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(54) Title: A PITCH CONTROL SYSTEM FOR A WIND TURBINE BLADE

(57) Abstract: A pitch control system for a wind turbine blade According to an exemplary embodiment of the invention, a pitch control system 100 for a wind turbine blade is disclosed. The wind turbine blade may be mounted on a wind turbine hub 102 via a bearing. The bearing may include a pair of rings 104, 106 such that one ring 104 may be concentric to the other ring 106. The pitch control system 100 may include at least one magnetic element 108, 110 coupled to each ring 104, 106. The arrangement of the magnetic elements 108, 110 in the pitch control system 100 may be such that the at least one magnetic element 108 coupled to one ring 104,106 may be selectively excited to produce a magnetic flux having a polarity opposite to the polarity of the magnetic element 108, 110 coupled to the other ring 104,106 thereby controlling the pitch of wind turbine blade.

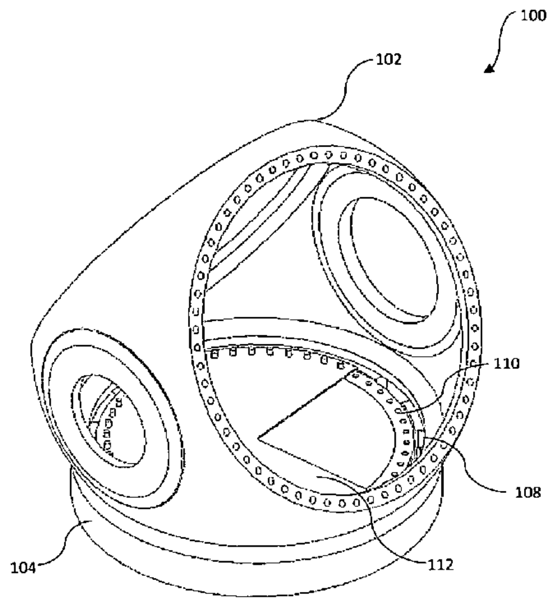

Figure 1

ABSTRACT

A pitch control system for a wind turbine blade

According to an exemplary embodiment of the invention, a pitch control system 100 for a wind turbine blade is disclosed. The wind turbine blade may be mounted on a wind turbine hub 102 via a bearing. The bearing may include a pair of rings 104, 106 such that one ring 104 may be concentric to the other ring 106. The pitch control system 100 may include at least one magnetic element 108, 110 coupled to each ring 104, 106. The arrangement of the magnetic elements 108, 110 in the pitch control system 100 may be such that the at least one magnetic element 108 coupled to one ring 104, 106 may be selectively excited to produce a magnetic flux having a polarity opposite to the polarity of the magnetic element 108, 110 coupled to the other ring 104,106 thereby controlling the pitch of wind turbine blade.

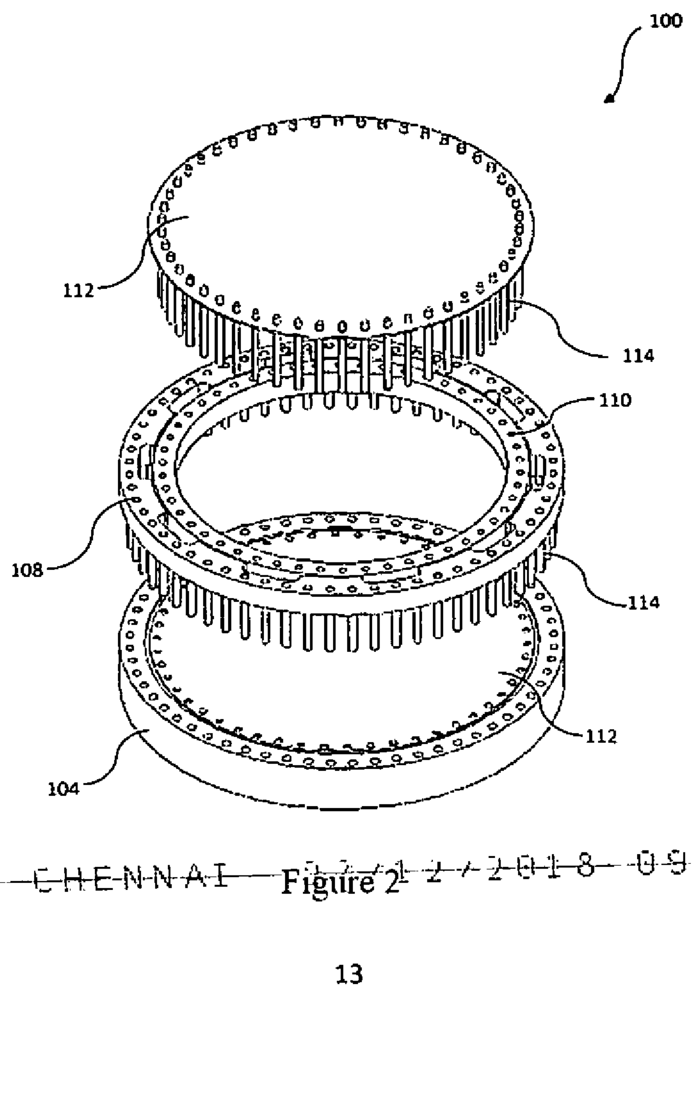

Figure 2

We claim:

1. A pitch control system 100 for a wind turbine blade, the blade being mounted on a wind turbine hub 102 via a bearing, the bearing having a pair of concentric rings 104, 106, the pitch control system 100 comprising:

   at least one magnetic element 108, 110 being coupled to each ring 104, 106, such that the at least one magnetic element 108, 110 coupled to one ring 104, 106 being selectively excited to provide a magnetic flux having a polarity opposite to the polarity of the magnetic element 108, 110 coupled to the other ring 104, 106 thereby controlling the pitch of wind turbine blade.

2. The pitch control system 100 for the wind turbine blade as claimed in claim 1, wherein the magnetic elements 108, 110 are coupled to the respective rings 104, 106 via a plurality of studs 114.

3. The pitch control system 100 for the wind turbine blade as claimed in claim 1, wherein the magnetic elements 108, 110 are coupled to the respective rings 104, 106 via a plurality of bolts 114.

4. The pitch control system 100 for the wind turbine blade as claimed in claim 1, wherein the bearing includes a plurality of balls 116 in between the concentric rings 104, 106.

5. The pitch control system 100 for the wind turbine blade as claimed in claim 1, wherein the bearing includes a plurality of rollers 116 in between the concentric rings 104, 106.

6. The pitch control system 100 for the wind turbine blade as claimed in claim 1, wherein the magnetic element 108 coupled to the one ring 104 may be separated from the magnetic element 110 coupled to the other ring 106 by an air gap.

7. The pitch control system 100 for the wind turbine blade as claimed in claim 1, wherein the pitch control system 100 further includes at least one plate 112 on each side of the magnetic elements 108, 110.

8. The pitch control system 100 for the wind turbine blade as claimed in claim 1, wherein the pitch angle of the wind turbine blade is restricted between 0 to 100 degrees.

Dated this 26th day of December 2017

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FIELD OF INVENTION

The invention generally relates to wind turbine and more particularly to a pitch control system for a wind turbine blade.

BACKGROUND

A wind turbine with a pitch control system comprises of a means for adjusting the angle of the wind turbine blades. The wind turbine blades pitch in reaction to the wind flowing onto the blades to control the production of output power. A conventional wind turbine includes a rotor having a hub and one or more blades are mounted on the hub. The blades transform the wind energy into a rotational motion of a drive shaft. The drive shaft on being rotated drives an electrical generator to produce electrical power that is fed to a power grid.

During varying wind speed conditions, each of the wind turbine blades may pitch about a pitch axis, via a pitch control system, to maintain an optimum Revolutions Per Minute (RPM). The optimum RPM of the wind turbine blade may enable the wind turbine to produce an optimum electrical power output. The pitch control system in the conventional wind turbines consist of a bearing on which the blade is attached. One part of the bearing i.e. the fixed or stationary part is coupled to the hub, while the moving part of the bearing is coupled to the blade root. The said blade, in turn, is connected to a hydraulic or an electrical pitch control system which causes the blade to pitch.

In the hydraulic pitch control system, one or more hydraulic actuators control the pitch of the blades. The actuator works against a spring/piston-cylinder that functions as a stop fail-safe upon loss of hydraulic pressure. However, the hydraulic pitch control system includes a hydraulic fluid that often results in a leakage problem. Additionally, the hydraulic pitch control systems tend to use more energy as the hydraulic pump must run continuously to keep the pressure high.

An electric pitch control system needs fail-safe batteries or supercapacitors to allow for loss of primary power or control. Fail-safe batteries typically last only two to three years, and then must be replaced. The replacement of the fail-safe batteries is not a simple task as the fail-safe batteries are located in the hub of the rotor and not in the nacelle.

Hence there is a need for an improved pitch control system for a wind turbine blade

SUMMARY OF THE INVENTION

According to an exemplary embodiment of the invention, a pitch control system for a wind turbine blade is disclosed. The wind turbine blade may be mounted on a wind turbine hub. The mounting of the wind turbine blade on the wind turbine hub may be achieved via a bearing. The bearing may include a pair of rings such that one ring may be concentric to the other ring. The pitch control system may include at least one pair of magnetic elements. Each magnetic element may be coupled to each ring. The arrangement of the magnetic elements in the pitch control system may be such that the at least one magnetic element coupled to the one ring may be selectively excited to produce a magnetic flux having a polarity opposite to the polarity of the other magnetic element coupled to the other ring. The excitation of the one magnetic element may be managed to control the pitch of wind turbine blade.

BRIEF DESCRIPTION OF DRAWINGS

Other objects, features, and advantages of the invention will be apparent from the following description when read with reference to the accompanying drawings. In the drawings, wherein like reference numerals denote corresponding parts throughout the several views:

Figure 1 illustrates an isometric view of a pitch control system in a wind turbine hub according to an exemplary embodiment of the invention.

Figure 2 illustrates an exploded view of the pitch control system according to an exemplary embodiment of the invention.

Figure 3 illustrates a cross sectional view of the pitch control system according to an exemplary embodiment of the invention.

Figure 4 illustrates a diagrammatic drawing of the pitch control system according to an exemplary embodiment of the invention.

DETAILED DESCRIPTION OF DRAWINGS

The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skilled in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

Figure 1 illustrates an isometric view of a pitch control system 100 in a wind turbine hub 102 according to an exemplary embodiment of the invention. The pitch control system 100 may be employed or installed in a wind turbine for adjusting the angle of one or more wind turbine blades. The pitch control system 100 may enable the wind turbine blades to pitch based on the speed of the wind flowing onto the wind turbine blades. The pitch of the wind turbine blade may not only cause a rotor to run efficiently, but may also protect the wind turbine blade from damage due to excessive wind forces. The arrangement of the pitch control system 100 may be such that each pitch control system 100 may control the pitch of only one wind turbine blade. In other words, for a wind turbine having two wind turbine blades, there may be two pitch control systems 100, and for a wind turbine having three wind turbine blades, there may be three pitch control systems 100. It will be apparent to a person skilled in the art that the pitch control system 100 may be employed in varied capacities of wind turbine and may not be limited to wind turbines of a fixed range of capacities. By way of an example, for a wind turbine of large size and capacity, the components of the pitch control system 100 may be larger in size and stronger in strength. Similarly, for a wind turbine of a comparatively smaller size and capacity, the components of the pitch control system 100 may be comparatively smaller in size and of lesser strength.

The wind turbine blade may be mounted on the wind turbine hub 102. The mounting of the wind turbine blade on the wind turbine hub 102 may be achieved via a bearing. The bearing may enable the wind turbine blade to pitch freely on a pitch axis of the wind turbine blade. The bearing may include a pair of rings 104, 106, where one ring 104 may be concentric to the other ring 106 (shown in figure 3). In the bearing, the one ring 104 may be an outer ring and the other ring 106 may be an inner ring. The outer ring 104 of the bearing may be coupled to the periphery of a hub opening where the wind turbine blade is mounted and therefore the outer ring 104 may be stationary. The inner ring 106 of the bearing may be coupled to a root of the wind turbine blade and may freely rotate with respect to the outer ring 104.

Figure 2 illustrates an exploded view of the pitch control system 100 according to an exemplary embodiment of the invention. The pitch control system 100 may include at least one magnetic element 108, 110 coupled to each of the rings 104, 106. In other words, one magnetic element 108 may be coupled to the outer ring 104 and the other magnetic element 110 may be coupled to the inner ring 106 (shown in figure 3). According to an embodiment, the magnetic elements 108, 110 may be electromagnets. According to another embodiment, the magnetic elements 108, 110 may be permanent magnets. According to yet another embodiment, one magnetic element 108 may be an electromagnet and the other magnetic element 110 may be a permanent magnet. According to yet another embodiment the magnetic elements 108, 110 may be a magnetic bearing where the magnetic element 108 may be an outer ring and the magnetic element 110 may be an inner ring of the magnetic bearing

According to an embodiment, the magnetic element 108 may be substantially similar in shape and size of the outer ring 104. According to another embodiment, the shape and size of the magnetic element 108 may be different to the shape and size of the outer ring 104. According to an embodiment, the magnetic element 110 may be substantially similar in shape and size of the inner ring 106. According to another embodiment, the shape and size of the magnetic element 110 may be different to the shape and size of the inner ring 106.

As shown in figure 1, the magnetic elements 108, 110 may be arranged inside the wind turbine hub 102. According to an embodiment, the magnetic elements 108, 110 may be coupled to the rings 104, 106 through a plurality of studs 114. According to another embodiment, the magnetic elements 108, 110 may be coupled to the rings 104, 106 through a plurality of bolts. According to yet another embodiment, the magnetic elements 108, 110 may be coupled to the rings 104, 106 by any fastening means. It will be apparent to a person skilled in the art that the fastening means is not limited to the depicted implementation and other fastening means known in the art may also be employed. The magnetic elements 108, 110 may be coupled to the rings 104, 106 in such a way that the magnetic elements 108, 110 may be detachable from the ring 104, 106 for servicing requirements.

Figure 3 illustrates a cross sectional view of a pitch control system 100 according to an exemplary embodiment of the invention. The bearing coupled to the wind turbine hub 104 and the wind turbine blade includes the outer ring 104 and the inner ring 106. According to an embodiment, the rotation of the inner ring 106 with respect to the outer ring 104 may be achieved via a plurality of balls 116 accommodating between the outer ring 104 and the inner ring 106. According to another embodiment, the rotation of the inner ring 106 with respect to the outer ring 104 may be achieved via a plurality of rollers 116 accommodating between the outer ring 104 and the inner ring 106. According to an embodiment, the bearing coupled to the wind turbine hub 102 and the wind turbine blade may be a ball bearing. According to another embodiment, the bearing coupled to the wind turbine hub 102 and the wind turbine blade may be a roller bearing. According to yet another embodiment, the bearing coupled to the wind turbine hub 102 and the wind turbine blade may be of any type such as, but not limited to, a deep groove ball bearing, an angular contact ball bearing, a thrust roller bearing, a spherical roller bearing, a tapered roller bearing, a cylindrical roller bearing etc. It will be apparent to a person skilled in the art that the bearing coupled to the wind turbine hub 102 and the wind turbine blade is not limited to the depicted implementation and other bearings known in the art may also be employed. The bearing may be constructed from materials or combination of materials that may include, but are not limited to one or more of metal, alloy, and any other suitable material known in the art.

According to an embodiment, the magnetic element 108 on one ring 104 may be separated to the magnetic element 110 on the other ring 106 by an air gap. The air gap between the magnetic elements 108, 110 may prevent the wear and tear of the magnetic elements 108, 110 connected to each of the rings 104, 106. The pitch control system 100 may further include at least one plate 112 on each side of the magnetic elements 108, 110 to enclose the air gap between the magnetic elements 108, 110. The plates 112 may protect the air gap from foreign particles such as, but not limited to dust, water, bolts, wind turbine components etc and therefore may enable smooth working of the magnetic elements 108, 110.

Figure 4 illustrates a diagrammatic drawing of the pitch control system 100 according to an exemplary embodiment of the invention. The pitch control system 100 may enable the wind turbine blade coupled to the inner ring 106 to pitch along the pitch axis of the blade. According to an embodiment, the magnetic element 110 coupled to the inner ring 106 may be a permanent magnet and the magnetic element 108 coupled to the outer ring 104 may be an electromagnet. When the blade needs to be pitched, the magnetic element 108 may be selectively excited by a source of electric power. On being excited, the magnetic element 108 may produce a magnetic flux having a magnetic polarity opposite to the polarity of the magnetic element 110. As the inner ring 106 is free to rotate with respect to the outer ring 104, the wind turbine blade coupled to the inner ring 106 may pitch due to the magnetic flux of opposite polarity acting on the magnetic element 110. According to another embodiment, the magnetic element 110 coupled to the inner ring 106 may be an electromagnet and the magnetic element 108 coupled to the outer ring 104 may be a permanent magnet. The magnetic element 110 may be selectively excited to produce a magnetic flux having a magnetic polarity opposite to the polarity of the magnetic element 108. As the inner ring 106 is free to rotate with respect to the outer ring 104, the wind turbine blade coupled to the inner ring 106 may pitch due to the magnetic flux of opposite polarity acting on the magnetic element 110.

According to an embodiment, the pitch control system 100 may further include a sensor 118 to determine the orientation of the wind turbine blade. The sensor 118 for identifying the pitch blade orientation may be a position sensor. The sensor 118 may send the information regarding the orientation of the wind turbine blade to a controller 120. The controller 120 may include a processor and a memory. The memory may store processor instructions, which on execution cause the processor to operate the pitch control system 100. The memory may be a non-volatile memory or a volatile memory. Examples of the non-volatile memory, may include, but are not limited to a flash memory, a Read Only Memory (ROM), a Programmable ROM (PROM), Erasable PROM (EPROM), and Electrically EPROM (EEPROM) memory. Examples of the volatile memory may include, but are not limited Dynamic Random-Access Memory (DRAM), and Static Random-Access memory (SRAM). The controller 120 may control flow of current from the electric power source to the magnetic element 108 acting as the electromagnets. The current from the electric power source may cause the excitation of the magnetic element 108. The pitch control system 100 may further include a system to restrict the motion of the bearing within 0 to 100 degrees. The system may lock the movement of the bearing by a mechanical system.

It is understood that the above description is intended to be illustrative, and not restrictive. It is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined in the appended claims. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein," respectively.

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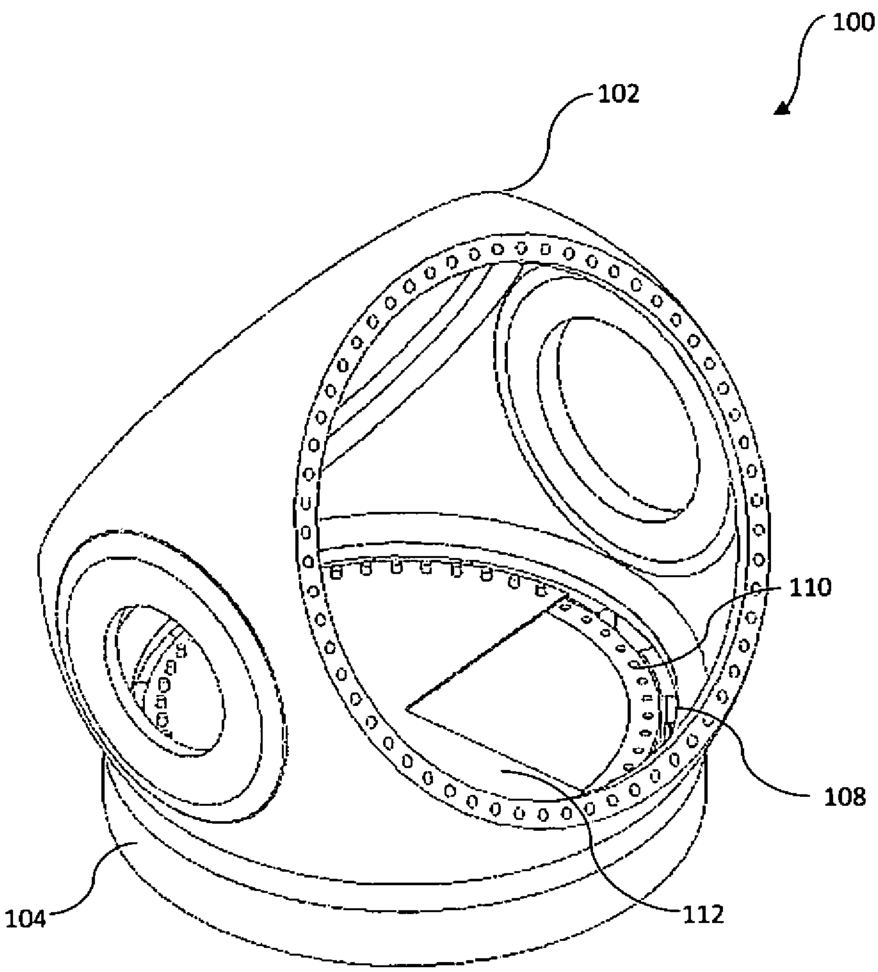

Figure 1

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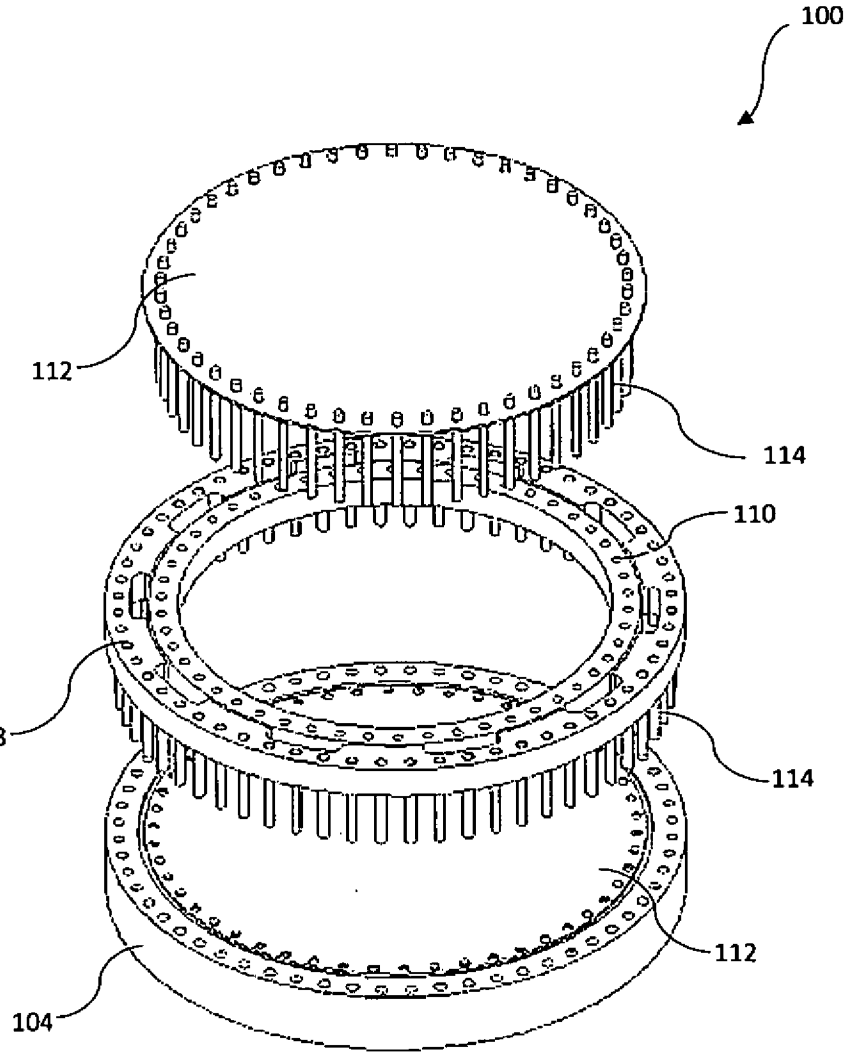

Figure 2

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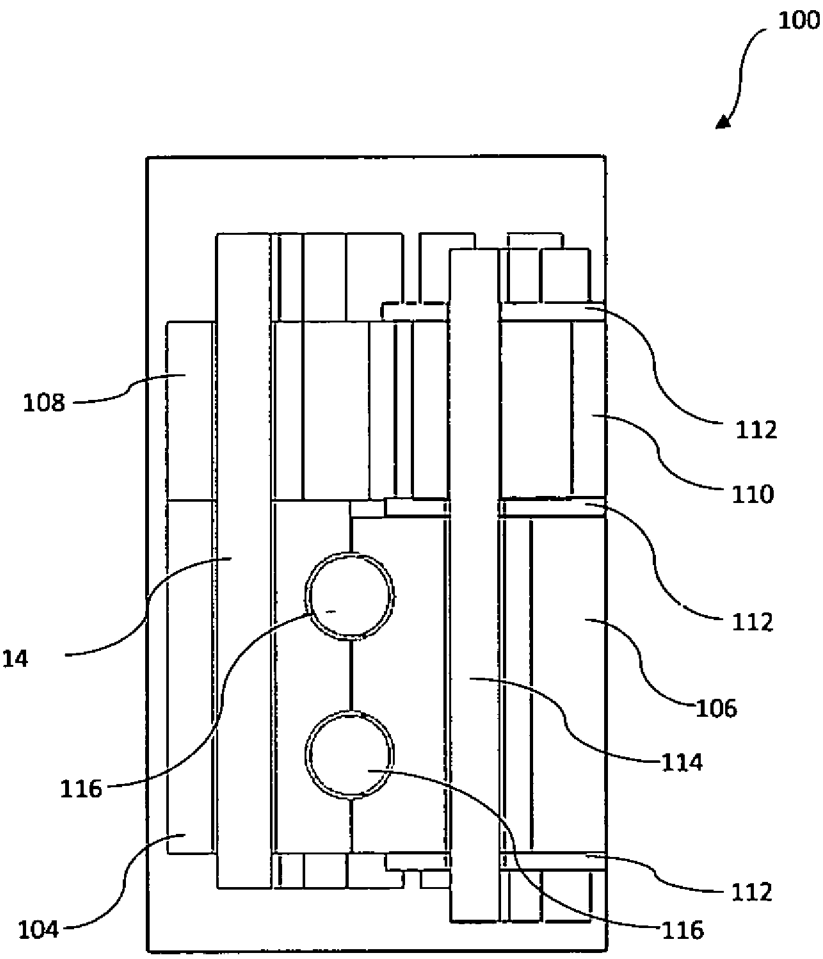

Figure 3

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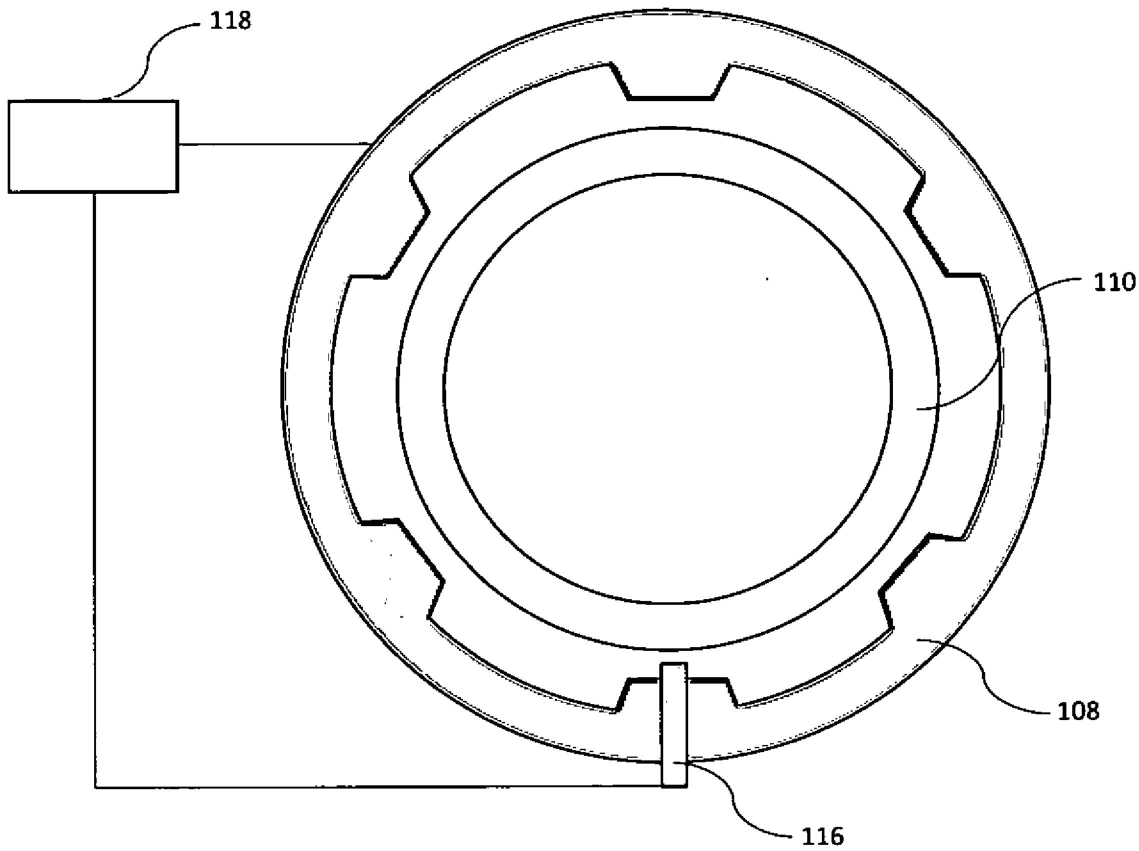

Figure 4

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