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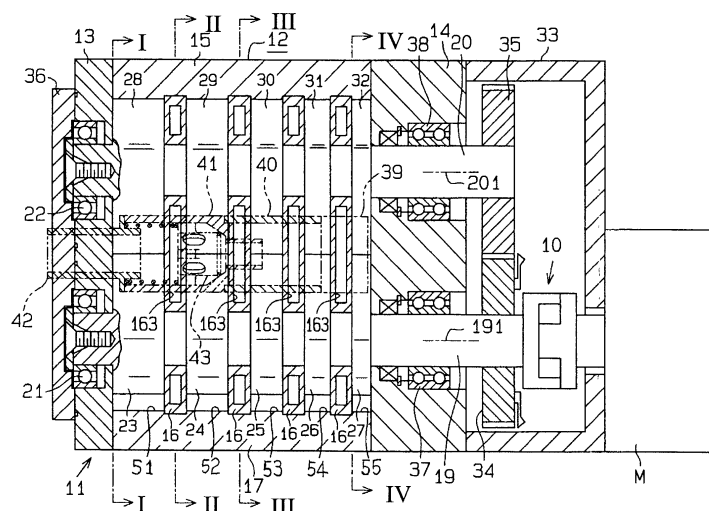
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(54) **Vacuum pump**

(57) Passage structure for a vacuum pump has a rotary shaft, a gas transferring assembly and a backflow preventing means. The gas transferring assembly is driven based on rotation of the rotary shaft. Vacuum action is generated by transferring gas due to motion of the gas transferring assembly. The backflow preventing means is constituted of a guide pipe, a valve hole forming portion, a valve body and a return spring, and is interposed in a gas passage. The guide pipe accommodates the valve body and the return spring, and forms a tapered valve hole. The valve body is constituted of a

shutter closing the valve hole, a cylindrical circumferential wall, a plurality of slide contact portions disposed on an outer circumferential surface of the circumferential wall so as to be distributed around the inner circumferential surface of the guide pipe, and a seal ring fitted to a periphery of the shutter. The valve body opens and closes the valve hole. The return spring urges the valve body in a direction to close the valve hole. A plurality of the slide contact portions keeps in slide contact with one of the guide pipe and the valve body, and is interposed between an inner circumferential surface of the guide pipe and the valve body.

Fig. 1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to passage structure for a vacuum pump that drives a gas transferring assembly based on rotation of a rotary shaft, generates vacuum action by transferring gas due to motion of the gas transferring assembly, and a backflow preventing means is interposed in a gas passage.

[0002] Japanese Unexamined Patent Publication No. 2-157490 and No. 8-14172 disclose a roots pump, a kind of vacuum pump, having a pair of coadjacent rotors. The rotors are engaged with each other and relatively rotate. Rotation motion of a pair of the rotors rotating in mesh with each other transfers gas as compresses the gas. A first rotary shaft is driven by a motor, and a second rotary shaft is driven by the first rotary shaft through gear mechanism. The gas discharged from a main body of the pump is led to an exhaust gas control device via a gas passage outside the main body of the pump. Japanese Unexamined Patent Publication No. 2-157490 discloses a device that has a muffler interposed in the gas passage outside the main body of the pump. In the vacuum pump, pulsation arises in the gas passage outside the main body of the pump, which causes to produce noise. A muffler is provided for restraining such noise, and a check valve is employed as the muffler. A valve body constituting the check valve opens and closes a valve hole. The valve body closes the valve hole when the amount of the gas exhausted from the pump is zero. The check valve restrains the above-mentioned pulsation.

[0003] Some kind of exhaust [e.g. Perfluorocarbon (PFC), etc.] is solidified when temperature becomes lower or pressure becomes higher. If such solidified exhaust is caught into a gap between the valve body and its guide portion and remains in the gap, the valve body cannot smoothly open and close the valve hole. Accordingly, the check valve may not function as a device that prevents the pulsation.

SUMMARY OF THE INVENTION

[0004] The present invention contemplates to alleviate the above-mentioned inconveniences. Accordingly, it is an object of the present invention to prevent an operational failure from occurring at a backflow preventing means which is interposed in a gas passage of exhaust.

To achieve this object, a vacuum pump has a rotary shaft, a gas transferring assembly and a backflow preventing means. The gas transferring assembly is driven based on rotation of the rotary shaft. Vacuum action is generated by transferring gas due to motion of the gas transferring assembly. The backflow preventing means is interposed in a gas passage. According to the present invention, the backflow preventing means is constituted of a guide pipe, a valve body, a valve hole

forming portion and an urging means. The guide pipe forms as a part of the gas passage. The valve body is slidably guided in an axial direction of the guide pipe therein. The valve hole forming portion forms a valve hole which is opened and closed by the valve body. The urging means urges the valve body in a direction to close the valve hole. A slide contact means provided with a plurality of slide contact portions keeps in slide contact with one of the guide pipe and the valve body. The slide contact means is interposed between an inner circumferential surface of the guide pipe and the valve body. A plurality of the slide contact portions is disposed so as to be distributed around the inner circumferential surface of the guide pipe. As seen in a direction in which the valve body moves, a slide contact range where the guide pipe and a plurality of the slide contact portions slide with respect to each other and a slide contact range where the valve body and a plurality of the slide contact portions slide with respect to each other in a circumferential direction of the guide pipe are a part of entire circumference of the guide pipe. Such constitution prevents the solidified exhaust from being caught into gaps between the slide contact portions and the valve body and between the slide contact portions and the guide pipe, and avoids the solidified exhaust from remaining in the gaps.

The present invention further includes a valve guide portion which slide guides the valve body along the inner circumferential surface of the guide pipe. A plurality of the slide contact portions is disposed on one of the outer circumferential surface of the valve body and the inner circumferential surface of the valve guide portion, and the slide contact portions are distributed around the circumferential wall so as to keep in slide contact with the other. Also, the present invention has such a feature that the valve guide portion is provided with a basic inner circumferential surface and the valve body is provided with a basic outer circumferential surface which is similar to the basic inner circumferential surface. The slide contact portions are disposed on one of the basic inner circumferential surface and the basic outer circumferential surface so as to slide contact with the other. Accordingly, the guide pipe and the valve body keep in slide contact with each other via a plurality of the slide contact portions. As seen in a direction in which the valve body moves, a slide contact range where the guide pipe and the valve body slide with respect to each other in a circumferential direction of the guide pipe are a part of entire circumference of the guide pipe. Such constitution prevents the solidified exhaust from being caught into the gap between the valve guide portion and the valve body, and avoids the solidified exhaust from remaining in the gap.

Furthermore, the present invention has such a feature that the valve body is provided with a shutter and an annular circumferential wall. A plurality of the slide contact portions is disposed on the circumferential wall of the valve body. The valve body which slides in the

guide pipe is provided with the slide contact portions, so that the valve guide portion on the guide pipe side and the slide contact portions smoothly slide relative to each other.

Furthermore, the present invention has such a feature that each shape of the slide contact portions is long in a direction in which the valve body moves. Accordingly, the slide contact portions are long in the direction in which the valve body moves, so that the valve body smoothly moves.

[0005] The present invention also includes a communication hole formed through the circumferential wall of the valve body so as to intercommunicate an outside of the circumferential wall and an inside of the circumferential wall. Accordingly, the communication hole is efficient in reducing flow resistance to the gas at the valve body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a cross-sectional plan view illustrating a whole multi-stage roots pump according to a first embodiment of the present invention;

Fig. 2a is a cross-sectional view, taken along the line I-I in Fig. 1;

Fig. 2b is a cross-sectional view, taken along the line II-II in Fig. 1;

Fig. 3a is a cross-sectional view, taken along the line III-III in Fig. 1;

Fig. 3b is a cross-sectional view, taken along the line IV-IV in Fig. 1;

Fig. 4a is an essential cross-sectional plan view illustrating a first embodiment of the present invention;

Fig. 4b is a cross-sectional view, taken along the line V-V in Fig. 4a;

Fig. 5 is an essential perspective view illustrating the first embodiment of the present invention;

Fig. 6 is an essential perspective view illustrating a second embodiment of the present invention;

Fig. 7 is an essential perspective view illustrating a

third embodiment of the present invention;

Fig. 8 is an essential perspective view illustrating a fourth embodiment of the present invention;

Fig. 9 is an essential perspective view illustrating a fifth embodiment of the present invention;

Fig. 10 is an essential perspective view illustrating a sixth embodiment of the present invention;

Fig. 11a is an essential cross-sectional plan view illustrating a seventh embodiment of the present invention; and

Fig. 11b is a cross-sectional view, taken along the line VI-VI in Fig. 11a.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0007] A first embodiment of the present invention will now be described with reference to Figs. 1 through 5. The present invention is applied to a multi-stage roots pump in the first embodiment.

As shown in Fig. 1, a multi-stage roots pump 11 has a rotor housing 12, a front housing 13, an end plate 36, a rear housing 14, a cylinder block 15 and a plurality of partition walls 16. The front housing 13 is coupled to the front end of the rotor housing 12. The end plate 36 is coupled to the front housing 13. The rear housing 14 is coupled to the rear end of the rotor housing 12. The rotor housing 12 is constituted of the cylinder block 15 and a plurality of the partition walls 16. As shown in Fig. 2b, the cylinder block 15 is constituted of a pair of block pieces 17, 18, and the partition walls 16 are constituted of a pair of wall pieces 161, 162. As shown in Fig. 1, a space between the front housing 13 and a frontmost partition wall 16, spaces between the partition walls 16 and a space between the rear housing 14 and a rearmost partition wall 16 are defined as pump chambers 51, 52, 53, 54, 55, respectively.

A rotary shaft 19 is rotatably supported by the front housing 13 and the rear housing 14 via radial bearings 21, 37. Also, a rotary shaft 20 is rotatably supported by the front housing 13 and the rear housing 14 via radial bearings 22, 38. Both the rotary shafts 19, 20 are disposed in parallel with each other in a horizontal direction. The rotary shafts 19, 20 extend through the partition walls 16.

A plurality of rotors 23, 24, 25, 26, 27 is integrally formed with the rotary shaft 19 as gas transferring assemblies. Also, the same number of rotors 28, 29, 30, 31, 32 as the rotary shaft 19 is integrally formed with the rotary shaft 20. The rotors 23 through 32 are congruously formed as seen in a direction of axes 191, 201 of the rotary shafts 19, 20. Thickness of the rotors 23, 24, 25, 26, 27 become thinner in this order. Also, thickness

of the rotors 28, 29, 30, 31, 32 become thinner in this order. A pair of the rotors 23, 28 is accommodated in the pump chamber 51 so as to engage with each other with a small gap. Also, a pair of the rotors 24, 29 is accommodated in the pump chamber 52 so as to engage with each other. Likewise, a pair of the rotors 25, 30, a pair of the rotors 26, 31 and a pair of the rotors 27, 32 are accommodated in the pump chambers 53, 54, 55, respectively.

A gear housing 33 is coupled to the rear housing 14. The rotary shafts 19, 20 extend through the rear housing 14 and protrude their rear ends into the gear housing 33. A pair of gears 34, 35 engaged with each other is secured to the respective rear ends of the rotary shafts 19, 20. An electric motor M is installed to the gear housing 33. Driving force of the electric motor M is transmitted to the rotary shaft 19 through a coupling 10, and the rotary shaft 19 is rotated by the electric motor M in a direction of an arrow R1 in Figs. 2a, 2b, 3a, 3b. The rotary shaft 20 is driven by the electric motor through a pair of the gears 34, 35, and the rotary shaft 20 is rotated in a direction of an arrow R2 (a counter direction relative to the direction which the rotary shaft 19 rotates) as shown in Figs. 2a, 2b, 3a, 3b.

As shown in Figs. 1 and 2b, passages 163 are defined within the partition walls 16. As shown in Fig. 2b, inlets 164 and outlets 165 of the passages 163 are formed at the partition walls 16. The coadjacent pump chambers 51, 52, 53, 54, 55 are intercommunicated via the passages 163, respectively.

As shown in Fig. 2a, an intake port 171 is formed through the block piece 17 so as to communicate with the pump chamber 51. As shown in Fig. 3b, an exhaust port 181 is formed through the block piece 18 so as to communicate with the pump chamber 55. Gas introduced into the pump chamber 51 via the intake port 171 is transferred to the pump chamber 52 via the frontmost inlet 164, the frontmost passage 163 and the frontmost outlet 165 by rotation of the rotor 23, 28. Likewise, the gas is transferred in order of reducing volume, that is, in order of the pump chambers 52, 53, 54, 55. The gas transferred into the pump chamber 55 is exhausted outside via the exhaust port 181. Besides, the rotors 23 through 32 are the gas transferring assemblies in order to transfer the gas.

As shown in Fig. 3b, a flange 39 is coupled to the exhaust port 181. As shown in Fig. 4a, a muffler 40 is coupled to the flange 39, and a cylindrical guide pipe 41 is coupled to the muffler 40. Also, an exhaust pipe 42 is coupled to the guide pipe 41. The exhaust pipe 42 is coupled to an exhaust gas control device (not shown). The flange 39, the muffler 40, the guide pipe 41 and the exhaust pipe 42 constitute passage structure for transferring exhaust discharged from the multi-stage roots pump 11 to the exhaust gas control device.

A valve body 43 and a return spring 44 are accommodated in the guide pipe 41. A tapered valve hole 411 is formed in the guide pipe 41, and the valve body 43

opens and closes the valve hole 411 in accordance with a reciprocation thereof. The valve body 43 is constituted of a shutter 45 closing the valve hole 411, a cylindrical circumferential wall 46, a plurality of protrusions 47 (four in the present embodiment) disposed on an outer circumferential surface 462 of the circumferential wall 46, and a seal ring 50 secured to an outer periphery of the shutter 45. The guide pipe 41, the valve body 43 and the return spring 44 constitute a backflow preventing means. The guide pipe 41 also functions as a valve hole forming portion forming the valve hole 411 which is opened and closed by the valve body 43. The return spring 44 is an urging means for urging the valve body 43 in a direction to close the valve hole 411.

A plurality of the protrusions 47 is disposed on the outer circumferential surface 462 of the circumferential wall 46 of the valve body 43 in equiangular positions so as to be distributed around the circumferential wall. The seal ring 50 contacts with and separates from a tapered surface of the valve hole 411. When the seal ring 50 is in contact with the tapered surface of the valve hole 411, the valve hole 411 is closed by the valve body 43. Communication holes 461 are bored through the circumferential wall 46 between the coadjacent protrusions 47.

As shown in Fig. 5, each shape of the protrusions 47 is long in a direction in which the valve body 43 moves, that is, a direction of an axis L2 of the valve body 43. Protrusion ends 471 of the protrusions 47 keep in slide contact with an inner circumferential surface 412 as a valve guide portion of the guide pipe 41.

As shown in Fig. 4b, the inner circumferential surface 412 of the guide pipe 41 and the outer circumferential surface 462 of the circumferential wall 46 of the valve body 43 are cylindrical surfaces. As shown in Fig. 4a, an axis L1 of the inner circumferential surface 412 and the axis L2 of the outer circumferential surface 462 are substantially correspondent with each other. The inner circumferential surface 412 as a basic inner circumferential surface and the outer circumferential surface 462 as a basic outer circumferential surface are similar to each other, and the protrusions 47 disposed on the basic outer circumferential surface 462 of the valve body 43 keep in slide contact with the basic inner circumferential surface 412 of the guide pipe 41. The protrusions 47 integrally formed on the valve body 43 are slide contact portions which keep in slide contact with the guide pipe 41, and a plurality of the protrusions constitutes a slide contact means which is interposed between the inner circumferential surface 412 of the guide pipe 41 and the valve body 43.

[0008] The exhaust is discharged from the smallest pump chamber 55 to the flange 39 via the exhaust port 181, and finally reaches the valve hole 411 via the muffler 40. When force acting on the shutter 45 of the valve body 43 based on pressure in the muffler 40 is higher than force acting on the shutter 45 based on resultant force of pressure in the guide pipe 41 and urging force of the return spring 44, the valve body 43 opens the

valve hole 411. The exhaust passed through the valve hole 411 passes by the circumferential wall 46 of the valve body 43, then passes through the communication holes 461, and finally flows into the exhaust pipe 42.

[0009] The following advantageous effect can be obtained in the first embodiment.

(1-1) The valve body 43 is guided by the inner circumferential surface 412 of the guide pipe 41 when it opens and closes, however, the guide pipe 41 and the valve body 43 keep in slide contact with each other through a plurality of the protrusions 47 disposed on the outer circumferential surface 462 of the circumferential wall 46 of the valve body 43 so as to be distributed around the circumferential wall. The protrusions 47 sliding with respect to the inner circumferential surface 412 keep in slide contact with only a part of the inner circumferential surface 412 of the guide pipe 41 as seen in a direction in which the valve body 43 moves (the direction of the axis L2). Namely, a slide contact range where the guide pipe 41 and a plurality of the protrusions 47 keep in slide contact with each other is only a part of a circumference of the guide pipe 41. Such structure that the valve body 43 keeps in slide contact with only a part of the circumference of the guide pipe 41 avoids solidified exhaust from being caught into a gap between the inner circumferential surface 412 and the valve body 43. Accordingly, an operational failure of the backflow preventing means can be avoided without deteriorating smooth motion of the valve body 43.

(1-2) The inner circumferential surface 412 of the guide pipe 41 is the cylindrical surface, however, the inner circumferential surface 412 of the guide pipe 41 can easily be formed as the cylindrical surface. Preferable shape of the protrusion ends 471 of the protrusions 47 to keep in slide contact with the inner circumferential surface 412 accurately are substantially the same cylindrical surfaces as the inner circumferential surface 412. Structure for integrally forming the protrusions 47 on the outer circumferential surface 462 of the circumferential wall 46 of the valve body 43 has an advantage of working desired shapes of the protrusion ends 471.

(1-3) Each shape of the protrusions 47 which keep in slide contact with the inner circumferential surface 412 is long in a direction in which the valve body 43 moves. Structure that the protrusions 47 are long in the direction in which the valve body 43 moves contributes to stabilizing a posture while the valve body 43 moves. If the posture of the valve body 43 stabilizes while the valve body moves, the valve body can smoothly slide. Accordingly, the protrusions 47 are long in the direction in which the valve body 43 moves, which contributes to sliding smoothly.

(1-4) Part of the exhaust passed through the

valve hole 411 flows from the outer circumferential surface 462 of the circumferential wall 46 into an inside of the circumferential wall 46 via the communication holes 461. To increase a degree of vacuum rapidly after starting an operation of the multi-stage roots pump 11, the flow resistance to the exhaust at the valve body 43 is needed to reduce, however, the communication holes 461 are efficient in reducing the flow resistance to the exhaust at the valve body 43.

[0010] A second embodiment of the present invention will now be described with reference to Fig. 6. The same reference numerals denote the same components in Fig. 6 as compared with Figs. 1 through 5.

The communication holes 463 are open at an opposite end of the circumferential wall 46 relative to the shutter 45. In other words, a periphery of the circumferential wall 46 at the opposite end relative to the shutter 45 is separated by forming the communication holes 463. Such the communication holes 463 further reduce the flow resistance to the exhaust, and are more efficient than those of the first embodiment.

[0011] A third embodiment of the present invention will now be described with reference to Fig. 7. The same reference numerals denote the same components in Fig. 7 as compared with Figs. 1 through 5.

A plurality of protrusions 47B is provided with a pair of tip portions 472, 473 in a direction in which the valve body 43 moves. Such sharp tip shape of the protrusions 47B is efficient in avoiding the solidified exhaust from being caught into the gaps between the protrusion end 471 of the protrusions 47B and the inner circumferential surface 412.

[0012] A fourth embodiment of the present invention will now be described with reference to Fig. 8. The same reference numerals denote the same components in Fig. 8 as compared with Figs. 1 through 5.

A pair of chamfered surfaces 464, 465 is formed on the communication hole 461. Providing with a pair of the chamfered surfaces 464, 465 makes the gas flow smoothly, so that the flow resistance to the exhaust at the valve body 43 reduces.

[0013] A fifth embodiment of the present invention will now be described with reference to Fig. 9. The same reference numerals denote the same components in Fig. 9 as compared with Figs. 1 through 5.

A pair of protrusions 47C, 47D is disposed at a predetermined interval so as to wrap over each other as seen in a direction in which the valve body 43 moves, and a plurality of a pair of the protrusions 47C, 47D is disposed on the circumferential wall 46 so as to be distributed around the circumferential wall 46. Disposed at a distant interval, a pair of the protrusions 47C, 47D further contributes to stabilizing a posture while the valve body 43 moves.

[0014] A sixth embodiment of the present invention will now be described with reference to Fig. 10. The

same reference numerals denote the same components in Fig. 10 as compared with Figs. 1 through 5.

A plurality of protrusions 47E is disposed between the coadjacent communication holes 461, and a plurality of protrusions 47F is disposed at a lower reaches of the communication holes 461. A plurality of the protrusions 47E, which is disposed on the circumferential wall 46 so as to be distributed around the circumferential wall 46, and a plurality of the protrusions 47F, which is disposed on the circumferential wall 46 so as to be distributed around the circumferential wall 46, are not wrapped over each other as seen in a direction in which the valve body 43 moves. The protrusions 47F make the exhaust flow smoothly into the communication holes 461.

[0015] A seventh embodiment of the present invention will now be described with reference to Figs. 11a and 11b. The same reference numerals denote the same components in Figs. 11a and 11b as compared with Figs. 1 through 5.

A plurality of protrusions 48 (four in the present embodiment) is disposed on a basic inner circumferential surface 413 of the guide pipe 41 and is disposed in equiangular positions so as to be distributed in a direction of a circumference of the basic inner circumferential surface 413. The protrusions 48 are long in a direction in which a valve body 49 moves. Protrusion ends 481 of the protrusions 48 keep in slide contact with a basic outer circumferential surface 466 of the valve body 49. The basic outer circumferential surface 466 is similar to the basic inner circumferential surface 413.

The same advantageous effects as the paragraphs (1-1), (1-3) and (1-4) in the first embodiment can be obtained in the seventh embodiment.

[0016] The present invention is not limited to the embodiments described above, but may be modified into examples as follows.

(1) The number of the communication holes in the above-described embodiments can be varied.

(2) Another slide contact means is prepared separately relative to both the guide pipe and the valve body, and a plurality of slide contact portions of the slide contact means are interposed between the guide pipe and the valve body so as to keep in slide contact with one of the guide pipe, the valve body, and both the guide pipe and the valve body.

(3) The present invention may be applied to a backflow preventing means which is interposed in a suction pipe coupling to a main body of a vacuum pump.

(4) The present invention may be applied to a vacuum pump except a roots pump.

[0017] According to the present invention described above, a slide contact means provided with a plurality

of the slide contact portions which keeps in slide contact with one of the guide pipe and the valve body is interposed between the circumferential surface of the guide pipe and the valve body, and a plurality of the slide contact portions is disposed on the circumferential surface of the guide pipe so as to be distributed around the circumferential wall. Thereby, the solidified exhaust can be prevented from being caught into the gaps between the slide contact portions and the valve body and between the slide contact portions and the guide pipe and can be prevented from remaining therebetween, and an operational failure at the backflow preventing means interposed in the exhaust passage can be avoided from occurring, so that above-mentioned advantageous effects can be performed.

[0018] Therefore the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.

[0019] Passage structure for a vacuum pump has a rotary shaft, a gas transferring assembly and a backflow preventing means. The gas transferring assembly is driven based on rotation of the rotary shaft. Vacuum action is generated by transferring gas due to motion of the gas transferring assembly. The backflow preventing means is constituted of a guide pipe, a valve hole forming portion, a valve body and a return spring, and is interposed in a gas passage. The guide pipe accommodates the valve body and the return spring, and forms a tapered valve hole. The valve body is constituted of a shutter closing the valve hole, a cylindrical circumferential wall, a plurality of slide contact portions disposed on an outer circumferential surface of the circumferential wall so as to be distributed around the inner circumferential surface of the guide pipe, and a seal ring fitted to a periphery of the shutter. The valve body opens and closes the valve hole. The return spring urges the valve body in a direction to close the valve hole. A plurality of the slide contact portions keeps in slide contact with one of the guide pipe and the valve body, and is interposed between an inner circumferential surface of the guide pipe and the valve body.

Claims

1. Passage structure for a vacuum pump comprising:

- a rotary shaft;
- a gas transferring assembly driven based on rotation of the rotary shaft;
 - wherein vacuum action is generated by transferring gas due to motion of the gas transferring assembly;
- a backflow preventing means interposed in a gas passage;
 - wherein said backflow preventing means

comprises a guide pipe forming as a part of the gas passage, a valve body slidably guided in an axial direction of the guide pipe therein, a valve hole forming portion forming a valve hole being opened and closed by the valve body and an urging means for urging the valve body in a direction to close the valve hole;
 a slide contact means provided with a plurality of slide contact portions keeping in slide contact with one of the guide pipe and the valve body;

wherein said slide contact means is interposed between an inner circumferential surface of the guide pipe and the valve body; and

wherein a plurality of said slide contact portions is disposed so as to be distributed around the inner circumferential surface of the guide pipe.

2. Passage structure for a vacuum pump according to claim 1 further comprising:

a valve guide portion formed at the inner circumferential surface of the guide pipe so as to guide slidably the valve body;

wherein a plurality of said slide contact portions is disposed on one of the valve body and the valve guide portion so as to keep in slide contact with the other; and

wherein a plurality of said slide contact portions is disposed so as to be distributed around the other in a circumferential direction.

3. Passage structure for a vacuum pump according to claim 2,

wherein the valve guide portion is provided with a basic inner circumferential surface,
 wherein the valve body is provided with a basic outer circumferential surface which is similar to the inner circumferential surface,
 wherein said slide contact portions are disposed on one of the basic inner circumferential surface and the basic outer circumferential surface, and
 wherein said slide contact portions keep in slide contact with the other.

4. Passage structure for a vacuum pump according to claim 2, wherein the valve body includes a shutter closing the valve hole and an annular circumferential wall, and

wherein a plurality of said slide contact portions is disposed on the circumferential wall of the valve body.

5. Passage structure for a vacuum pump according to

claim 4, wherein the valve body is provided with a communication hole at the circumferential wall so as to intercommunicate an outside of the circumferential wall and an inside of the circumferential wall.

6. Passage structure for a vacuum pump according to claim 4, wherein each shape of said slide contact portions is long in a direction in which the valve body moves.

Fig. 1

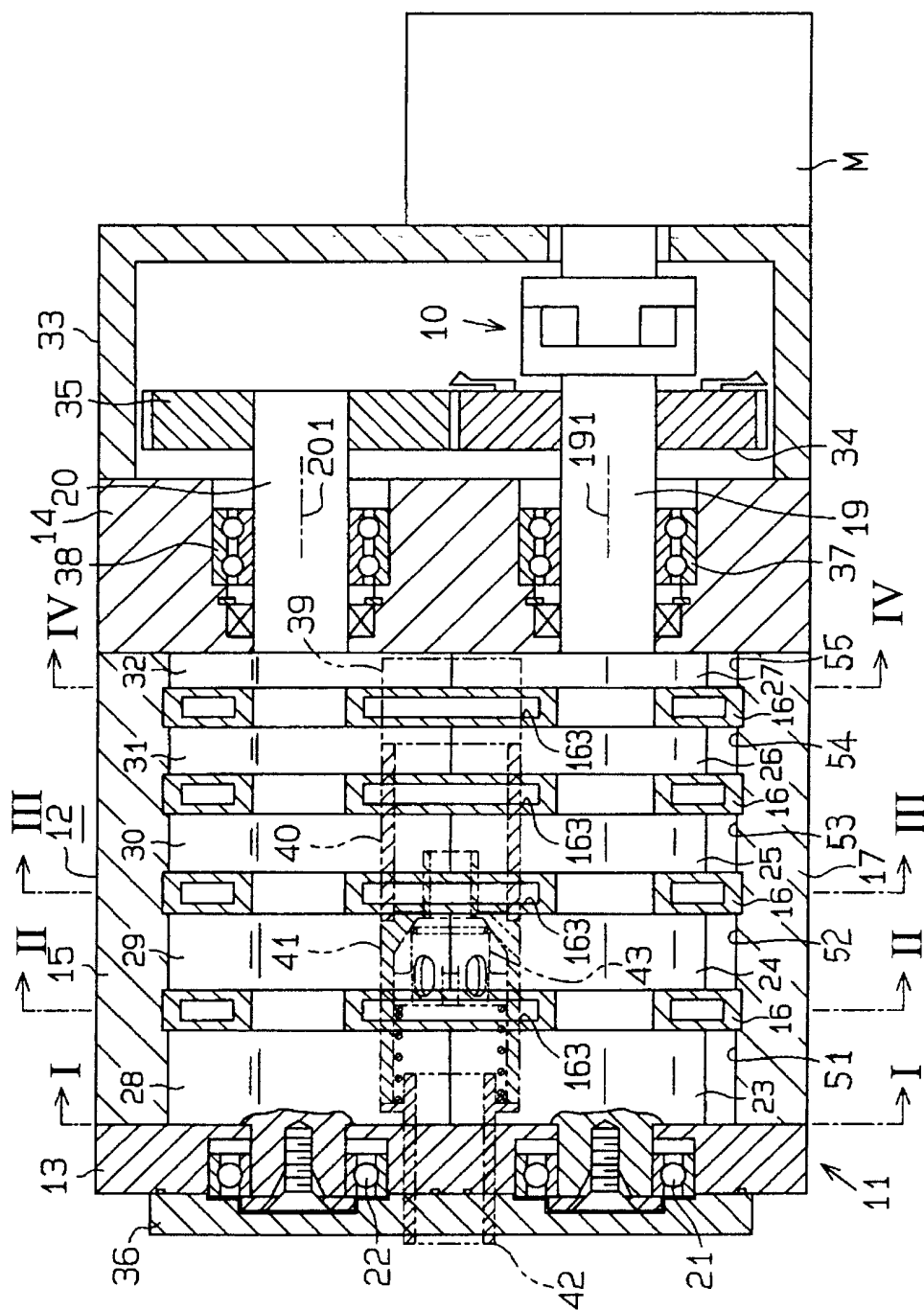


Fig. 2a

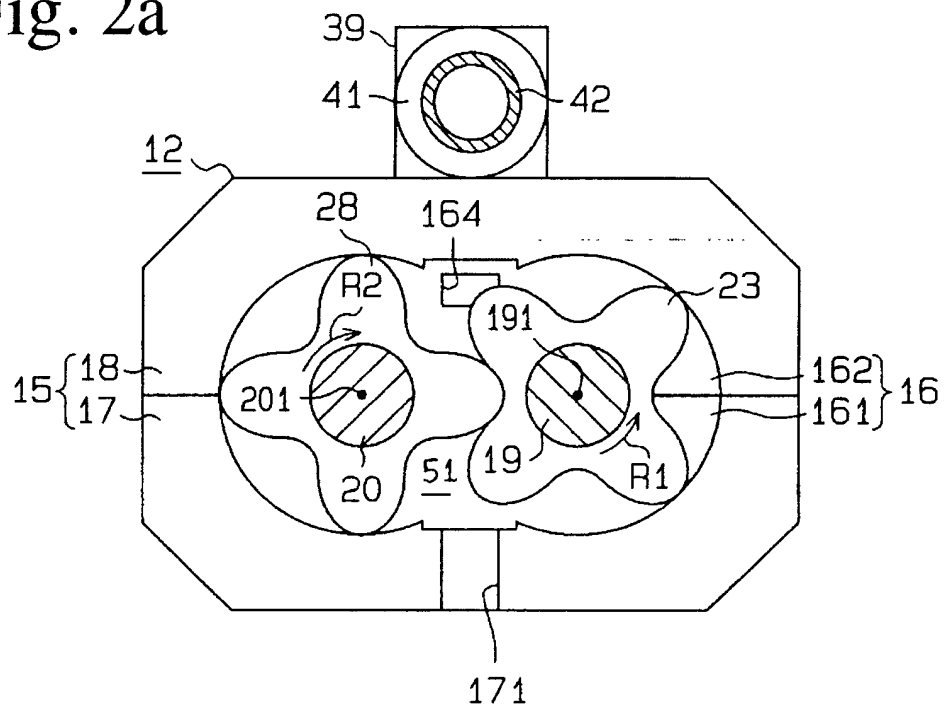


Fig. 2b

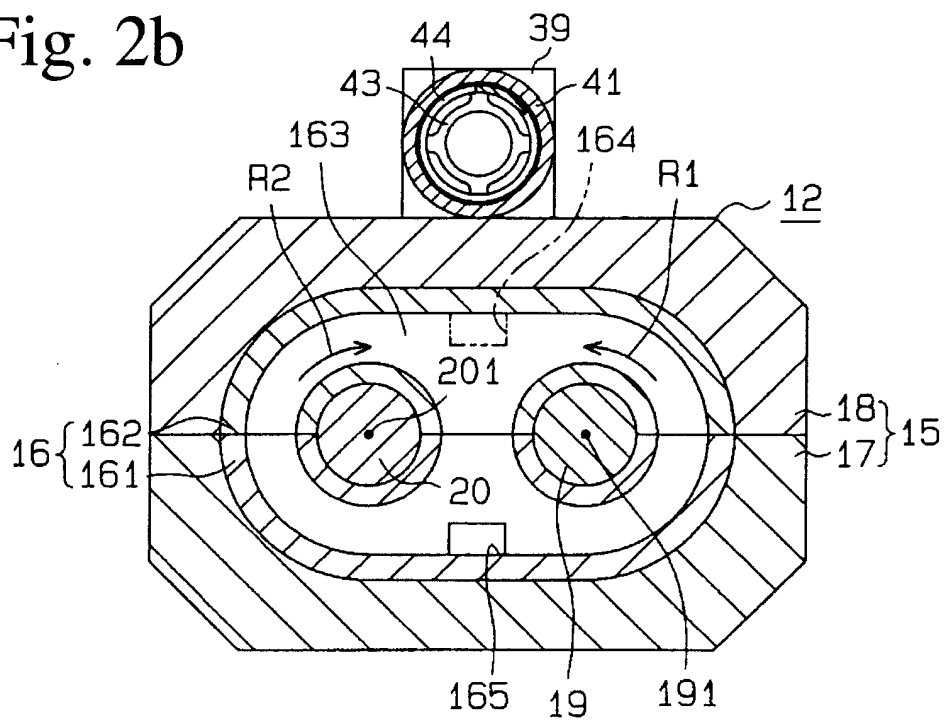


Fig. 3a

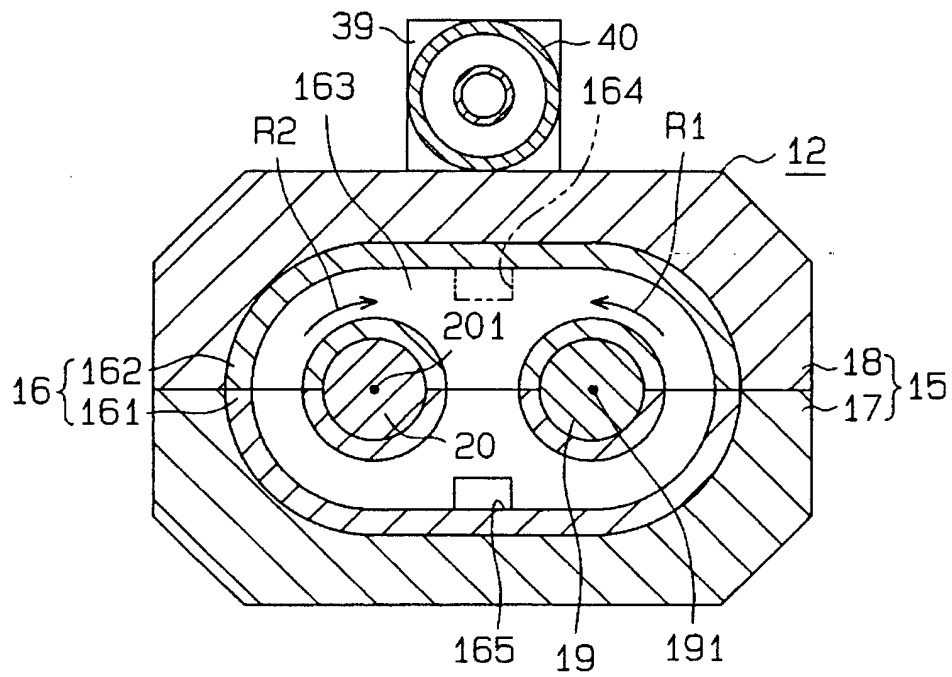


Fig. 3b

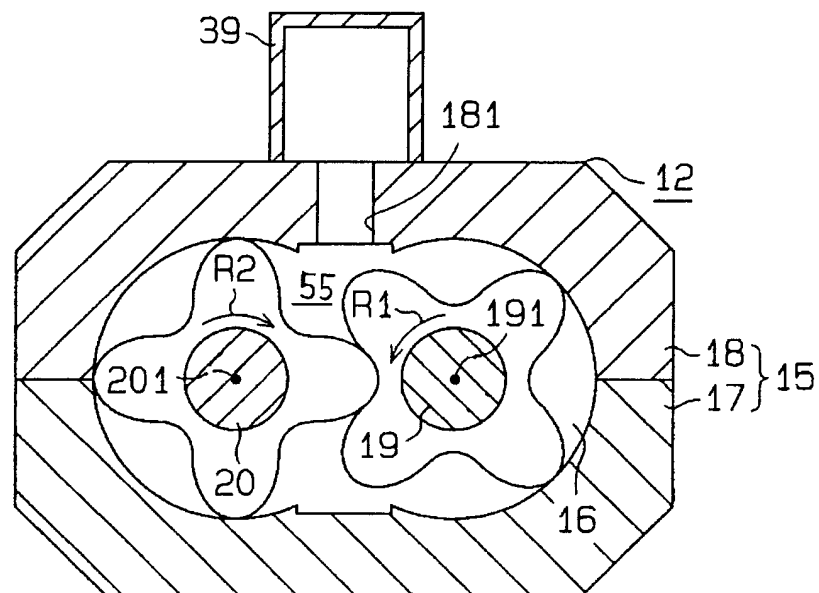


Fig. 4a

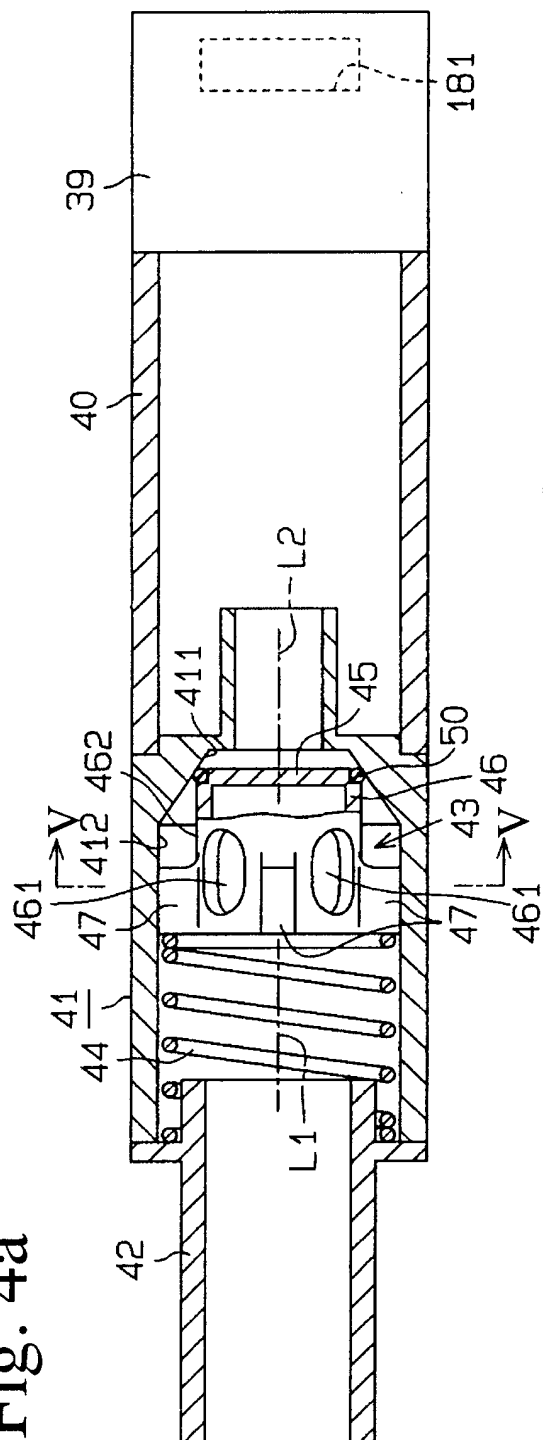


Fig. 4b

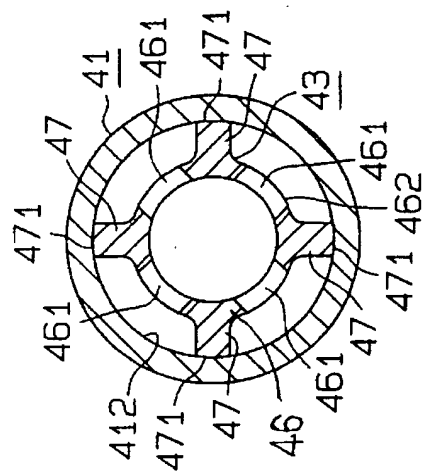


Fig. 5

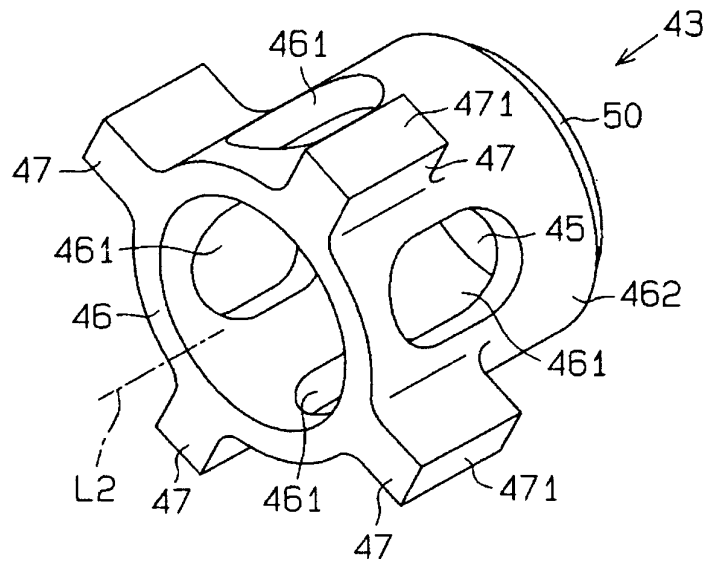


Fig. 6

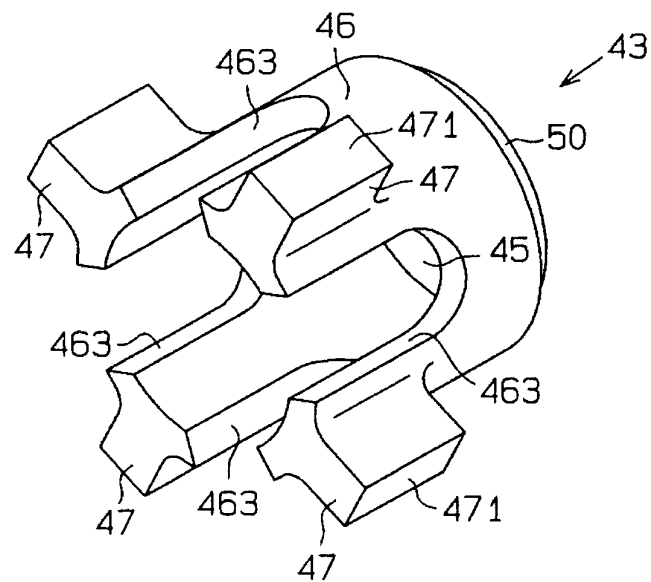


Fig. 7

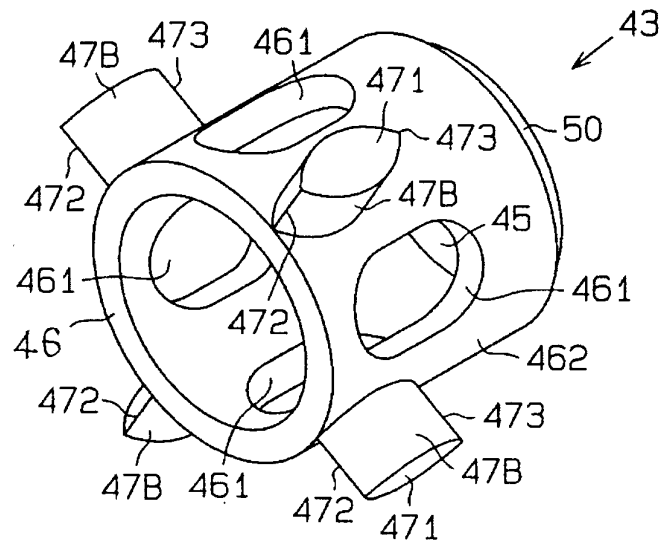


Fig. 8

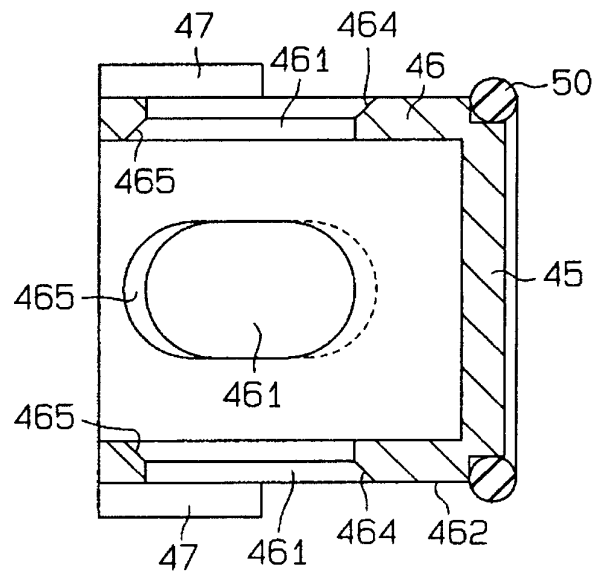


Fig. 9

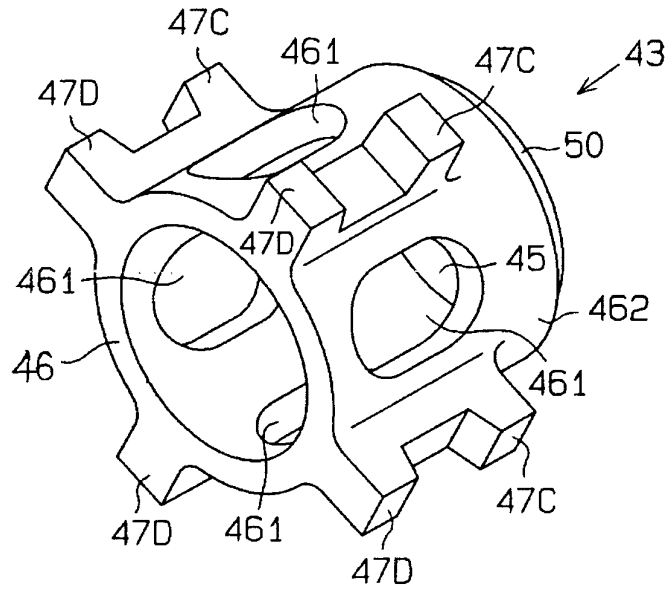


Fig. 10

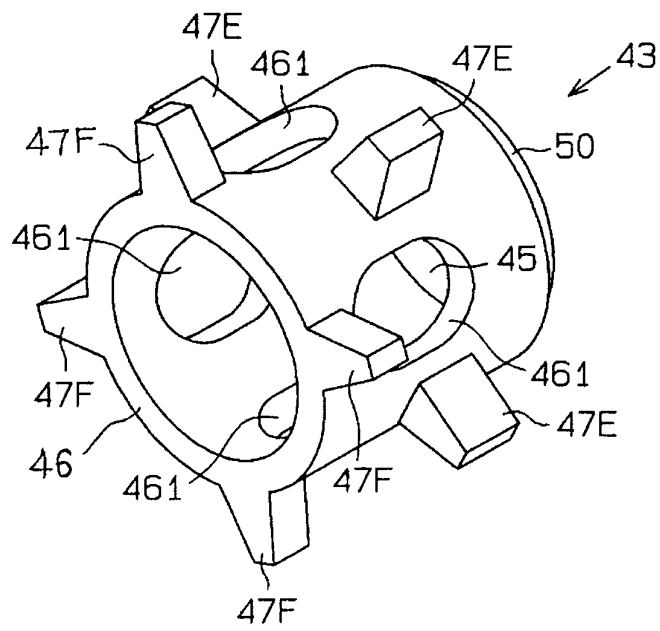


Fig. 11a

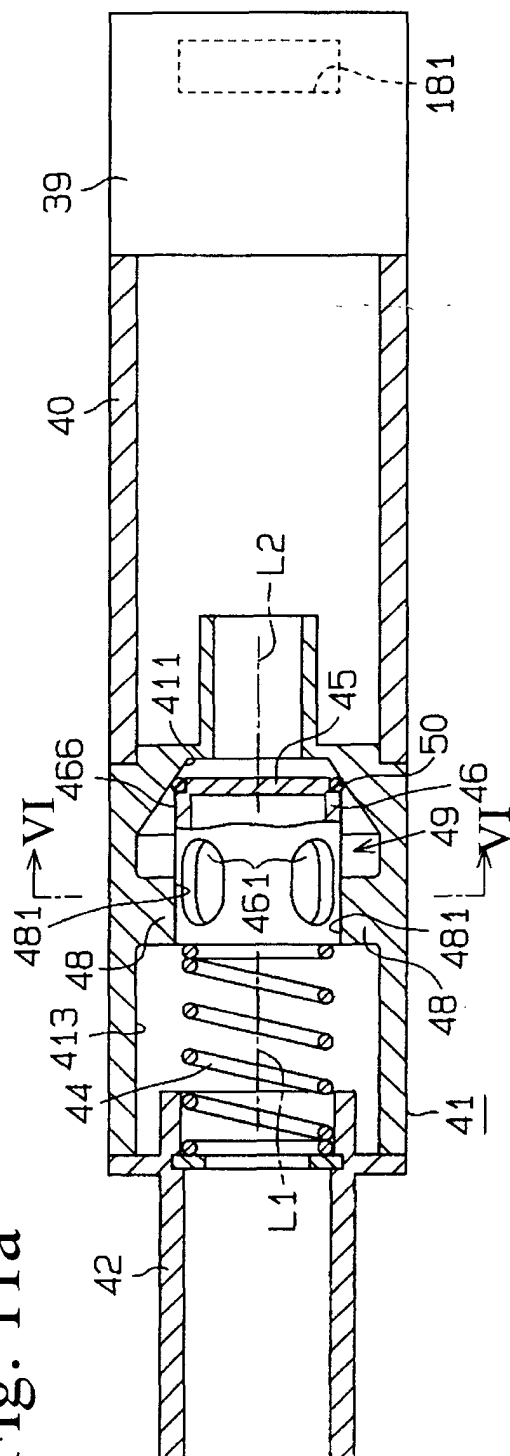


Fig. 11b

