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

(11) EP 4 563 822 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
04.06.2025 Bulletin 2025/23

(21) Application number: **23845686.7**

(22) Date of filing: **28.07.2023**

(51) International Patent Classification (IPC):
F04C 14/28 *(2006.01)* ***F04C 2/10*** *(2006.01)*
F04C 15/00 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F04C 2/10; F04C 14/28; F04C 15/00

(86) International application number:
PCT/CN2023/109821

(87) International publication number:
WO 2024/022482 (01.02.2024 Gazette 2024/05)

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

(30) Priority: **29.07.2022 CN 202210910293**
29.07.2022 CN 202210912059

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(54) **ELECTRIC PUMP**

(57) An electric pump. The electric pump has a first cavity, and when the electric pump works, a working medium is present in the first cavity. The electric pump comprises a control assembly and a rotating assembly, the control assembly is located in the first cavity, and at least part of the rotating assembly is located in the first cavity. The control assembly comprises a circuit board, a magnetic element and a sensor; the circuit board is in electrical connection and/or signal connection to the sensor; the end portion of the rotating assembly relatively close to the circuit board is fixedly connected or limitedly connected to the magnetic element; the circuit board comprises a first surface, and the first surface faces the magnetic element; at least part of the sensor is located on the first surface; the magnetic element is within the sensing range of the sensor; the projection of the magnetic element on the first surface at least partially overlaps the sensor, or the sensor is located in the projection range of the magnetic element on the first surface. The present application allows for better detection of rotation of electric pumps.

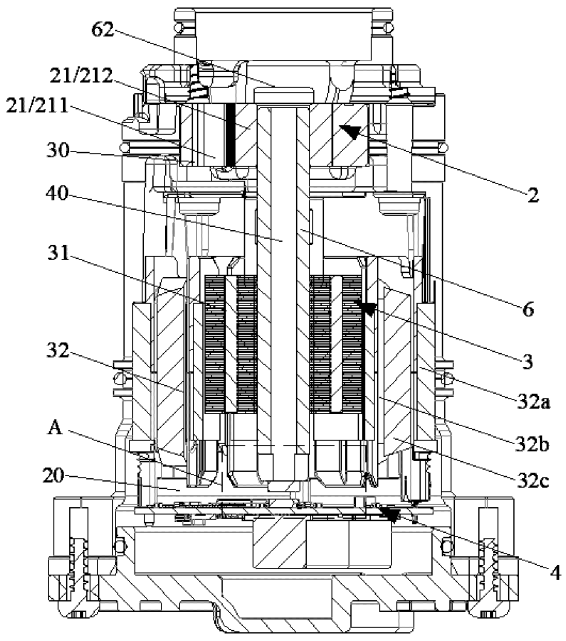

FIG. 2A

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Description

[0001] The present application claims the priority to Chinese Patent Application No. 202210910293.1, titled "ELECTRIC PUMP", filed with the China National Intellectual Property Administration on July 29, 2022; and the priority to Chinese Patent Application No. 202210912059.2, titled "ELECTRIC PUMP", filed with the China National Intellectual Property Administration on July 29, 2022, the entire disclosures of which are incorporated herein by reference.

FIELD

[0002] The present application relates to the technical field of vehicles, and in particular to components of a vehicle lubrication system and/or a vehicle cooling system.

BACKGROUND

[0003] An electric pump mainly provides a power source for the vehicle lubrication system. When the electric pump works, a circuit board is immersed in the working medium. At this time, there is a problem of how to monitor the rotation of the electric pump.

SUMMARY

[0004] An object of the present application is to provide an electric pump, which can better monitor the rotation of the electric pump.

[0005] In order to achieve the above object, the following technical solutions are proposed in an embodiment of the present application.

[0006] An electric pump has a first cavity, and when the electric pump works, a working medium is present in the first cavity. The electric pump includes a control assembly and a rotating assembly. The control assembly is located in the first cavity, and at least part of the rotating assembly is located in the first cavity. The control assembly includes a circuit board, a magnetic element and a sensor. The circuit board is in electrical connection and/or signal connection with the sensor. One end portion of the rotating assembly relatively close to the circuit board is connected to the magnetic element in a fixed manner or in a limited manner. The circuit board includes a first surface, and the first surface faces the magnetic element. At least part of the sensor is located on the first surface. The magnetic element is within the sensing range of the sensor. The projection of the magnetic element on the first surface at least partially overlaps with the sensor, or the sensor is located within the projection range of the magnetic element on the first surface.

[0007] In the above technical solution, the sensor is in electrical connection and/or signal connection with the circuit board, and one end portion of the rotating assembly relatively close to the circuit board is connected to the magnetic element in a fixed manner or in a limited manner, the magnetic element being in the sensing range of the sensor, and the projection of the magnetic element on the first surface at least partially overlapping with the sensor, or the sensor being located within the projection range of the magnetic element on the first surface. In this way, the sensor and the magnetic element may be cooperated with each other to monitor the rotation of the electric pump.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic view of an electric pump according to an embodiment of the present application;

FIG. 2A is a first schematic sectional view taken along line A-A in FIG. 1;

FIG. 2B is an enlarged view of a first embodiment of part A in FIG. 2A;

FIG. 2C is an enlarged view of a second embodiment of part A in FIG. 2A;

FIG. 2D is a schematic view of a magnetic element in FIG. 2C;

FIG. 3 is a second schematic sectional view taken along line A-A in FIG. 1;

FIG. 4 is a schematic sectional view of an electric pump according to another embodiment of the present application;

FIG. 5A is a schematic view of a rotating shaft and a second rotor assembly according to an embodiment of the present application;

FIG. 5B is a schematic side view of FIG. 5A;

FIG. 6A is a schematic view of a rotating shaft and a second rotor assembly according to an embodiment of the present application;

FIG. 6B is a schematic side view of FIG. 6A;

FIG. 7A is a schematic view of a rotating shaft and a second rotor assembly according to an embodiment of the present application;

FIG. 7B is a schematic side view of FIG. 7A;

FIG. 8A is a schematic view of a rotating shaft and a second rotor assembly according to an embodiment of the present application;

FIG. 8B is a schematic side view of FIG. 8A;

FIG. 9A is a schematic view of a rotating shaft and a second rotor assembly according to an embodiment of the present application;

FIG. 9B is a schematic side view of FIG. 9A;

FIG. 9C is a schematic sectional view taken along line A-A in FIG. 9B;

FIG. 10 is a schematic sectional view of an electric pump according to an embodiment of the present application;

FIG. 11 is an enlarged view of part A of a first embodiment in FIG. 10;

FIG. 12 is an enlarged view of part A of a second embodiment in FIG. 10;

FIG. 13 is a schematic view of a magnetic element in FIG. 11 or 12;

FIG. 14 is an enlarged view of part A of a third embodiment in FIG. 10 when no magnetic element is placed;

FIG. 15 is an enlarged view of part A of the third embodiment in FIG. 10 after a magnetic element is placed;

FIG. 16 is an enlarged view of part A of a fourth embodiment in FIG. 10;

FIG. 17 is a schematic view of a magnetic element in FIG. 15 or 16;

FIG. 18 is another schematic sectional view of an electric pump according to an embodiment of the present application;

FIG. 19 is a schematic sectional view of an electric pump according to another embodiment of the present application; and

FIG. 20 is a schematic view of FIGs. 2A, 4, 10, 18 or 19 with a pump cover removed.

List of reference numerals:

[0009]

1.	pump housing;	11.	pump cover;	12.	first housing;
13.	second housing;	2.	pump assembly;	21.	first rotor assembly;

(continued)

211.	first rotor;	212.	second rotor;	3.	motor assembly;
31.	second rotor assembly;	32.	stator assembly;	32a.	stator core;
32b.	insulation frame;	32c.	winding;	33.	magnetic element;
331.	upper magnetic surface;	332.	lower magnetic surface;		
333.	second through hole;	334.	second accommodating hole,		
335.	through hole;	4.	control assembly;	41.	circuit board;
411.	first surface;	412.	second surface;	42.	sensor;
5.	inlet;	6.	rotating shaft;	61/61'.	first end portion;
611.	first end face;	612.	first side surface;	62/62'.	second end portion;
621.	second end face;	63.	first accommodating hole;	7.	outlet;
8.	connection portion;	81.	accommodating hole;	82.	first through-hole;
9.	anti-magnetic conductive part;	10.	hydraulic chamber;	20.	first cavity;
30.	second cavity;	301.	base wall;	40.	first channel;
401/401'.	first opening;	402/402'.	second opening;	50.	second channel.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] The present application will be further explained in conjunction with the accompanying drawings and specific embodiments.

[0011] In order to make those skilled in the art better understand the technical solutions of the present application, the present application will be further explained in detail in conjunction with the accompanying drawings and specific embodiments. Obviously, the accompanying drawings in the following description are only some of the embodiments of the present application. Based on these accompanying drawings, those skilled in the art can obtain other accompanying drawings without creative work. The orientation terms such as upper and lower involved herein are defined with reference to the relative positions of the components shown in the accompanying drawings, only for the purpose of clearly and conveniently expressing the technical solutions. It should be understood the orientation terms used herein shall not limit the protection scope claimed in the present application.

[0012] Referring to FIGs. 1, 2A to2D, 3, 4, 5A to 5B, 6A to 6B, 7A to 7B, 8A to 8B, 9A to 9C, and 10 to 20, there is provided an electric pump, which is mounted in a driving device of a vehicle, for example. The electric pump includes a pump housing 1, in which a pump assembly 2, a motor assembly 3 and a control assembly 4 are provided. The motor assembly 3 is supplied with electric power to generate a rotary driving force. The control assembly 4 detects the rotation of the motor assembly 3, and the pump assembly 2 is driven by the motor assembly 3 to suck a working medium, for example a liquid, such as oil.

[0013] Referring to FIGs. 1 and 10, the pump housing 1 includes a pump cover 11, a first housing 12 and a second housing 13. The pump cover 11 is fixedly connected to the first housing 12, and the first housing 12 is fixedly connected to the second housing 13. The pump cover 11, the first housing 12 and the second housing 13 are all made of metal material. Alternatively, the first housing 12 or the second housing 13 may be made of metal material. For example, the pump cover 11 and/or the second housing 13 are made of plastic material, and the first housing 12 is made of metal material. In this embodiment, the pump cover 11 is connected to the first housing 12 by screws or bolts. If the screws or bolts are screwed into the pump cover 11 from the inside of the pump, they are not easily corroded by an external environment, and the strength of the connection between the pump cover 11 and the first housing 12 may be improved. If the screws or bolts are screwed into the pump from the pump cover 11, the electric pump may be assembled and disassembled more conveniently, which is beneficial to the maintenance of the pump assembly 2 of the electric pump. Of course, the pump cover 11 may also be connected to the first housing 12 by any other connection means, such as plug-in connection means or snap fit. The first housing 12 is fixedly connected to the second housing 13. The first housing 12 is connected to the second housing 13 by screws or bolts. In this way, on the one hand, the electric pump may be assembled and disassembled more conveniently. In this embodiment, since the control assembly 4 is located in a cavity between the first housing 12 and the second housing 13, it is beneficial to the maintenance of the control assembly 4 in the electric pump. On the other hand, the first housing 12 may be more reliably connected to the second housing 13. Of course, the first housing 12 may also be connected to the second housing 13 by any other connection means, e.g., plug-in connection means, snap-fit, or bonding connection means. Reference may be made to FIGs. 2A, 3 to 4, 10, and 18 to 19. The pump cover (not shown), the first housing (not shown) and the second housing (not shown) may be connected as described above, which will not be repeatedly described here.

[0014] Referring to FIGs. 1, 2A to 2D, 3, 4, 5A to 5B, 6A to 6B, 7A to 7B, 8A to 8B, 9A to 9C, and 10 to 20, the pump assembly 2 includes a first rotor assembly 21, which includes a first rotor 211 and a second rotor 212. The first rotor 211 includes multiple internal teeth, and the second rotor 212 includes multiple external teeth. A hydraulic chamber 10 is formed between the internal teeth of the first rotor 211 and the external teeth of the second rotor 212. In this embodiment, the pump assembly 2 has the same rotational speed as the motor assembly 3. In other embodiments, the pump assembly 2 has a different rotational speed from the motor assembly 3. For example, a speed reduction mechanism may be provided between the pump assembly 2 and the motor assembly 3. The motor assembly 3 includes a second rotor assembly 31 and a stator assembly 32 which surrounds the second rotor assembly 31 at a radially outer side of the second rotor assembly 31.

[0015] The electric pump further includes a rotating assembly, which is in transmission connection with the second rotor assembly 31 and the first rotor assembly 21. The rotating assembly includes a rotating shaft 6, which can drive the first rotor 211 to rotate. In this embodiment, one end of the rotating shaft 6 is connected to the second rotor 212 and the other end of the rotating shaft 6 is connected to the second rotor assembly 31. Via the rotating shaft 6, the second rotor assembly 31 drives the first rotor 211 to rotate, thereby achieving the rotation of the first rotor assembly 21.

[0016] Referring to FIGs. 1, 2A to 2D, 3, 4, and 10 to 20, the pump housing 1 may define a pump inner cavity. The pump assembly 2, the motor assembly 3 and the control assembly 4 are located in the pump inner cavity, which includes a first cavity 20 and a second cavity 30. The second rotor assembly 31 (or part of the second rotor assembly 31), the control assembly 4 and part of the rotating assembly are located in the first cavity 20. The first rotor assembly 21 is located in the second cavity 30. The stator assembly 32 is in electrical connection and/or signal connection with a circuit board 41, the stator assembly 32 (or at least part of the stator assembly 32) is located in the first cavity 20, and the control assembly 4 and the stator assembly 32 are located in the same cavity, so that the electric pump may have a reduced size in an axial direction, resulting in a compact structure, and thereby reducing the production cost of the electric pump. The rotating shaft 6 is located at the inner side of the stator assembly 32. The stator assembly 32 includes a stator core 32a, an insulating frame 32b and a winding 32c. The insulating frame 32b covers at least part of a surface of the stator core 32a, and the winding 32c is wound around the insulating frame 32b. When the electric pump works, the control assembly 4 controls a current in the winding 32c of the stator assembly 32 to change according to a predetermined rule, thereby controlling the stator assembly 32 to generate a changing excitation magnetic field. The second rotor assembly 31 rotates under the action of the excitation magnetic field. The second rotor assembly 31 may directly or indirectly drive the first rotor assembly 21 to rotate. When the first rotor assembly 21 rotates, there is an eccentric distance between the first rotor 211 and the second rotor 212. When the second rotor 212 rotates, some of the external teeth of the second rotor 212 are meshed with some of the internal teeth of the first rotor 211, thus driving the first rotor 211 to rotate. In the process of the first rotor 211 and the second rotor 212 rotating one revolution, a volume of the hydraulic chamber 10 changes. Specifically, when the first rotor assembly 21 rotates to an angular position from the home position, the volume in the hydraulic chamber 10 gradually increases, thus partially creating a vacuum. Then, the working medium is sucked into the hydraulic chamber 10 from an inlet 5 of the electric pump. When the first rotor 211 and the second rotor 212 continue to rotate, the volume of the hydraulic chamber 10 filled with the working medium gradually decreases, and the working medium is squeezed, so that the working medium entering the hydraulic chamber 10 is pushed out to an outlet 7 of the electric pump, thereby generating flowing power.

[0017] Referring to FIGs. 2A to 2D, 3 to 4, and 18 to 19, the first cavity 20 is communicated with the second cavity 30. The electric pump includes a base wall 301. The first cavity 20 is located on one side of the base wall 301, and the second cavity 30 is located on the other side of the base wall 301. The base wall 301 supports the first rotor assembly 21. The electric pump includes a second channel 50 which extends through an upper surface and a lower surface of the base wall 301 to communicate the first cavity 20 with the second cavity 30. Specifically, the second channel 50 is communicated with the first cavity 20, and the second channel 50 is communicated with the second cavity 30. At least part of the working medium in the second cavity 30 may flow into the first cavity 20 through the second channel 50 and contact with at least part of the control assembly 4 located in the first cavity 20, so that the working medium contained in the first cavity 20 may exchange heat with the control assembly 4, thereby facilitating the heat dissipation of the control assembly 4, and further facilitating the increase of the service life of the electric pump. Further, at least part of the stator assembly 32 may also be in contact with the working medium in the first cavity 20, so that the working medium in the first cavity 20 may exchange heat with the stator assembly 32, thereby facilitating the heat dissipation of the stator assembly 32.

[0018] Referring to FIGs. 2A to 2D and 3, the electric pump further includes a first channel 40, which is communicated with the first cavity 20. The rotating assembly includes a first end portion 61, which is closer to the circuit board 41 than the second rotor assembly 31. The first channel 40 has a first opening 401 at a side wall of the first end portion 61. The rotating assembly includes a second end portion 62, which is farther away from the circuit board 41 than the first end portion 61 in the axial direction of the electric pump. The first channel 40 has a second opening 402 at a side wall of the second end portion 62. Part of the working medium in the first cavity 20 may run out of the first cavity 20 through the first channel 40. In the axial direction of the electric pump, the second opening 402 of the first channel 40 is closer to an inlet 5 of the electric pump than the first opening 401 of the first channel 40, and the pressure of the working medium at an entrance of the

second channel 50 is greater than the pressure of the working medium at the second opening 402 of the first channel 40, so that a pressure difference for the working medium is formed between the entrance of the second channel 50 and the second opening 402 of the first channel 40. According to the principle that the working medium flows from a place with high pressure to a place with low pressure, the working medium in the first cavity 20 may flow towards the second opening 402 of the first channel 40, that is, the working medium in the first cavity 20 may flow out of the first cavity 20 through the first channel 40. Since the stator assembly 32 and the control assembly 4 are located in the first cavity 20, the working medium may take away part of the heat generated by the stator assembly 32 and the control assembly 4, thus further improving the heat dissipation efficiency of the stator assembly 32 and the control assembly 4.

[0019] FIG. 3 shows flow of the working medium. Referring to FIGs. 3 and 20, the electric pump includes the inlet 5, which is communicated with the second cavity 30. The working medium flows in two flow directions. In a first flow direction S1 (shown by thick dashed lines) of the working medium, the working medium flows into the hydraulic chamber 10 of the first rotor assembly 21 from the inlet 5, and then flows out of the hydraulic chamber 10 through the outlet 7. In a second flow direction S2 (shown by thick solid line) of the working medium, part of the working medium that enters the hydraulic chamber 10 of the first rotor assembly 21 flows into the first cavity 20 through the second channel 50, and then the working medium in the first cavity 20 flows into the first channel 40 via the first opening 401.

[0020] Referring to FIGs. 2A to 2B, 3, 5A to 5B, 6A to 6B, 7A to 7B, 8A to 8B and 9A to 9C, the first channel 40 includes a second opening 402 and at least one first opening 401. Further, as shown in FIGs. 8A to 8B, the number of the first openings 401 is at least two. The first openings 401 are arranged in a radial direction of the rotating shaft 6 or in an axial direction of the rotating shaft 6, and there is a spacing between adjacent first openings 401. The first channel 40 has multiple first openings 401, which can increase the amount of the working medium flowing into the first channel 40 from the first cavity 20 within a unit time, thereby improving the heat dissipation effect on the control assembly 4. Referring to FIGs. 2A, 2C and 2D, the magnetic element 33 is connected fixedly or limitedly to the first end portion 61. Specifically, the first end portion 61 includes a first end face 611, and the magnetic element 33 is connected fixedly or limitedly to the first end face 611. The magnetic element 33 includes a second through hole 333 communicated with both the first channel 40 and the first cavity 20.

[0021] Referring to FIGs. 5A to 5B, together with FIG. 3 or 4, the first end portion 61 is located on the rotating shaft 6, and the first end portion 61 includes a first end face 611 and a first side surface 612. Part of the first opening 401 is located on the first end face 611, and part of the first opening 401 is located on the first side surface 612. The magnetic element 33 is connected fixedly or limitedly to the first end face 611, and the first opening 401 is communicated with the first cavity 20. In this way, on the one hand, the rotating assembly is in transmission connection with the second rotor assembly 31, and the magnetic element 33 is connected to the first end face 611 of the rotating assembly in a fixed manner or in a positional limiting manner, the first end portion 61 being relatively close to the circuit board (or the sensor) so that the magnetic element 33 and the sensor may cooperate to monitor the rotation of the second rotor assembly 31. On the other hand, the working medium in the first cavity 20 may flow out of the first cavity 20 via the first opening 401, and thus may take away part of the heat generated by the stator assembly 32 and the control assembly 4 through the first opening 401 since the stator assembly 32 and the control assembly 4 are located in the first cavity 20.

[0022] Referring to FIGs. 7A to 7B, together with FIG. 3 or 4, the rotating shaft 6 includes a first side surface 612, and the first channel 40 has a first opening 401 on the first side surface 612, the first cavity 20 being communicated with the first opening 401. The working medium flows into the first channel 40 from the first opening 401, and flows out of the first channel 40 via the second opening 402. Part of the working medium that has exchanged heat with the control assembly 4 may flow away through the first channel 40. Due to fluidity of the working medium, it is possible to ensure the heat dissipation effect of the working medium on the control assembly 4. Referring to FIGs. 8A to 8B, together with FIG. 3 or 4, the rotating shaft 6 includes a first side surface 612. The first channel 40 has at least two first openings 401 on the first side surface 612, and the first openings 401 are arranged in the radial direction of the rotating shaft 6 and/or in the axial direction of the rotating shaft 6. The first cavity 20 is communicated with the first opening 401. The working medium flows into the first channel 40 from the first opening 401, and flows out of the first channel 40 via the second opening 402. Part of the working medium that has exchanged heat with the control assembly 4 may flow away through the first channel 40. Due to fluidity of the working medium, it is possible to ensure the heat dissipation effect of the working medium on the control assembly 4.

[0023] Referring to FIG. 4, it is a schematic view of another embodiment of the electric pump according to the present application, which differs from the embodiment shown in FIG. 3 at least in the flow direction of the working medium. Referring to FIGs. 4 and 20, the first cavity 20 is communicated with the second cavity 30. In this embodiment, the first cavity 20 is communicated with the second cavity 30 via a second channel 50. Part of the working medium in the first cavity 20 may flow into the second cavity 30 through the second channel 50. The working medium in the first cavity 20 is in contact with at least part of the control assembly 4 located in the first cavity 20, so that the working medium contained in the first cavity 20 may exchange heat with the control assembly 4, thereby facilitating the heat dissipation of the control assembly 4, and thus facilitating the increase of the service life of the electric pump. Further, at least part of the stator assembly 32 may also be in contact with the working medium contained in the first cavity 20, so that the working medium in the first cavity 20 may exchange heat with the stator assembly 32, thereby facilitating the heat dissipation of the stator assembly 32.

[0024] The electric pump further includes a first channel 40. The rotating assembly includes a first end portion (not shown), which is closer to the circuit board (not shown) than the second rotor assembly 31, and the first channel 40 has a first opening 401 at a side wall of the first end portion (not shown). The rotating assembly includes a second end portion 62, which is farther away from the circuit board than the first end portion 61 in the axial direction of the electric pump, and the first channel 40 has a second opening 402 at the second end portion (not shown), e.g., at the end face of the second end portion. The working medium enters the first cavity 20 from an inlet 5 through the first channel 40. In the axial direction of the electric pump, the second opening 402 of the first channel 40 is closer to the inlet 5 of the electric pump than the first opening 401 of the first channel 40. The pressure of the working medium at the second opening 402 of the first channel 40 is greater than that the pressure of the working medium at an outlet of the second channel 50, so that a pressure difference for the working medium is formed between the second opening 402 of the first channel 40 and the outlet of the second channel 50. According to the principle that the working medium flows from a place with high pressure to a place with low pressure, the working medium in the first cavity 20 may flow towards the outlet of the second channel 50. Since the stator assembly 32 and the control assembly 4 are located in the first cavity 20, the working medium may take away part of the heat generated by the stator assembly 32 and the control assembly 4, thereby further improving the heat dissipation efficiency of the stator assembly 32 and the control assembly 4.

[0025] FIG. 4 shows the flow of the working medium. Referring to FIGs. 3 and 20, the electric pump includes an inlet 5, which is communicated with the second opening 402. The working medium flows in two flow directions. In a first flow direction S1 (shown by thick dashed lines) of the working medium, part of the working medium entering via the inlet 5 flows into the hydraulic chamber 10 of the first rotor assembly 21, and then flows out of the hydraulic chamber 10 through the outlet 7. In a second flow direction S2 (shown by thick solid line) of the working medium, part of the working medium entering via the inlet 5 flows into the first cavity 20 through the first channel 40, and part of the working medium in the first cavity 20 flows into the second cavity 30 through the second channel 50, and then part of the working medium in the second cavity 30 flows out of the outlet 7.

[0026] Referring to FIGs. 2A to 2D, 3 to 4, 5A to 5B, 6A to 6B, 7A to 7B and 8A to 8B, the control assembly 4 includes a circuit board 41, a magnetic element 33 and a sensor 42. The sensor 42 is in electrical connection and/or signal connection with the circuit board 41, and the sensor 42 senses a magnetic field of the magnetic element 33. The magnetic element 33 includes an upper magnetic surface 331 and a lower magnetic surface 332 which are opposite to each other. In the axial direction of the electric pump, the upper magnetic surface 331 is farther away from the circuit board 41 than the lower magnetic surface 332. The first end portion 61 includes a first end face 611, and the magnetic element 33 is fixed to the first end face 611. In the axial direction of the electric pump, the lower magnetic surface 332 of the magnetic element 33 is closer to the circuit board 41 than the first end face 611, and the magnetic element 33 is closer to the sensor 42 which has a high sensing accuracy.

[0027] Referring to FIGs. 9A to 9C, they are schematic views of the rotating shaft 6 and the second rotor assembly 31 according to an embodiment of the present application. Referring to FIGs. 3 and 9A to 9C, the rotating assembly includes a connecting portion 8, which has an accommodating hole 81. At least part of the rotating shaft 6 is located in the accommodating hole 81, and the side wall forming the accommodating hole 81 is connected to at least part of an outer side wall of the rotating shaft 6 in a fixed manner or in a limited manner. The connecting portion 8 includes a first through hole 82 which is communicated with the first opening 401 of the first channel 40. The magnetic element 33 is connected to an outer side wall of the connecting portion 8 in a fixed manner or in a limited manner. The first cavity 20 and the first channel 40 are communicated with each other via the first opening 401 and the first through hole 82. The magnetic element 33 rotates together with the rotating shaft 6 through the connecting portion 8. On the one hand, the connecting portion 8 enables the magnetic element 33 to be close to the sensor 42, thus improving the accuracy of the sensor 42 in sensing the magnetic element 33. On the other hand, the rotating shaft 6 is generally made of metal material, and the connecting portion 8 may reduce the influence of metal on magnetic induction lines of the magnetic element 33, thereby improving the accuracy of the control assembly 4 in sensing magnetism.

[0028] Referring to FIGs. 6A to 6B, they are schematic views of a rotating shaft 6 and a second rotor assembly 31 according to an embodiment of the present application. The rotating assembly includes an anti-magnetic conductive part 9. In the axial direction of the electric pump, the magnetic element 33 is located on one side of the anti-magnetic conductive part 9, and the rotating shaft 6 is located on the other side of the anti-magnetic conductive part 9. The magnetic element 33 is fixed to a side wall of the anti-magnetic conductive part 9, or the magnetic element 33 is integrated with the anti-magnetic conductive part 9. The rotating shaft 6 is generally made of metal material, and the anti-magnetic conductive part 9 may reduce the influence of metal on magnetic induction lines of the magnetic element 33, thereby improving the sensing accuracy of the control assembly 4.

[0029] Referring to FIGs. 10 to 20, the electric pump further includes a rotating shaft 6, which is in transmission connection with the second rotor assembly 31. The rotating shaft 6 includes a first end portion 61' and a second end portion 62'. The first end portion 61' is farther away from the circuit board 41 than the second end portion 62' in the axial direction of the rotating shaft 6. The second end portion 62' is located in the first cavity 20, and the first end portion 61' is in transmission connection with the first rotor assembly 21. The first cavity 20 is communicated with the second cavity 30. The electric

pump includes a base wall 301. The first cavity 20 is located on one side of the base wall 301, and the second cavity 30 is located on the other side of the base wall 301. The base wall 301 supports the first rotor assembly 21. The electric pump includes a second channel 50 running through an upper surface and a lower surface of the base wall 301 to communicate the first cavity 20 with the second cavity 30.

[0030] Referring to FIGs. 10 to 18, the electric pump further includes a first channel 40, and the first channel 40 has a first opening 401' and a second opening 402'. The first opening 401' is located at the first end portion 61' of the rotating shaft 6, and the second opening 402' is communicated with the first cavity 20. In some embodiments, the second end portion 62' includes a first end face 611. The first channel 40 has a second opening 402' at the first end face 611. The first end portion 61' includes a second end face 621, and the first channel 40 has a first opening 401' at the second end face 621. Part of the working medium in the first cavity 20 may flow out of the first cavity 20 through the first channel 40. In the axial direction of the electric pump, the first opening 401' of the first channel 40 is closer to an inlet 5 of the electric pump than the second opening 402' of the first channel 40. The pressure of the working medium at an entrance of the second channel 50 is greater than the pressure of the working medium at the first opening 401' of the first channel 40, so that a pressure difference for the working medium is formed between the entrance of the second channel 50 and the first opening 401' of the first channel 40. According to the principle that the working medium flows from a place with high pressure to a place with low pressure, the working medium in the first cavity 20 may flow towards the first opening 401' of the first channel 40, i.e., the working medium in the first cavity 20 may flow out of the first cavity 20 via the first channel 40. Since the stator assembly 32 and the control assembly 4 are located in the first cavity 20, the working medium may take away part of the heat generated by the stator assembly 32 and the control assembly 4, thus further improving the heat dissipation efficiency of the stator assembly 32 and the control assembly 4.

[0031] FIG. 18 shows the flow of the working medium. Referring to FIGs. 18 and 20, the electric pump includes an inlet 5 communicated with the first cavity 20. The working medium flows in two flow directions. In the first flow direction S1 (shown by thick dashed lines) of the working medium, the working medium flows into a hydraulic chamber 10 of the first rotor assembly 21 from the inlet 5, and then flows out of the hydraulic chamber 10 through an outlet 7. In the second flow direction S2 (shown by thick solid line) of the working medium, part of the working medium that enters the hydraulic chamber 10 of the first rotor assembly 21 flows into the first cavity 20 via the second channel 50, and then the working medium in the first cavity 20 flows into the first channel 40 via the second opening 402'.

[0032] Referring to FIG. 19, it is a schematic view of another embodiment of the electric pump of the present application, which differs from the embodiment shown in FIG. 18 at least in the flow direction of the working medium. Referring to FIGs. 19 and 20, part of the working medium in the first cavity 20 may flow into the second cavity 30 through the second channel 50, and the working medium in the first cavity 20 is in contact with at least part of the control assembly 4 located in the first cavity 20, so that the working medium located in the first cavity 20 may exchange heat with the control assembly 4, thereby facilitating the heat dissipation of the control assembly 4, and further facilitating the increase of the service life of the electric pump. Further, at least part of the stator assembly 32 may also be in contact with the working medium in the first cavity 20, so that the working medium in the first cavity 20 may exchange heat with the stator assembly 32, thereby facilitating the heat dissipation of the stator assembly 32.

[0033] Referring to FIG. 19, the second end portion 62' includes a first end face, and the first end portion 61' includes a second end face. The electric pump further includes a first channel 40, which runs through the first end face and the second end face. The electric pump includes an inlet 5 communicated with a first opening 401'. The working medium enters the first cavity 20 from the inlet 5 through the first channel 40. In the axial direction of the electric pump, a first opening 401' of the first channel 40 is closer to the inlet 5 of the electric pump than a second opening 402' of the first channel 40. The pressure of the working medium at the first opening 401' of the first channel 40 is greater than the pressure of the working medium at an outlet of the second channel 50, so that a pressure difference for the working medium is formed between the first opening 401' of the first channel 40 and the outlet of the second channel 50. According to the principle that the working medium flows from a place with high pressure to a place with low pressure, the working medium in the first cavity 20 may flow towards the outlet of the second channel 50. Since the stator assembly 32 and the control assembly 4 are located in the first cavity 20, the working medium may take away part of the heat generated by the stator assembly 32 and the control assembly 4, thus further improving the heat dissipation efficiency of the stator assembly 32 and the control assembly 4.

[0034] Referring to FIGs. 10 to 20, the control assembly 4 includes a circuit board 41, a magnetic element 33 and a sensor 42. The sensor 42 is in electrical connection and/or signal connection with the circuit board 41, and the sensor 42 senses a magnetic field of the magnetic element 33. One end of the rotating shaft 6 relatively close to the circuit board 41 is connected to the magnetic element 33 in a fixed manner or in a limited manner. Specifically, the magnetic element 33 is connected to the second end portion 62' in a fixed manner or in a limited manner.

[0035] Referring to FIGs. 14, 15 and 17, the second end portion 62' has a first accommodating hole 63 in which at least part of the magnetic element 33 is located. The side wall forming the first accommodating hole 63 is connected to an outer peripheral side of the magnetic element 33 (or an outer peripheral wall of the magnetic element 33) in a fixed manner or in a limited manner. In FIG. 15, the side wall of the first accommodating hole 63 is formed with a step, and the outer peripheral wall of the magnetic element 33 abuts against the step. The second opening 402' of the first channel 40 is located at an

outer side wall of the second end portion 62'; or the magnetic element 33 has a through hole 335 communicated with the first channel 40 and the first cavity 20. On the one hand, the magnetic element 33 is provided on a radial inner side of the rotating shaft 6, so that the electric pump may have a reduced size in the axial direction, resulting in a compact structure, and thereby reducing the production cost of the electric pump. On the other hand, the working medium in the first cavity 20 may flow out of the first cavity 20 via the through hole 335 and the second opening 402', and may take away part of the heat generated by the stator assembly 32 and the control assembly 4 via the through hole 335 and the second opening 402' since the stator assembly 32 and the control assembly 4 are located in the first cavity 20.

[0036] Referring to FIGs. 16 and 17, the second end portion 62' includes a first end face 611, and the magnetic element 33 is connected to the first end face 611 in a fixed manner or in a limited manner. The magnetic element 33 includes a through hole 335 communicated with the second opening 402' and the first cavity 20. On the one hand, the magnetic element 33 is connected to the first end face 611 in a fixed manner or in a limited manner, and the magnetic element 33 is close to the sensor 42, so that the sensor 42 may sense the magnetic element 33 with high accuracy. On the other hand, the working medium in the first cavity 20 may flow out of the first cavity 20 via the through hole 335 and the second opening 402', and may take away part of the heat generated by the stator assembly 32 and the control assembly 4 via the through hole 335 and the second opening 402' since the stator assembly 32 and the control assembly 4 are located in the first cavity 20.

[0037] Referring to FIGs. 11 to 13, the magnetic element 33 has a second accommodating hole 334, in which at least part of the second end portion 62' is located. An outer peripheral side of the second end portion 62' is connected to the side wall forming the second accommodating hole 334 in a fixed manner or in a limited manner. The second end portion 62' includes a first end face 611, and the first channel 40 has a second opening 402' at the first end face 611. On the one hand, the magnetic element 33 is provided on a radial outer side of the rotating shaft 6, so that the electric pump may have a reduced size in the axial direction, resulting in a compact structure, and thereby reducing the production cost of the electric pump. On the other hand, the working medium in the first cavity 20 may flow out of the first cavity 20 through the second opening 402', and may take away part of the heat generated by the stator assembly 32 and the control assembly 4 via the second opening 402' since the stator assembly 32 and the control assembly 4 are located in the first cavity 20.

[0038] Referring to FIGs. 10 and 11, in the radial direction of the rotating shaft 6, the rotating shaft 6 is located at one side of the anti-magnetic conductive part 9, and the magnetic element 33 is located on the other side of the anti-magnetic conductive part 9. Specifically, the anti-magnetic conductive part 9 is located outside of the rotating shaft 6, and the magnetic element 33 is located outside of the anti-magnetic conductive part 9. The anti-magnetic conductive part 9 is fixed to a wall of the magnetic element 33, or the anti-magnetic conductive part 9 is integrated with the magnetic element 33. The rotating shaft 6 is generally made of metal material, and the anti-magnetic part 9 may reduce the influence of the metal on magnetic induction lines of the magnetic element 33, thus improving the accuracy of the control assembly in sensing the magnetic field.

[0039] Referring to FIGs. 2A to 2D, 3 to 4, 5A to 5B, 6A to 6B, 7A to 7B, 8A to 8B, 9A to 9C, and 10 to 20, the circuit board 41 includes a first surface 411 and a second surface 412. The first surface 411 faces the magnetic element 33 or the stator assembly 32, and at least part of the sensor 42 is located on the first surface 411 of the circuit board 41. The sensor 42 is, for example, a magnetic sensor such as a Hall Integrated Circuit (IC) or a magnetoresistive element. When the magnetic element 33 rotates, the magnetic flux changes, and the sensor 42 detects the change in the magnetic flux caused by the rotation of the magnetic element 33. Since the rotating assembly (or the rotating shaft 6) is in transmission connection with the second rotor assembly 31, the position of the second rotor assembly 31 may be detected. In some embodiments, the sensor 42 may also be an encoder. There is a predetermined gap between the magnetic element 33 and the sensor 42 in the axial direction of the electric pump or in the axial direction of the rotating shaft 6, and the magnetic element 33 has a circular or substantially circular projection on the first surface 411 (when the magnetic element 33 changes in shape, the projection of the magnetic element 33 will change in shape accordingly). The sensor 42 may be located within the projection range of the magnetic element 33 on the first surface 411. For example, the projection of the magnetic element 33 on the first surface 411 is shaped as a circle, and the sensor 42 located within the circle. Alternatively, the projection of the magnetic element 33 on the first surface 411 at least partially overlaps with the sensor 42. As such, the magnetic induction lines are dense, and the magnetic field is strong, so that the sensing accuracy of the sensor 42 is high. Further, a central axis of the rotating shaft 6 or an extension line of the central axis of the rotating shaft 6 passes through the sensor 42. In some embodiments, the magnetic element 33 includes an upper magnetic surface 331 and a lower magnetic surface 332, and the upper magnetic surface 331 is farther away from the control assembly 4 (or the circuit board 41) than the lower magnetic surface 332 in the axial direction of the rotating shaft 6. An axial distance between the sensor 42 and the lower magnetic surface 332 of the magnetic element 33 is not greater than 2 cm, which on the one hand may ensure the accuracy of the sensor 42, and on the other hand, may form a flow channel with a certain width for the working medium to ensure the heat dissipation effect of the working medium on the control assembly 4. Further, the axial distance between the sensor 42 and the lower magnetic surface 332 is not greater than 1 cm. Further, the axial distance between the sensor 42 and the lower magnetic surface 332 is not greater than 6 mm. Of course, provided that the axial distance between the sensor 42 and the lower magnetic surface 332 is not greater than 2 cm, the sensor 42 may be provided at any other position on the

second surface 412.

[0040] It should be noted that, the above embodiments are only intended to illustrate the present application rather than to limit the technical solutions described in the present application. Although the present specification has been described in detail with reference to the embodiments as described above, it should be understood by those skilled in the art that modifications or equivalent substitutions may still be made by those skilled in the art to the technical solutions of the present application, and all technical solutions and improvements thereof that do not depart from the spirit and scope of the present application shall be included within the scope of the claims of the present application.

Claims

1. An electric pump, comprising a first cavity (20) for containing a working medium when the electric pump works, a control assembly (4) and a rotating assembly, wherein

   the control assembly (4) is located in the first cavity (20), and at least part of the rotating assembly is located in the first cavity (20);
   the control assembly (4) comprises a circuit board (41), a magnetic element (33) and a sensor (42); the circuit board (41) is in electrical connection and/or signal connection with the sensor (42);
   one end portion of the rotating assembly relatively close to the circuit board (41) is connected fixedly or limitedly to the magnetic element (33);
   the circuit board (41) comprises a first surface (411) facing the magnetic element (33), at least part of the sensor (42) is located on the first surface (411), and the magnetic element (33) is located within a sensing range of the sensor (42); and
   a projection of the magnetic element (33) on the first surface (411) at least partially overlaps with the sensor (42), or the sensor (42) is located within a projection range of the magnetic element (33) on the first surface (411).

2. The electric pump according to claim 1, wherein the rotating assembly comprises a first end portion (61), the magnetic element (33) is connected fixedly or limitedly to the first end portion (61); and
   the electric pump has a first channel (40), which has a first opening (401) at a side wall of the first end portion (61) and is communicated with the first cavity (20).

3. The electric pump according to claim 1,wherein the rotating assembly comprises a rotating shaft (6), and the rotating shaft (6) comprises a first end portion (61), and the first end portion (61) comprises a first end face (611) and a first side surface (612);

   the electric pump has a first channel (40), and the first channel (40) has a first opening (401), part of the first opening (401) is located on the first end face (611), and another part of the first opening (401) is located on the first side surface (612), and the magnetic element (33) is fixedly or limitedly connected to the first end face (611); and the first opening (401) is communicated with the first cavity (20).

4. The electric pump according to claim 2, wherein the rotating assembly comprises a rotating shaft (6), and the rotating shaft (6) comprises the first end portion (61), and the first end portion (61) comprises a first end face (611) and a first side surface (612), and the magnetic element (33) is connected fixedly or limitedly to the first end face (611);
   the first channel (40) has at least two first openings (401) at the first side surface (612), the first openings (401) are arranged in a radial direction of the rotating shaft (6) and/or in an axial direction of the rotating shaft (6), and the first openings (401) are communicated with the first cavity (20).

5. The electric pump according to any one of claims 2 to 4, wherein the rotating assembly comprises a rotating shaft (6) and an anti-magnetic conductive part (9);

   in an axial direction of the electric pump, the magnetic element (33) is located on one side of the anti-magnetic conductive part (9), and the rotating shaft (6) is located on the other side of the anti-magnetic conductive part (9); and
   the magnetic element (33) is fixed to a side wall of the anti-magnetic conductive part (9), or the magnetic element (33) is integrated with the anti-magnetic conductive part (9).

6. The electric pump according to any one of claims 2 to 4, wherein the rotating assembly comprises a rotating shaft (6) and a connecting portion (8), and the connecting portion (8) comprises an accommodating hole (81), and at least part

of the rotating shaft (6) is located in the accommodating hole (81);

a side wall forming the accommodating hole (81) is connected fixedly or limitedly to at least part of an outer side wall of the rotating shaft (6), and the magnetic element (33) is connected fixedly or limitedly to an outer side wall of the connecting portion (8); and
the connecting portion (8) comprises a first through hole (82) communicated with both the first opening (401) and the first cavity (20).

7. The electric pump according to any one of claims 2 to 4, wherein the first end portion (61) comprises a first end face (611), and the magnetic element (33) is connected fixedly or limitedly to the first end face (611); the magnetic element (33) comprises a second through hole (333) communicated with both the first channel (40) and the first cavity (20).

8. The electric pump according to claim 5, wherein the first end portion (61) comprises a first end face (611), the magnetic element (33) is connected fixedly or limitedly to the first end face (611); the magnetic element (33) comprises a second through hole (333) communicated with both the first channel (40) and the first cavity (20).

9. The electric pump according to claim 1, wherein the electric pump comprises a first rotor assembly (21), a second rotor assembly (31), a second cavity (30) and a first channel (40);

the rotating assembly comprises a rotating shaft (6), the rotating shaft (6) comprises a first end portion (61') and a second end portion (62'), and the first end portion (61') is farther away from the circuit board (41) than the second end portion (62') in an axial direction of the rotating shaft (6);
the first rotor assembly (21) is located in the second cavity (30), and the second rotor assembly (31) is located in the first cavity (20) and is in transmission connection with the rotating shaft (6);
the first channel (40) has a first opening (401') and a second opening (402'), wherein the first opening (401') is located at the first end portion (61'), and the second opening (402') is communicated with the first cavity (20); and the second end portion (62') is located in the first cavity (20), and the first end portion (61') is in transmission connection with the first rotor assembly (21), and the magnetic element (33) is connected fixedly or limitedly to the second end portion (62').

10. The electric pump according to claim 9, wherein the second end portion (62') has a first accommodating hole (63), at least part of the magnetic element (33) is located in the first accommodating hole (63), and a side wall forming the first accommodating hole (63) is connected fixedly or limitedly to an outer peripheral side of the magnetic element (33); and the second opening (402') of the first channel (40) is located on an outer side wall of the second end portion (62').

11. The electric pump according to claim 9, wherein the magnetic element (33) has a second accommodating hole (334), and at least part of the second end portion (62') is located in the second accommodating hole (334), and an outer peripheral side of the second end portion (62') is connected fixedly or limitedly to a side wall forming the second accommodating hole (334); and
the second end portion (62') comprises a first end face (611), and the first channel (40) has the second opening (402') at the first end face (611).

12. The electric pump according to claim 9, wherein the second end portion (62') comprises a first end face (611), and the magnetic element (33) is connected fixedly or limitedly to the first end face (611); and
the magnetic element (33) has a through hole (335) communicated with both the first opening (401') and the first cavity (20).

13. The electric pump according to any one of claims 9 to 12, wherein the electric pump comprises an anti-magnetic conductive part (9);

in a radial direction of the rotating shaft (6), the magnetic element (33) is located on one side of the anti-magnetic conductive part (9), and the rotating shaft (6) is located on the other side of the anti-magnetic conductive part (9); and
the anti-magnetic conductive part (9) is fixed to an inner side wall of the magnetic element (33), or the anti-magnetic conductive part (9) is integrated with the magnetic element (33).

14. The electric pump according to claim 2, wherein the magnetic element (33) comprises an upper magnetic surface (331) and a lower magnetic surface (332), the upper magnetic surface (331) is farther away from the circuit board (41)

than the lower magnetic surface (332) in an axial direction of the rotating shaft (6), and an axial distance between the lower magnetic surface (332) and the sensor (42) is less than or equal to 2 cm.

15. The electric pump according to claim 2 or 14, wherein the electric pump comprises a base wall (301), and the electric pump has a second cavity (30);

in an axial direction of the electric pump, the second cavity (30) is located on one side of the base wall (301), and the first cavity is located on the other side of the base wall (301); and
the electric pump comprises a second channel (50) extending through the base wall (301) from an upper surface to a lower surface of the base wall (301), and the second channel (50) communicates the first cavity (20) with the second cavity (30).

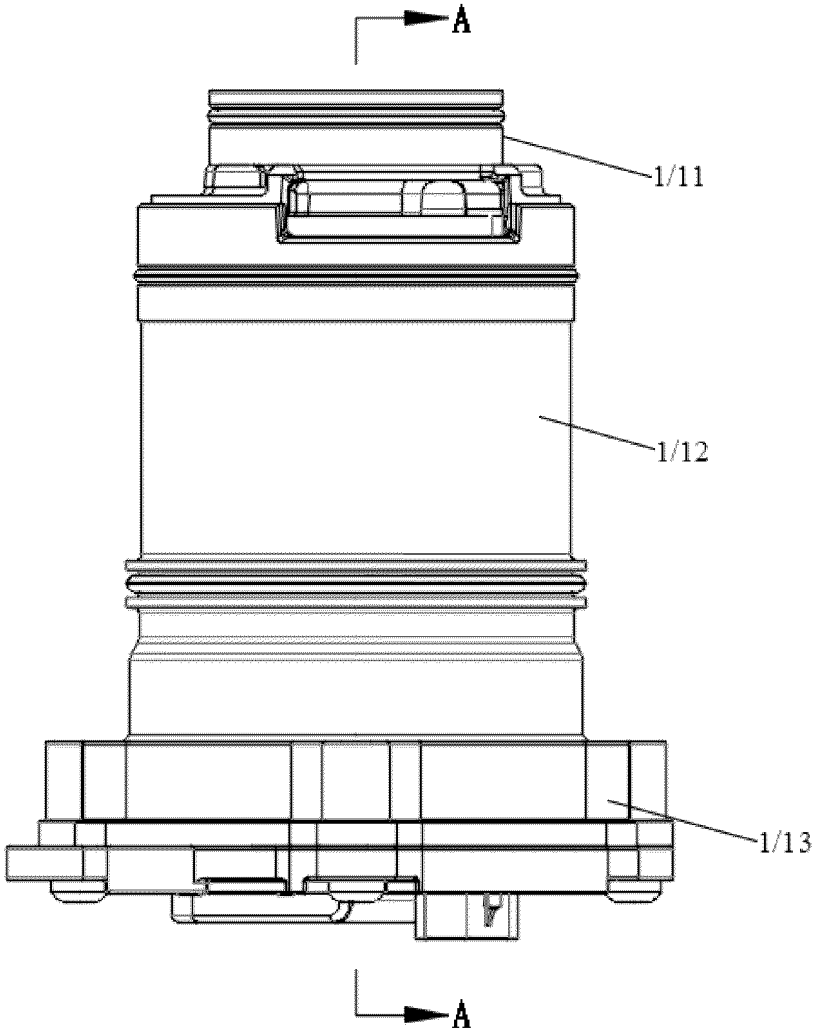

FIG. 1

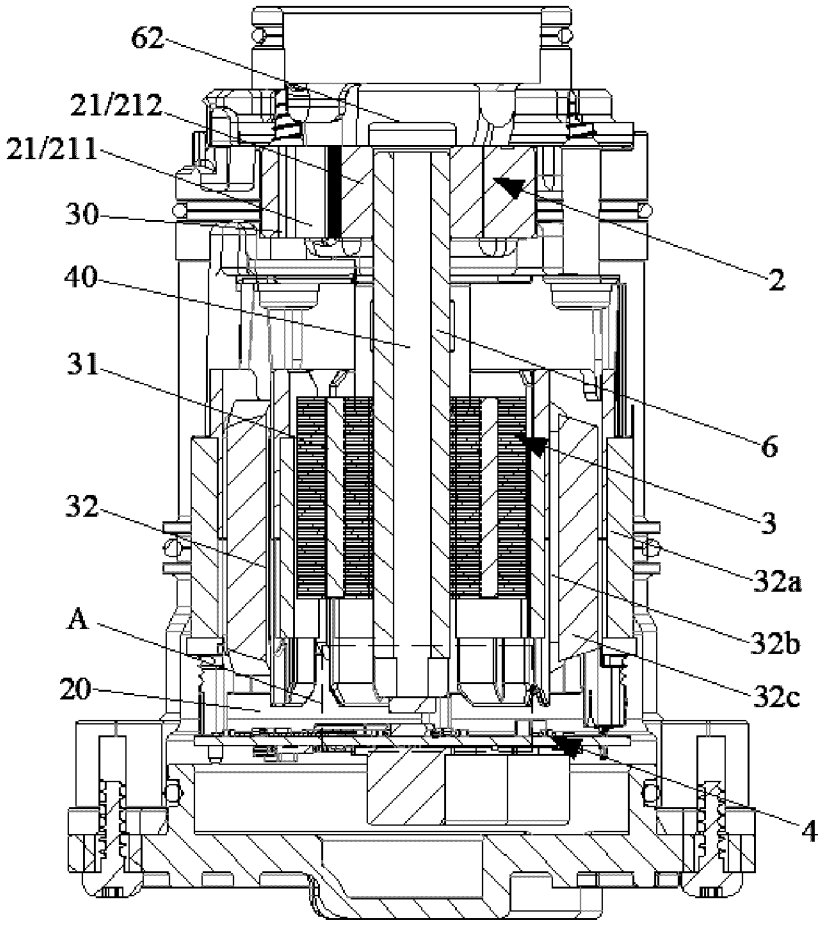
62
21/212
21/211
30
40
31
32
A
20
2
6
3
32a
32b
32c
4

FIG. 2A

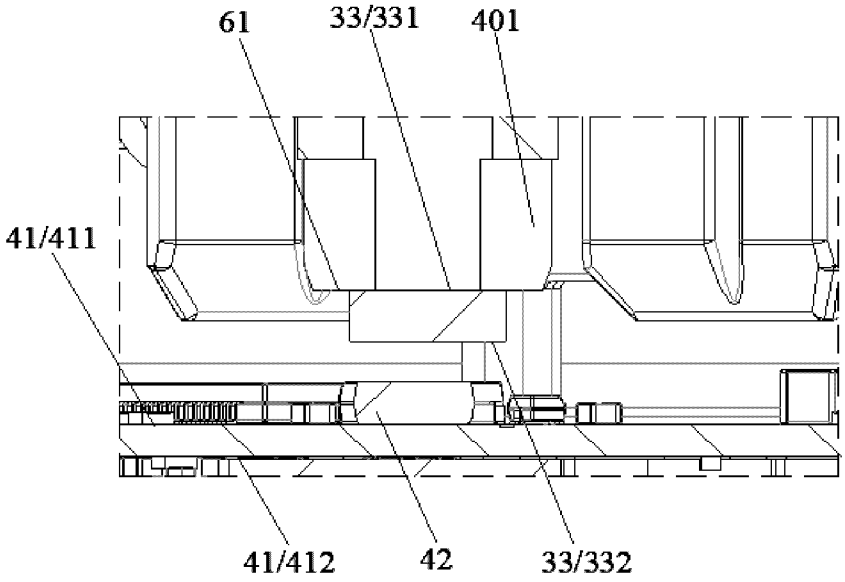
61
33/331
401
41/411
41/412
42
33/332

FIG. 2B

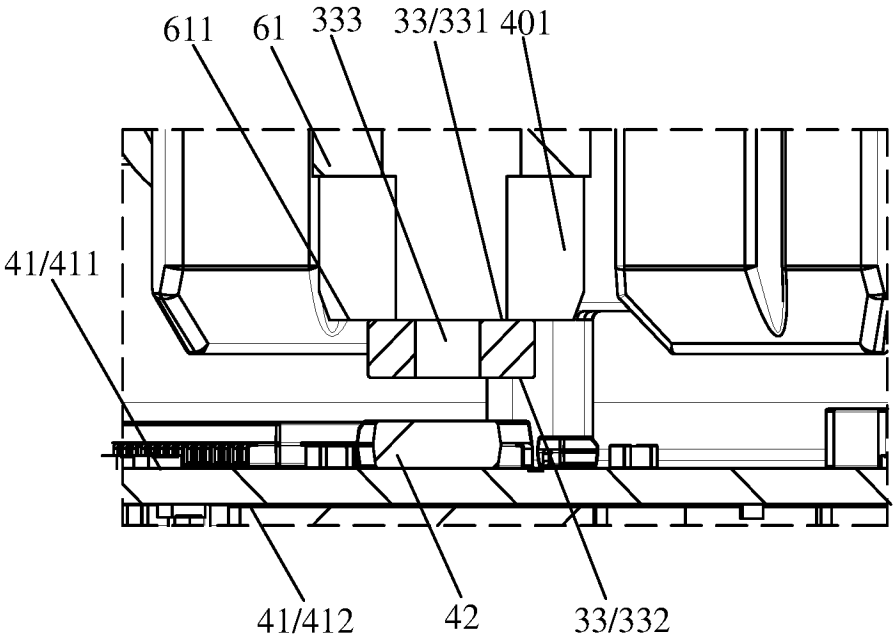

FIG. 2C

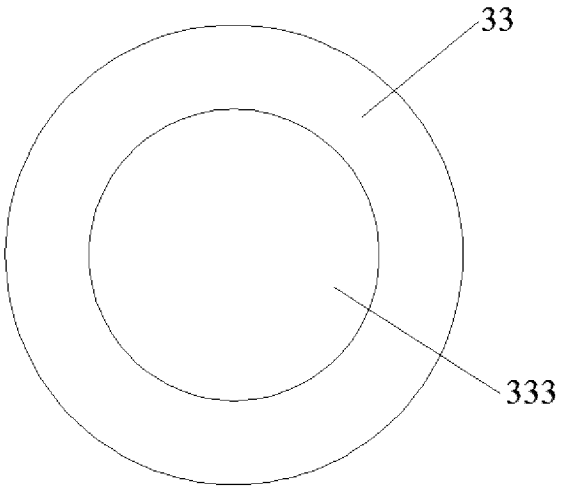

FIG. 2D

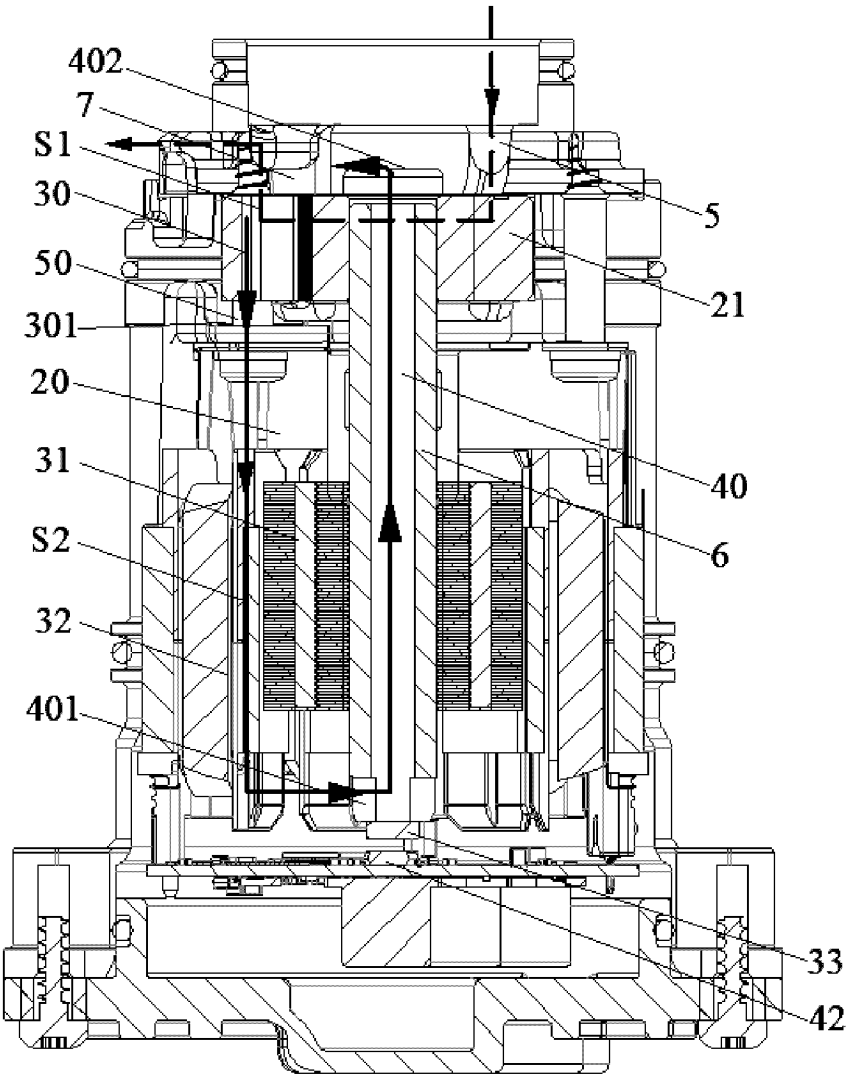

FIG. 3

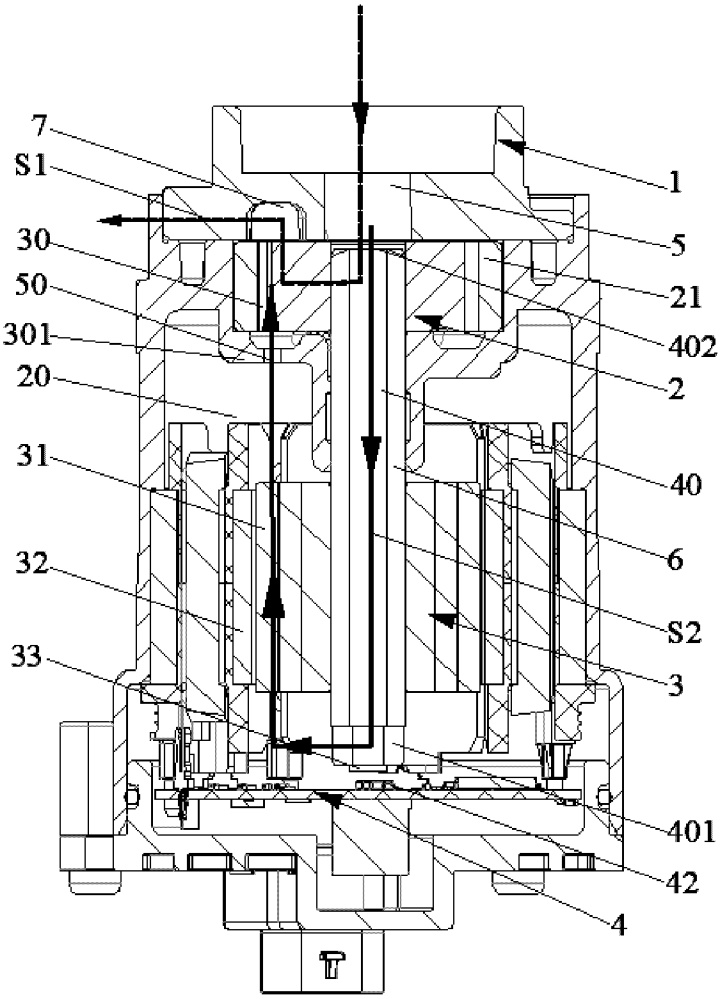
7
S1
30
50
301
20
31
32
33
1
5
21
402
2
40
6
S2
3
401
42
4

FIG. 4

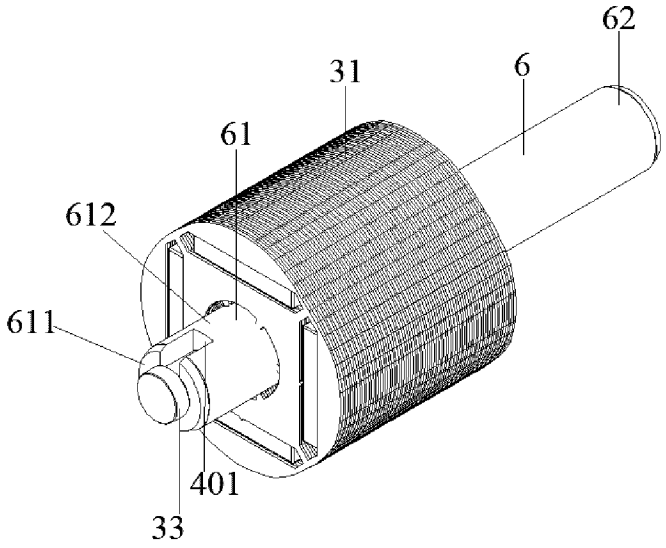
62
31
6
61
612
611
401
33

FIG. 5A

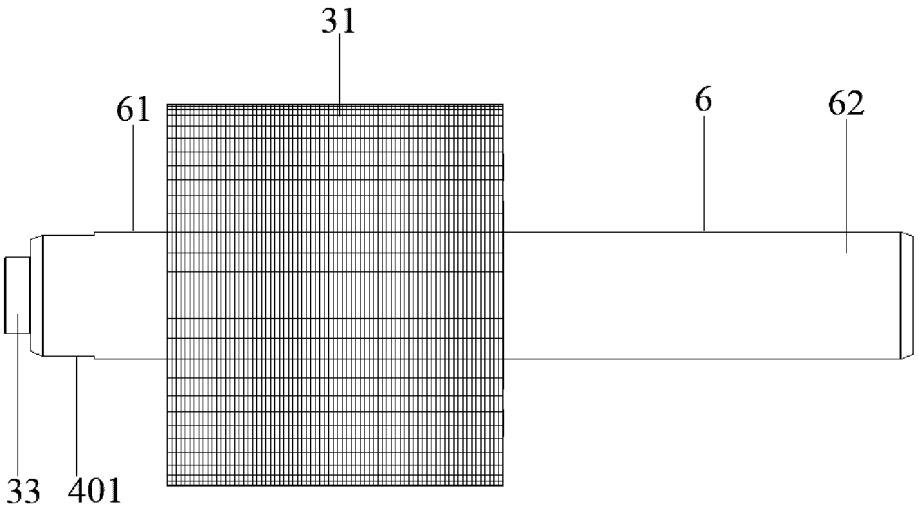

FIG. 5B

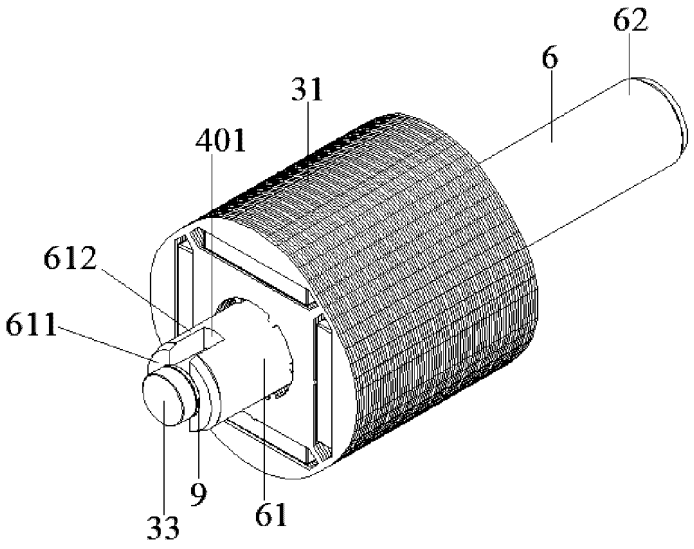

FIG. 6A

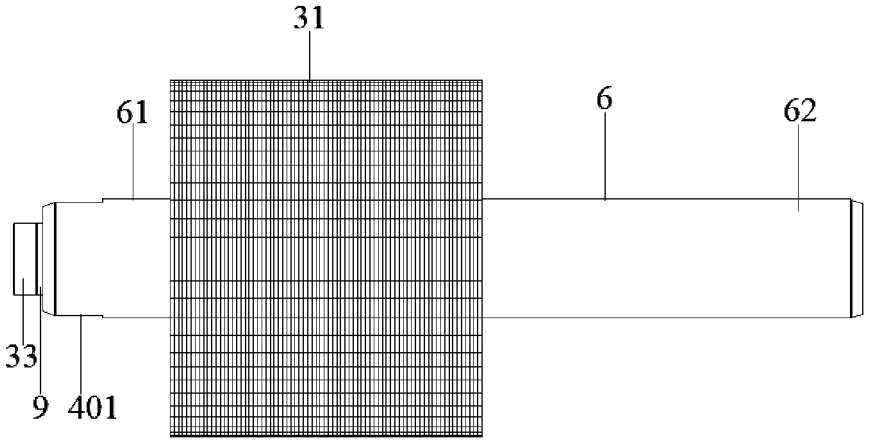

FIG. 6B

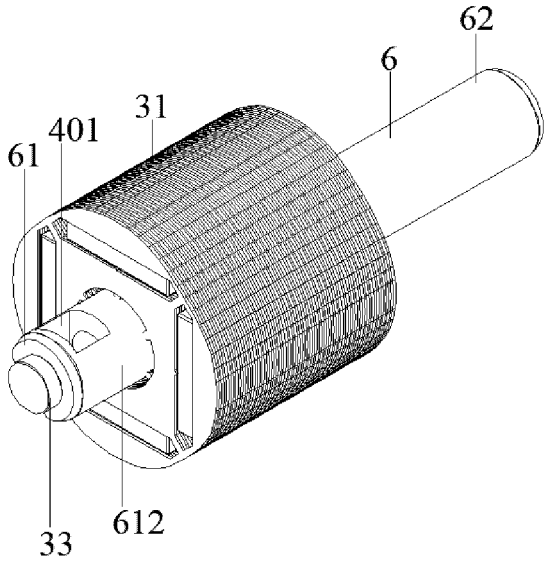

FIG. 7A

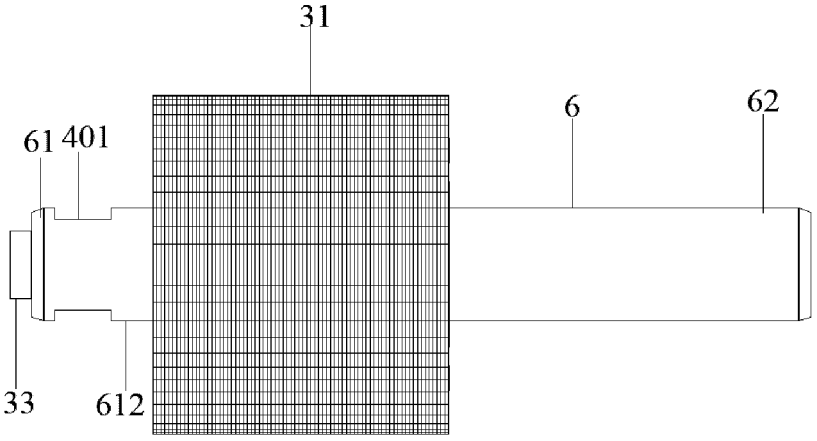

FIG. 7B

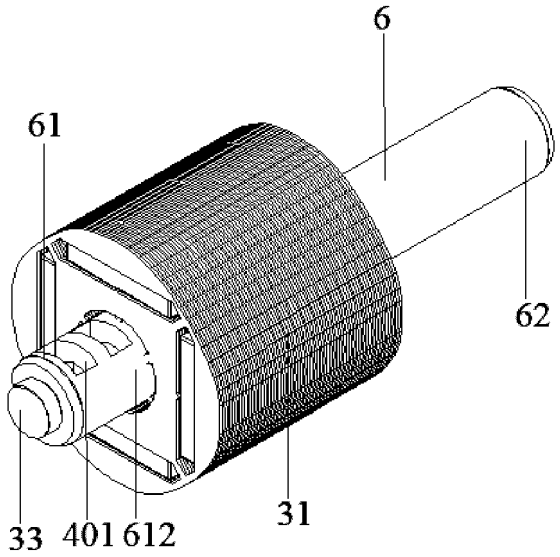

FIG. 8A

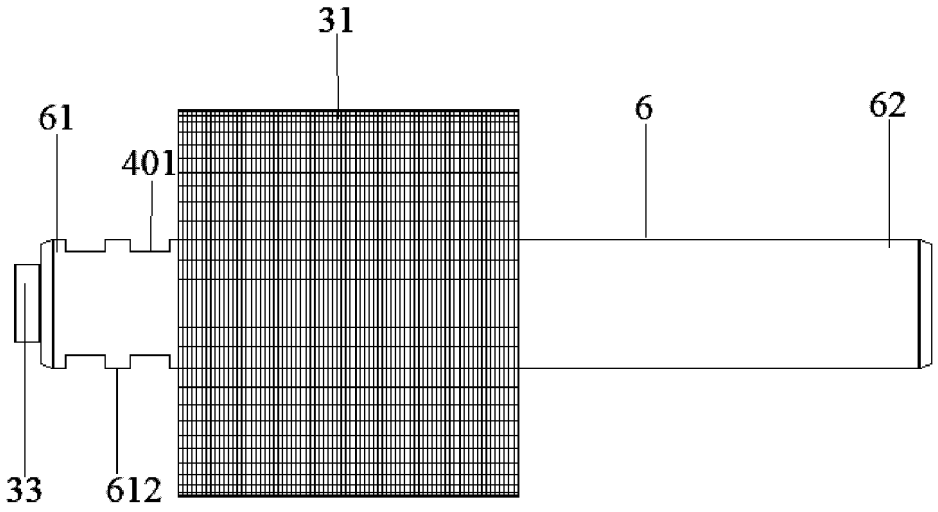

FIG. 8B

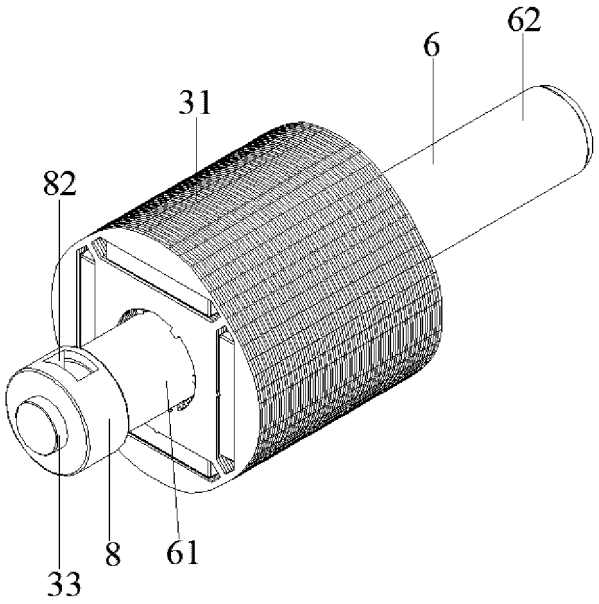

FIG. 9A

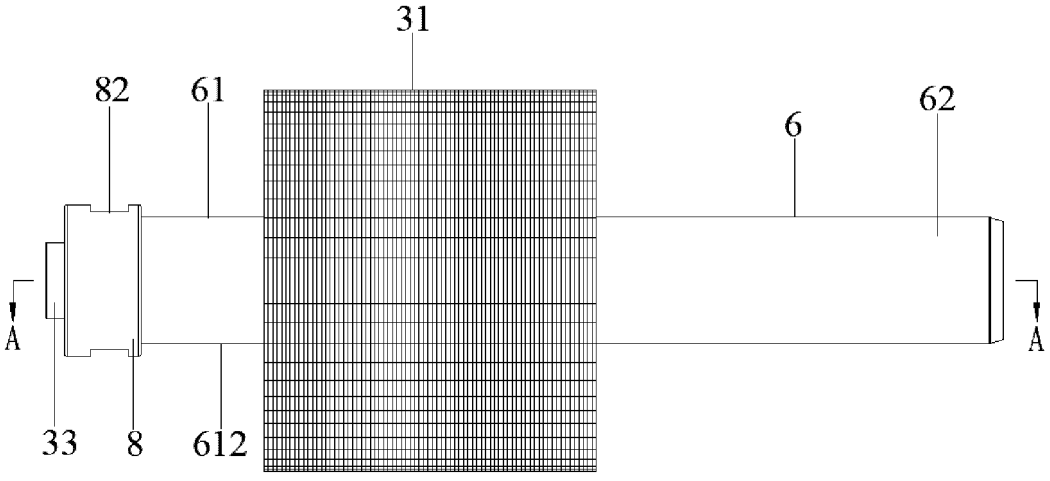

FIG. 9B

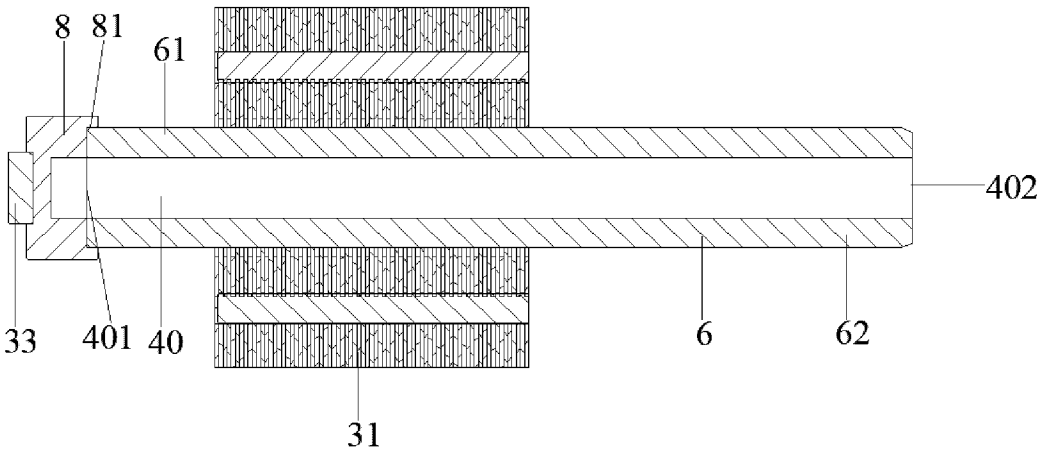
8
81
61
402
33
401
40
6
62
31

FIG. 9C

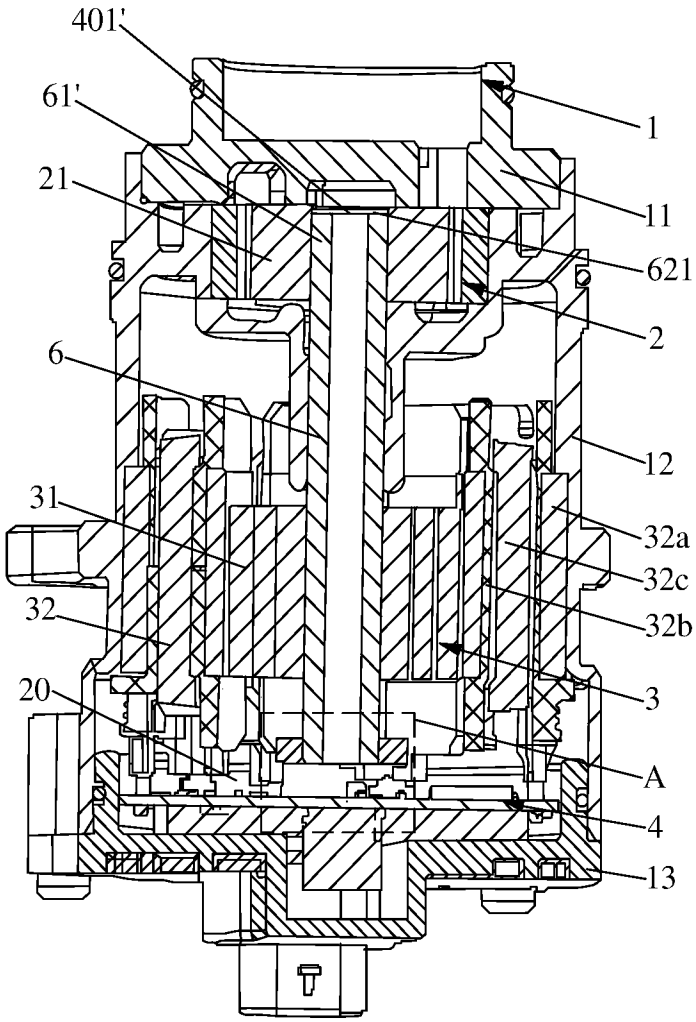
401'
61'
1
21
11
621
2
6
12
31
32a
32c
32b
32
3
20
A
4
13

FIG. 10

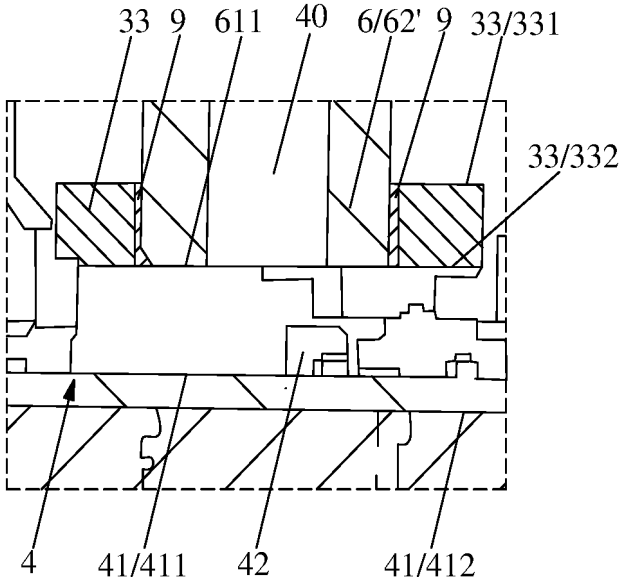
33
9
611
40
6/62'
9
33/331
33/332
4
41/411
42
41/412

FIG. 11

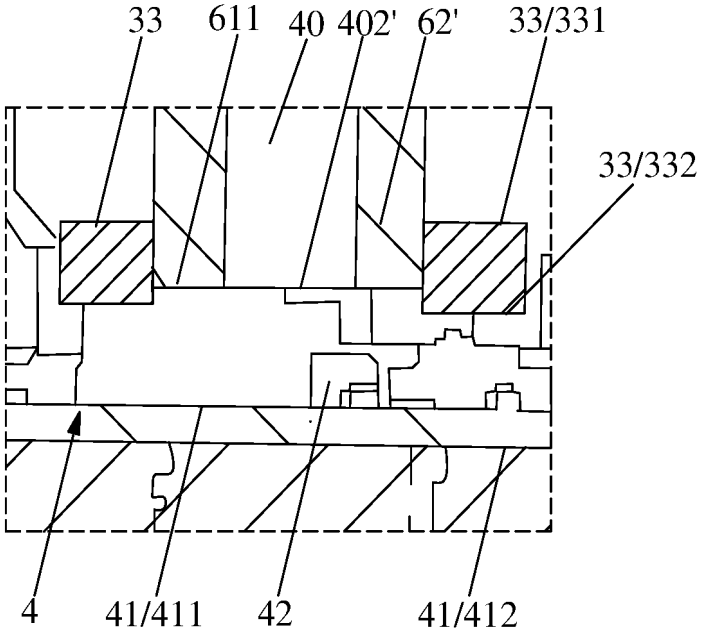
33
611
40
402'
62'
33/331
33/332
4
41/411
42
41/412

FIG. 12

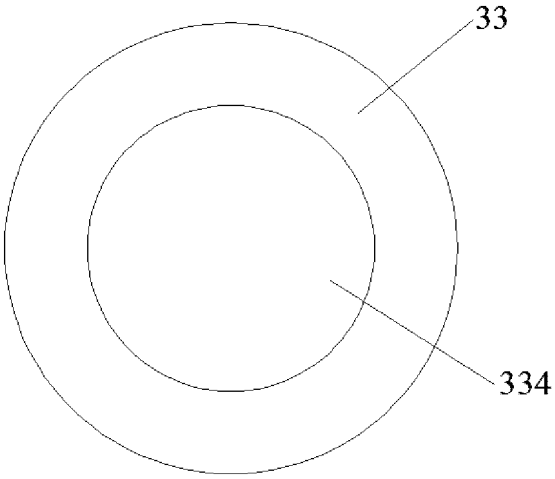

FIG. 13

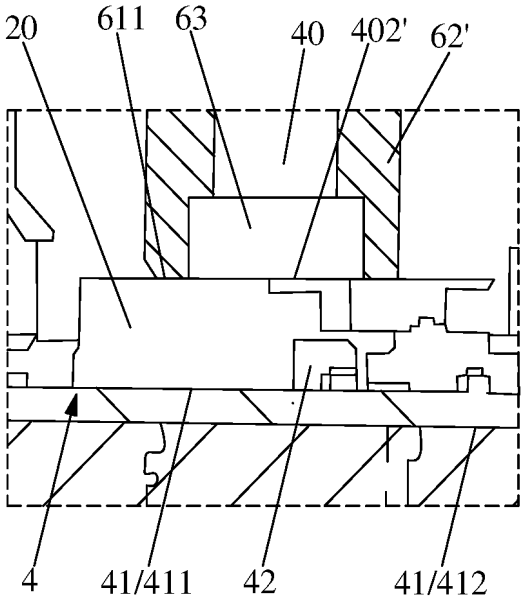

FIG. 14

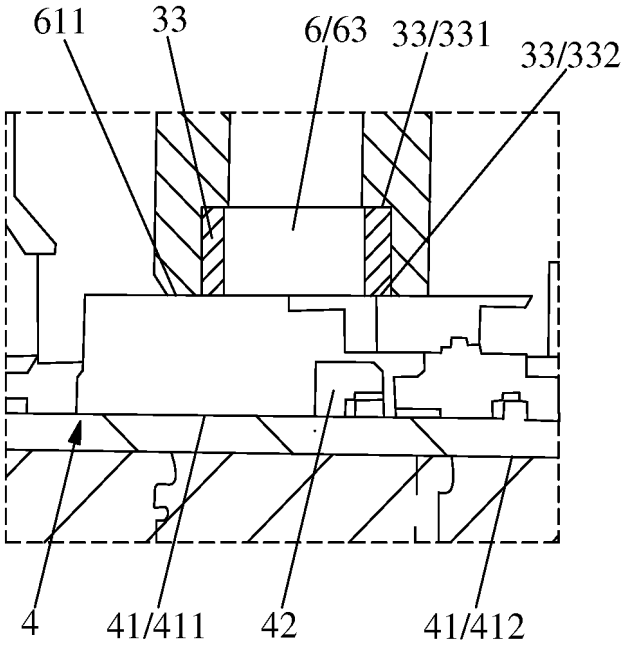
611
33
6/63
33/331
33/332
4
41/411
42
41/412

FIG. 15

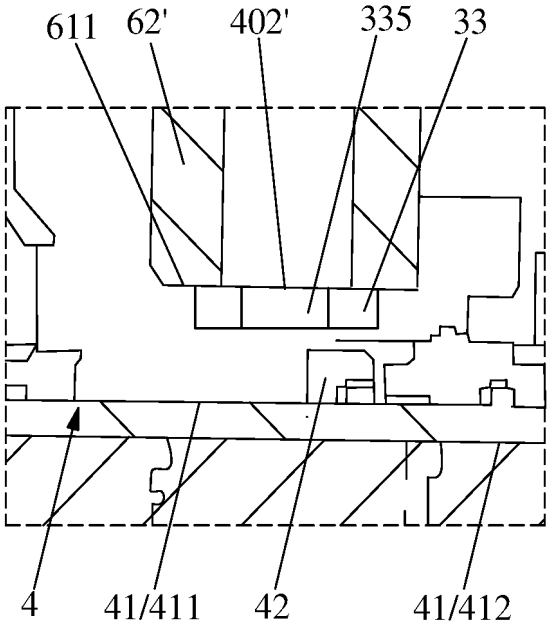
611
62'
402'
335
33
4
41/411
42
41/412

FIG. 16

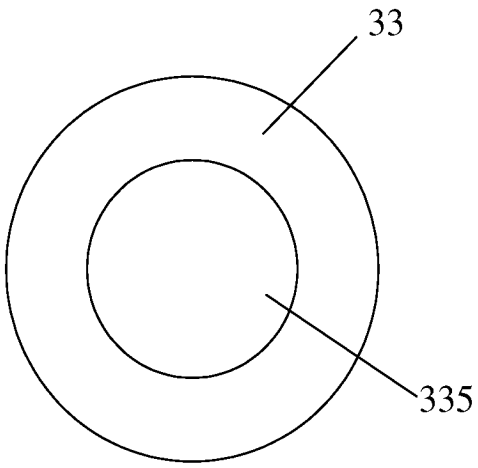

FIG. 17

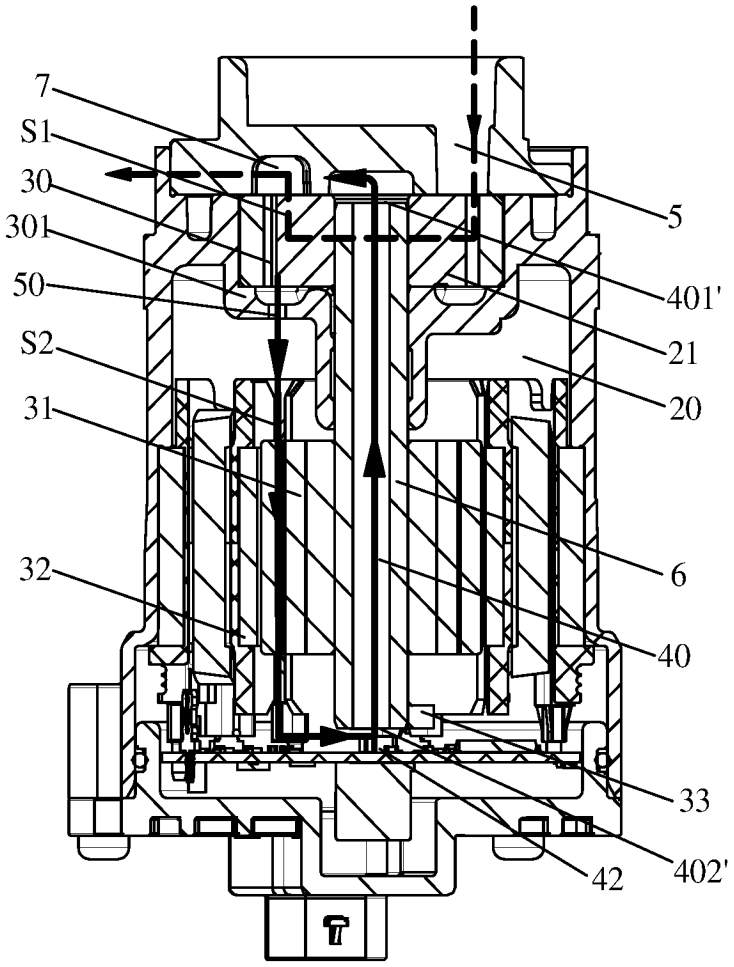

FIG. 18

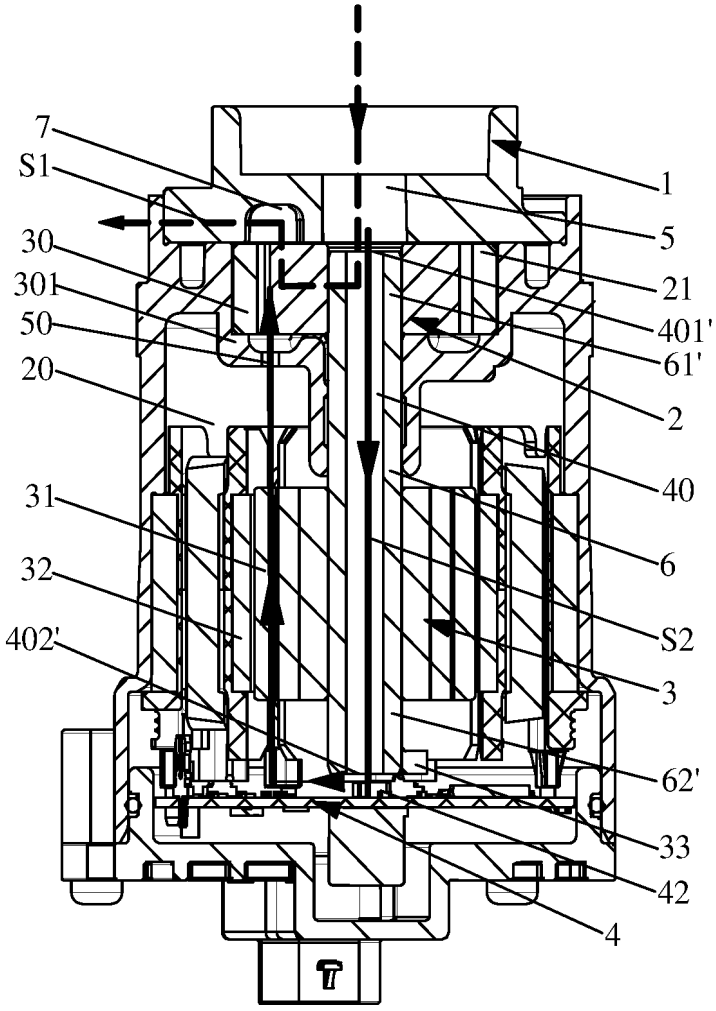
7
S1
30
301
50
20
31
32
402'
1
5
21
401'
61'
2
40
6
S2
3
62'
33
42
4

FIG. 19

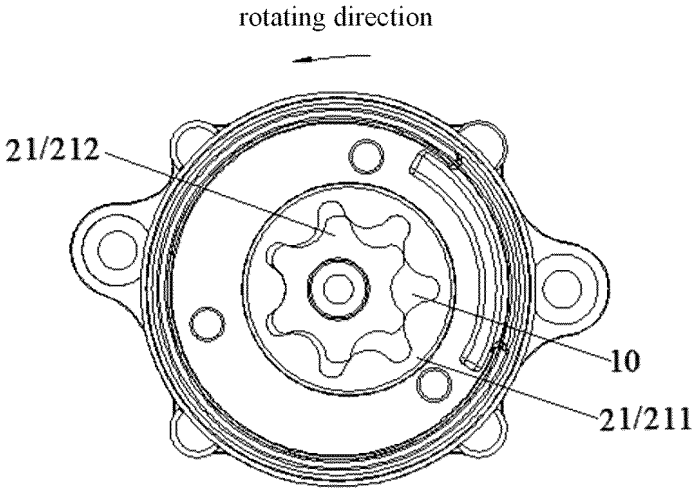
rotating direction
21/212
10
21/211

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/109821

A. CLASSIFICATION OF SUBJECT MATTER

F04C14/28(2006.01)i; F04C2/10(2006.01)i; F04C15/00(2006.01)i

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)

IPC:F04C

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)

CNABS, CNTXT, ENTXTC, CNKI: 泵, 电机, 电动机, 轴, 旋转, 转动, 检测, 监测, 磁性, 传感器, 感应器, 对置, 正对, 重叠, 投影; VEN, USTXT, EPTXT, WOTXT: pump, electric, machine, shaft, rotate, detect, monitor, magentic, sensor, align, superpose, overlap, projection.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 209818295 U (NIDEC TOSOK CORP.) 20 December 2019 (2019-12-20) description, paragraphs 24-95, and figures 1-5	1
Y	CN 209818295 U (NIDEC TOSOK CORP.) 20 December 2019 (2019-12-20) description, paragraphs 24-95, and figures 1-5	2-15
X	CN 113217405 A (KUNSHAN LONGZHONG MAXGREEN AUTO PARTS CO., LTD.) 06 August 2021 (2021-08-06) description, paragraphs 17-28, and figures 1-6	1-15
X	CN 106855051 A (FTE AUTOMOTIVE GMBH) 16 June 2017 (2017-06-16) description, paragraphs 34-141, and figures 1-9	1
Y	CN 106855051 A (FTE AUTOMOTIVE GMBH) 16 June 2017 (2017-06-16) description, paragraphs 34-141, and figures 1-9	2-15
Y	CN 112112796 A (HANGZHOU SANHUA RESEARCH INSTITUTE CO., LTD.) 22 December 2020 (2020-12-22) description, paragraphs 27-36, and figures 1-6	2-15

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 November 2023	**12 November 2023**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/109821

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2018025127 A (AISIN SEIKI CO., LTD.) 15 February 2018 (2018-02-15) entire document	1-15

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/109821

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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		US 2019234406 A1	01 August 2019
		JPWO 2018062089 A1	26 September 2019
CN 113217405 A	06 August 2021	CN 215672737 U	28 January 2022
CN 106855051 A	16 June 2017	EP 3179106 A1	14 June 2017
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		JP 2017127183 A	20 July 2017
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		EP 3988789 A1	27 April 2022
		JP 2022539958 A	14 September 2022
		US 2022325712 A1	13 October 2022
JP 2018025127 A	15 February 2018	None	

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REFERENCES CITED IN THE DESCRIPTION

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- CN 202210910293 **[0001]**
- CN 202210912059 **[0001]**