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(54) FLUID CONTROL DEVICE AND ELECTRIC PUMP DEVICE

(57) A fluid control device (1) and an electric pump device. The fluid control device (1) comprises a driving assembly (100), a pump assembly (20), a limiting assembly (50), and a main housing (40). The driving assembly (100) comprises a stator assembly (130). The pump assembly (20) comprises a rotor assembly (22), a positioning shaft (222) and an isolation sleeve (23), at least part of the rotor assembly (22) and the stator assembly (130) being arranged in a sleeving/sleeved manner, and at least part of the isolation sleeve (23) being located between the stator assembly (130) and the rotor assembly (22). The main housing (40) has a first chamber (401), at least part of the pump assembly (20) being located in the first chamber (401). The positioning shaft (222) is located in the rotor assembly (22); a first side of the positioning shaft (222) in the axial direction and the isolation sleeve (23) are configured to achieve limiting; the limiting assembly (50) is arranged close to a second side of the positioning shaft (222) in the axial direction, and the limiting assembly (50) and the positioning shaft (222) are configured to achieve limiting; therefore, axial limiting of the positioning shaft (222) and the rotor assembly (22) is facilitated.

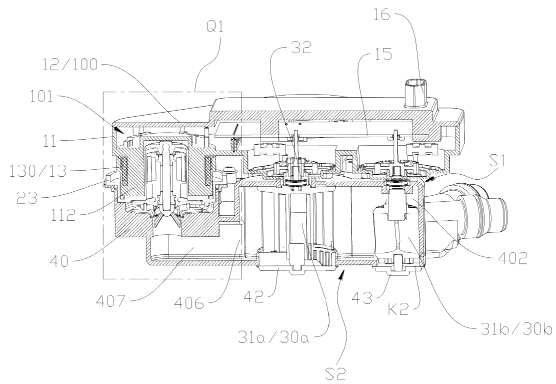

FIG. 17

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Description

[0001] The present application claims priorities to the Chinese Patent Application No. 202210472211.X, titled "FLUID CONTROL APPARATUS AND ELECTRIC PUMP DEVICE", filed on April 29, 2022 with the China National Intellectual Property Administration, and the Chinese Patent Application No. 202210472384.1, titled "FLUID CONTROL APPARATUS AND MANUFACTURING METHOD THEREFOR", filed on April 29, 2022 with the China National Intellectual Property Administration, both of which are incorporated herein by reference in their entireties.

FIELD

[0002] The present application relates to the technical field of fluid control, and in particular to a fluid control apparatus and an electric pump device.

BACKGROUND

[0003] A thermal management system generally includes multiple fluid elements, at least one of which includes a pump assembly. Therefore, how to better axially limit the pump assembly is an urgent problem to be solved.

SUMMARY

[0004] An object of the present application is to provide a fluid control apparatus and an electric pump device, in order to facilitate of axially limiting a pump assembly.

[0005] In an aspect, a fluid control apparatus is provided according to an embodiment of the present application. The fluid control apparatus includes an actuation assembly, at least two fluid subassemblies, a limiting assembly and a main housing. At least one of the fluid subassemblies includes a pump assembly, and the actuation assembly includes a stator assembly. The pump assembly includes a rotor assembly, a positioning shaft and an isolation sleeve, where the rotor assembly and the positioning shaft are limitedly arranged. The rotor assembly includes a magnetic assembly, at least a part of the magnetic assembly is located within a range of a magnetic field of the stator assembly in an operation state. At least a part of the isolation sleeve is located between the stator assembly and the rotor assembly. The main housing is provided with a first chamber, and at least a part of the pump assembly is located inside the first chamber,

the positioning shaft is located in the rotor assembly, where a first side of the positioning shaft in an axial direction and the isolation sleeve are limitedly arranged, the limiting assembly is arranged close to a second side of the positioning shaft in the axial direction, and the limiting assembly and the positioning shaft are limitedly arranged.

[0006] In another aspect, an electric pump device is provided according to an embodiment of the present application. The electric pump device includes a stator assembly, a pump assembly and a limiting assembly. The pump assembly includes a rotor assembly, a positioning shaft and an isolation sleeve, where the rotor assembly and the positioning shaft are limitedly arranged. The rotor assembly includes a magnetic assembly, at least a part of the magnetic assembly is located within a range of a magnetic field of the stator assembly in an operation state. At least a part of the isolation sleeve is located between the stator assembly and the rotor assembly,

the positioning shaft is located in the rotor assembly, where a first side of the positioning shaft in an axial direction and the isolation sleeve are limitedly arranged, the limiting assembly is arranged close to a second side of the positioning shaft in the axial direction, and the limiting assembly and the rotor assembly are limitedly arranged.

[0007] In the fluid control apparatus and the electric pump device according to the embodiment of the present application, the fluid control apparatus includes a pump assembly and a limiting assembly, where a first side of a positioning shaft of the pump assembly is limitedly connected with an isolation sleeve, and the other side and the limiting assembly are limitedly arranged, so that the limiting assembly can axially limit the positioning shaft. Further, the rotor assembly and the positioning shaft are limitedly arranged, so that the rotor assembly can be axially limited, and the pump assembly can be better axially limited by the limiting assembly. In case that the electric pump device includes the limiting assembly, it is beneficial to axially limiting the rotor assembly and the positioning shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic exploded structural view of a fluid control apparatus according to a first embodiment of the present application;

FIG 2 is a schematic perspective structural view of the fluid control apparatus shown in FIG. 1;

FIG. 3 is a schematic exploded structural view of an actuation assembly according to an embodiment of the present application;

FIG. 4 is a schematic perspective structural view of the actuation assembly shown in FIG. 3;

FIG. 5 is a schematic sectional structural view of the actuation assembly shown in FIG. 4;

FIG 6 is a partial schematic sectional structural view of a combined structure of a first housing and an actuation component according to an embodiment of the present application;

FIG. 7 is a schematic sectional structural view of another actuation assembly according to the present application;

FIG. 8 is a schematic sectional structural view of yet another actuation assembly according to the present application;

FIG. 9 is a schematic perspective structural view of a stator assembly shown in FIG. 4;

FIG. 10 is a schematic exploded structural view of a fluid assembly according to an embodiment of the present application;

FIG. 11 is a schematic perspective structural view of the fluid assembly shown in FIG. 10;

FIG. 12 is a schematic sectional structural view of a first fluid assembly shown in FIG. 11 at one position;

FIG. 13 is a partial schematic sectional structural view of a fluid assembly according to a second embodiment of the present application;

FIG. 14 is a schematic perspective structural view of a main housing according to an embodiment of the present application;

FIG. 15 is a schematic sectional structural view of the main housing shown in FIG. 14;

FIG. 16 is a schematic sectional structural view of the fluid assembly shown in FIG. 13;

FIG. 17 is a partial schematic sectional structural view of a fluid control apparatus according to a first embodiment of the present application;

FIG. 18 is an enlarged schematic structural view at Q1 in FIG. 17;

FIG. 19 is a partial schematic sectional structural view of a first combined structure of an actuation assembly and a fluid assembly of the present application;

FIG. 20 is a partial enlarged schematic structural view of the combined structure of the actuation assembly and the fluid assembly shown in FIG. 19;

FIG. 21 is a partial schematic sectional structural view of a second combined structure of the actuation assembly and the fluid assembly of the present application;

FIG. 22 is a partial schematic sectional structural view of a third combined structure of the actuation assembly and the fluid assembly of the present application;

FIG. 23 is a partial schematic sectional structural view of a fourth combined structure of the actuation assembly and the fluid assembly of the present application;

FIG. 24 is a partial schematic sectional structural view of a fifth combined structure of the actuation assembly and the fluid assembly of the present application;

FIG. 25 is a partial schematic sectional structural view of a sixth combined structure of the actuation assembly and the fluid assembly of the present application;

FIG. 26 is a partial schematic sectional structural view of a seventh combined structure of the actuation assembly and the fluid assembly of the present application;

FIG. 27 is a schematic exploded structural view of a fluid control apparatus according to a second embodiment of the present application;

FIG. 28 is a schematic perspective structural view of the fluid control apparatus shown in FIG. 27;

FIG. 29 is a schematic exploded structural view of the actuation assembly shown in FIG. 27;

FIG. 30 is a schematic perspective structural view of the actuation assembly shown in FIG. 29;

FIG. 31 is a schematic sectional structural view of an actuation assembly shown in FIG. 29;

FIG. 32 is a schematic exploded structural view of a fluid assembly shown in FIG. 27;

FIG. 33 is a schematic perspective structural view of the fluid assembly shown in FIG. 32;

FIG. 34 is a schematic front structural view of the fluid control apparatus shown in FIG. 27;

FIG. 35 is a schematic sectional structural view of the fluid control apparatus shown in FIG. 34 taken along line A-A;

FIG. 36 is a schematic sectional structural view of the fluid control apparatus shown in FIG. 34 taken along line B-B;

FIG. 37 is a schematic sectional structural view of the fluid assembly shown in FIG. 33 at one position;

FIG. 38 is a schematic sectional structural view of the fluid assembly shown in FIG. 33 at another position;

FIG. 39 is a partial schematic structural view of the fluid control apparatus shown in FIG. 27;

FIG. 40 is a schematic sectional structural view of the fluid control apparatus shown in FIG. 27 at yet another position;

FIG. 41 is a schematic connection diagram of a first valve assembly, a first pump assembly and a second pump assembly shown in FIG. 27 in a first operation mode;

FIG. 42 is a schematic connection diagram of the first valve assembly, the first pump assembly and the second pump assembly shown in FIG. 27 in a second operation mode;

FIG. 43 is a schematic connection diagram of the first valve assembly, the first pump assembly and the second pump assembly shown in FIG. 27 in a third operation mode;

FIG. 44 is a schematic connection diagram of the first valve assembly, the first pump assembly and the second pump assembly shown in FIG. 27 in a fourth operation mode; and

FIG. 45 is a schematic flow diagram of a method for manufacturing a fluid control apparatus according to an embodiment of the present application.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0009] The features and exemplary embodiments of various aspects of the present application will be described in detail below. In order to make the purpose, technical solutions and advantages of the present application more clear, the present application will be further described in detail below in conjunction with the accompanying drawings and specific embodiments. Moreover, relational terms such as "first" and "second" etc. are only used to distinguish one element from another having the same name and do not necessarily require or imply any such actual existence of relationship or order between those elements.

[0010] The fluid control apparatus according to an embodiment of the present application can be applied to a thermal management system, for example to a vehicle thermal management system. A fluid is controlled by the fluid control apparatus so as to achieve a communication of the fluid in the thermal management system.

[0011] As shown in FIG. 1 to FIG. 8, a fluid control apparatus 1 is provided according to an embodiment of the present application. The fluid control apparatus 1 includes an actuation assembly 100 and a fluid assembly 200, where the actuation assembly 100 is sealedly connected with the fluid assembly 200. In an embodiment, the actuation assembly 100 may be integrally assembled with the fluid assembly 200, and a seal is provided between the actuation assembly 100 and the fluid assembly 200 to achieve a sealed connection there between.

[0012] The actuation assembly 100 includes at least two actuation components 13, each of which may include a stator assembly 130 and a motor 132 or a combination of the motor 132 and a gear set 133. The fluid assembly 200 includes at least two fluid subassemblies LK, each of which may include an actuator. The fluid subassembly LK may include one of a valve assembly 30 and a pump assembly 20 or a combination thereof. The actuator in the valve assembly 30 includes a valve core, and the actuator in the pump assembly 20 includes a rotor assembly. When power is supplied to the actuation component 13, the actuation component 13 can drive the actuator in the fluid subassembly LK to act. For example, when being energized, the stator assembly 130 generates a magnetic field and the rotor assembly rotates under an action of the magnetic field, or when the motor 132 is energized, an output shaft of the motor 132 rotates so as to drive the valve core in the valve assembly 30 to rotate. Optionally, the number of the actuation components 13 may be the same with that of the fluid subassemblies LK, and the actuation components 13 and the fluid subassemblies LK may be arranged in a one-to-one correspondence. After being energized, one of the actuation components 13 can drive the actuator in a corresponding one of the fluid subassemblies LK to move, and the fluid may flow in the fluid control apparatus 1 through the action of the fluid subassembly LK in the fluid assembly 200. It can be understood that the number of the actuation components 13 may also be different from that of the fluid subassemblies LK. For example, the number of the actuation components 13 may be less than the number of fluid subassemblies LK, so that one actuation component 13 may drive at least two fluid subassemblies LK, for example, to drive at least two fluid subassemblies LK by a clutch mechanism. As shown in FIG. 1, in this embodiment, the number of the fluid subassemblies LK is five, and correspondingly, the number of the actuation components 13 is five, where the five actuation components and the five fluid subassemblies LK are arranged in a one-to-one correspondence. In other embodiments, the number of the fluid subassemblies LK and the number of the actuation components 13 may be set based on requirements of users, which may be two, three, four or six or more.

[0013] Further, an actuation assembly 100 is further provided according to an embodiment of the present application. As shown in FIG. 3 to FIG. 9, the actuation assembly 100 further includes a first housing 11 and a second housing 12. The actuation assembly 100 has a first accommodating chamber 101, and the first housing 11 and the second housing 12 form at least a part of a wall portion of the first accommodating chamber 101. In this embodiment, the second housing 12 includes a top cover portion, which is arranged to be opposite to a bottom wall portion 111 along a height direction of the actuation assembly 100. The first housing 11 and the second housing 12 are enclosedly fitted to form the first accommodating chamber 101, and at least a part of each of the at least two actuation components 13 is located inside the first accommodating chamber 101, so that the at least two actuation components 13 are integrated into one actuation assembly 100. Compared to an arrangement in which the multiple drive assemblies controlling the fluid assembly are arranged separately, the arrangement described above not only reduces the number of lead wires, but also reduces the space occupied by the actuation assembly 100. Optionally, all the actuation components 13 may be limitedly connected with the first housing 11, or only a part of the actuation components 13 are limitedly connected with the first housing 11, which is not limited in the present application.

[0014] As shown in FIG. 3 to FIG. 9, in the actuation assembly 100, the first housing 11 includes the bottom wall portion 111, a limiting portion 112 and a circumferential side wall 113, where the circumferential side wall 113 is connected to the bottom wall portion 111, and the bottom wall portion 111 is connected to the limiting portion 112. For example, the circumferential side wall 113, the bottom wall portion 111 and the limiting portion 112 may be formed into an integral structure by injection molding, or be fixedly connected by welding, or be limitedly connected by a fastener. At least a part of the limiting portion 112 protrudes from the bottom wall portion 111 along the height direction of the actuation assembly 100, and a part of the wall portion of the first accommodating chamber 101 is formed by the bottom wall portion 111 and the circumferential side wall 113. At least one of the actuation components 13 include the stator assembly 130, where the actuation component including the stator assembly 130 is defined as a first actuation component, and at least a part of the first actuation component is limitedly connected in the limiting portion 112. As shown in FIG. 3 to FIG. 8, at least a part of the stator assembly 130 included in the first actuation component is located in the limiting portion 112, or the first actuation component may further include a pump housing, and at least a part of the stator assembly 130 is located inside a chamber of the pump housing. For example, the stator assembly 130, as an insert, may be fixedly with the pump housing by injection molding or assembled inside the chamber of the pump housing. In this case, the pump housing is or the pump housing and at least a part of the whole stator assembly 130 are located in the limiting portion 112. Herein, at least a part of the stator assembly 130 is limitedly connected with the limiting portion 112, which means that at least a part of the first actuation component and the limiting portion 112 are formed into an integral structure by injection molding, so that at least a part of the first actuation component is located in the limiting portion 112; or the first actuation component and the first housing 11 are separately formed, and the limiting portion 112 has a chamber, so that at least a part of the first actuation component may also be located inside the chamber formed by the limiting portion 112. It can integrate at least two stator assemblies 130 in one actuation assembly 100 by limitedly connecting at least a part of the first actuation component in the limiting portion 112. Compared to an arrangement in which multiple actuation components are provided, the fluid control apparatus according to an embodiment of the present application can reduce the space occupied by the actuation assembly 100 and improve the integration degree of the actuation assembly 100.

[0015] With further reference to FIG. 1 to FIG. 9, in this embodiment, the number of the actuation components 13 included in the actuation assembly 100 is five, and gaps are provided among orthographic projections of the five actuation components 13 along the height direction of the actuation assembly 100. Three of the five actuation components 13 each includes the stator assembly 130, and all these three stator assemblies 130 may be limitedly connected with the corresponding limiting portions 112 and located in the corresponding limiting portions 112, respectively. Alternatively, in some other embodiments, one of the actuation components 13 of the actuation assembly 100 includes a stator assembly 130, and the other actuation components may be motors and the like, thus achieving the integration of the actuation components 13 in different types.

[0016] In order to limit the stator assembly 130, in some embodiments, at least a part of the limiting portion 112 extends from the bottom wall portion 111 in a direction away from the first accommodating chamber 101. In this case, at least a part of the limiting portion 112 extends from the bottom wall portion 111 in a direction close to the fluid subassembly LK, and at least a part of the limiting portion 112 protrudes from the bottom wall portion 111 in a direction away from the second housing 12. Optimally, the stator assembly 130 may be fixed with the limiting portion 112 by injection molding, where "being fixed by injection molding" means to be formed into an integral structure by injection molding. Specifically, the stator assembly 130 may be used as an insert and fixed with the first housing 11 by injection molding, so that the stator assembly 130 and the limiting portion 112 are formed into the integrated structure by injection molding. In this case, electric connection wires may be led out from the stator assembly 130 during injection molding, and the stator assembly 130 may be electrically connected to a controller through the electric connection wires. Alternatively, as shown in FIG. 7, the limiting portion 112 includes a mounting chamber QS, where at least a part of the stator assembly 130 is located inside the mounting chamber QS, and the stator assembly 130 may be connected to the first housing 11 in the position-limiting manner by the fastener. With the above arrangement, it facilitates of limit arranging the stator assembly 130 and the limiting portion 112. When the at least two actuation components 13 each includes the stator assembly 130, all the stator assemblies 130 and the limiting portion 112 may be formed into an integral structure by injection molding; or all the stator assemblies 130 may be assembled inside the mounting chamber QS formed by the limiting portion 112; or a part of the stator assemblies 130 may be formed into an integral structure with the limiting portion 112 by injection molding and another part of the stator assemblies 130 and the limiting portion 112 may be formed into an integral structure with the limiting portion 112 by injection molding.

[0017] As shown in FIG. 8 and FIG. 9, in order to implement a function of the actuation assembly, the actuation assembly according to the embodiments of the present application further includes a controller 15, which may be a circuit board, and the actuation component including the stator assembly 130 is defined as the first actuation component. In other embodiments, the first actuation component further includes a pump housing 135, a transition terminal 134 connected to the pump housing 135, and a connecting plate 136. The stator assembly 130 and the first housing 11 are separately formed, and the stator assembly 130 may be formed into an integral structure with the pump housing 135 by injection molding, or assembled inside a chamber defined by the pump housing 135. In this case, both the stator assembly 130 and the pump housing 135 are assembled inside the mounting chamber QS formed by the limiting portion 112. At least a part of the stator assembly 130 and the connecting plate 136 are located inside the chamber of the pump housing 135, and the pump housing 135 is sealedly connected with the first housing 11. For example, in FIG. 8, the pump housing 135 may be sealedly connected with the first housing 11 by a sealing ring; or the pump housing 135 and the limiting portion 112 of the first housing 11 are formed into an integral structure by injection molding. The stator assembly 130 includes a coil winding 1303, which is electrically connected to a pin in the transition terminal 134 through a conductive member in the connecting plate 136. Part of the transition terminal 134 passes through the bottom wall portion 111 and is located inside the first accommodating chamber 101, and the transition terminal 134 is electrically connected to the controller 15. It should be noted that the actuation component herein includes the stator assembly 130 or the motor 132, and the actuation component may further include a lead wire structure or a terminal structure, by which the controller 15 can be electrically connected to the stator assembly 130 or to the motor 132.

[0018] In order to achieve the electrical connection between the stator assembly 130 and the controller 15, a metal conductive structure may be provided in the first housing 11, and the metal conductive structure may be formed into an integral structure with the first housing 11 by injection molding, so that the metal conductive structure is embedded in the first housing 11. An insulation displacement connectors (IDC) may be used in an output terminal 1304 of the stator assembly 130, and thus the output terminal 1304 of the stator assembly 130 may be electrically connected to the controller 15.

[0019] In this embodiment, the actuation assembly 100 according to the embodiment of the present application includes three stator assemblies 130. Correspondingly, the stator assembly 130 includes an insulation frame 1301, a stator core 1302 and a coil winding 1303. A part of the stator core 1302 is embedded in the insulation frame 1301, and the coil winding 1303 is wound around the insulating frame 1301. When being energized, the coil winding 1303 may generate a magnetic field. The rotor assembly 22 in the pump assembly 20 can be located within the range of the magnetic field of the corresponding stator assembly 130, so that the stator assembly 130 can drive the rotor assembly 22 to rotate. With the above arrangement, the stator assembly 130 may be integrated into the actuation assembly 100.

[0020] In some embodiments, as shown in FIG. 24, the fluid control apparatus may further include an isolation sleeve 23, a part of which is located on an inner circumferential side of the stator assembly 130. Optionally, the isolation sleeve 23 and the first housing 11 may be formed into an integral structure by injection molding. For example, the isolation sleeve 23 and the limiting portion 112 may be formed into an integral structure by injection molding. In this case, the stator assembly 130 and the limiting portion 112 may be formed into an integral structure by injection molding; or the stator assembly 130 may be located inside the mounting chamber QS of the limiting portion 112. Optionally, as shown in FIG. 19 to FIG. 24, the isolation sleeve 23 and the stator assembly 130 are formed into an integral structure by injection molding, or at least a part of the stator assembly 130 is located inside the chamber formed by the isolation sleeve 23, and the isolation sleeve 23 and the stator assembly 130, as an integral structure, are separately arranged from the first housing 11 and are sealedly connected to the first housing 11. A sealing ring is provided between the integral structure formed by the isolation sleeve 23 and the stator assembly 130 and the first housing 11, and a sealing arrangement between the integral structure and the first housing 11 is achieved by clamping the sealing ring. With the above arrangement, the limit arrangement and a sealed connection between the first housings 11 and the isolation sleeve 23 can be achieved.

[0021] In an embodiment, when the stator assembly 130 and the limiting portion 112 are formed into an integral structure by injection molding, the isolation sleeve 23 may be formed into an integral structure with the first housing 11 by injection molding, or the isolation sleeve 23 and the first housing 11 may be separately arranged and sealedly connected. When the stator assembly 130 is assembled inside the mounting chamber QS of the limiting portion 112, the isolation sleeve 23 and the first housing 11 may be formed into an integral structure by injection molding; or the isolation sleeve 23 and the first housing 11 are separately arranged and sealedly connected with each other; or the isolation sleeve 23 and the stator assembly 130 are formed into an integral structure by injection molding, and the isolation sleeve 23 and the stator assembly 130, as an integral structure, are separately arranged from the first housing 11 and are sealedly connected to the first housing 11. In case that the number of the stator assemblies 130 is at least two, the ways of limit connection between different stator assemblies 130 and the first housing 11 may be the same or different. The connection ways between the isolation sleeves 23 corresponding to different stator assemblies 130 and the first housing 11 may also be the same or different..

[0022] With regard to the fluid assembly 200, reference is further made to FIG. 10 to FIG. 15. In some embodiments, the fluid assembly 200 further includes a main housing 40 with chambers, and at least a part of the fluid subassembly LK is located inside a corresponding one of the chambers. For example, the fluid subassembly LK includes at least two pump assemblies 20, and the pump assemblies 20 each includes the rotor assembly 22, where a part of the rotor assembly 22 may be sleeved with the corresponding stator assembly 130, so that the stator assembly 130, when being energized, may drive the rotor assembly 22 to rotate. The stator assembly 130 and the rotor assembly 22 may also be of a disk-shaped structure. One of the pump assemblies is defined as a first pump assembly 20a, and the other of the pump assemblies is defined as a second pump assembly 20b. The first pump assembly 20a includes a first rotor assembly 22a, and the second pump assembly 20b includes a second rotor assembly 22b. The first rotor assembly 22a may be located within the range of the magnetic field of the first stator assembly 130a, and the second rotor assembly 22b may be located within the range of the magnetic field of the second stator assembly 130b. In an embodiment, the number of the pump assemblies may be set based on the requirements of the users, for example, it may be two, three, four or more. In this embodiment, the three fluid subassemblies LK include the pump assemblies 20, which are the first pump assembly 20a, the second pump assembly 20b and the third pump assembly 20c respectively, and gaps are provided among the three pump assemblies. With the above arrangement, the integration of the at least two pump assemblies 20 can be achieved and the pipeline connection between the pump assemblies 20 can be reduced.

[0023] Alternatively, in order to implement multiple operation modes of the fluid control apparatus, in some embodiments, at least one of the fluid subassemblies LK includes a pump assembly 20, and at least one of the fluid subassemblies LK includes a valve assembly 30, which includes a valve core 31 and a valve core shaft 32. The valve core 31 and the valve core shaft 32 may be formed into an integral structure by injection molding, or be connected by interference fit or connection keys. The valve core 31 is transmission connected with the output shaft of the motor 132 through the valve core shaft 32, and the valve core 31 can rotate and translate under the action of the motor 132. In this embodiment, the valve core 31 may be driven to rotate, thus implementing multiple operation modes of the fluid control apparatus 1. Herein, the transmission connected between two components means that the driving force can be transmitted between the two components, and the two components may be directly or indirectly transmission connected with each other. Specifically, the valve core shaft 32 of the valve assembly 30 may be directly transmission connected with the motor 132, or the actuation assembly 100 may further include a gear set 133, and the motor 132 may be transmission connected with the valve core shaft 32 of the valve core 31 through the gear set 133. In an embodiment, the number of the valve assemblies 30 may be set based on the requirements of the users. For example, in FIG. 1, the two fluid subassemblies LK in this embodiment include the valve assemblies 30, and correspondingly, the actuation assembly 100 includes two motors 132, so that the motors 132 may actuate the corresponding valve assemblies 30 to act.

[0024] Further, as shown in FIG. 3 to FIG. 16, in some embodiments, the pump assembly 20 includes the rotor assembly 22, and the isolation sleeve 23 of the fluid control apparatus is sleeved on an outer circumferential side of the rotor assembly 22. The stator assembly 130 and the corresponding rotor assembly 22 may be isolated from each other by arranging the isolation sleeve 23, which prevents the working fluid from entering a space where the stator assembly 130 is located.

[0025] In order to achieve a fluid communication inside the fluid control apparatus 1, in some embodiments, at least a part of the main housing 40 is located on a side of the first housing 11 away from the first accommodating chamber 101, as shown in FIG. 1, and at least a part of the main housing 40 is located on a side of the first housing away from the second housing 12. The main housing 40 further includes a connecting pipe 41, which may be arranged along a circumferential direction of the main housing 40 or integrated on at least one mounting surface. As shown in FIG. 11 to FIG. 17, in order to achieve the fluid communication inside the pump assembly 20, the main housing 40 has a first chamber 401, a first duct 404 and a second duct 405, both of which are in communication with the first chamber 401. At least a part of the pump assembly 20 is located inside one of the first chambers 401. The rotor assembly 22 can be rotated to drive the fluid to flow through the first duct 404 and the second duct 405. Optionally, the rotor assembly 22 includes an impeller assembly 221 and a magnetic assembly 223, and the pump assembly 20 further includes a positioning shaft 222. The impeller assembly 221 is sleeved on the outer circumferential side of the positioning shaft 222, and at least a part of the impeller assembly 221 may be located inside the first chamber 401. At least a part of the first duct 404 and the impeller assembly 221 are arranged along the height direction of the pump assembly 20, and the second duct 405 is located corresponding to the position of the impeller assembly 221. Optionally, at least a part of the wall portion of the first duct 404 may be arranged coaxially with a rotating axis of the impeller assembly 221, and a mouth of the second duct 405 is located at a circumferential edge of the impeller assembly 221, so that the fluid can enter the impeller assembly 221 through the first duct 404 and the fluid can be discharged through the second duct 405 under a centrifugal force of the impeller assembly 221. In this case, the first duct 404 may be an inlet duct of the pump assembly 20, and the second duct 405 may be an outlet duct of the pump assembly 20.

[0026] In case that at least one fluid subassembly LK further includes the valve assembly 30, the main housing 40 further includes a second chamber 402, which is spaced apart from the first chamber 401. At least a part of the pump assembly 20 is sealedly arranged in the first chamber 401, and at least a part of the valve core 31 is located inside one second chamber 402. Optionally, a seal may be provided between at least a part of the pump assembly 20 and the main housing 40; or a part of the structure of the pump assembly 20 may be connected to the main housing 40 by welding to achieve the sealing arrangement there between. Similarly, a seal may be provided between the valve core 31 and the main housing 40; or multiple components, which are separately arranged, of the main housing 40 may be welded to sealedly arrange the valve core 31 inside the second chamber 402. With the above arrangement, at least one pump assembly 20 and at least one valve core 31 may be integrated in one main housing 40, thus reducing the space occupied by the fluid assembly 200 and further reducing the space occupied by the fluid control apparatus 1.

[0027] As shown in FIG. 12 to FIG. 19, in order to achieve the fluid communication between the pump assembly 20 and the valve assembly 30, in some embodiments, the main housing 40 further has a communication passage 407 and multiple flow passages 406. The main housing 40 has a flow passage plate 44 and a chamber casing 45, which are formed into an integral structure by injection molding. The first chamber 401, the second chamber 402 and the flow passage 406 are located in the chamber casing 45, and the communication passage 407 is located in the flow passage plate 44. At least a part of the flow passage plate 44 is connected between the two fluid subassemblies LK, for example, the flow passage plate 44 may be connected between the pump assembly 20 and the valve assembly 30, or the flow passage plate 44 may also be connected between two valve assemblies 30. In the embodiment of the present application, the flow passage plate 44 and the chamber casings 45 are formed into an integral structure, which is facilitated of reducing the pipeline connection between the chamber casings 45 and improves the integration degree of the fluid control apparatus. Further, the multiple flow passages 406 are distributed on the outer circumferential side of the second chamber 402, and one flow passages 406 is in communication with one of the first duct 404 and the second duct 405 through one communication passage 407. The valve core 30 includes a communication chamber 31, which can communicate at least two flow passages 406. Extension directions of the communication passage 407, the flow passage 406 and the first duct 404 or the second duct 405, which are in communication with each other, are intersected.

[0028] In some embodiments, with further reference to FIG. 1 to FIG. 19, the pump assembly 20 includes a first pump assembly 20a, a second pump assembly 20b and a third pump assembly 20c. The valve assembly 30 includes a first valve assembly 30a and a second valve assembly 30b. The first valve assembly 30a includes a first valve core 31a and a first seal (not shown), and the second valve assembly 30b includes a second valve core 31b and a second seal (not shown). The first pump assembly 20a, the second pump assembly 20b, the third pump assembly 20c and the second valve assembly 30b are distributed on the outer circumferential side of the first valve assembly 30a, and the flow passage 406 located on the outer circumferential side of the first valve assembly 30a is defined as the first flow passage 4061, which is located on the wall portion of the chamber where the first valve assembly 30a is located. The number of the first flow passages 4061 may be at least eight, for example, eight, and the flow passage located on the outer circumferential side of the second valve assembly 30b is defined as the second flow passage 4062, which is located on the wall portion of the chamber where the second valve assembly 30b is located. The number of the second flow passages 4062 may be at least three, for example, three. One of the first flow passages 4061 is in communication with one of the second flow passages 4062, and the first valve core 31a includes at least four communication chambers 311. The communication chambers 311 of the first valve core 31a may communicate the first flow passages 4061 in pairs, and the communication chambers of the second valve core 31b may communicate two or three second flow passages 4062. By rotating the first valve core 31a, at least one first flow passages 4061 can be in communication and switched, and by rotating the second valve core 31b, a communication, a switching and a flow regulation among the second flow passages 4062 can be achieved.

[0029] Based on this, the communication passage 407 of the main housing 40 may include a first communication passage 407a, a second communication passage 407b and a third communication passage 407c. The first chamber 401 includes a first sub-chamber A1, a second sub-chamber A2 and a third sub-chamber A3, and the second chamber 402 includes a fourth sub-chamber A4 and a fifth sub-chamber A5. At least a part of the first pump assembly 20a is located inside the first sub-chamber A1, at least a part of the second pump assembly 20b is located inside the second sub-chamber A2, and at least a part of the third pump assembly 20c is located inside the third sub-chamber A3. At least a part of the first valve assembly 30a is located inside the fourth sub-chamber A4, and at least a part of the second valve assembly 30b is located inside the fifth sub-chamber A5, where the first sub-chamber A1, the second sub-chamber A2 and the third sub-chamber A3 are all in communication with the fourth sub-chamber A4, and the fifth sub-chamber A5 is in communication with the fourth sub-chamber A4. The first duct 404 includes a first sub-duct 404a, a second sub-duct 404b and a third sub-duct 404c, and the second duct 405 includes a fourth sub-duct 405a, a fifth sub-duct 405b and a sixth sub-duct 405c. Both the first sub-duct 404a and the fourth sub-duct 405a are in communication the first sub-chamber A1, both the second sub-duct 404b and the fifth sub-duct 405b are in communication with the second sub-chamber A2, and both the third sub-duct 404c and the sixth sub-duct 405c are in communication with the third sub-chamber A3. The first communication passage 407a communicates the first sub-chamber A1 with the fourth sub-chamber A4. In particular, the first communication passage 407a communicates the first sub-duct 404a with a first flow passage 4061 located on the outer circumferential side of the first valve core 31a, and the fourth sub-duct 405a is in communication with the inner chamber of the connecting pipe 41. The second communication passage 407b communicates the second sub-chamber A2 and the fourth sub-chamber A4. In particular, the second communication passage 407b communicates the second sub-duct 404b with another first flow passage 4061 located on the outer circumferential side of the first valve core 31a, and the fifth sub-duct 405b is in communication with the inner chamber of the connecting pipe 41. The third communication passage 407c communicates the third sub-chamber A3 with the fourth sub-chamber A4. In particular, the third communication passage 407c communicates the sixth sub-duct 405c with another first flow passage 4061 located on the outer circumferential side of the first valve core 31a, and the third sub-duct 404c is in communication with the inner chamber of the connecting pipe 41.

[0030] Further, the main housing 40 further includes a fourth communication passage 407d which communicates the fifth sub-chamber A5 and the fourth sub-chamber A4. The first communication passage 407a, the second communication passage 407b, the third communication passage 407c and the fourth communication passage 407d are respectively arranged on the outer circumferential surface of the wall portion of the fourth sub-chamber A4. As shown in FIG. 15, in some embodiments, at least a part of the first communication passage 407a, at least a part of the second communication passage 407b, at least a part of the third communication passage 407c and at least a part of the fourth communication passage 407d are arranged at intervals along the circumferential direction of the wall portion of the fourth sub-chamber A4. In other embodiments, the communication passages described above may also be arranged in other forms, for example, at least a part of the communication passages are arranged along the height direction of the fluid control apparatus. With the above arrangement, the pump assembly 20 and the valve assembly 30 may work together to achieve multiple operation modes of the fluid control apparatus. When the fluid control apparatus is applied to the thermal management system, multiple operation states of the thermal management system may be achieved, thus implementing the cooling and temperature-reducing functions on different heat sources.

[0031] The fluid control apparatus according to the embodiment of the present application will be described below.

[0032] With reference to FIG. 1 to FIG. 26 together, in some embodiments, at least two of the actuation components 13 each includes the stator assembly 130, and at least two of the fluid subassemblies LK each includes the pump assembly 20. One of the pump assemblies is defined as a first pump assembly 20a and the other is defined as a second pump assembly 20b, and one of the stator assemblies is defined as a first stator assembly 130a and the other is defined as a second stator assembly 130b. The limiting portion 112 includes a first limiting portion 112a and a second limiting portion 112b, where at least a part of the first stator subassembly 130a is limitedly connected to the first limiting portion 112a, and at least a part of the second stator subassembly 130b is limitedly connected to the second limiting portion 112b. The first pump assembly 20a includes a first rotor assembly 22a, and the second pump assembly 20b includes a second rotor assembly 22b. The first rotor assembly 22a can be located within the range of the magnetic field of the first stator assembly 130a, and the second rotor assembly 22b can be located within the range of the magnetic field of the second stator assembly 130a. Optionally, a part of the first rotor assembly 22a is located on an inner side of the first stator assembly 130a, and a part of the second rotor assembly 22b is located on an inner side of the second stator assembly 130a. With the above arrangement, at least two of the stator assemblies 130 may be integrated in one actuation assembly 100, which can improve the integration degree of the actuation assembly 100 compared to the arrangement of separately providing two stator assemblies 130 in different actuation assemblies.

[0033] As shown in FIG. 1 to FIG. 9, in this embodiment, the three actuation components 13 each includes the stator assembly 130, which is defined as a first stator subassembly 130a, a second stator subassembly 130b and a third stator subassembly 130c, respectively. Correspondingly, the first housing 11 includes a first limiting portion 112a, a second limiting portion 112b and a third limiting portion 112c. The number of fluid subassemblies LK including the pump assemblies 20 may also be two, three, four or more. In this embodiment, the fluid subassemblies LK include three pump assemblies 20, which are defined as a first pump assembly 20a, a second pump assembly 20b and a third pump assembly 20c, respectively. A part of the third rotor assembly 22c is located inside of the third stator assembly 130c, and the third rotor assembly 22c may be located within the range of the magnetic field of the third stator assembly 130c. Optionally, the first stator subassembly 130a and the first limiting portion 112a may be formed into an integral structure by injection molding, the second stator assembly 130b and the second limiting portion 112b may be formed into an integral structure may be injection molding, the third stator assembly 130c and the third limiting portion 112c may be formed into an integral structure by injection molding, and the limiting portion 112 and the bottom wall portion 111 may be formed into an integral structure by injection molding.

[0034] In some embodiments, at least one of the fluid subassemblies LK includes a pump assembly 20, and at least one of the fluid subassemblies LK includes a valve assembly 30. At least one actuation component 13 includes a stator assembly 130, and at least one of the rest actuation components 13 includes a motor 132. The first housing 11 further includes a mounting portion 114 (shown in FIG. 6), which is arranged at a distance from the limiting portion 112, and the motor 132 is limitedly connected to the mounting portion. With the above arrangement, it facilitates of integrating at least one stator assembly 130 and at least one motor 132 in one actuation assembly 100. The valve assembly 30 includes a valve core 31 and a valve core shaft 32. The valve core 31 and the valve core shaft 32 may be formed into an integral structure by injection molding, or connected with each other by interference fit or a connecting key. The valve core 31 is transmission connected with the output shaft of the motor 132 through the valve core shaft 32, and can rotate or translate under the action of the motor 132. In this embodiment, the valve core 31 can be driven to rotate, thus implementing multiple operation modes of the fluid control apparatus 1. Specifically, the valve core shaft 32 of the valve assembly 30 may be directly transmission connected with the motor 132; or the actuation assembly 100 may further include a gear set 133, and the motor 132 may be transmission connected with the valve core shaft 32 of the valve core 31 through the gear set 133. With the above arrangement, at least one stator assembly 130 and at least one motor 132 may be integrated in the same actuation assembly 100, which facilitates of reducing the space occupied by the actuation assembly 100. In an embodiment, the number of the valve assemblies 30 and the number of the motors 132 may be set based on the requirements of users. For example, in FIG. 1, two of the fluid subassemblies LK in this embodiment include valve assemblies 30, and correspondingly, the actuation assembly 100 includes two motors 132, so that the motors 132 drive the corresponding valve assemblies 30 to act.

[0035] Specifically, with further reference to FIG. 1 to FIG. 26, the actuation assembly 100 includes five actuation components 13, where three of the actuation components 13 each includes the stator assembly 130, which is defined as a first stator subassembly 130a, a second stator subassembly 130b and a third stator subassembly 130c, respectively, and the rest two of the actuation components 13 each includes the transmission assembly consisting of the motor 132 and the gear set 133. One set of the transmission assemblies includes a first motor 132a and a first gear set 133a, and the other of the transmission assemblies includes a second motor 132b and a second gear set 133b. Accordingly, the fluid assembly 200 includes five fluid subassemblies LK, where three of the fluid subassemblies LK each includes the pump assembly 20, which is defined as a first pump assembly 20a, a second pump assembly 20b and a third pump assembly 20c, respectively, and the rest two of the fluid subassemblies LK each includes the valve assembly 30, one of which includes a first valve core 31a and the other of which includes a second valve core 31b. The first stator subassembly 130a can drive the rotor subassembly in the first pump subassembly 20a to rotate, the second stator subassembly 130b can drive the rotor subassembly in the second pump subassembly 20b to rotate, and the third stator subassembly 130c can drive the rotor subassembly in the third pump subassembly 20c to rotate. The first transmission subassembly composed of the first motor 132a and the first gear subassembly 133a can drive the first valve core 31a to rotate, and the second transmission subassembly composed of the second motor 132b and the second gear subassembly 133b may drive the second valve core 31b to rotate. Optionally, along the height direction of the fluid control apparatus 1, the sides of the first pump assembly 20a, the second pump assembly 20b and the third pump assembly 20c away from the main housing 40 are located at the same level, that is, the ends of these three pump assemblies close to the actuation assembly 100 may be located at the same level, which facilitates the assembling with the three stator assemblies in the actuation assembly 100. Optionally, the sides of the three stator assemblies corresponding to the three pump assemblies away from the main housing 40 may also be located at the same level, which facilitates the assembling and electrical connection with the controller, and a part of the valve assembly 30 and a part of the pump assembly 20 are located at the same level. With the above arrangement, the height of the fluid control apparatus can be reduced, and the controllers of both the valve assembly 30 and the pump assembly 20 can be assembled with the first housing and can be electrically connected with one single controller.

[0036] The operation modes of the fluid control apparatus shown in FIG. 1 to FIG. 26 will be described below. Seven first flow passages 4061 are defined as a first sub flow passage P1, a second sub flow passage P2, a third sub flow passage P3, a fourth sub flow passage P4, a sixth sub flow passage P6, a seventh sub flow passage P7 and an eighth sub flow passage P8. Two second flow passages 4062 are defined as a fifth sub flow passage P5 and a ninth sub flow passage P9. The communication chamber of the first valve core 31a is defined as the first communication chamber, and the communication chamber of the second valve core 31b is defined is defined as a second communication chamber. The fluid control apparatus according to the embodiment of the present application has at least one of the following operation modes.

[0037] In a first operation mode, the first valve core 31a rotates to the first position, where the first sub flow passage P1 is in communication with the second sub flow passage P2 through one of the first communication chambers, the third sub flow passage P3 is in communication with the fourth sub flow passage P4 through another first communication chamber, the sixth sub flow passage P6 is in communication with the seventh sub flow passage P7 through yet another first communication chamber, and at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the eighth sub flow passage P8 through yet another first communication chamber, the fourth communication passage 407d and the second communication chamber.

[0038] In a second operation mode, the first valve core 31a rotates to the second position, where the third sub flow passage P3 is in communication with the second sub flow passage P2 through one of the first communication chambers, at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the fourth sub flow passage P4 through another first communication chamber, the fourth communication passage 407d and the second communication chamber, the seventh sub flow passage P7 is in communication with the eighth sub flow passage P8 through yet another first communication chamber, and the sixth sub flow passage P6 is in communication with the first sub flow passage P1 through yet another first communication chamber.

[0039] In a third operation mode, the first valve core 31a rotates to the third position, where the first sub flow passage P1 is in communication with the eighth sub flow passage P8 through one of the first communication chambers, the third sub flow passage P3 is in communication with the fourth sub flow passage P4 through another first communication chamber, at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the sixth sub flow passage P6 through yet another first communication chamber, the fourth communication passage 407d and the second communication chamber, and the second sub flow passage P2 is in communication with the seventh sub flow passage P7 through yet another first communication chamber.

[0040] In a fourth operation mode, the first valve core 31a rotates to the fourth position, where the first sub flow passage P1 is in communication with the second sub flow passage P2 through one of the first communication chambers, at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the fourth sub flow passage P4 through another first communication chamber, the fourth communication passage 407d and the second communication chamber, the sixth sub flow passage P6 is in communication with the seventh sub flow passage P7 through yet another first communication chamber, and the third sub flow passage P3 is in communication with the eighth sub flow passage P8 through yet another first communication chamber.

[0041] In a fifth operation mode, the first valve core 31a rotates to the fifth position, where the third sub flow passage P3 is in communication with the second sub flow passage P2 through one of the first communication chambers, the seventh sub flow passage P7 is in communication with the eighth sub flow passage P8 through another first communication chamber, at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the sixth sub flow passage P6 through yet another first communication chamber, the fourth communication passage 407d and the second communication chamber, and the first sub flow passage P1 is in communication with the fourth sub flow passage P4 through yet another first communication chamber.

[0042] In a sixth operation mode, the first valve core 31a rotates to the sixth position, where the first sub flow passage P1 is in communication with the eighth sub flow passage P8 through one of the first communication chambers, the third sub flow passage P3 is in communication with the fourth sub flow passage P4 through another first communication chamber, the sixth sub flow passage P6 is in communication with the seventh sub flow passage P7 through yet another first communication chamber, and at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the second sub flow passage P2 through yet another first communication chamber, the fourth communication passage 407d and the second communication chamber.

[0043] In a seventh operation mode, the first valve core 31a rotates to the seventh position, where the first sub flow passage P1 is in communication with the second sub flow passage P2 through one of the first communication chambers, the seventh sub flow passage P7 is in communication with the eighth sub flow passage P8 through another first communication chamber, at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the fourth sub flow passage P4 through yet another first communication chamber, the fourth communication passage 407d and the second communication chamber, and the sixth sub flow passage P6 is in communication with the third sub flow passage P3 through yet another first communication chamber.

[0044] In an eighth operation mode, the first valve core 31a rotates to the eighth position, where the first sub flow passage P1 is in communication with the eighth sub flow passage P8 through one of the first communication chambers, the second sub flow passage P2 is in communication with the third sub flow passage P3 through another first communication chamber, at least one of the fifth sub flow passage P5 and the ninth sub flow passage P9 is in communication with the sixth sub flow passage P6 through yet another first communication chamber, the fourth communication passage 407d and the second communication chamber, and the fourth sub flow passage P4 is in communication with the seventh sub flow passage P7 through yet another first communication chamber.

[0045] Optionally, the communication modes between different flow passages or the proportional adjustment between the passages corresponding to the second valve core 31b can be achieved by rotating the second valve core 31b. It can be understood that, in case that the fluid control apparatus has more flow passages or ports, the fluid control apparatus may further include three or more valve cores in order to switch the communication modes among the multiple flow passages or ports, which is not limited in the present application.

[0046] Both the first chamber 401 and the second chamber 402 have openings located on a surface of the main housing 40. In order to facilitate the assembly of the pump assembly 20 and the valve assembly 30, a first mounting port K1 of the first chamber 401 and a second mounting port K2 of the second chamber 402 are respectively located on different sides of the main housing 40. As shown in FIG. 1, the openings of the first chamber 401 and the second chamber 402 are respectively located on two opposite sides in the height direction of the main housing 40. In this case, the main housing 40 includes a chamber casing 45 and a bottom cover, which can be sealedly connected with the chamber casing 45 by welding and other processes. For example, the bottom cover includes a first bottom cover 42 and a second bottom cover 43. Each of the flow passages and the chambers may be located in the chamber casing 45, and both the first bottom cover 42 and the second bottom cover 43 are sealedly connected with the chamber casing 45, for example, by welding, bonding, a sealing ring or the like.

[0047] In some embodiments, the chamber casing 45 includes a chamber casing side wall and a chamber casing top wall, a part of which form at least a part of the wall portion of the first chamber 401. The chamber casing side wall and the chamber casing top wall are formed into an integral structure, and the chamber casing top wall and the first mounting port K1 are located on the same side of the main housing 40. With the above arrangement, the assembly errors between the valve assembly 30 and the corresponding actuation component 13 can be reduced, and the strength of the chamber casing 45 can be improved, and the corresponding actuation components of the valve assembly 30 and the pump assembly 20 can be located on the same side of the main housing 40.

[0048] In an embodiment, the main housing 40 includes a first end portion S1 and a second end portion S2, which are oppositely arranged in the height direction of the main housing 40. The first mounting port K1 of the first chamber 401 is located at the first end portion S1, and the second mounting port K2 of the second chamber 402 is located at the second end portion S2, and the actuation assembly 100 is located on a side of the first end portion S1 away from the second end portion S2. With the above arrangement, the pump assembly 20 can be assembled with the main housing 40 on one side of the main housing 40, and the valve assembly 30 may be assembled with the main housing 40 from the other side, which facilitates of locating the actuation component for driving the pump assembly 20 and the actuation component for driving the valve assembly 30 on the same side so as to achieve the integration of multiple actuation components. In case that the number of the valve assemblies 30 is at least two, all the valve assemblies 30 may be mounted on the same side of the main housing 40, which facilitated of unifying the assembly reference, and then all the pump assemblies 20 may be mounted on the other side of the main housing 40, which facilitates of reducing the assembly errors and better achieving the coaxially between at least two valve assemblies 30 and the corresponding actuation components 13. It can be understood that the first mounting port K1 of the first chamber 401 and the second mounting port K2 of the second chamber 402 may also be arranged on the same side of the main housing 40, so that both the pump assembly 20 and the valve assembly 30 are assembled from the same side of the main housing 40, which is not limited in the present application.

[0049] With further reference to FIG. 16 to FIG. 26, in some embodiments, in case that each pump assembly 20 further includes an isolation sleeve 23 ,which is sealedly connected with the first housing 11, for example, when the isolation sleeve 23 and the first housing 11 are formed into an integral structure by injection molding or are separately formed, the isolation sleeve 23 may be formed into an integral structure with the main housing 40 by injection molding. Alternatively, in case that the isolation sleeve 23 and the first housing 11 are formed into an integral structure by injection molding or are separately formed, the isolation sleeve 23 is arranged separately from the main housing 40, and one side of the isolation sleeve 23 in a thickness direction is sealedly connected with the main housing 40 through a sealing ring, which may be an O-ring or an X-ring. With the above arrangement, a limit and sealed connection between the isolation sleeve 23 and the main housing 40 can be achieved. In this case, the stator assembly 130 and the first housing 11 may be formed into an integral structure by injection molding, or the stator assembly 130 and the first housing 11 may be separately formed and assembled with each other.

[0050] In an embodiment, in order to achieve the sealed connection between the isolation sleeve 23 and the first housing 11 as well as the main housing 40, the fluid control apparatus 1 may optionally include sealing rings. In case that the isolation sleeve 23 and the first housing 11 are separately formed, one of the sealing rings may be sandwiched between one side of the isolation sleeve 23 in the thickness direction and the first housing 11. In case that the isolation sleeve 23 and the main housing 40 are separately arranged, one of the sealing rings may be sandwiched between the other side of the isolation sleeve 23 in the thickness direction and the main housing 40, so that the sealing performance of the fluid control apparatus 1 is achieved, which reduces the leakage of fluid and can reduce or prevent the fluid from entering the stator assembly, and thus has a protective effect on the stator assembly.

[0051] With further reference to FIG. 12 and FIG. 26, in some embodiments, the pump assembly 20 further includes a pump cover 24, which is sealedly connected with the isolation sleeve 23. Specifically, the pump cover 24 may be welded with the isolation sleeve 23, and the rotor assembly 22 is located in a space formed between the pump cover 24 and the isolation sleeve 23. The pump cover 24 has a first port 241 and a second port 242, and the rotor assembly 22 can drive fluid to flow between the first port 241 and the second port 242. At least a part of the pump cover 24 is located inside the first chamber 401, and the pump cover 24 is sealedly connected with the main housing 40. The first port 241 is in communication with the first duct 404, and the second port 242 is in communication with the second duct 405. In an embodiment, the pump assembly 20 has a pump chamber 201, a first passage 202 and a second passage 203, and the pump cover 24 forms at least a part of the wall portion of the pump chamber 201. The first passage 202 and the second passage 203 may also be located in the pump cover 24. The first port 241 is located in the first passage and the second port 242 is located in the second passage. At least a part of the first passage 202 is located in the first duct 404, and at least a part of the second passage 203 located in the second duct 405.

[0052] In order to achieve the sealed connection between the pump cover 24 and the main housing 40, in some embodiments, as shown in FIG. 26, a sealing ring may be sandwiched between the pump cover 24 and the main housing 40, or the pump cover 24 and the main housing 40 may be into an integral structure by injection molding. Herein, the integral structure formed by two structural members may be formed by injection molding or other processes, which is not limited in the present application.

[0053] With further reference to FIG. 1 to FIG. 8, in order to control the actuation component 1 in the actuation assembly 100, in some embodiments, the fluid control apparatus 1 further includes a controller 15 and a connecting terminal 16. The controller includes multiple electronic components, which may include resistors, capacitors, inductors or integrated circuits. The controller 15 is located inside the first accommodating chamber 101. At least a part of the connecting terminal 16 is located outside the first accommodating chamber 101. For example, as shown in FIG. 1 to FIG. 5, the connecting terminal 16 is located on a side of the second housing 12 away from the first accommodating chamber 101, and the connecting terminal 16 and the second housing 12 are formed integrally by injection molding, where the connecting terminal 16 is electrically connected with the controller 15, and at least two actuation components 13 are each electrically connected with the controller 15. With the above arrangement, at least two actuation components 13 can be controlled by one controller 15, which saves space and reduces the cost of the actuation assembly 100. Moreover, an external electrical equipment can be connected by one connecting terminal 16, which simplifies the operation of the fluid control apparatus 1. In order to control the multiple actuation components by one controller 15, in some embodiments, at least a part of the first stator subassembly 130a, at least a part of the second stator subassembly 130a, at least a part of the third stator subassembly 130c, at least a part of the first motor 132a and at least a part of the second motor 132b are all located inside the first accommodating chamber 101, and the first stator subassembly 130a, the second stator subassembly 130b, the third stator subassembly 130c, the first motor 132a, and the second motor 132b are all electrically connected with the controller 15. The connecting terminal 16 may be electrically connected with an external wiring structure, so that the controller 15 may control the motor to rotate, thereby causing the valve core in the valve assembly to rotate. Further, the controller 15 may also control the on-off of the power supply of the stator assembly. When the controller 15 controls the stator assembly to be powered on, the stator assembly generates a magnetic field, so that the rotor assembly rotates under the action of the magnetic field, which allows the fluid to flow through the first passage and the second passage under the centrifugal force of the impeller assembly, thereby driving the fluid to flow in the valve assembly, and achieving a fluid direction change and/or a flow rate regulation of the fluid through the valve assembly.

[0054] As shown in FIG. 25, the actuation component including the stator assembly 130 is defined as the first actuation component, which further includes a pump housing 135, a transition terminal 134 connected with the pump housing 135, and a connecting plate 136. The stator assembly 130 and the first housing 11 are separately formed, and at least a part of the stator assembly 130 and the connecting plate are located inside the chamber of the pump housing 135, and the pump housing 135 is sealedly connected with the first housing 11. For example, in FIG. 25, the pump housing 135 may be sealedly connected with the first housing 11 through a sealing ring, or the pump housing 135 and the limiting portion 112 of the first housing 11 may be formed into an integral structure by injection molding. The stator assembly 130 includes a coil winding 1303, which is electrically connected with a pin in the transition terminal 134 through a conductive member in the connecting plate 136. A part of the transition terminal 134 passes through the bottom wall portion 111 and is located inside the first accommodating chamber 101, and the transition terminal 134 is electrically connected with the controller 15. It should be noted that the actuation component herein includes a stator assembly 130 or a motor 132, and may further include a lead wire structure or a terminal structure by which the stator assembly 130 or the motor 132 is electrically connected with the controller 15.

[0055] With further reference to FIG. 1 to FIG. 26, in some embodiments, the fluid control apparatus 1 further includes a limiting assembly 50, which may be located in the fluid assembly 200. The pump assembly 20 includes a rotor assembly 22, a positioning shaft 222 and an isolation sleeve 23. At least a part of the rotor assembly 22 is sleeved with the stator assembly 130, the isolation sleeve 23 is sleeved to cover a part of the outer circumstantial side of the rotor assembly 22, and at least a part of the isolation sleeve 23 is located between the stator assembly 130 and the rotor assembly 22. The positioning shaft 222 is sleeved on the inner side of the rotor assembly 22, and a first side portion of the positioning shaft 222 in the axial direction is limited to the isolation sleeve 23. The limiting assembly 50 is arranged close to a second side portion of the positioning shaft 222 in the axial direction, and the limiting assembly 50 and the rotor assembly 22 are limitedly arranged, for example, the limiting assembly 50 abuts with the rotor assembly 22. In this embodiment, the axial direction of the positioning shaft 222 is parallel to or coincident with the height direction of the fluid control apparatus. With the above arrangement, both sides of the positioning shaft 222 in the axial direction can be limited, which reduces an axial play of the positioning shaft 222 and further reduces an axial play of the rotor assembly 22 and the noise of the pump assembly 20.

[0056] In some embodiments, the rotor assembly 22 includes a magnetic assembly 223 and an impeller assembly 221. At least a part of the impeller assembly 221 and the magnetic assembly 223 are arranged along the axial direction of the rotor assembly 22, and at least a part of the magnetic assembly 223 is sleeved on an inner surface side of the stator assembly 130, so that at least a part of the magnetic assembly 222 can be located within the range of the magnetic field of the stator assembly 130. The isolation sleeve 23 includes an end wall portion 231, a connecting portion 232 and a peripheral wall portion 233, where an extending direction of the end wall portion 231 intersects with the axial direction of the rotor assembly 22, the end wall portion 231 is arranged close to the first housing 11, the peripheral wall portion 233 protrudes from the end wall portion 231. At least a part of the peripheral wall portion 233 is located between the rotor assembly 22 and the stator assembly 130 in the radial direction of the rotor assembly 22. In the axial direction of the rotor assembly 22, at least a part of the connecting portion 232 protrudes from the end wall portion 231 in the direction of the rotor assembly 22, one side of the positioning shaft 222 is limited to the connecting portion 232, and the magnetic assembly 223 is located between the connecting portion 232 and the limiting assembly 50.

[0057] As shown in FIG. 26, in some embodiments, when the pump assembly 20 further includes a pump cover 24, at least a part of the pump cover 24 is located on the outer circumferential side of the impeller assembly 221, at least a part of the pump cover 24 is located inside the first chamber 401, and at least a part of the limiting assembly 50 is located on the pump cover 24. The limiting assembly 50 has a groove 521, and an end of the second side of the positioning shaft 222 is located in the groove 521 and abuts with the bottom wall portion of the groove 521. With the above arrangement, the isolation sleeve 23 matches with the pump cover 24 to achieve an axial limit of the rotor assembly 22. Optionally the pump cover 24 and the main housing 40 may be formed into an integral structure by injection molding, or the pump cover 24 and the main housing 40 may be separately formed and limitedly connected with each other. In this case, a sealing ring is provided between the pump cover 24 and the main housing 40 to seal them.

[0058] As shown in FIG. 18 to FIG. 25, when the pump cover 24 and the main housing 40 are formed into an integrated structure by injection molding, at least a part of the impeller assembly 221 is located inside the first chamber 401. The main housing 40 includes a first duct 404 and a second duct 405 that are in communication with the first chamber 401. The impeller assembly 221 can be rotated to drive the fluid to flow between the first duct 404 and the second duct 405. The limiting assembly 50 includes a supporting portion 52 and at least two connecting ribs 51, where the connecting ribs 51 are connected with the peripheral wall of the first duct 404, distributed on the outer circumferential side of the supporting portion 52, and connected with the supporting portion 52. The groove 521 is located in the supporting portion 52, and one end of the positioning shaft 222 is embedded in the groove 521. With the above arrangement, not only the fluid communication in the first duct 404 can be achieved, but also the axial limit of the positioning shaft 222 can be achieved.

[0059] Alternatively, as shown in FIG. 26, when the pump cover 24 and the main housing 40 are separately formed, the pump assembly 20 has a pump chamber 201, a first passage 202 and a second passage 203. The pump cover 24 forms at least a part of the wall portion of the pump chamber 201, where both the first passage 202 and the second passage 203 are in communication with the pump chamber 201. In case that the limiting assembly 50 includes the supporting portion 52 and at least two connecting ribs 51, the connecting ribs 51 are connected with the peripheral wall of the first passage 202 of the pump cover 24. The connecting ribs 51 are distributed on the outer circumferential side of the supporting portion 52, and the supporting portion 52 is connected with the connecting rib 51. The groove 521 is located at the supporting portion 52, and one end of the positioning shaft 222 is embedded in the groove 521.

[0060] In some embodiments, the rotor assembly 22 further includes a first bearing 251 and a second bearing 252, which are arranged along the axial direction of the rotor assembly 22. In the axial direction of the rotor assembly 22, the first bearing 251 is located between the connecting portion 232 of the isolation sleeve 23 and the magnetic assembly 223, and the second bearing 252 is located between the magnetic assembly 223 and the limiting assembly 50. With the above arrangement, it can achieve the rotation of the magnetic element 223 and the rotation of the impeller assembly 221 in the rotor assembly 22.

[0061] As shown in FIG. 26, in some embodiments, the limiting assembly 50 includes a first gasket 53 and the pump cover 24, and the first gasket 53 is abutted between the second bearing 252 and the pump cover 24. Specifically, the pump cover 24 includes a supporting portion 52 and at least two connecting ribs 51, and the first gasket 53 is abutted between the second bearing 252 and the supporting portion 52. With the above arrangement, the wear between the pump cover 24 and the second bearing 252 can be reduced. In an embodiment, the positioning shaft 222 and the isolation sleeve 23 may be formed into an integral structure by injection molding, and/or the magnetic assembly 223, the impeller assembly 221, the first bearing 251 and the second bearing 252 may be formed into an integral structure by injection molding, so as to achieve a stable connection among the structural components and simplify the assembly process of the fluid control apparatus.

[0062] In other embodiments, as shown in FIG. 22, the limiting assembly 50 includes a first limiting component 541, a second gasket 542 and a third gasket 543. The first limiting component 541 is fixedly connected with the positioning shaft 222, and the second gasket 542 is abutted between the first bearing 251 and the connecting portion 232 along the axial direction of the rotor assembly 22. The first limiting component 541 includes a first flange portion 5411 and a cylindrical portion. In the axial direction of the first limiting component 541, at least a part of the orthographic projection of the cylindrical portion 5412 is located within the orthographic projection of the first flange portion 5411, and the third gasket 543 is limited between the first flange portion 5411 and the second bearing 252. With the above arrangement, when the electric pump device 20 is assembled with the main housing 40, the impeller assembly 22 of the electric pump device 20 may be arranged downward (in the up-down direction in the drawing). In this case, the structures, such as the impeller assembly 22, are limited by the limiting assembly 50, which facilitates of assembling the electric pump device 20 with the main housing 40. In this embodiment, the positioning shaft 222 and the isolation sleeve 23 may be formed into an integral structure by injection molding, and/or the magnetic assembly 223, the impeller assembly 221, the first bearing 251 and the second bearing 252 may be formed into an integral structure by injection molding, thus achieving a stable connection among the structural components and simplifying the assembly process of the fluid control apparatus.

[0063] In order to achieve the fixed connection between the first limiting component 541 and the positioning shaft 222, in some embodiments, the first limiting component 541 has a first threaded portion which is located at the cylindrical portion 5412, and the positioning shaft 222 has a second threaded portion, and the first threaded portion is threadedly connected with the second threaded portion. Alternatively, the first limiting component 541 may be connected with the positioning shaft 222 by riveting.

[0064] In other embodiments, as shown in FIG. 23, at least a part of the first bearing 251 is sleeved between the outer circumferential side of the positioning shaft 222 and the connecting portion 232 of the isolation sleeve 23, and the limiting assembly 50 is located between the magnetic assembly 223 and the impeller assembly 221 along the axial direction of the rotor assembly 22. The limiting assembly 50 includes a second limiting component 551 and a fourth gasket 552, where the second limiting component 551 and the isolation sleeve 23 are limitedly arranged and sealedly connected . For example, the second limiting component 551 is welded with the isolation sleeve 23, and the second limiting component 551 is located on the side of the magnetic assembly 223 away from the connecting portion 232. The second bearing 252 is sleeved between the outer circumferential side of the positioning shaft 222 and the second limiting component 551. Along the axial direction of the rotor assembly 22, the fourth gasket 552 is abutted between the second bearing 252 and the magnetic assembly 223. Specifically, the second limiting component 551 includes a second flange portion 5511 and a second cylindrical portion 5512. In the axial direction of the second limiting component 551, at least a part of the orthographic projection of the second cylindrical portion 5512 is located within the orthographic projection of the second flange portion 5511, and the second flange portion 5511 is sealedly connected with the isolation sleeve 23. During implementation, in this embodiment, the positioning shaft 222 and the magnetic assembly 223 may be formed into an integral structure by injection molding, the isolation sleeve 23 and the first bearing 251 may be formed into an integral structure by injection molding, and the impeller assembly 221 is assembled with and connected to the positioning shaft 222. With the above arrangement, the axial limiting of the rotor assembly 22 can be achieved.

[0065] Further, as shown in FIG. 27 to FIG. 44, a fluid control apparatus 1 according to another embodiment of the present application is provided, which has a similar structure with the fluid control apparatus shown in FIG. 1 to FIG. 26, where the first housing 11, the stator assembly 130, the rotor assembly 22, the isolation sleeve 23, the positioning shaft 222 and the main housing 40 are all arranged in the same or similar manner with those shown in FIG. 1 to FIG. 26. The difference between the fluid control apparatuses according to these two embodiments is at least in that: the number of the actuation components 13 included in the actuation assembly 100 is four, where two of the four actuation components each includes the stator assembly and the other two of the four actuation components each includes the motor. The number of the fluid subassemblies LK according to the embodiment of the present application is four, where two of the four fluid subassemblies LK each includes the pump assembly 20 and the other two of the four fluid subassemblies LK each includes the valve assembly 30.

[0066] For the actuation assembly 100, with reference to FIG. 18 to FIG. 26, FIG. 29 to FIG. 31, and FIG. 34 to FIG. 36, the actuation assembly 100 further includes a first housing 11 and a second housing 12. The actuation assembly 100 has a first accommodating chamber 101, and the first housing 11 and the second housing 12 form at least a part of the wall portion of the first accommodating chamber 101. In this embodiment, the second housing 12 includes a top cover portion, which is arranged to be opposite to the bottom wall portion 111 along the height direction of the actuation assembly 100. The first housing 11 and the second housing 12 are jointed by snap-fitting to form a first accommodating chamber 101. At least two actuation components 13 are each partially located inside the first accommodating chamber 101, so that at least two actuation components 13 are integrated in one actuation assembly 100. Compared to an arrangement in which the multiple drive assemblies are arranged separately, the arrangement described above can not only reduce the number of lead wires, but also reduce the space occupied by the actuation assembly 100. Optionally, all the actuation components 13 may be limitedly connected with the first housing 11, or a part of the actuation components 13 may be limitedly connected to the first housing 11, which is not limited in the present application.

[0067] In the actuation assembly 100, the first housing 11 includes a bottom wall portion 111, a limiting portion 112 and a circumferential side wall 113, where the circumferential side wall 113 and the bottom wall portion 111 are connected with the limiting portion 112. For example, the circumferential side wall 113, the bottom wall portion 111 and the limiting portion 112 may be formed into an integral structure by injection molding, or fixedly connected by welding, or limitedly connected by fasteners and the like. At least a part of the limiting portion 112 protrudes from the bottom wall portion 111 along the height direction of the actuation assembly 100, and the bottom wall portion 111 and the circumferential side wall 113 form part of the wall portion of the first accommodating chamber 101. At least one actuation component 13 includes a stator assembly 130, and the actuation component including the stator assembly 130 is defined as a first actuation component, and at least a part of the first actuation component is connected in the limiting portion 112. At least a part of the stator assembly 130 included in the first actuation component is located in the limiting portion 112, or the first actuation component may also include a pump housing, and at least a part of the stator assembly 130 is located inside the chamber of the pump housing. For example, the stator assembly 130, as an insert, may be fixed to the pump housing by injection molding or assembled into the chamber of the pump housing. In this case, the pump housing or the pump housing and at least a part of the whole stator assembly 130 is located in the limiting portion 112. At least two stator assemblies 130 may be integrated to one actuation assembly 100 by limitedly connecting at least a part of the first actuation component in the limiting portion 112. Compared to an arrangement in which multiple actuation components are provided, the fluid control apparatus according to the embodiment of the present application can reduce the space occupied by the actuation assembly 100 and improve the integration degree of the actuation assembly 100.

[0068] In this embodiment, the number of the actuation components 13 included in the actuation assembly 100 is four, and gaps exist between the orthographic projections of the four actuation components 13 along the height direction of the actuation assembly 100. Two of the actuation components13 each includes the stator assembly 130 and may be limitedly connected with and located in corresponding limiting portions 112. Alternatively, in some other embodiments, one of the actuation components 13 of the actuation assembly 100 includes a stator assembly 130, and the other actuation components may be motor and the like, thus achieving the integration of different types of actuation components 13.

[0069] In order to limit the positioning of the stator assembly 130, in some embodiments, at least a part of the limiting portion 112 extends from the bottom wall portion 111 in a direction away from the first accommodating chamber 101. In this case, at least a part of the limiting portion 112 extends from the bottom wall portion 111 in a direction close to the fluid assembly, and at least a part of the limiting portion 112 protrudes from the bottom wall portion 111 in a direction away from the second housing 12. Optionally, the stator assembly 130 may be fixedly with the limiting portion 112 by injection molding, which herein means to be formed into an integrated structure by injection molding. Specifically, the stator assembly 130 may be used as an insert and formed into an integral structure by injection molding, so that the stator assembly 130 and the limiting portion 112 may be formed into an integral structure by injection molding. In this case, electric connection wires may be led out from the stator assembly 130 during injection molding, and the stator assembly 130 may be electrically connected to a controller through the electric connection wires. Alternatively, the limiting portion 112 includes a mounting chamber QS, where at least a part of the stator assembly 130 is located inside the mounting chamber QS, and the stator assembly 130 is limitedly connected with the first housing 11 by fasteners and the like. With the above arrangement, it facilitates of limitedly arranging the stator assembly 130 and the limiting portion 112. When at least two actuation components 13 each includes the stator assembly 130, all the stator assemblies 130 and the limiting portion 112 may be formed into an integral structure by injection molding; or all the stator assemblies 130 may be assembled into the mounting chamber QS formed by the limiting portion 112; or a number of the stator assemblies 130 and the limiting portion 112 may be formed into an integral structure by injection molding, and the rest part of the stator assemblies 130 and the limiting portion 112 may be formed into an integral structure by injection molding.

[0070] As shown in FIG. 29, in order to implement the function of the actuation component, the actuation component according to the embodiment of the present application further includes a controller 15, which may be a circuit board. The actuation component including a stator component 130 is defined as a first actuation component, which further includes a pump housing 135, a transition terminal 134 connected to the pump housing 135, and a connecting plate 136, where the stator component 130 is separately arranged from the first housing 11. In this case, the stator assembly 130 is assembled into the mounting chamber QS formed by the limiting portion 112, at least a part of the stator assembly 130 and the connecting plate 136 are located inside the chamber of the pump housing 135, and the pump housing 135 is sealedly connected with the first housing 11. For example, the pump housing 135 may be sealedly connected with the first housing 11 through a sealing ring; or the pump housing 135 and the limiting portion 112 of the first housing 11 are formed into an integral structure by injection molding. The stator assembly 130 includes a coil winding 1303, which is electrically connected with a pin in the transition terminal 134 through a conductive member in the connecting plate 136. A part of the transition terminal 134 passes through the bottom wall portion 111 and is located in the first accommodating chamber 101, and the transition terminal 134 is electrically connected with the controller 15. It should be noted that the actuation component herein includes a stator assembly 130 or a motor 132, and the actuation component may further include a lead structure or a terminal structure, which can electrically connect the controller 15 with the stator assembly 130 or the motor 132.

[0071] In order to achieve an electrical connection between the stator assembly 130 and the controller 15, a metal conductive structure may be provided in the first housing 11, and the metal conductive structure and the first housing 11 may be formed into an integral structure by injection molding, so that the metal conductive structure is pre-embedded in the first housing 11. The output terminal 1304 of the stator assembly 130 may use insulation displacement connectors (IDC), and in this case, the output terminal 1304 may be electrically connected with the controller 15 through IDC pins.

[0072] In some embodiments, as shown in FIG. 36, the fluid control apparatus may further include an isolation sleeve 23, a part of which is located on an inner circumferential side of the stator assembly 130. Optionally, the isolation sleeve 23 and the first housing 11 may be formed into an integral structure by injection molding, and in this case, the stator assembly 130 and the limiting portion 112 may be formed into an integral structure by injection molding or the stator assembly 130 may be located inside the mounting chamber QS of the limiting portion112. Alternatively, as shown in FIG. 19 to FIG. 24, the isolation sleeve 23 and the stator assembly 130 may be formed into an integral structure by injection molding or at least a part of the stator assembly 130 is located inside the chamber formed by the isolation sleeve 23. In this case, the isolation sleeve 23 and the stator assembly 130, together as a whole, is separately formed from the first housing 11 and sealedly connected with the first housing 11. A sealing ring is arranged between the integral structure formed by the isolation sleeve 23 and the stator assembly 130 and the first housing 11, and thus the sealing arrangement between the integral structure and the first housing 11 is achieved by clamping the sealing ring. With the above arrangement, a limiting arrangement and a sealing connection between the isolation sleeve 23 and the first housing 11 can be achieved.

[0073] In an embodiment, in case that the stator assembly 130 and the limiting portion 112 are formed into an integral structure by injection molding, the isolation sleeve 23 and the first housing 11 may be formed into an integral structure by injection molding, or the isolation sleeve 23 may be separately formed from the first housing 11 and sealedly connected with the first housing 11. When the stator assembly 130 is assembled into the mounting chamber QS of the limiting portion 112, the isolation sleeve 23 and the first housing 11 may be formed into an integral structure by injection molding; or the isolation sleeve 23 is separately formed from the first housing 11 and sealedly connected with the first housing 11; or the isolation sleeve 23 and the stator assembly 130 are formed into an integral structure by injection molding, and the isolation sleeve 23 and the stator assembly 130 together as a whole is separately formed from and sealedly connected to the first housing 11. In case that the number of the stator assemblies 130 is at least two, the limit connection ways between different stator assemblies 130 and the first housing 11 may be the same or different. The connection ways between the isolation sleeves 23 corresponding to different stator assemblies 130 and the first housing 11 may also be the same or different.

[0074] As shown in FIG. 25, the actuation component including the stator assembly 130 is defined as the first actuation component, which further includes a pump housing 135, a transition terminal 134 connected with the pump housing 135, and a connecting plate 136. The stator assembly 130 is separately formed from the first housing 11, and at least a part of the stator assembly 130 and the connecting plate are located inside the chamber of the pump housing 135. The pump housing 135 is sealedly connected with the first housing 11. For example, as shown in FIG. 13, the pump housing 135 may be sealedly connected with the first housing 11 through a sealing ring, or as shown in FIG. 14, the pump housing 135 and the limiting portion 112 of the first housing 11 may be formed into an integral structure by injection molding.

The stator assembly 130 includes a coil winding 1303, which is electrically connected with a pin in a transition terminal 134 through a conductive member in a connecting plate 136. A part of the transition terminal 134 passes through the bottom wall portion 111 and is located inside the first accommodating chamber 101, and the transition terminal 134 is electrically connected with the controller 15. It should be noted that the actuation component herein includes a stator assembly 130 or a motor 132, and may further include a lead wire structure or a terminal structure by which the stator assembly 130 or the motor 132 is electrically connected with the controller 15.

[0075] For the fluid assembly 200, the fluid assembly 200 includes a main housing 40. The main housing 40 includes chamber casings 45 and a flow passage plate 44, where the flow passage plate 44 may be connected between the two chamber casings 45. The main housing 40 has a first chamber 401, a second chamber 402, a first duct 404, a second duct 405, multiple flow passages 406 and a communication passage 407. Both the first duct 404 and the second duct 405 are in communication with the first chamber 401, at least a part of the pump assembly 20 is located in the first chamber 401, and at least a part of the valve assembly 30 is located inside the second chamber 402. The first duct 404 corresponding to the pump assembly 20 is in communication with one of the flow passages 406 located on the outer circumferential side of the valve assembly 30.

[0076] In order for the fluid to flow in the fluid control apparatus 1, in some embodiments, at least a part of the main housing 40 is located on a side of the first housing 11 away from the first accommodating chamber 101, as shown in FIG. 27, and at least a part of the main housing 40 is located on a side of the first housing 11 away from the second housing 12. The main housing 40 further includes a connecting pipe 41, which may be arranged along the circumferential direction of the main housing 40 or integrated on at least one mounting surface.

[0077] In the embodiment of the present application, the pump assembly 20 includes a rotor assembly 22, and the isolation sleeve 23 of the fluid control apparatus is sleeved on the outer peripheral side of the rotor assembly 22. By providing the isolation sleeve 23, the stator assembly 130 and the corresponding rotor assembly 22 can be isolated from each other to prevent the working fluid from entering the space where the stator assembly 130 is located. The rotor assembly 22 includes an impeller assembly 221 and a magnetic assembly 223, and the pump assembly 20 further includes a positioning shaft 222. The impeller assembly 221 is sleeved on the outer peripheral side of the positioning shaft 222, and at least a part of the impeller assembly 221 may be located inside the first chamber 401. At least a part of the first duct 404 is arranged along the height direction of the pump assembly 20, and the second duct 405 is located corresponding to the position of the impeller assembly 221. Optionally, at least a part of the wall portion of the first duct 404 may be arranged coaxially with the rotating axis of the impeller assembly 221, and an opening of the second duct 405 is located at an edge of the circumferential direction of the impeller assembly 221, so that the fluid can enter the impeller assembly 221 through the first duct 404 and can be discharged through the second duct 405 under a centrifugal force of the impeller assembly 221. In this case, the first duct 404 may be an inlet duct of the pump assembly 20, and the second duct 405 may be an outlet duct of the pump assembly 20.

[0078] In some embodiments, the main housing 40 has a flow passage plate 44 and a chamber casing 45. The chamber casing 45 and the flow passage plate 44 are formed into an integral structure by injection molding. The first chamber 401, the second chamber 402 and the flow passage 406 are located in the chamber casing 45, and the communication passage 407 is located in the flow passage plate 44. At least a part of the flow passage plate 44 is connected between two fluid subassemblies LK. For example, the flow passage plate 44 may be connected between the pump assembly 20 and the valve assembly 30; or the flow passage plate 44 may also be connected between the two valve assemblies 30. In the embodiment of the present application, the flow passage plate 44 and the chamber casings 45 are integrally formed, which reduces the pipeline connection between the chamber casings 45 and improves the integration degree of the fluid control apparatus. Further, the multiple flow passages 406 are distributed on the outer circumferential side of the second chamber 402, and one of the flow passages 406 is in communication with one of the first duct 404 and the second duct 405 through a communication passage 407. The valve core 30 includes a communication chamber 311, which can communicate at least two flow passages 406. An extending direction of the communication duct 407, an extending direction of the flow passage 406 and an extending direction of the first duct 404 and the second duct 405 are intersected with each other.

[0079] Optionally, the pump assembly 20 may further include a pump cover 24, which is sealedly connected with the isolation sleeve 23. Specifically, the pump cover 24 may be welded with the isolation sleeve 23, and the rotor assembly 22 is located inside a space formed between the pump cover 24 and the isolation sleeve 23. The pump cover 24 has a first port 241 and a second port 242, and the rotor assembly 22 can drive the fluid to flow between the first port 241 and the second port 242. At least a part of the pump cover 24 is located inside the first chamber 401, and the pump cover 24 is sealedly connected with the main housing 40. The first port 241 is in communication with the first duct 404, and the second port 242 is in communication with the second duct 405. In an embodiment, the pump assembly 20 has a pump chamber 201, a first passage 202 and a second passage 203, and the pump cover 24 forms at least a part of the wall portion of the pump chamber 201. The first passage 202 and the second passage 203 may also be located at the pump cover 24. The first port 241 is located in the first passage and the second port 242 is located in the second passage, at least a part of the first passage 202 is located in the first duct 404, and at least a part of the second passage 203 is located in the second duct 405.

[0080] In order to achieve a sealed connection between the pump cover 24 and the main housing 40, in some embodiments, as shown in FIG. 26, a sealing ring may be sandwiched between the pump cover 24 and the main housing 40, or the pump cover 24 and the main housing 40 may be formed into an integral structure by injection molding. Herein, the integral structure formed by two structural members may be formed by injection molding or other processes, which is not limited in this application.

[0081] In order to for the fluid to flow in the main housing 40, in some embodiments, the first chamber 401 includes a first sub-chamber A1 and a second sub-chamber A2, and the second chamber 402 includes a third sub-chamber A3 and a fourth sub-chamber A4. Two pump assemblies are defined as a first pump assembly 20d and a second pump assembly 20e, and two valve assemblies are defined as a first valve assembly 30c and a second valve assembly 30e. At least a part of the first pump assembly 20d is located inside the first sub-chamber A1, at least a part of the second pump assembly 20e is located inside the second sub-chamber A2, at least a part of the first valve assembly 30c is located inside the third sub-chamber A3, and at least a part of the second valve assembly 30d is located inside the fourth sub-chamber A4, where the first sub-chamber A1 and the second sub-chamber A2 are both in communication with the third sub-chamber A3. With the above arrangement, the fluid communication between the two pump assemblies and one of the valve assemblies in the main housing 40 can be achieved.

[0082] Both the first chamber 401 and the second chamber 402 have openings located on a surface of the main housing 40. In order for the assembly of the pump assembly 20 and the valve assembly 30, a first mounting port of the first chamber 401 and a second mounting port of the second chamber 402 are respectively located on different sides of the main housing 40. As shown in FIG. 27, the openings of the first chamber 401 and the second chamber 402 are respectively located two opposite sides in the height direction of the main housing 40. In this case, the main housing 40 includes a chamber casing 45 and a bottom cover, which may be sealedly connected with the chamber casing 45 by welding or other processes.

[0083] In some embodiments, the chamber casing 45 includes a chamber casing side wall and a chamber casing top wall. A part of the chamber casing side wall and the chamber casing top wall form at least a part of the wall portion of the first chamber 401. The chamber casing side wall and the chamber casing top wall are in an integral structure, and the chamber casing top wall and the first mounting port are located on the same side of the main housing 40. With the above arrangement, the assembly errors between the valve assembly 30 and the corresponding actuation component 13 can be reduced, and the strength of the chamber casing 45 can be improved, and the actuation components corresponding to the valve shell 30 and the pump assembly 20 can be located on the same side of the main housing 40.

[0084] In an embodiment, the main housing 40 includes a first end S1 and a second end S2, which are arranged opposite with each other along the height direction of the main housing 40. The first mounting port of the first chamber 401 is located at the first end S1, and the second mounting port of the second chamber 402 is located at the second end S2, and the actuation assembly 100 is located on the side of the first end S1 away from the second end S2. With the above arrangement, the pump assembly 20 can be assembled with the main housing 40 on one side of the main housing 40, and the valve assembly 30 can be assembled with the main housing 40 on the other side, which facilitates of arranging the actuation assemblies for actuating the pump assembly 20 and the actuation components for actuating the valve assembly 30 on the same side and of the integration of multiple actuation components. In case that the number of the valve assemblies 30 is at least two, all of the valve assemblies 30 may be mounted on the same side of the main housing 40, which facilitates of unifying the assembly reference. After that, all of the pump assemblies 20 may be mounted from the other side of the main housing 40 to reduce the assembly errors for better achieving the coaxiality between at least two valve assemblies 30 and the corresponding actuation components 13. It can be understood that the first mounting port of the first chamber 401 and the second mounting port of the second chamber 402 may also be arranged on the same side of the main housing 40, so that both the pump assembly 20 and the valve assembly 30 are assembled from the same side of the main housing, which is not limited in the present application.

[0085] The valve cores in the two valve assemblies 30 provided by the embodiment of the present application are similar in structure, which include a first valve assembly 30c and a second valve assembly 30d. One of the two valve cores is defined as a first valve core 31c, and the other is defined as a second valve core 31d. The number of flow passages 406 on the outer peripheral side of the first valve core 31c may be at least five, and the number of flow passages 406 on the outer peripheral side of the second valve core 31d may be at least five. Further, one of the pump assemblies 20 is defined as the first pump assembly 20d and the other is defined as the second pump assembly 20e, where a first duct 404d corresponding to the first pump assembly 20d and a first duct 404e corresponding to the second pump assembly 20e are all in communication with the third sub-chamber A3 through the communication passage 407. The flow passage of the flow passage 406 located on the outer peripheral side of the first valve core 31c is defined as the first flow passage 4061, which is located on the side wall portion of the third sub-chamber A3. The flow passage 406 located on the outer periphery side of the second valve core 31d is a second flow passage 4062, which is located on the side wall portion of the fourth sub-chamber A4. In this embodiment, the number of the first flow passage 4061 is five, and the number of the second flow passage 4062 is five. The number of the first flow passage 4061 and the second flow passage 4062 may also be set based on the requirements of users, for example, it may be three, four, six, seven or more, and the number of the first flow passage 4061 and the second flow passage 4062 may be the same or different. With the above arrangement, a pump assembly 20 and a valve assembly 30 can be fitted to achieve fluid control

[0086] In order for the integration of the actuation components of the respective pump assemblies and of the respective valve assemblies, in some embodiments, along the height direction of the fluid control apparatus, the first pump assembly 20d and the second pump assembly 20e are located at the same level on the side away from the main housing 40, which facilitates of the assembly and mounting with their corresponding stator assemblies, and a part of the valve assembly 30 is located at the same level as a part of the pump assembly 20, so as to reduce the axial height of the fluid control apparatus. Specifically, a part of the first valve assembly 30c, a part of the first pump assembly 20d and a part of the second pump assembly 20e may be located at the same level .

[0087] Further, in some embodiments, the main housing 40 further includes a first communication passage 407d and a second communication passage 407e, where the first communication passage 407d communicates the first sub-chamber A1 and the third sub-chamber A3, and the second communication passage 407e communicates the second sub-chamber A2 and the third sub-chamber A3. At least a part of the first communication passage 407d and at least a part of the second communication passage 407e are spaced apart along the circumferential direction of the wall portion of the third sub-chamber A3.

[0088] As shown in FIG. 36 and FIG. 37, in order to better achieve the fluid communication between the pump assembly 20 and the valve assembly 30, the main housing 40 includes a first duct 404 and a second duct 405. The first duct 404 may be an inlet channel of the pump assembly 20, and the second duct 405 may be an outlet channel of the pump assembly 20. In this embodiment, the first duct 404 includes a first sub-duct 404d and a second sub-duct 404e, and the second duct 405 includes a third sub-duct 405d and a fourth sub-duct 405e, where both of the first sub-duct 404d and the third sub-duct 405d are in communication with the first sub-chamber A1, and both of the second sub-duct 404e and the fourth sub-duct 405e are communication with the second sub-chamber A2. The first pump assembly 20d includes a first impeller assembly 221d, and the second pump assembly 20e includes a second impeller assembly 221e. At least a part of the wall portion of the first sub-duct 404d is coaxially arranged with the rotating axis of the first impeller assembly 221d, and at least a part of the opening of the third sub-duct 405d is located at a circumferential edge of the first impeller assembly 221d. At least a part of the wall portion of the second sub-duct 404e is coaxially arranged with the rotating axis of the second impeller assembly 221e, and at least a part of the opening of the fourth sub-duct 405e is located at a circumferential edge of the second impeller assembly 221e. The first sub-duct 404d is in communication with the third sub-chamber A3 through the first communication passage 407d, and the second sub-duct 404e is in communication with the third sub-chamber A3 through the second communication passage 407e.

[0089] As shown in FIG. 27 to FIG. 44, the first valve core 31c includes at least three communication chambers, where the communication chambers of the first valve core 31c can communicate at least two first flow passages 4061 and isolate at least one first flow passage 4061. The communication chamber of the second valve core 31d can communicate at least two second flow passages 4062 and isolate at least one second flow passage 4062. With the above arrangement, multiple operation modes of the fluid control apparatus can be achieved. Herein, the flow passage isolation means that the flow passage is not in communicating with any other flow passage after passing through the corresponding valve core.

[0090] The operation modes of the first valve assembly 30c will be described below. The first flow passages corresponding to the first valve assembly 30c are defined as a first sub flow passage P1, a second sub flow passage P2, a third sub flow passage P3, a fourth sub flow passage P4 and a fifth sub flow passage P5, respectively. The second sub flow passage P2 communicates with the duct corresponding to the first pump assembly 20d, and the fourth sub flow passage P4 communicates with the duct corresponding to the second pump assembly 20e. By adjusting the positions of the multiple first flow passages on the wall portion of the corresponding third sub-chamber A3 and adjusting the opening angles among the three communication chambers of the first valve core 31c, the first valve assembly 30c according to the embodiment of the present application has at least one of the following operation modes.

[0091] In the first operation mode, as shown in FIG. 41, the first valve core 31c is located at the first position, where one of the communication chambers of the first valve core 31c communicates the first sub flow passage P1 with the fourth sub flow passage P4, another communication chamber communicates the second sub flow passage P2 with the third sub flow passage P3, and yet another communication chamber isolates the fifth sub flow passage P5.

[0092] In the second operation mode, as shown in FIG. 42, the first valve core 31c is located at the second position, where one of the communication chambers of the first valve core 31c communicates the fifth sub flow passage P5 with the fourth sub flow passage P4, another communication chamber communicates the second sub flow passage P2 with the third sub flow passage P3, and yet another communication chamber isolates the first sub flow passage P1.

[0093] In the third operation mode, as shown in FIG. 43, the first valve core 31c is located at the third position, where one of the communication chambers of the first valve core 31c communicates the third sub flow passage P3 with the fourth sub flow passage P4, another communication chamber communicates the second sub flow passage P2 with the first sub flow passage P1, and yet another communication chamber isolates the fifth sub flow passage P5.

[0094] In the fourth operation mode, as shown in FIG. 44, the first valve core 31c is located at the fourth position, where one of the communication chambers of the first valve core 31c communicates the third sub flow passage P3 with the fourth sub flow passage P4, another communication chamber communicates the second sub flow passage P2 with the fifth sub flow passage P5, and yet another communication chamber isolates the first sub flow passage P1.

[0095] The corresponding operation modes of the second valve assembly 30d for communicating the second flow passage according to the embodiment of the present application may be the same with the operation mode of the first valve assembly 30c, which is not repeated here. The flow passages corresponding to the two valve assemblies may be in communication through an external pipe, or a flow passage may be provided in the main housing 40, which is not described in detail in the present application.

[0096] Further, the actuation assembly 100 of the fluid control apparatus 1 includes a first housing 11, a first stator assembly 130d, a second stator assembly 130e, a first motor 132c and a second motor 132d. The first pump assembly 20d includes a first rotor assembly 22d, and the second pump assembly 20e includes a second rotor assembly 22e. The first rotor assembly 22d may be located within the range of the magnetic field of the first stator assembly 130d, and the second rotor assembly 22e may be located within the range of the magnetic field of the second stator assembly 130e. The first valve core 31c of the first valve assembly 30c is transmission connected with the first motor 132c, and the second valve core 31d of the second valve assembly 30d is transmission connected with the second motor 132d. The actuation assembly 100 has a first accommodating chamber 101, and the first housing 11 forms at least a part of the wall portion of the first accommodating chamber 101. At least a part of the first stator assembly 130d, at least a part of the second stator assembly 130e, at least a part of the first motor 132c and at least a part of the second motor 132d are all located inside the first accommodating chamber 101.

[0097] Further, the actuation assembly 100 may further include a controller 15 located inside the first accommodating chamber 101, and the first stator subassembly 130d, the second stator subassembly 130e, the first motor 132c and the second motor 132d are all electrically connected with the controller 15. In order to reduce an area of the controller 15, as shown in FIG. 26, the first pump assembly 20d, the first valve assembly 30c, the second pump assembly 20e and the second valve assembly 30d are arranged at intervals along the outer peripheral direction of the fluid control apparatus. The actuation assembly 100 further includes a first gear set 133c and a second gear set 133d, where the first motor 132c is transmission connected with the first valve core 31c through the first gear set 133c, and the second motor 132d is transmission connected with the second valve core 31d through the second gear set 133d. The first motor 132c and the second motor 132d are arranged in a first direction X, and the first stator assembly 130d and the second stator assembly 130e are arranged in a second direction Y, where the first direction X intersects with the second direction Y. A part of the first gear set 133c and a part of the second gear set 133d are located between the first motor 132c and the second motor 132d, which facilitates of centralizedly arranging the control parts of the first motor 132c and the second motor 133d. The output terminals of the first stator assembly 130d and the second stator assembly 130e are arranged close to each other and centrally located in the actuation assembly 100. In this case, the control part of the pump assembly 20 and the control part of the valve assembly 30 can be arranged centralizedly so as to reduce the area of the controller 15.

[0098] Further, as shown in FIG. 36, in some embodiments, the fluid control apparatus 1 further includes a limiting assembly 50, which may be located in the fluid assembly 200. The pump assembly 20 includes a rotor assembly 22, a positioning shaft 222 and an isolation sleeve 23, where at least a part of the rotor assembly 22 is sleeved with the stator assembly 130, the isolation sleeve 23 is sleeved outside the part of the outer periphery side of the rotor assembly 22, and at least a part of the isolation sleeve 23 is located between the stator assembly 130 and the rotor assembly 22. The positioning shaft 222 is sleeved on inner side of the rotor assembly 22, and a first side of the positioning shaft 222 in the axial direction is limited to the isolation sleeve 23. The limiting assembly 50 is arranged close to a second side of the positioning shaft 222 in the axial direction, and the limiting assembly 50 and the rotor assembly 22 are limitedly arranged, for example, the limiting assembly 50 abuts with the rotor assembly 22. In this embodiment, the axial direction of the positioning shaft 222 is parallel to or coincides with the height direction of the fluid control apparatus. With the above arrangement, both sides of the positioning shaft 222 in the axial direction can be limited, which reduces the axial play of the positioning shaft 222 and thus reduces the axial play of the rotor assembly 22 and reduces the noise of the pump assembly 20.

[0099] In some embodiments, the pump assembly 20 further includes a pump cover 24, where at least a part of the pump cover 24 is located on the outer peripheral side of the impeller assembly 221, and at least a part of the pump cover 24 is located inside the first chamber 401. At least a part of the limiting assembly 50 is located on the pump cover 24, and the limiting assembly 50 has a groove 521, and an end of the second side of the positioning shaft 222 is located in the groove 521 and abuts WITH the bottom wall portion of the groove 521. With the above arrangement, the isolation sleeve 23 matches with the pump cover 24 to achieve an axial limit of the rotor assembly 22. Optionally, the pump cover 24 and the main housing 40 may be formed into an integral structure by injection molding, or the pump cover 24 may be separately formed from the main housing 40 and limitedly connected with the main housing 40. In this case, a sealing ring is provided between the pump cover 24 and the main housing 40 to seal the pump cover 24 and the main housing 40.

[0100] In some embodiments, the rotor assembly 22 further includes a first bearing 251 and a second bearing 252, which are arranged along the axial direction of the rotor assembly 22. In the axial direction of the rotor assembly 22, the first bearing 251 is located between the connecting portion 232 of the isolation sleeve 23 and the magnetic assembly 223, and the second bearing 252 is located between the magnetic assembly 223 and the limiting assembly 50. With the above arrangement, the rotation of the magnetic element 223 and of the impeller assembly 221 in the rotor assembly 22 can be achieved.

[0101] As shown in FIG. 26, in some embodiments, the limiting assembly 50 includes a first gasket 53 and the pump cover 24, and the first gasket 53 is abutted between the second bearing 252 and the pump cover 24. Specifically, the pump cover 24 includes a supporting portion 52 and at least two connecting ribs 51, and the first gasket 53 is abutted between the second bearing 252 and the supporting portion 52. With the above arrangement, the wear between the pump cover 24 and the second bearing 252 can be reduced. In an embodiment, the positioning shaft 222 and the isolation sleeve 23 may be formed into an integral structure by injection molding, and/or the magnetic assembly 223, the impeller assembly 221, the first bearing 251 and the second bearing 252 may be formed into an integral structure by injection molding, so as to achieve a stable connection among the structural components and simplify the assembly process of the fluid control apparatus.

[0102] In other embodiments, as shown in FIG. 22, the limiting assembly 50 includes a first limiting component 541, a second gasket 542 and a third gasket 543. The first limiting component 541 is fixedly connected with the positioning shaft 222, and the second gasket 542 is abutted between the first bearing 251 and the connecting portion 232 along the axial direction of the rotor assembly 22. The first limiting component 541 includes a first flange portion 5411 and a cylindrical portion. In the axial direction of the first limiting component 541, at least a part of the orthographic projection of the cylindrical portion 5412 is located within the orthographic projection of the first flange portion 5411, and the third gasket 543 is limited between the first flange portion 5411 and the second bearing 252. With the above arrangement, when the electric pump device 20 is assembled with the main housing 40, the impeller assembly 22 of the electric pump device 20 may be arranged downward (in the up-down direction in the drawing), and in this case, the structure, such as the impeller assembly 22 are limited by the limiting assembly 50, which facilitates the assembly of the electric pump device 20 with the main housing 40. In this embodiment, the positioning shaft 222 and the isolation sleeve 23 may be formed into an integral structure by injection molding, and/or the magnetic assembly 223, the impeller assembly 221, the first bearing 251 and the second bearing 252 may be formed into an integral structure by injection molding, to achieve a stable connection among the structural components and simplify the assembly process of the fluid control apparatus.

[0103] In order to achieve a stable connection between the first limiting component 541 and the positioning shaft 222, in some embodiments, the first limiting component 541 has a first threaded portion which is located at the cylindrical portion 5412, and the positioning shaft 222 has a second threaded portion, and the first threaded portion is threadedly connected with the second threaded portion. Alternatively, the first limiting component 541 may be connected with the positioning shaft 222 by riveting.

[0104] In other embodiments, as shown in FIG.23, at least a part of the first bearing 251 is sleeved between the outer peripheral side of the positioning shaft 222 and the connecting portion 232 of the isolation sleeve 23, and the limiting assembly 50 is located between the magnetic assembly 223 and the impeller assembly 221 along the axial direction of the rotor assembly 22. The limiting assembly 50 includes a second limiting component 551 and a fourth gasket 552, where the second limiting component 551 is limitedly and sealedly connected with the isolation sleeve 23. For example, the second limiting component 551 is welded to the isolation sleeve 23, and the second limiting component 551 is located on the side of the magnetic assembly 223 away from the connecting portion 232. The second bearing 252 is sleeved between the outer circumferential side of the positioning shaft 222 and the second limiting component 551. In the axial direction of the rotor assembly 22, the fourth gasket 552 is abutted between the second bearing 252 and the magnetic assembly 223. Specifically, the second limiting component 551 includes a second flange portion 5511 and a second cylindrical portion 5512. In the axial direction of the second limiting component 551, at least a part of the orthographic projection of the second cylindrical portion 5512 is located within the orthographic projection of the second flange portion 5511, and the second flange portion 5511 is sealedly connected with the isolation sleeve 23. During implementation, in this embodiment, the positioning shaft 222 and the magnetic assembly 223 may be formed into an integral structure by injection molding, the isolation sleeve 23 and the first bearing 251 may be formed into an integral structure by injection molding, and the impeller assembly 221 is assembled with and connected to the positioning shaft 222. With the above arrangement, the axial limiting of the rotor assembly 22 can be achieved.

[0105] In summary, the fluid control apparatus 1 according to the embodiment of the present application includes an actuation assembly 100 and at least two fluid subassemblies LK, where the actuation assembly 100 includes at least two actuation components 13. At least one actuation component 13 includes a stator assembly 130, and at least a part of the stator assembly 130 is limitedly connected in the limiting portion 112 of the first housing 11. At least one fluid subassembly LK includes a pump assembly 20, and the pump assembly 20 includes a rotor assembly 22. By arranging the rotor assembly 22 within the range of the magnetic field of the corresponding stator assembly 130, and configuring the actuation component 13 to drive the corresponding fluid subassembly LK to act, the actuation assembly 100 includes the actuation component 13 that drives at least two fluid subassemblies LK to act. Compared to providing a separate driving device for each fluid subassembly LK, the fluid control apparatus 1 according to the embodiment of the present application can reduce the space occupied by the actuation assembly 100. Further, at least two fluid subassemblies LK may also be integrated to one main housing 40, thus improving the integration degree of the fluid control device 1 and reducing the space occupied by the fluid control apparatus 1. Moreover, by providing the limiting assembly 50, the positioning shaft 222 can be axially limited, so that the structure, such as rotor assembly 22 may be better axially limited.

[0106] In another aspect, an electric pump device is further according to the embodiment of the present application, which includes a stator assembly 130, a pump assembly 20 and a limiting assembly 50. The pump assembly 20 includes a rotor assembly 22, a positioning shaft 222, an isolation sleeve 23 and a pump cover 24, and at least a part of the rotor assembly 22 is sleeved with the stator assembly 130. Optionally, at least a part of the rotor assembly 22 is located on an inner side of the stator assembly 130, and the isolation sleeve 23 is sleeved on a part of the outer peripheral side of the rotor assembly 22, and at least a part of the isolation sleeve 23 is located between the stator assembly 130 and the rotor assembly 22. The positioning shaft 222 is sleeved on the inner side of the rotor assembly 22, a first side of the positioning shaft 222 in the axial direction is limited by the isolation sleeve 23, the limiting assembly 50 is arranged close to a second side of the positioning shaft 222 in the axial direction and abuts with the rotor assembly 22. With the above arrangement, the axial limit of the rotor assembly 22 and the positioning shaft 222 can be achieved. In the embodiment of the present application, the stator assembly 130, the pump assembly 20 and the limiting assembly 50 have the same or similar structures as those of the stator assembly 130, the pump assembly 20 and the limiting assembly 50 provided in any embodiment shown in FIG. 1 to FIG. 27, which will not be described in detail.

[0107] In some embodiments, the rotor assembly 22 includes a magnetic assembly 223 and an impeller assembly 221. At least a part of the impeller assembly 221 and the magnetic assembly 223 are arranged along the axial direction of the rotor assembly 22, and at least a part of the magnetic assembly 223 is sleeved on an inner surface side of the stator assembly 130. The isolation sleeve 23 includes an end wall portion 231 and a connecting portion 232, and an extending direction of the end wall portion 231 intersects with an axial direction of the rotor assembly 22. The rotor assembly 22 includes a first bearing 251 and a second bearing 252, which are arranged along the axial direction of the rotor assembly 22. The first bearing 251 is located between the connecting portion 232 and the magnetic assembly 223, and the second bearing 252 is located between the magnetic assembly 223 and the limiting assembly 50. With the above arrangement, the rotor assembly 22 can be stably rotated and can be axially limited.

[0108] As shown in FIG. 22, in some embodiments, the limiting assembly 50 includes a first limiting component 541, a second gasket 542 and a third gasket 543. The first limiting component 541 is fixedly connected with the positioning shaft 222, and the second gasket 542 is abutted between the first bearing 251 and the connecting portion 232 along the axial direction of the rotor assembly 22. The first limiting component 541 includes a first flange portion 5411 and a cylindrical portion 5412. In the axial direction of the first limiting component 541, at least a part of the orthographic projection of the cylindrical portion 5412 is located within the orthographic projection of the first flange portion 5411, and the third gasket 543 is limited between the first flange portion 5411 and the second bearing 252.

[0109] Alternatively, as shown in FIG. 23, in some embodiments, the limiting assembly 50 is located between the magnetic assembly 223 and the impeller assembly 221. The limiting assembly 50 includes a second limiting component 551 and a fourth gasket 552. The second limiting component 551 and the isolation sleeve 23 are limitedly arranged and sealedly connected, and the second limiting component 551 is located on a side of the magnetic assembly 223 away from the connecting portion 232. The second bearing 252 is sleeved between the outer peripheral side of the positioning shaft 222 and the second limiting piece 551, and the fourth gasket 552 is abutted between the second bearing 252 and the magnetic assembly 222 along the axial direction of the rotor assembly 22.

[0110] In the electric pump device, it may include a pump housing, which is arranged to cover on the outside the stator assembly. At least a part of the pump housing is located on a side of the stator assembly away from the rotor assembly. The limiting way of the pump housing and the stator assembly is similar to that of the first housing 11 and the stator assembly 130 described in any of the above embodiments, for example, the stator assembly 130 and the pump housing may be formed into an integral structure by injection molding or the stator assembly 130 may be provided inside the chamber of the pump housing. In an embodiment, in case that the stator assembly 130 and the pump housing are formed into an integral structure by injection molding, the isolation sleeve 23 and the pump housing may be formed into an integral structure by injection molding or the isolation sleeve 23 may be separately formed with and sealedly connected to the pump housing. When the stator assembly 130 is assembled into the mounting chamber QS of the pump housing, the isolation sleeve 23 and the pump housing may be formed into an integral structure by injection molding; or the isolation sleeve 23 is separately formed with and sealedly connected to the pump housing; or the isolation sleeve 23 and the stator assembly 130 are formed into an integral structure by injection molding and then the isolation sleeve 23 and the stator assembly 130, together as a whole, is separately formed with and sealedly connected to the pump housing. In case that the number of the stator assemblies 130 is at least two, the limit connection ways between different stator assemblies 130 may be the same or different, and the connecting ways of the isolation sleeves 23 corresponding to different stator assemblies 130 with the first housing 11 may be the same or different.

[0111] In yet another aspect, as shown FIG. 1 to FIG. 45, a manufacturing method 1000 for a fluid control apparatus is further provided according to an embodiment of the present application, which includes:

[0112] Step S110: forming an actuation assembly 100.

[0113] In some embodiments, the step S 110 of forming the actuation assembly 100 includes: providing a first housing 11 and at least two actuation components 13, where the first housing 11 has a first accommodating chamber 101, and the first housing 11 includes a bottom wall portion 111 and a limiting portion 112, where the bottom wall portion 111 forms a part of the wall portion of the first accommodating chamber 101, and at least a part of the limiting portion 112 protrudes from the bottom wall portion 111, and at least one actuation component 13 includes a stator assembly 130; and limitedly connecting at least a part of the stator assembly 130 to the limiting portion 112. The limiting portion 112 protrudes from the bottom wall portion 112 along the height direction of the actuation assembly 100, and the limiting portion 112 may extend in a direction away from the first accommodation chamber 101.

[0114] In some embodiments, limitedly connecting at least a part of the stator assembly 130 in the limiting portion 112 includes: use the stator assembly 130 as an injection molding insert, form at least a part of the stator assembly 130 and the limiting portion 112 into an integral structure by injection molding; or the limiting portion 112 includes a mounting chamber QS, and mount at least a part of the stator assembly 130 inside the mounting chamber QS and limitedly match at least a part of the stator assembly 130 with the limiting portion 112 of the first housing 11. In this case, at least a part of the output terminal 1304 in the stator assembly 130 is located inside the first accommodating chamber 101, which facilitates of the electrical connection of the output terminal 1304 with the controller 15 in the actuation assembly 100 or with external controller.

[0115] In some other embodiments, the fluid control apparatus may further include an isolation sleeve 23. In this case, after the step of limitedly connecting at least a part of the stator assembly 130 to the limiting portion 112, the isolation sleeve 23 and the first housing 11 may be further formed into an integral structure by injection molding, so that a part of the isolation sleeve 23 is located on the inner side of the stator assembly 130. In that case, the isolation sleeve 23 is sealedly connected with the first housing 11, which facilitates of isolating the stator assembly 130 from the outside and preventing the external water vapor from affecting the stator assembly 130.

[0116] Step S120, forming at least a part of the fluid assembly 200.

[0117] In this embodiment, the step S120 of forming the fluid assembly 200 includes: provide at least two fluid subassemblies LK and provide the main housing 40.

[0118] In this embodiment, at least one fluid subassembly LK includes a pump assembly 20. As shown in FIG. 1 to FIG. 26, the number of fluid subassemblies LK in this embodiment is five, where three fluid subassemblies each includes a pump assembly 20 and the other two fluid subassemblies each includes a valve assembly 30. In other embodiments, the number of the fluid subassemblies LK may be two, and both the fluid subassemblies LK each may include the pump assembly 20; or one of the fluid subassemblies LK includes the pump assembly 20 and the other of the fluid subassemblies LK includes the valve assembly 30. The number of fluid subassemblies LK may be set based on the requirements of users, and the number of pump assemblies 20 and valve assemblies 30 included may also be set based on the requirements of users.

[0119] The main housing 40 has a first chamber 401 that are arranged at intervals, a first duct 404 and a second duct 405, and both the first duct 404 and the second duct 405 are in communication with the first chamber 401. In this case, the step S120 of forming at least a part of the fluid assembly 200 may further include assembling the pump assembly 20 with the main housing 40 in such a way that at least a part of the pump assembly 20 is located inside the first chamber 401, so that the rotor assembly 22 can be rotated to drive the fluid to flow through the first duct 404 and the second duct 405. With the above arrangement, the pump assembly 20 can be arranged inside the first chamber 401.

[0120] In an embodiment, in case that at least two fluid subassemblies LK each includes the pump assembly 20, the multiple pump assemblies 20 may be all assembled with the main housing to form at least a part of the fluid assembly 200. Specifically, the pump assembly 20 may include the isolation sleeve 23 and the rotor assembly 22. In this case, before the step of assembling the pump assembly 20 with the main housing 40, a step of forming the pump assembly 20 may be included. For example, the rotor assembly 22 may be first sleeved on the inner side of the isolation sleeve 23 first, so that the isolation sleeve 23 and the rotor assembly 22 are assembled into an integral structure to form the pump assembly 20, and then assemble the whole structure with the main housing 40. In case that the pump assembly 20 further includes the pump cover 40, the isolation sleeve 23, the rotor assembly 22 and the pump cover 24 may be assembled into an integral structure first. The step of assembling the pump assembly 20 with the main housing 40 may further include: separately assembling the isolation sleeve 23 and the rotor assembly 22 to the main housing 40, and then sealedly connecting the isolation sleeve 23 with the main housing 40. In case that the pump assembly 20 further includes the limiting assembly 50, the limiting assembly 50 may limitedly match with the positioning shaft 222 to form an integral structure, and then the formed integral structure may be assembled with the main housing 40. In case that the limiting assembly 50 is located at the main housing 40, the pump assembly 20 may be assembled with the main housing 40 to achieve an axial limit to the structures, such as the positioning shaft 222 and the rotor assembly 22, which is not limited in this application.

[0121] In some embodiments, in case that at least one fluid subassembly LK includes a pump assembly 20, at least one fluid subassembly LK includes a valve assembly 30, the valve assembly 30 includes a valve core 31 and a valve core shaft 32, at least one actuation component 13 includes a motor 132, and the main housing 40 further includes a bottom cover and a chamber casing 45. In this case, the step S120 of forming at least a part of the fluid assembly 200 includes following steps:

[0122] Step 1: providing a main housing 40. The main housing 40 has a first chamber 401, a second chamber 402, a first duct 404, a second duct 405 and multiple flow passages 406. The first chamber 401 and the second chamber 402 are spaced apart, and both the first duct 404 and the second duct 405 are in communication with the first chamber 401.

[0123] Step 2: assembling the pump assembly 20 with the main housing 40 in such a way that at least a part of one pump assembly 20 is located inside the first chamber 401, so that the rotation of the rotor assembly 22 can drive the fluid to circulate in the first duct 404 and the second duct 405, and then realizing the driving function of the pump assembly 20 on the fluid.

[0124] Step 3: assembling at least a part of the valve assembly 30 inside the corresponding chamber of the main housing 40, that is, assembling at least a part of the valve assembly 30 inside one second chamber 402 of the main housing 40, and limitedly connect the valve assembly 30 with the main housing 40, and thus the communication chamber 31 of the valve core 31 can communicate at least two flow passages 406. Specifically, the valve core 31 and the valve core shaft 32 may be assembled inside the second chamber 402, and at least a part of the valve core shaft 32 passes through the second chamber 402 and is in transmission connected with the output shaft of the motor 132. In case that the actuation assembly 100 further includes a gear set 133, the gear set 133 is transmission connected to the actuation assembly 100, and at least a part of the valve core shaft 32 passes through the second chamber 402 and is connected to the gear set 133.

[0125] Step 4: sealedly connecting the bottom cover with the main housing 40.

[0126] For example, the bottom cover and the main housing may be sealed by welding, so as to achieve the limit connection between the valve assembly 30 and the main housing 40. In an embodiment, the valve assembly 30 may include a first valve assembly 30a and a second valve assembly 30b, and the main housing 40 includes a chamber casing 45, a first bottom cover 42 and a second bottom cover 43. For the first bottom cover 42, it can be understood that the steps 2 and 3 may be implemented simultaneously; or one of the step 1 and the step 2 may be implemented first, and then the other is implemented.

[0127] Step S130, sealedly connecting the actuation assembly 100 and the fluid assembly 200.

[0128] In an embodiment, the actuation assembly 100 may cooperate with the pump assembly 20, so as to, for example, position at least a part of the rotor assembly 22 of the pump assembly 20 at the inner side of the corresponding stator assembly 130, and to position part of the isolation sleeve 23 between the stator assembly 130 and the corresponding rotor assembly 22. The rotor assembly 22 can be located within the range of the magnetic field of the corresponding stator assembly 130. When the coil winding in the stator assembly 130 is energized, a magnetic field can be generated, and thus the rotor assembly 22 is driven to rotate by the stator assembly 130. In order to achieve the sealed connection between the actuation assembly 100 and the fluid assembly 200, a sealing ring may be arranged between the actuation assembly 100 and the fluid assembly 200, and the actuation assembly 100 and the fluid assembly 200 may be connected by fasteners, such as screws, and the sealing ring is compressed, so as to achieve the sealed connection between the actuation assembly 100 and the fluid assembly 200.

[0129] In some embodiments, in case that the fluid subassembly LK further includes the valve assembly 30 and the main housing 40 further includes multiple flow passages 406, the first chamber 401 has a first mounting port K1 and the second chamber 402 has a second mounting port K2, where the first mounting port K1 is located on a first side portion of the chamber casing 45 and the second mounting port K2 is located on a second side portion of the chamber casing 45, and the first side portion and the second side portion are located on two sides of the chamber housing in a height direction of the chamber casing. The multiple flow passages 406 are distributed on the outer peripheral side of the second chamber 402, and the first mounting port K1 of the first chamber 401 and the second mounting port K2 of the second chamber 402 are respectively arranged on different surfaces of the main housing 40. For example, as shown in FIG. 1 to FIG. 25, the first mounting port K1 of the first chamber 401 and the second mounting port K2 of the second chamber 402 are respectively arranged at two opposite sides of the main housing 40 along its own height direction.

[0130] In this case, the step S120 of forming at least a part of the fluid assembly 200 includes: assembling the pump assembly 20 with the main housing 40 from one side of the main housing 40, and the pump assembly 20 passes through the first mounting port K1 so that at least a part of the pump assembly 20 is located inside the first chamber 401; assembling at least a part of the valve assembly 30 inside one second chamber 402 of the main housing 40 from the other side of the main housing 40, and thus at least a part of the valve assembly 30 passes through the second mounting port K2, so that at least a part of the valve assembly 30 is located inside the second chamber 402. In an embodiment, in case that the valve assembly 30 includes a valve core 31 and a valve core shaft 32, the valve core 31 and the valve core shaft 32 may pass through the second mounting port K2, so that the valve core 31 is located inside the second chamber 402, and at least a part of the valve core shaft 32 is located outside the main housing 40, which achieves a transmission connection between the transmission assemblies, such as the valve core shaft 32 and the motor 132. In case that the number of the pump assemblies 20 is at least two and the number of the valve assemblies 30 is at least two, all the pump assemblies 20 may be assembled with the main housing 40 from one side of the main housing 40 through the first mounting port K1, and all the valve assemblies 30 may be assembled with the main housing 40 from the other side through the second mounting port K2. After that, the bottom cover may be sealedly connected to the chamber casing 45 of the main housing 40.

[0131] Alternatively, at least a part of the pump assembly 20 may be assembled inside the first chamber 401 of the main housing 40, and then the actuation assembly 100 is sealedly connected with the main housing 40 fitted with the pump assembly 20. In this case, after the actuation assembly 100 is sealedly connected with the fluid assembly 200, the step S130 may further include: assembling at least a part of the valve assembly 30 inside the corresponding second chamber 402 of the main housing 40, and limitedly connecting the valve assembly 30 with the main housing 40. In some embodiments, the main housing 40 further includes a bottom cover, which may be sealedly connected with the chamber of the main housing 40 after at least a part of the valve assembly 30 is assembled inside the corresponding chamber of the main housing 40. For example, the bottom cover may be sealed to the main housing by welding, so as to achieve the limit connection between the valve assembly 30 and the main housing 40 and seal the second mounting port K2.

[0132] In summary, according to the manufacturing method for the fluid control apparatus according to the embodiment of the present application, it facilitates of integrating at least two actuation components 13 to one actuation assembly. Compared to providing separate actuation components for each fluid subassembly LK, the fluid control apparatus 1 provided by the embodiment of the application can reduce the occupied space of the actuation assembly 100 and improve the integration degree of the actuation assembly 100. Further, at least two fluid subassemblies LK may also be integrated in one main housing 40, which improves the integration degree of the fluid control apparatus 1 and reducing the space occupied by the fluid control apparatus 1. Moreover, by providing the limiting assembly 50, the positioning shaft 222 can be axially limited, so that the structures, such as rotor assembly 22 may be better axially limited. The structure of the fluid control apparatus manufactured by the manufacturing method described above is shown in FIG. 1 to 44, which will not be described again.

[0133] It should be noted that the above embodiments are only used to illustrate the present application and not limit the technical solutions described in the present application, for example, the definition of directions such as "front", "rear", "left", "right", "upper", "lower". Although the present application has been described in detail in the specification with reference to the above embodiments, those skilled in the art should understand that modifications, combinations or equivalent replacements can be made to the present application by those skilled in the art, and all technical solutions and improvements thereof without deviating from the spirit and scope of the present application shall fall within the scope of the claims of the present application.

Claims

1. A fluid control apparatus, comprising:

an actuation assembly;
at least two fluid subassemblies;
a limiting assembly; and
a main housing, wherein
at least one of the fluid subassemblies comprises a pump assembly, the actuation assembly comprises a stator assembly, and the pump assembly comprises a rotor assembly, a positioning shaft and an isolation sleeve;
the rotor assembly and the positioning shaft are limitedly arranged , the rotor assembly comprises a magnetic assembly, at least a part of

the magnetic assembly is located within a range of a magnetic field of the stator assembly in an operation state, and at least a part of the isolation sleeve is located between the stator assembly and the rotor assembly, wherein the main housing is provided with a first chamber, and at least a part of the pump assembly is located inside the first chamber; and

the positioning shaft is located in the rotor assembly, a first side of the positioning shaft in an axial direction and the isolation sleeve are limitedly arranged, the limiting assembly is arranged close to a second side of the positioning shaft in the axial direction, and the limiting assembly and the positioning shaft are limitedly arranged.

2. The fluid control apparatus according to claim 1, wherein the rotor assembly further comprises an impeller assembly, at least a part of the impeller assembly and the magnetic assembly are arranged in the axial direction of the rotor assembly, at least a part of the magnetic assembly is sleeved on an inner surface side of the stator assembly, and the isolation sleeve comprises an end wall portion and a connecting portion, wherein an extending direction of the end wall portion intersects with an axial direction of the rotor assembly; and
in the axial direction of the rotor assembly, at least a part of the connecting portion protrudes from the end wall portion and a side of the positioning shaft and the connecting portion are limitedly arranged.

3. The fluid control apparatus according to claim 2, wherein the pump assembly further comprises a pump cover, at least a part of the pump cover is located on an outer peripheral side of the impeller assembly, at least a part of the pump cover is located inside the first chamber, at least a part of the limiting assembly is located at the pump cover;

the limiting assembly has a groove, and an end portion of a second side of the positioning shaft is located in the groove and abuts with a bottom wall of the groove; and

the pump cover is fixed with the main housing by injection molding, or the pump cover is separately formed with and sealedly connected to the main housing.

4. The fluid control apparatus according to claim 3, wherein the limiting assembly comprises a connecting rib and a supporting portion, wherein the connecting rib is distributed on an outer peripheral side of the supporting portion, the supporting portion is connected with the connecting rib, and the groove is located at the supporting portion; and
the pump cover is fixed with the main housing by injection molding, at least a part of the impeller assembly is located inside the first chamber, the main housing comprises a first duct and a second duct that are in communication with the first chamber, the connecting rib is connected with a peripheral wall of the first duct; or the pump cover is separately formed with the main housing, the pump assembly has a pump chamber, a first passage and a second passage, the pump cover forms at least a part of a wall portion of the pump chamber, and the first passage and the second passage are located at the pump cover and are in communication with the pump chamber.

5. The fluid control apparatus according to claim 3 or 4, wherein the rotor assembly comprises a first bearing and a second bearing, and the first bearing and the second bearing are arranged in the axial direction of the rotor assembly; and
in the axial direction of the rotor assembly, the first bearing is located between the connecting portion and the magnetic assembly, and the second bearing is located between the magnetic assembly and the limiting assembly.

6. The fluid control apparatus according to claim 5, wherein the limiting assembly comprises a first gasket, and the first gasket is abutted between the second bearing and the pump cover.

7. The fluid control apparatus according to claim 5, wherein the limiting assembly comprises a first limiting component, a second gasket and a third gasket, the first limiting component is fixedly connected with the positioning shaft, and the second gasket is abutted between the first bearing and the connecting portion in the axial direction of the rotor assembly; and
the first limiting component comprises a first flange portion, and the third gasket is limited between the first flange portion and the second gasket.

8. The fluid control apparatus according to claim 7, wherein the first limiting component has a first threaded portion, the positioning shaft has a second threaded portion, and the first threaded portion is threadedly connected with the second threaded portion.

9. The fluid control apparatus according to any one of claims 6 to 8, wherein the isolation sleeve and the positioning shaft are fixed by injection molding, and the magnetic assembly, the impeller assembly, the first bearing and the second bearing are fixed by injection molding.

10. The fluid control apparatus according to claim 5, wherein at least a part of the first bearing is sleeved between the outer peripheral side of the positioning shaft and the connecting portion of the isolation sleeve, and the limiting assembly is located between the magnetic assembly and the impeller assembly in the axial direction of the rotor assembly;

the limiting assembly comprises a second limiting component and a fourth gasket, wherein the second limiting component and the isolation sleeve are limitedly arranged and sealedly connected, and the second limiting component is located on a side of the magnetic assembly away from the connecting portion; and
the second bearing is sleeved between the outer peripheral side of the positioning shaft and the second limiting component, and the fourth gasket is abutted between the second bearing and the magnetic assembly in the axial direction of the rotor assembly.

11. The fluid control apparatus according to any one of claims 1 to 4, wherein the main housing is further provided with second chambers and a communication passage, the first chamber and the second chamber are spaced apart, and the first chamber and at least one of the second chambers are in communication through the communication passage; and
at least one of the at least two the fluid subassemblies comprises a valve assembly, the valve assembly comprises a valve core, and at least a part of the valve core is sealedly located inside the second chamber.

12. An electric pump device, wherein the electric pump device comprises a stator assembly, a pump assembly and a limiting assembly, the pump assembly comprises a rotor assembly, a positioning shaft and an isolation sleeve, the rotor assembly and the positioning shaft are limitedly arranged;

the rotor assembly comprises a magnetic assembly, at least a part of the magnetic assembly is located within a range of a magnetic field of the stator assembly in an operation state, and at least a part of the isolation sleeve is located between the stator assembly and the rotor assembly; and
the positioning shaft is located in the rotor assembly, a first side of the positioning shaft in an axial direction and the isolation sleeve are limitedly arranged, the limiting assembly is arranged close to a second side of the positioning shaft in the axial direction, and the limiting assembly and the rotor assembly are limitedly arranged.

13. The electric pump device according to claim 12, wherein the rotor assembly further comprises an impeller assembly, at least a part of the impeller assembly and the magnetic assembly are arranged in an axial direction of the rotor assembly, at least a part of the magnetic assembly is sleeved on an inner surface side of the stator assembly, and the isolation sleeve comprises an end wall portion and a connecting portion, wherein an extending direction of the end wall portion intersects with the axial direction of the rotor assembly; and
the rotor assembly comprises a first bearing and a second bearing, which are arranged in the axial direction of the rotor assembly, the first bearing is located between the connecting portion and the magnetic assembly, and the second bearing is located between the magnetic assembly and the limiting assembly.

14. The electric pump device according to claim 13, wherein the limiting assembly comprises a first limiting component, a second gasket and a third gasket, the first limiting component is fixedly connected with the positioning shaft, the second gasket is abutted between the first bearing and the connecting portion in the axial direction of the rotor assembly; and
the first limiting component comprises a flange portion, and the third gasket is limited between the flange portion and the second bearing.

15. The electric pump device according to claim 13, wherein the limiting assembly is located between the magnetic assembly and the impeller assembly and comprises a second limiting component and a fourth gasket;

the second limiting component and the isolation sleeve are limitedly arranged and sealedly connected, the second limiting component is located on a side of the magnetic assembly away from the connecting portion; and
the second bearing is sleeved between an outer peripheral side of the positioning shaft and the second limiting component, and the fourth gasket is abutted between the second bearing and the magnetic assembly in the axial direction of the rotor assembly.

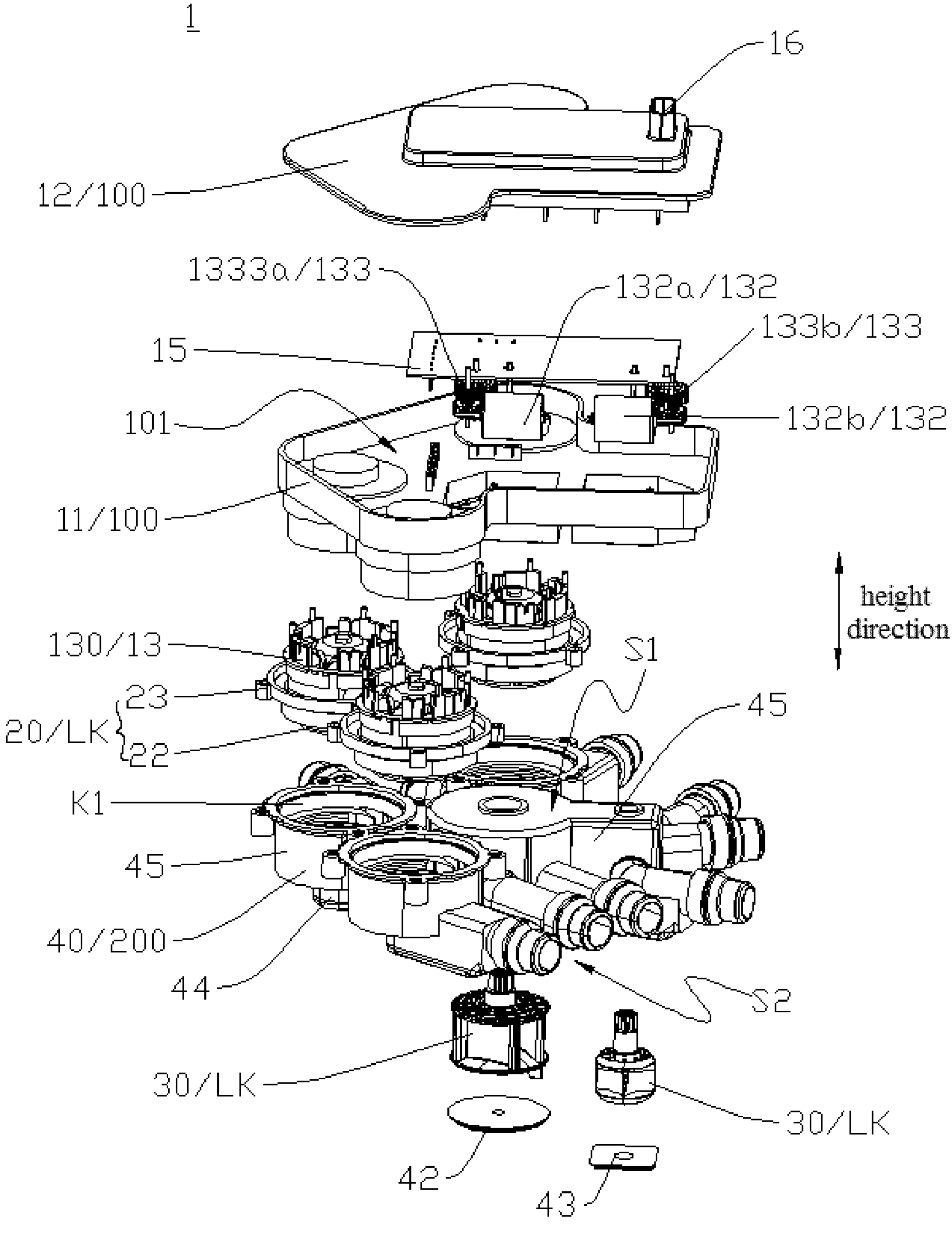

1
16
12/100
1333a/133
132a/132
133b/133
15
101
132b/132
11/100
height direction
130/13
S1
23
20/LK
22
45
K1
45
40/200
44
S2
30/LK
30/LK
42
43

FIG. 1

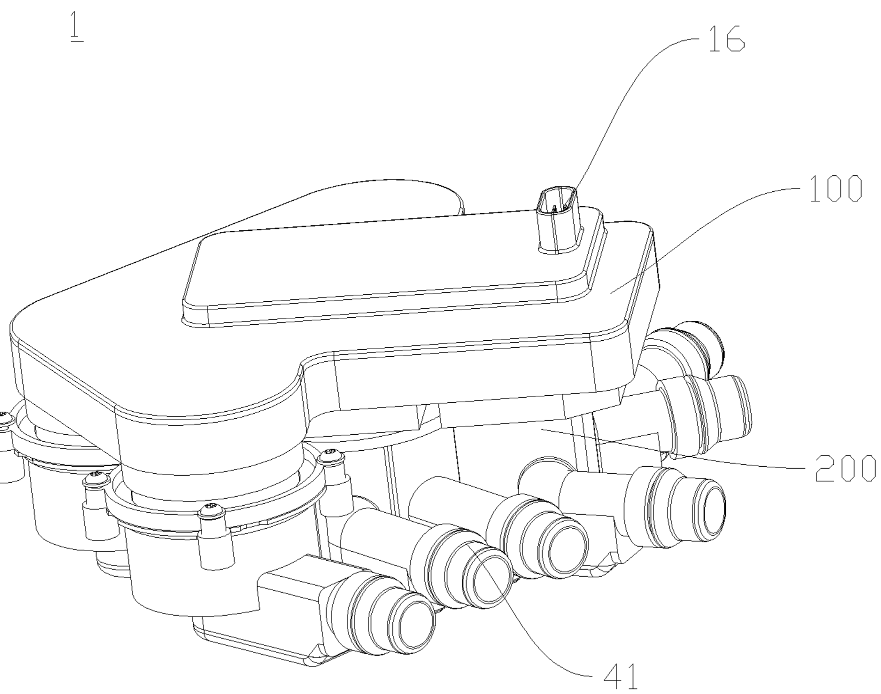


FIG. 2

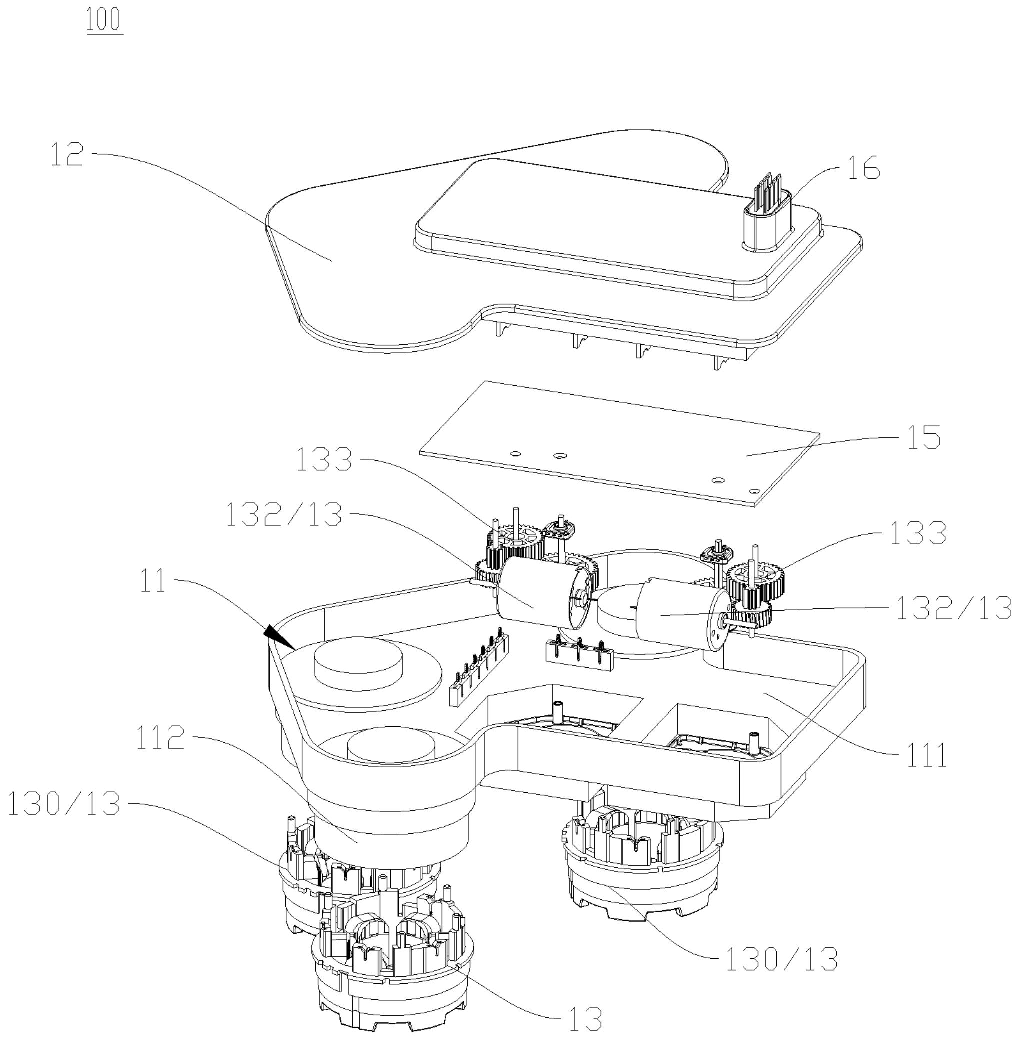


FIG. 3

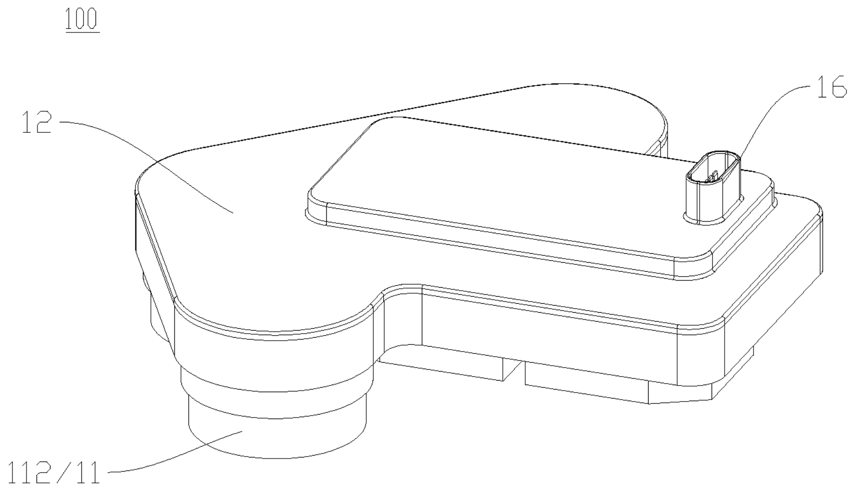


FIG. 4

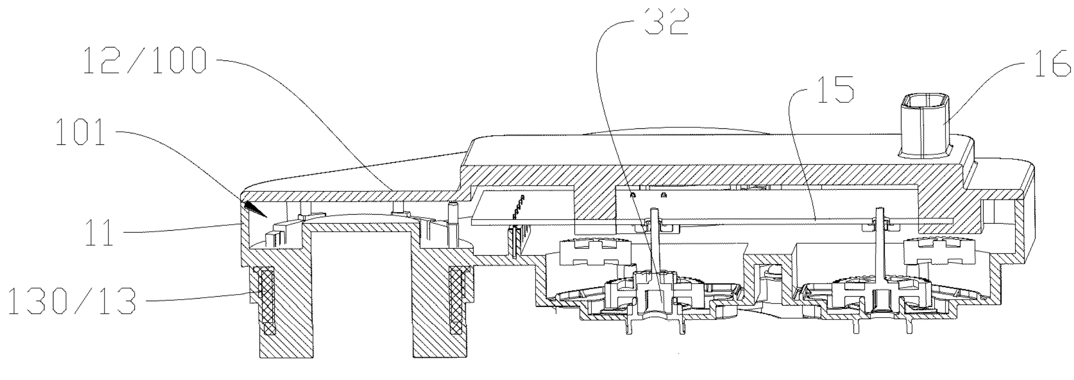


FIG. 5

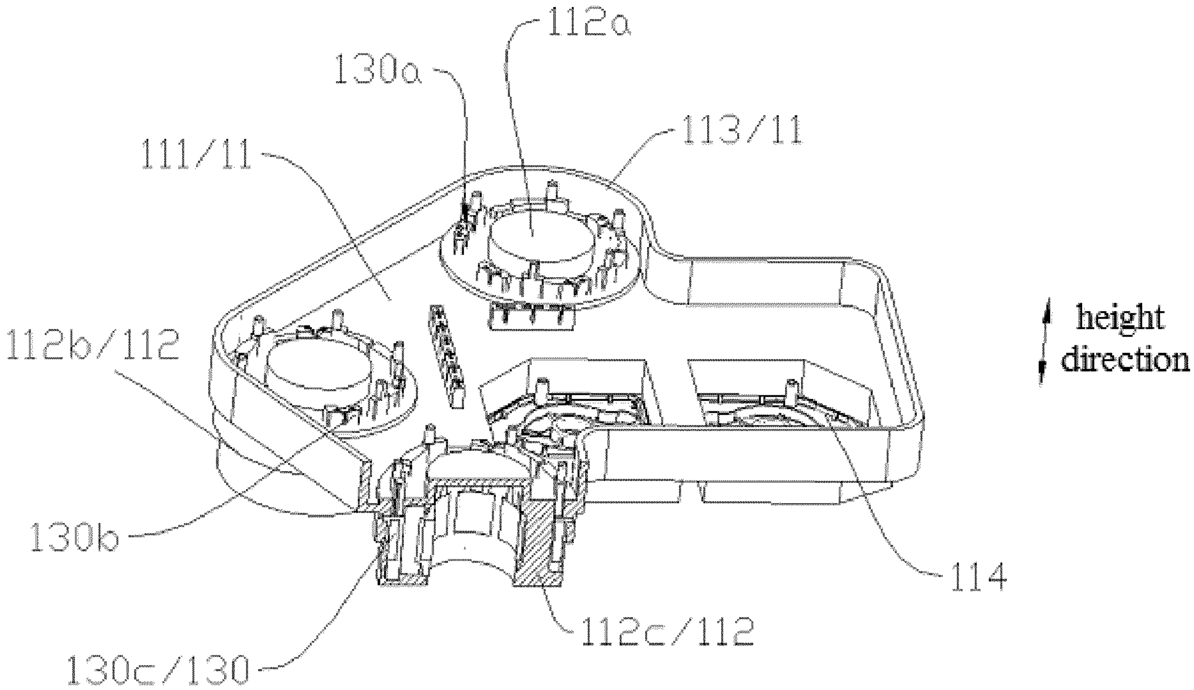

112a
130a
113/11
111/11
112b/112
height direction
130b
114
112c/112
130c/130

FIG. 6

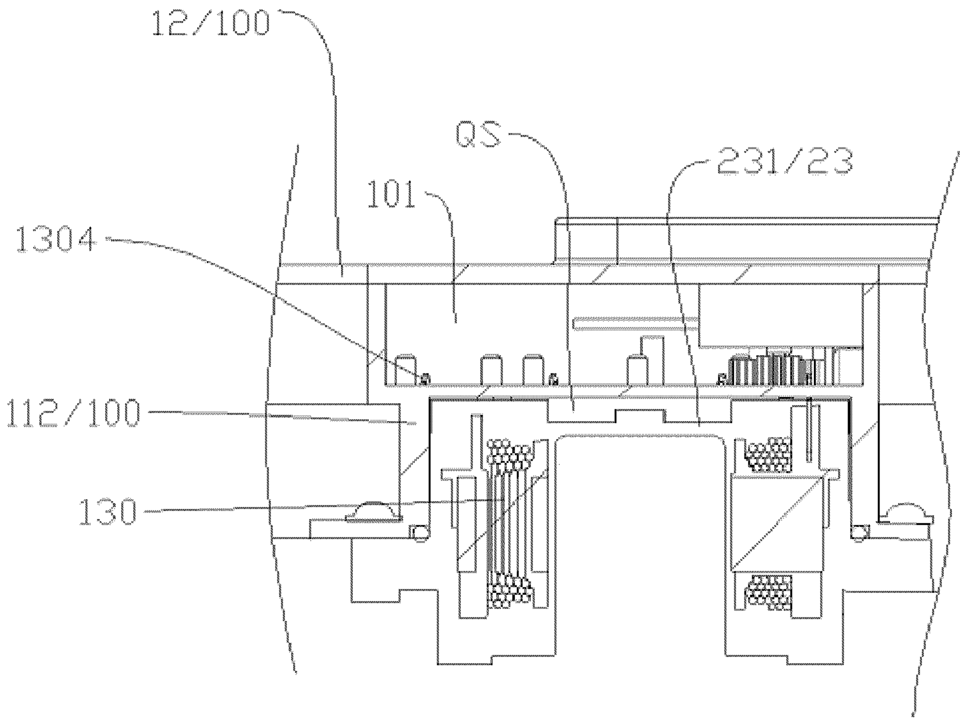

12/100
QS
231/23
101
1304
112/100
130

FIG. 7

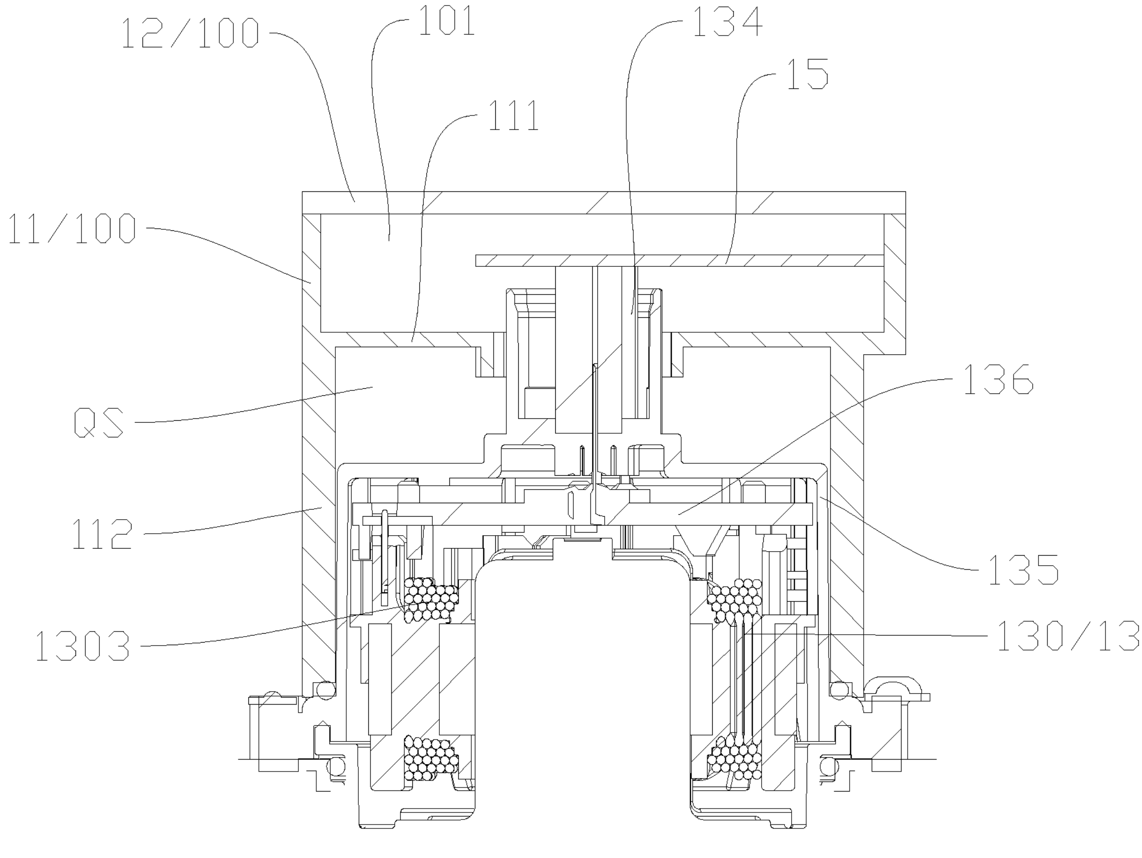

12/100
101
134
15
111
11/100
136
QS
112
135
1303
130/13

FIG. 8

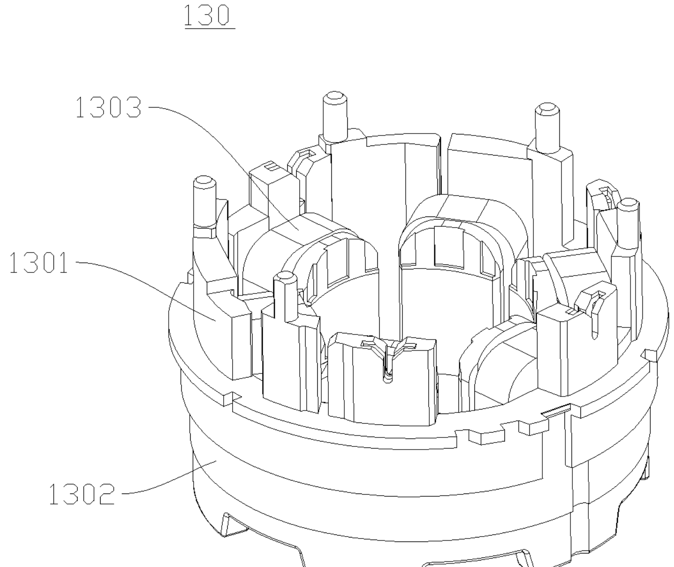

130
1303
1301
1302

FIG. 9

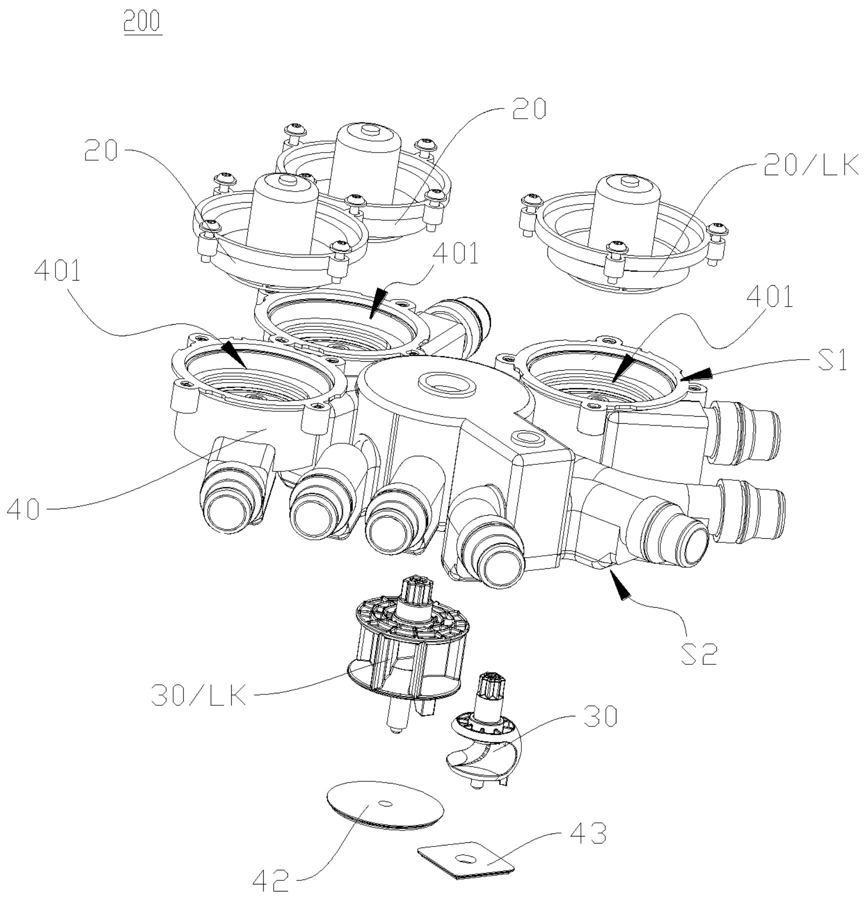


FIG. 10

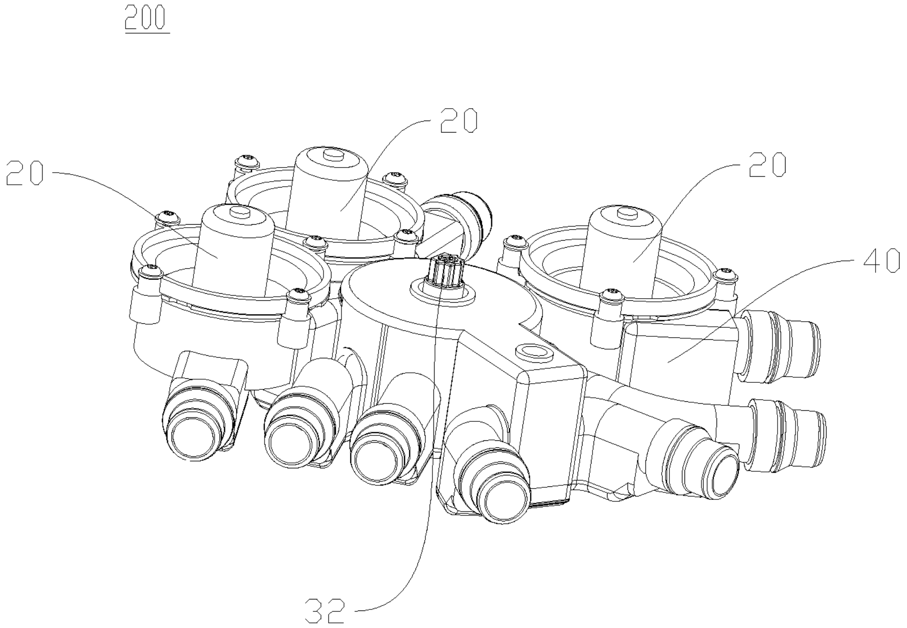

200
20
20
20
40
32

FIG. 11

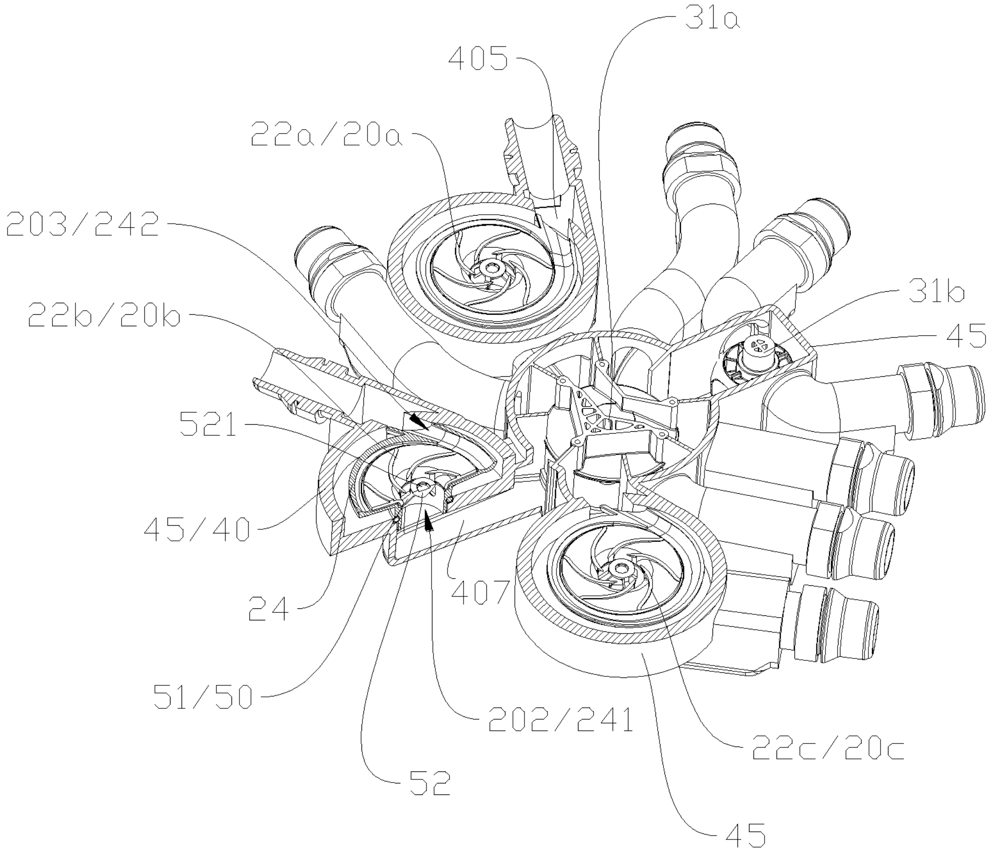

31a
405
22a/20a
203/242
22b/20b
31b
45
521
45/40
407
24
51/50
202/241
22c/20c
52
45

FIG. 12

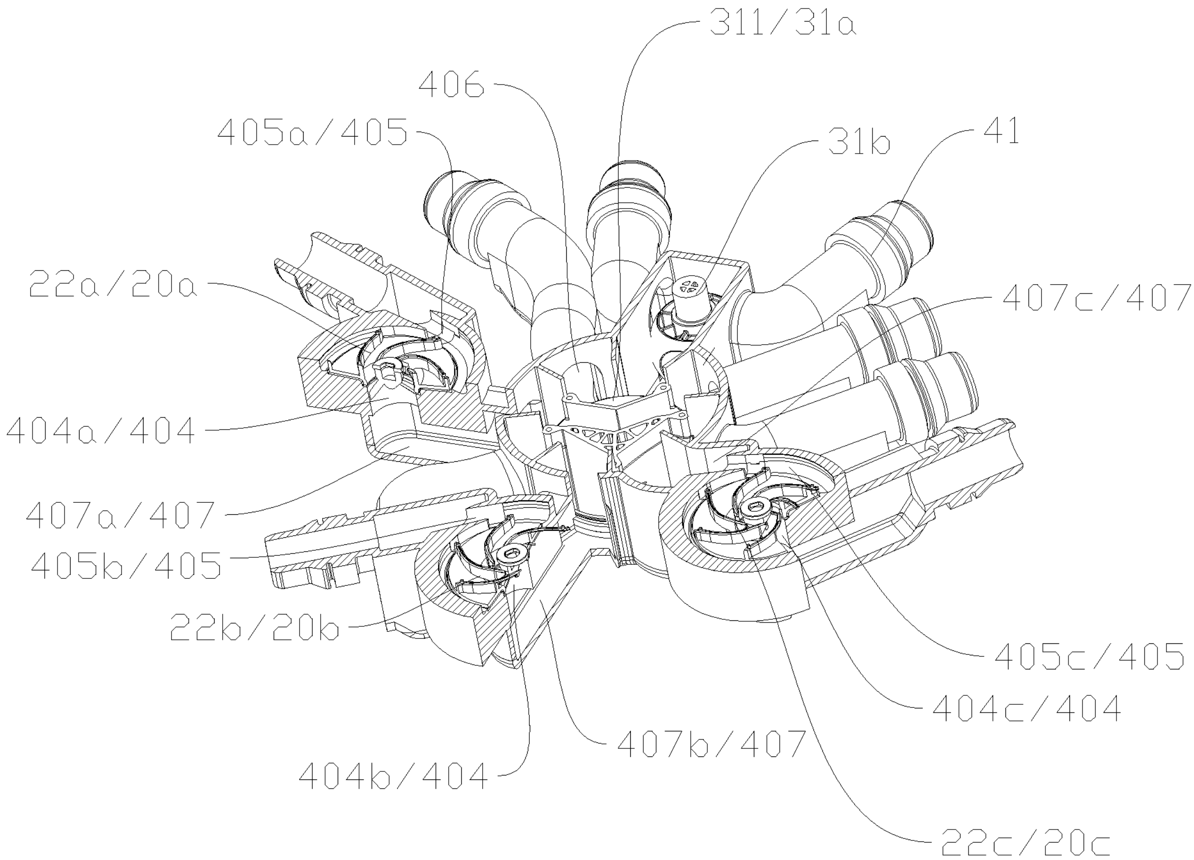

311/31a
406
405a/405
31b
41
22a/20a
407c/407
404a/404
407a/407
405b/405
22b/20b
405c/405
404c/404
407b/407
404b/404
22c/20c

FIG. 13

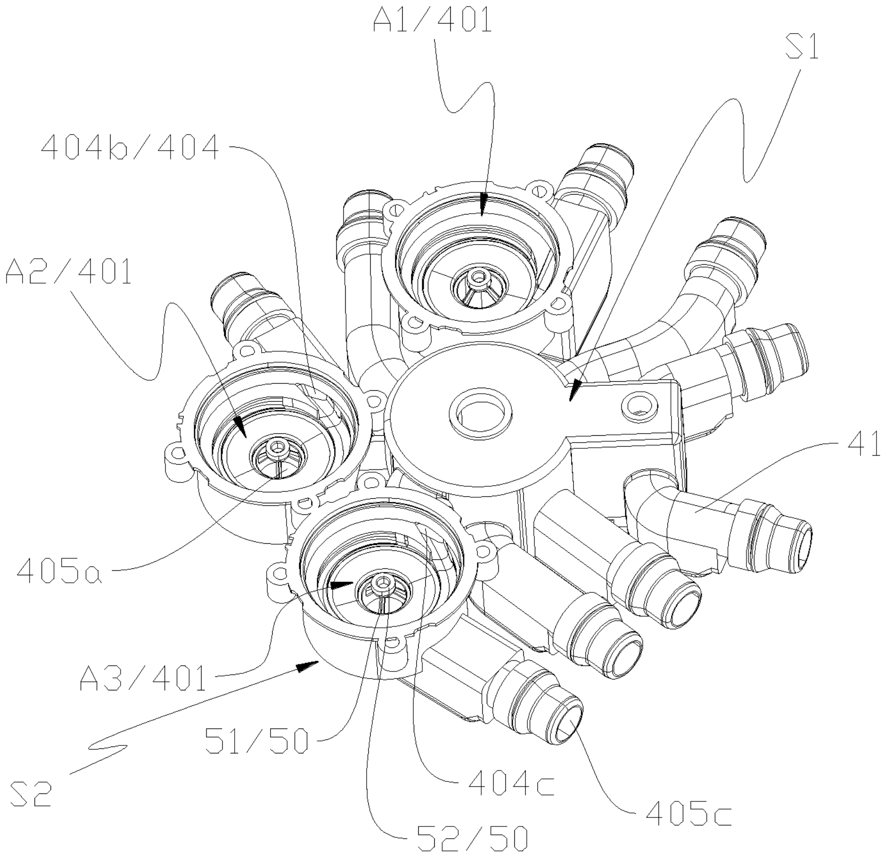


FIG. 14

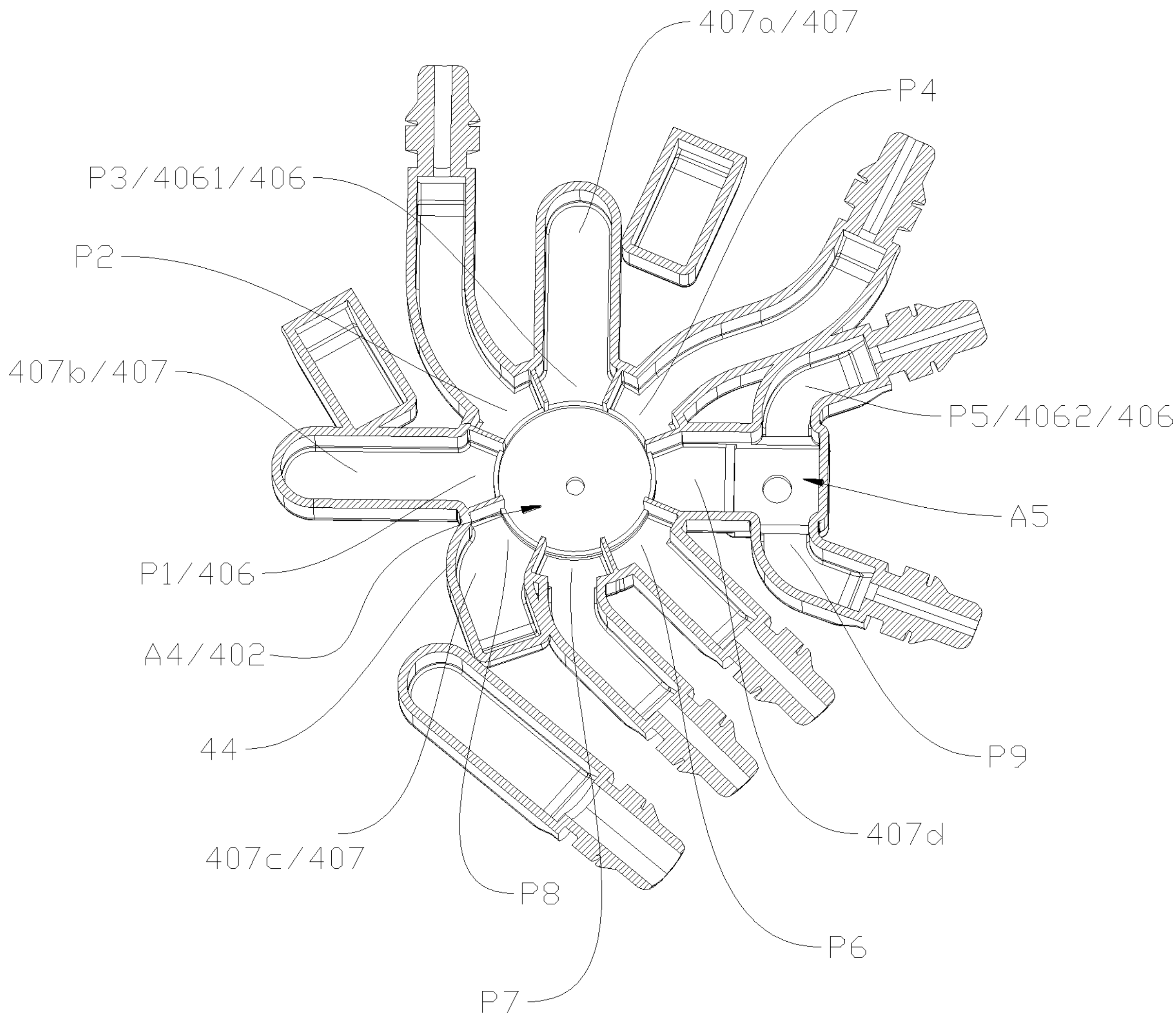

407a/407
P4
P3/4061/406
P2
407b/407
P5/4062/406
A5
P1/406
A4/402
44
P9
407d
407c/407
P8
P6
P7

FIG. 15

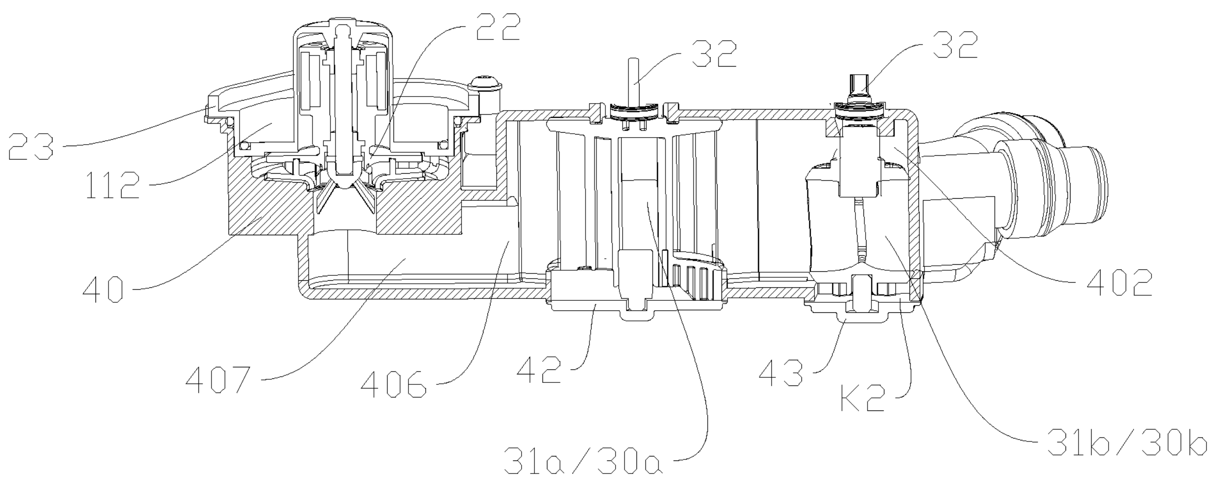

22
32
32
23
112
40
402
407
406
42
43
K2
31a/30a
31b/30b

FIG. 16

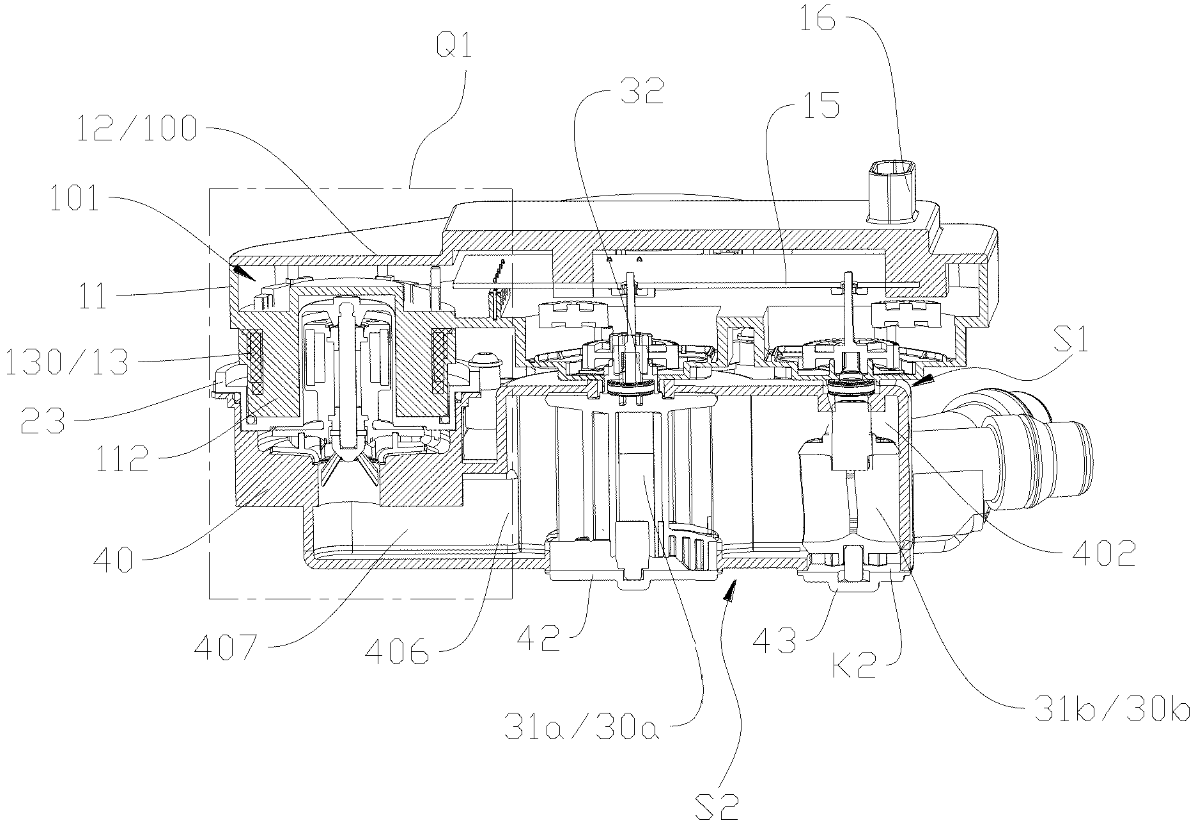

16
Q1
32
15
12/100
101
11
130/13
23
112
40
407
406
42
31a/30a
S2
43
K2
31b/30b
402
S1

FIG. 17

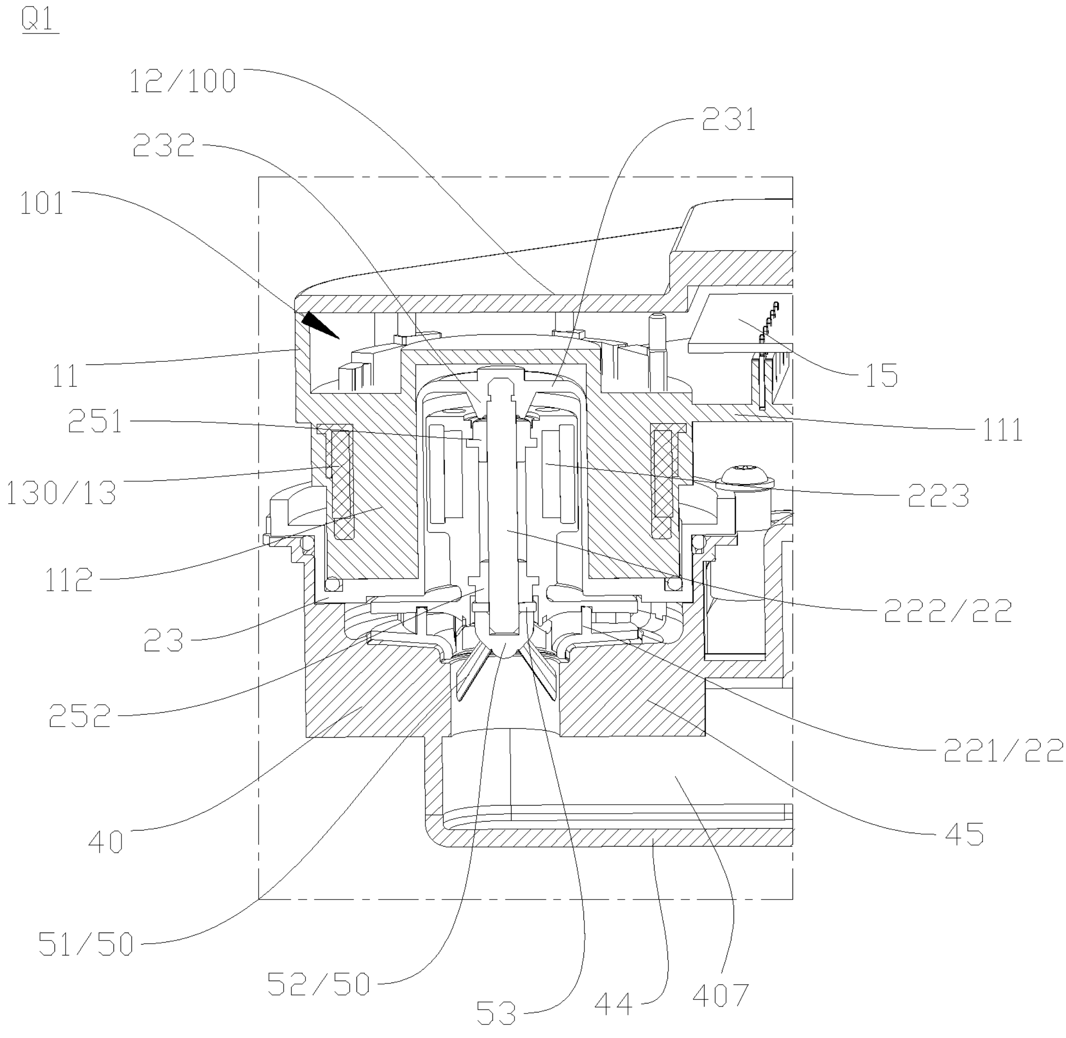
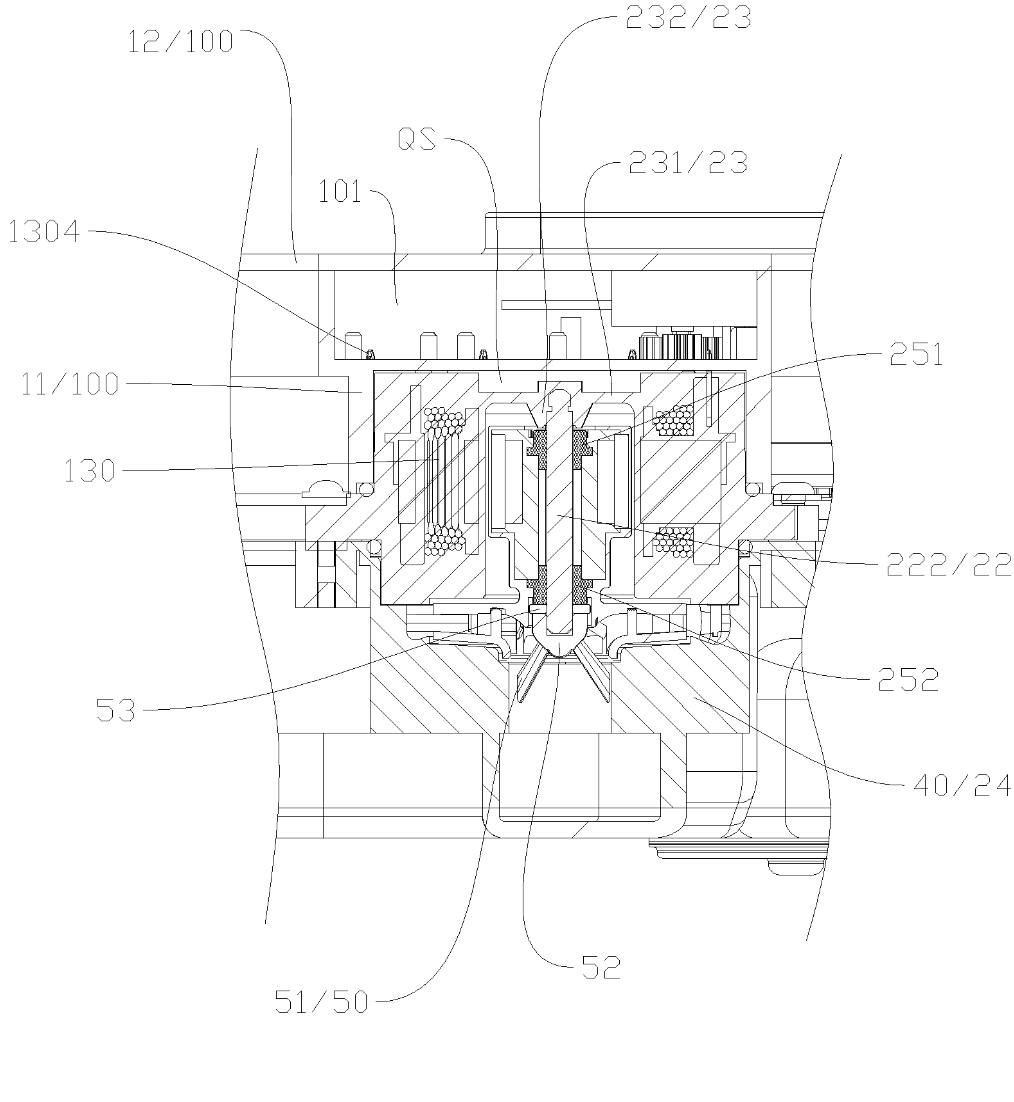

Q1
12/100
231
232
101
15
11
111
251
223
130/13
112
222/22
23
252
221/22
40
45
51/50
52/50
53
44
407

FIG. 18


232/23
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QS
231/23
101
1304
251
11/100
130
222/22
252
53
40/24
52
51/50

FIG. 19

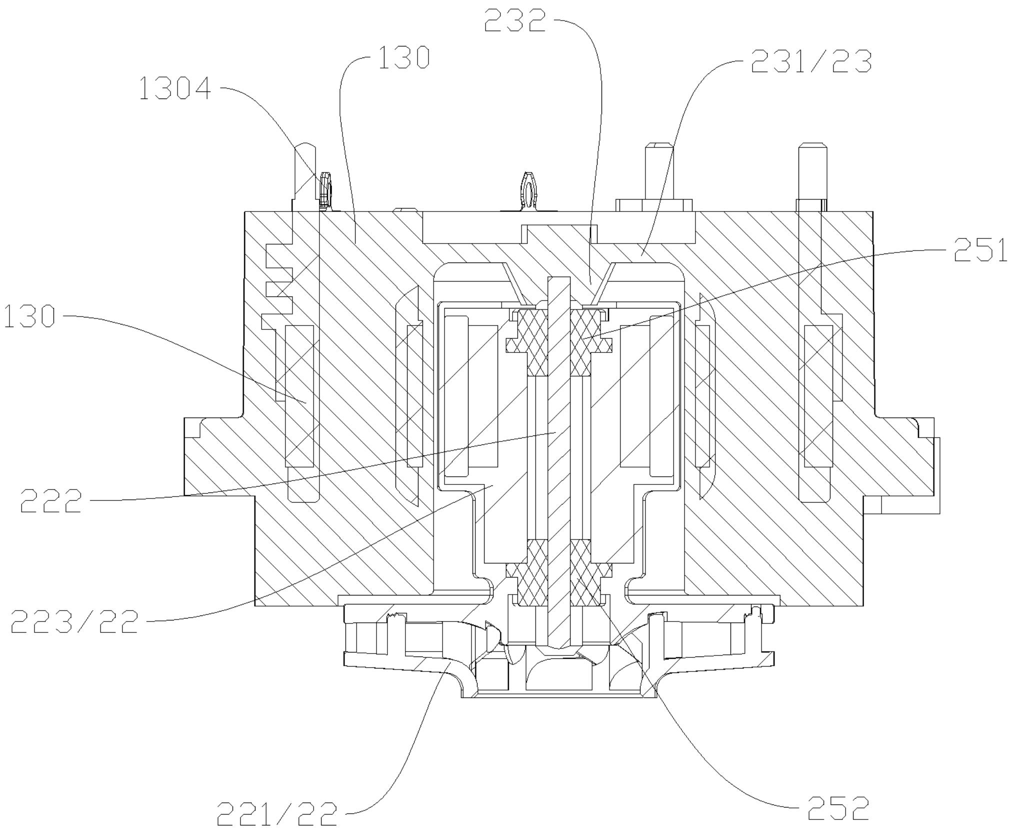


FIG. 20

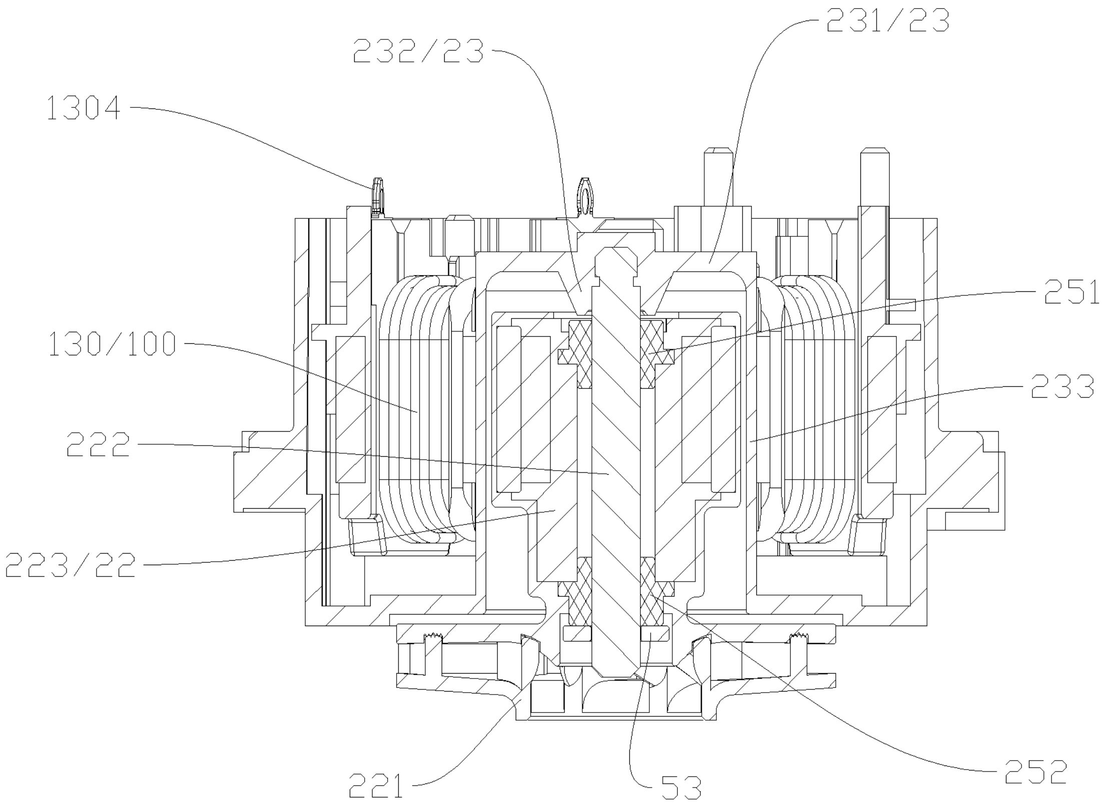


FIG. 21

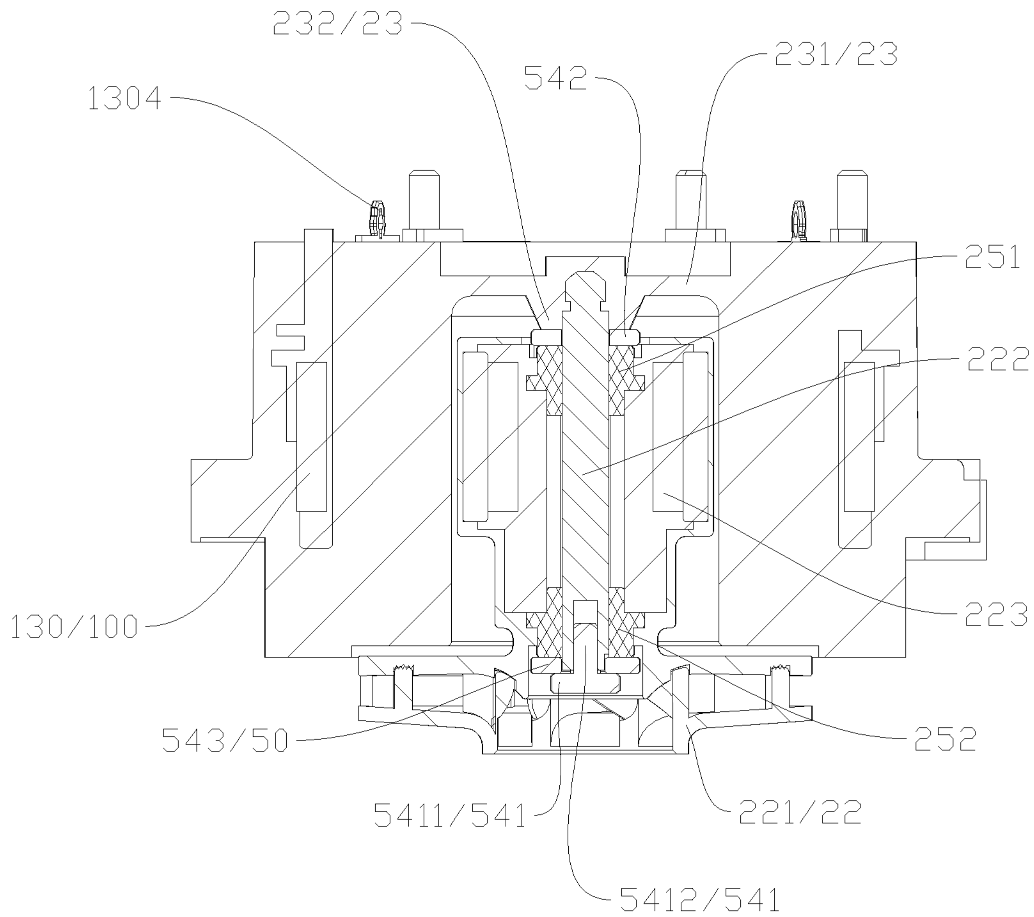
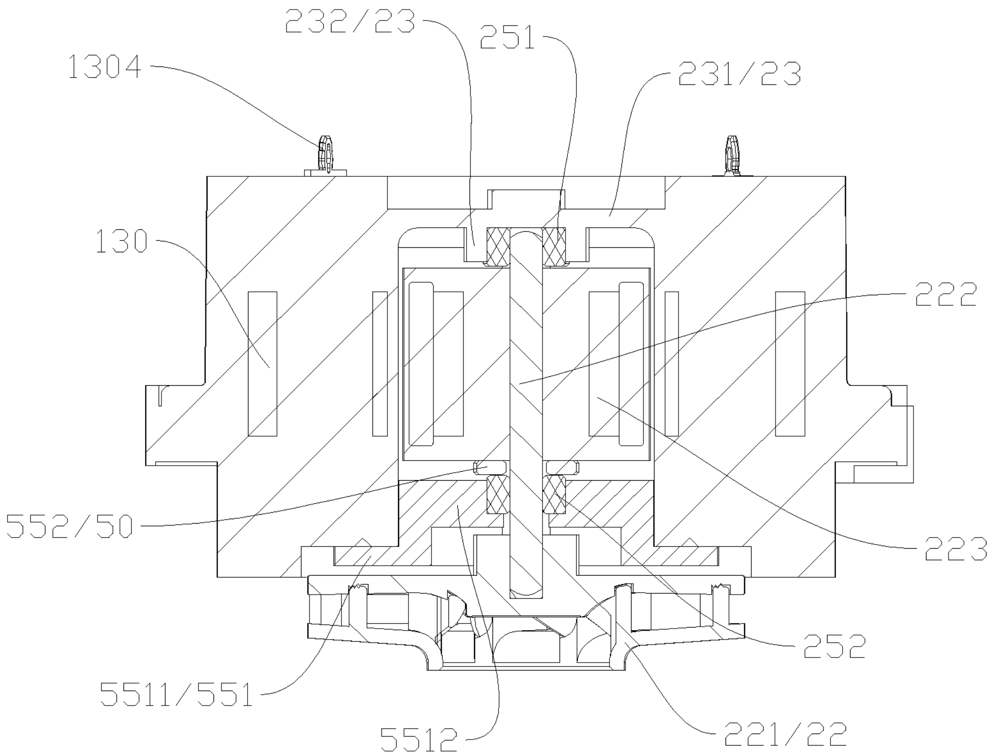

232/23
231/23
542
1304
251
222
223
130/100
543/50
252
5411/541
221/22
5412/541

FIG. 22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1304
231/23
130
222
552/50
223
252
5511/551
5512
221/22

FIG. 23

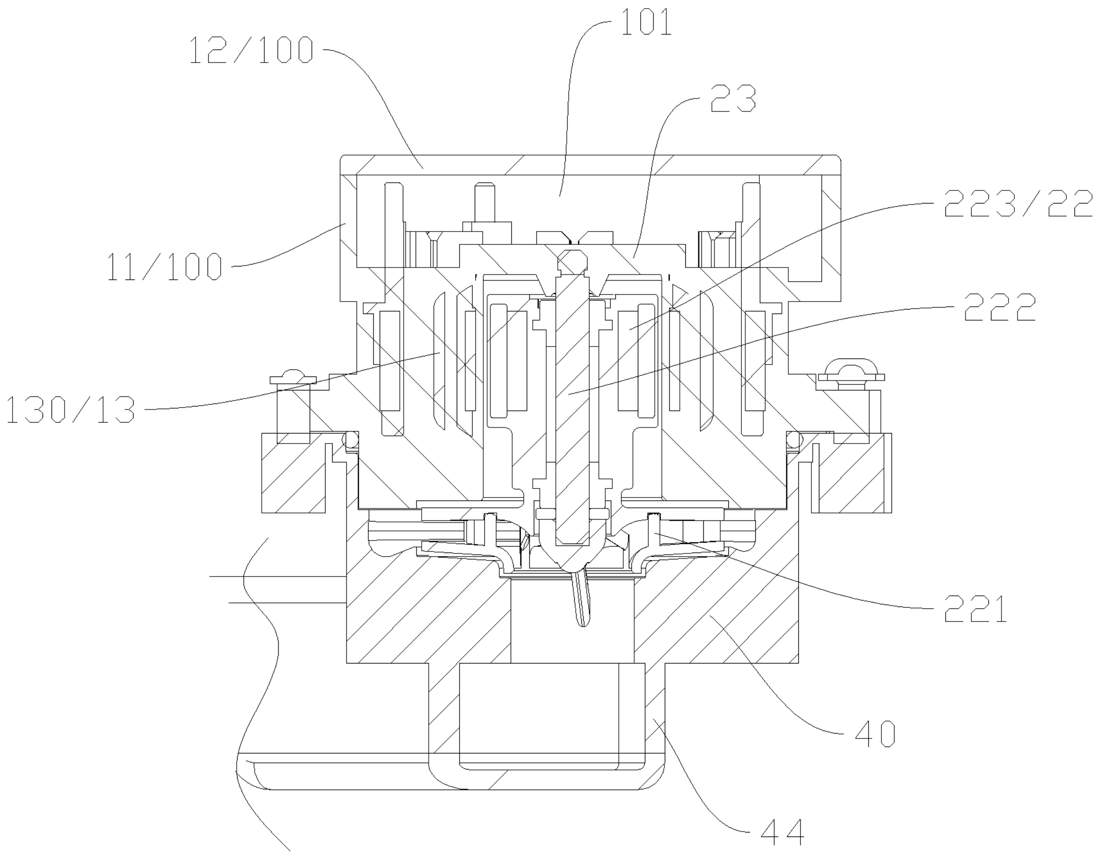
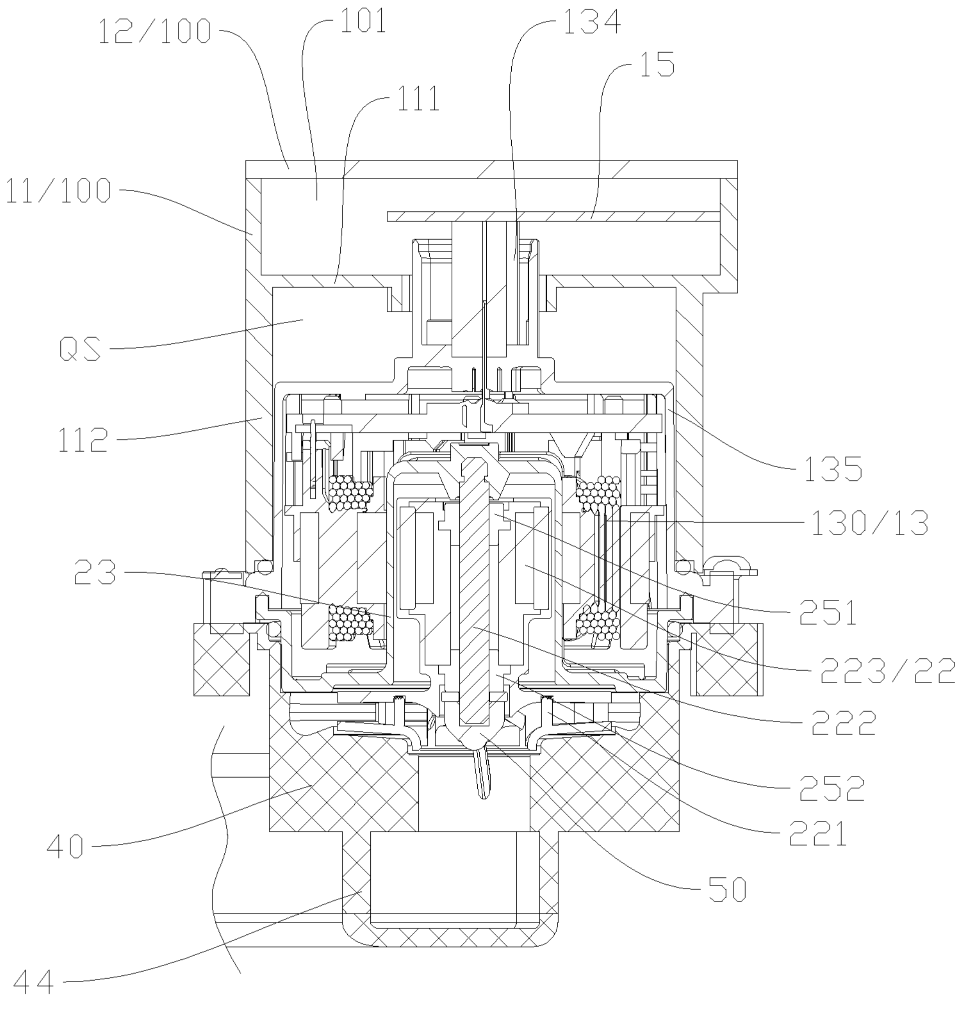


FIG. 24


12/100
101
134
15
111
11/100
QS
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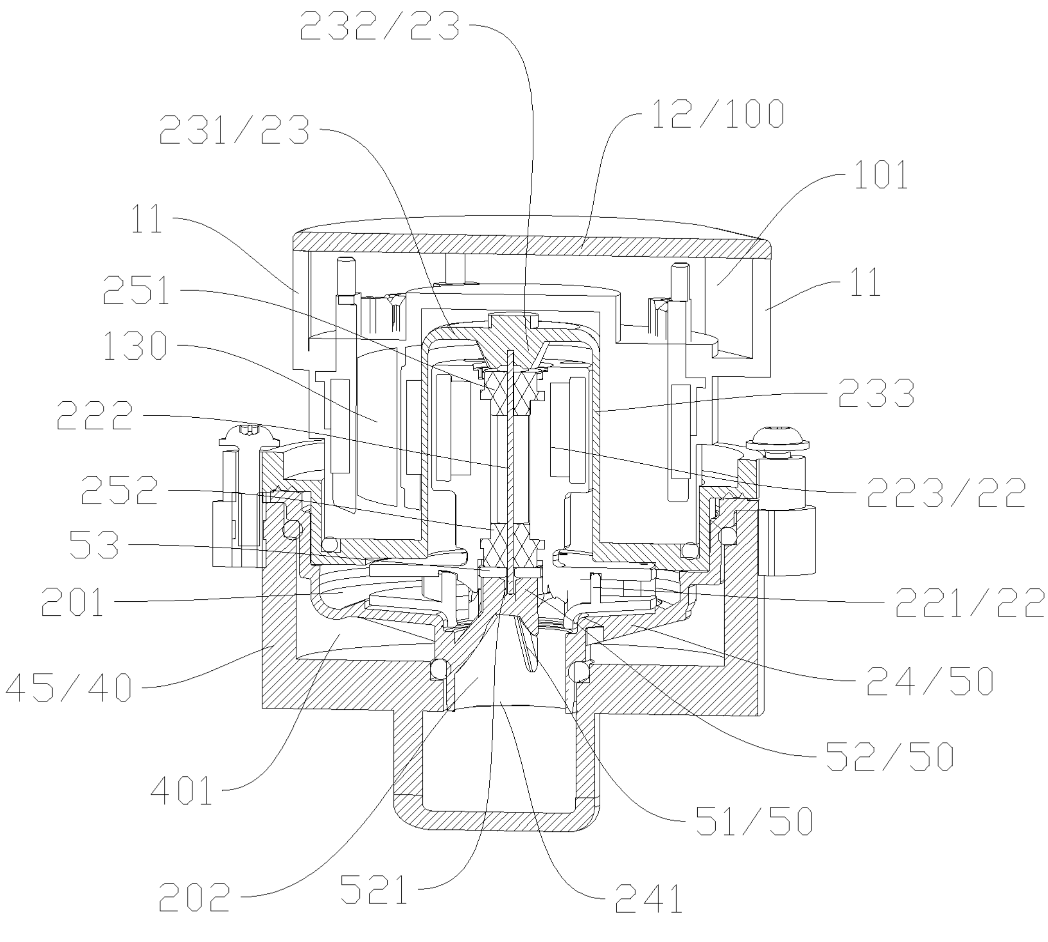
130/13
23
251
223/22
222
252
40
221
50
44

FIG. 25


232/23
231/23
12/100
101
11
11
251
130
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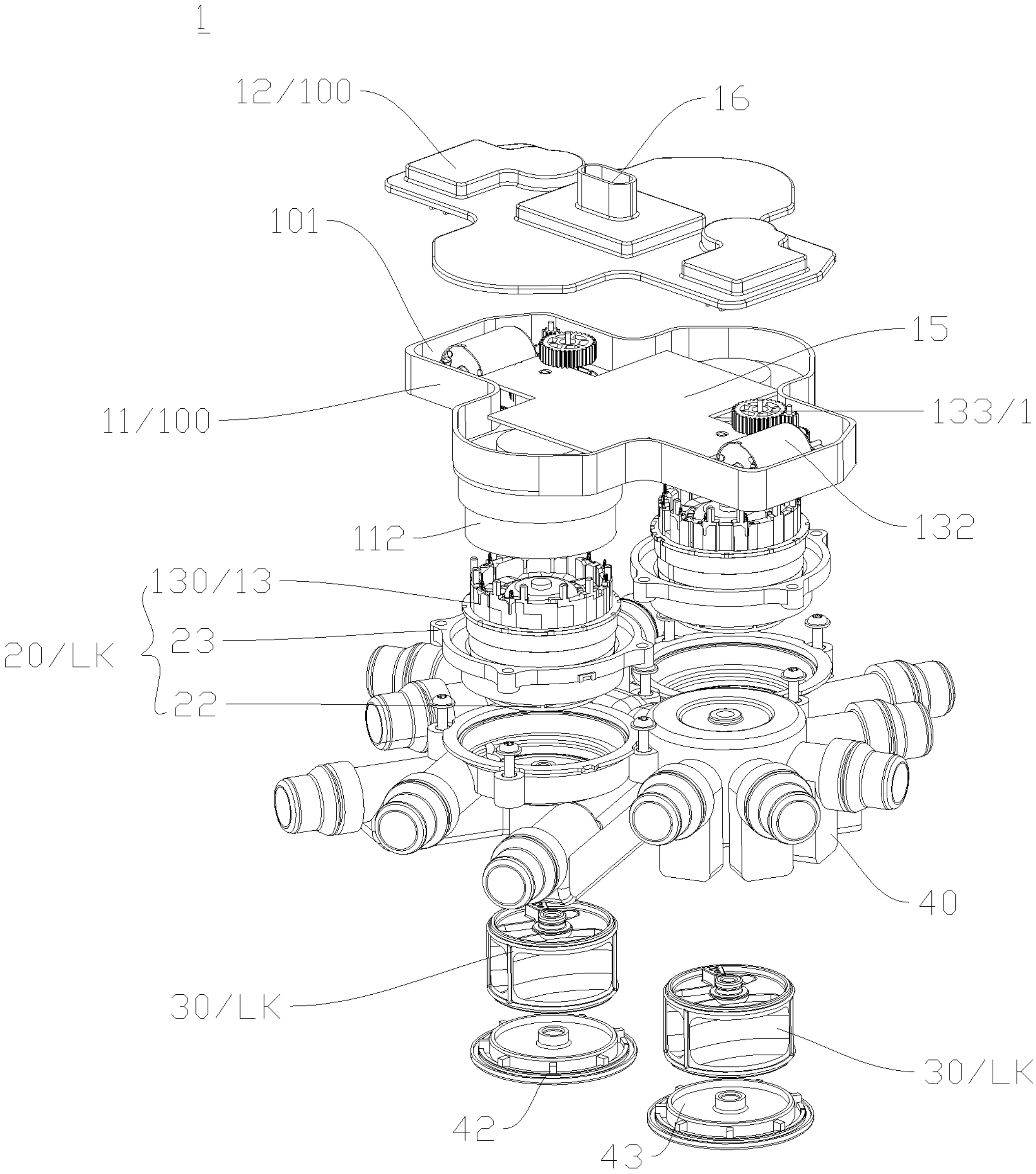
222
223/22
252
53
201
221/22
45/40
24/50
52/50
401
51/50
202
521
241

FIG. 26


1
12/100
16
101
15
133/13
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132
112
130/13
20/LK
23
22
40
30/LK
30/LK
42
43

FIG. 27

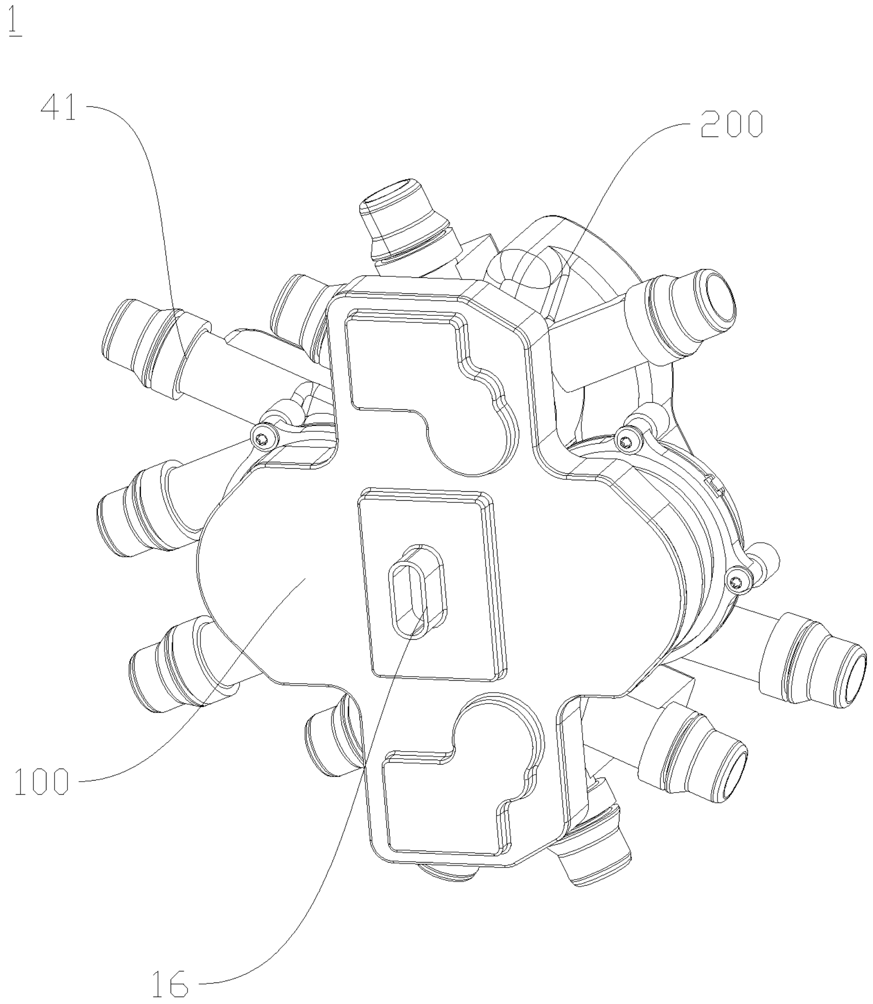

FIG. 28

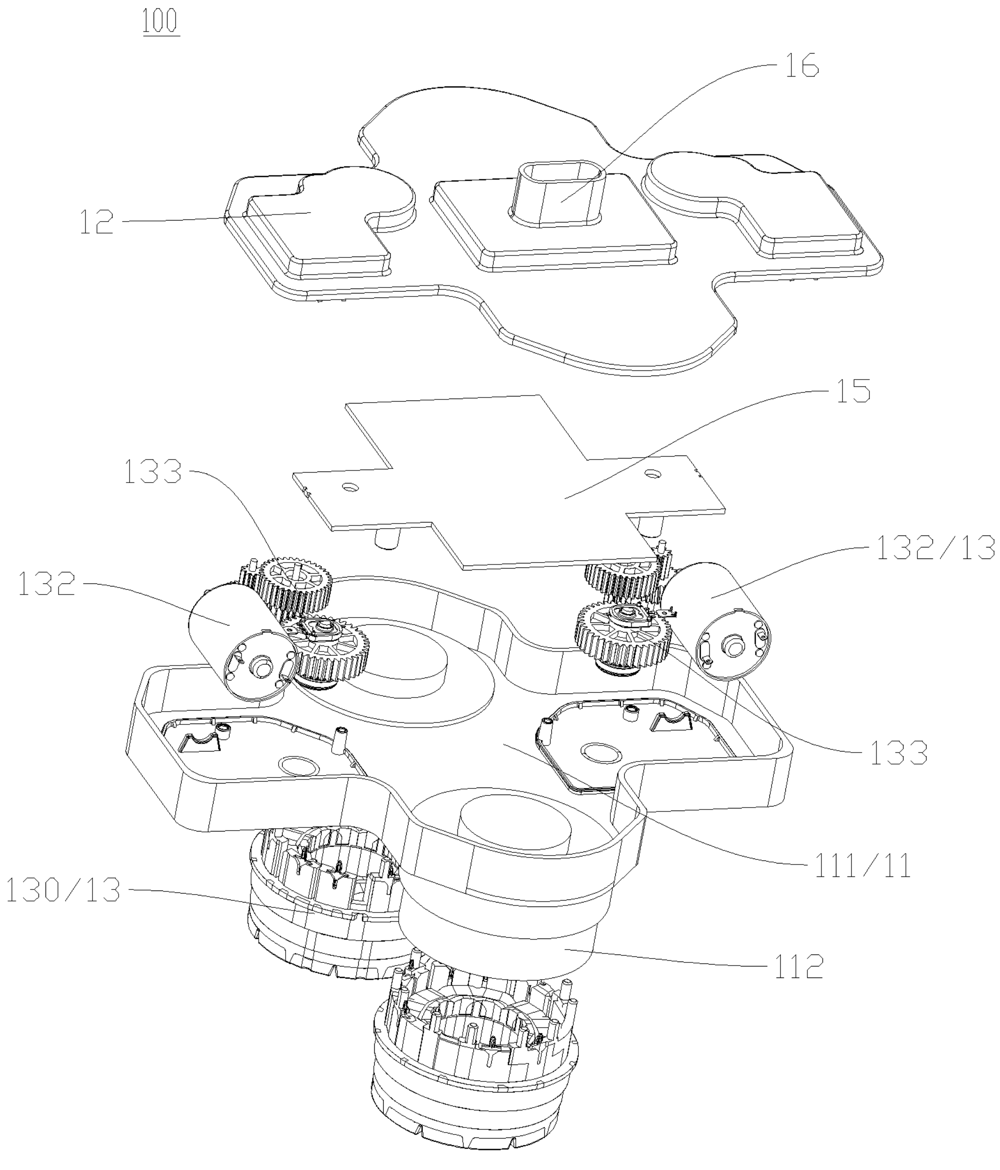

FIG. 29

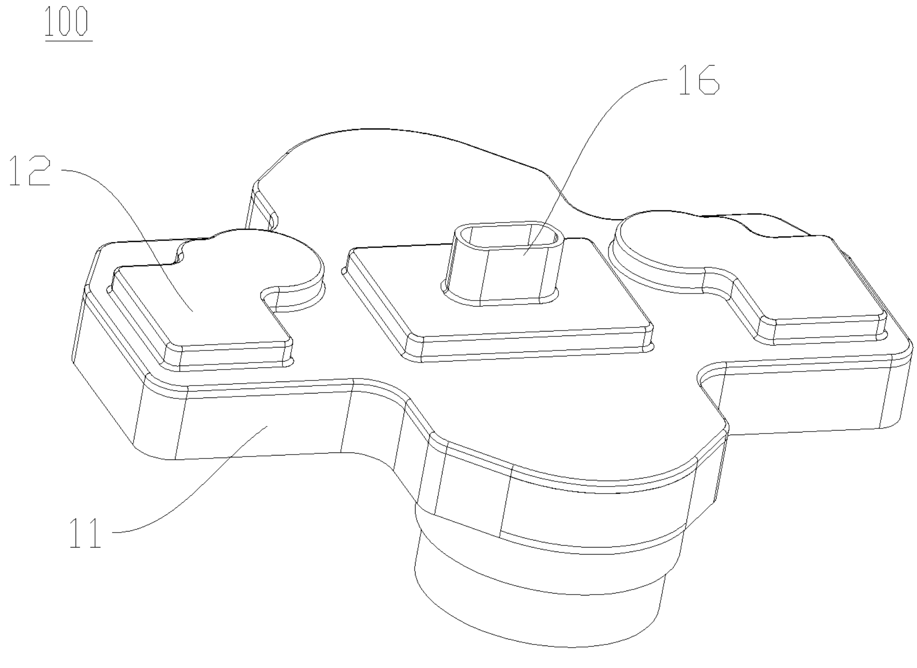

FIG. 30

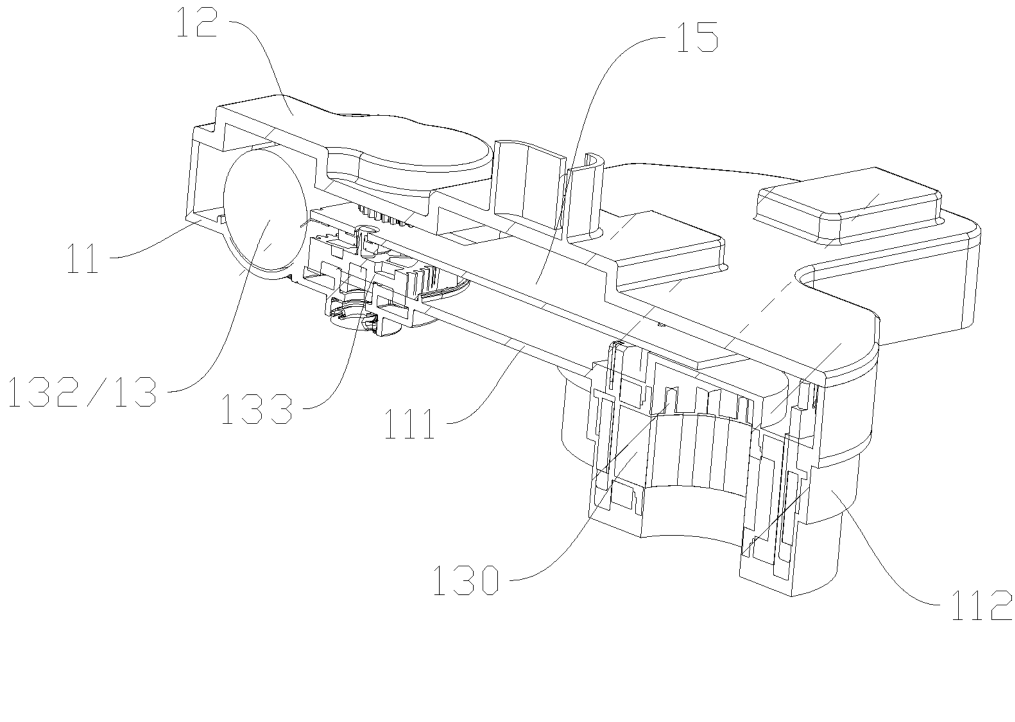

FIG. 31

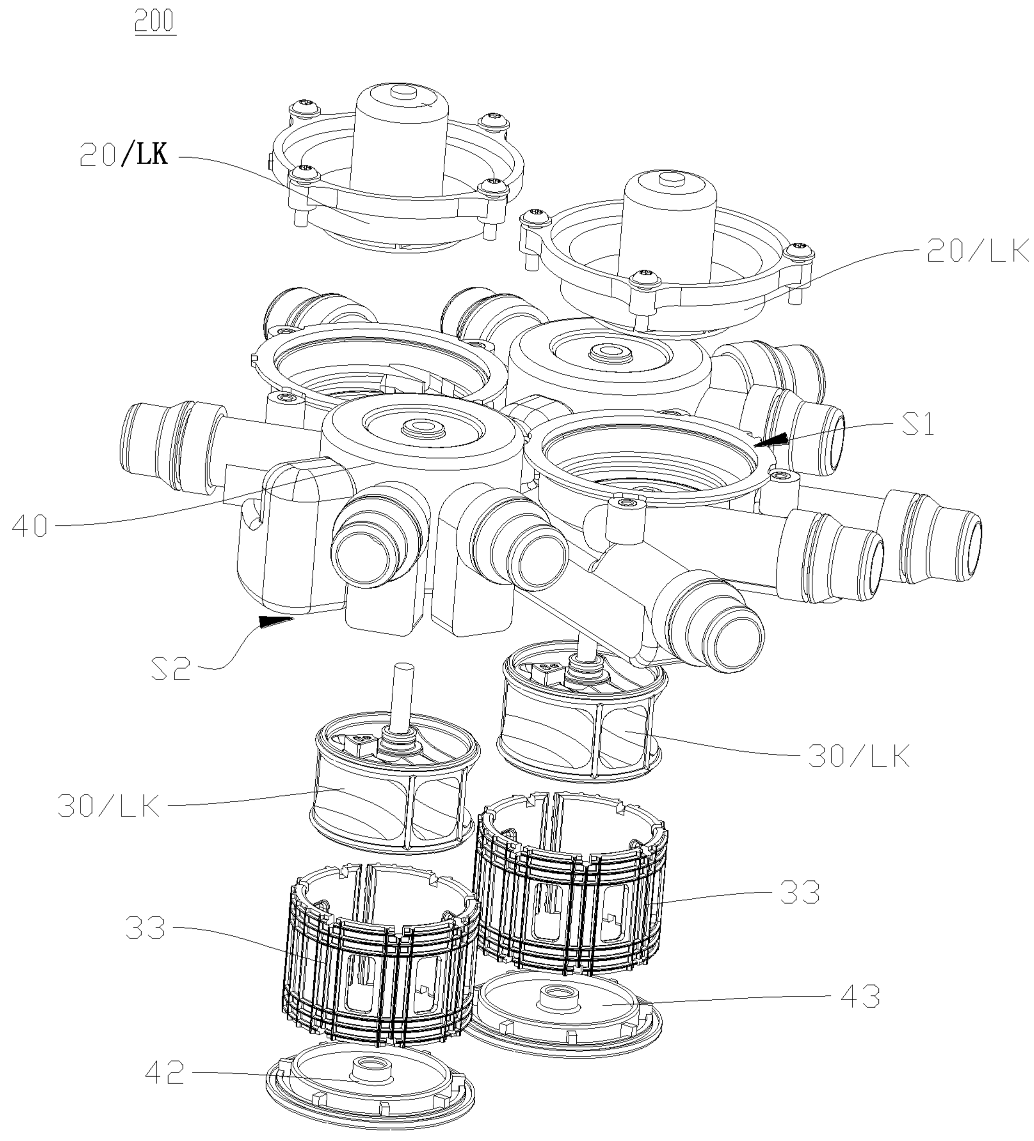

FIG. 32

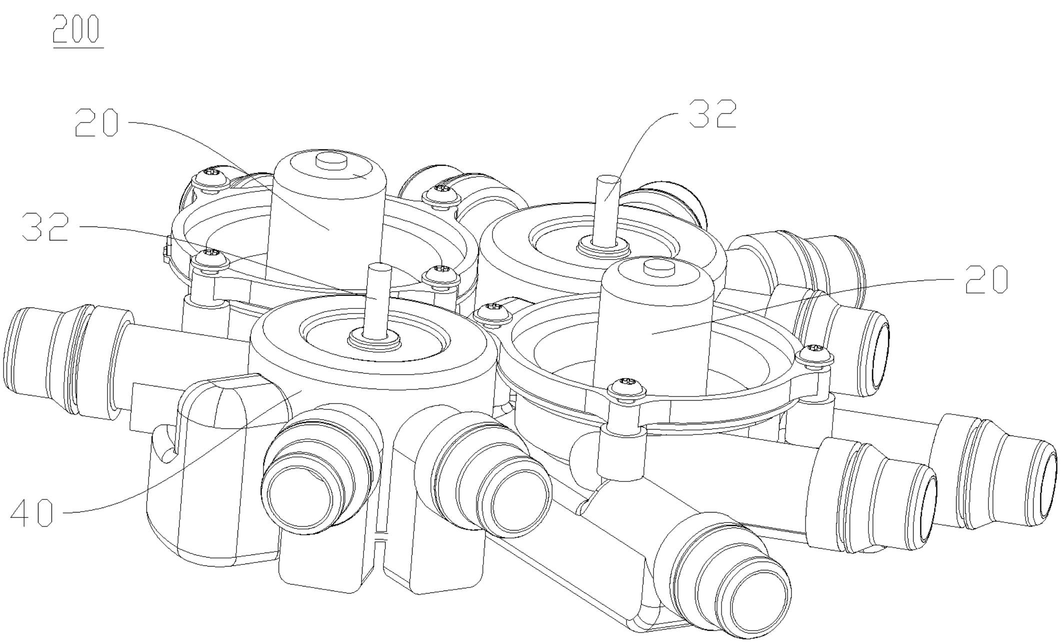

FIG. 33

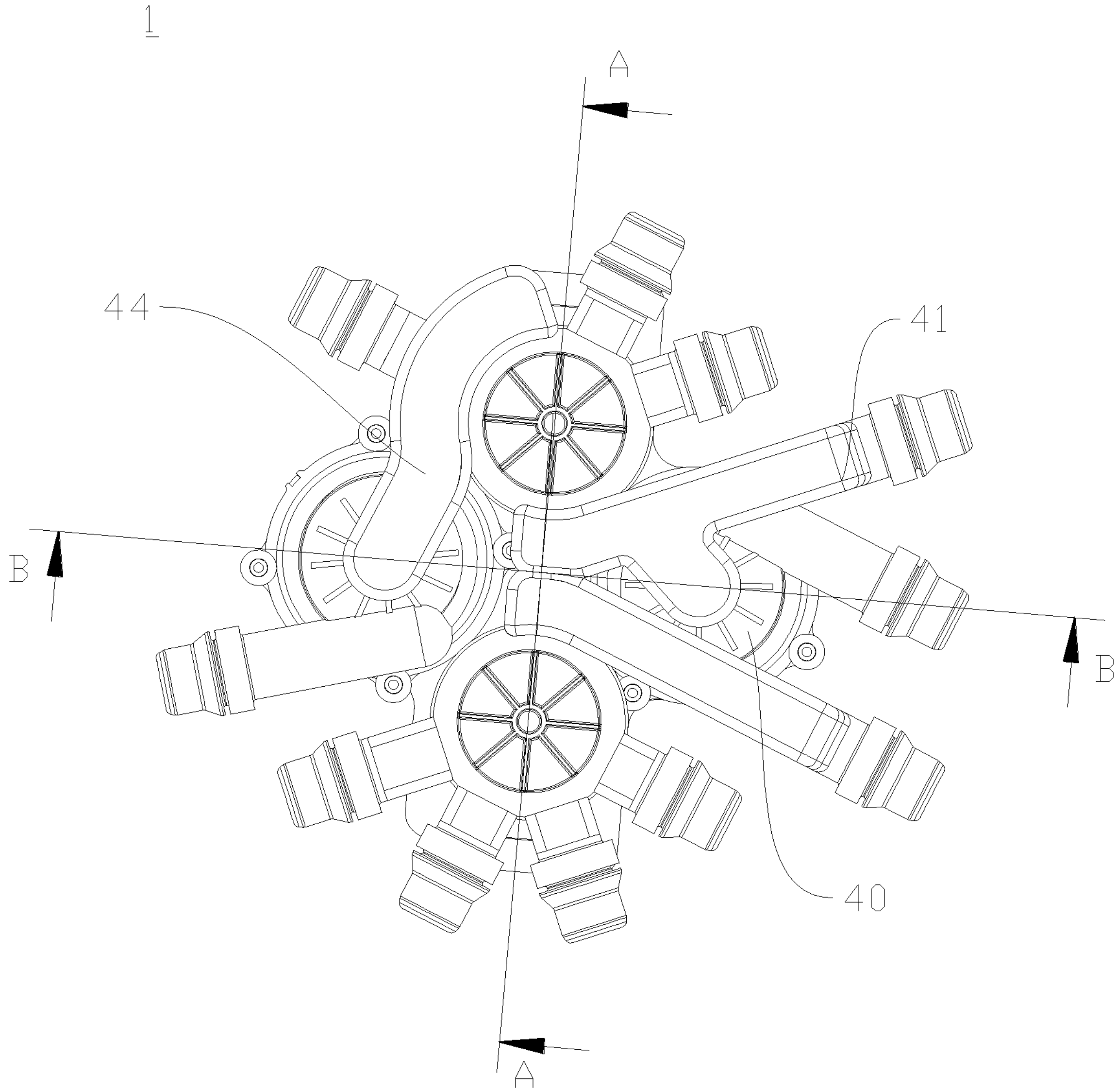

FIG. 34

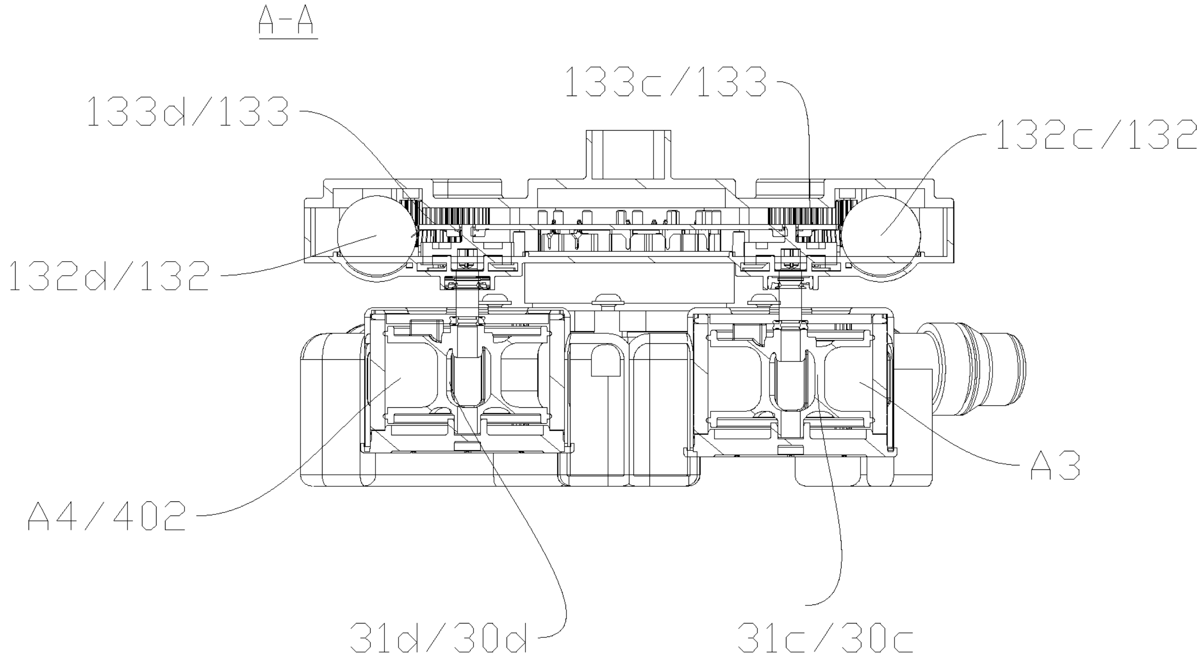
A-A
133d/133
133c/133
132c/132
132d/132
A3
A4/402
31d/30d
31c/30c

FIG. 35

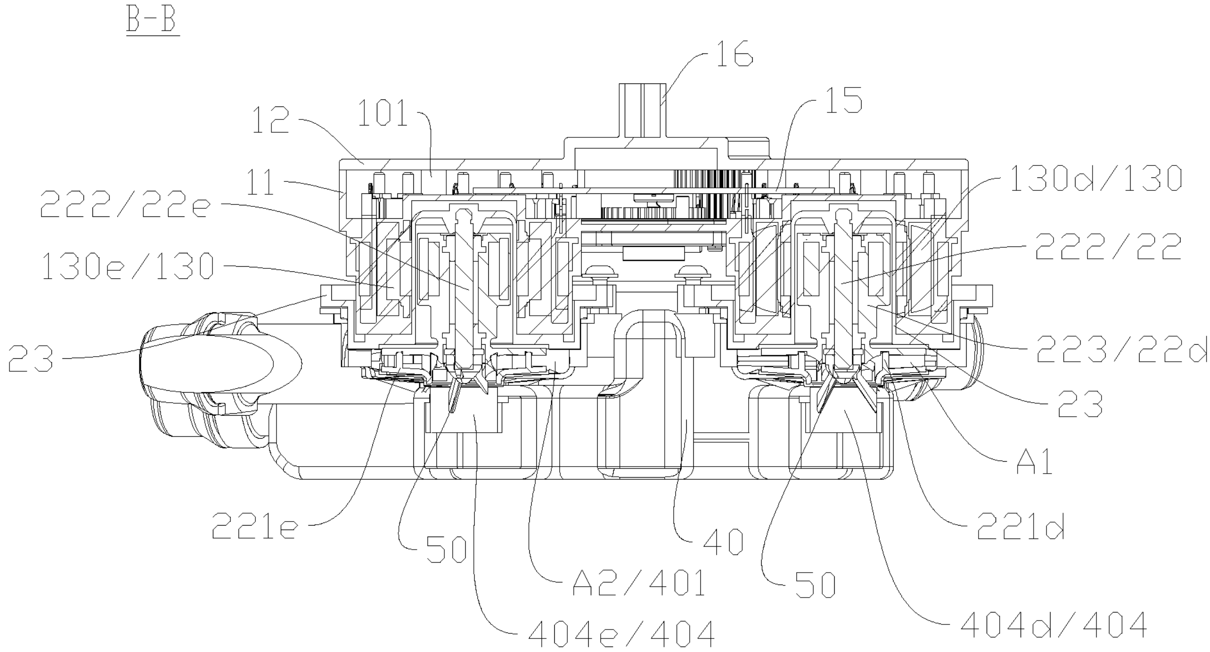
B-B
16
15
12
101
11
130d/130
222/22e
222/22
130e/130
223/22d
23
23
A1
221d
221e
50
40
50
A2/401
404e/404
404d/404

FIG. 36

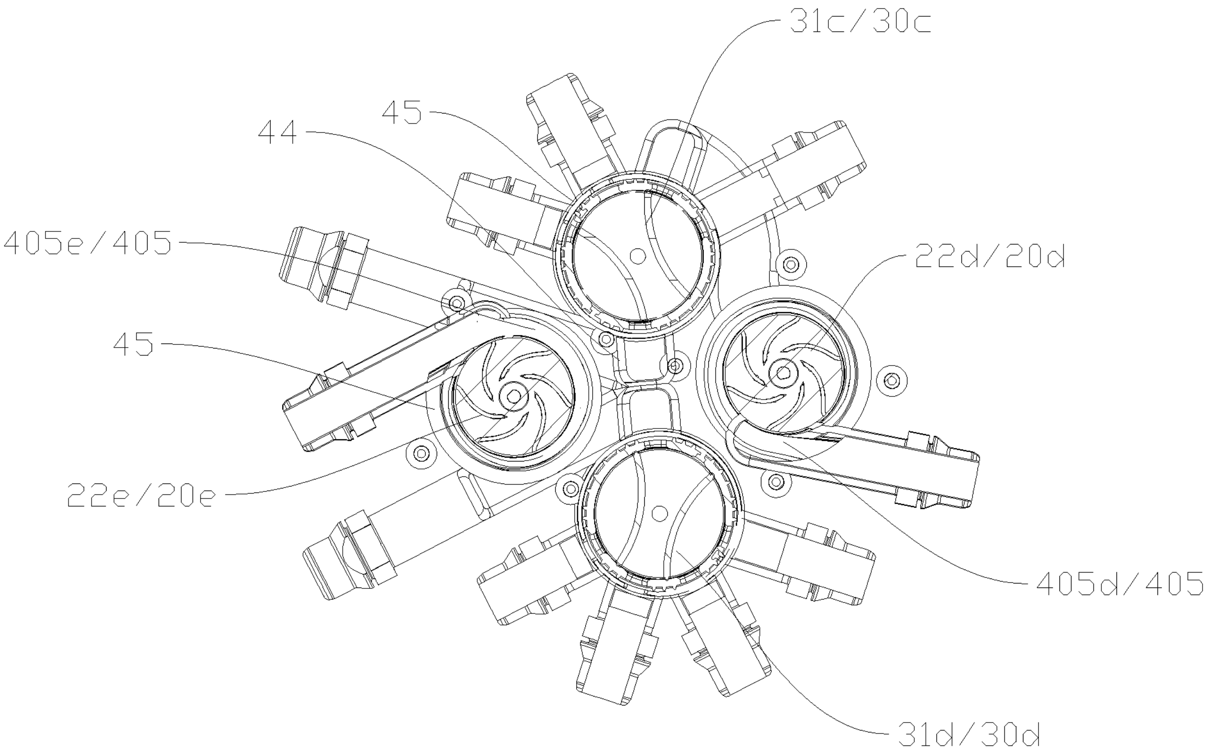

FIG. 37

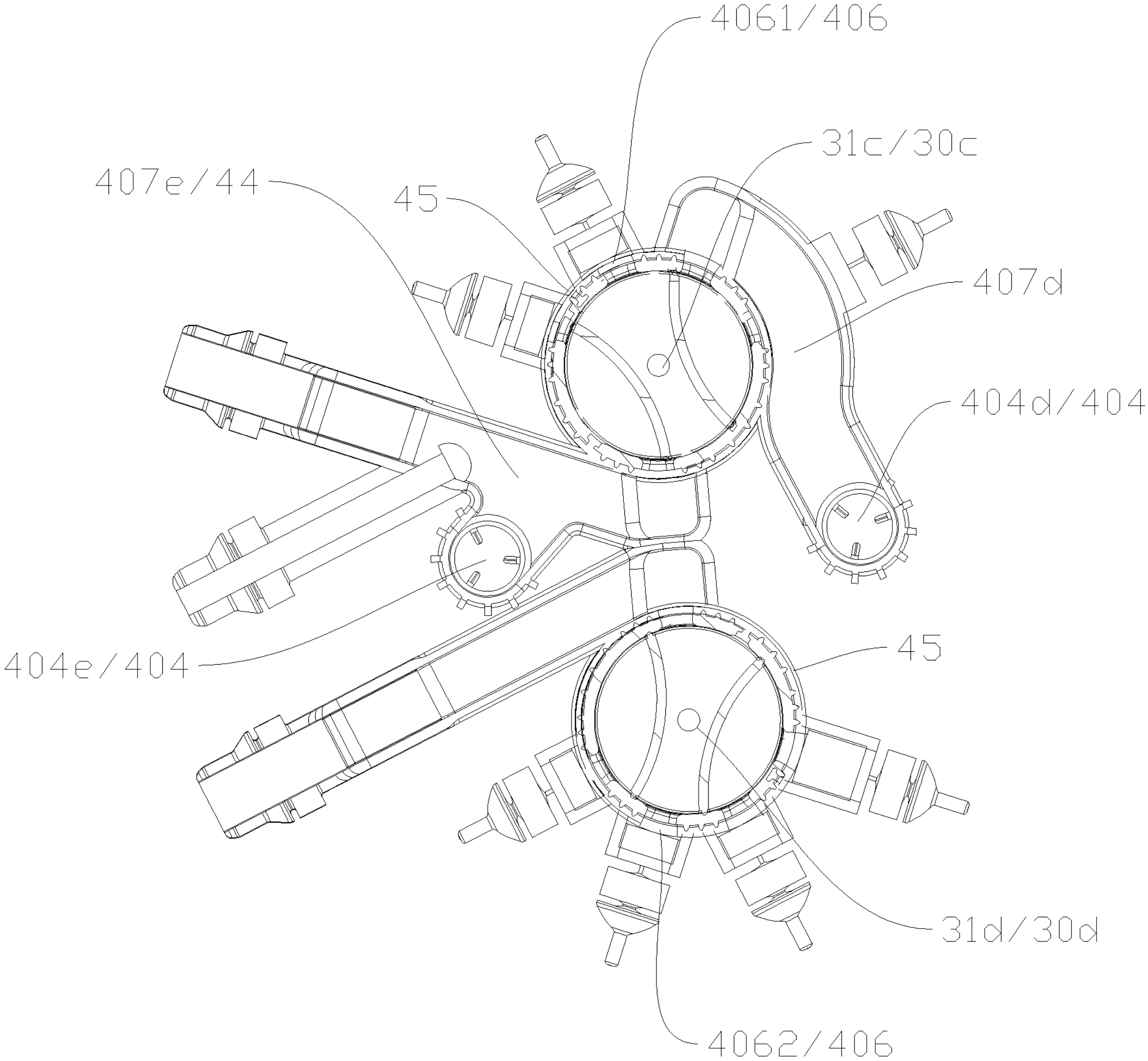
4061/406
31c/30c
407e/44
45
407d
404d/404
404e/404
45
31d/30d
4062/406

FIG. 38

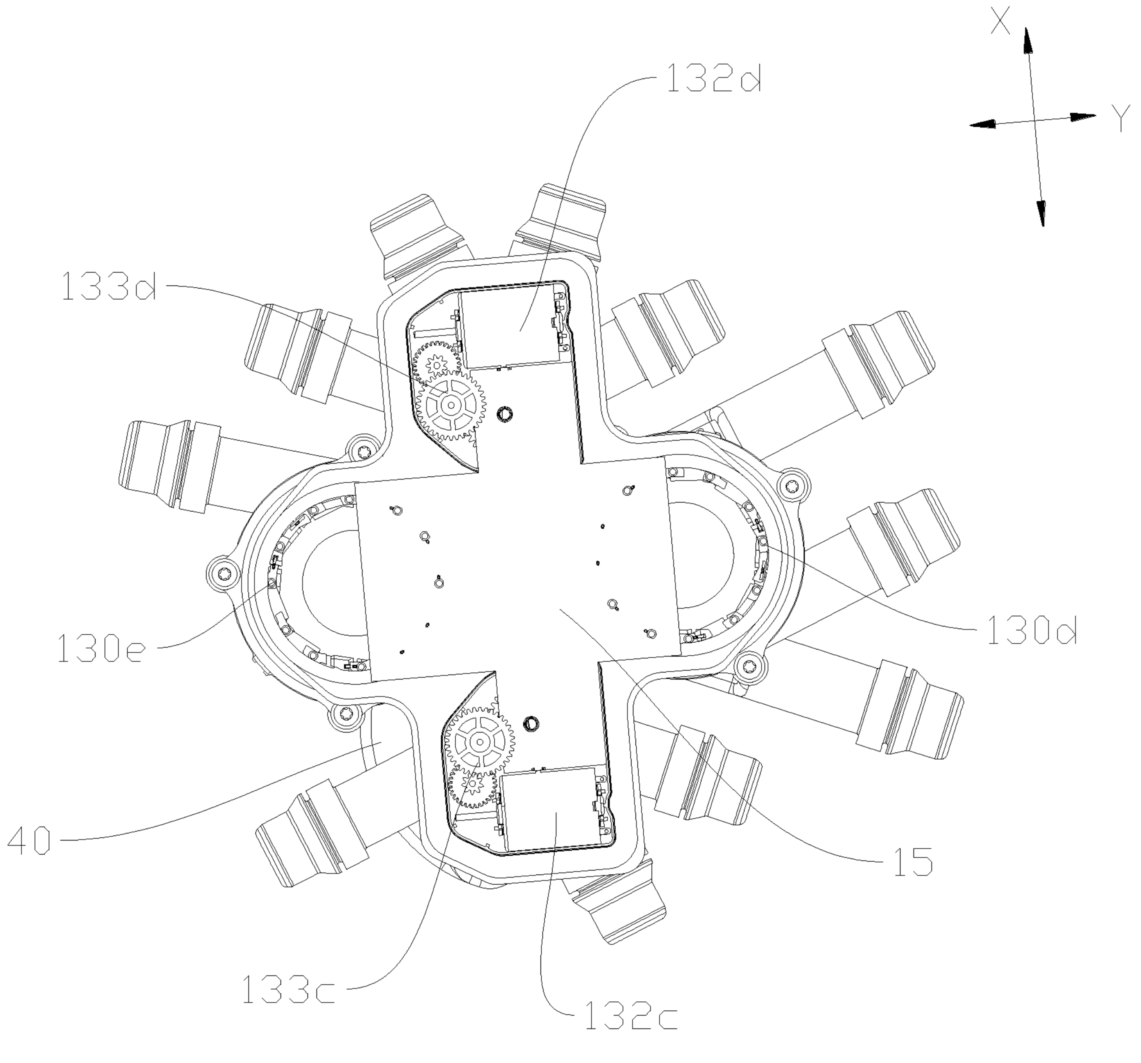

FIG. 39

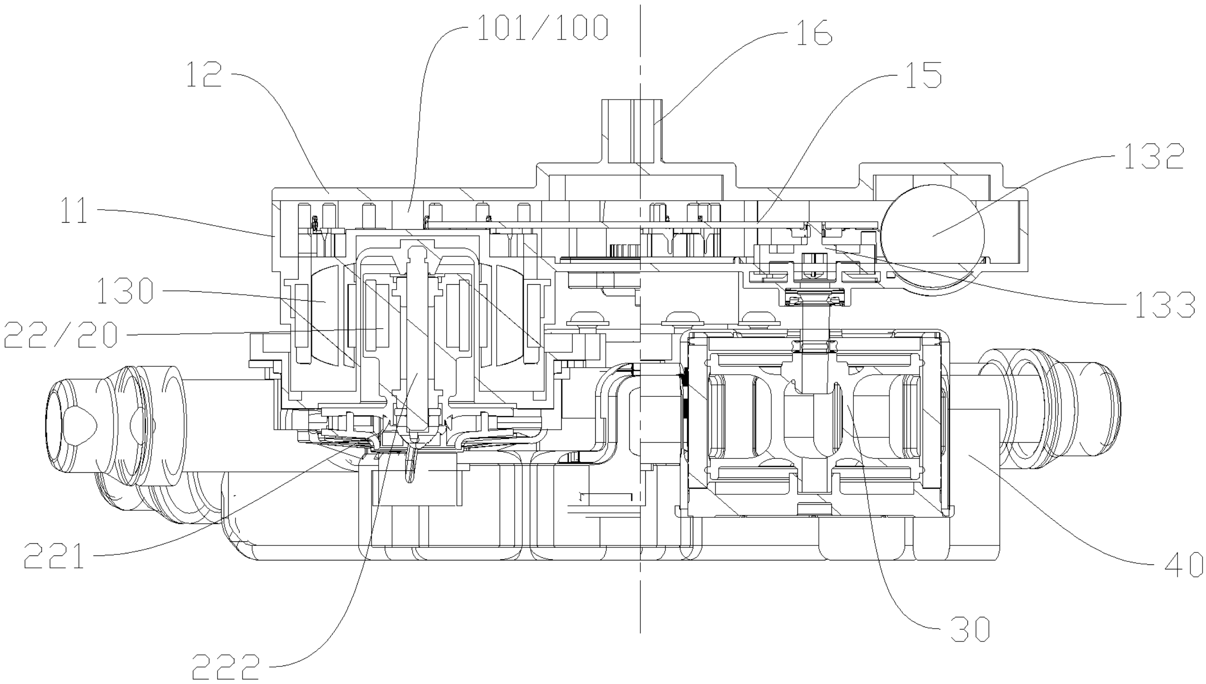
101/100
16
12
15
132
11
133
130
22/20
221
40
30
222

FIG. 40

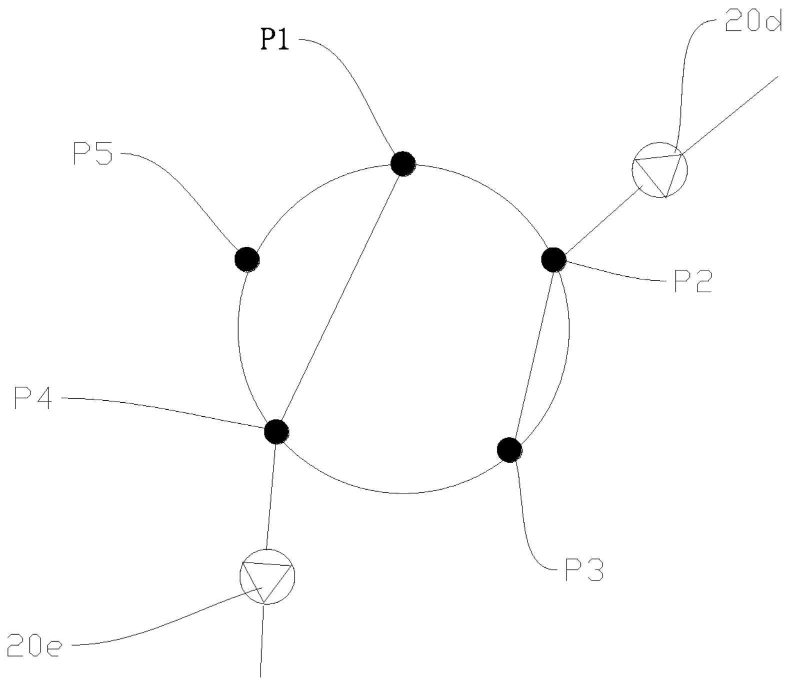
P1
20d
P5
P2
P4
P3
20e

FIG. 41

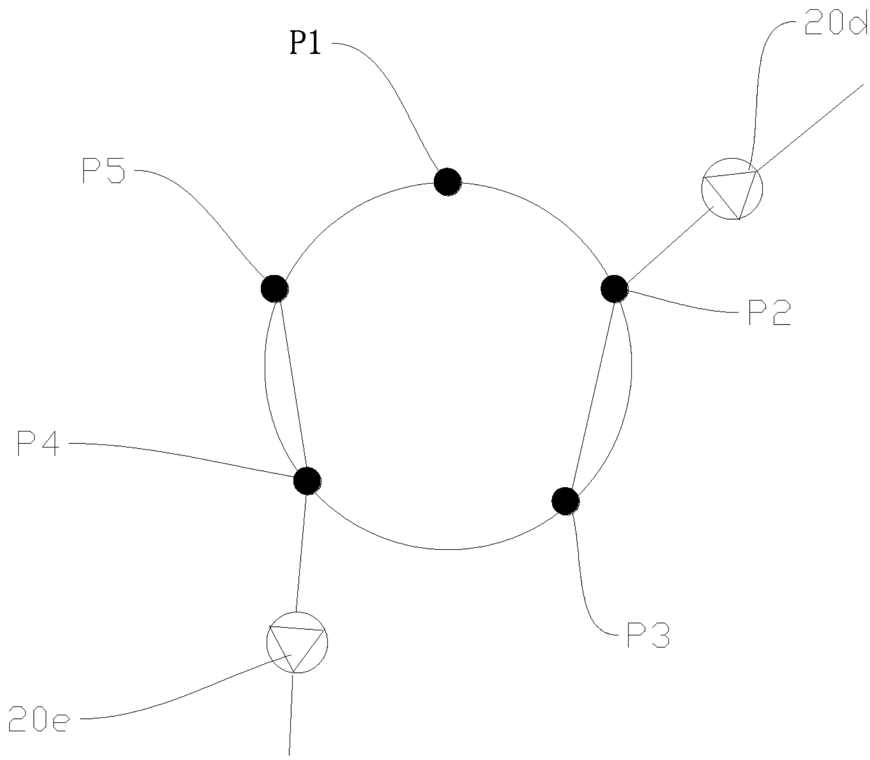

FIG. 42

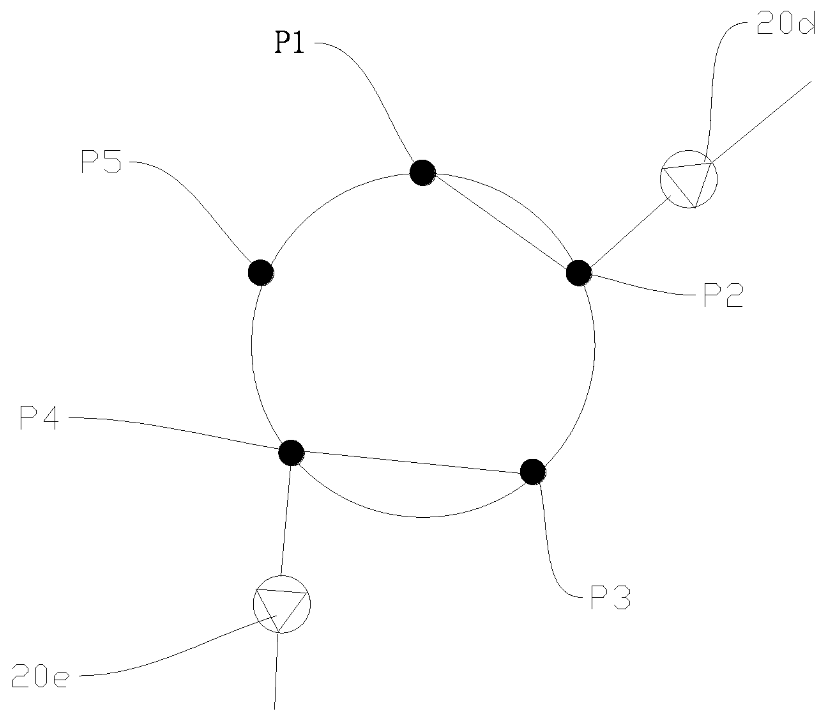

FIG. 43

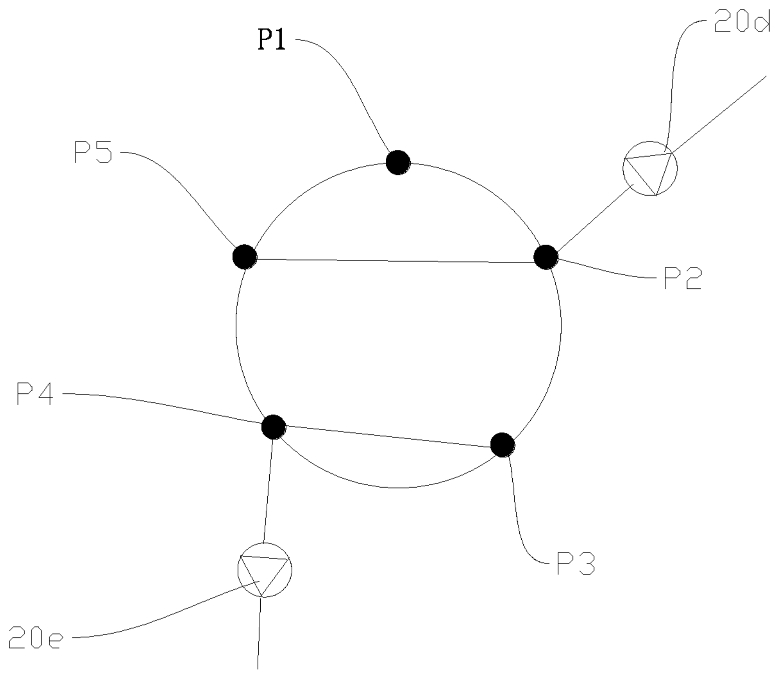
P1
20d
P5
P2
P4
P3
20e

FIG. 44

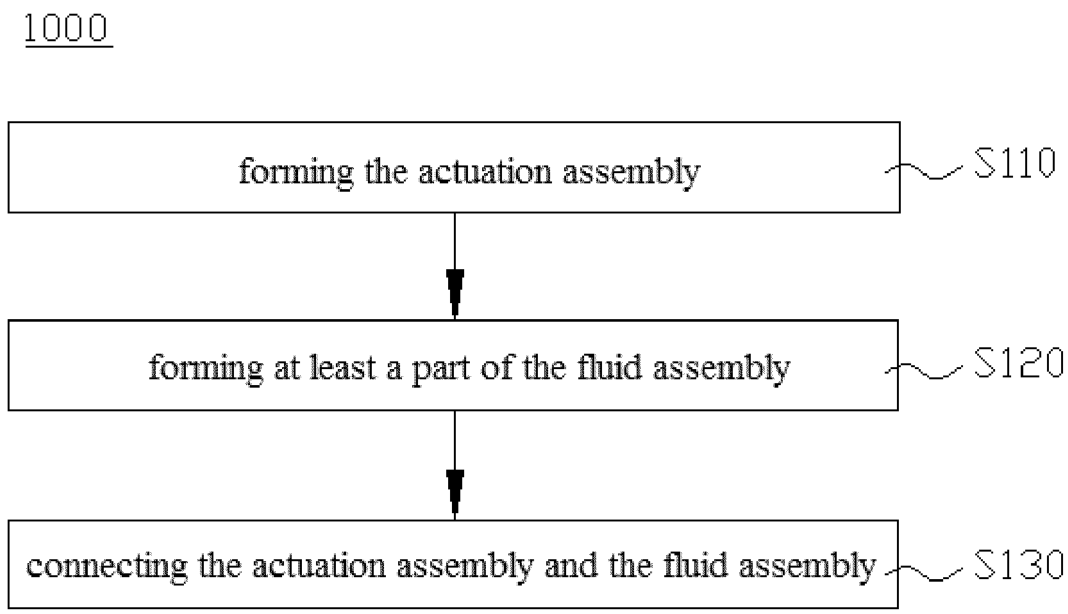
1000
forming the actuation assembly
S110
forming at least a part of the fluid assembly
S120
connecting the actuation assembly and the fluid assembly
S130

FIG. 45

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/091086

A. CLASSIFICATION OF SUBJECT MATTER

F04D13/06(2006.01)i；F04D29/62(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:F04D

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)

CNTXT, VEN, CNKI: 泵, 转子, 定子, 隔离套, 轴, 限位, pump, rotor, stator, spacer w sleeve, shaft, limit+, spac+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 106640674 A (ZHEJIANG SANHUA AUTOMOTIVE COMPONENTS CO., LTD.) 10 May 2017 (2017-05-10) description, paragraphs [0032]-[0070], and figure 2	1-15
Y	CN 105782063 A (HANGZHOU SANHUA RESEARCH INSTITUTE CO., LTD.) 20 July 2016 (2016-07-20) description, paragraphs [0026]-[0038], and figure 2	1-15
A	CN 109510369 A (REGAL BELOIT AMERICA, INC. et al.) 22 March 2019 (2019-03-22) entire document	1-15
A	US 5949171 A (SIEMENS CANADA LTD.) 07 September 1999 (1999-09-07) entire document	1-15
A	US 5997261 A (SIEMENS CANADA LTD.) 07 December 1999 (1999-12-07) entire document	1-15

☐ 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
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- "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
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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
12 June 2023	**24 June 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
Information on patent family members

International application No.
PCT/CN2023/091086

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	106640674	A	10 May 2017	None			
CN	105782063	A	20 July 2016	None			
CN	109510369	A	22 March 2019	DE	102018122292	A1	14 March 2019
				US	2019078571	A1	14 March 2019
				US	10605245	B2	31 March 2020
US	5949171	A	07 September 1999	US	6111334	A	29 August 2000
				DE	69917138	D1	17 June 2004
				DE	69917138	T2	04 May 2005
				EP	0967707	A2	29 December 1999
				EP	0967707	A3	18 April 2001
				EP	0967707	B1	12 May 2004
				EP	1124302	A2	16 August 2001
				EP	1124302	A3	29 August 2001
US	5997261	A	07 December 1999	DE	69804745	D1	16 May 2002
				DE	69804745	T2	21 November 2002
				EP	0913910	A1	06 May 1999
				EP	0913910	B1	10 April 2002

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REFERENCES CITED IN THE DESCRIPTION

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- CN 202210472211X **[0001]**
- CN 202210472384 **[0001]**