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(54) Multifunction valve and heating or cooling system including same

(57) Valve assembly for controlling the flow of a fluid between a plurality of ports including at least one high pressure port (12) and one low pressure port (11), with a selection means for its use in a heating or cooling mode in a heat exchanging system, characterized in that it comprises an expansion means.

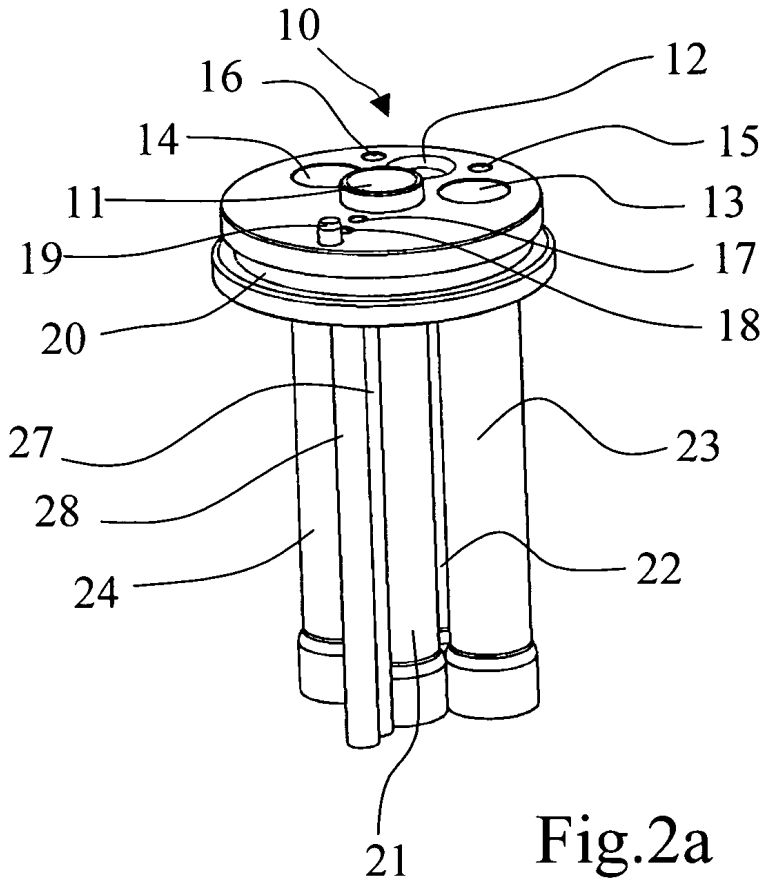

Fig.2a

EP 1 701 116 A1

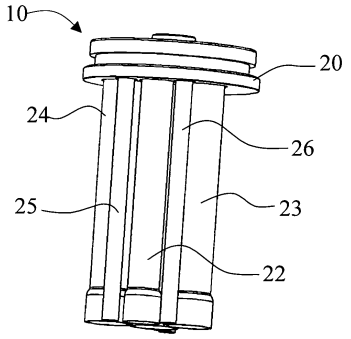

Fig.2b

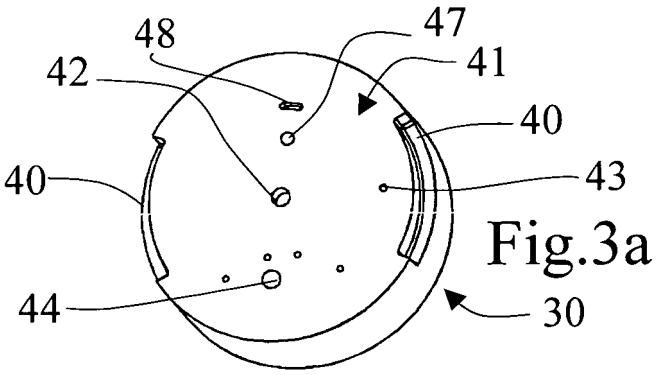

Fig.3a

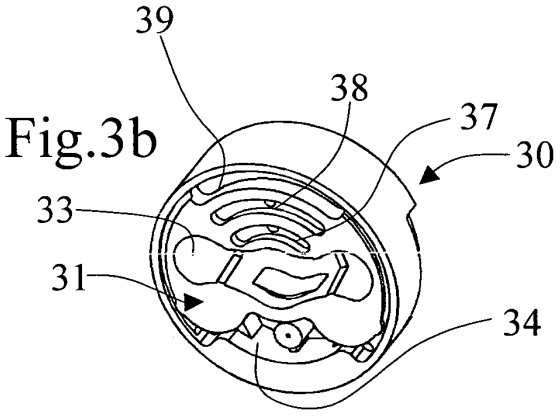

Fig.3b

Fig.4a

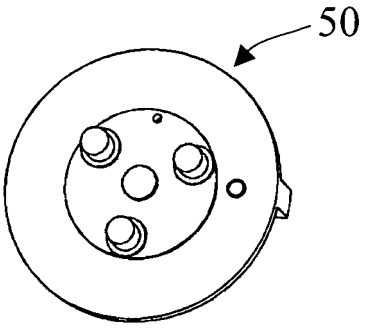

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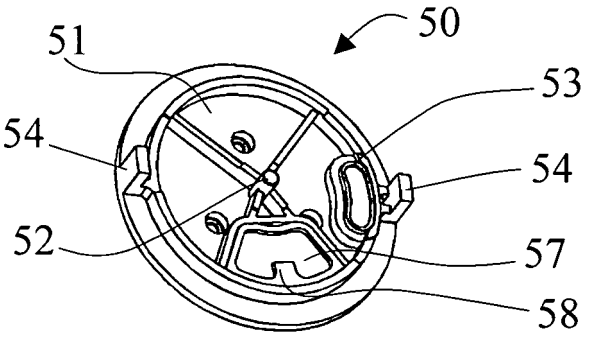
Fig.4b



Description

[0001] The present invention relates to a valve assembly for controlling the flow of a fluid between a plurality of ports. The invention is particularly useful as a four-way change-over valve assembly in an air conditioning system, and method, for selectively operating the system according to a cooling mode or a heating mode, and is also useful as an expansion valve and is therefore described below particularly with respect to corresponding applications. The present invention relates also to a heat exchanging system like cooling, refrigeration, heating, comprising a valve assembly according to the invention, as well as a regulation method of such a system. It will be appreciated that the invention and features thereof could also advantageously be used in many other applications, where a multifunctions valve could be useful.

[0002] Document US6076365 discloses a valve assembly comprising a valve member, a coupling disk, a part of a drive, all enclosed within a housing hermetically sealed to a base having four main pressure ports. This assembly can accommodate large pressure differentials without leakage and can be actuated by the use of a relatively small amount of force for the performance of the change-over valve function for changing-over the operation of a system from cooling to heating and vice versa. It provides also other functions like preventing frosting or defrosting and reducing system capacity when required, without turning off the system. This valve 1 can be used in a cooling system as described in figure 1, in combination with a compressor 2, an evaporator 3, a condenser 4, a thermal expansion valve 5. This expansion valve is used for the flow regulation of the whole system in order to avoid any liquid presence within the compressor. Such a system has the drawback that two valves are necessary, with their own control and motor systems. This makes the system expensive.

[0003] A general object of the present invention consists in a valve having the prior art advantages without the drawbacks.

[0004] More precisely, a first object of the invention consists in a valve assembly with the dual function cooling / heating.

[0005] A second object of the invention consists in a valve assembly with an expansion function.

[0006] A third object of the invention consists in a valve assembly with the flow reduction capacity

[0007] A fourth object of the invention consists in a valve assembly with simple and easy actuation mechanism.

[0008] A fifth object of the invention consists in a valve assembly with a frost /defrost function.

[0009] A sixth object of the invention consists in a simple and inexpensive cooling or heating system.

[0010] A seventh object of the invention consists in a control process for a cooling or heating system.

[0011] The concept of the invention consists in a valve assembly for controlling the flow of a fluid between a plurality of ports including at least one high pressure port and one low pressure port, with a selection means for its use in a heating or cooling mode in a heat exchanging system, characterized in that it comprises in addition of the heating or cooling control an expansion means.

[0012] This valve is particularly adapted for its use in a heat exchanging system, heating or cooling, with a first function being able to select the heating or cooling mode and to regulate the flow within the compressor, and with a second function of expansion means being able to regulate the flow between the two inside and outside heat exchangers of the system in order to achieve full vaporizing of fluid before entering the compressor.

[0013] The invention is more precisely defined by the claims.

[0014] The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein :

Figure 1 is a schematic view of a prior art cooling system ;
figures 2 to 4 are exploded 3-dimensional views illustrating a preferred embodiment of a valve assembly in accordance with the present invention;
figure 2a is a perpective view of the upper face of the base element of an embodiment of present invention ;
figure 2b is a perpective view of the bottom face of the base element of an embodiment of present invention ;
figure 3a is a perpective view of the upper face of the selector of an embodiment of present invention ;
figure 3b is a perpective view of the bottom face of the selector of an embodiment of present invention ;
figure 4a is a perpective view of the upper face of the pilot member of an embodiment of present invention ;
figure 4b is a perpective view of the bottom face of the pilot member of an embodiment of present invention ;
figure 5 is a schematical view of the use of a valve of the invention in a cooling system ;
figures 6 illustrate different relative positions of the selector regarding to the base member of a valve assembly of an embodiment of the invention in a cooling mode ;
figure 6a illustrates the maximum flow of the cooling mode ;
figure 6b illustrates a reduced flow in the cooling mode ;
figure 6c illustrates a defrost operating function in the cooling mode ;
figure 7 is a schematical view of the use of a valve assembly of the invention in a heating system ;
figures 8 illustrate different relative positions of the selector regarding to the base member of a valve assembly of an embodiment of the invention in an heating mode ;

figure 8a illustrates the maximum flow of the heating mode ;
figure 8b illustrates a reduced flow in the heating mode ;
figure 8c illustrates a defrost operating function in the heating mode ;
figures 9 illustrate different relative positions of the pilot member regarding to the selector of a valve assembly of an embodiment of the invention for the expansion valve regulation ;
figure 9a illustrates a reduced expansion function ;
figure 9b illustrates a medium expansion function ;
figure 9c illustrates a maximum expansion function ;
figures 10 illustrate the relative positions of the pilot member regarding to the selector of a valve assembly of an embodiment of the invention in the pilot phase of the relative position of the selector to the base member;
figure 10a illustrates the counter clockwise rotation phase of the selector relative to the base member;
figure 10b illustrates the clockwise rotation phase of the selector relative to the base member;

[0015] The construction of an embodiment of a valve assembly according to the present invention is particularly illustrated in Figures 2 to 4.

[0016] It includes a base 10 comprising four main ports 11, 12, 13, 14 able to be connected to a compressor 2, an inside and outside heat-exchangers 3, 4 of a heat exchanging system, as described in relation with figures 5 and 7, through respectively tubes 21, 22, 23, 24. The base 10 also comprises two ports 15 and 16 for the defrost function and two ports 17 and 18 for the expansion function, whose use is described with details below, linked to the external system through respectively tubes 25, 26, 27, 28.

[0017] The base 10 also comprises a support ring 20 for hermetically supporting a selector 30 and further includes a projection stop 19 on its upper face, which cooperates with an aperture 39 of the selector 30 and allows the relative rotation of both elements 10, 30 between two maximum positions.

[0018] Then, the valve assembly further includes a selector 30, which is rotatable regarding the base 10 in order to determine the two main operational positions to control the flow of the gas between the four ports 11, 12, 13, 14 to produce the cooling or heating modes, as this will be described below. This selector 30 includes a lower face 31 that contacts the base 10 and an upper face 41. The lower face 31 comprises a central cavity 33, a lateral cavity 34 and three circular arc shaped cavities 37, 38 and 39. This last cavity 39 cooperates with stop 19 of base member 10.

[0019] The upper face 41 of selector 30 comprises an aperture 43 linked to bottom central cavity 33, an aperture 44 linked to bottom lateral cavity 34, and apertures 47 and 48 respectively linked to cavities 37, 38 of bottom face 31.

[0020] The upper face 41 comprises two diametrally opposed grooves 40, cooperating with pins 54 of a pilot member 50.

[0021] Then, the valve assembly further includes the pilot member 50, rotatably mounted on selector 30. Bottom face 51 of pilot member 50 has a central pin 52 cooperating with central hole 42 of upper face 41 of selector 30 and two lateral pins 54 cooperating with lateral grooves 40 of selector 30.

[0022] The pilot member 50 further comprises a trapezoïd cavity 57, with a lateral closure projection 58, cooperating with apertures 47 and 48 of selector 30 for the performance of the expansion function, described below. It also comprises a cavity 53, which cooperates with hole 43 of selector.

[0023] The valve assembly is rotated to its operational positions by a drive, not illustrated, and a coupling member or disk, as described in patents US6076365. Moreover, the valve assembly is able to be automatically controlled by an electronic control device, not illustrated.

[0024] The use of such valve assembly will now be described.

[0025] Figure 5 illustrates a cooling system including a valve assembly of the invention. In this mode, ports 11 and 13 are connected together and ports 12 and 14 are connected together, thanks to the cooling position of the selector 30 as illustrated in figure 6a. Port 13 is linked to the low pressure inlet of compressor 2 and port 12 is connected to high pressure outlet of the compressor 2. Port 14 is connected to the inlet of evaporator 3 and port 17 is connected to the outlet of the evaporator 3. Port 18 is connected to the inlet of condenser 4 and port 13 is connected to the outlet of the condenser 4. For clarity reasons, ports 17 and 18, which are part of the valve assembly of the invention, are separated on the figure from the rest of the valve assembly.

[0026] In this cooling mode, the valve assembly can be placed in the configuration of figure 6a, where the stop 19 of base member 10 is placed in its maximum left position within groove 39 after a maximum counter clockwise rotation of selector 30. In this configuration, ports 11 and 13 are fully linked together in cavity 33 of selector 30 and a maximum flow is flowing from port 11 to port 13. Ports 12 and 14 are linked together within cavity 34 of selector 30.

[0027] However, still in the cooling mode, the selector 30 can be rotated to another position, as illustrated in figure 6b for instance. In this configuration, there is a significant flow reduction since only a small surface of port 13 is still comprised within cavity 33. This valve assembly performs in this way a flow reduction that allows the cooling system regulation, simply by rotating the selector 30 relative to the base member 10, without turning off the whole system. This allows to adapt the cooling capacity of the system for instance when the volume of the enclosed space to be cooled is significantly reduced as by shutting off rooms, etc. This makes sure that a right flow is flowing through the compressor, avoiding any

liquid presence within the compressor, with a solution adapted to any kind of compressor, even very simple. Prior art air-conditioning systems are generally merely turned-off in order to reduce the cooling capacity. However, this manner of reducing the capacity also reduces the overall efficiency of the system and wastes energy. Moreover, frequent interruption of the system tends to reduce the useful life of the compressor and the fan.

[0028] Figure 6c illustrates a particular position of selector 30 where some high temperature fluid is by-passed into the condenser 4 in order to perform the defrost function. This is performed thanks to the position of port 15, linked to inlet of the condenser 4, within cavity 34 in order to be connected to ports 14 and 12. This solution solves the frosting or icing problem, which can occur to the condenser. The usual remedy is to shut-off the compressor and/or to stop or change the speed of the fan, which thereby also involves a loss of energy, time, and cooling capacity. Moreover, interrupting the operation of the compressor is unhealthy to the compressor and requires waiting several minutes before its operation can be resumed. Further, to prevent frosting in the cooling mode, the system is generally designed to operate the evaporator at a temperature significantly above freezing, e.g. about 7 degrees C., to accommodate changes in the outside temperature; this also reduces the efficiency and cooling capacity of the system as compared, for example, when operating at a temperature closer to 0 degree C.

[0029] Figure 7 illustrates a heating system including a valve assembly of the invention in a heating mode, as illustrated in figures 8a to 8c. In this mode, ports 11 and 14 are connected together and ports 12 and 13 are connected together, thanks to a heating position of the selector 30. Port 14 is linked to the low pressure inlet of compressor 2 and port 12 is connected to high pressure outlet of the compressor 2. Port 13 is connected to the inlet of inside heat exchanger 4 and port 18 is connected to the outlet of the inside heat exchanger 4. Port 17 is connected to the inlet of outside heat exchanger 3 and port 11 is connected to the outlet of the outside heat exchanger 3. For clarity reasons, ports 17 and 18, which are part of the valve assembly of the invention, are separated from the rest of the valve assembly.

[0030] In the heating positions of figure 8a, stop 19 of base member 10 is placed in its maximum right position within groove 39, thanks to a maximum clockwise rotationof the selector 30 regarding the base member 10. In this configuration, ports 11 and 14 are fully linked together through cavity 33 of selector and a maximum flow is flowing from port 11 to port 14. Ports 12 and 13 are linked together within cavity 34 of selector 30.

[0031] However, still in the heating mode, the selector 30 can be rotated to another position of figure 8b. In this configuration, there is a flow reduction since a small surface of port 14 is still comprised within cavity 33. This valve assembly performs in this way a flow reduction that allows the heating system regulation, simply by rotating the selector 30 relative to the base member 10, without turning off the whole system.

[0032] Figure 8c illustrates a particular position of selector 30 where some high temperature fluid is by-passed into the heat exchanger 3 in order to perform the defrost function. This is performed thanks to the position of port 16, linked to inlet of heat exchanger 3, within cavity 34 in order to be connected to ports 12 and 13. As a further remark, this defrost flow can also be precisely controled and defined. In the configuration of figure 6b for instance, a small surface of port 16 is already positioned within cavity 34 for defining a low defrost flow.

[0033] Moreover, in every illustrated configuration of figures 5 to 8, the valve assembly is able to perform a further function of expansion valve, thanks to ports 17 and 18.

[0034] A flow is in fact possible from port 17 to 18 or vice versa of base member 10 through cavities 37 and 38 and holes 47 and 48 of selector 30 and cavity 57 of pilot member 50. In a normal operational mode, pilot member 50 is in configuration as illustrated in figures 9a to 9c relative to selector 30. In such configurations, high pressure flow is transmitted through hole 44 in the space located between upper surface 41 of selector 30 and bottom surface 51 of pilot member 50. This high pressure ensures a strong link between selector 30 and base member 10, which can not rotate one relative to the other but only together relative to pilot member 50.

[0035] As illustrated in figure 9a, the pins 54 of pilot member 50 are placed very close to the centre of grooves 40 of the selector 30. In this configuration, elongated aperture 48 of the selector 30 is almost closed by the protuberant part 58 of bottom face 51 of pilot member 50. This configuration induces a very low flow between ports 17 and 18 and a pressure change, called expansion function. In an intermediate configuration, as illustrated in figure 9b, after a small counter clockwise rotation of pilot member 50 relative to the rest of the valve assembly, the expansion value is increased since only half of the aperture 48 is closed by closure protuberant part 58. In another configuration, illustrated in figure 9c, the maximum possible flow between ports 17 and 18 is achieved since the whole aperture 48 is linked to aperture 47 within cavity 57. In this way, the valve assembly is able to regulate the flow between the two inside and outside heat exchangers, for instance to adapt the system to external pressure and temperature conditions, in order to garanty the total performance of the condensing or vaporizing functions and to avoid any indirect liquid presence within the compressor. The valve is able to provide a regulated expansion function.

[0036] The change-over operation, wherein the system is changed-over from a cooling mode (in the summer) to a heating mode (in the winter), or vice versa, will now be described.

[0037] First, the pilot member 50 has to be placed in one of its two extreme positions, as illustrated in figures 10a and 10b. In such configurations, hole 43 is superposed with cavity 53, which allows low pressure fluid to be in contact with the volume in between upper face 41 of selector 30 and bottom face 51 of pilot member 50. This equilibrates the pressure

between the whole valve assembly and makes possible the rotation of selector 30 relative to the basis 10.

[0038] Secondly, from one of the positions of figure 10a or 10b, pilot member 50 can be rotated : its pin 54, in abutment with border of groove 40, can induce the simultaneous rotation of selector 30 relative to the base 10. In this way, the modification from cooling to heating can be performed and more generally, anyone of configuration of figures 6a to 6c or 8a to 8c and other intermediate solutions can be selected. Once this selection is performed, the pilot member 50 comes back to one of positions of figures 9a to 9c for the expansion function regulation.

[0039] Finally, the valve assembly of the invention allows a regulation/control function of a heat exchanger system comprising the following steps :

a - rotation of pilot member 50 in a first direction relative to the rest of the valve assembly into one extreme position (as illustrated in figure 10a or 10b) ;
b - further rotation of pilot member 50 in the first direction and simultaneously, rotation of selector 30 relative to base member 10, in order to select a cooling or heating configuration ;
c - rotation of pilot member 50 in opposite direction of first direction relative to the rest of the valve assembly and stop into a position corresponding to a predefined expansion value.

[0040] Different configurations of relative position of the selector 30 and the base member 10 could be chosen for the cooling and heating modes during the above step b, allowing a predefined flow value to be chosen and allowing a defrost function to be performed if necessary.

[0041] The above regulation method of valve assembly is automatically performed, on the basis of temperature and pressure sensors within the heat exchanging system and reference values fixed by an operator, through an electronic module which receives the data, analyses the values, decides the right configuration of the valve assembly, sends order to the actuating system of the valve assembly.

[0042] Finally, the solution presents the following advantages :

- it consists in a valve assembly with the dual function cooling /heating and the expansion function ;
- in the described embodiments, the valve has two more optional functions : for any specific mode, heating or cooling, it is able to reduce or increase the flow, particularly the flow crossing the compressor, and it is also able to involve a defrost function ;
- the valve assembly consists in a simple superposition of cylindrical elements, easy to actuate with an automatic simple actuator ;
- the valve assembly leads to simple and inexpensive cooling or heating system, with an easy autoregulation process.

Claims

1. Valve assembly for controlling the flow of a fluid between a plurality of ports including at least one high pressure port (12) and one low pressure port (11), with a selection means for its use in a heating or cooling mode in a heat exchanging system, **characterized in that** it comprises an expansion means.

2. Valve assembly according to claim 1, **characterized in that** it comprises a base member (10) having two ports (17, 18) and a pilot member (50) able to perform a connection between ports (17, 18) and to control the flow between the two ports (17, 18) through a cavity (57) and a closure means (58) of pilot member (50) in order to perform the expansion function according to a predefined expansion value.

3. Valve assembly according to claim 1 or 2, **characterized in that** it comprises a selector (30) rotatably linked to a base member (10) for selecting the heating or cooling mode of the valve assembly, and **in that** it comprises a pilot member (50) rotatably mounted regarding the unit including both the base member (10) and the selector (30) in order to define the expansion value of the valve assembly.

4. Valve assembly according to claims 3 and 2, **characterized in that** the base member (10) comprises four ports (11, 12, 13, 14), **in that** the bottom face (31) of the selector (30) comprises two cavities (33, 34) in order to link together at least partly respectively low pressure ports (11, 13) and high pressure (12, 14) for a cooling mode configuration or low pressure ports (11, 14) and high pressure ports (12, 13) for a heating mode configuration, the selector being able to define different flows in each mode.

5. Valve assembly according to claims 4, **characterized in that** the base member (10) comprises two further ports (15, 16) and **in that** the selector is able to link at least partly port (15) with high pressure ports (12, 14) in the cooling

mode and able to link at least partly port (16) with high pressure ports (12, 13) in the heating mode for a defrost function performance.

6. Valve assembly according to claim 4 or 5, **characterized in that** the the bottom face (31) of the selector (30) comprises circular arc shaped cavities (37, 38) cooperating with ports (17, 18) of base member (10) in any relative position of both the selector (30) and the base member (10) and **in that** the cavities (37, 38) respectively corresponds to apertures (47, 48) of selector upper face (41).

7. Valve assembly according to claim 6, **characterized in that** the bottom face (51) of pilot member (50) comprises a cavity (57) which corresponds to apertures (47, 48) and a closure protuberance means (58) able to completely or partially closed elongated aperture (48) according to pilot position (50) relative to the selector (30) in order to impose a predefined flow value between ports (17, 18) and to perform in this way a controlled expansion function.

8. Valve assembly according to claim 7, **characterized in that** base member (10) comprises a support ring (20) for hermetically supporting the selector (30) and further includes a projection stop (19) on its upper face, which cooperates with an aperture (39) of the selector (30) for guiding and limiting the relative rotation between these two elements.

9. Valve assembly according to claim 8, **characterized in that** the upper face (41) of the selector (30) further comprises two apertures (43, 44) respectively linked to low pressure central cavity (33) and high pressure lateral cavity (34) of bottom face (31) of the selector (30), the high pressure aperture (44) communicating with the space between the selector (30) and the pilot member (50) for higly pressed together the base member (10) and the selector (30) in a normal mode of expansion regulation and the low pressure aperture (43) communicating with the same space (53) only in specific extreme pilot positions for allowing the pilot member (50) to carry the selector (30) in rotation relative to the base member (10).

10. Valve assembly according to claim 9, **characterized in that** the upper face (41) of selector (30) comprises at least one lateral groove (40) cooperating with a pin (54) of pilot member, the pin (54) being able to carry the selector (30) in rotation when in abutment in one side of the groove (40).

11. Valve assembly according to previous claims, **characterized in that** it comprises an actuation mechanism linked to pilot member (50) in order to induce pilot member rotation.

12. Cooling or refigerating or heating system including a valve assembly according to previous claims.

13. Cooling or refrigerating system according to claim 12, **characterized in that** it comprises a valve assembly according to one of claims 4 to 11 in a cooling configuration, and **in that** port (13) is linked to the low pressure inlet of a compressor (2), port (12) is connected to high pressure outlet of the compressor (2), port (14) is connected to the inlet of an evaporator (3) and port (17) is connected to the outlet of the evaporator (3), port (18) is connected to the inlet of a condenser (4) and port (13) is connected to the outlet of the condenser (4).

14. Cooling or refrigerating system according to claim 13, **characterized in that** defrost port (15) is linked to inlet of condenser (4).

15. Heating system according to claim 12, **characterized in that** it comprises a valve assembly according to one of claims 4 to 11 in a heating configuration, port (14) is linked to the low pressure inlet of a compressor (2) and port (12) is connected to high pressure outlet of the compressor (2), port (13) is connected to the inlet of inside heat exchanger (4) and port (18) is connected to the outlet of the inside heat exchanger (4), port (17) is connected to the inlet of outside heat exchanger (3) and port (11) is connected to the outlet of the outside heat exchanger (3).

16. Heating system according to claim 15, **characterized in that** defrost port (16) is linked to inlet of outside heat exchanger (3).

17. Regulation method of a cooling, refrigerating or heating system according to one of claims 12 to 16, **characterized in that** it comprises the following steps :

a - rotation of pilot member (50) in a first direction relative to the rest of the valve assembly into one extreme position ;

b - further rotation of pilot member (50) in the first direction for carrying in rotation the selector (30) relative to base member (10), in order to select a cooling or heating configuration ;
c - rotation of pilot member (50) in opposite direction of first direction relative to the linked unit of the base member (10) and the selector (30) and stop into a position corresponding to a predefined expansion value.

Fig.1

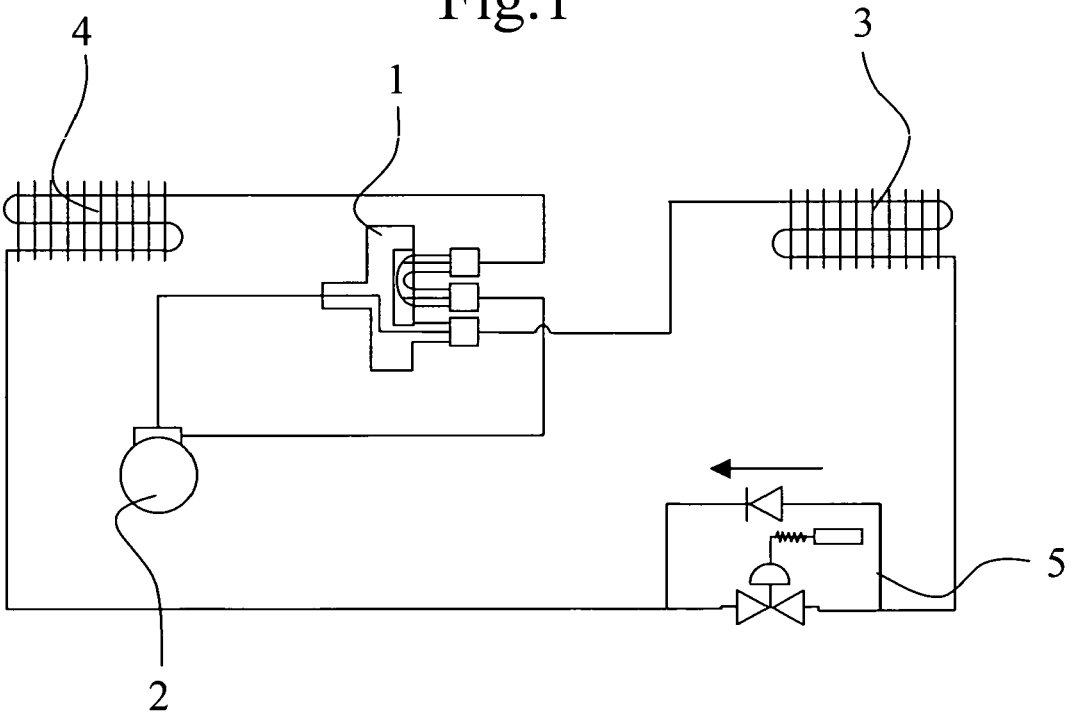


Fig.4b

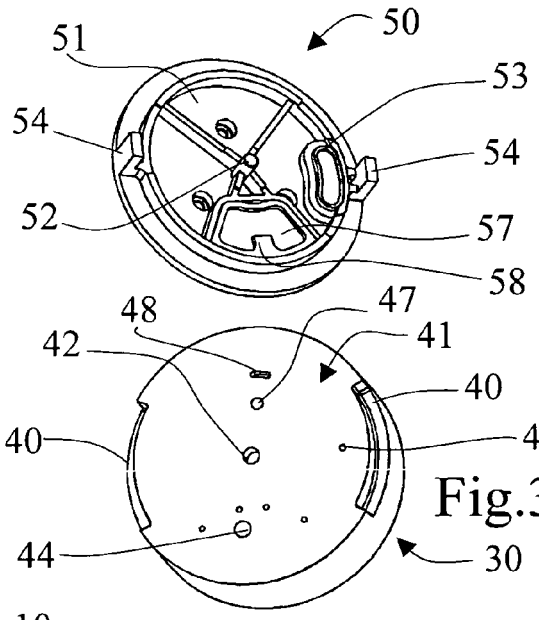


Fig.4a

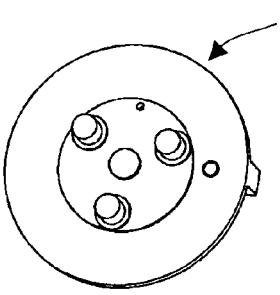
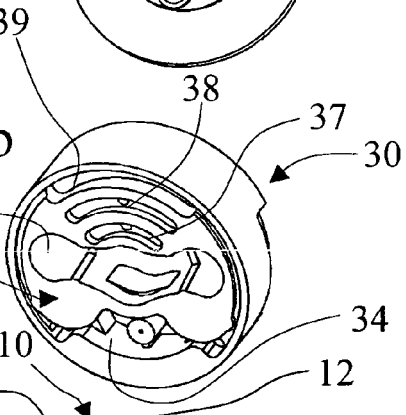
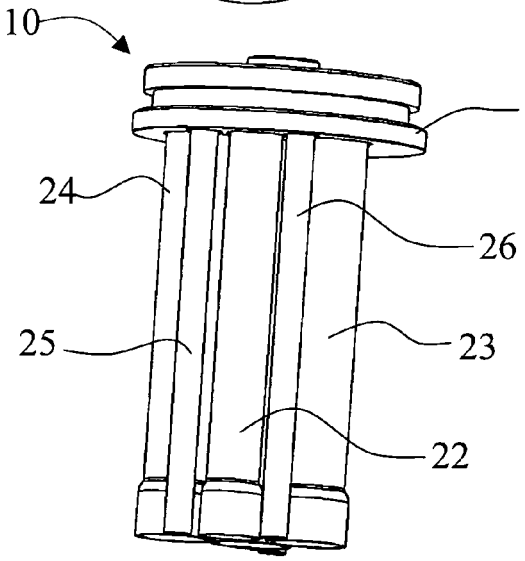


Fig.3a

Fig.3b





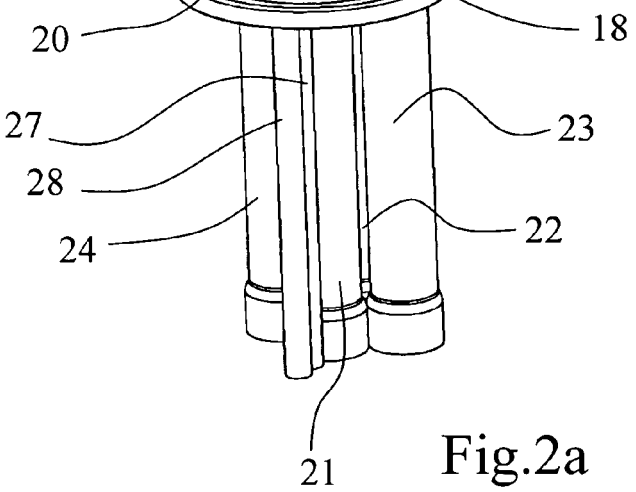


Fig.2b

Fig.2a

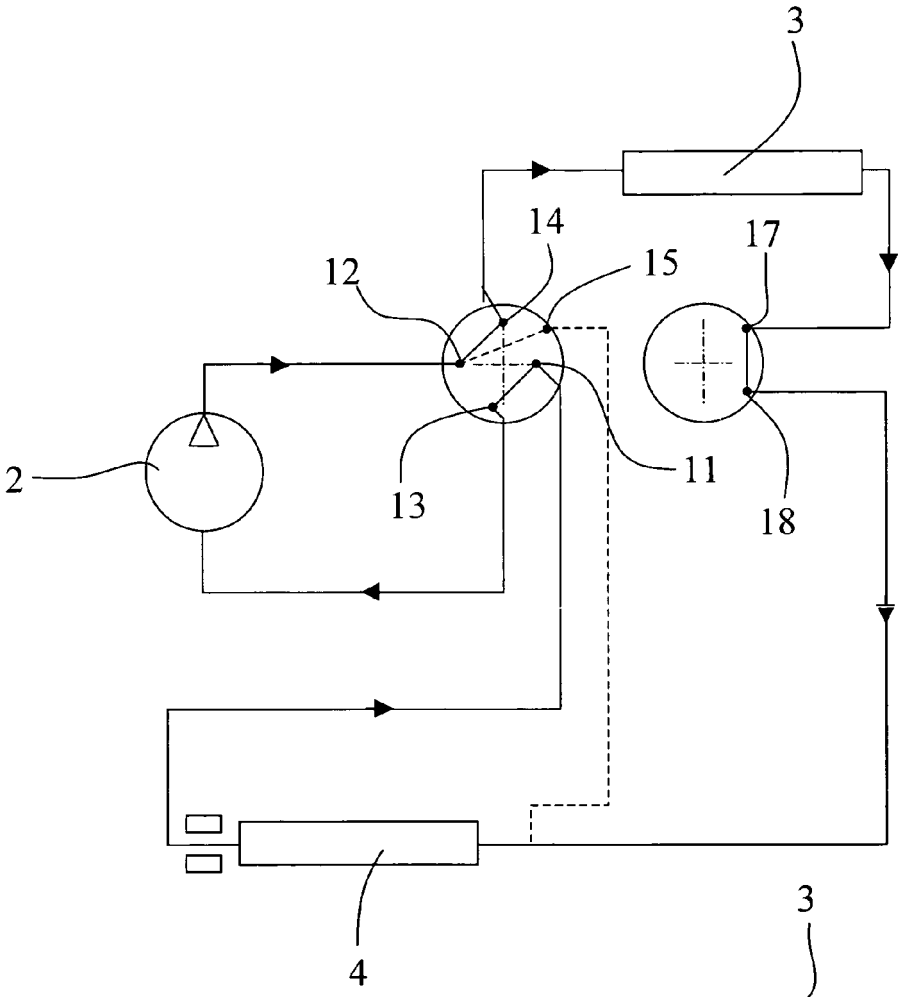


Fig.5

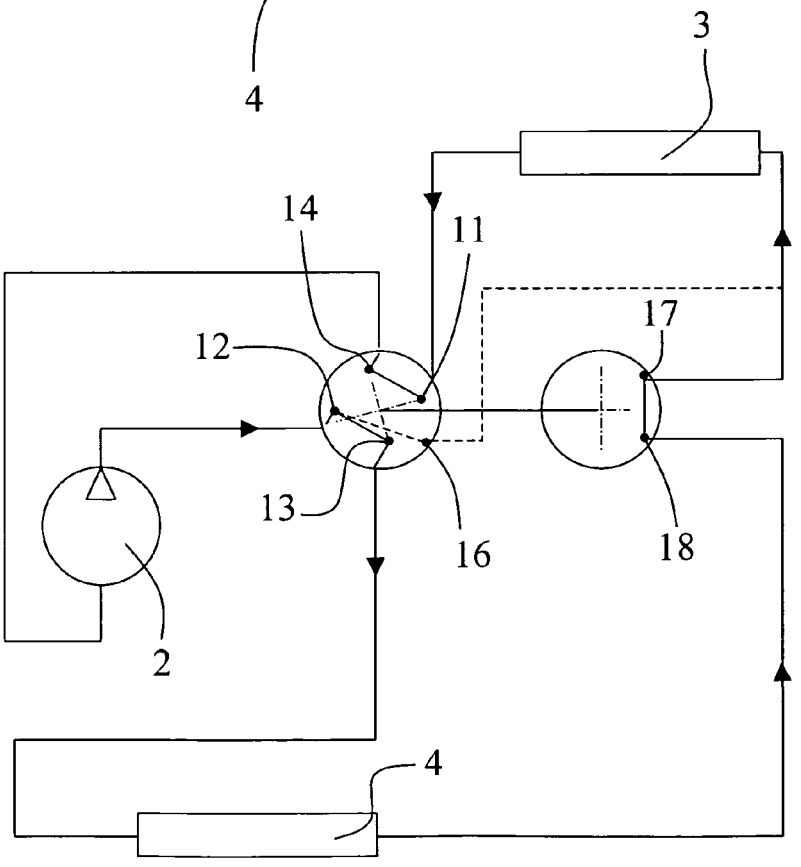


Fig.7

Fig.6a

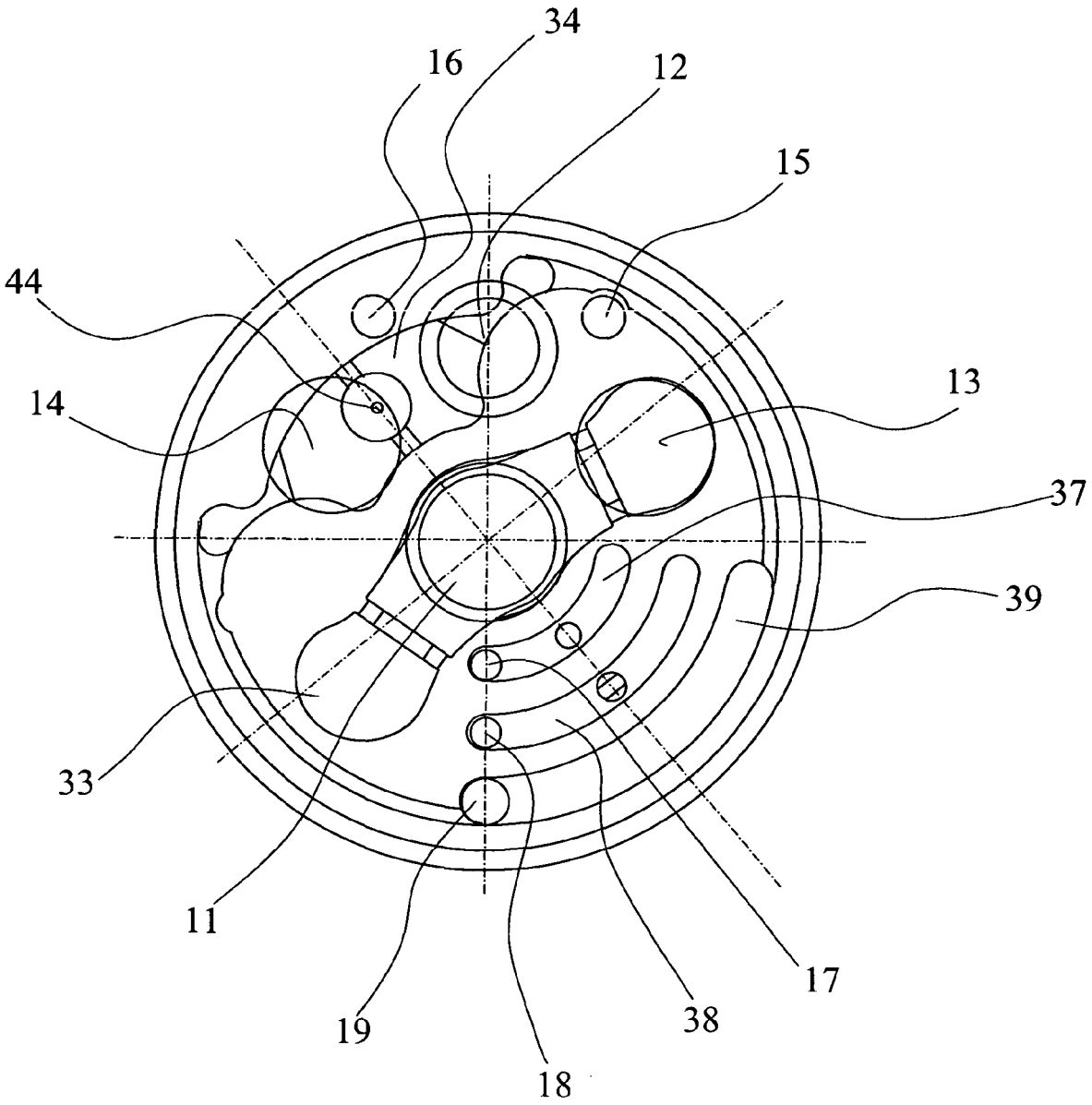


Fig.6b

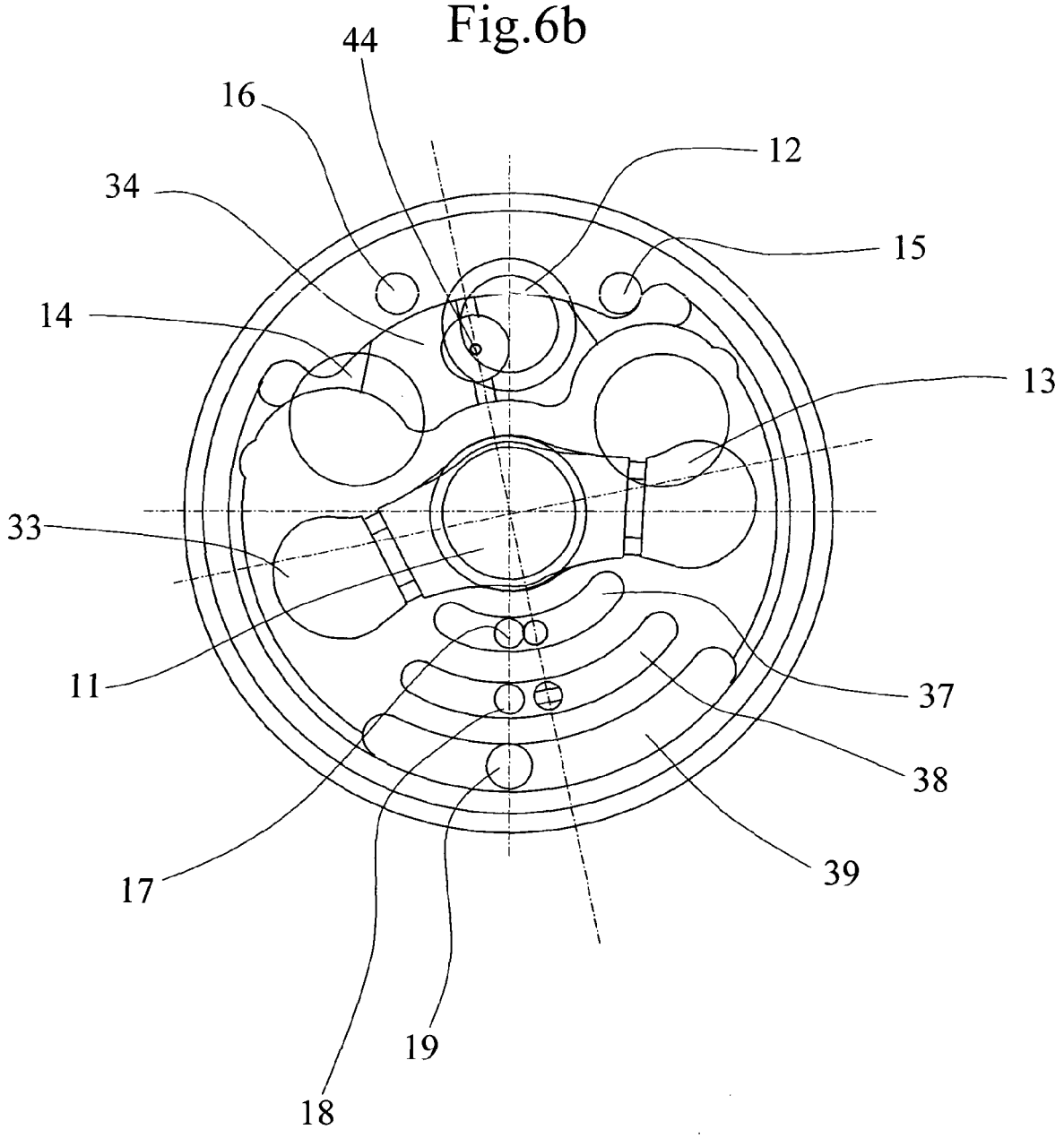


Fig.6c

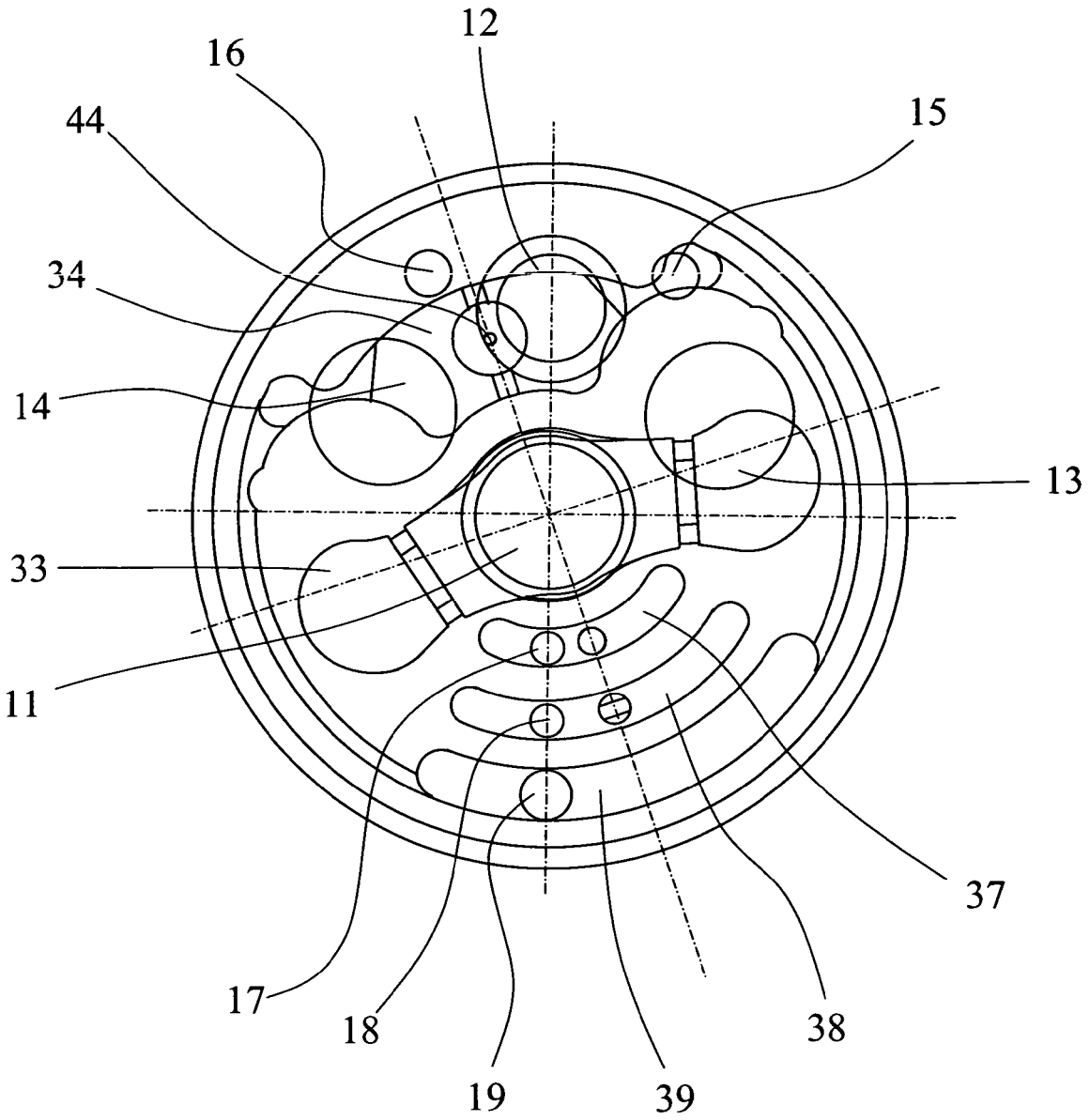


Fig.8a

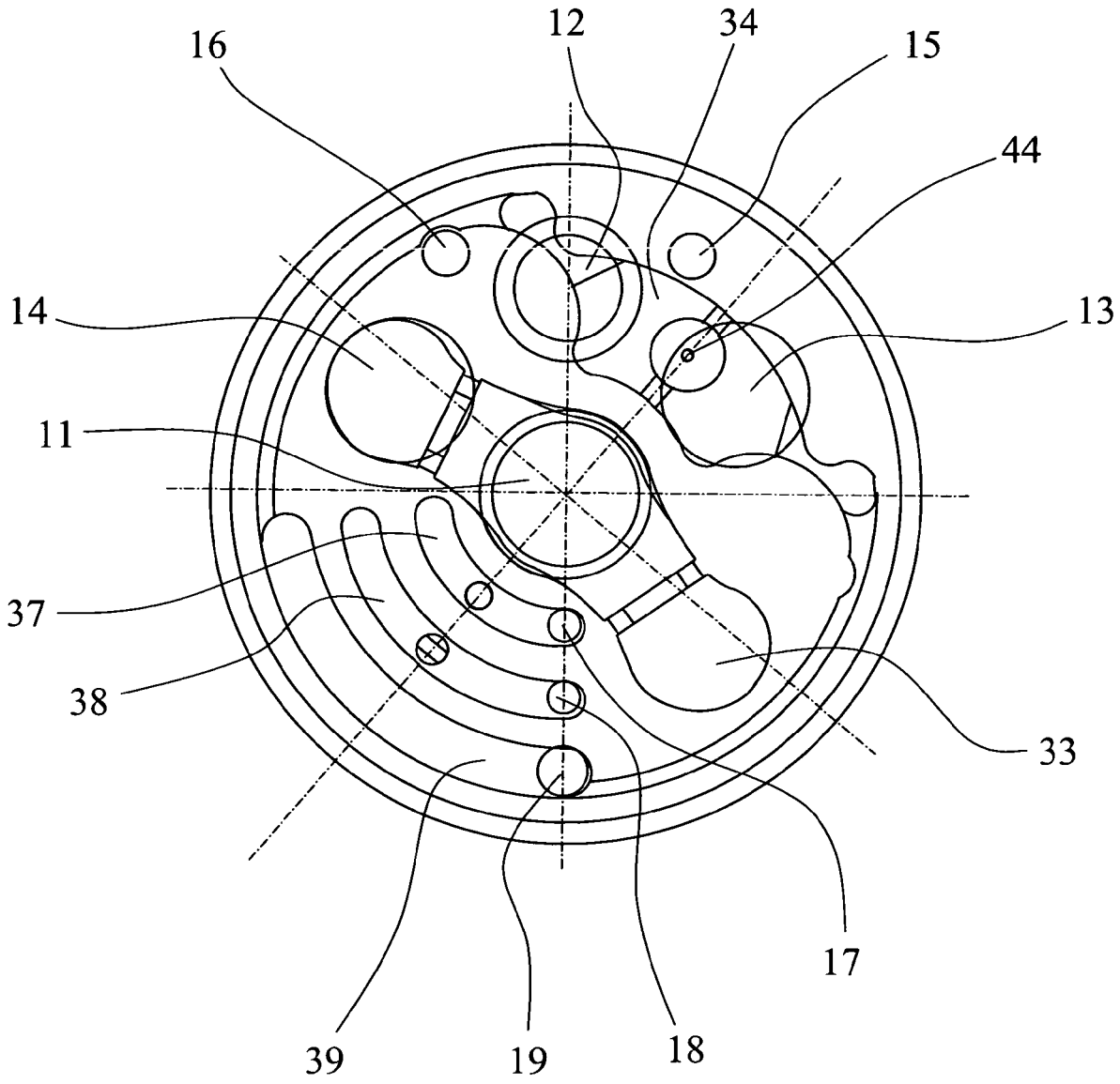


Fig.8b

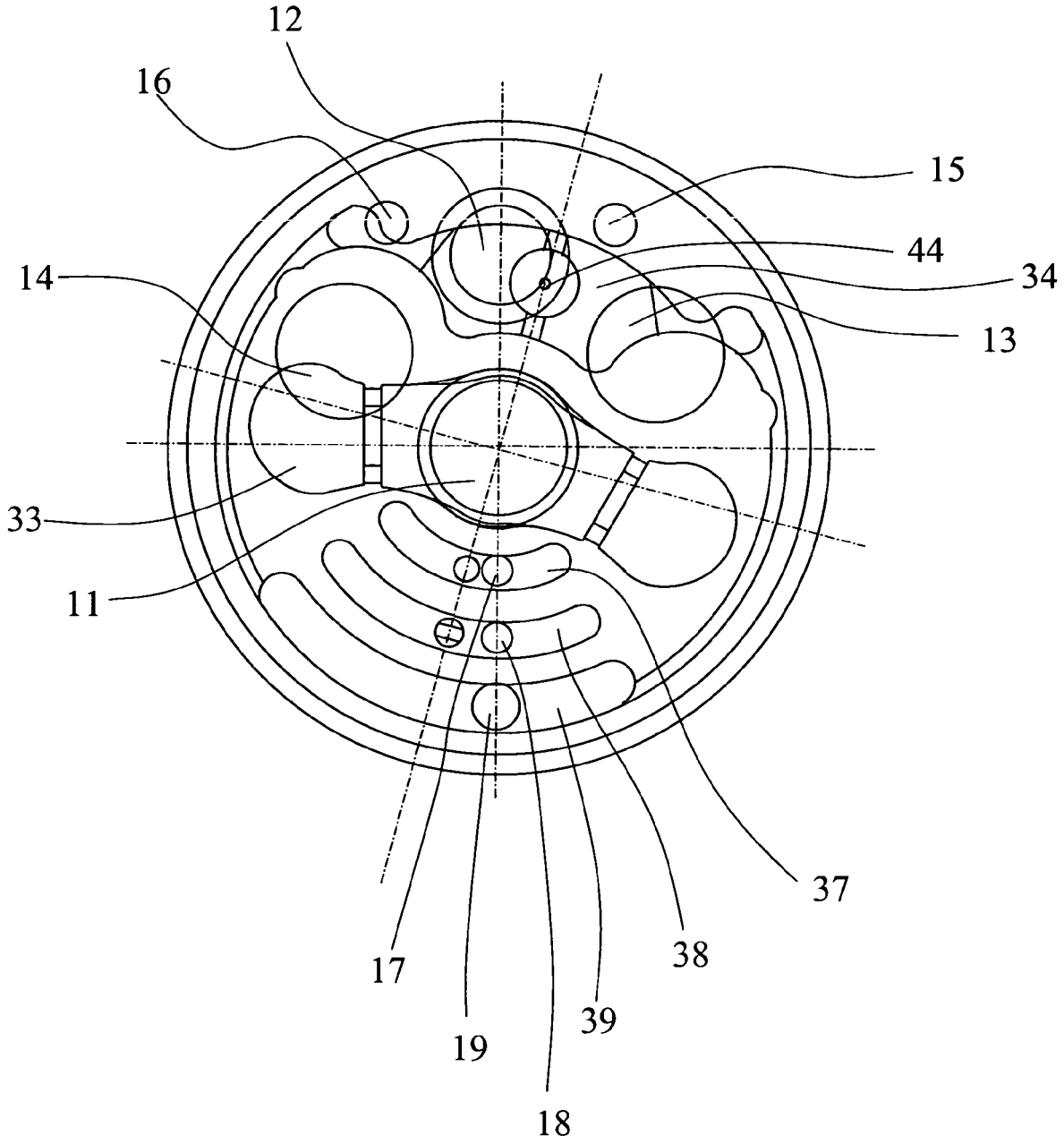


Fig.8c

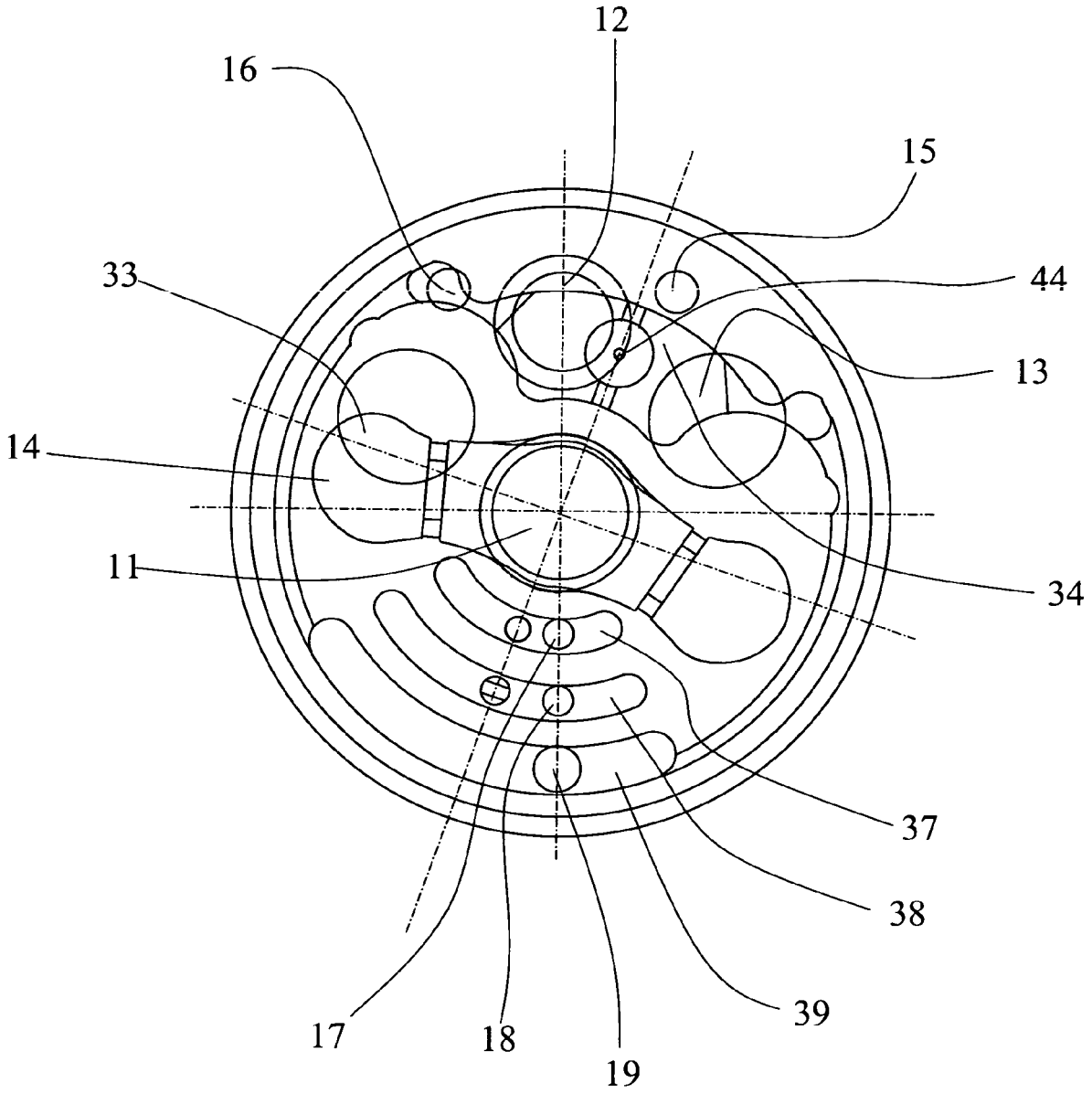


Fig.9a

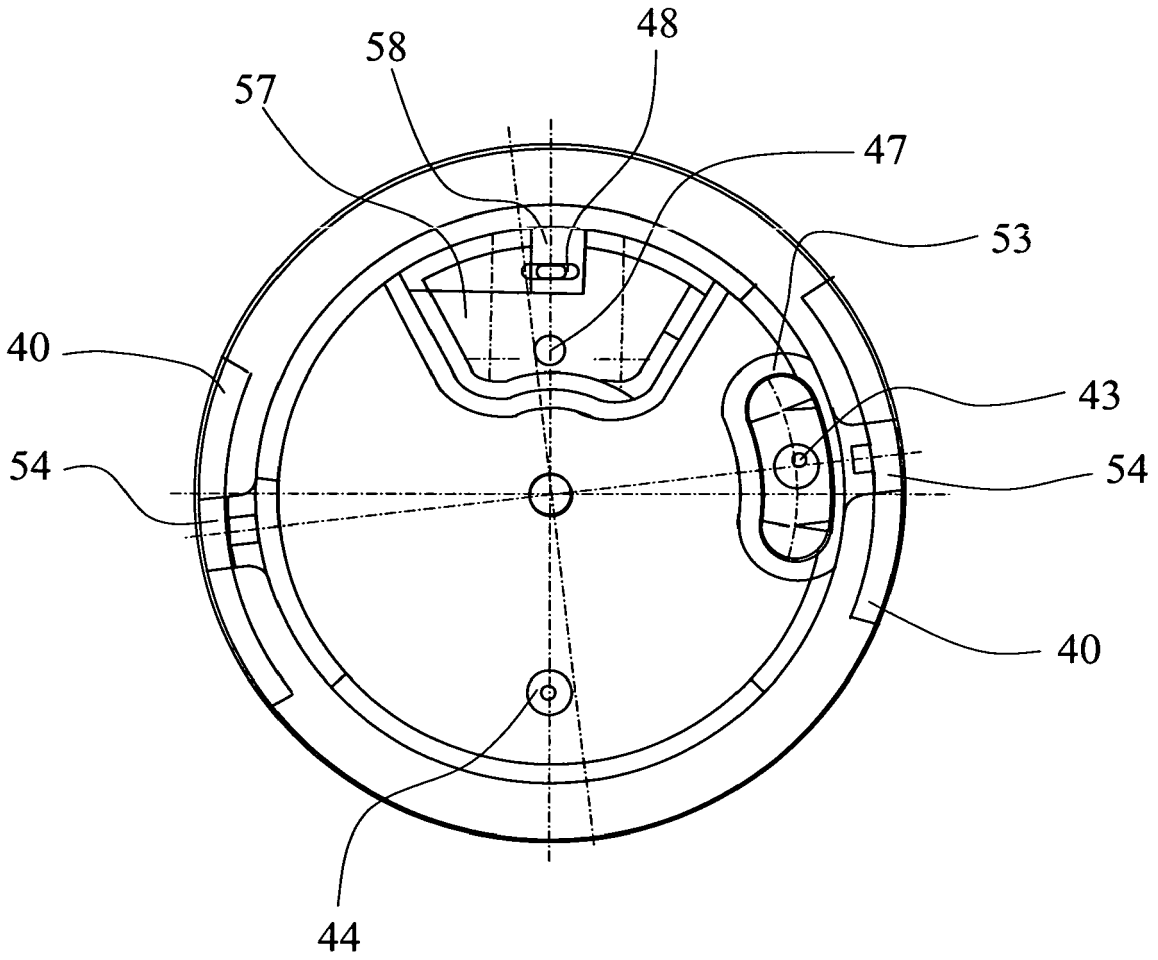


Fig.9b

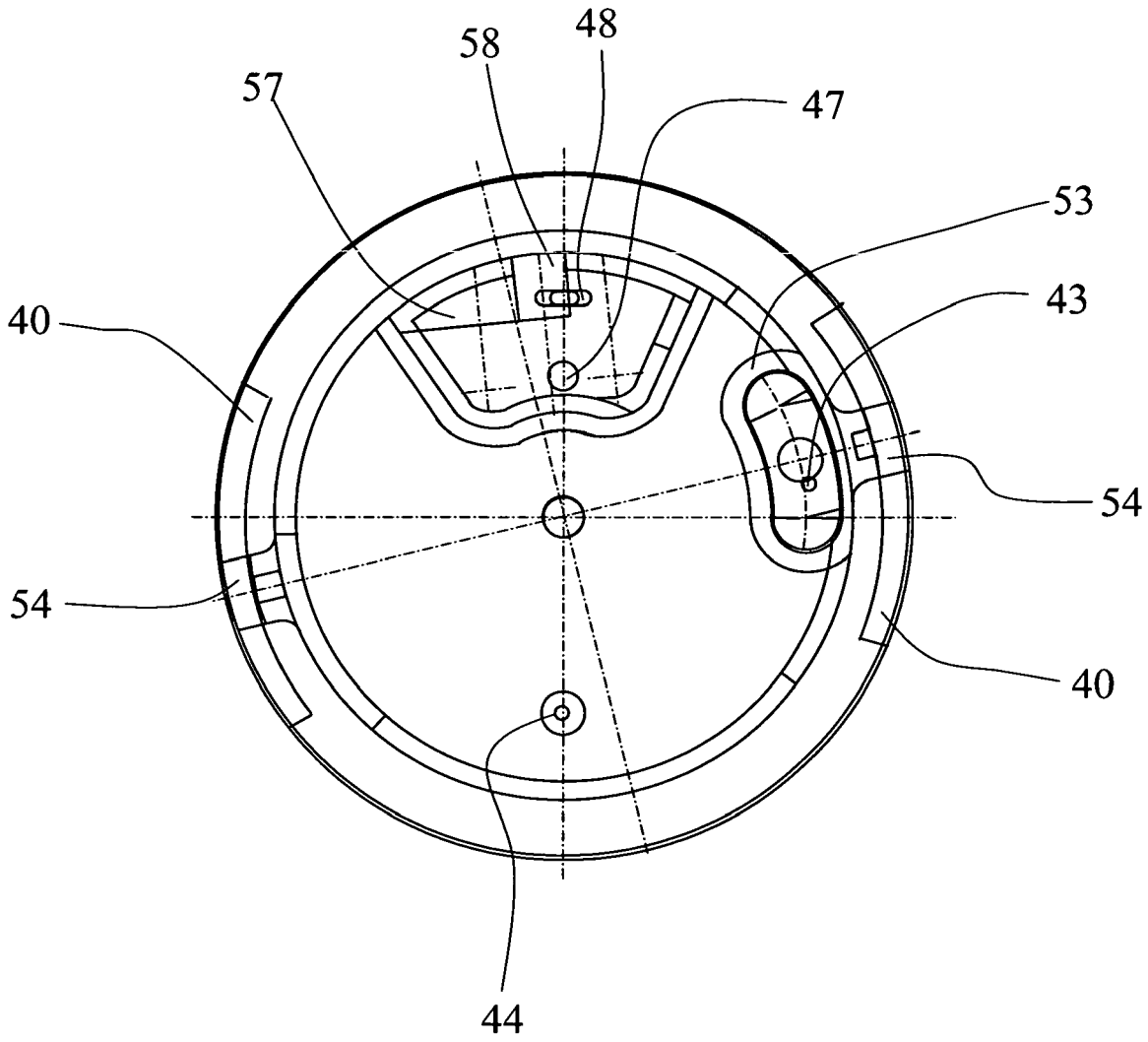


Fig.9c

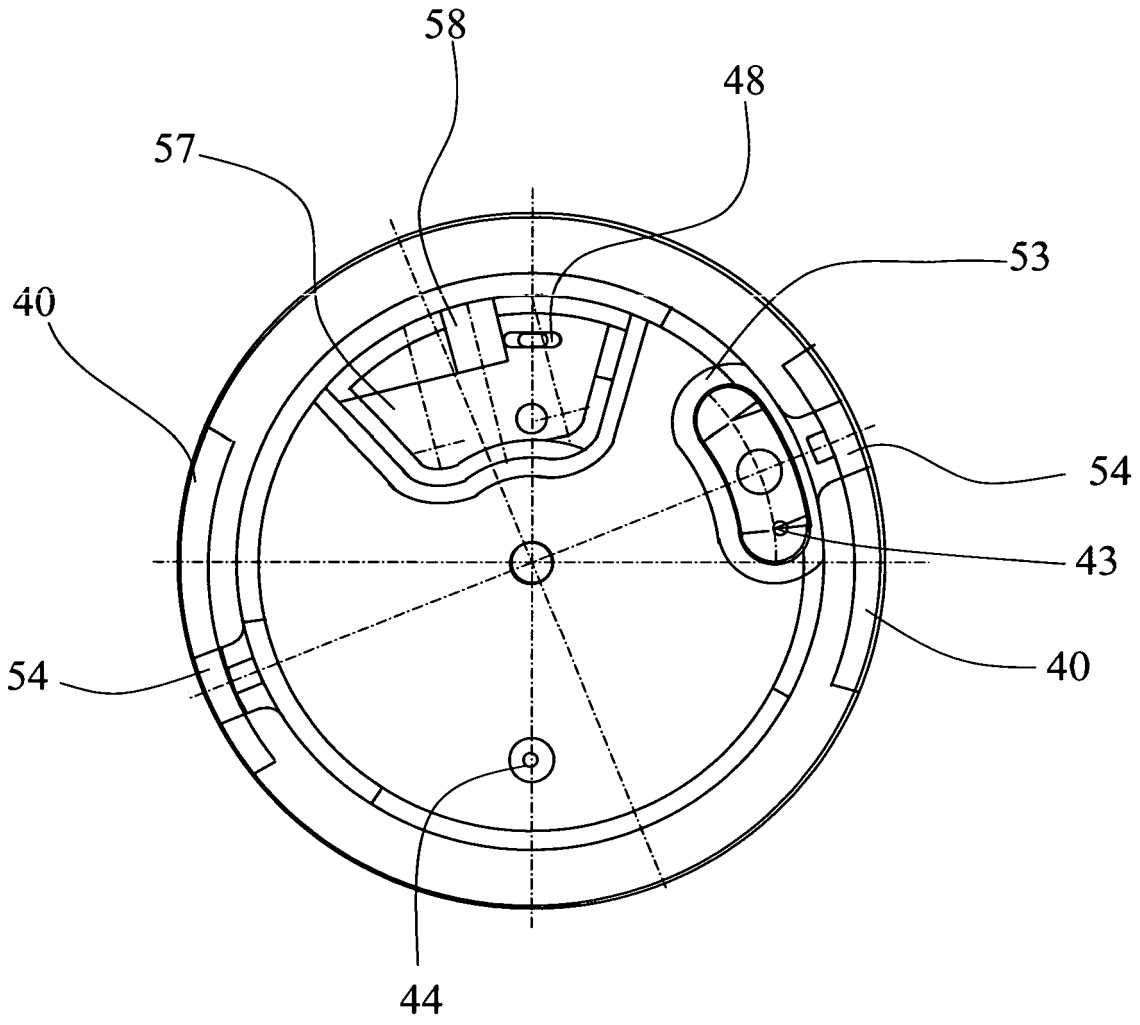


Fig.10a

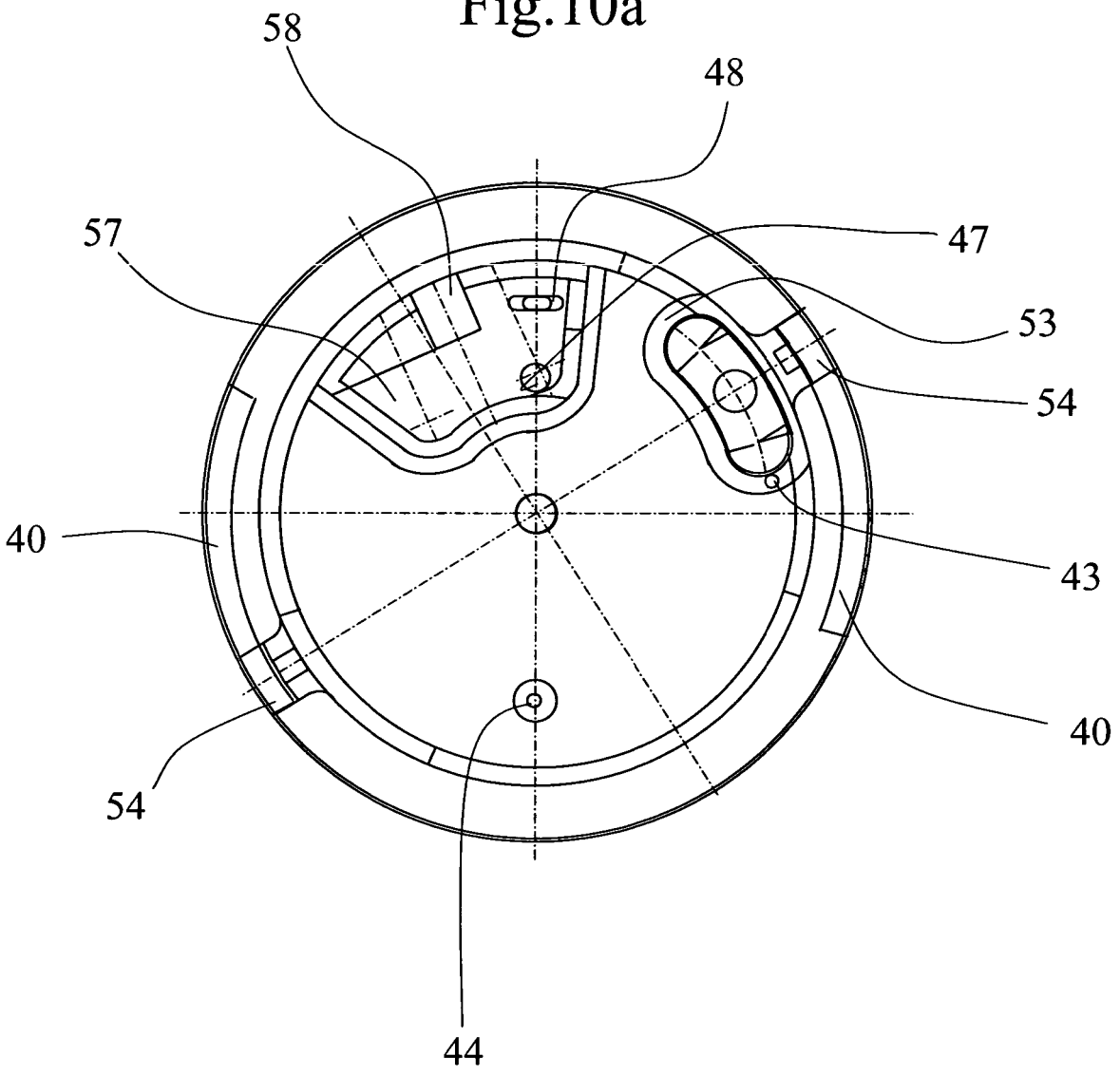
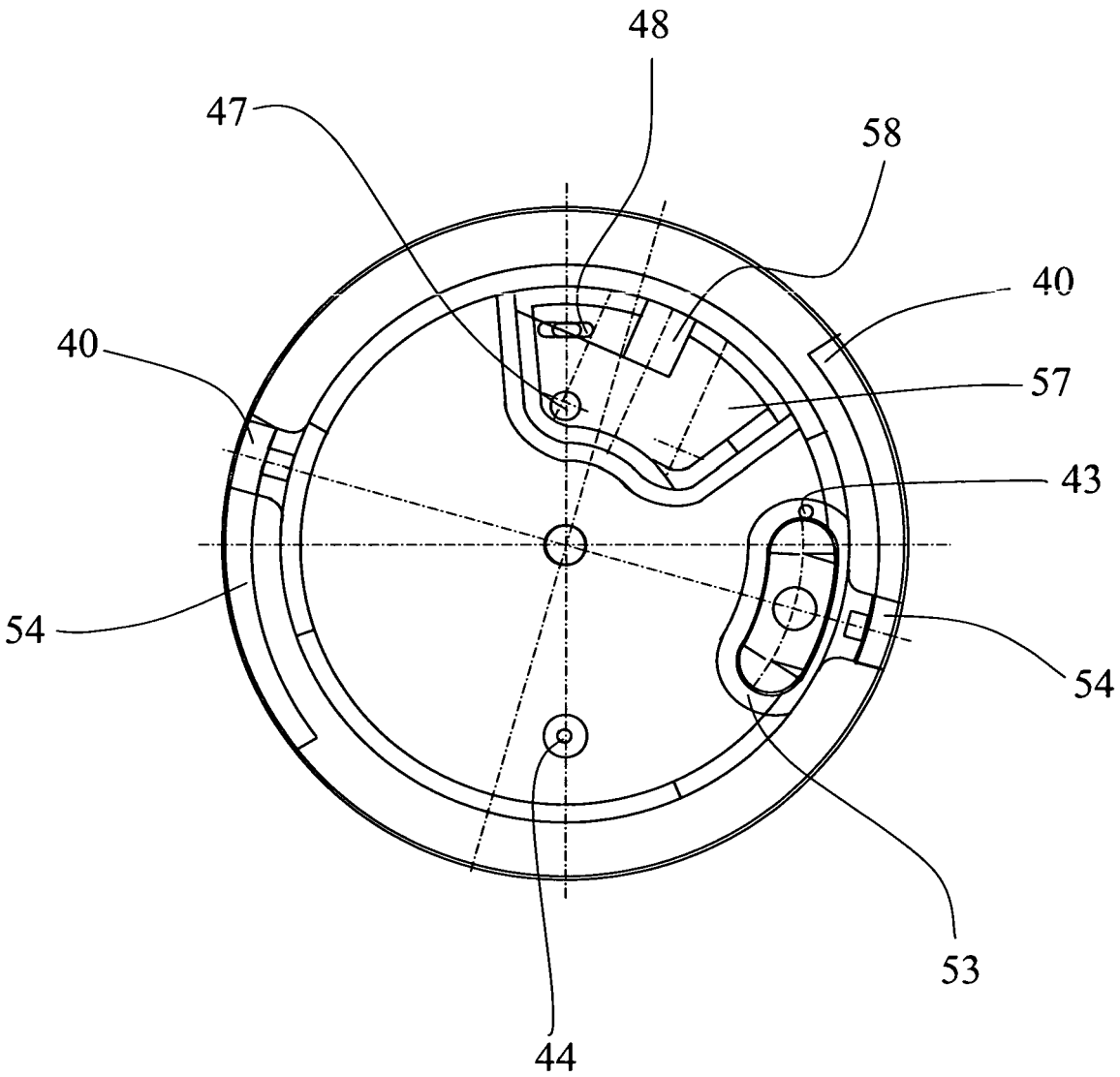


Fig.10b



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Application Number
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The present search report has been drawn up for all claims

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Munich	28 July 2005	Ritter, C

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