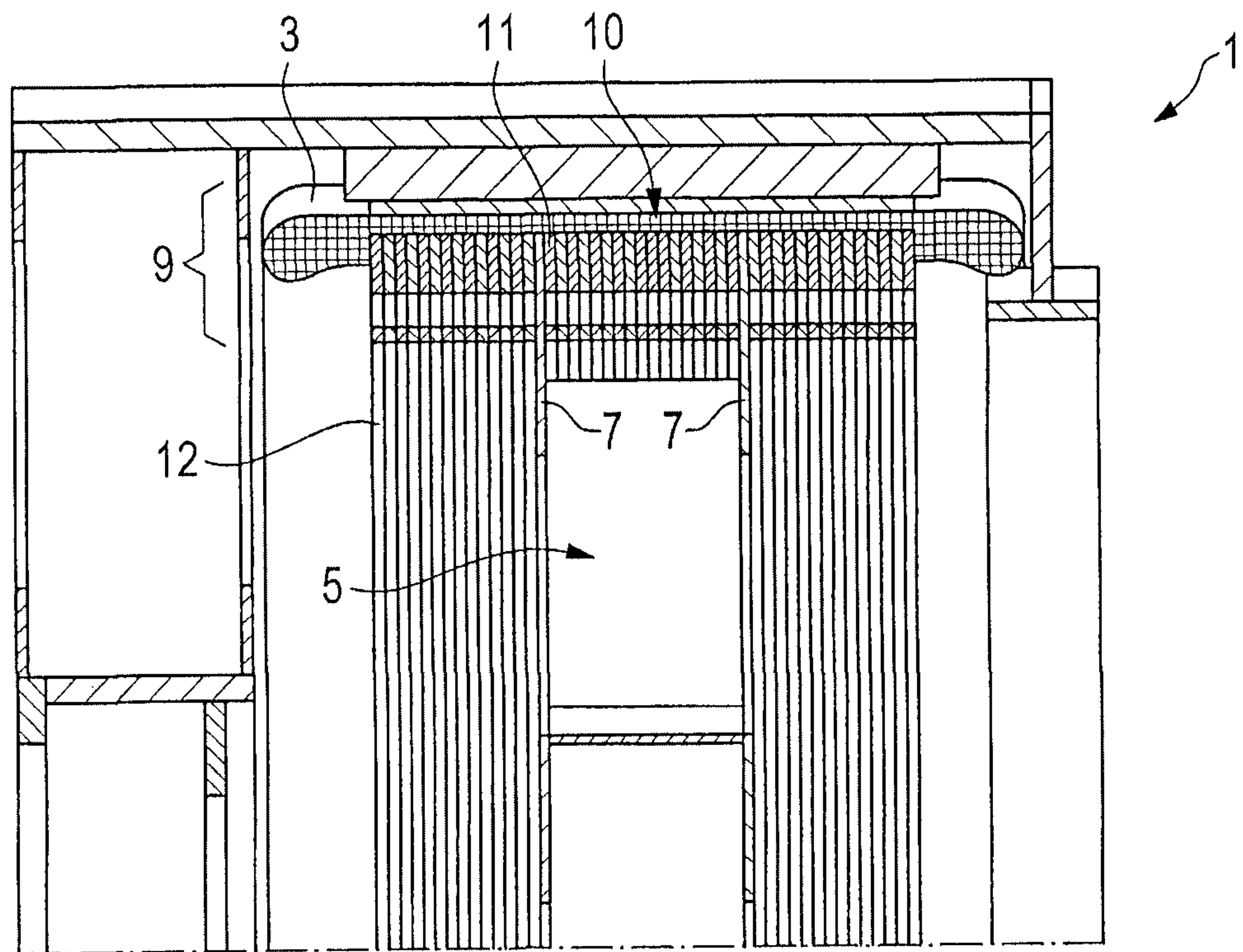


Fig. 3

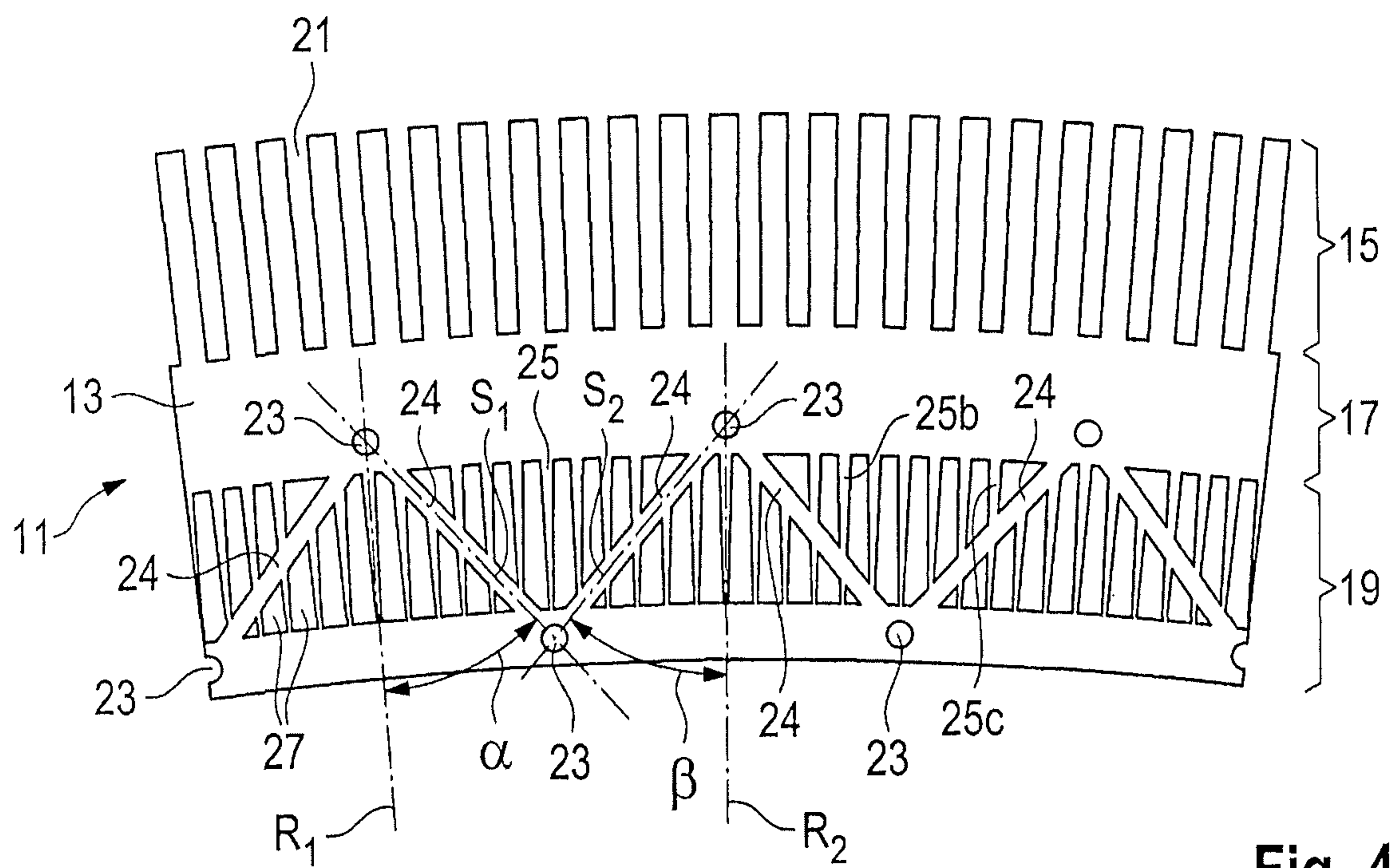


Fig. 4

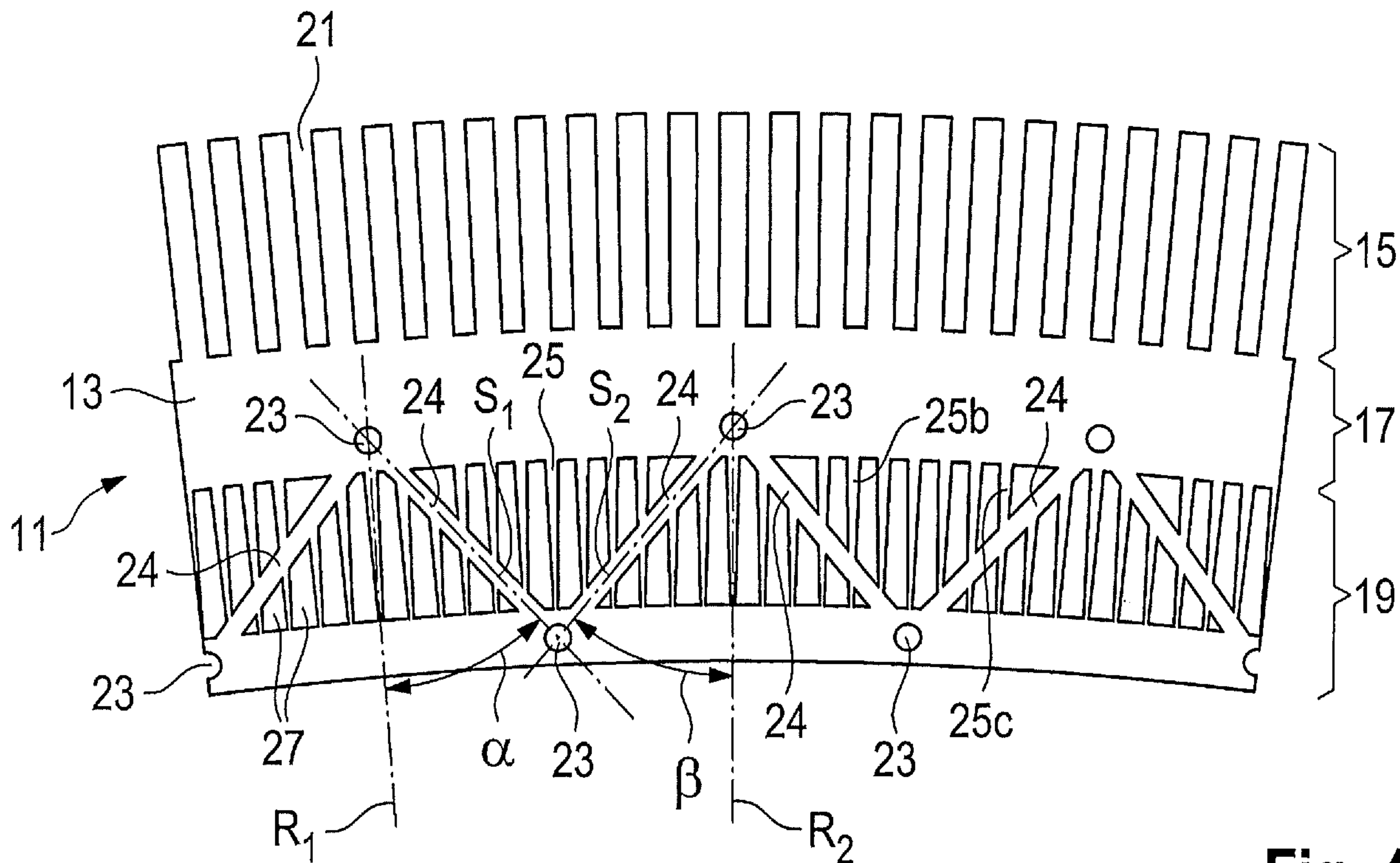


Fig. 4