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(54) Title: HYDRAULIC POWER GENERATOR AND METHODS FOR THE PRODUCTION AND OPERATION THEREOF

(54) Bezeichnung: WASSERKRAFTGENERATOR UND VERFAHREN ZU DESSEN HERSTELLUNG UND BETRIEB

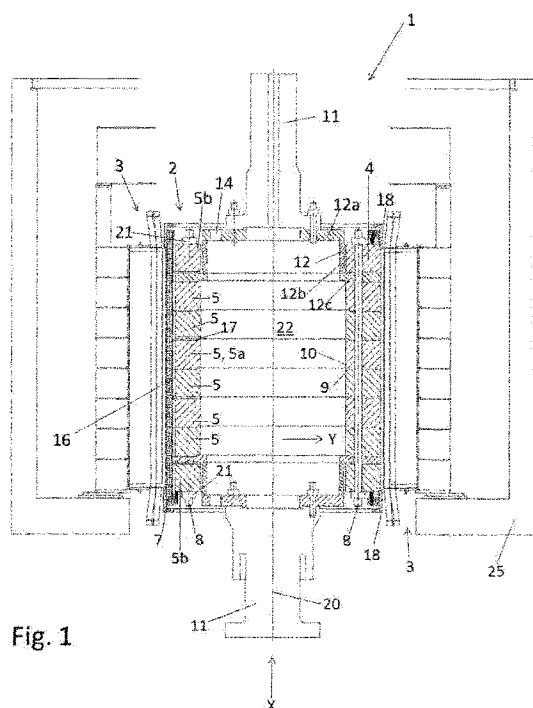


Fig. 1

(57) Abstract: The invention relates to a hydraulic power generator (1) designed as a synchronous electric machine which has an air-cooled rotor (2) and a stator (3) and which comprises at least eight poles (19) formed by the rotor windings (7). The invention also relates to a method for manufacturing the disclosed hydraulic power generator (1) as well as a method for operating same.

(57) Zusammenfassung: Den Gegenstand dieser Erfindung bildet ein Wasserkraftgenerator (1), der als elektrische Synchronmaschine mit einem luftgekühlten Rotor (2) und einem Stator (3) ausgebildet ist, mit mindestens acht Pole (19), die durch die Rotorwicklungen (7) gebildet werden. Den Gegenstand dieser Erfindung bildet auch ein Verfahren zum Herstellen und Betreiben des erfindungsgemäßen Wasserkraftgenerators (1).

Veröffentlicht:

- mit internationalem Recherchenbericht (Artikel 21 Absatz 3)

HYDRO GENERATOR AND METHOD FOR ITS MANUFACTURE AND OPERATION

The subject of the present invention is a hydro generator that is designed as an electrical, synchronous machine with an air-cooled rotor and a stator, with at least eight poles on the rotor, which are formed by the pole winding.

A method for manufacturing and operating the hydro generator according to the invention is also the subject of the present invention.

Hydro generators must always be operated with sufficient margin to the critical speeds (critical bending speeds), preferably below the first critical speed.

In the region of the critical speed, the forces of the rotating unbalanced mass set a part of or the entire machine vibrating in resonance. This can destroy the generator. The critical speed is largely determined by the bearing assembly, the rigidity of the rotating parts, and by their mass. If the rotor mass is increased, this reduces the first critical speed.

Operation of very large, high-speed hydro generators then becomes problematic. Due to the very large rotor mass, the first critical speed is comparatively low. In order to avoid coming close to the operating speed, efforts are made to keep the mass of the rotor low. Smaller rotor mass at the same output requires very efficient cooling, so rotors of this kind are equipped with water cooling.

However, water cooling is more complex and more expensive than simple air cooling.

It is an object of the present invention to substantially overcome or at least ameliorate one or more disadvantages of the prior art, or at least provide a useful alternative.

Embodiments seek to provide a hydro generator that can be fitted with air cooling for the rotor, but is still suitable for high-speed, high-performance plants (e.g. in a range higher than 500 MVA).

In an aspect of the present invention, there is provided a hydro generator designed as an electrical, synchronous machine comprising: a stator and an air-cooled rotor with axes in an axial direction and a radial direction and where a winding on the rotor forms at least eight poles wherein the rotor comprises: a self- supporting rotor body without a central shaft, and several forged steel rings connected to one another, where each steel ring has grooves into which the rotor winding is directly placed.

As a result of this construction without a central shaft, the rotor mass is reduced on the one hand and thus, the first critical speed is increased. On the other hand, the rotor construction with forged steel rings can form a particularly rigid rotor body, with the result that the first critical bending speed is also increased. In this way, a hydro generator of this kind can be operated at relatively high speeds for hydro generators, for example in the region of 400 to 900 r.p.m., in spite of its high output, and the rotor can be cooled with air.

The individual steel rings are connected or clamped to one another by means of bolts running in axial direction (= parallel to the axis of rotation). The steel rings can also be centered or aligned to one another with the aid of centering seats.

It is favorable if the two generator shafts are each connected to the steel rings or the rotor body by means of a transition piece, where the transition pieces can extend in axial direction so that they yield in radial direction.

This compensates for expansion of the steel rings caused by the operating temperature and, above all, by the centrifugal forces. These transition pieces can be bell- shaped, cylindrical, or conical.

The structure formed by the steel rings has the advantage that radial cooling channels for the cooling air are formed easily by the grooves or recesses in the contact surfaces between the rings.

The rotor body formed by the steel rings may preferably have cooling channels running in axial direction (parallel to the axis of rotation) at the base of the grooves. The cooling air is then fed preferably through an opening in the face end into the inside of the rotor body and directed from there through the radial cooling channels and on to the channels running at the base of the grooves. The cooling air can then leave the rotor through radial bore holes in the winding. This provides good cooling of the rotorwinding.

The axial cooling channels can either run continuously over the entire length of the rotor body, or they can also be sub-divided in longitudinal direction, thus distribution of the cooling air can be set to an optimum.

There is also disclosed a method for operating a hydro generator, where the hydro generator is operated below the first critical bending speed.

There is also disclosed a method for manufacturing a hydro generator, where the grooves are already worked into the individual steel rings before they are joined together to form the rotor body.

The finish-machined steel rings can then be shipped to the final operating location and joined together there. This makes transport much easier.

Preferred embodiments of the present invention will now be described, by way of examples only, with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic longitudinal section through a hydro generator according to the invention;

Fig. 2 shows a schematic cross-section through the rotor;

Fig. 3 shows a detailed cut-out of the rotor in Fig. 2;

Figs. 4, 5, and 6 show detailed cut-outs of the rotor in Fig. 1;

Fig. 7 shows a view of the rotor;

The same reference numerals in the individual figures refer to the same plant components in each case.

Fig. 1 shows a sectional view along the axis of rotation 20 through an embodiment of the hydro generator 1 according to the invention without respective bearings for the shaft 11.

The vertically arranged rotor 2 is inside the stator 3, which is resting on a foundation 25. The rotor body 4 is formed by a large number of steel rings 5, 5a, 5b, which are clamped together by threaded bolts 8 and nuts 21. The individual steel rings 5, 5a, 5b are centered in relation

to one another by centering shoulders 9, which engage the recesses (clearances) 10 in an adjacent steel ring 5, 5a, 5b.

On the outside of the rotor body 4 there are grooves 6 in the steel rings 5, 5a, 5b for the rotor winding 7. The winding head is stabilized via the end winding support (rotor retaining rings) 18.

The rotor body 4 is screwed to the shaft 11 at each end via a transition piece 12 in each case.

The transition piece 12 has a section 12a running essentially in radial direction y, which is connected to the shaft 11. In addition, the transition piece 12 comprises a second section 12c running in radial direction y, which is clamped between the two outer steel rings 5 and 5b, thus forming the connection between the transition piece 12 and the steel rings 5, 5a, 5b.

Between the two radial sections 5a and 5c there is a section 5b of the transition piece 12 running in axial direction x. The cylindrical section 12b enables a certain degree of yield in radial direction y. This can thus compensate for the centrifugal and heat expansion of the rotor body 4 in operation. Expansion can quite easily be in the range of several millimeters.

Cooling air can be directed into the inside of the rotor 22 through a face-end opening 14 in the rotor body 4 (in the transition piece 12a). This cooling air passes through cooling channels 17 running in radial direction y into the channels 16 at the base of the grooves running in axial direction x and cools down the rotor winding 7 via radial cooling channels 23 (shown in Fig. 3) in the winding 7. Finally, the cooling air leaves the rotor 2 at the air gap.

Figure 2 shows a cross-section through the rotor 2 of an 18-pole hydro generator 1. The individual grooves 6 in the steel ring and the bore holes 25 for the bolts 8 are shown here clearly.

Figure 3 provides a detailed view of the grooves 5 with the winding 7 from Figure 2 inserted. The cooling channels 16 running in axial direction at the base of the groove are shown here clearly. The cooling air can escape into the air gap between rotor 2 and stator 3 through radial cooling channels 23 in the winding 7 and the groove wedges 15.

Figure 4 shows the centering seat of two steel rings 5 centered to one another. The annular centering shoulder 9 of the steel ring 5 engages the recess 10 of an adjacent steel ring 5.

Figure 5 shows how the transition piece 12 is connected to the steel rings 5 and 5b. The section 12c running in radial direction y is clamped between the outermost steel ring 5b and the steel ring 5 by the bolts 8. In this area, cooling air is fed through the ring slot 24 between the outer steel ring 5b and the section 12b of the transition piece 12 running in axial direction x to the radial cooling channels 17 and thus enters the axial cooling channels 16 at the base of the groove.

Figure 6 shows a radial cooling channel 17 between two steel rings 5 on the inside of the rotor 22. These cooling channels 17 can be formed by radial grooves in the contact surfaces of the steel rings 5.

The structure of the end winding, which is stabilized by the rotor retaining rings 18 (end winding support), is shown in Figure 7. Here, the rotor winding 7 forms eighteen poles 19.

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As the construction according to the invention is specially intended for very large and heavy hydro generators, the grooves 6 are preferably formed before assembly of the steel rings 5, 5a, 5b because smaller machining equipment

10

CLAIMS:

1. Hydro generator designed as an electrical, synchronous machine comprising:
a stator; and
an air-cooled rotor with axes running in an axial direction and a radial direction and,
where a rotor winding on the rotor forms at least eight poles
wherein the rotor comprises:
a self-supporting rotor body without a central shaft, and
several forged steel rings connected to one another, where each steel ring has
grooves into which the rotor winding is directly placed.
2. Hydro generator according to Claim 1, wherein the individual steel rings are connected to
one another by means of bolts running in the axial direction.
3. Hydro generator according to Claim 1 or 2, wherein the steel rings have centering
shoulders, each of which engage recesses in an adjacent steel ring.
4. Hydro generator according to any one of Claims 1 to 3, wherein the steel rings that form a
middle section of the rotor have a different inner diameter to the steel rings in the peripheral
sections of the rotor, a inner diameter of the steel rings in the middle section being larger than a
inner diameter of the steel rings in the peripheral sections.
5. Hydro generator according to any one of Claims 1 to 3, wherein the steel rings in the
peripheral sections are each connected to a shaft via a transition piece, where the transition
pieces extend in the axial direction so that they yield in the radial direction.
6. Hydro generator according to Claim 5, wherein the transition pieces are bell-shaped.
7. Hydro generator according to Claim 5, wherein one section of the transition pieces has a
cylindrical or conical shape.
8. Hydro generator according to any one of Claims 5 to 7, wherein the transition pieces are
each secured between two steel rings.

9. Hydro generator according to any one of Claims 1 to 8, wherein the rotor body has cooling channels running in the radial direction.
10. Hydro generator according to Claim 9, wherein the rotor body has cooling channels running in the axial direction at a base of the grooves when the rotor winding is installed, where the cooling channels running in the radial direction open into the cooling channels running in the axial direction.
11. Hydro generator according to Claim 10, wherein the cooling channels running in the axial direction extend largely over the entire length of the grooves.
12. Hydro generator according to any one of Claims 9 to 11, wherein the rotor body has at least one opening on a face end for supplying cooling air to an inside of the rotor.
13. Hydro generator according to any one of Claims 1 to 12, wherein the stator is also air-cooled.
14. Hydro generator according to any one of Claims 1 to 12, wherein the stator is water-cooled.
15. Method for operating a hydro generator according to any one of Claims 1 to 14, wherein the hydro generator is operated below its first critical bending speed.
16. Method for manufacturing a hydro generator according to any one of Claims 1 to 14, wherein the grooves are worked into each of the steel rings before the steel rings are joined together to form the rotor body.
17. Method for assembly of a hydro generator according to any one of Claims 1 to 14, wherein each of the steel rings are assembled at the hydro generator's ultimate operating location.

Andritz Hydro GmbH

Patent Attorneys for the Applicant/Nominated Person

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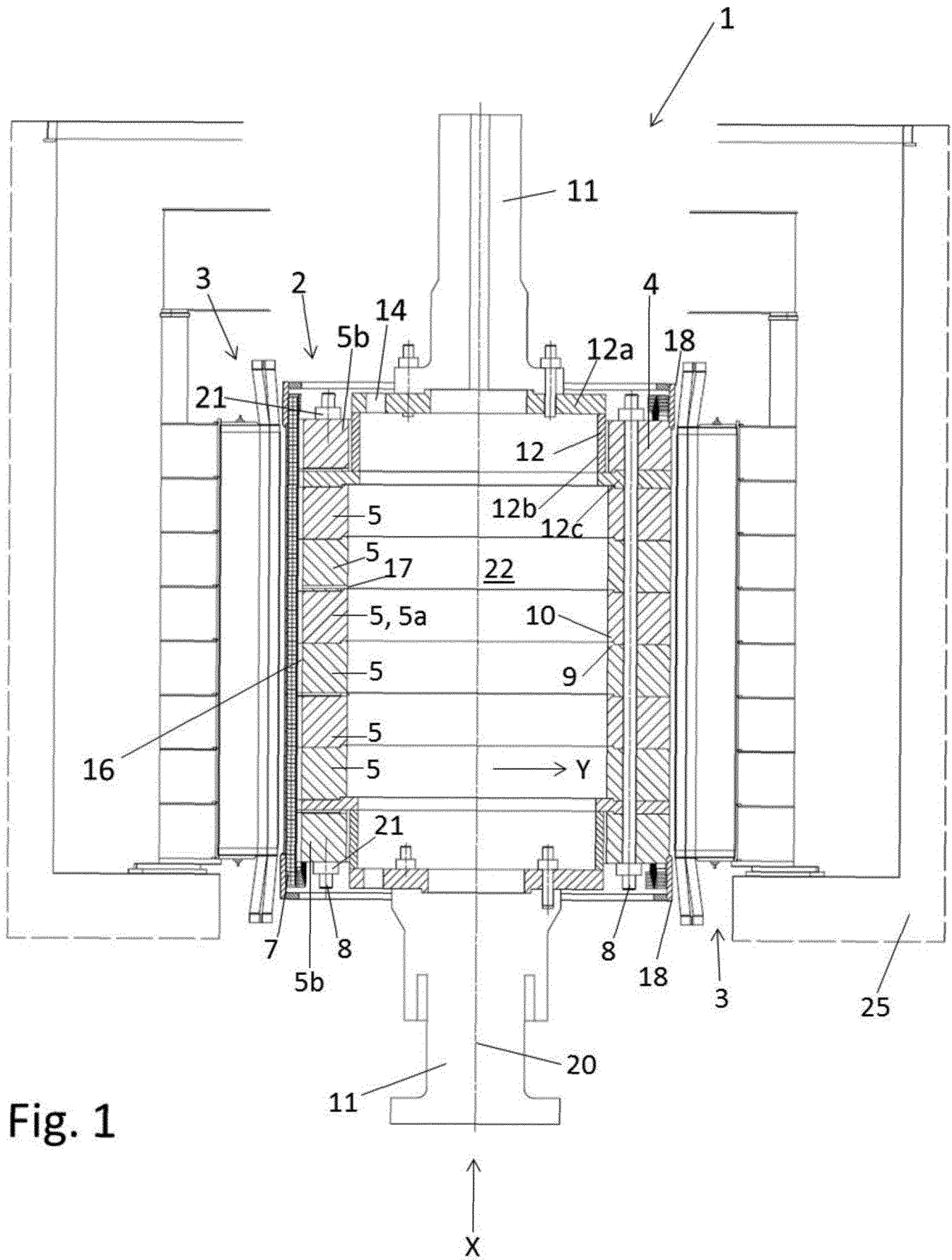


Fig. 1

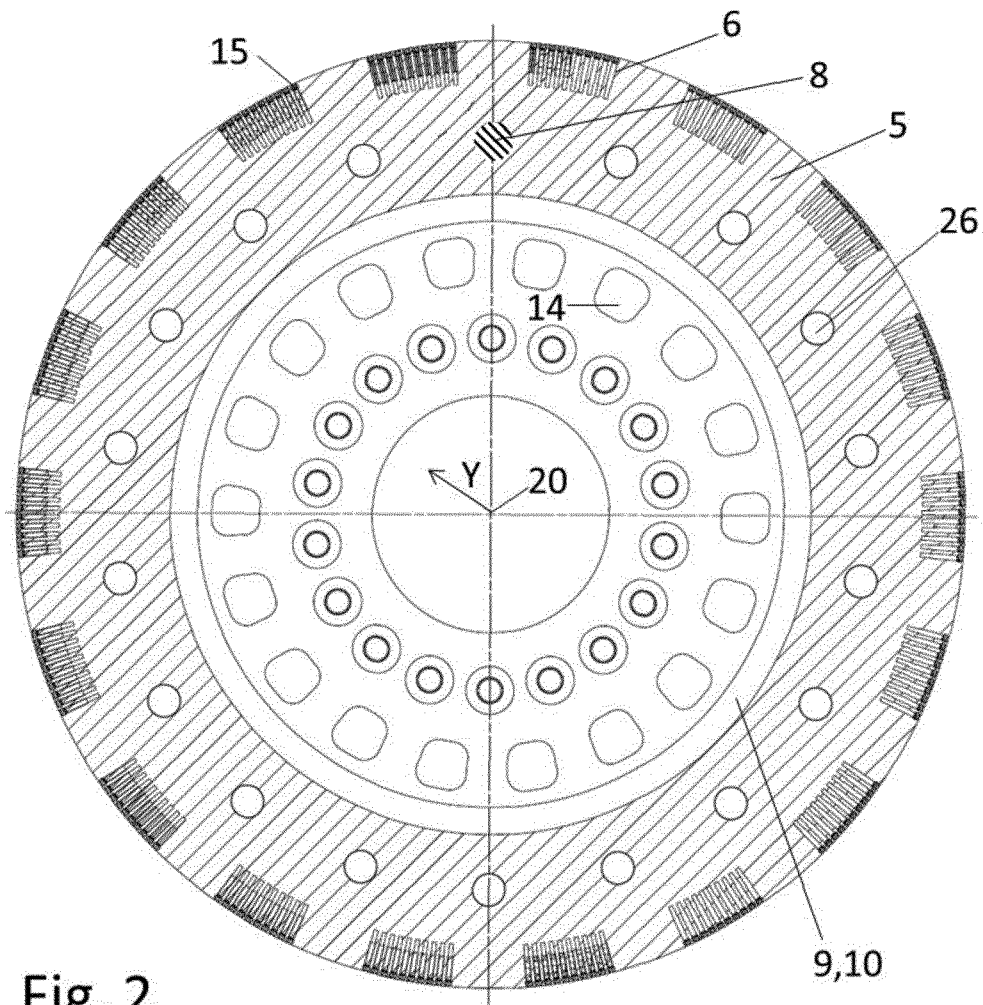


Fig. 2

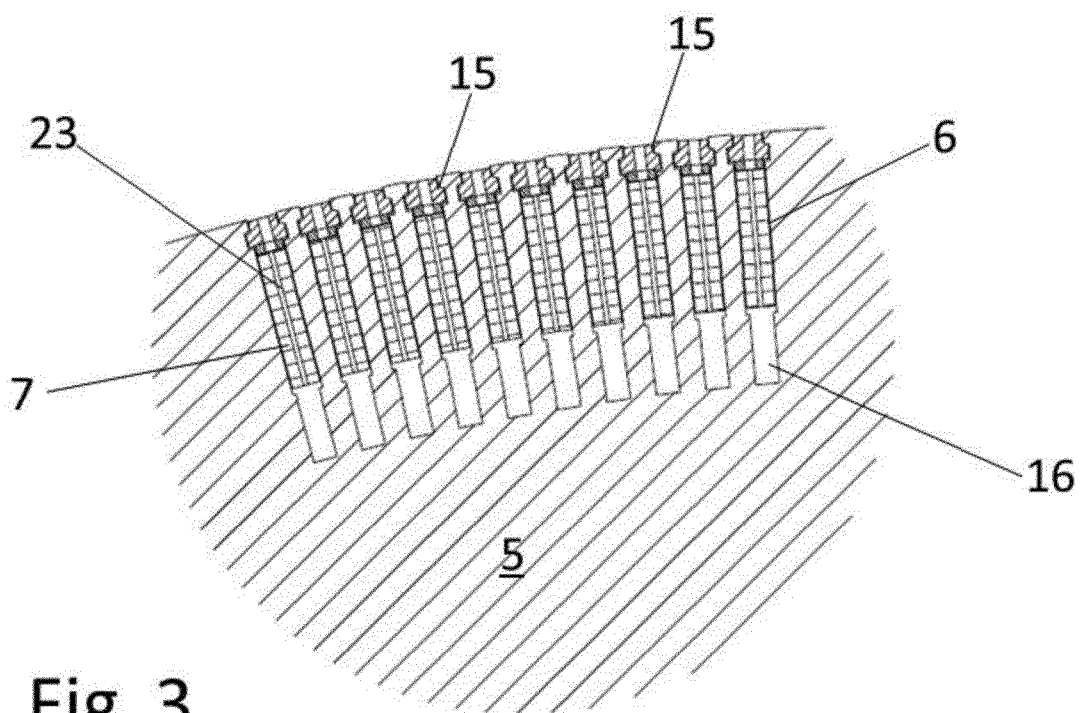


Fig. 3

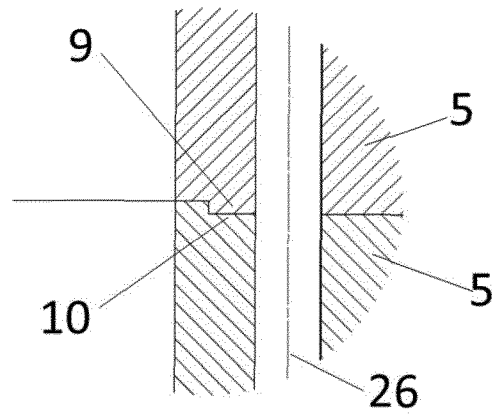


Fig. 4

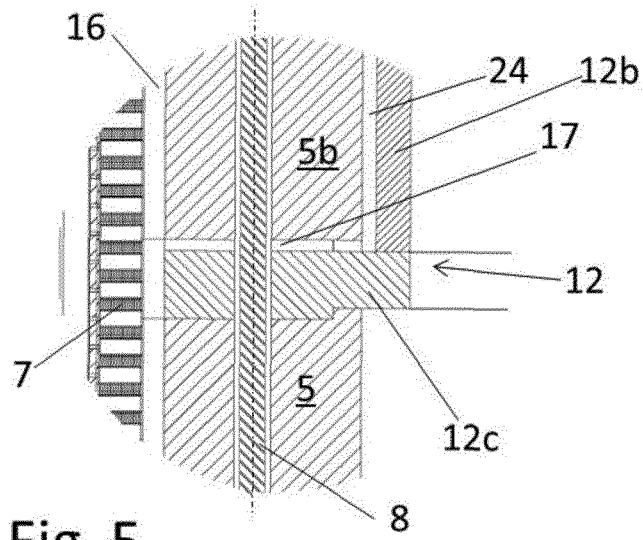


Fig. 5

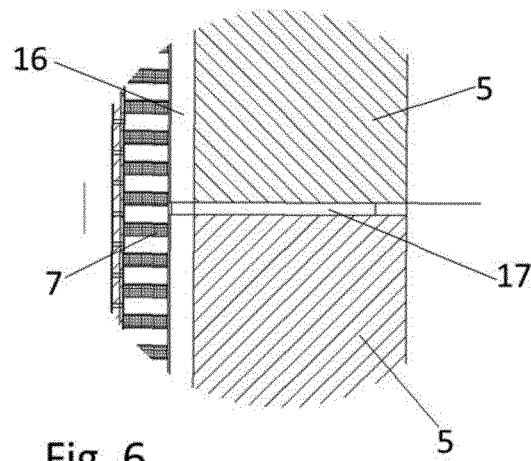


Fig. 6

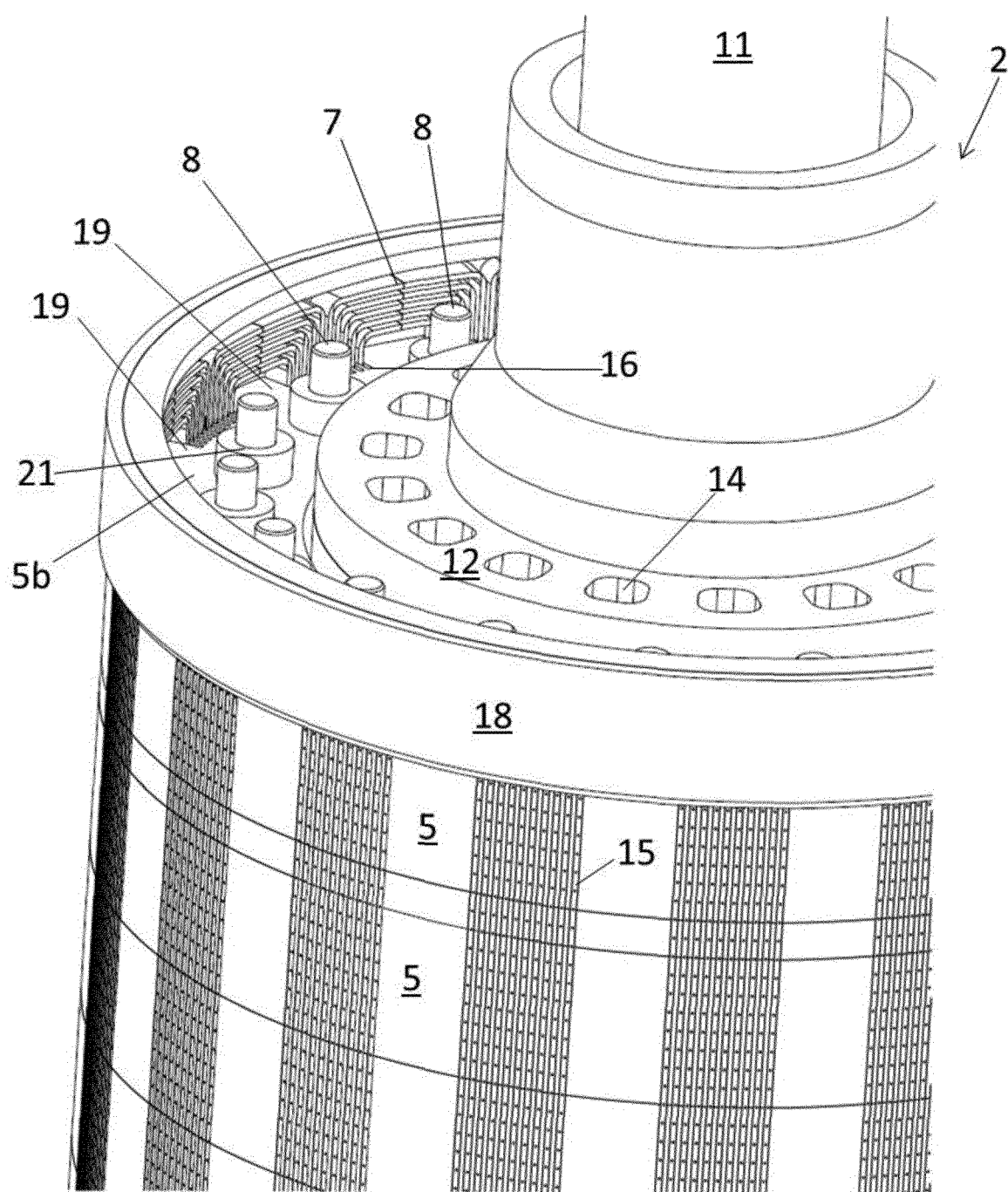


Fig. 7