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(54) PERMANENT MAGNET LINEAR PISTON PUMP

(57) A permanent magnet linear piston pump comprises a piston body (1), a cylinder body (2), a permanent magnet assembly (6) and an electromagnetic coil (3). The piston body is arranged in a piston cavity (201) by a liquid sealing movable fit mode. An inner magnetic body (603) and an outer magnetic body (604) are disposed on at least one side surface of the cylinder body (2). An electromagnetic coil (3) is axially and distributively wound around a coil supporting member which is disposed at an outside surface of the cylinder body (2). The electromagnetic coil (3) is disposed between the inner magnetic body (603) and the outer magnetic body (604) . By the above structure, the pump needs not subject the electromagnetic coil (3) to a sealing treatment, thereby attaining a simple structure, more convenient manufacture, lower costs, a reliable operation and convenient maintenance.

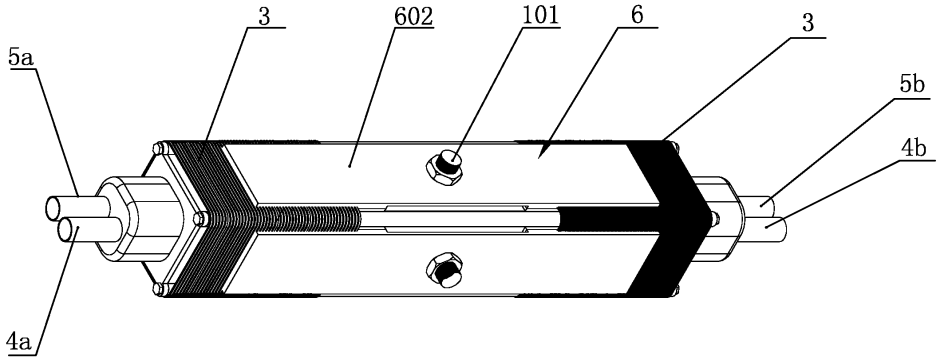

FIG. 5

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a linear piston pump, and more particularly to a permanent magnet linear piston pump.

2. Description of the Related Art

[0002] The advantages of the magnetic-force linear piston pump contain a high operating pressure, a simple structure, a low consumption of energy and noises and a long durability. Therefore, it becomes more and more important and is applied to more and more applications. The mechanical movement and principle of the magnetic-force linear piston pump are similar to those of the plunger pump. Both of them take advantage of the relative reciprocating motion between the piston and the cylinder body to incur the variable capacity of the sealed piston cavity inside the pump, thereby inputting and outputting the fluid medium. A prior disclosure of CN1554868 as published on 2004/12/15 and named by "magnetic-force linear piston pump" discloses a magnetic-force linear piston pump which comprises a housing in which a cylinder body and a piston are disposed. The piston is disposed inside the cylinder body with an axial movable airtight fit. On the outer periphery of the cylinder body is an electromagnetic coil. The electromagnetic coil is fixed into the housing. The electromagnetic coil is connected to an oscillating power supply. A permanent magnet is further disposed on the outer periphery of the cylinder body. The permanent magnet and the cylinder body are connected and positioned. One end of the piston is fixed to the housing, and the other end thereof is disposed within an inner hole of the cylinder body. A fluid hole is disposed on the piston. A first unidirectional valve and a second unidirectional valve are relatively disposed in the fluid hole or in the inner cavity of the cylinder body, thereby constructing three opposite and independent cavities in sequence, namely a low-pressure cavity, a variable-capacity operating cavity and a high-pressure cavity. The low-pressure cavity is communicated with an inlet pipe. The high-pressure cavity is communicated with an outlet pipe. However, since the electromagnetic coil is disposed inside the housing, the structure is unreasonable, which incurs an inconvenient installation. Furthermore, the electromagnetic coil and the permanent magnet are all set in the low-pressure cavity, so the sealing treatment to the electromagnetic coil and the permanent magnet is necessary, which incurs a complexity of the manufacture, high costs and hard promotions.

SUMMARY OF THE INVENTION

[0003] The object of the present invention is to overcome the aforementioned problems and to provide a permanent magnet linear piston pump having a simple structure, more convenient manufacture and lower costs.

[0004] The permanent magnet linear piston pump in accordance with the present invention comprises a piston body, a cylinder body, a permanent magnet assembly and an electromagnetic coil. It is characterized in that the cylinder body is in a shape of a polygonal prism, an interior of which arranges a piston cavity formed by an axial columnar accommodating cavity. The piston body is arranged in the piston cavity by a liquid sealing movable fit mode. A one-way inlet valve and a one-way outlet valve are disposed on an end face of the piston cavity opposite to an end face of a piston. A set of permanent magnet assembly is disposed on at least one side surface of the cylinder body. The permanent magnet assembly includes an inner mounting plate and an outer mounting plate disposed parallel to the side surface of the cylinder body. The inner plate and the outer mounting plate are made of a permeability magnetic material. An inner magnetic body and an outer magnetic body are respectively disposed on opposite surfaces of the inner mounting plate and the outer mounting plate. The inner magnetic body and the outer magnetic body are disposed oppositely and provide contrary magnetic poles at opposite faces thereof. A coil supporting member is disposed at an outside surface of the cylinder body. The electromagnetic coil is axially and distributively wound around the coil supporting member into a barrel shape. A barrel wall formed by the electromagnetic coil is disposed between the inner magnetic body and the outer magnetic body. An axial sliding slot is formed on the side surface of the cylinder body where the permanent magnet assembly is disposed. A connecting post is disposed on a side surface of the piston body in a radial direction to fit in with the sliding slot by a clearance fit mode. The connecting post penetrates through the sliding slot to be in connection with and in linkage with the inner mounting plate and the outer mounting plate.

[0005] By comparison with the prior technique, the present invention has the electromagnetic coil which is axially and distributively wound around the coil supporting member at the outside surface of the cylinder body and needs not subject the electromagnetic coil to a sealing treatment, which attains a simple structure, more convenient manufacture, lower costs, a reliable operation and convenient maintenance.

[0006] Preferably, two parts of the columnar accommodating cavity in the cylinder body are disposed symmetrically. The piston body is disposed at a middle portion of the columnar accommodating cavity. Two ends of the piston body are in cooperation with the two parts of the columnar accommodating cavity by the liquid sealing movable fit mode respectively, whereby the two parts of the columnar accommodating cavity are respectively defined as a first piston cavity and a second piston cavity, and the two ends of the piston body are respectively defined as a first piston body and a second piston body. A

first one-way inlet valve and a first one-way outlet valve are disposed on an end face of the first piston cavity opposite to an end face of the first piston body. A second one-way inlet valve and a second one-way outlet valve are disposed on an end face of the second piston cavity opposite to an end face of the second piston body. A first inner magnetic body and a second inner magnetic body are respectively and symmetrically disposed at two ends of the inner mounting plate. A first outer magnetic body and a second outer magnetic body are respectively and symmetrically disposed at two ends of the outer mounting plate. A first electromagnetic coil and a second electromagnetic coil are respectively and correspondingly disposed on ribs at two sides of the cylinder body. Accordingly, the same cylinder body forms two permanent magnet linear piston pumps, and the piston body can be in the operating status during the reciprocating motion to attain the higher efficiency.

[0007] Preferably, one set of permanent magnet assembly is arranged at each side surface of the cylinder body, which allows the permanent magnet linear piston pump to have a greater power.

[0008] Preferably, the cylinder body includes a barrel unit and lids at two ends thereof. Sealing rings are respectively disposed between the lids at the two ends and two end faces of the barrel unit. The barrel unit and the lids at the two ends are connected with each other by a plurality of axial shanks and nuts around an outer periphery of the barrel unit. The shanks construct the coil supporting member. Accordingly, such arrangement designing the cylinder body and the coil supporting member attains a simple structure, a simple manufacturing technique and lower costs.

[0009] Preferably, ribs are disposed on edges of the cylinder body. The ribs construct the coil supporting member. The inner mounting plate and the inner magnetic body are disposed in a recess between the ribs at two sides of a same side surface of the cylinder body. Accordingly, such arrangement designing the cylinder body and the coil supporting member attains a simple structure, a simple manufacturing technique, a firm structure and high mechanical intensity.

[0010] Preferably, the cylinder body can be a prism having four to six sides, especially a quadrangular prism whose cross-section is in a rectangular shape, whereby the cylinder body in this shape is easier to be processed.

[0011] Preferably, the inner mounting plate and the outer mounting plate are made of a permeability magnetic material. A magnetizing coil is sleeved on the inner mounting plate or/and the outer mounting plate. A magnetic field line created by the magnetizing coil is formed in a closed annular shape along the inner mounting plate, the inner magnetic body, the outer magnetic body and the outer mounting plate. Accordingly, the magnetizing coil is sleeved on the inner mounting or/and the outer mounting plate, so an external magnetizing power supply in connection with the magnetizing coil magnetizes the inner magnetic body and the outer magnetic body to retrieve their intensity of magnetism when the intensity of magnetism of two magnetic bodies becomes lessened due to a long term of using the permanent magnet linear piston pump, thereby prolonging the duration of the permanent magnet linear piston pump.

[0012] The present invention is further described upon reading following preferred embodiments in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a perspective view showing a first preferred embodiment of the present invention;
Fig. 2 is a cross-sectional view showing the interior of the first preferred embodiment of the present invention;
Fig. 3 is a perspective view showing the piston body of the first preferred embodiment of the present invention;
Fig. 4 is a perspective view showing the cylinder body of the first preferred embodiment of the present invention;
Fig. 5 is a perspective view showing a second preferred embodiment of the present invention;
Fig. 6 is an exploded view showing a part of the second preferred embodiment of the present invention;
Fig. 7 is a cross-sectional view showing the interior of the second preferred embodiment of the present invention;
Fig. 8 is an enlarged view showing the "I" part of Fig. 7;
Fig. 9 is an enlarged view showing the "II" part of Fig. 7;
Fig. 10 is a schematic view showing the piston body in combination with the cylinder body of the second preferred embodiment;
Fig. 11 is a perspective view showing the cylinder body of the second preferred embodiment;
Fig. 12 is a perspective view showing a third preferred embodiment;
Fig. 13 is an exploded view showing a part of the third preferred embodiment;
Fig. 14 is a cross-sectional view showing the interior of the third preferred embodiment;
Fig. 15 is an enlarged view showing the "III" part of Fig. 14; and
Fig. 16 is an enlarged view showing the "IV" part of Fig. 14.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The 1st preferred embodiment

[0014] Referring to Fig. 1 and Fig. 2, a permanent magnet linear piston pump 3 of the present invention com-

prises a piston body 1, a cylinder body 2, a permanent magnet assembly 6 and an electromagnetic coil 3. The cylinder body is in a shape of a polygonal prism, such as in a prism with four to six sides. Preferably, a quadrangular prism is adopted. As shown in Fig. 4, this preferred embodiment has a quadrangular cylinder body 2 whose cross-section is shaped by a rectangular contour. An interior of the cylinder 2 arranges a piston cavity 201 formed by an axial columnar accommodating cavity. The piston body 1 is arranged in the piston cavity 201 by a liquid sealing movable fit mode. A cross-section of one end of the piston body 1 can be the same as the cross-section of the piston cavity 201. This end is inserted into the piston cavity 201 by the liquid sealing movable fit mode. In this preferred embodiment, as shown in Fig. 2 and Fig. 3, the piston body 1 is a prism whose cross-section is the same as the cross-section of the piston cavity 201. The end of the piston body 1 is inserted into the piston cavity 201 by the liquid sealing movable fit mode; preferably, the other end thereof can arrange a supporting structure having an orientation effect. A one-way inlet valve 4 and a one-way outlet valve 5 are disposed on an end face of the piston cavity 201 opposite to an end face of a piston. A set of permanent magnet assembly 6 is disposed on at least one side surface of the cylinder body 2. The permanent magnet assembly 6 includes an inner mounting plate 601 and an outer mounting plate 602 disposed parallel to the side surface of the cylinder body 2. An inner magnetic body 603 and an outer magnetic body 604 are respectively disposed on opposite surfaces of the inner mounting plate 601 and the outer mounting plate 602, whereby the permanent magnet linear piston pump has a greater power. One set of the permanent magnet assembly 6 is disposed on every side surface of the cylinder body 2. A coil supporting member is disposed at an outside surface of the cylinder body 2. The arrangement of the coil supporting member is to space the electromagnetic coil 3 and the outside surface of the cylinder body apart by a distance in order that the inner mounting plate 601 and the inner magnetic body 603 can be placed in this space. The electromagnetic coil 3 is axially and distributively wound around the coil supporting member into a barrel shape. Herein, the cylinder body 2 can include a barrel unit and lids at two ends thereof. Sealing rings are respectively disposed between the lids at the two ends and two end faces of the barrel unit. The barrel unit and the lids at the two ends are connected with each other by a plurality of axial shanks and nuts around an outer periphery of the barrel unit. The shanks are located at every edge of the cylinder body 2. The shanks construct the coil supporting member. The cylinder body 2 and the coil supporting member of this arrangement are simple in structure and easier to manufacture and have lower costs although the mechanical intensity may be relatively lower. As shown in Fig. 4, in this preferred embodiment, ribs 202 are disposed on every edge of the cylinder body 2. The ribs 202 construct the coil supporting member. The ribs 202 can be extended throughout the full edge or extended to the part of the two ends where the electromagnetic coil 3 is wound. The ribs 202 are disposed to allow the surface of the cylinder body 2 to have a sufficient space where the inner mounting plate 601 and the inner magnetic body 603 are placed. The inner mounting plate 601 and the inner magnetic body 603 are disposed in a recess between the ribs 202 at two sides of a same side surface of the cylinder body 2. The inner magnetic body 603 and the outer magnetic body 604 are disposed oppositely and provide contrary magnetic poles at opposite faces thereof. An interstice is formed between the inner magnetic body 603 and the outer magnetic body 604. The interstice can be lessened possibly to satisfy the coiling of the electromagnetic coil 3. The electromagnetic coil 3 is axially and distributively wound around the ribs 202 of every edge into a barrel type. Alternatively, it can be wound around the ribs 202 on which a pad or a bracket is disposed in advance. The electromagnetic coil 3 is disposed between the inner magnetic body 603 and the outer magnetic body 604. The side surface of the cylinder body 2 where the permanent magnet assembly 6 is disposed forms an axial sliding slot 203. A length of the sliding slot 203 is equal to a designed stroke length of the piston body 1. A connecting post 101 is disposed on a side surface of the piston body 1 in a radial direction to fit in with the sliding slot 203 by a clearance fit mode. The connecting post 101 penetrates through the sliding slot 203 to be connected to the inner mounting plate 601 and the outer mounting plate 602, thereby forming a linkage. In this preferred embodiment, through holes are respectively formed on the inner mounting plate 601 and the outer mounting plate 602 to fit in with the connecting post 101 by a clearance fit mode. The connecting post 101 penetrates through the sliding slot 203 and the through holes of the inner mounting plate 601 and the outer mounting plate 602 to be in connection with and in linkage with the inner mounting plate 601 and the outer mounting plate 602.

The 2nd preferred embodiment

[0015] To attain the higher efficiency of the permanent magnet linear piston pump, the piston body 1 is in the operating state during the reciprocating motion. In the present invention, two permanent magnet linear piston pumps are formed in the same cylinder body 2. Referring to Figs. 5-7, two parts of the columnar accommodating cavity in the cylinder body 2 are disposed symmetrically. The piston body 1 is a prism whose cross-section is the same as the cross-section of the piston cavity 201. The piston body 1 is disposed at a middle portion of the columnar accommodating cavity. Two ends of the piston body 1 are in cooperation with the two parts of the columnar accommodating cavity by the liquid sealing movable fit mode respectively, whereby the two parts of the columnar accommodating cavity are respectively defined as a first piston cavity 2011 and a second piston cavity

2012, and the two ends of the piston body 1 are respectively defined as a first piston body 1a and a second piston body 1b. A first one-way inlet valve 4a and a first one-way outlet valve 5a are disposed on an end face of the first piston cavity 2011 opposite to an end face of the first piston body 1a. A second one-way inlet valve 4b and a second one-way outlet valve 5b are disposed on an end face of the second piston cavity 2012 opposite to an end face of the second piston body 1b. Likewise, the permanent magnet assembly 6, as shown in Figs. 7-9, includes an inner mounting plate 601 and an outer mounting plate 602 disposed parallel to the side surface of the cylinder body 2. A first inner magnetic body 603a and a second inner magnetic body 603b are respectively and symmetrically disposed at two opposite end faces of the inner mounting plate 601. A first outer magnetic body 604a and a second outer magnetic body 604b are respectively and symmetrically disposed at two ends of the outer mounting plate 602. A first electromagnetic coil 3a and a second electromagnetic coil 3b are respectively and correspondingly disposed on ribs 202 at two sides of the cylinder body 2. Likewise, the inner mounting plate 601 and the inner magnetic body 603 are disposed in a recess between the ribs 202 at two sides of the same side surface of the cylinder body 2. The first inner magnetic body 603a and the first outer magnetic body 604a at the two ends are disposed oppositely and provide contrary magnetic poles at opposite faces thereof. The second inner magnetic body 603b and the second outer magnetic body 604b at the two ends are disposed oppositely and provide contrary magnetic poles at opposite faces thereof. Interstices are respectively formed between the first inner magnetic body 603a and the first outer magnetic body 604a and between the second inner magnetic body 603b and the second outer magnetic body 604b. The interstice can be lessened possibly to satisfy the coiling of the electromagnetic coil 3. The electromagnetic coil 3 is axially and distributively wound around the ribs 202 of every edge of the two ends of the cylinder body 2 into a barrel type. Alternatively, it can be wound around the ribs 202 on which a pad or a bracket is disposed in advance. The electromagnetic coils 3 are respectively disposed between the first inner magnetic body 603a and the first outer magnetic body 604a and between the second inner magnetic body 603b and the second outer magnetic body 604b. The side surface of the cylinder body 2 where the permanent magnet assembly 6 is disposed forms an axial sliding slot 203. In this preferred embodiment, four permanent magnet assemblies 6 are respectively set on four side surfaces of the cylinder body 2, with four sliding slots 203 formed on the four side surfaces of the cylinder body 2 respectively. A length of the sliding slot 203 is equal to a designed stroke length of the piston body 1. Four connecting posts 101 are respectively disposed on four sides of the piston body 1 in a radial direction to fit in with the sliding slots 203 by a clearance fit mode. The connecting posts 101 penetrate through the sliding slots 203 to be connected to the inner mounting plate 601 and the outer mounting plate 602, thereby forming a linkage. Referring to Figs. 5-6, this preferred embodiment forms through holes which are respectively formed on the inner mounting plate 601 and the outer mounting plate 602 to fit in with the connecting post 101 by a clearance fit mode. The connecting posts 101 penetrate through the sliding slots 203 and the through holes of the inner mounting plate 601 and the outer mounting plate 602 to be in connection with and in linkage with the inner mounting plate 601 and the outer mounting plate 602.

The 3rd preferred embodiment

[0016] To retrieve the intensity of magnetism of the inner magnetic body 603 and the outer magnetic body 604 by magnetizing and to prolong the duration of the permanent magnet linear piston pump, the permanent magnet linear piston pump of the present invention can be magnetized. Referring to Figs. 12-16, the remaining structure of the magnetizing permanent magnet linear piston pump is the same as the first and the second preferred embodiments. Differently, the inner mounting plate 601 and the outer mounting plate 602 are made of a permeability magnetic material. A magnetizing coil 7 is sleeved on the inner mounting plate 601 or the outer mounting plate 602. To enhance the intensity of the recharging magnetic field, the magnetizing coil 7 of this embodiment is sleeved on the inner mounting plate 601 and the outer mounting plate 602. The magnetizing coil 7 can be wound around a coil frame 8 of a "□" shape at first. Then, the inner mounting plate 601 or the outer mounting plate 602 can penetrate through the center of the coil frame 8. The coil frame 8 is fixed onto the cylinder body 2. A magnetic field line created by the magnetizing coil 7 is formed in a closed annular shape along the inner mounting plate 601, the inner magnetic body 603, the outer magnetic body 604 and the outer mounting plate 602.

[0017] From the above preferred embodiments, the one-way inlet valve 4 and the one-way outlet valve 5 can be designed by using a diaphragm structure or by disposing a steel ball and a compression spring in the valve cavity. These arrangements can all satisfy the requirements.

Claims

1. A permanent magnet linear piston pump comprising a piston body (1), a cylinder body (2), a permanent magnet assembly (6) and an electromagnetic coil (3);
characterized in that said cylinder body (2) is in a shape of a polygonal prism, in which a piston cavity (201) is formed by an axial columnar accommodating cavity, said piston body (1) being disposed in said piston cavity (201) by a liquid sealing movable fit mode, a one-way inlet valve (4) and a one-way outlet

valve (5) being disposed on an end face of said piston cavity (201) opposite to an end face of a piston, a set of permanent magnet assembly (6) being disposed on at least one side surface of said cylinder body (2), said permanent magnet assembly (6) including an inner mounting plate (601) and an outer mounting plate (602) disposed parallel to said side surface of said cylinder body (2), said inner mounting plate (601) and said outer mounting plate (602) being made of a permeability magnetic material, an inner magnetic body (603) and an outer magnetic body (604) being respectively disposed on opposite surfaces of said inner mounting plate (601) and said outer mounting plate (602), said inner magnetic body (603) and said outer magnetic body (604) being disposed oppositely and providing contrary magnetic poles at opposite faces thereof, a coil supporting member being disposed at an outside surface of said cylinder body (2), said electromagnetic coil (3) being axially and distributively wound around said coil supporting member into a barrel shape, a barrel wall formed by said electromagnetic coil (3) being disposed between said inner magnetic body (603) and said outer magnetic body (604), an axial sliding slot (203) being formed on said side surface of said cylinder body (2) where said permanent magnet assembly (6) is disposed, a connecting post (101) being radially disposed on a side surface of said piston body (1) to fit in with said sliding slot (203) by a clearance fit mode, said connecting post (101) penetrating through said sliding slot (203) to be in connection with and in linkage with said inner mounting plate (601) and said outer mounting plate (602).

2. The permanent magnet linear piston pump according to claim 1, wherein two parts of said columnar accommodating cavity in said cylinder body (2) are disposed symmetrically, said piston body (1) being disposed at a middle portion of said columnar accommodating cavity, two ends of said piston body (1) being in cooperation with said two parts of said columnar accommodating cavity by said liquid sealing movable fit mode respectively, whereby said two parts of said columnar accommodating cavity are respectively defined as a first piston cavity (2011) and a second piston cavity (2012) and said two ends of said piston body are respectively defined as a first piston body (1a) and a second piston body (1b), a first one-way inlet valve (4a) and a first one-way outlet valve (5a) being disposed on an end face of said first piston cavity (2011) opposite to an end face of said first piston body (1a), a second one-way inlet valve (4b) and a second one-way outlet valve (5b) being disposed on an end face of said second piston cavity (2012) opposite to an end face of said second piston body (1b), a first inner magnetic body (603a) and a second inner magnetic body (603b) being respectively and symmetrically disposed at two ends of said inner mounting plate (601), a first outer magnetic body (604a) and a second outer magnetic body (604b) being respectively and symmetrically disposed at two ends of said outer mounting plate (602), a first electromagnetic coil (3a) and a second electromagnetic coil (3b) being respectively and correspondingly disposed on ribs (202) at two sides of said cylinder body (2).

3. The permanent magnet linear piston pump according to claim 1, wherein one set of permanent magnet assembly (6) is arranged at each side surface of said cylinder body (2).

4. The permanent magnet linear piston pump according to claim 1, wherein ribs (202) are disposed on edges of said cylinder body (2), said ribs (202) constructing said coil supporting member, said inner mounting plate (601) and said inner magnetic body (603) being disposed in a recess between said ribs (202) at two sides of a same side surface of said cylinder body (2).

5. The permanent magnet linear piston pump according to claim 1, wherein said cylinder body (2) includes a barrel unit and lids at two ends thereof, sealing rings being respectively disposed between said lids at said two ends and two end faces of said barrel unit, said barrel unit and said lids at said two ends being connected with each other by a plurality of axial shanks and nuts around an outer periphery of said barrel unit, said shanks constructing said coil supporting member.

6. The permanent magnet linear piston pump according to claim 1, wherein said cylinder body (2) is a prism having four to six sides.

7. The permanent magnet linear piston pump according to claim 1, wherein said cylinder body (2) is a quadrangular prism, a cross-section of which is in a rectangular shape.

8. The permanent magnet linear piston pump according to claim 1, wherein said inner mounting plate (601) and said outer mounting plate (602) are made of a permeability magnetic material, a magnetizing coil (7) being sleeved on said inner mounting plate (601) or/and said outer mounting plate (602), a magnetic field line created by said magnetizing coil (7) being formed in a closed annular shape along said inner mounting plate (601), said inner magnetic body (603), said outer magnetic body (604) and said outer mounting plate (602).

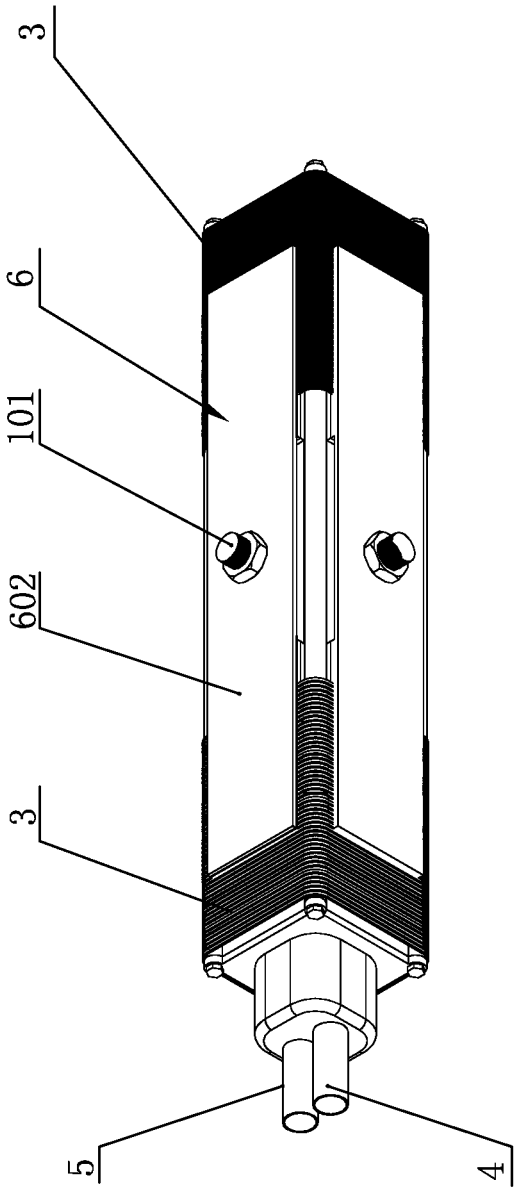

FIG. 1

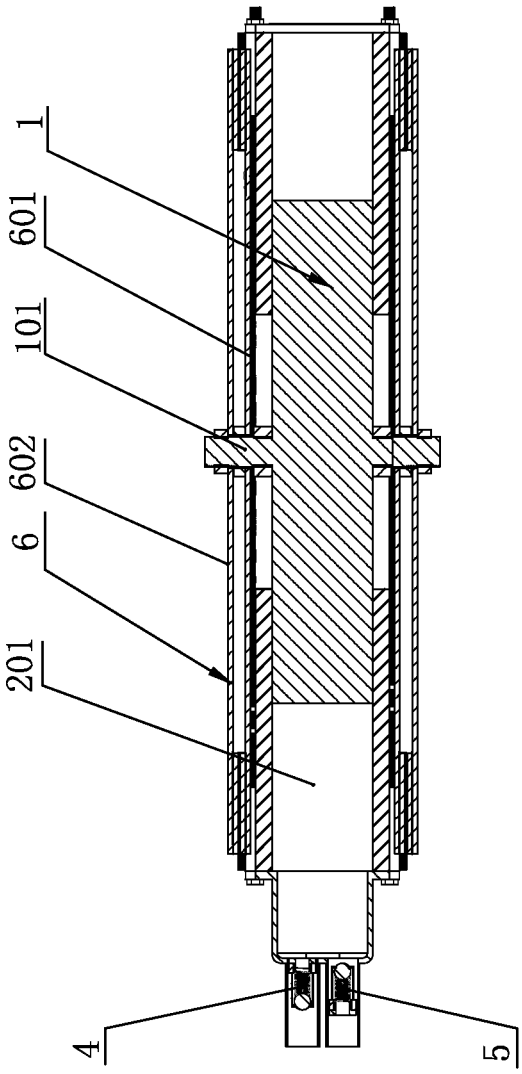

FIG. 2

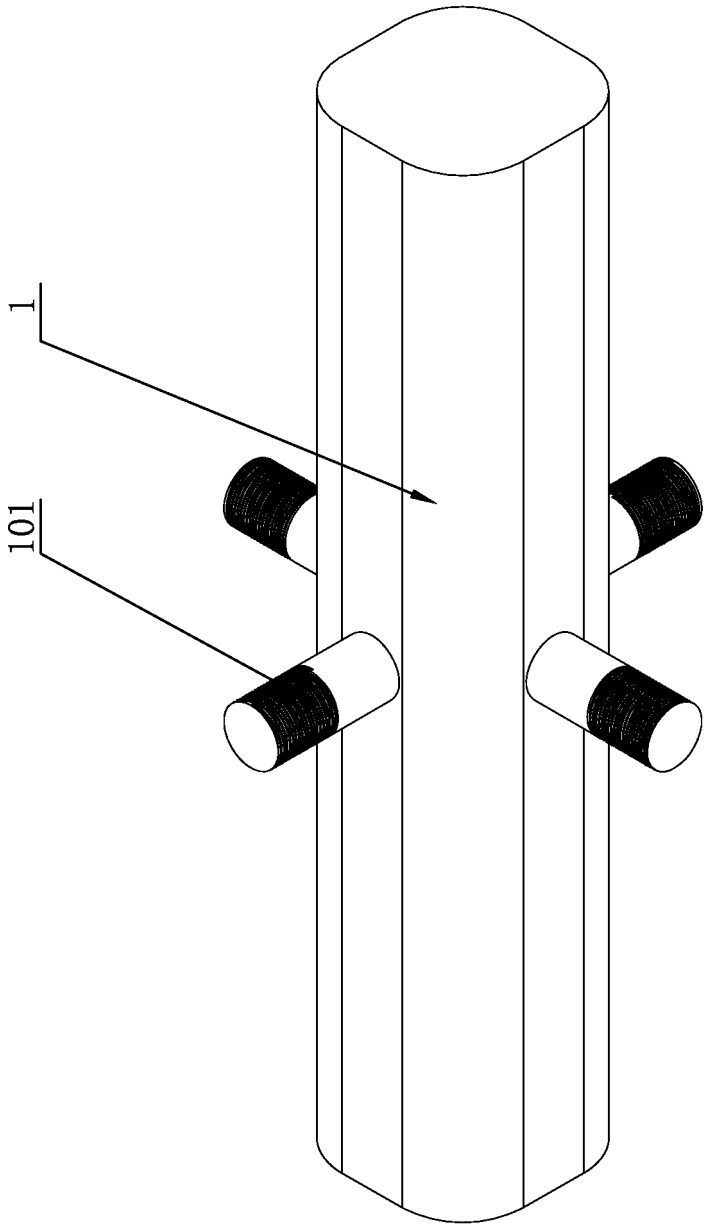

FIG. 3

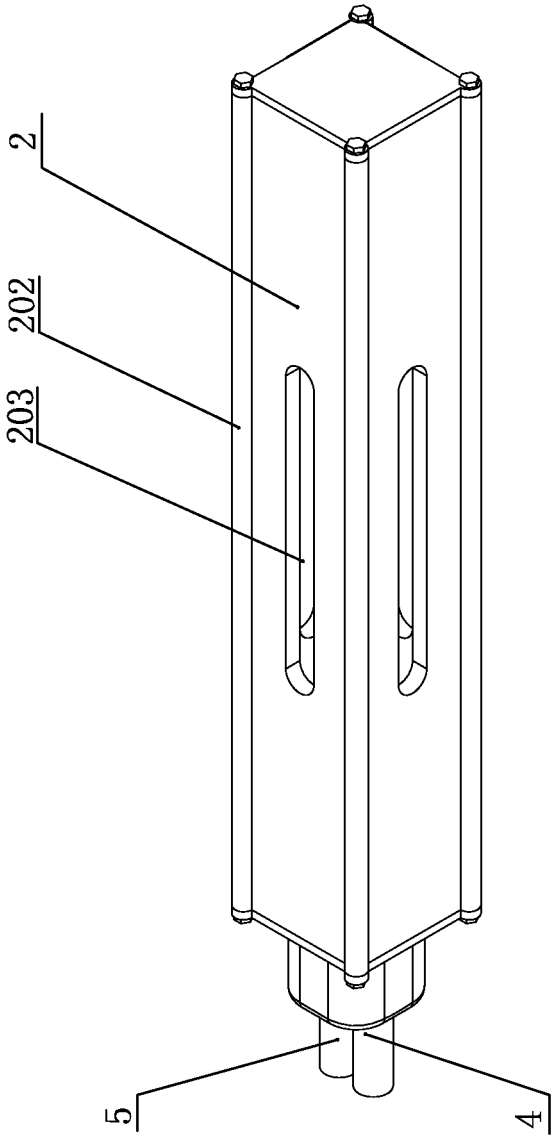

FIG. 4

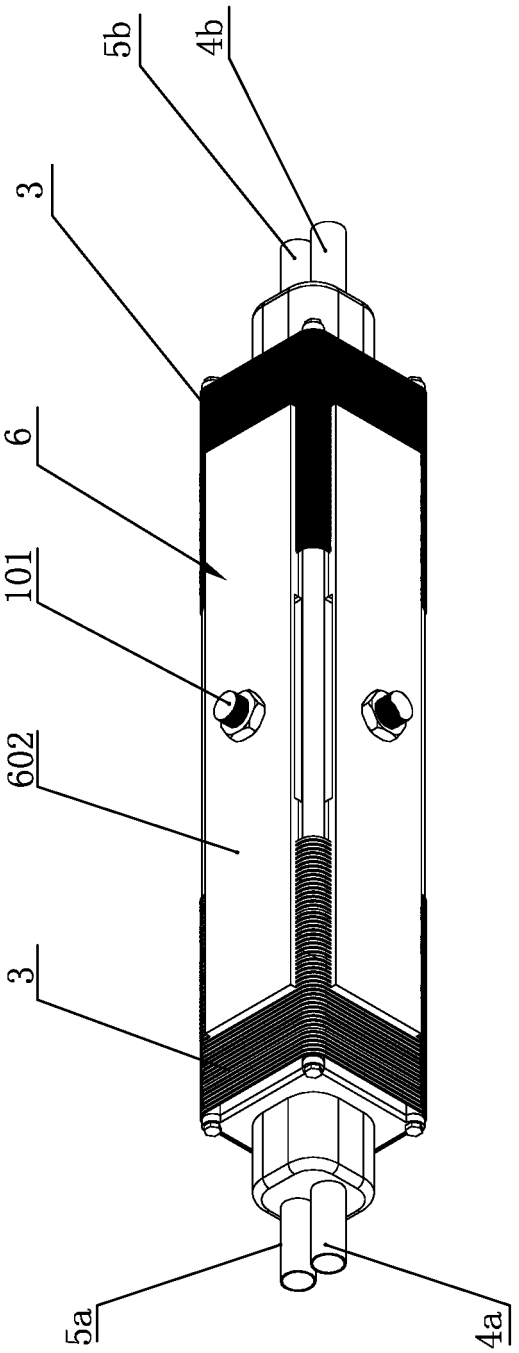

FIG. 5

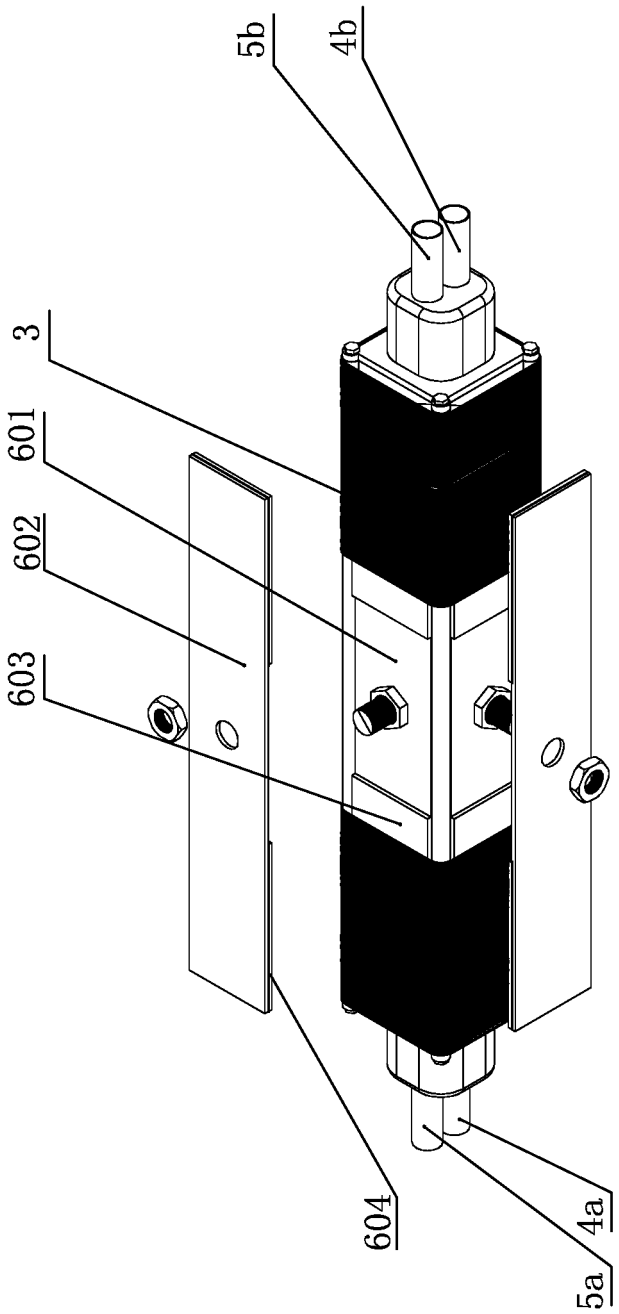

FIG. 6

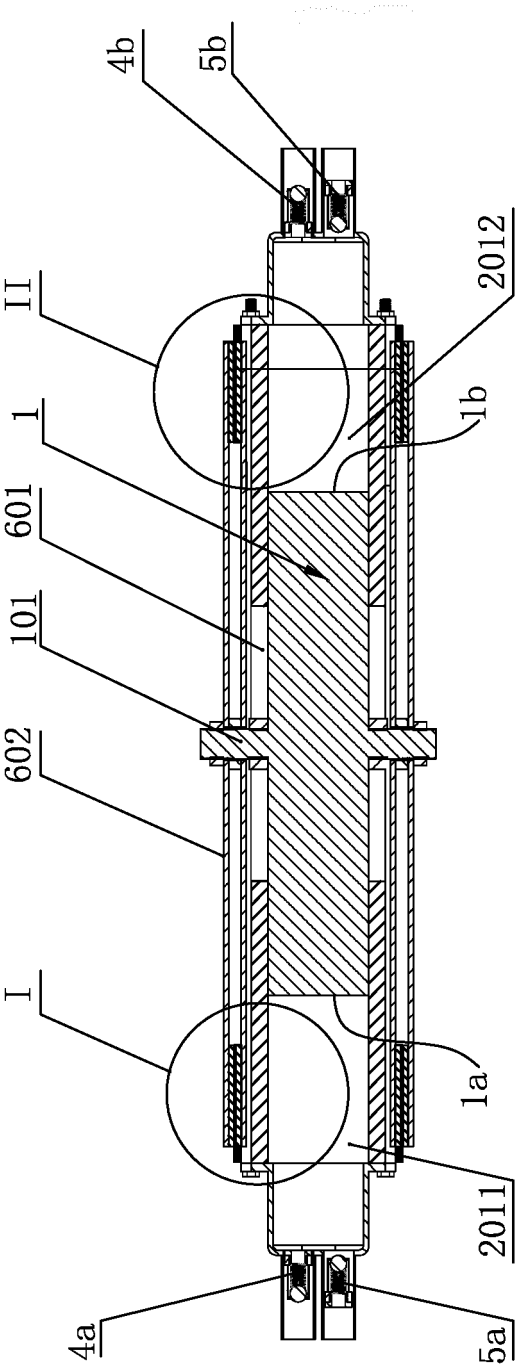

FIG. 7

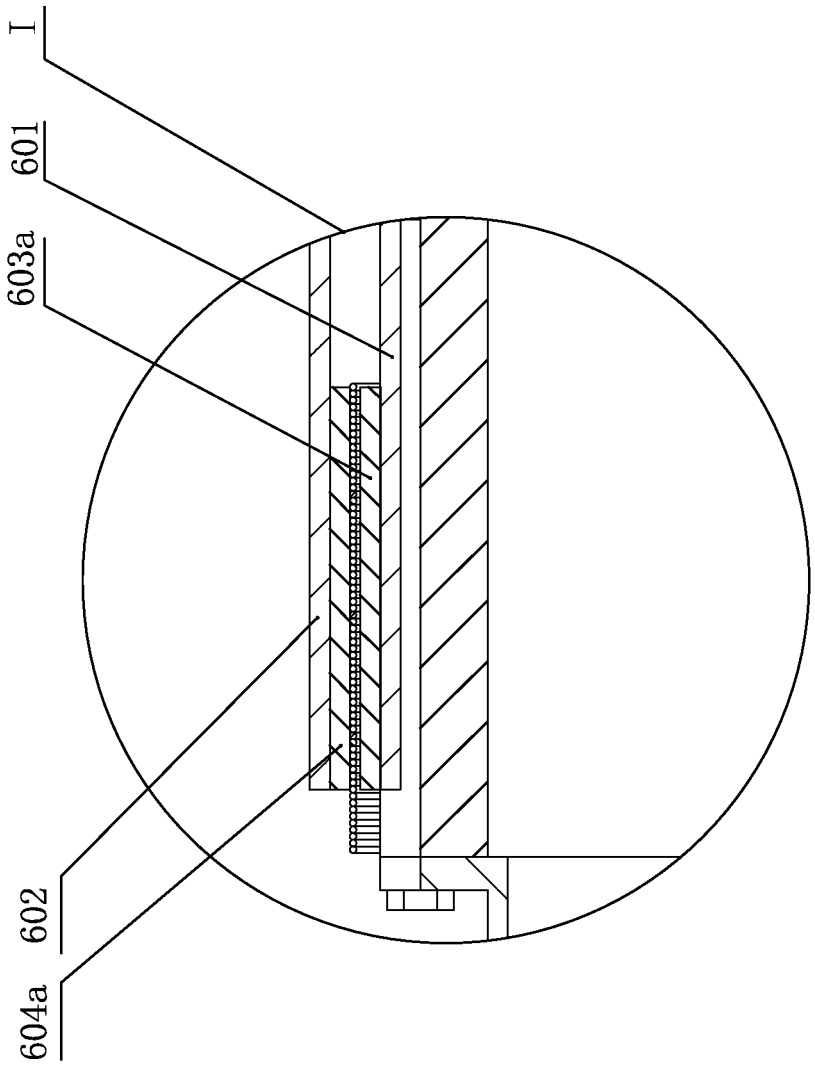

FIG. 8

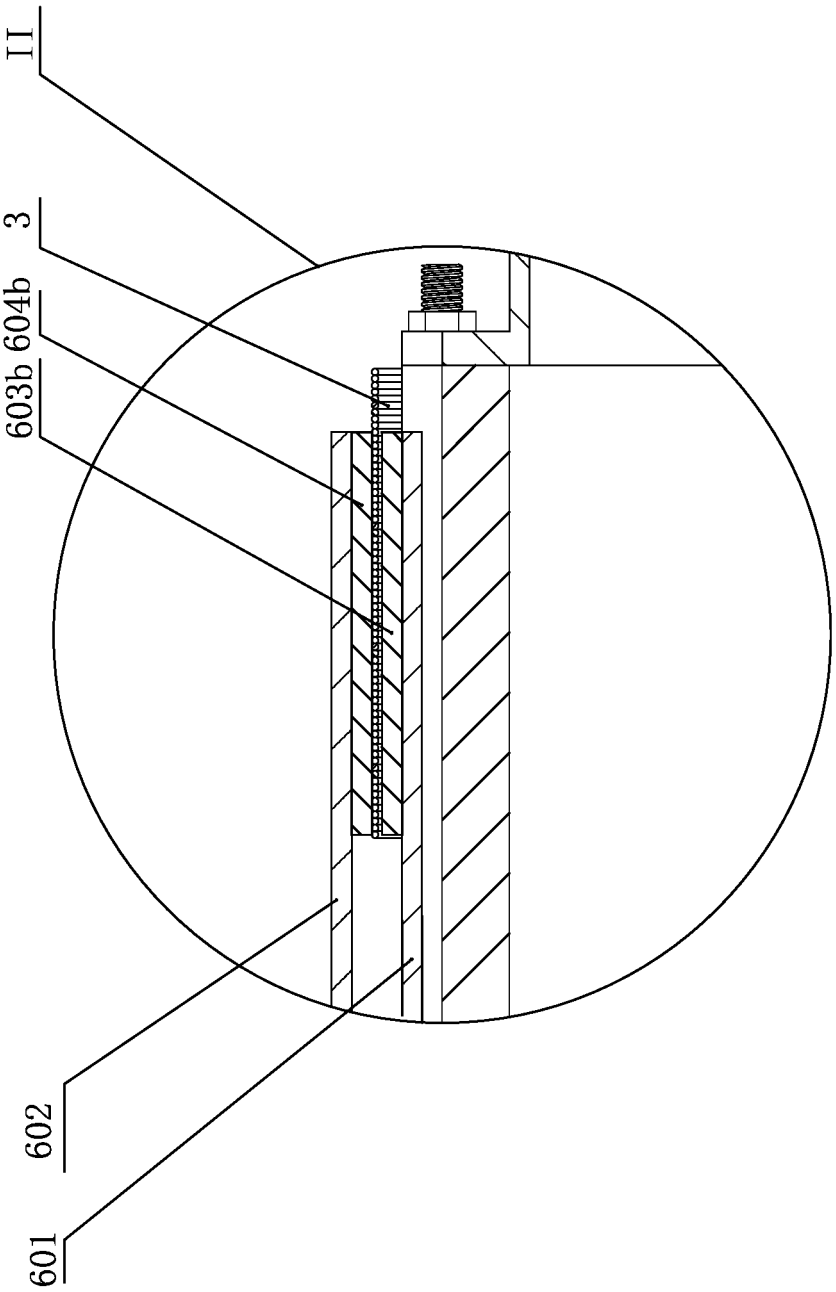

FIG. 9

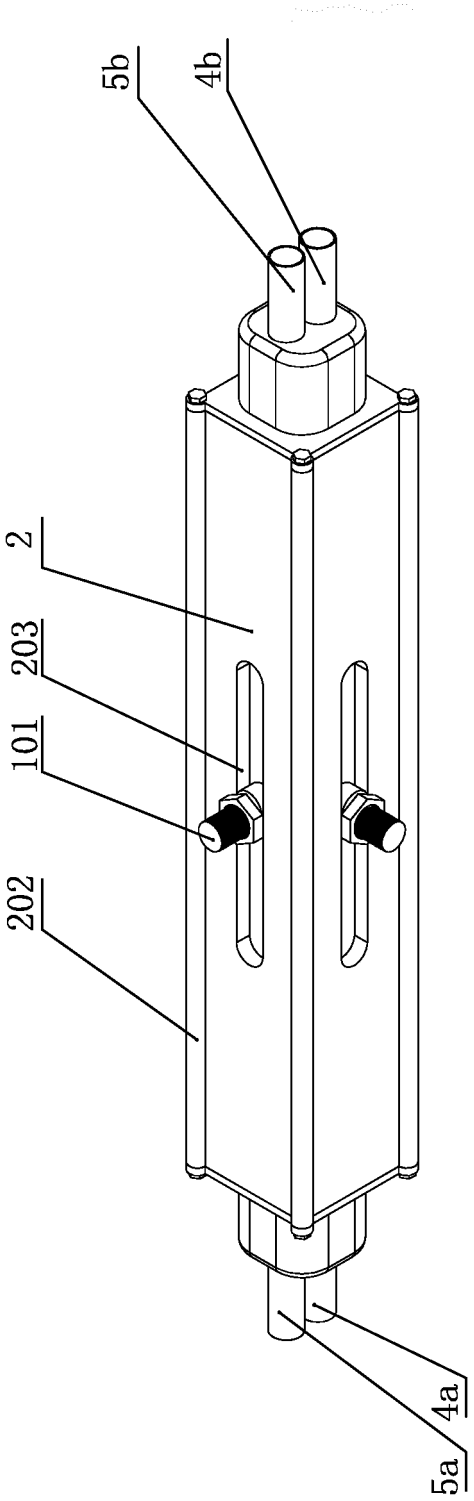

FIG. 10

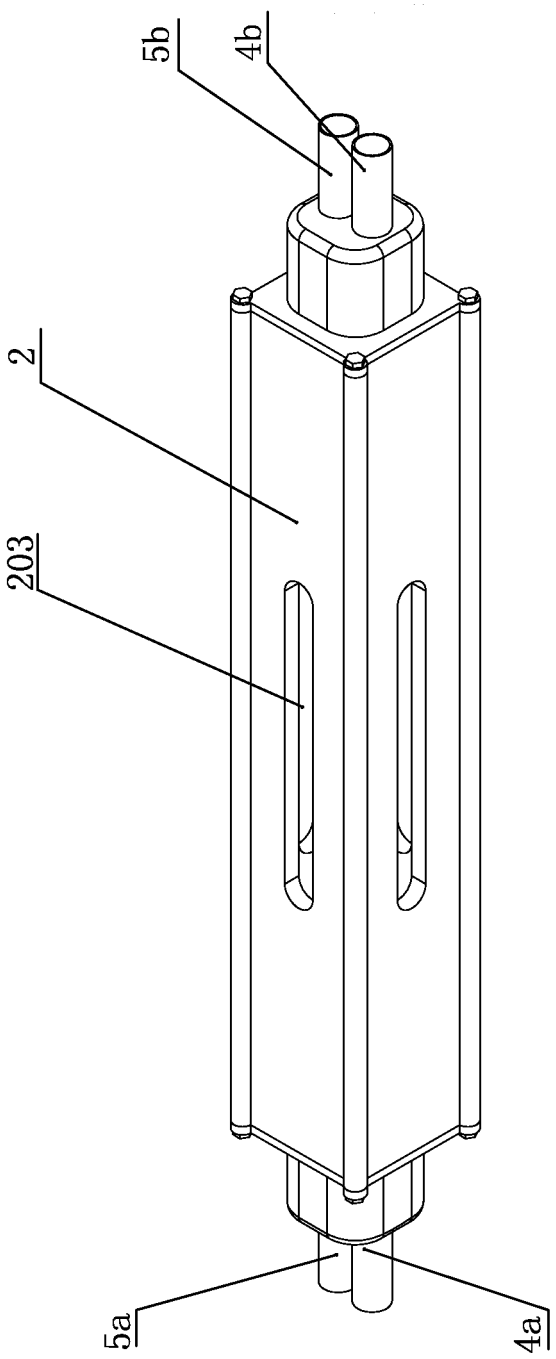

FIG. 11

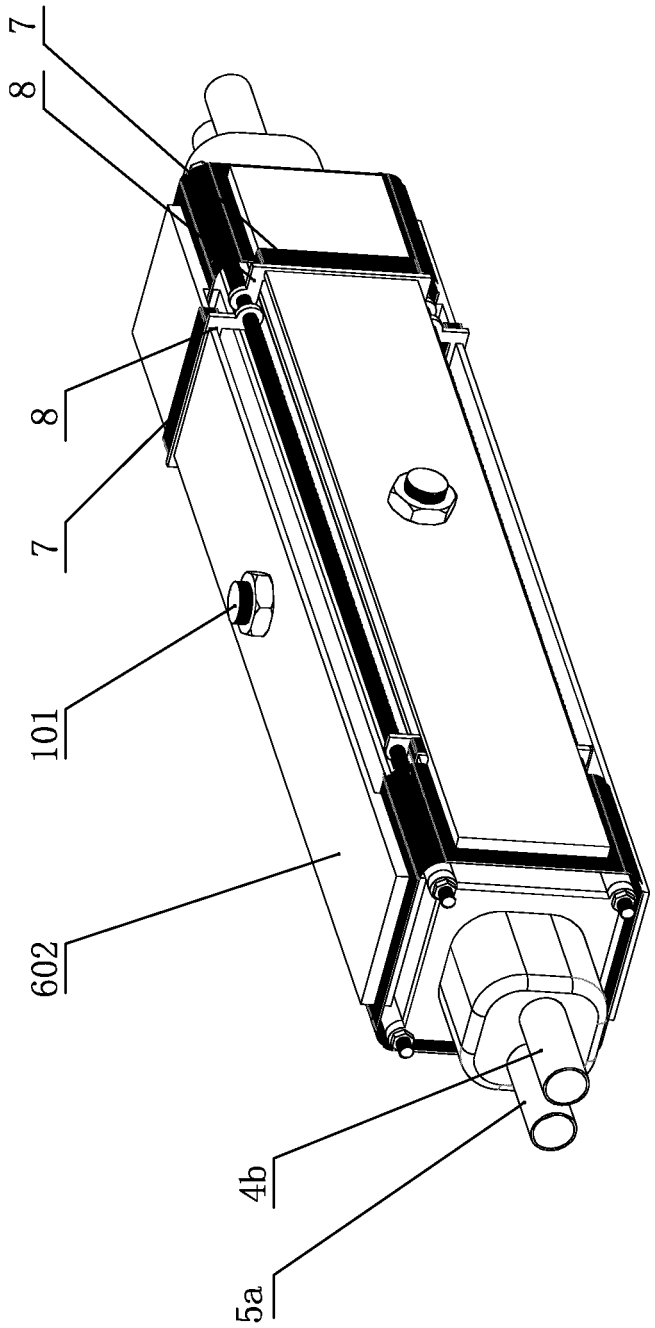

FIG. 12

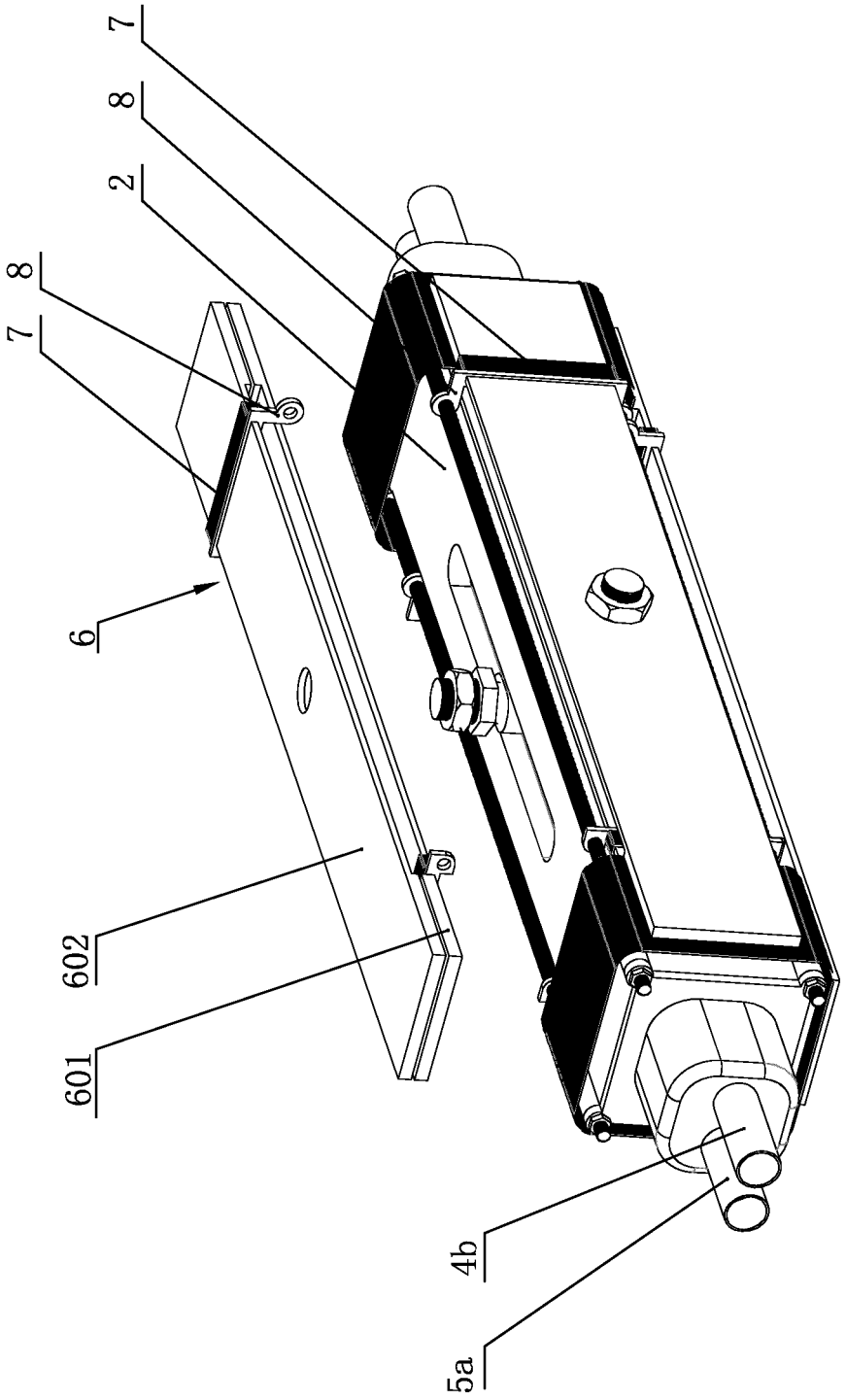

FIG. 13

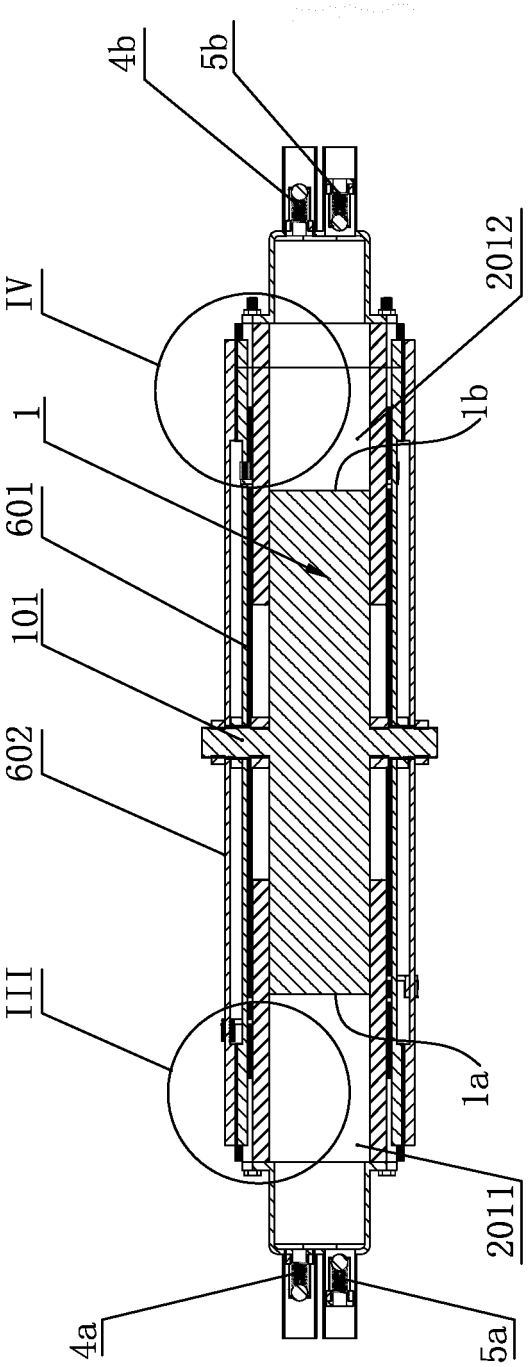

FIG. 14

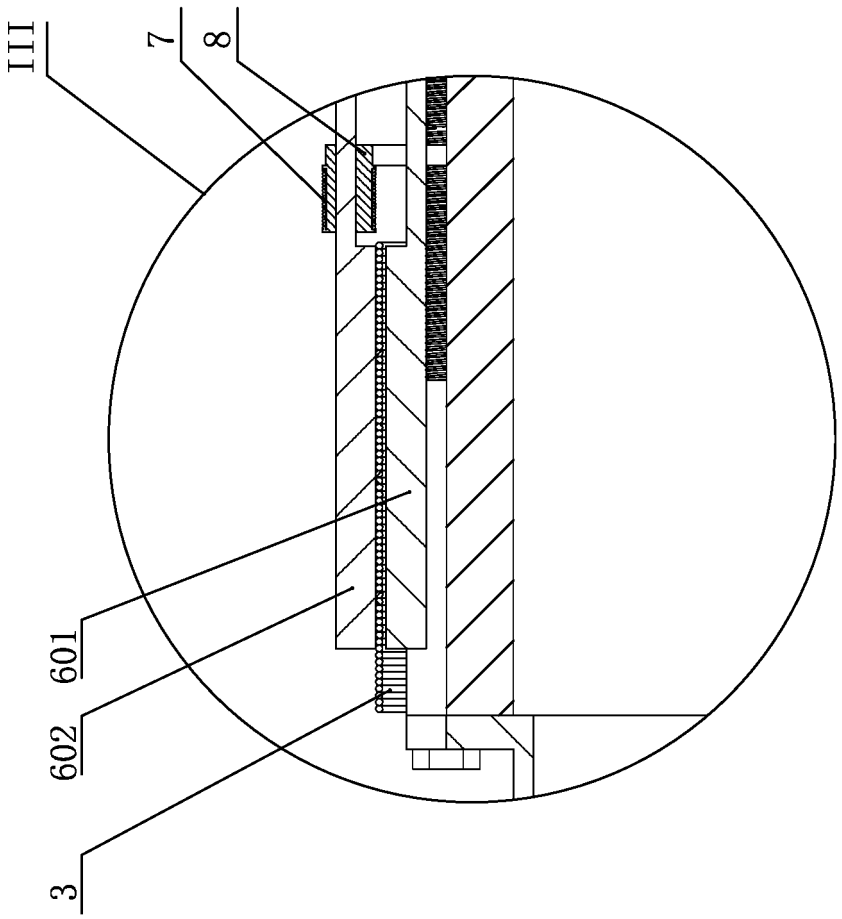

FIG. 15

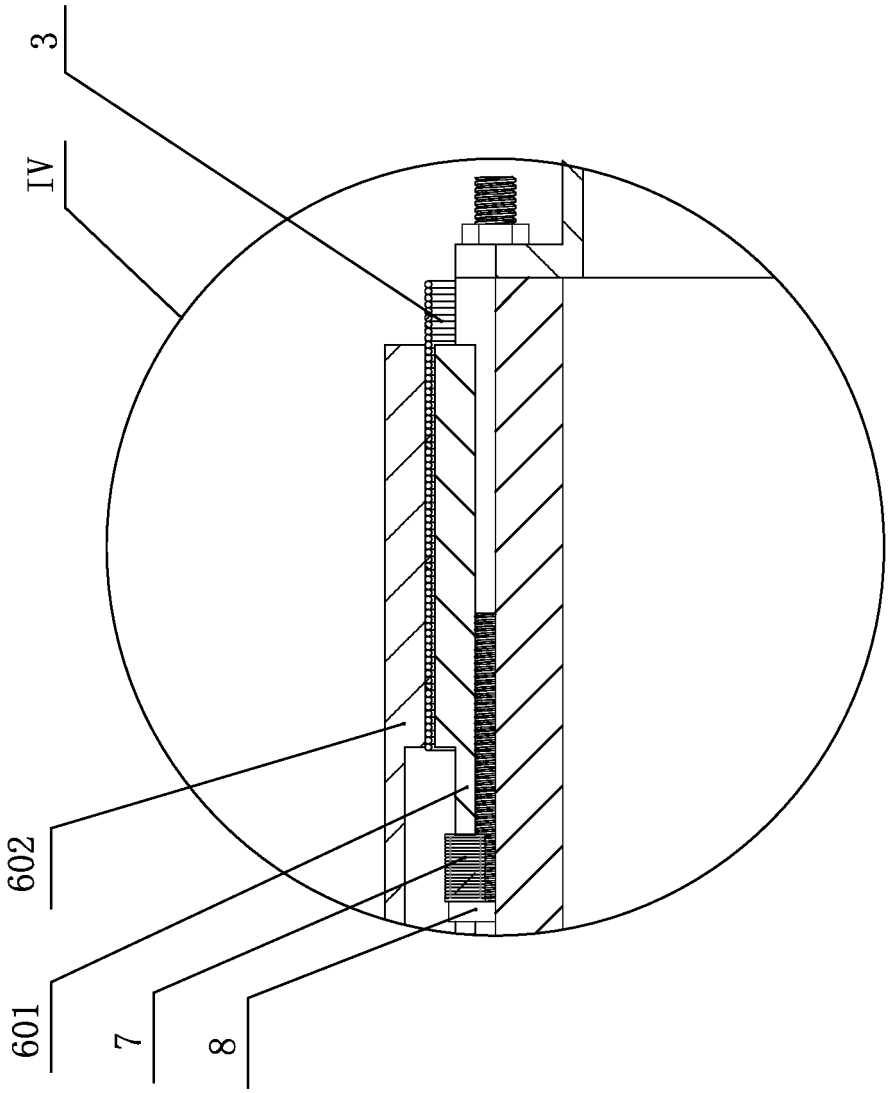

FIG. 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/082961

A. CLASSIFICATION OF SUBJECT MATTER

F04B 17/04 (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: F04B

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)

EPODOC, WPI, CNPAT: straight-line, vibration, oscillation, magnetic force, pump, magnetism, plunger, permanent magnet, magnetic, liner, piston, magnet, cylinder, inner, outer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	CN 102748277 A (XU, Ronglan), 24 October 2012 (24.10.2012), see claims 1-8	1-8
Y	KR 20100062665 A (LG ELECTRONICS INC.), 10 June 2010 (10.06.2010), see figures 4-5	1-8
Y	CN 1554868 A (YU, Guomiao), 15 December 2004 (15.12.2004), see description, page 3, lines 10-25, and figures 1-2	1-8
A	CN 2048903 U (KONG, Zhaochen), 06 December 1989 (06.12.1989), see the whole document	1-8
A	CN 101240793 B (LIU, Xinchun), 27 April 2011 (27.04.2011), see the whole document	1-8
A	DE 2903817 A1 (KOFINK SIEGFRIED DR ING), 07 August 1980 (07.08.1980), see the whole document	1-8

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 April 2013 (22.04.2013)	**09 May 2013 (09.05.2013)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **WANG, Qinghua** Telephone No.: (86-10) **62085252**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/082961

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102748277 A	24.10.2012	None	
KR 20100062665 A	10.06.2010	None	
CN 1554868 A	15.12.2004	None	
CN 2048903 U	06.12.1989	None	
CN 101240793 B	27.04.2011	CN 101240793 A	13.08.2008
DE 2903817 A1	07.08.1980	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 1554868 **[0002]**