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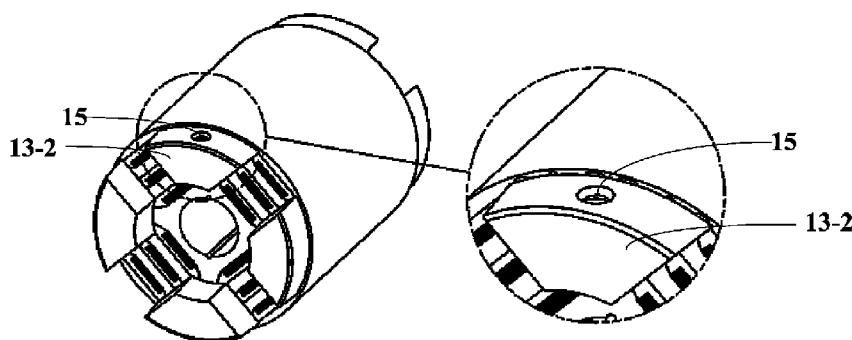
kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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(54) Title: ROTOR AND MOTOR HAVING THE ROTOR

[Fig. 8]



(57) Abstract: Embodiments of the present invention provide a rotor and a motor having the rotor. The rotor includes a rotor core that rotates about a central axis and is composed of electromagnetic steel plates laminated along an axial direction. The rotor core includes a plurality of flux barriers penetrating through the electromagnetic steel plates along the axial direction, and a permanent magnet is accommodated in at least one of the flux barriers. An end cap assembly covering at least a part of the rotor core is respectively disposed at two axial ends of the rotor core. The end cap assembly includes at least two end caps separately disposed along a circumferential direction. In the embodiments of the present invention, the end cap does not impede installation of the permanent magnet, so that more permanent magnets can be installed into the flux barrier, thereby improving output efficiency of the motor.

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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Description

Title of Invention: ROTOR AND MOTOR HAVING THE ROTOR

Technical Field

[0001] The present invention relates to the field of motor technologies, and in particular, to a rotor and a motor having the rotor.

Background Art

[0002] In conventional motor technologies, in order to meet the requirement of higher output efficiency (for example, a level equal to or greater than IE4), a synchronous permanent magnet motor or a synchronous reluctance motor is commonly used.

[0003] However, the synchronous permanent magnet motor needs to be made of an expensive permanent magnet material, and the synchronous reluctance motor has an efficiency bottleneck. Therefore, in recent years, a permanent-magnet auxiliary synchronous reluctance motor has been proposed. In the permanent-magnet auxiliary synchronous reluctance motor, a permanent magnet such as cheap ferrite is placed in a flux barrier of a rotor of the conventional synchronous reluctance motor, so as to improve the output efficiency of the motor. In this way, the requirement of output efficiency equal to or greater than IE4 level can be met at relatively low costs.

[0004] All of the foregoing types of motors use a closed loop drive controller. However, line-start motors are mostly used in industrial applications. Therefore, a permanent-magnet auxiliary self-starting synchronous reluctance motor of a cast aluminum type becomes a popular research topic.

[0005] In the following patent document 1, a permanent-magnet auxiliary self-starting synchronous reluctance motor of a cast aluminum type is proposed. In order to realize the self-starting characteristic of the motor, annular end caps are respectively formed at two axial ends of the rotor, and the end caps constitute a part of the conductive path of the induced current.

[0006] It should be noted that, the above introduction of the technical background is only for the purpose of facilitating a clear and complete description of the technical solutions of the present invention and facilitating the understanding by those skilled in the art. The above technical solutions are not considered to be well known to those skilled in the art simply because these solutions are described in the background section of the present invention.

Citation List

Patent Literature

[0007] [PTL 1] Chinese Patent Publication Gazette CN108141070A

Summary of Invention

Technical Problem

[0008] The inventor found that in the patent document 1, during manufacturing of a motor, it is required to form the annular end caps at two ends of the rotor, and then insert a permanent magnet into the flux barrier of the rotor. In the patent document 1, because the annular end caps are disposed opposite to a part of the flux barrier along an axial direction, after the end caps are formed at two ends of an end, the end cap impedes installation of the permanent magnet into the part of the flux barrier. Consequently, fewer permanent magnets can be installed into the flux barrier of the rotor, resulting in lower output efficiency of the motor.

[0009] In order to resolve the foregoing problem or other similar problems, embodiments of the present invention provide a rotor and a motor having the rotor, so that the end cap does not impede installation of the permanent magnet, and more permanent magnets can be installed into the flux barrier, thereby improving output efficiency of the motor.

Solution to Problem

[0010] According to the first aspect of the embodiments of the present invention, a rotor is provided. The rotor includes a rotor core. The rotor core rotates about a central axis and is composed of electromagnetic steel plates laminated along an axial direction. The rotor core includes a plurality of flux barriers penetrating through the electromagnetic steel plates along the axial direction, and a permanent magnet is accommodated in at least one of the flux barriers. An end cap assembly covering at least a part of the rotor core is respectively disposed at two axial ends of the rotor core. The end cap assembly includes at least two end caps separately disposed along a circumferential direction.

[0011] According to the second aspect of the embodiments of the present invention, a motor is provided, and the motor has the rotor according to the first aspect.

[0012] The embodiments of the present invention bring the following beneficial effects: the end cap assembly is designed to include the at least two end caps separately disposed along the circumferential direction, so that the end cap does not impede installation of the permanent magnet, and more permanent magnets can be installed into the flux barrier, thereby improving the output efficiency of the motor.

[0013] The implementations of the present invention are disclosed in detail with reference to the following description and the accompanying drawings. It should be understood that the implementations of the present invention are not limited in scope thereby. The implementations of the present invention include many variations, modifications, and equivalents within the spirit and scope of the appended claims.

[0014] Features described and/or illustrated with respect to one embodiment may be used in one or more other embodiments in the same or similar manner, in combination with, or in place of, features in other embodiments.

[0015] It should be emphasized that as used in this specification, the term "comprise/include/have" specifies the presence of features, assemblies, or components, but does not exclude the presence or addition of one or more other features, assemblies, or components.

Brief Description of Drawings

[0016] [fig.1]Fig. 1 is a schematic perspective diagram of a rotor according to Embodiment 1 of the present invention.

[fig.2]Fig. 2 is a schematic perspective diagram obtained when the rotor according to Embodiment 1 of the present invention is viewed along an axial direction.

[fig.3]Fig. 3 is a schematic diagram of an end cap assembly according to Embodiment 1 of the present invention.

[fig.4]Fig. 4 is a schematic diagram of a conductive path formed by the rotor of an implementation according to Embodiment 1 of the present invention.

[fig.5]Fig. 5 is another schematic diagram obtained when the rotor according to Embodiment 1 of the present invention is viewed along the axial direction.

[fig.6]Fig. 6 is a schematic diagram obtained before the end cap assembly is formed on the rotor according to Embodiment 1 of the present invention.

[fig.7]Fig. 7 is a schematic diagram of a manner in which an end cap is in contact with a conductive component when the end cap assembly is formed on the rotor according to Embodiment 1 of the present invention.

[fig.8]Fig. 8 is another schematic perspective diagram of the rotor according to Embodiment 1 of the present invention.

Description of Embodiments

[0017] The foregoing and other features of the present invention will become apparent from the following specification with reference to the accompanying drawings. Specific implementations of the present invention are disclosed in the specification and the accompanying drawings, which illustrate some implementations in which the principles of the present invention may be adopted. It should be understood that, the present invention is not limited to the implementations described, and conversely, the present invention includes all modifications, variations and equivalents that fall within the scope of the appended claims.

[0018] In the embodiments of the present invention, the singular form such as "a", "the", and the like includes the plural form, and should be broadly understood as "one kind" or "one category" rather than limited to "one". In addition, the term "the" should be understood to include both the singular form and the plural form, unless the context clearly indicates otherwise. In addition, the term "according to" should be understood to mean "at least in part according to", and the term "based on" should be understood

to mean "at least in part based on", unless the context clearly indicates otherwise.

[0019] In the following description of the present invention, for convenience of description, a center line around which a rotor core of a motor rotates is referred to as a "central axis", a direction that is the same as or parallel to a direction in which the central axis extends is referred to as an "axial direction", a radial direction that is centered on the central axis is referred to as a "radial direction", and a direction around the central axis is referred to as a "circumferential direction".

[0020] The following describes the embodiments of the present invention with reference to the accompanying drawings.

[0021] Embodiment 1

[0022] Embodiment 1 provides a rotor. The rotor is applied to a motor, such as a permanent-magnet auxiliary self-starting synchronous reluctance motor.

[0023] FIG. 1 is a schematic perspective diagram of the rotor according to the present embodiment. FIG. 2 is a schematic diagram obtained when the rotor according to the present embodiment is viewed along the axial direction. FIG. 3 is a schematic diagram of an end cap assembly according to the present embodiment.

[0024] As shown in FIG. 1 and FIG. 2, the rotor 10 has a rotor core 11, and the rotor core 11 rotates about a central axis O-O' and is composed of electromagnetic steel plates laminated along the axial direction. The rotor core 11 includes a plurality of flux barriers 11s penetrating through the electromagnetic steel plates along the axial direction, and a permanent magnet 12 is accommodated in at least one of the flux barriers. An end cap assembly 13 covering at least a part of the rotor core 11 is respectively disposed at two axial ends of the rotor core 11.

[0025] In the present embodiment, the end cap assembly 13 includes at least two end caps separately disposed along the circumferential direction.

[0026] FIG. 1 and FIG. 2 show a case in which the end cap assembly 13 includes four end caps 13-1, 13-2, 13-3, and 13-4, but the present embodiment is not limited thereto. A quantity of the end caps included in the end cap assembly 13 may be set according to the actual requirement.

[0027] For clarity, a set of flux barriers and a set of permanent magnets that are arranged along the radial direction are marked with reference numbers 11s and 12 in FIG. 1 and FIG. 2 merely by way of example. In FIG. 1, four sets of electromagnetic barriers 11s and four sets of permanent magnets 12 are disposed. Other sets of electromagnetic barriers and permanent magnets that are unmarked are disposed in a manner same as that in which the marked electromagnetic barriers and permanent magnets are disposed.

[0028] In the foregoing embodiment, the end cap assembly 13 is designed to include at least two end caps separately disposed along the circumferential direction, so that each end

cap can be disposed at a location freely in the circumferential direction, and can be located away from a location at which the permanent magnet 12 is inserted along the axial direction. Therefore, the end cap does not impede installation of the permanent magnet 12, so that more permanent magnets 12 can be installed into the flux barrier 11s, thereby improving output efficiency of the motor in which the rotor 10 is located.

[0029] In the present embodiment, the permanent magnet 12 may be exposed from adjacent end caps (for example, from the end cap 13-1 and the end cap 13-2, from the end cap 13-2 and the end cap 13-3, from the end cap 13-3 and the end cap 13-4, or from the end cap 13-4 and the end cap 13-1). The permanent magnet 12 may be exposed from adjacent end caps through setting of a distance between the adjacent end caps. In other words, the distance between adjacent end caps may be set to such a value that the end cap does not impede insertion of the permanent magnet 12 into the flux barrier 11s.

[0030] In the present embodiment, as shown in FIG. 1, the permanent magnet 12 may be accommodated in each of the plurality of flux barriers 11s. Therefore, more permanent magnets 12 can be installed into the flux barrier 11s of the rotor, thereby improving output efficiency of the motor. However, the present embodiment is not limited thereto, and the permanent magnet 12 may be accommodated in only some of the flux barriers 11s.

[0031] In the present embodiment, as shown in FIG. 1, the end caps 13-1, 13-2, 13-3, and 13-4 may be disposed at equal intervals along the circumferential direction. However, the present embodiment is not limited thereto, and the end caps 13-1, 13-2, 13-3, and 13-4 may also be disposed at different intervals along the circumferential direction, or some end caps may be disposed at equal intervals while other end caps are disposed at different intervals along the circumferential direction. A specific disposing manner may be determined according to the actual requirement.

[0032] In the present embodiment, the end caps 13-1, 13-2, 13-3, and 13-4 may be made of materials that are conductive but not magnetic, such as aluminum or copper.

[0033] In the present embodiment, as shown in FIG. 1 and FIG. 2, a conductive component 14 that is conductive but not magnetic may be further accommodated in the plurality of flux barriers 11s, and the conductive component 14 is connected to adjacent end caps. Similar to a manner of marking the flux barrier 11s and the permanent magnet 12, a set of conductive components 14 arranged in the radial direction is marked in FIG. 1 and FIG. 2 merely by way of example. The conductive component 14 is configured to generate an induction torque, and the conductive component 14 and the end cap connected to the conductive component 14 jointly form a conductive path of an induced current. As a result, the induced current generated during rotation of the rotor 10 can flow through the conductive path, so that the motor in which the rotor 10 is located can realize a self-starting characteristic.

- [0034] In the present embodiment, the conductive component 14 may be formed in the following manner: a jig (a shape and a size of the jig are corresponding to those of the permanent magnet 12) is inserted into the flux barrier 11s, a liquid material of the conductive component 14 is injected into the remaining space of the flux barrier 11s, and then the liquid material is solidified, thereby forming a solid conductive component 14 in the flux barrier 11s. Afterwards, the jig may be pulled out of the flux barrier 11s to form space for inserting a permanent magnet, and the permanent magnet 12 is inserted into the space.
- [0035] In an implementation, as shown in FIG. 1 and FIG. 2, the conductive component 14 is accommodated in each flux barrier 11s. Therefore, adjacent end caps are connected through each of a plurality of conductive components 14, thereby forming a plurality of conductive paths. In this way, the motor can have a high load capacity during self-starting, so that the motor has a good self-starting characteristic.
- [0036] FIG. 4 is a schematic diagram of the conductive path formed according to this implementation. As shown in FIG. 4, adjacent end caps 13-2 and 13-3 are conducted using each conductive component 14 in each flux barrier 11s, thereby forming a plurality of conductive paths Pa -> P1 -> Pb, Pa -> P2 -> Pb, and Pa -> P3 -> Pb.
- [0037] FIG. 5 is another schematic diagram obtained when the rotor according to the present embodiment is viewed in the axial direction.
- [0038] In another implementation, as shown in FIG. 5, the conductive component 14 is accommodated only in the radially outermost flux barrier of the plurality of flux barriers 11s, and the conductive component 14 is not accommodated in other flux barriers. Therefore, the adjacent end caps are conducted using only the radially outermost flux barrier of the plurality of flux barriers 11s. That is, the adjacent end caps are conducted using the conductive component 14 in the radially outermost flux barrier of the plurality of flux barriers 11s, thereby forming a conductive path.
- [0039] In this implementation, the induced current can still flow through a conductive path, and therefore, the motor still has a relatively high load capacity during self-starting. In addition, because the conductive component 14 is accommodated only in the radially outermost flux barrier, a permanent magnet of a maximum volume can be filled in the flux barriers other than the radially outermost flux barrier, thereby further improving output efficiency of the motor. In other words, in this implementation, the motor can have both a high load self-starting capacity and high output efficiency.
- [0040] In the present embodiment, the end cap may be in contact with a part of the conductive component 14, so that the end cap can be conducted to the conductive component 14, thereby forming a conductive path of the induced current. FIG. 6 is a schematic diagram obtained before the end cap assembly is formed on the rotor. FIG. 7 is a schematic diagram of a manner in which the end cap is in contact with the

conductive component 14 when the end cap assembly is formed on the rotor. As shown in FIG. 6 and FIG. 7, the end caps 13-1, 13-2, 13-3, and 13-4 are in contact with a part of the conductive component 14 shown using dashed lines.

[0041] In the present embodiment, as shown in FIG. 7, each end cap has a plurality of contact portions 13t in contact with the conductive component 14. Each contact portion 13t is at a location indicated using dashed lines in FIG. 7, and an area of each contact portion 13t may be determined according to the actual requirement.

[0042] During formation of the conductive component 14, the liquid material of the conductive component 14 needs to be injected into flux barrier space corresponding to the dashed-line location in FIG. 7. If the flux barrier space is pretty small (that is, the area of the contact portion is pretty small), it may be difficult to inject the liquid material into the flux barrier space. Consequently, the end cap cannot be in contact with the conductive component 14 in a desired manner. In the present embodiment, the area of each contact portion 13t may be set to be greater than four square millimetres, so that the liquid material of the conductive component 14 can be reliably injected into the flux barrier space corresponding to the dashed-line location in FIG. 7, and the end cap can be in contact with the conductive component 14 in a desired manner, thereby forming a corresponding conductive path.

[0043] FIG. 8 is another schematic perspective diagram of the rotor according to the present embodiment.

[0044] In the present embodiment, as shown in FIG. 8, a hole 15 may be formed on the end cap. Heat dissipation and/or maintaining of dynamic balance can be realized through formation of the hole 15. For heat dissipation, the hole 15 may be formed as a through hole. For maintaining of dynamic balance, the hole 15 may be formed as a through hole or as a non-through hole. For both heat dissipation and maintaining of dynamic balance, the hole 15 may be formed as a through hole. A size of the hole and a depth of the non-through hole may be determined according to the requirement for heat dissipation and/or maintaining of dynamic balance.

[0045] In FIG.8, the hole 15 is formed on one end cap (13-2), but the present embodiment is not limited thereto. The hole 15 may also be formed on a plurality of end caps. In FIG.8, the hole 15 is formed on a side surface of the end cap, but the present embodiment is not limited thereto. The hole 15 may also be formed on other locations of the end cap.

[0046] In the present embodiment, a shape of the end cap may be designed according to the actual requirement. For example, as shown in FIG. 1 to FIG. 5 and FIG. 7 to FIG. 8, the end cap is designed to be roughly arc-shaped when viewed along the axial direction. The present embodiment is not limited thereto, and the end cap may be designed to be circular, polygonal, or the like.

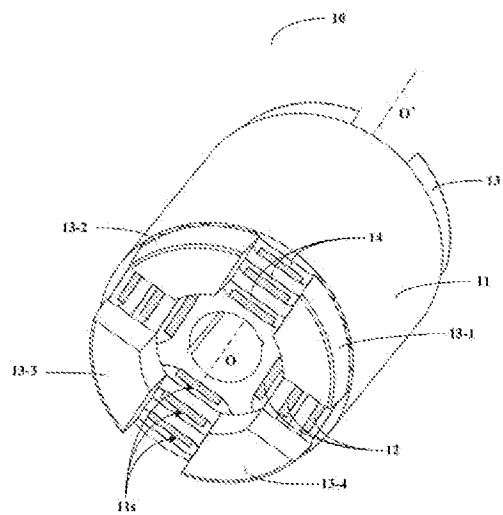
- [0047] According to the rotor in the present embodiment, the end cap assembly is designed to include at least two end caps separately disposed along the circumferential direction, so that the end cap does not impede installation of the permanent magnet, and more permanent magnets can be installed into the flux barrier, thereby improving output efficiency of the motor.
- [0048] Embodiment 2
- [0049] Embodiment 2 provides a motor having a stator and a rotor. The rotor may be as described in Embodiment 1, and the descriptions thereof are omitted herein. The motor may also include other components. For details, please refer to the conventional art.
- [0050] The motor in the present embodiment may be a permanent-magnet auxiliary self-starting synchronous reluctance motor.
- [0051] According to the motor in the present embodiment, the end cap does not impede installation of the permanent magnet, and more permanent magnets can be installed into the flux barrier, thereby improving output efficiency of the motor.
- [0052] The embodiments of the present invention are described in detail with reference to the accompanying drawings, which illustrate the manner in which the principles of the present invention may be adopted. It should be understood that the implementation of the present invention is not limited to manners of the above embodiments, and further includes all variations, modifications, and equivalents within the scope of the present invention.

Claims

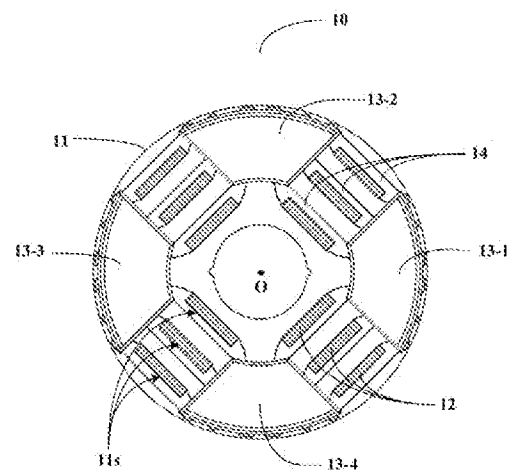
- [Claim 1] A rotor, comprising:
a rotor core rotating about a central axis and being composed of a plurality of electromagnetic steel plates laminated along an axial direction, the rotor core comprising a plurality of flux barriers penetrating through the electromagnetic steel plates along the axial direction, and a permanent magnet being accommodated in at least one of the flux barriers; and
an end cap assembly covering at least a part of the rotor core and being respectively disposed at two axial ends of the rotor core, wherein the end cap assembly comprises at least two end caps separately disposed along a circumferential direction.
- [Claim 2] The rotor according to claim 1, wherein
the at least two end caps are disposed at equal intervals along the circumferential direction.
- [Claim 3] The rotor according to claim 1, wherein
the permanent magnet is exposed from adjacent end caps.
- [Claim 4] The rotor according to claim 1, wherein
the permanent magnet is accommodated in each of the flux barriers.
- [Claim 5] The rotor according to claim 1, wherein
the end cap is made of a material that is conductive and not magnetic.
- [Claim 6] The rotor according to claim 1, wherein
a conductive component that is conductive and not magnetic is further accommodated in the plurality of flux barriers, the conductive component being connected to the adjacent end caps.
- [Claim 7] The rotor according to claim 6, wherein
the conductive component is accommodated in each of the flux barriers.
- [Claim 8] The rotor according to claim 6, wherein
the conductive component is accommodated in a radially outermost flux barrier of the plurality of flux barriers.
- [Claim 9] The rotor according to any one of claims 6 to 8, wherein
each of the end caps comprises a plurality of contact portions in contact with the conductive component, an area of each of the contact portions being greater than 4 square millimetres.
- [Claim 10] The rotor according to claim 1, wherein
a hole is formed on the end cap.

- [Claim 11] The rotor according to claim 1, wherein the end cap is arc-shaped when viewed along the axial direction.
- [Claim 12] A motor, comprising a stator and the rotor according to any one of claims 1 to 11.

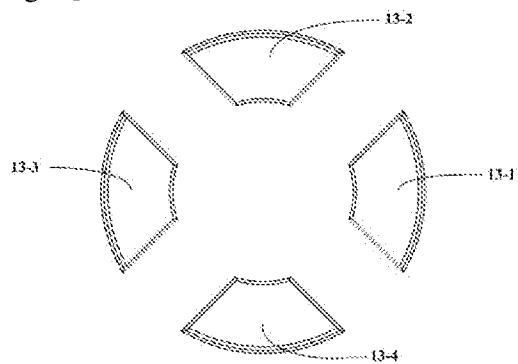
[Fig. 1]



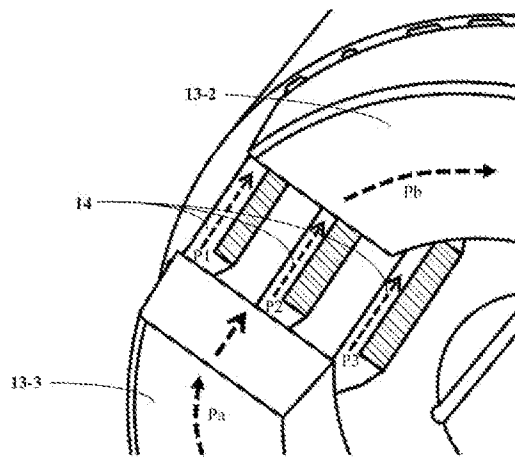
[Fig. 2]



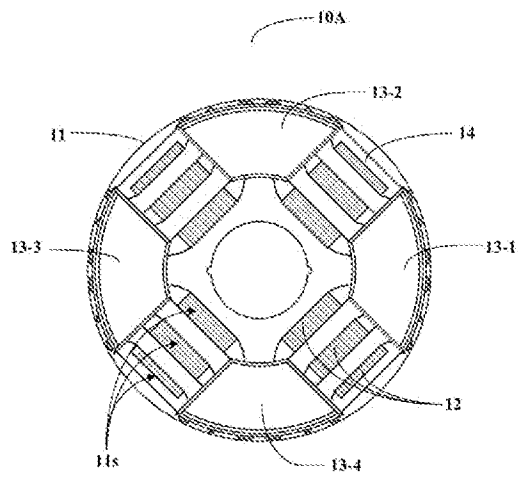
[Fig. 3]



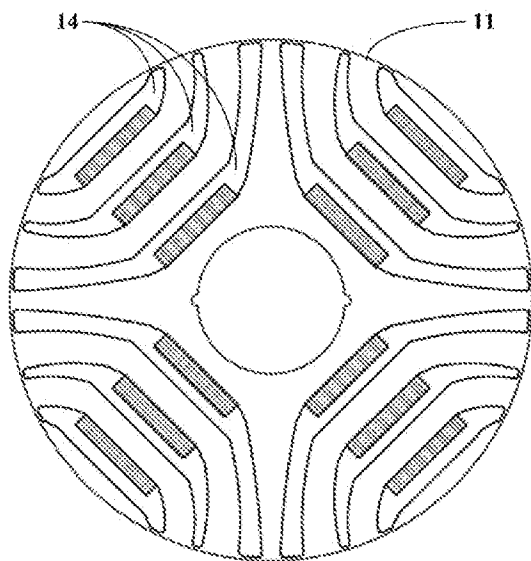
[Fig. 4]



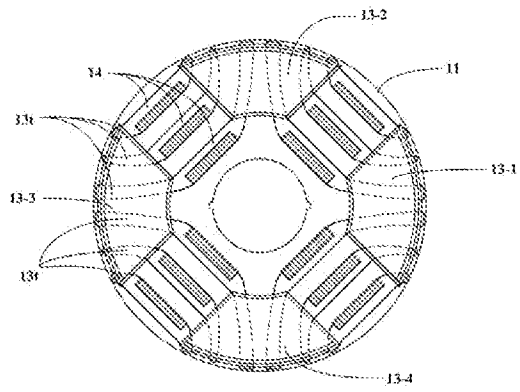
[Fig. 5]



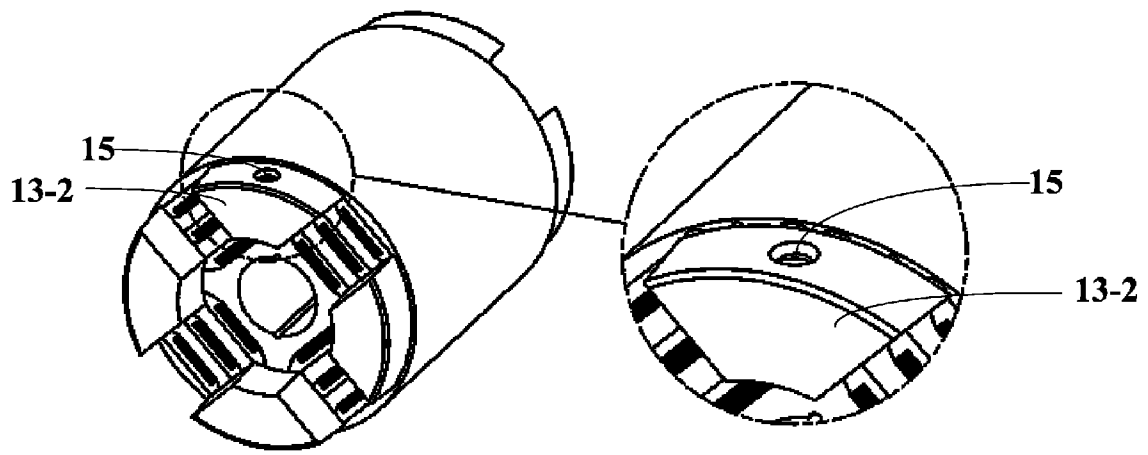
[Fig. 6]



[Fig. 7]



[Fig. 8]



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2020/000014

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02K1/24 H02K19/14 H02K21/46
ADD. H02K1/27

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 3 160 013 A1 (ABB SCHWEIZ AG [CH]) 26 April 2017 (2017-04-26)	1-9,11, 12
Y	Paragraphs 1, 12, 29, 30; figures 1,2,5,7	10
X	CN 107 834 800 A (WOLONG ELECTRIC GROUP CO LTD) 23 March 2018 (2018-03-23)	1-9,11, 12
Y	Paragraphs 32, 35; figure 2	10
Y	US 4 490 638 A (LIND LEROGER J [US]) 25 December 1984 (1984-12-25) figure 7	10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

11 March 2020

Date of mailing of the international search report

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Authorized officer

Jabri, Tarak

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP2020/000014

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