



- (51) **International Patent Classification:**
H02K 5/20 (2006.01) *H02K 9/19* (2006.01)
- (21) **International Application Number:**
PCT/EP2016/057224
- (22) **International Filing Date:**
1 April 2016 (01.04.2016)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
201520192856.3 1 April 2015 (01.04.2015) CN
201510153598.2 1 April 2015 (01.04.2015) CN
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- (81) **Designated States** (*unless otherwise indicated, for every
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, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
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, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, 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).

Published:

— with international search report (Art. 21(3))

- (54) **Title:** A MOTOR FOR ELECTRIC VEHICLES AND THE STATOR THEREOF

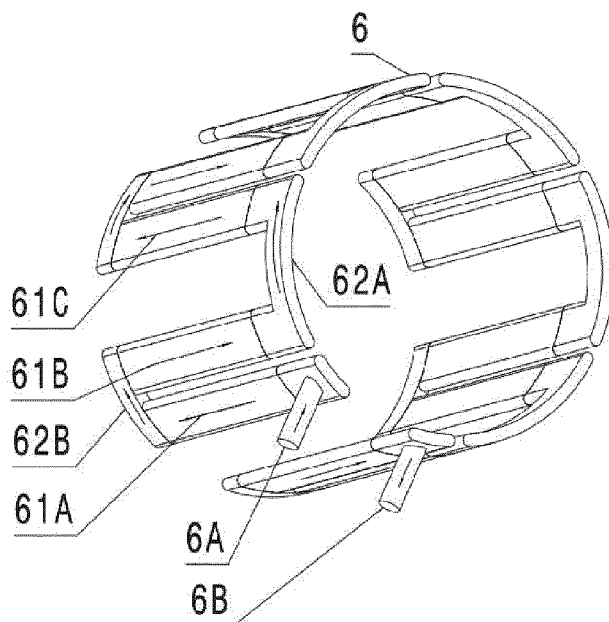


Figure 5

(57) **Abstract:** The present invention provides a motor stator comprising a stator body; a stator casing which circumferentially surrounds the outer contour of the stator body and is fitted on said stator body; a first end cap and a second end cap which are respectively located on the two side ends in the axial direction of said stator casing; a cooling flow passage for the stator which is distributed in said stator casing, first end cap, and second end cap; and fasteners which are used to fasten the stator casing and the end caps on the two sides to form the sealed structure of said cooling flow passage. Through the design of a brand-new stator structure with a cooling flow passage, the present invention makes it possible that a relatively simple extrusion process can be applied to improve the yield of finished products and lower the manufacturing cost.

Specification

A Motor for Electric Vehicles and the Stator Thereof

5 **Technical Field**

The present invention relates to the technical field of motor manufacturing of electric vehicles, and in particular relates to a motor for electric vehicles and the stator thereof.

10 **Background Art**

With the high-speed development of the automotive industry, a series of problems such as oil shortage, environmental warming, and climate warming have emerged. As representatives of new energy vehicles, electric vehicles will inevitably become one of the important development directions of the automotive industry in China. The performance of the electric driving system which serves as the only power source of electric vehicles directly affects the power performance, stability, and comfort of the vehicles.

20

Originally, DC motors were developed to serve as traction motors of electric vehicles because DC motors have advantages such as a large starting accelerating traction and a simple control system. However, the disadvantage of DC motors is that they have a mechanical commutator. When DC motors run at high speed and heavy duty, sparks will be produced on the surface of the commutator. Therefore, the revolving speed of DC motors must not be too large. For this reason, the traction motors of electric vehicles have mainly been AC asynchronous motors and permanent magnet motors in recent years. The vector control based speed regulation technology of AC asynchronous motors is relatively well-developed and the driving system of AC asynchronous motors has significant advantages. Therefore, AC asynchronous motors were used as the driving system of electric vehicles early on, and currently, they are still the leading products of the driving system of electric vehicles. Compared with permanent magnet

motors, AC asynchronous motors have a lower power density, however.

The design of the motors for electric vehicles requires that characteristics such as small volume, light weight, high power density, and good heat dissipation should be satisfied. Therefore, liquid cooling is generally used as a heat dissipation method for the motors (mainly AC asynchronous motors and permanent magnetic motors) for electric vehicles. The cooling flow passage of motors is generally set around the motor stator, and the heat of motors is taken away through the flowing/circulation of a cooling medium. The common methods of setting a cooling flow passage around the motor stator are as follows:

Method 1: For example, as shown in Figure 1, the flow passage (7) of a cooling medium (referred to as cooling flow passage), disclosed in China patent application No.201410697450.0, is arranged on the end cap which is fitted on one side of the motor stator casing. Currently, such a structure can be implemented only by use of sand casting.

Method 2: For example, as shown in Figure 2, the cooling flow passage disclosed in China patent application No.201410475426.2 is arranged on the support base used to fasten the stator armature. Currently, such a structure can be implemented only by use of sand casting.

Method 3: For example, as shown in Figure 3, the cooling flow passage (8) disclosed in China patent application No.201420488233.6 is arranged in the motor casing and the cooling flow passage (8) helically surrounds the circumference of the outer contour of the stator body in the upper die cavity (1) according to the direction of the stator winding in the motor casing and the length of the stator core. Currently, such a structure can be implemented only by use of die casting.

Method 4: The inner and outer casings of the motor stator are machined, the decomposed structures of the cooling flow passage are arranged on the inner and outer casings, and the breakdown structures of the cooling flow passage can form a sealed flow passage after the inner and outer casings are assembled.

For all motors in the prior art of adopting a cooling flow passage for heat dissipation, the stator is manufactured by use of sand casting, die casting, or machining and assembling of inner and outer casings. However, (1) the sand casting process has the following problems: blow holes are easily produced during casting to bring about a leaky cooling flow passage; in addition, dies need to be re-developed for stators with different lengths in different series of products, and thus the manufacturing cost of motors is too high; moreover, the stators cast by use of sand casting have low strength and are apt to wear. (2) The process of machining and assembling of inner and outer casings has the following problems: a high fit dimension precision is required between the inner and outer casings and the assembly process is complex. (3) The die casting process has the following problems: restricted by the design of the casting dies, the cross section of the cooling flow passage will increase and the actual cooling effect will be poorer than the expected cooling effect; dies need to be re-developed for stators with different lengths in different series of products and thus the manufacturing cost is high; moreover, the stators cast by use of die casting have low strength and are apt to wear.

Therefore, on the one hand, the process of sand casting, die casting, or machining and manufacturing of inner and outer casings itself is unfavorable to the production of small motors, and on the other hand, the rate of rejects is high, the reliability of motors is low, and the machining and assembling difficulty is great so that the manufacturing cost of motors stays at a high level.

In view of the technical problems existing in the heat dissipating structures of motors of electric vehicles in the prior art, new manufacturing processes need to be sought for and corresponding mechanical structures need to be designed so that the yield of finished products of stators with a cooling flow passage can be improved greatly and the machining and assembling difficulty can be lowered, thus realizing mass manufacturing of motors and reducing the manufacturing cost of motors.

10 **Summary of the Invention**

For the above-mentioned technical problems, the present invention designs a new stator casing for electric vehicles on the basis of a lot of trial manufacturing experiments and the stator casing can be integrated and manufactured by use of the extrusion process so that the yield of finished products of stators with a cooling flow passage is improved and the manufacturing cost of motors is lowered.

To achieve the above-mentioned object, firstly, the present invention provides a cooling flow passage for stators. The cooling flow passage comprises straight-through cooling sub-passages which are set in the stator casing, extend in the axial direction of said stator casing and run through said stator casing, and connecting grooves which are set in the end caps of the stator casing and are used to seal and connect different cooling sub-passages after the end caps are fitted with the stator casing so that a cooling medium can flow in different cooling sub-passages continuously.

Secondly, the present invention also provides a motor stator casing for electric vehicles, which is applicable to stators of AC asynchronous motors or permanent magnet motors, comprises the above-mentioned straight-through cooling sub-passages, and is manufactured into an integral body by use of the extrusion process.

Thirdly, the present invention also provides a motor stator assembly accommodating device, which comprises a stator casing used to accommodate the motor stator, end caps fitted at the ends on the two axial sides of said stator casing, and a cooling flow
5 passage distributed in said stator casing and said end caps, wherein said cooling flow passage distributed in said stator casing and said end caps is the above-mentioned cooling flow passage for stators.

10 Fourthly, the present invention also provides a motor stator for electric vehicles, which comprises a stator body, a stator casing circumferentially surrounding the outer contour of the stator body and fitted on said stator body, a first end cap and a second
15 end cap respectively located on the two side ends in the axial direction of said stator casing, a cooling flow passage for the stator distributed in said stator casing, first end cap, and second end cap, and fasteners used to fasten the stator casing and the end caps on the two sides to form the sealed structure of said cooling flow passage, wherein said cooling flow passage
20 distributed in said stator casing and said end caps is the above-mentioned cooling flow passage for stators.

Fifthly, the present invention also provides a motor for electric vehicles, which comprises the above-mentioned stator.

25 The innovation of the present invention lies in that through the design of a brand new stator structure with a cooling flow passage, a relatively simple extrusion process can be applied to improve the yield of finished products and lower the
30 manufacturing cost.

Further, the manufacturing process of the cooling flow passage manufactured by use of the extrusion process is simple, the sealing performance of the cooling flow passage is greatly
35 improved, the cooling flow passage is sealed by ends, and the assembling process is simple and reliable. By comparison, the cooling flow passage manufactured by use of the extrusion process

is by far better than the cooling flow passage obtained by use of sand casting, die casting, or machining and assembling of inner and outer casings.

5 Further, since the extrusion process is adopted, the stator casing can have any length as required and the same set of dies can be used for a series of stators with different lengths to meet different specifications of different types of motors, thus improving the application scope of the extrusion process and the
10 manufacturing efficiency of the stator structure and lowering the manufacturing cost.

Further, the motor stator casing for electric vehicles in the present invention is manufactured into an integral body with a
15 cooling flow passage by use of the extrusion process and is sealed through the end caps preset with connecting grooves to form a closed circulation passage for a cooling medium. Such a structure and the extrusion process can greatly improve the yield of finished products and lower the manufacturing cost.

20 The additional aspects and advantages of the present invention will be given in the description below and they will become obvious in the description below or be learned through practice of the present invention.

25

Brief Description of the Drawings

The drawings described here are used to provide a better understanding of the present invention and constitute a part of the application. The exemplary embodiments of the present
30 invention and the description are used to explain the present invention, but do not constitute an improper limitation of the present invention. In the drawings,

Figure 1 is a schematic diagram for the first structure of the
35 motor stator with a cooling flow passage in the prior art.

Figure 2 is a schematic diagram for the second structure of the motor stator with a cooling flow passage in the prior art.

5 Figure 3 is a schematic diagram for the third structure of the motor stator with a cooling flow passage in the prior art.

Figure 4A and Figure 4B are exploded views of the motor stator with a cooling flow passage in one embodiment of the present invention.

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Figure 5 is a three-dimensional view of the cooling flow passage after the stator casing in the embodiment in Figure 4A and Figure 4B is assembled.

15 Figure 6 is a front view of the assembled stator in the embodiment in Figure 4A, viewed from the side of fasteners to the opposite side.

20 Figure 7 is a cutaway view of section A-A in the embodiment in Figure 6.

Figure 8 is a cutaway view of section B-B in the embodiment in Figure 6.

25 Figure 9 is a cutaway view of section C-C in the embodiment in Figure 8.

Figure 10 is a cutaway view of section D-D in the embodiment in Figure 8.

30

Figure 11 is a perspective view of section D-D in the embodiment in Figure 8.

Detailed Description of the Invention

35 To let those skilled in the art have a better understanding of the technical solution of the present invention, the following further describes in detail the present invention in combination

with drawings and specific embodiments. The following will describe in detail the embodiments of the present invention. The examples of the described embodiments are given in the drawings, where the same or similar reference number represents the same or similar element or an element having the same or similar function throughout. The embodiments described by reference to the drawings are exemplary and are only used to explain the present invention, but should not be interpreted as limitations to the present invention.

Those skilled in the art should understand that the singular form modified by "one", "said", and "the" may also include the plural form, unless specifically stated. It should be further understood that the word "comprises" or "comprising" used in the specification of the present invention means that said characteristic, integer, step, operation, element and/or assembly exist(s), but does not exclude one or more other characteristics, integers, steps, operations, elements, assemblies, and/or a group of them. It should be understood that when we say an element is "connected" or "coupled" to another element, it can be directly connected or coupled to another element, or connected to another element with an intermediate element. In addition, the word "connection" or "coupling" used here may also include wireless connection or coupling. The words "and/or" used here include any unit and all combinations of one or more associated items listed.

Those skilled in the art should understand that all terms (including technical terms and scientific terms) used here have the same meanings as those skilled in the art generally understand, unless otherwise defined. It should also be understood that the terms defined in common dictionaries should be interpreted as the meanings which agree with the meanings in the context of the prior art, and they will not be interpreted by use of ideal or too formal meanings unless defined like those in this document.

[Overall structure of stator] Figure 4A and Figure 4B are exploded views of the motor stator with a cooling flow passage in one embodiment of the present invention. Figure 5 is a three-dimensional view of the cooling flow passage after the stator casing in the embodiment in Figure 4A and Figure 4B is assembled. As shown in Figure 4A and Figure 4B, the motor stator provided in the present invention is applicable to AC asynchronous motors or permanent magnetic motors, and comprises a stator body (4); a stator casing (1) which circumferentially surrounds the outer contour of the stator body and is fitted on the stator body (4) (for example, assembled by use of shrink fit); a first end cap (2) and a second end cap (3) which are respectively located on the two side ends in the axial direction (longitudinal direction in Figure 4A and Figure 4B) of said stator casing (1); a cooling flow passage (6) (as shown in Figure 5) for the stator which is distributed in said stator casing (1), first end cap (2), and second end cap (3); and fasteners (5) which are used to fasten the stator casing and the end caps on the two sides to form the sealed structure of said cooling flow passage (6) (as shown in Figure 5).

As shown in Figure 4A, Figure 4B, and Figure 5, as one embodiment, straight-through cooling sub-passages are set in the stator casing (1), and connecting grooves are set in the first end cap (2) and the second end cap (3), respectively. Straight-through cooling sub-passages are set in the stator casing, extend in the axial direction of said stator casing and run through said stator casing; connecting grooves are set in the end caps of the stator casing and are used to seal and connect different cooling sub-passages after the end caps are fitted with the stator casing so that a cooling medium can flow in different cooling sub-passages continuously. Further, the stator casing (1) has an interior wall and an exterior wall and straight-through cooling sub-passages are set between the interior wall and the exterior wall of the stator casing (1). Further, an uninterruptible separation area is set between different straight-through cooling sub-passages in the stator casing. Alike, an

uninterruptible separation area is also set between different connecting grooves in the same end cap.

It should be understood that the cooling flow passage (6) designed for stators in the present invention is divided into two different parts, with one part set in the end caps (2 and 3) on the two sides (and called connecting groove) and the other part set in the stator casing (1) (and called straight-through cooling sub-passage) so that the shape and size of the cross-section of straight-through cooling sub-passages set in the stator casing 1 are set according to the radian of the outer contour of the stator body to maximize the contact area between said cooling sub-passages and the stator body. As one embodiment, the cross-sectional shape of straight-through cooling sub-passages agrees with the radian shape of the outer contour of the stator body. Preferably, the shape of the cross-section of straight-through cooling sub-passages looks like a waist or flattened mouth, as shown in Figure 4A and Figure 4B.

[Innovation description] One of the innovations of the present invention lies in that the distributed design concept is innovatively introduced to the design of the cooling structure of the stator. The distributed design divides the cooling flow passage which is conventionally designed and manufactured into an integral body into straight-through cooling sub-passages and connecting grooves, where straight-through cooling sub-passages are set in the stator casing and connecting grooves are set in the end caps of the stator casing. The "cooling sub-passage" concept introduced in the distributed design simplifies the conventional design scheme for a cooling flow passage. In addition, the "cooling sub-passage" which can be manufactured according to a standard is set in the stator casing so that the stator casing with cooling sub-passages in the present invention can be manufactured by use of the extrusion process. Further, the shape, size, and structure of connecting grooves can be adjusted at any time according to different design schemes for straight-through cooling sub-passages. For example, when the

diameter of cooling sub-passages is enlarged or reduced, the cross-sectional size of the connecting grooves can be increased or decreased accordingly; when the spacing distance between cooling sub-passages is enlarged or reduced, the cross-sectional width can be increased or decreased accordingly. The design scheme provided in the present invention greatly simplifies the structure of the stator with a cooling flow passage. The reliability of products and the yield of finished products are improved by use of the extrusion process. In addition, the manufacturing cost is greatly lowered since machining is avoided.

[Straight-through cooling sub-passage] The major function of straight-through cooling sub-passages lies in that the adoption of the standard design facilitates the manufacturing by use of the extrusion process and that the area of contact with the stator body is maximized to improve the cooling efficiency. As shown in Figure 5, straight-through cooling sub-passages (61) in the stator casing (1) are passages which are set in the stator casing (1) and extend in the direction parallel to the axis of the stator (4). In addition, straight-through sub-passages (61) in the stator casing run through the stator casing (1) in the axial direction, and thus a plurality of sub-passages running from one axial end of the stator casing (1) to the other axial end of the stator casing (1) are formed. Those skilled in the art can set the quantity, and the cross-sectional shape (for example, an elliptical cross-section) and size of straight-through cooling sub-passages (61) according to the actual requirements. These variants are all within the scope of protection of the present invention. In addition, each cooling sub-passage in the stator casing is closed, straight-through, and parallel to the axial direction of the stator in accordance with the standard design, which facilitates the manufacturing by use of the extrusion process.

[Shrink fit process] Further, in the present invention, the shrink fit process (for example, heat the aluminum or aluminum alloy casing and extrude the casing so that the inner hole of the

casing is increased to produce a clearance between the inner hole and the outside diameter of the stator) can be adopted to position and assemble the stator and the stator casing with a fixture, and after cooling, an interference pre-tightening force is produced between the stator and a the stator casing so that the stator casing can be tightly combined with the stator body.

[Hot extrusion process] Further, in the present invention, the open-die hot extrusion process can be adopted. The aluminum ingot used to be manufactured into stator casings is set in the die cavity and is extruded into a long blank casing body being used for manufacturing stator casing, and the length of the casing body is cut according to the length of the stator. For example, first set an extrusion die according to the shape and size of the required motor stator, then fasten the extruded section bar used to be manufactured into a stator casing on the slider of the die base, use the ejector block to push the slider to bring the section bar to the extrusion position and extrude the section bar into the required shape, and finally perform annealing setting and gumming to obtain the stator casing. For the casing structure provided in the present invention and the corresponding manufacturing process, a set of manufacturing dies can be adopted to manufacture different types of stators. This avoids the repeated design of stator casings and the structure and size of the corresponding cooling flow passage, and in addition, the dies are simple. Thus, the manufacturing cost is greatly lowered.

[Connecting groove] The major function of connecting grooves lies in that they connect adjacent cooling sub-passages. Connecting grooves can be designed into one type or two types, or can be configured according to the type of the cooling sub-passages. Preferably, the connecting grooves described in the embodiments of the present invention are of two types, namely, Type I connecting grooves (62B) and Type II connecting grooves (62A). As shown in Figure 4A, Figure 4B, and Figure 5, one or more Type I connecting grooves (62B) which extend in the circumferential direction of the first end cap (2) are set on the end face of the

first end cap (2) adjacent to the stator casing (1), and one or more Type II connecting grooves (62A) which extend in the circumferential direction of the second end cap (3) are set on the end face of the second end cap (3) adjacent to the stator casing (1). Type I connecting grooves (62B) and Type II connecting grooves (62A) are uniformly called groove structures (62). The shape and size of groove structures (62) are so designed that each groove structure (62) can respectively connect the fluids in two adjacent cooling sub-passages (61) in the stator casing (1), that is to say, the cross-section of each groove structure (62) can completely overlap the cross-sections of two adjacent cooling sub-passages (61). That is to say, the groove structure (62) is a cooling sub-passage set on the first end cap (2). Type I connecting grooves (62B) are used to connect two adjacent cooling sub-passages (61A and 61B) between which a first spacing distance is, and Type II connecting grooves (62A) are used to connect two adjacent cooling sub-passages (61B and 61C) between which a second spacing distance is. Type I connecting grooves (62B) can be set in the first end cap (2), and Type II connecting grooves (62A) can be set in the second end cap (3). In the present invention, a part of the cooling flow passage is set in the end caps on the two sides so that the overall structure of the cooling flow passage is simple and a closed flow passage is formed for a circulating cooling medium after the end caps on the two sides and the stator casing are assembled. Further, such a design allows the sealing performance of the end faces to be improved greatly and the structure to be simple and reliable.

It should be understood that since the cooling flow passage provided by the prior art for a stator is restricted by the manufacturing process or the size and shape of the configured component, the required contact area can be calculated only in advance, the contact shape will be designed according to the contact area, and the stator will be manufactured by use of sand casting, die casting, or machining and assembling of inner and outer casings. For such a method, repeated die development is required, the process of manufacturing the cooling flow passage

is not flexible, and the cost is high. However, in the present invention, the distributed cooling flow passage design is introduced and the extrusion process is adopted to manufacture the stator casing with straight-through cooling sub-passages so that the manufacturing process is flexible without repeated die development and the manufacturing cost is lowered.

[Type I connecting groove] As one embodiment, since Type I connecting grooves (62B) are used to connect two adjacent cooling sub-passages (61A and 61B) between which the first spacing distance is, Type I connecting grooves (62B) can be grooves directly opened on the first end cap (2). For example, the specific positions of Type I connecting grooves (62B) are indicated by reference number 62 in Figure 4B, and their shapes and structures are indicated by reference number 62B in Figure 5. Preferably, the two-dimensional shape of Type I connecting grooves (62B) is a rectangle and Type I connecting grooves are used to connect the cooling sub-passages (61A and 61B).

[Type II connecting groove] As one embodiment, since Type II connecting grooves (62A) are used to connect two adjacent cooling sub-passages (61B and 61C) between which the second spacing distance is, and screw holes or similar structures need to be reserved between cooling sub-passages (61B and 61C) to screw in fasteners (5), the following solution can be adopted for Type II connecting grooves (62A): a groove is respectively opened at the two ends and the two grooves are then connected through the built-in passage in the end cap body. For example, a Type II connecting groove (62A) comprises three parts: a first sub-groove opened in the second end cap (3) to connect the cooling sub-passage (61B), a second sub-groove opened in the second end cap (3) to connect the cooling sub-passage (61C), and a built-in passage which is buried in the second end cap (3) to combine the first sub-groove and the second sub-groove respectively. The specific positions of Type II connecting grooves (62A) are indicated by reference number 7 in Figure 4A, and their shapes and structures are indicated by reference number (62A) in Figure

5. Preferably, the two-dimensional shape of Type II connecting grooves (62A) is trouser-like or concave and Type II connecting grooves are used to connect the cooling sub-passages (61B and 61C). It should be understood that since screw holes or similar structures need to be reserved to screw in fasteners, the spacing distance (hereinafter referred to as second spacing distance) between cooling sub-passages (61B and 61C) to be connected by Type II connecting grooves (62A) is greater than the spacing distance (hereinafter referred to as first spacing distance) between cooling sub-passages (61A and 61B) to be connected by Type I connecting grooves (62B).

It should be understood that the trouser-like or concave structure of Type II connecting grooves (62A) and the rectangular structure of Type I connecting grooves (62B) are interconnecting structures, which is also a preferred embodiment of the present invention. The trouser-like or concave structure of Type II connecting grooves (62A) implements the function of mixing the cooling medium flowing in the second end cap (3), and the rectangular structure of Type I connecting grooves (62B) implements the function of mixing the cooling medium flowing in the first end cap (2).

It should be understood that according to one embodiment of the present invention, the rectangular Type I connecting grooves (62B) cooperate with the trouser-like or concave Type II connecting grooves (62A) to connect cooling sub-passages (61A, 61B, and 61C) so that the grooves and sub-passages form a closed cooling flow passage for the stator. As one embodiment, the cooling flow passage is distributed in the S shape in the axial direction of the stator casing to effectively increase the contact area between the cooling flow passage and the stator body, and thus the cooling efficiency can be improved. As one embodiment, straight-through cooling sub-passages are rotationally arranged around the circumference of the stator body. Preferably, 12 flattened-mouth, closed, and straight-through fluid passage structures are rotationally

arranged around the stator. Such an arrangement allows the temperature field to be distributed evenly and enhances the cooling effect. As another embodiment, the cross-sectional shape of straight-through cooling sub-passages looks like a waist or flattened mouth. As a third embodiment, straight-through cooling sub-passages are parallel to the axial direction of the stator.

[Cross-sectional size of connecting groove] The cross-sectional shape and size of said grooves are configured according to the cross-sectional shape and size of different cooling sub-passages and the spacing distances therebetween, so that the end caps can transversely seal different cooling sub-passages and longitudinally connect these different cooling sub-passages after the end caps are fitted with the stator casing.

[Unequal spacing distance] As one embodiment, when the quantity of straight-through cooling sub-passages set in the stator casing is at least three, the first spacing distance between the first cooling sub-passage (61A) and the second cooling sub-passage (61B) is smaller than the second spacing distance between the second cooling sub-passage (61B) and the third cooling sub-passage (61C) so that a screw hole can be set within the area of the second spacing distance to screw in a fastener to tightly fasten the end caps on the two sides of the stator to the stator casing. Further, when the first spacing distance is smaller than the second spacing distance, cross-sectional size W_{g1} of a Type I connecting groove $\geq$ cross-sectional size W_{a1} of the first cooling sub-passage (61A) + cross-sectional size W_{b1} of the second cooling sub-passage (61B) + first spacing distance $D1$; cross-sectional size W_{g2} of a Type II connecting groove $\geq$ cross-sectional size W_{b1} of the second cooling sub-passage (61B) + cross-sectional size W_{c1} of the third cooling sub-passage (61C) + second spacing distance $D2$. **[Equal spacing distance]** As another embodiment, if the first spacing distance is equal to the second spacing distance, connecting grooves must be of the same type of grooves, that is to say, if the spacing distances between cooling sub-passages are equal, the shapes of the grooves set in the end caps on the two sides can be completely the same, but connecting

grooves in the end caps on the two sides should be set accordingly when the end caps are fitted with the stator casing, so that a closed cooling flow passage is formed. Further, cross-sectional size of connecting grooves $\geq$ cross-sectional size of any cooling sub-passage + cross-sectional size of the other of two adjacent cooling sub-passages + spacing distance between two adjacent cooling sub-passages.

[Flow rate control scheme] Further, the longitudinal depth of said grooves is configured according to the required flow rate of the cooling medium. It should be understood that those skilled in the art can design a specific mechanical structure by reference to the mathematical relationship between the cross-section of a component and the physical properties of different circulating media in physics or mechanics.

[Inlet and outlet of cooling medium] In the present invention, the inlet (6A) and outlet (6B) of a cooling medium can be set on an end cap. It should be understood that the inlet (6A) and the outlet (6B) can both be set on the same end cap on one side, or the inlet (6A) and the outlet (6B) can respectively be set on different end caps on the two sides. It should be understood that when the inlet (6A) and the outlet (6B) for a cooling medium are set on the same end cap on one side, no connecting passage is directly set between the inlet (6A) and the outlet (6B) to avoid the flow passage from being shortened. Such a design idea is aimed at enabling a cooling medium to run along the longest cooling passage. Therefore, a separation structure should be set between the inlet (6A) and the outlet (6B) in advance. As one embodiment, the inlet (6A) and the outlet (6B) of a cooling medium can be set on the second end cap (3) where Type II connecting grooves (62A) are located. For example, when the inlet (6A) and outlet (6B) for a cooling medium are set on the second end cap (3), the inlet (6A) is set on the first sub-groove interconnecting one cooling sub-passage, and the outlet (6B) is set on the second sub-groove interconnecting another cooling sub-passage, and in addition, no built-in passage is set between the cooling sub-passage fitted

with the inlet (6A) and the other cooling sub-passage fitted with the outlet (6B).

Therefore, the cooling passage (6) provided in the present invention for a stator can comprise: straight-through cooling sub-passages (61) which are set in the stator casing (1), extend in the axial direction of said stator casing (1) and run through said stator casing; and connecting grooves (62) which are set in the end caps of the stator casing (1) and are used to seal and connect different cooling sub-passages after the end caps are fitted with the stator casing so that a cooling medium can flow in different cooling sub-passages continuously. It should be understood that after the stator casing (1), the first end cap (2) and the second end cap (3) are assembled together, the cooling sub-passages in the stator casing (1) and connecting grooves in the first end cap (2) and the second end cap (3) are connected through a fluid to form a complete cooling flow passage (6) shown in Figure 5.

It should be understood that straight-through cooling sub-passages shown in Figure 5 are not limited to the given shapes, sizes, structures, and spacing distances of cooling sub-passages (61A, 61B, and 61C), or limited to six pairs of (namely, twelve) cooling sub-passages (61A and 61B) which approach each other in pairs. For example, different sizes and shapes can be designed for the flow passage. For example, more than three cooling sub-passages can be connected. For example, a suitable quantity, such as two pairs (namely, four), three pairs (namely, six), four pairs (namely, eight), five pairs (namely, ten), eight pairs (namely, sixteen), and twelve pairs (namely, twenty-four), of cooling sub-passages can be set.

Figure 6 is a front view of the assembled stator in the embodiment in Figure 4A, viewed from the side of fasteners to the opposite side. Figure 7 is a cutaway view of section A-A in the embodiment in Figure 6. Figure 8 is a cutaway view of section B-B in the embodiment in Figure 6. Figure 9 is a cutaway view of section C-C

in the embodiment in Figure 8. Figure 10 is a cutaway view of section D-D in the embodiment in Figure 8. Figure 11 is a perspective view of section D-D in the embodiment in Figure 8. As shown in the above figures, after the stator casing (1), the first end cap (2) and the second end cap (3) are assembled together, and different parts of the cooling flow passage (6) are connected through a fluid to form a complete cooling flow passage (6) shown in Figure 5. As one embodiment, as shown in Figure 6- through Figure 11, the parts of the cooling flow passage in the stator casing (1) are cooling sub-passages (61) which are set in the stator casing (1) and extend in the direction parallel to the axis of the stator (4). In addition, cooling sub-passages (61) in the stator casing run through the stator casing (1) in the axial direction, and thus a plurality of sub-passages running from one axial end of the stator casing (1) to the other axial end of the stator casing (1) are formed. As shown in Figure 6- through Figure 11, a plurality of groove structures (62) (above-mentioned Type I connecting grooves (62B)) which extend in the circumferential direction of the first end cap (2) are set on the end face of the first end cap (2) adjacent to the stator casing (1), and the shape and size of groove structures (62) are so designed that each groove structure (62) can respectively connect the fluid in two adjacent cooling sub-passages (61) in the stator casing (1), that is to say, the cross-section of each groove structure (62) can completely overlap the cross-sections of two adjacent cooling sub-passages (61). That is to say, the groove structure (62) is a cooling sub-passage set on the first end cap (2).

As shown in Figure 6 through Figure 11, a plurality of opening grooves (7) (above-mentioned Type II connect grooves (62A)) are set on the end face of the second end cap (3) adjacent to the stator casing (1), and the shape of opening grooves (7) matches the cross-sectional shape of the cooling sub-passage (61) in the stator casing (1) so that these opening grooves (7) connect the fluid in each cooling sub-passage (61) in the stator casing (1). The built-in passages set in the second end cap (3) are a plurality of built-in passages which are set in the second cap (3) and extend

in the circumferential direction of the second end cap (3), and the fluid in each built-in passage is connected between two corresponding opening grooves (7).

5 After said stator casing (1), the first end cap (2), and the second end cap (3) are assembled together, on the ends adjacent to the first end cap (2), two adjacent cooling sub-passages (61) in the stator casing (1) are connected through the groove structure (62) on the first end cap (2); on the ends adjacent to the second end
10 cap (3), the two adjacent cooling sub-passages (61) in the stator casing (1) are connected through the built-in passage in the second end cap (3), and thus a complete cooling flow passage (6) is formed. When a motor runs, the cooling medium (for example cooling water) flowing in the cooling flow passage (6) will cool
15 the motor to control the temperature of the motor. The cooling flow passage in the present invention is set not only in the stator casing (1), but also in the first end cap (2) and the second end cap (3). As a result, the action area of the cooling medium is increased and the motor can be cooled quickly and uniformly.

20

In the above-mentioned embodiment of the present invention, the parts of the cooling flow passage in the first end cap (2) and the second end cap (3) are set to the above-mentioned two different forms. However, those skilled in the art should
25 understand that the parts in the first end cap (2) and the second end cap (3) can be set to the same form. For example, they can both be set to the groove structure (62) in the first end cap (2), or the built-in passage in the second end cap (3). Or, other forms can be set in the first end cap (2) and the second end cap (3)
30 to connect the parts of the cooling flow passage in the stator casing. These variants will be within the scope of protection of the present invention.

As shown in Figure 6 through Figure 11, the motor in the present
35 invention also comprises a cooling flow passage inlet (6A) and a cooling flow passage (6B). A cooling medium flows from the cooling flow passage inlet (6A) into the cooling flow passage (6),

then flows in the direction indicated by the arrows in Figure 5 and Figure 11 through the whole cooling flow passage (6), and finally flows out of the cooling flow passage outlet (6B) of the cooling flow passage (6). In Figure 6 through Figure 11, the cooling flow passage inlet (6A) and the cooling flow passage outlet (6B) are set on the second end cap (3). However, the cooling flow passage inlet (6A) and the cooling flow passage outlet (6B) can be set on the first end cap (2). Alternatively, one of the cooling flow passage inlet (6A) and the cooling flow passage outlet (6B) can be set on the first end cap (2), while the other can be set on the second end cap (3). Or, the cooling flow passage inlet (6A) and the cooling flow passage outlet (6B) can be set on the stator casing (1). Or, one of the cooling flow passage inlet (6A) and the cooling flow passage outlet (6B) can be set on an end cap, while the other can be set on the stator casing. These variants will be within the scope of protection of the present invention.

As shown in Figure 6 through Figure 11, the stator casing (1), the first end cap (2), and the second end cap (3) can be fastened together by use of a plurality of fasteners (5). The fasteners (5) can be assemblies of studs and nuts, and holes used together with fasteners (5) are set on the stator casing (1), the first end cap (2), and the second end cap (3). The stator casing (1), the first end cap (2) and the second end cap (3) can be fastened together in one direction by use of a set of fasteners (5). For example, as shown in Figure 1 through Figure 7, a plurality of fasteners (5) are first inserted into through-holes (8) in the first end cap (2) to pass through the first end cap (2), then inserted into through-holes (9) in the stator casing (1) to pass through the stator casing, and then inserted into the second end cap (3) through the holes (10) in the second end cap (3), and finally the stator casing (1), the first end cap (2) and the second end cap (3) are fastened together through the nuts at the end of the fasteners (5). Alternatively, the structure of the first end cap (2) and the second end cap (3) shown in Figure 1 through Figure 7 can be changed slightly so that the stator casing (1), the first

end cap (2) and the second end cap (3) can be fastened together in two different directions by use of two sets of fasteners (5). These variants will be within the scope of protection of the present invention.

5

In the motor with a cooling flow passage in the present invention, the cooling flow passage is set not only in the stator casing, but also in the first end cap and the second end cap. As a result, the action area of the cooling medium is increased and the motor
10 can be cooled quickly and uniformly. In addition, the stator casing and the end caps of the motor in the present invention can be fastened together only by use of fasteners, without any complex assembly process. Moreover, since the cooling flow passage in the stator casing in the present invention is structurally simple,
15 the mature, low-cost, and low-reject-rate extrusion technology can be adopted to manufacture stator casings, thus lowering the total manufacturing cost of motors and reducing the reject rate.

To achieve the above-mentioned object, firstly, the present
20 invention provides a cooling flow passage for stators. The cooling flow passage comprises straight-through cooling sub-passages which are set in the stator casing, extend in the axial direction of said stator casing and run through said stator casing, and connecting grooves which are set in the end caps of
25 the stator casing and are used to seal and connect different cooling sub-passages after the end caps are fitted with the stator casing so that a cooling medium can flow in different cooling sub-passages continuously.

30 As one embodiment, the longitudinal depth of said groove is configured according to the required flow rate of the cooling medium.

As one embodiment, the cross-sectional shape and size of said
35 grooves are configured according to the cross-sectional shape and size of different cooling sub-passages and the spacing distances between them so that the end caps can transversely seal different

cooling sub-passages and longitudinally connect these different cooling sub-passages after the end caps are fitted with the stator casing.

5 As one embodiment, when the quantity of straight-through cooling sub-passages set in the stator casing is at least three (61A, 61B, and 61C), a first spacing distance exists between the first cooling sub-passage (61A) and the second cooling sub-passage (61B), a second spacing distance exists between the second
10 cooling sub-passage (61B) and the third cooling sub-passage (61C), and the first spacing distance is smaller than or equal to the second spacing distance.

As one embodiment, when the first spacing distance is smaller than
15 the second spacing distance, said connecting grooves are classified into: Type I connecting grooves which are set in the end cap on one side of the stator and whose cross-sectional size satisfies inequality 1: cross-sectional size W_{g1} of Type I connecting groove $\geq$ cross-sectional size W_{a1} of the first cooling
20 sub-passage (61A) + cross-sectional size W_{b1} of the second cooling sub-passage (61B) + first spacing distance D_1 , and Type II connecting grooves which are set in the end cap on the other side and whose cross-sectional size satisfies inequality 2: cross-sectional size W_{g2} of a Type II connecting groove $\geq$
25 cross-sectional size W_{b1} of the second cooling sub-passage (61B) + cross-sectional size W_{c1} of the third cooling sub-passage (61C) + second spacing distance D_2 .

As one embodiment, the two-dimensional shape of said Type I
30 connecting grooves is a rectangle and Type I connecting grooves are used to connect the cooling sub-passages (61A and 61B); the two-dimensional shape of said Type II connecting grooves is trouser-like or concave and Type II connecting grooves are used to connect the cooling sub-passages (61B and 61C).

35 As one embodiment, said Type II connecting groove (62A) comprises a first sub-groove opened in the second end cap (3) to connect

the cooling sub-passage (61B), a second sub-groove opened in the second end cap (3) to connect the cooling sub-passage (61C), and a built-in passage which is embedded in the second end cap (3) to combine the first sub-groove and the second sub-groove respectively.

As one embodiment, said cooling flow passage comprises an inlet (6A) and an outlet (6B) for a cooling medium and they are configured on an end cap on the same side or the end caps on the two sides.

As one embodiment, when said inlet (6A) and outlet (6B) for a cooling medium are set on the second end cap (3), the inlet (6A) is set on the first sub-groove interconnecting one cooling sub-passage, and the outlet (6B) is set on the second sub-groove interconnecting another cooling sub-passage, and in addition, no built-in passage is set between the cooling sub-passage fitted with the inlet (6A) and the other cooling sub-passage fitted with the outlet (6B).

As one embodiment, a hole allowing a fastener to pass through is set at the geometric center of said second spacing distance so that the end caps on the two sides of the stator can be fastened to the stator casing by screwing in the fastener.

As one embodiment, the shape of the cross-section of straight-through cooling sub-passages looks like a waist or flattened mouth.

As one embodiment, said straight-through cooling sub-passages are parallel to the axial direction of the stator.

As one embodiment, said straight-through cooling sub-passages are rotationally arranged around the circumference of the stator body.

Secondly, the present invention also provides a motor stator casing for electric vehicles, which is applicable to stators of AC asynchronous motors or permanent magnet motors, comprises the above-mentioned straight-through cooling sub-passages and is
5 manufactured into an integral body by use of the extrusion process.

As one embodiment, said stator casing is manufactured from aluminum or an aluminum alloy into an integral body by use of the
10 extrusion process.

Thirdly, the present invention also provides a motor stator assembly accommodating device, which comprises a stator casing used to accommodate the motor stator, end caps fitted at the ends
15 on the two axial sides of said stator casing, and a cooling flow passage distributed in said stator casing and said end caps.

As one embodiment, said cooling flow passage distributed in said stator casing and said end caps is the above-mentioned cooling
20 flow passage for stators.

Fourthly, the present invention also provides a motor stator for electric vehicles, which is applicable to AC asynchronous motors or permanent magnet motors and comprises a stator body, a stator
25 casing circumferentially surrounding the outer contour of the stator body and fitted on said stator body, a first end cap and a second end cap respectively located on the two side ends in the axial direction of said stator casing, a cooling flow passage for the stator distributed in said stator casing, first end cap, and
30 second end cap, and fasteners used to fasten the stator casing and the end caps on the two sides to form the sealed structure of said cooling flow passage.

As one embodiment, said cooling flow passage distributed in said stator casing and said end caps is the above-mentioned cooling
35 flow passage for stators.

As one embodiment, said cooling flow passage is distributed in the S shape in the axial direction of the stator casing.

As one embodiment, the cross-sectional shape of said
5 straight-through cooling sub-passage agrees with the radian shape of the outer contour of the stator body so that the contact area between said cooling sub-passage and the stator body is maximized.

10 Fifthly, the present invention also provides an AC asynchronous motor or permanent magnet motor for electric vehicles, which comprises the above-mentioned stator.

The innovation of the present invention lies in that through the
15 design of a brand-new stator structure with a cooling flow passage, a relatively simple extrusion process can be applied to improve the yield of finished products and lower the manufacturing cost.

20 Further, the manufacturing process of the cooling flow passage manufactured by use of the extrusion process is simple, the sealing performance of the cooling flow passage is greatly improved, and by comparison, the cooling flow passage
manufactured by use of the extrusion process is by far better than
25 the cooling flow passage obtained by use of sand casting, die casting, or machining and assembling of inner and outer casings.

Further, since the extrusion process is adopted, the stator casing can have any length as required and the same set of dies
30 can be used for a series of stators with different lengths to meet different specifications of different types of motors, thus improving the application scope of the extrusion process and the manufacturing efficiency of the stator structure and lowering the manufacturing cost.

35 Further, the motor stator casing for electric vehicles in the present invention is manufactured into an integral body with a

cooling flow passage by use of the extrusion process and is sealed through the end caps preset with connecting grooves to form a closed circulation passage for a cooling medium. Such a structure and the extrusion process can greatly improve the yield of
5 finished products and lower the manufacturing cost.

Only some embodiments of the present invention are described above. It should be pointed out that those skilled in the art can make improvements and modifications without departure from the
10 principle of the present invention and these improvements and modifications also fall within the scope of protection of the present invention.

Claims

1. A cooling flow passage for the stator, characterized in that it comprises:

5 straight-through cooling sub-passages, which are set in the stator casing, extend in the axial direction of said stator casing and run through said stator casing; and connecting grooves, which are set in the end caps of the stator casing and are used to seal and connect different cooling
10 sub-passages after the end caps are fitted with the stator casing so that a cooling medium can flow in different cooling sub-passages continuously.

2. The cooling flow passage as claimed in claim 1,
15 characterized in that the longitudinal depth of said grooves is configured to meet the required flow rate of the cooling medium.

3. The cooling flow passage as claimed in claim 1,
characterized in that the shape and size of the cross-section of
20 said grooves are configured as claimed in the shape and size of the cross-section of different cooling sub-passages as well as the spacing distance between them so that the end caps can transversely seal different cooling sub-passages and longitudinally connect these different cooling sub-passages
25 after the end caps are fitted with the stator casing.

4. The cooling flow passage as claimed in claim 1,
characterized in that
the shape of the cross-section of said straight-through cooling
30 sub-passages looks like a waist or flattened mouth; and/or said straight-through cooling sub-passages are axially parallel to the stator; and/or said straight-through cooling sub-passages are rotationally arranged around the circumference of the stator body.

35 5. A motor stator casing for electric vehicles, characterized in that it comprises: straight-through cooling sub-passages as

claimed in any of claim 1 through claim 4, and said stator casing is manufactured into an integral body by use of the extrusion process.

5 6. A motor stator assembly accommodating device, characterized in that it comprises:
a stator casing, which is used to accommodate the motor stator;
end caps, which are fitted at the ends on the two axial sides of
said stator casing; and
10 a cooling flow passage, which is distributed in said stator casing
and said end caps;
wherein said cooling flow passage distributed in said stator casing and said end caps is a cooling flow passage for the stator as claimed in any of claim 1 through claim 4.

15 7. A motor stator for electric vehicles, characterized in that it comprises:
a stator body;
a stator casing, which circumferentially surrounds the outer
20 contour of the stator body and is fitted on said stator body;
a first end cap and a second end cap, which are respectively located on the two side ends in the axial direction of said stator casing;
a cooling flow passage for the stator, which is distributed in
25 said stator casing, first end cap, and second end cap; and
fasteners, which are used to fasten the stator casing and the end caps on the two sides to form the sealed structure of said cooling flow passage;
wherein said cooling flow passage distributed in said stator casing and said end caps is a cooling flow passage for the stator
30 as claimed in any of claim 1 through claim 4.

8. The motor stator as claimed in claim 7, characterized in that said cooling flow passage is distributed in the S shape in the
35 axial direction of the stator casing.

9. The motor stator as claimed in claim 7, characterized in that the cross-sectional shape of said straight-through sub-passage agrees with the radian shape of the outer contour of the stator body so that the contact area between said cooling sub-passages and the stator body is maximized.

10. A motor for electric vehicles, characterized in that it comprises:

a stator as claimed in any of claim 7 through claim 9.

Drawings

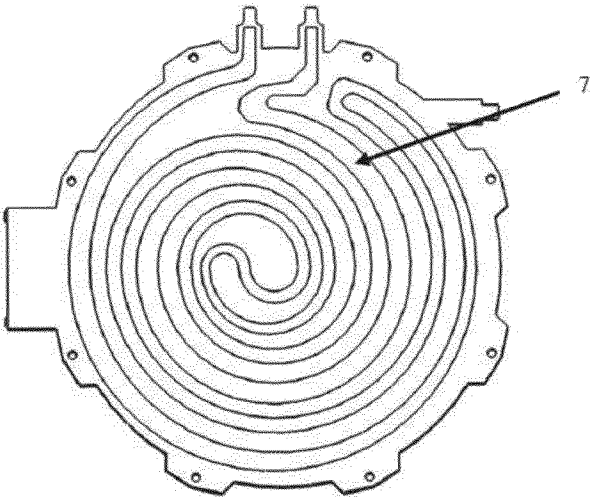


Figure 1

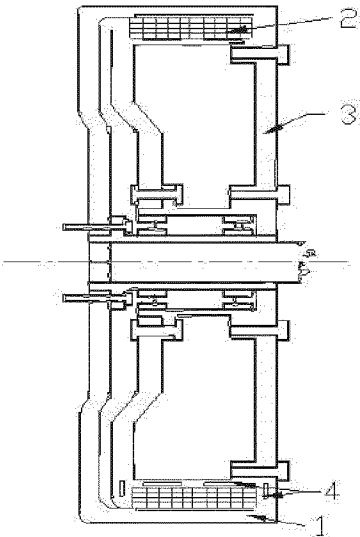


Figure 2

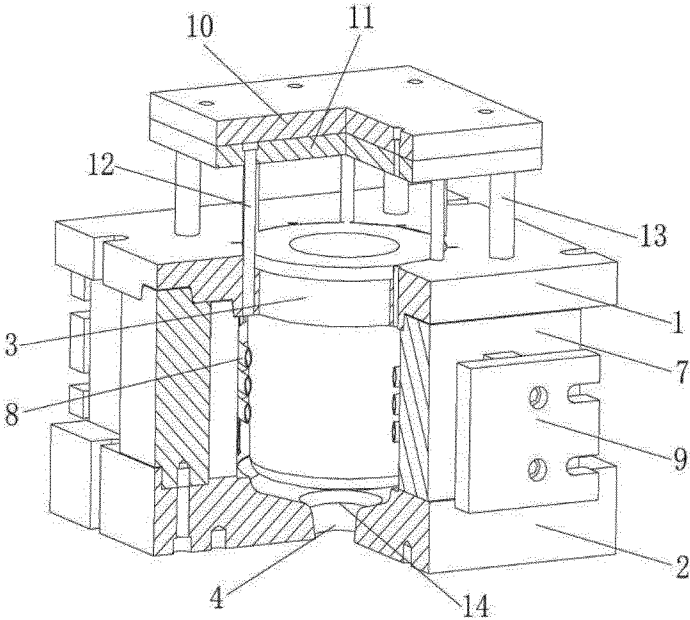


Figure 3

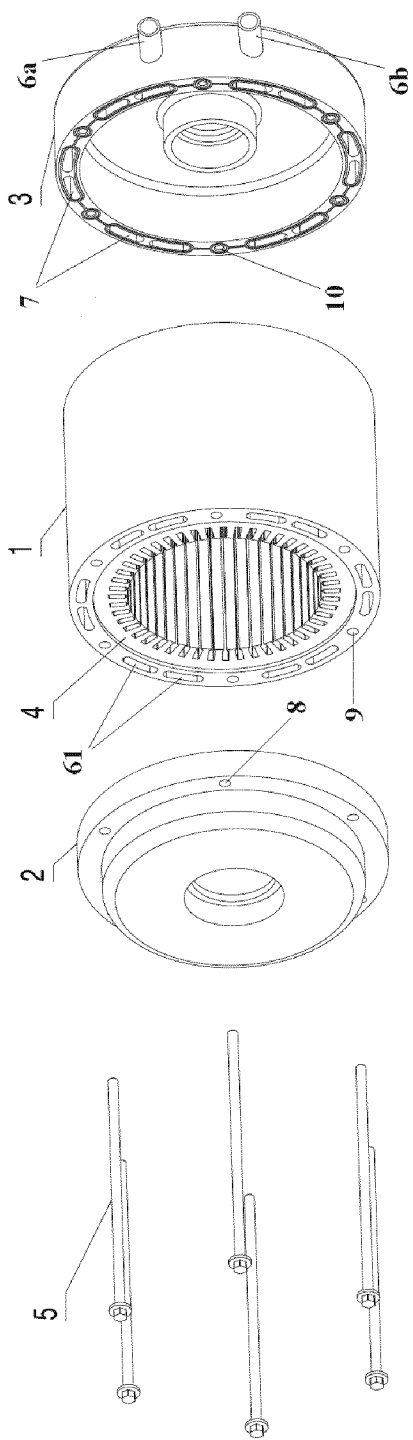


Figure 4A

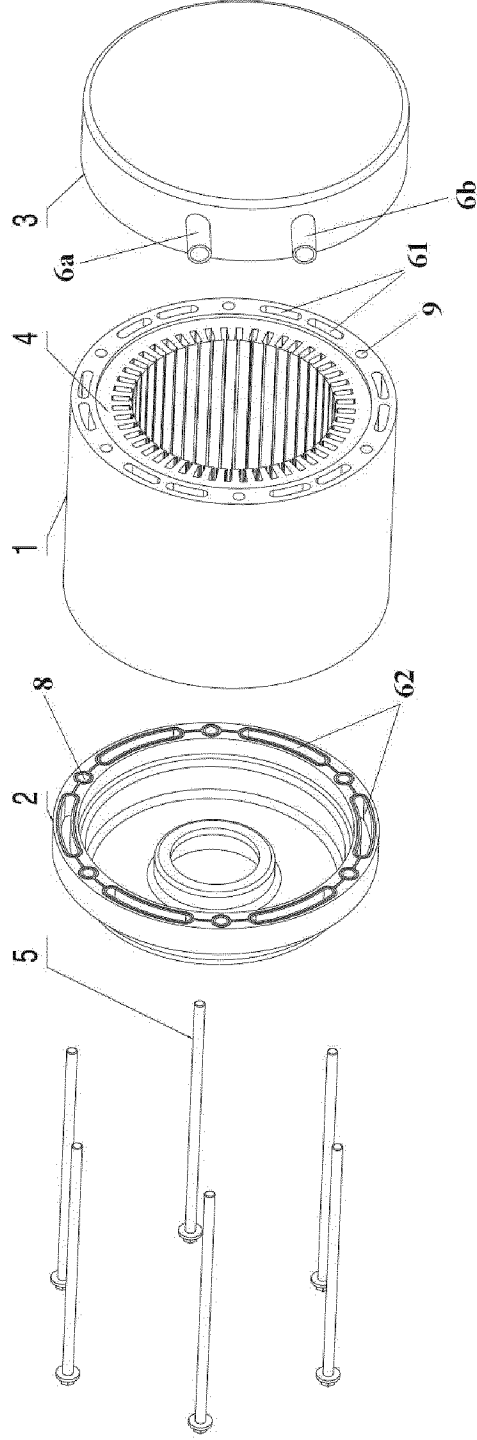


Figure 4B

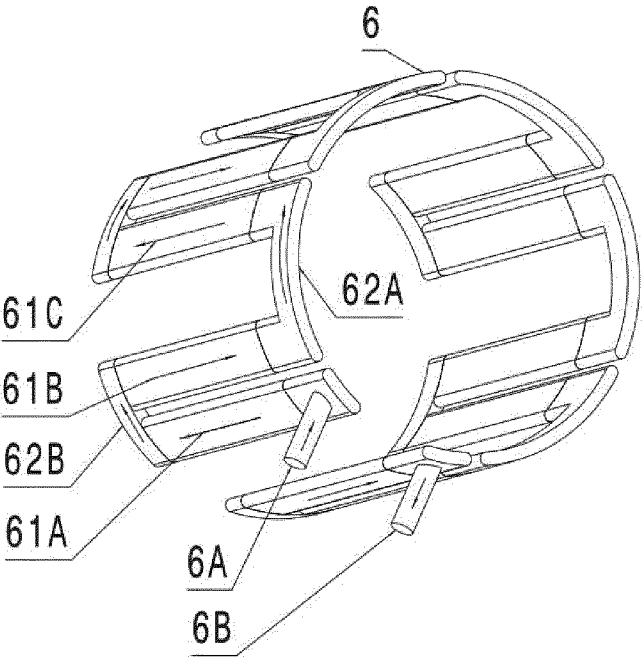


Figure 5

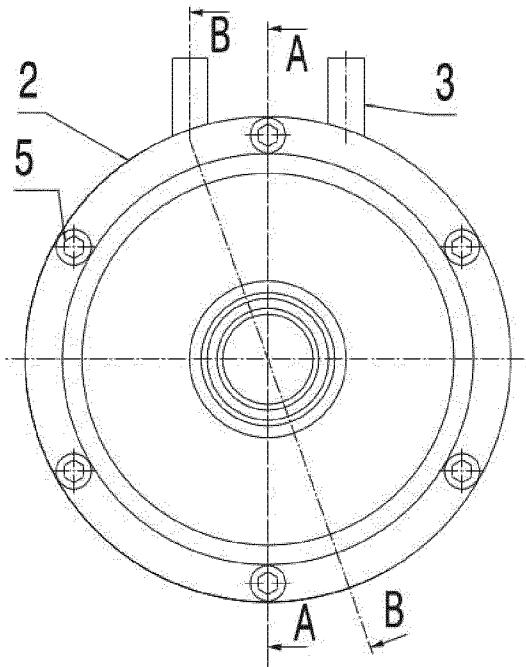


Figure 6

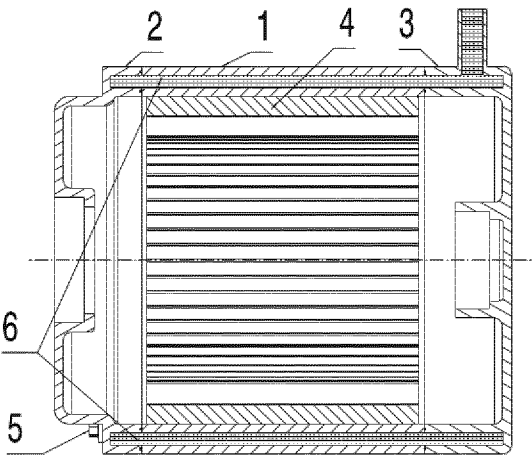


Figure 7

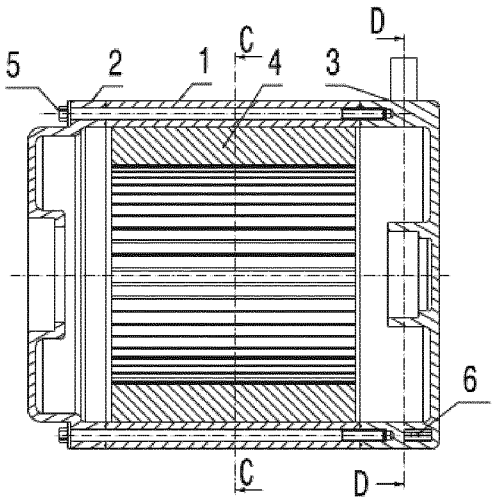


Figure 8

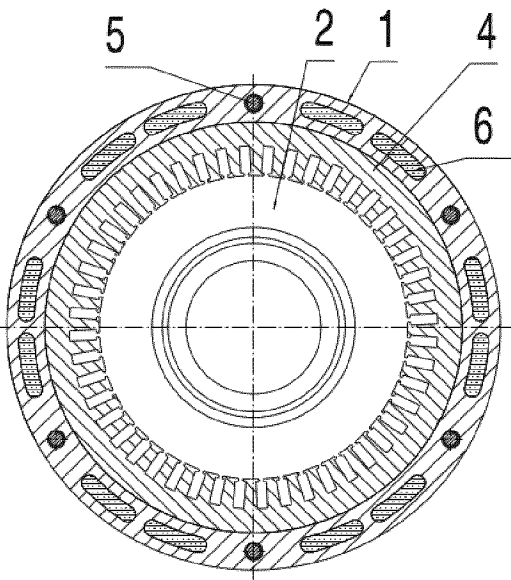


Figure 9

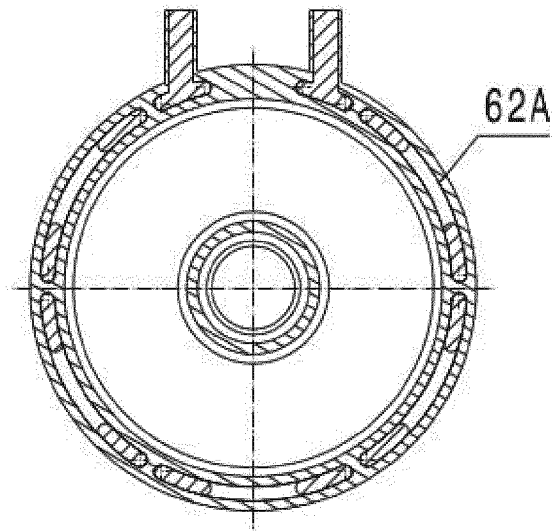


Figure 10

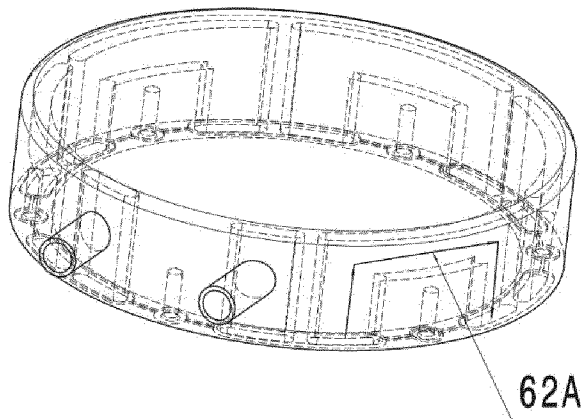


Figure 11

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/057224

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02K5/20

ADD. H02K9/19

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	WO 2014/054577 A1 (SCHAFT INC [JP]) 10 April 2014 (2014-04-10) paragraph [0059]; figures 1,5,6,8-12 -----	1-10
X	WO 2009/038957 A1 (ARVINMERITOR TECHNOLOGY LLC [US]; KRAMER DENNIS A [US]; RITCHIE ADAM []) 26 March 2009 (2009-03-26) page 3; figures 3-5 -----	1-10
X	WO 03/100946 A1 (EMERSON ELECTRIC CO [US]) 4 December 2003 (2003-12-04) figures 1,7,11,12 page 4 -----	1-10
X	US 2014/354090 A1 (CHAMBERLIN BRADLEY D [US]) 4 December 2014 (2014-12-04) abstract; figures 4-9 paragraph [0047] -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

27 May 2016

Date of mailing of the international search report

06/06/2016

Name and mailing address of the ISA/

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Authorized officer

Brandt, Isabelle

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/057224

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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