(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 075 962 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.10.2016 Bulletin 2016/40

(21) Application number: **15162406.1**

(22) Date of filing: **02.04.2015**

(51) Int Cl.:
F01D 9/04 *(2006.01)* ***F01D 17/16*** *(2006.01)*
F01D 25/28 *(2006.01)* ***F01D 17/14*** *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

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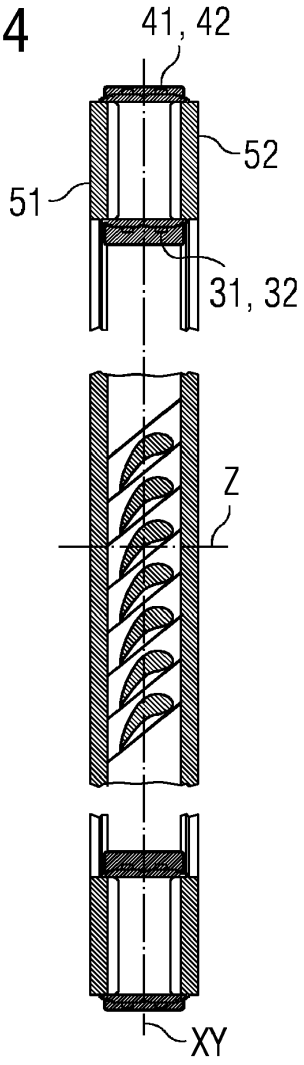
(54) METHOD FOR MANUFACTURING AN ADAPTIVE STAGE FOR A TURBINE

(57) A method for manufacturing an adaptive stage (10) for a turbine comprises the steps of:
- manufacturing a plurality of blades (20), each blade including a pressure side (23) and a suction side (24) extending from a leading edge (25) to a trailing edge (26),
- fixing each blade (20) to an inner blade ring (31, 32) and an outer blade ring (41, 42), in order that the leading edge (25) and the trailing edge (26) extend from one to the other of the inner blade ring (31, 32) and the outer blade ring (41, 42),
- fixing a first cover ring (51) and a second cover ring (52) between the inner blade ring (31, 32) and the outer blade ring (41, 42), the inner blade ring (31, 32) and the outer blade ring (41, 42) being interposed between the first cover ring (51) and the second cover ring (52).

FIG 4



EP 3 075 962 A1

Description

Field of invention

[0001] The present invention relates to a method for manufacturing an adaptive stage for a turbine, in particular a steam turbine.

Art Background

[0002] An adaptive stage, also known as grid valve, is a throttling device installed on the stationary part of industrial steam turbines for controlling the extraction pressure. The main advantage of such a device with respect to other throttling devices resides in its short axial length, thus reducing the axial span of the complete turbine and therefore reducing the overall costs.

[0003] According to the known prior art, an adaptive stage typically comprises a swivel ring, which is rotatable around an axis with respect to an integral collar.

The swivel ring comprises a plurality of leading portions of a respective plurality of guide blades. The leading portions radially extend from a first inner blade ring to a first outer blade ring and comprise respective leading edges.

The integral collar comprises a plurality of trailing portions of a respective plurality of guide blades. The trailing portions of the guide blades radially extend from a second inner blade ring to a second outer blade ring and comprise respective trailing edges.

The relative rotation of the swivel ring with respect to the integral collar moves the leading portions and trailing portions between an open position where they are aligned to constitute the blades and a close position where the leading portions are interposed between the trailing portions to close the passages between the blades.

[0004] A plurality of intermediate positions is possible between the open position and the close position. Each intermediate position is characterised by a respective offset between the leading portions and trailing portions of the blades. By controlling such offset it is possible regulate the extraction pressure of the steam turbine including the adaptive stage.

[0005] To produce the adaptive stage above described, the swivel ring and the integral collar are typically manufactured separately and then assembled. This may have a negative impact on the accuracy of the coupling between final assembled components. For example, in the close position, an offset may still exist between the leading portions and the trailing portions, thus making impossible to fully close the adaptive stage.

[0006] Therefore, there may be the need for a manufacturing method providing a better coupling between components in the final adaptive stage, in order to provide also a more precise control of the extraction pressure.

[0007] In addition, there may be the need for less expensive manufacturing method than the one above described.

Summary of the Invention

[0008] It may be an object of the present invention to provide a method for manufacturing an adaptive stage for a turbine, in particular a steam turbine, in order to achieve, with respect to the prior art, an improved level of accuracy in the coupling between rotary and stationary components.

[0009] It may be a further object of the present invention to provide a cost effective method for manufacturing an adaptive stage for a turbine, in particular a steam turbine.

[0010] In order to achieve the objects defined above, a method for manufacturing an adaptive stage for a turbine is provided in accordance to the independent claim. The dependent claims describe advantageous developments and modifications of the invention.

[0011] According to the present invention, a method for manufacturing an adaptive stage for a turbine includes a rotatable swivel ring and a stationary integral collar, the method comprising the steps of:

- manufacturing a plurality of blades, each blade including a pressure side and a suction side extending from a leading edge to a trailing edge,
- fixing each blade to an inner blade ring and an outer blade ring, in order that the leading edge and the trailing edge extend from one to the other of the inner blade ring and the outer blade ring,
- fixing a first cover ring and a second cover ring between the inner blade ring and the outer blade ring, the inner blade ring and the outer blade ring being interposed between the first cover ring and the second cover ring. Advantageously, this allows creating an assembly which can to better handled and manipulated for further processing, for example for further machining.

[0012] According to a possible embodiment of the present invention, the inner blade ring and the outer blade ring are coaxial and the first cover ring and the second cover ring are orthogonal to a common axis of the inner blade ring and the outer blade ring. Advantageously, this allows having a semifinished product having the same shape of the final adaptive stage.

[0013] According to another possible embodiment of the present invention, the method further includes the step of machining the inner blade ring and/or the outer blade ring, for creating respective coupling surfaces. Advantageously, this permits to machine the inner and outer surfaces of the inner and outer blade rings of the swivel ring and the integral collar in a same operation, thus helping in achieving a better coupling accuracy in the final adaptive stage.

[0014] According to another possible embodiment of the present invention, the method further includes the step of cutting the assembly of blades, the inner blade ring, outer blade ring, first cover ring and second cover

ring along a plane intermediate between the first cover ring and second cover ring, in order to:

- separate each blade into a leading portion including the leading edge and a trailing portion including the trailing edge,
- separate the inner blade ring into a first inner blade ring and a second inner blade ring,
- separate the outer blade ring into a first outer blade ring and a second outer blade ring, the leading portions extending between the first inner blade ring and the first outer blade ring and the trailing portions extending between the second inner blade ring and the second outer blade ring.

The cutting of the blades after they have been fixed to the inner and outer blade rings assures the desired level of accuracy in the coupling between rotary and stationary components, i.e., in particular between leading portions and trailing portions of the blades. This is achieved in by means of a simple and cost-effective manufacturing procedure.

The step of cutting may be performed through Electro Discharge Machining.

[0015] According to a further possible embodiment of the present invention, the method also including the steps of:

- attaching a first inner coupling ring to first inner blade ring and a first outer coupling ring to first outer blade ring,
- attaching a second inner coupling ring to second inner blade ring and a second outer coupling ring to second outer blade ring.

[0016] More particularly, each of the coupling rings may comprise two respective circular portions joined together.

[0017] The coupling rings may be efficiently used for coupling together the swivel ring and the integral collar, in such a way that the swivel ring can rotate with respect to the integral collar. This will allow the relative rotation of the leading portions with respect to the trailing portions is permitted, and, as a result, the control of the extraction pressure of the turbine.

[0018] According to another possible embodiment of the present invention, the method includes the steps of removing the first cover ring and the second cover ring, from the inner blade rings and the outer blade rings. In particular, this operation may be performed immediately before the swivel ring and the integral collar are coupled together. The removal of the cover rings will assure the operability of the adaptive stage, without affecting accuracy or precision.

The step of removing the first cover ring and the second cover ring may be performed through Electro Discharge Machining.

Brief Description of the Drawings

[0019] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 is a circumferential sectional partial view of an adaptive stage for a steam turbine, manufactured according to the method of the present invention,

Fig. 2 is a circumferential sectional partial view of the adaptive stage of Fig. 1, in a second operative condition,

Fig. 3 is a circumferential sectional partial view of the adaptive stage of Figs. 1 and 2, in a third operative condition,

Fig. 4 shows a longitudinal sectional view of a semifinished product obtained with the method of the present invention,

Fig. 5 shows a cross sectional view of the semifinished product figure 4, sectioned according to the plane XY of figure 4,

Fig. 6 is a longitudinal sectional view of a second semifinished product, obtained after with the method of the present invention,

Fig. 7 is a magnified view of the detail VII of Fig. 6,

Fig. 8 is a longitudinal sectional view of the integral collar of an adaptive stage for a steam turbine, during a manufacturing step according to the method of the present invention,

Fig. 9 is a front view of the component figure 8,

Fig. 10 is a longitudinal sectional view of the swivel ring of an adaptive stage for a steam turbine, during a manufacturing step according to the method of the present invention,

Fig. 11 is a front view of the component figure 10,

Fig. 12 is a longitudinal sectional view of an adaptive stage for a steam turbine, manufactured according to the method of the present invention,

Fig. 13 is a front view of the adaptive stage for a steam turbine of figure 12.

Detailed Description

[0020] With reference to attached figures, an adaptive stage 10 for a steam turbine is shown. The adaptive stage 10 has the overall shape of a ring having an axis Z and radially extending between an inner diameter D1 and an outer diameter D2. The term radial refers to a direction orthogonal to the axis of the adaptive stage 10.

[0021] The adaptive stage 10 is mounted on the stationary part of a steam turbine (not shown) to regulate the extraction pressure of the steam turbine.

[0022] The adaptive stage 10 comprises a first ring 11 and a second ring 12, axially adjacent to each other and both coaxial with respect to the axis Z of the adaptive stage 10. The first ring 11, also referred to as swivel ring 11, is rotatable around the axis Z, while the second ring 12, also referred to as integral collar 12 is stationary.

The swivel ring 11 comprises a plurality of leading portions 21 of a respective plurality of guide blades 20. The leading portions 21 of the guide blades 20 radially extend radially from a first inner blade ring 31 to a first outer blade ring 41 and comprise respective leading edges 25.

The integral collar 12 comprises a plurality of trailing portions 22 of a respective plurality of guide blades 20. The trailing portions 22 of the guide blades 20 radially extend from a second inner blade ring 32 to a second outer blade ring 42 and comprise respective trailing edges 26.

The first inner blade ring 31 has the same radial dimension of the second inner blade ring 32. The first outer blade ring 41 has the same radial dimension of the second outer blade ring 42.

[0023] Figures 1, 2 and 3 represents three circumferential partial sections taken along a circumferential surface comprised between the inner blade rings 31, 32 and the outer blade rings 41, 42. In each of the partial view of Figures 1, 2 and 3 only two blades 20 of the adaptive stage 10 are shown.

In a first open position (Figure 1), the relative position of the swivel ring 11 and integral collar 12 permits to align the respective leading portion 21 and trailing portion 22 of each blade 20 in such a way that the external surfaces of the leading portion 21 and trailing portion 22 constitute two continuous pressure and suction sides 23, 24, continuously extending from the leading edge 25 to the trailing edge 26.

A plurality of passages 30 are interposed between the blades 20 in such a way that each passage 30 is delimited by the suction and pressure sides 23, 24 of two consecutive blades 20, the inner blade rings 31, 32 and the outer blade rings 41, 42.

In a second intermediate position (Figure 2), the swivel ring 11 is rotated around the axis Z of the adaptive stage 10 (rotation is represented by the arrow R in Figures 2 and 3), in order to determine a discontinuity in the pressure and suction sides 23, 24 of each blade 20 and partially obstruct each passage 30. By controlling the offset between the leading portions 21 and trailing portions 22 of the blades 20 it is possible regulate the extraction pressure of the steam turbine including the adaptive stage 10.

In a final close position (Figure 3), the rotation R of the swivel ring 11 with respect to the integral collar 12 brings each leading portion 21 between two consecutive trailing portions 22, in such a way that the passages 30 are closed.

[0024] The swivel ring 11 and the integral collar 12 can be manufactured and assembled in the adaptive stage 10, according to the steps of the method of the present invention, as described in the following with reference to the attached figure 4 to 13.

[0025] The method comprises a first step during which:

- the plurality of blades 20 are manufactured. Each blade 20 is identical to the others and includes a respective pressure side 23 and suction side 24, both extending from the leading edge 25 to the trailing edge 26. This means that in the blade 20 manufactured in the first step of the manufacturing method both the leading portions 21 and trailing portions 22 are joined together in a single piece (i.e. the blade 20). In such a way the continuity along the pressure side 23 and the suction side 24 is assured,
- each blade 20 is then fixed to an inner blade ring 31, 32 and an outer blade ring 41, 42, in order that the leading edge 25 and the trailing edge 26 extend radially from one to the other of the inner blade ring 31, 32 and the outer blade ring 41, 42. The inner blade ring 31, 32 and the outer blade ring 41, 42 are coaxial, having in common the axis Z. The blades 20 are regularly distributed around the axis Z, in order to form identical passages 30, interposed between the blades 20. The inner blade ring 31, 32 is a semifinished component, from which both the first inner blade ring 31 and the second inner blade ring 32 are derived, in a further step of the present method. The outer blade ring 41, 42 is a semifinished component from which both the first outer blade ring 41 and the second outer blade ring 42 are derived, in a further step of the present method,
- at opposite axial positions of the semifinished assembly constituted by the plurality of blades 20, the inner blade ring 31, 32 and the outer blade ring 41, 42, it is then fixed a first cover ring 51 and a second cover ring 52, respectively. In the embodiment of the attached figures 4-13, the first cover ring 51 and the second cover ring 52 are both planar and orthogonal to the axis Z, i.e. both extend radially between the inner blade ring 31, 32 and the outer blade ring 41, 42. The inner blade ring 31, 32 and the outer blade ring 41, 42 are therefore interposed between the first cover ring 51 and the second cover ring 52, and extend axially between them.

The first cover ring 51 and the second cover ring 52 are fixed to the inner blade ring 31, 32 and the outer blade ring 41, 42 by welding. According to other embodiments, other fixing processes may be used instead of welding.

At the end of the first step of the method, a first semifinished product 91 (figure 4 and 5), which is an assembly including the blades 20, the inner blade ring 31, 32, the outer blade ring 41, 42, the first cover ring 51 and the second cover ring 52 is obtained. The presence of the first cover ring 51 and the second cover ring 52 permits to better handle and manipulate the first semifinished product 91 in the following steps of the method.

[0026] The method further includes a second step of machining the inner blade ring 31, 32 and the outer blade ring 41, 42, for creating respective coupling surfaces 31a, 32a, 41a, 42a, to which further components of the adaptive stage 10 will be connected, in further step of the present method. To perform the above connection, the inner blade ring 31, 32 comprises two inner bosses 20a and the outer blade ring 41, 42 comprises two outer bosses 20b. At the end of the first step of the method, a second semifinished product 92 (figure 6 and 7) is obtained. The second semifinished product 92 differs from the first semifinished product 91 for comprising also the inner coupling surfaces 31a, 32a on the radially internal side of the inner blade ring 31, 32 and outer coupling surfaces 41a, 42a on the radially external side of the outer blade ring 41, 42. According to other embodiments of the present invention, only the inner coupling surfaces 31a, 32a or the outer coupling surfaces 41a, 42a may be formed in this second step of the method.

[0027] The method further includes a third step of cutting the second semifinished product 92 along a plane XY orthogonal to the axis Z and intermediate between the first cover ring 51 and second cover ring 52. According to different embodiments of the present invention, the cutting of the third step of the present method may be performed through Electro Discharge Machining (EDM) or other convenient cutting method.
Such cutting permits to:

- separate each blade 20 into the leading portion 21 including the leading edge 25 and the trailing portion 22 including the trailing edge 26,
- separate the inner blade ring 31, 32 into the first inner blade ring 31 and the second inner blade ring 32,
- separate the outer blade ring 41, 42 into the first outer blade ring 41 and the second outer blade ring 42.

According to the different embodiment of the present invention, the order of the second and of the third step is inverted, i.e the cutting along the plane XY is performed before the inner coupling surfaces 31a, 32a or the outer coupling surfaces 41a, 42a or all of them are machined.

[0028] The method further includes a fourth step of:

- attaching a first inner coupling ring 61 to the first inner blade ring 31, coupled with one of the inner bosses 20a, and a first outer coupling ring 71 to the first outer blade ring 41, coupled with one of the outer bosses 20b. Each of the first inner and outer coupling rings 61, 71 comprises two respective circular portions 61a, 61b, and 71a, 72b, respectively, joined together by means, for example, of a removable screwed connection. Other types of connections may be envisaged, for example welding. Each of the circular portions 61a, 61b, 71a, and 71b extends angularly for 180° around the axis Z. According to other embodiments of the present invention, at least one of the first inner and outer coupling rings 61, 71 comprises more than two respective circular portions,
- attaching a second inner coupling ring 62 to the second inner blade ring 32, coupled with the other of the inner bosses 20b, and a second outer coupling ring 72 to the second outer blade ring 42, coupled with the other of the outer bosses 20b. Each of the second inner and outer coupling rings 62, 72 comprises two respective circular portions 62a, 62b, and 72a, 72b, respectively, joined together by means, for example, of a removable screwed connection. Other types of connections may be envisaged, for example welding. Each of the circular portions 62a, 62b, 72a, and 72b extends angularly for 180° around the axis Z. According to other embodiments of the present invention, at least one of the first inner and outer coupling rings 62, 72 comprises more than two respective circular portions.

[0029] The method further includes a fifth step of removing the first cover ring 51 and the second cover ring 52, from the inner blade rings 31, 32 and the outer blade rings 41, 42. The removing step of the fifth step of the method may be performed by cutting through Electro Discharge Machining (EDM). According to other embodiments, other removing processes may be used instead of Electro Discharge Machining. At the end of the fifth step of the method, the integral collar 12 (figures 8 and 9) and the swivel ring 11 (figures 10 and 11) are obtained.

[0030] The method further includes a sixth step of coupling together the first inner coupling ring 61 with the second inner coupling ring 62 and/or the first outer coupling ring 71 with the second outer coupling ring 72, in order to permit the rotation of the swivel ring 11 with respect to the integral collar 12 and, in particular, the rotation of the leading portions 21 with respect to the trailing portions 22. According to a different embodiment of the present invention the trailing portions 22 of each blade 20 are on the swivel ring 11 and the leading portions 21 are on the integral collar 12, i.e. the trailing portions 22 rotates with respect to the leading portions 21 for regulating the extraction pressure of the turbine.
In the embodiment of the attached figure 13, the first outer coupling ring 71 is provided with a plurality of circular slots 94 along is peripheral border. Each slot is coupled to a pin 95, which is fixed toe second outer coupling ring 72. The sliding of each slot 94 with respect to the respective pin 95 guides the rotation of the swivel ring 11 with respect to the integral collar 12. The rotation is controlled by means of a lever 96, fixed to the first outer coupling ring 71 and actuated by means of an actuator (not

shown).
At the end of the sixth step of the method, the final adaptive stage 10 is obtained.

Claims

1. A method for manufacturing an adaptive stage (10) for a turbine including a rotatable swivel ring (11) and a stationary integral collar (12), the method comprising the steps of:

   - manufacturing a plurality of blades (20), each blade including a pressure side (23) and a suction side (24) extending from a leading edge (25) to a trailing edge (26),
   - fixing each blade (20) to an inner blade ring (31, 32) and an outer blade ring (41, 42), in order that the leading edge (25) and the trailing edge (26) extend from one to the other of the inner blade ring (31, 32) and the outer blade ring (41, 42),
   - fixing a first cover ring (51) and a second cover ring (52) between the inner blade ring (31, 32) and the outer blade ring (41, 42), the inner blade ring (31, 32) and the outer blade ring (41, 42) being interposed between the first cover ring (51) and the second cover ring (52).

2. The method according to claim 1, wherein the inner blade ring (31, 32) and the outer blade ring (41, 42) are coaxial and the first cover ring (51) and the second cover ring (52) are orthogonal to a common axis (Z) of the inner blade ring (31, 32) and the outer blade ring (41, 42).

3. The method according to claim 1 or 2, further including the step of machining the inner blade ring (31, 32) and/or the outer blade ring (41, 42), for creating respective coupling surfaces (31a, 32a, 41a, 42a).

4. The method according to any of the preceding claims, further including the step of cutting the assembly of blades (20), the inner blade ring (31, 32), outer blade ring (41, 42), first cover ring (51) and second cover ring (52) along a plane intermediate between the first cover ring (51) and second cover ring (52), in order to:

   - separate each blade (20) into a leading portion (21) including the leading edge (25) and a trailing portion (22) including the trailing edge (26),
   - separate the inner blade ring (31, 32) into a first inner blade ring (31) and a second inner blade ring (32),
   - separate the outer blade ring (41, 42) into a first outer blade ring (41) and a second outer blade ring (42), the leading portions (21) extending between the first inner blade ring (31) and the first outer blade ring (41) and the trailing portions (22) extending between the second inner blade ring (41) and the second outer blade ring (42).

5. The method according to claim 4, wherein the step of cutting is performed through Electro Discharge Machining (EDM).

6. The method according to claim 4 or 5, further including the steps of:

   - attaching a first inner coupling ring (61) to the first inner blade ring (31) and a first outer coupling ring (71) to the first outer blade ring (41),
   - attaching a second inner coupling ring (62) to the second inner blade ring (32) and a second outer coupling ring (72) to the second outer blade ring (42).

7. The method according to claim 6, wherein each of the coupling rings (61, 62, 71, 72) comprises two respective circular portions (61a, 62a, 71a, 72a; 61b, 62b, 71b, 72b) joined together.

8. The method according to any of the claims 4 to 7, further including the steps of removing the first cover ring (51) and the second cover ring (52), from the inner blade rings (31, 32) and the outer blade rings (41, 42).

9. The method according to claim 8, wherein the steps of removing the first cover ring (51) and the second cover ring (52) are performed through Electro Discharge Machining (EDM).

10. The method according to claim 8 or 9, including the further step of coupling together the first inner coupling ring (61) with the second inner coupling ring (62) and /or the first outer coupling ring (71) with the second outer coupling ring (72), in order to permit a relative rotation of the leading portions (21) with respect to the trailing portions (22).

FIG 1

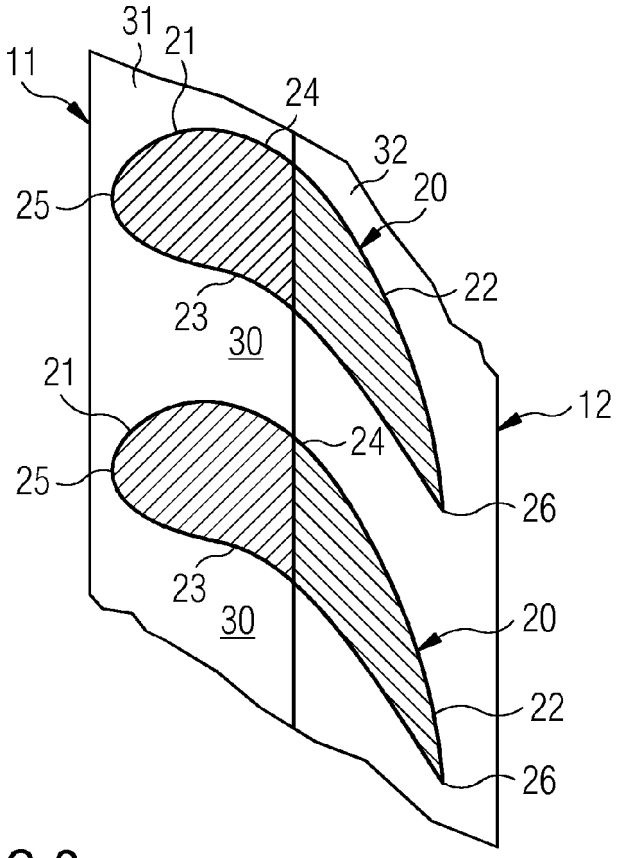

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FIG 2

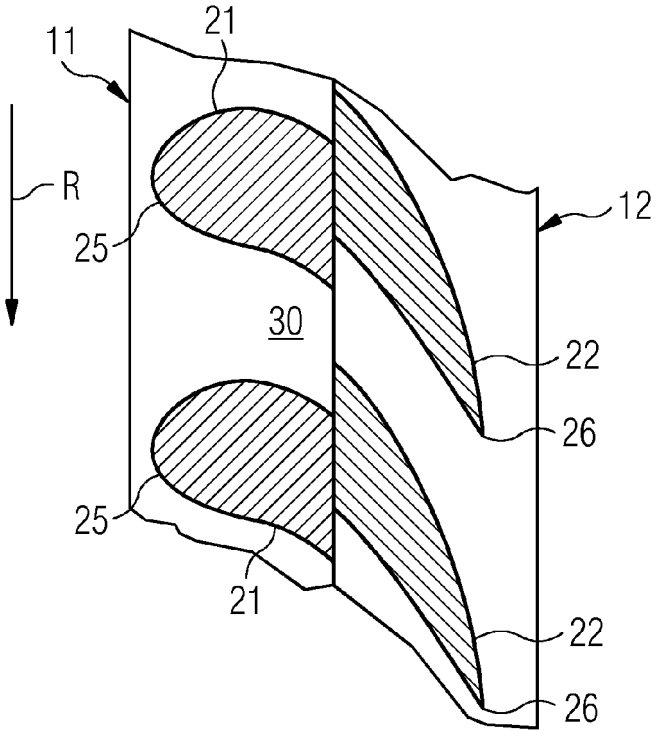
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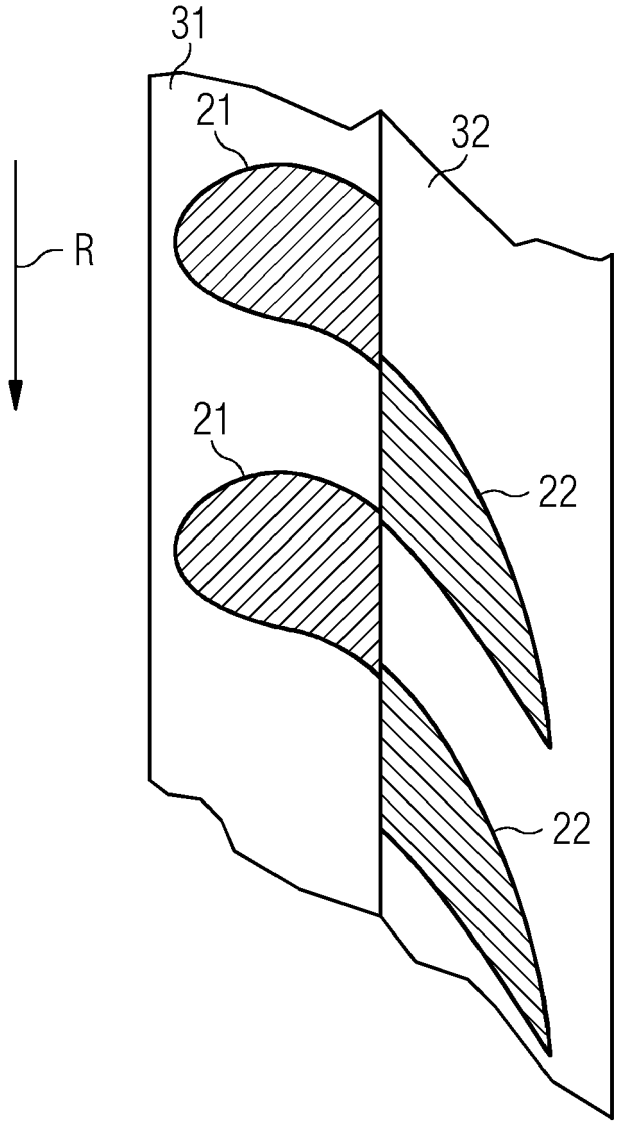
FIG 3



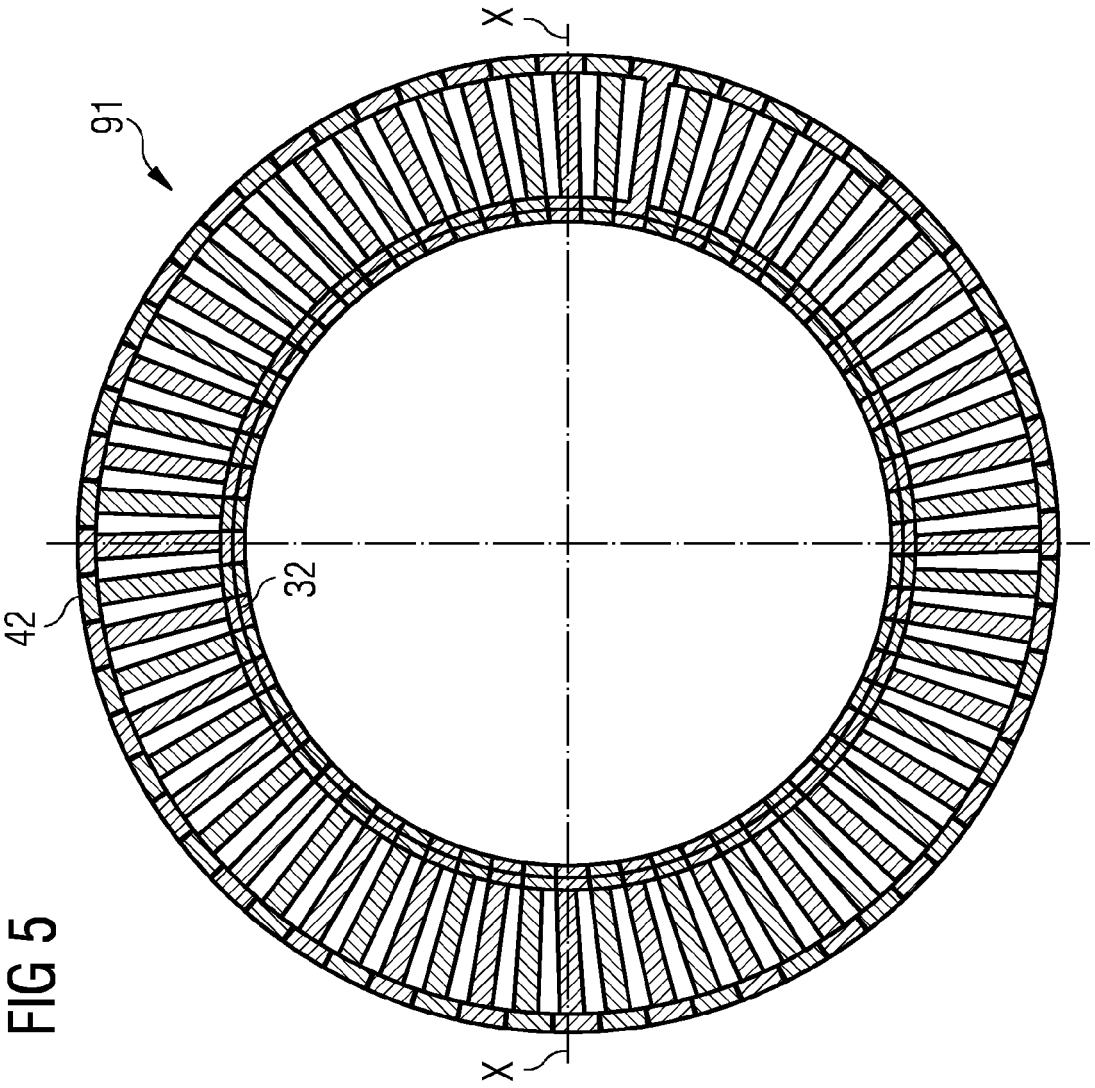


FIG 5

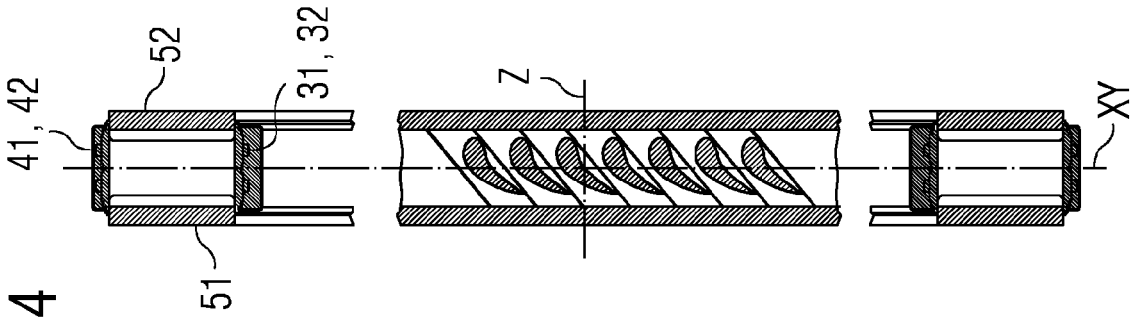


FIG 4

FIG 7

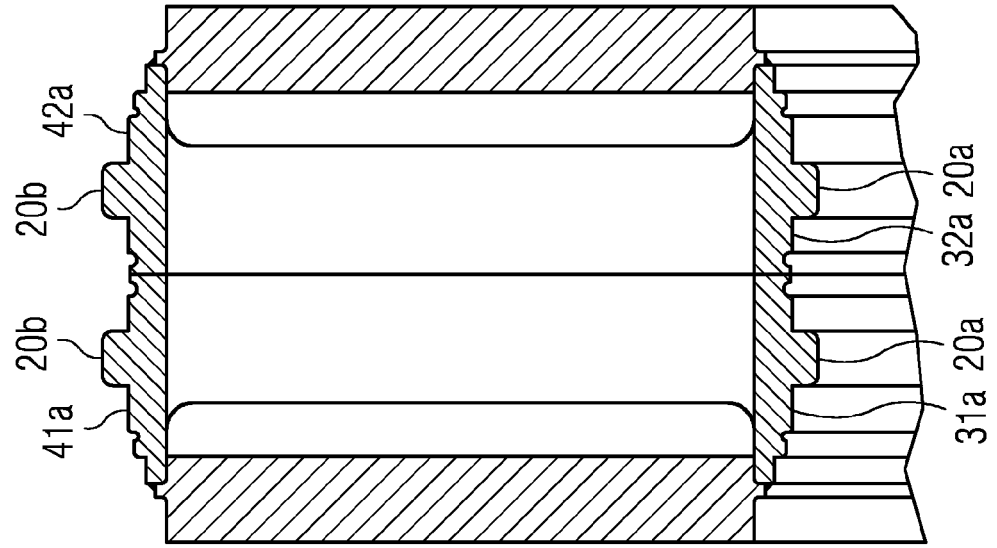


FIG 6

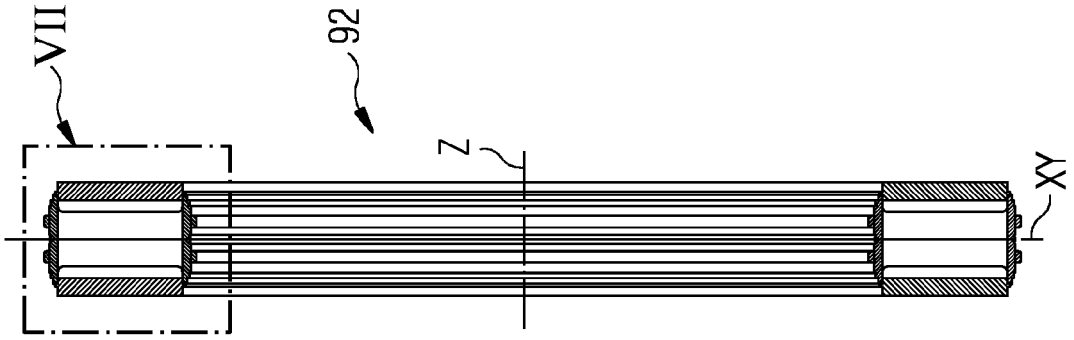


FIG 9

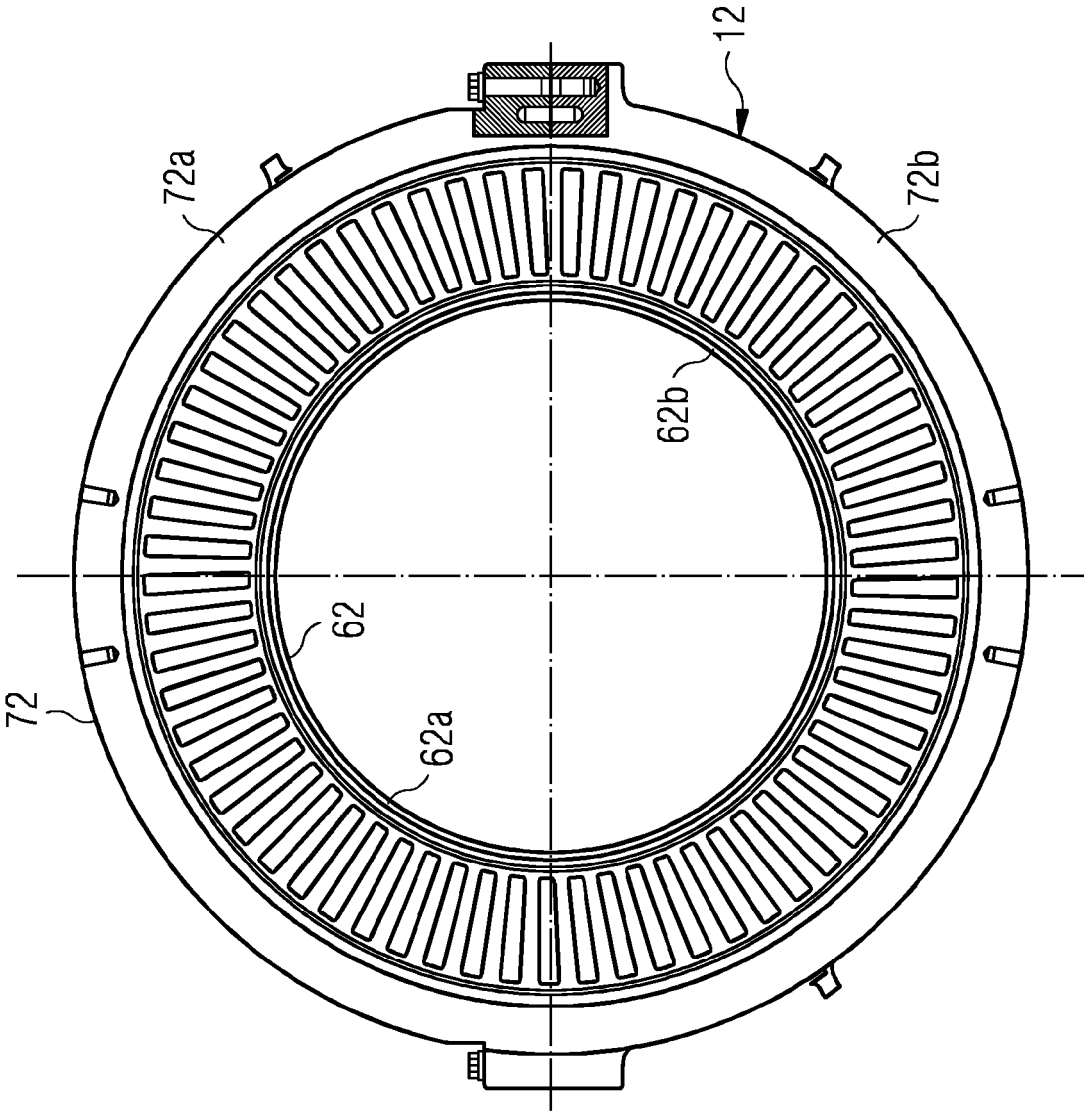


FIG 8

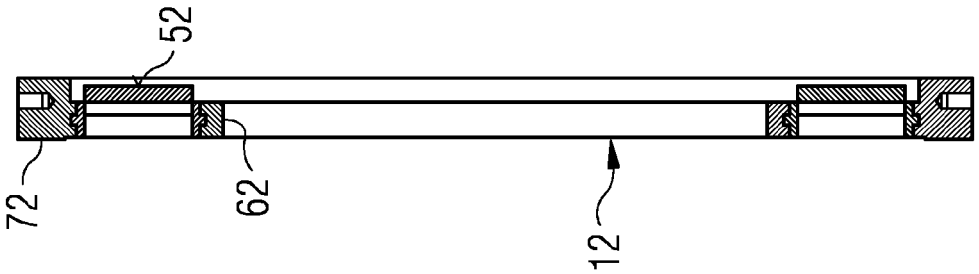


FIG 11

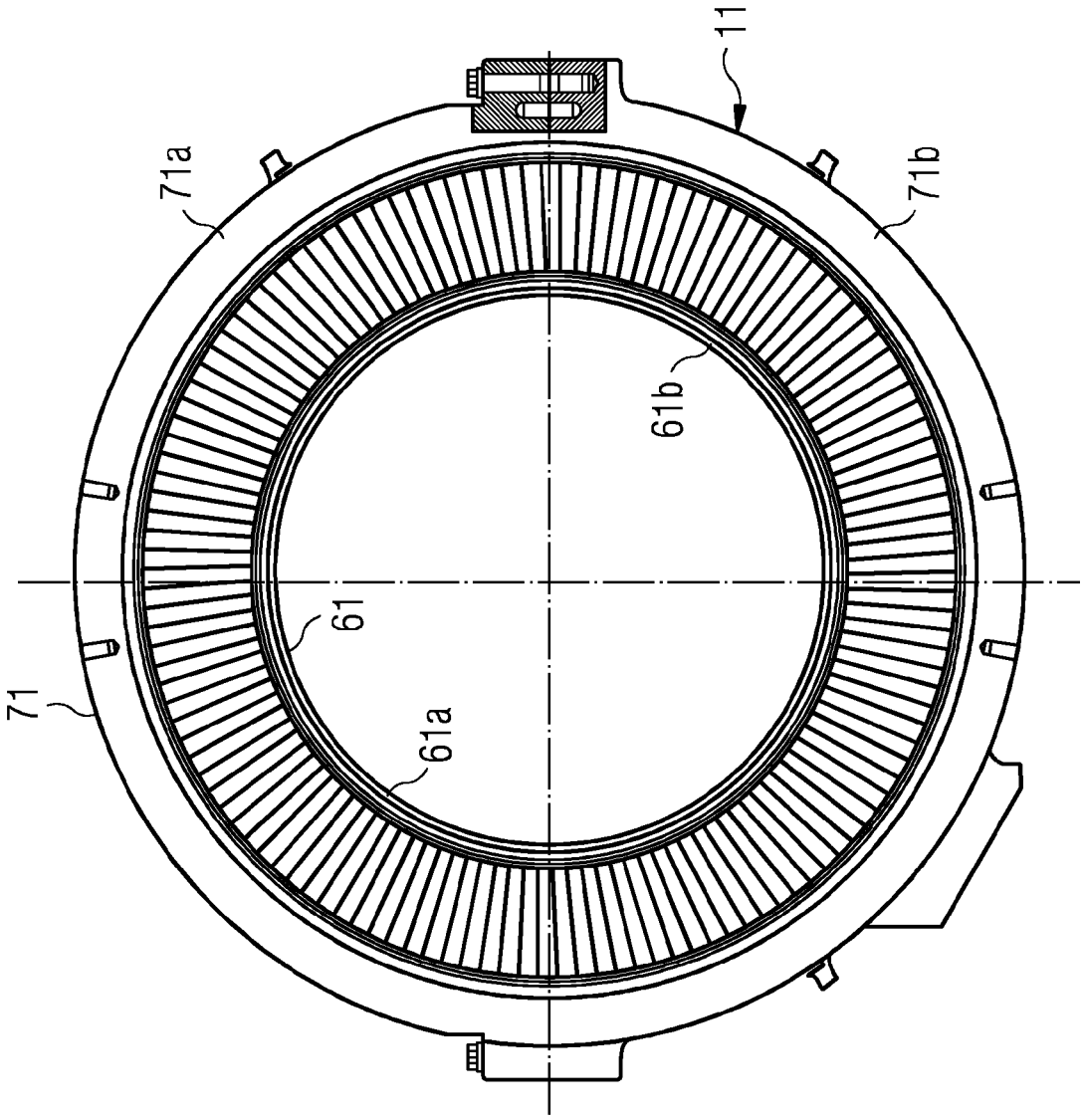


FIG 10

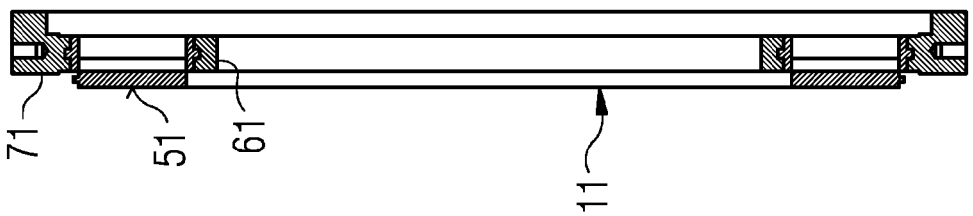


FIG 13

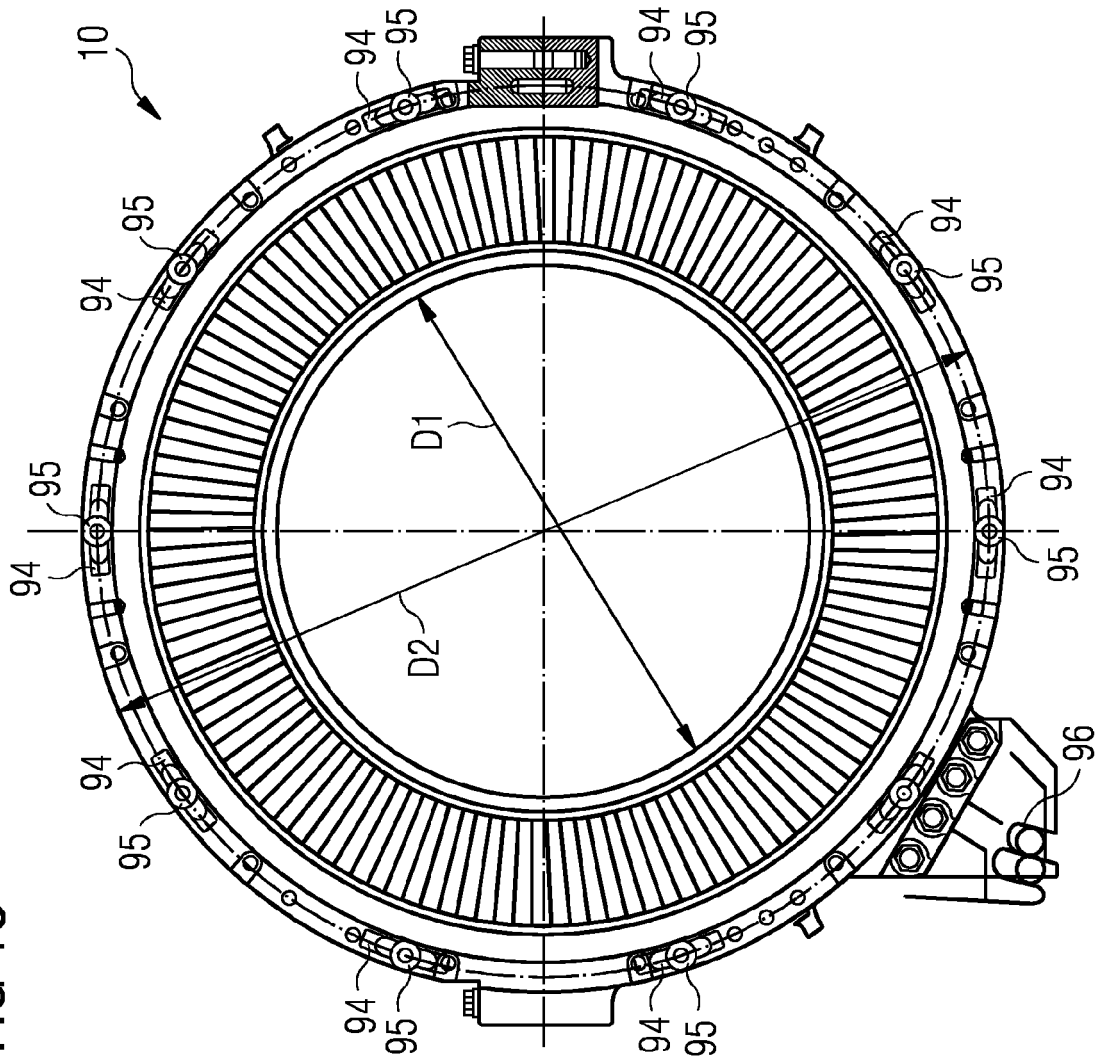
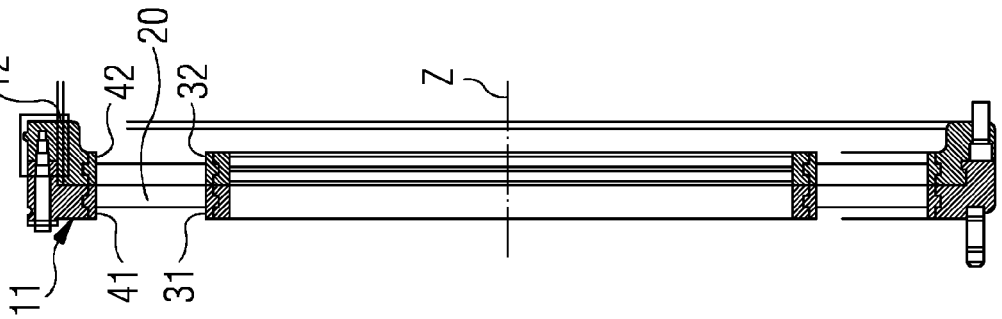


FIG 12



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European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 15 16 2406

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 44 25 344 A1 (ABB PATENT GMBH [DE]) 25 January 1996 (1996-01-25) * claims 18-20; figures 4-8 * * column 3, line 16 - line 31 * * column 5, line 28 - line 59 * -----	1-10	INV. F01D9/04 F01D17/16 F01D25/28 F01D17/14

TECHNICAL FIELDS SEARCHED (IPC)

F01D
B23Q
B23P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 September 2015	Lutoschkin, Eugen

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 16 2406

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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