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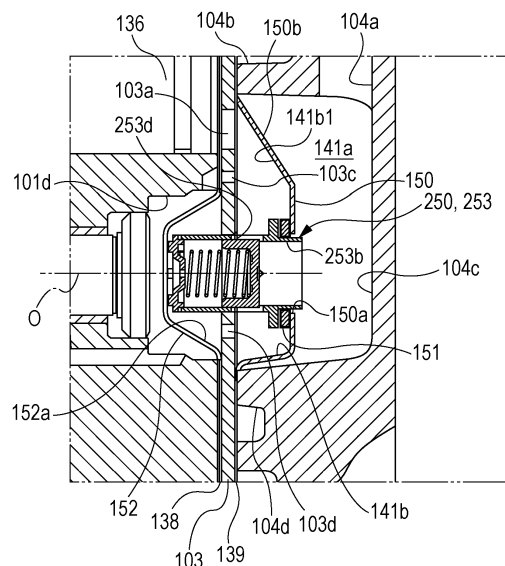
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(54) **Reciprocating compressor**

(57) A reciprocating compressor (100) includes: a suction chamber (141) into which a refrigerant flows from a suction passage (104a); a plurality of cylinder bores (101a) surrounding the drive shaft (110); a suction hole (103a); and a discharge chamber (142) surrounding the suction chamber (141). The reciprocating compressor (100) includes: a partition member (150) partitioning the suction chamber (141) into a first space portion (141a) connected to the suction passage (104a) and a second space portion (141b) connected to the suction hole (103a), and a suction throttle valve (250) that adjusts the area of an opening of a housing (253), the a suction throttle valve (250) being configured to increase the opening area as a pressure difference between the first space portion (141a) and the second space portion (141b) is increased and to decrease the opening area as the pressure difference is decreased.

FIG. 4



Description

BACKGROUND

1. Technical Field

[0001] The present invention relates to reciprocating compressors.

2. Related Art

[0002] Reciprocating compressors compress refrigerant by reciprocatingly moving a piston. Some of the reciprocating compressors are equipped with a refrigerant suction throttle valve (an aperture control valve). In a reciprocating compressor used in a conventional vehicle air conditioner system or the like, a connection port for external refrigerant circuit and a suction chamber are in communication with each other via a suction passage. The suction passage allows the refrigerant to flow into the suction chamber. Then, the reciprocating motion of the piston allows the refrigerant to be suctioned from the suction chamber via a suction hole, and then compresses and discharges the suctioned refrigerant. A suction valve disposed at a position corresponding to the suction hole is known to cause self-excited vibration, particularly when the flow rate of the refrigerant is small. Such vibration or the like may produce pressure pulsation. Then, transmission of the pressure pulsation may occur via connection piping connecting the suction chamber, the suction passage, the connection port, and the external refrigerant circuit to one another, thereby causing vibration of a heat exchanger and the like in the external refrigerant circuit.

[0003] Thus, the reciprocating compressor described in JP-A-2011-32878, for example, is provided with an aperture control valve (so-called suction throttle valve). The aperture control valve is designed to increase the opening degree of the suction passage when the flow rate of refrigerant to the suction chamber is increased. When the flow rate of refrigerant to the suction chamber is decreased, the aperture control valve decreases the opening degree of the suction passage. The aperture control valve is disposed at the suction chamber side end of the suction passage (i.e., at the outlet of the suction passage). Thus, the outlet side of the suction passage can be narrowed when the flow rate is low. In this way, transmission of pressure pulsation to the external refrigerant circuit side can be restricted. As a result, vibration of the heat exchanger and the like can be decreased.

[0004] However, in the reciprocating compressor described in JP-A-2011-32878, the vehicle layout or the like restricts the position and orientation of the suction passage. In this case, the aperture control valve may be hardly disposed at the outlet of the suction passage (suction chamber side end). Therefore, a person skilled in the art desires a means for solving such a problem.

SUMMARY

[0005] The present invention has been made in consideration of the above problem, and an object of the present invention is to provide a reciprocating compressor in which an aperture control valve can be installed without being restricted by the position and/or orientation of a suction passage.

[0006] To achieve the object, a reciprocating compressor of a first embodiment of the present invention, includes: a suction chamber disposed on one end side of a drive shaft and into which a refrigerant flows from a suction passage; a plurality of cylinder bores arranged around the drive shaft; a suction hole corresponding to each of the cylinder bores; and a discharge chamber in annular shape concentrically disposed outside the suction chamber. Pistons in the cylinder bores are reciprocated by rotation of the drive shaft to compress the refrigerant suctioned into the cylinder bores from the suction chamber via the suction hole and discharge the compressed refrigerant via the discharge chamber. the reciprocating compressor includes: a partition member partitioning the suction chamber into a first space portion connected to the suction passage and a second space portion connected to the suction hole, and an aperture control valve that adjusts the area of an opening of a communication portion penetrating the partition member and providing communication between the first space portion and the second space portion, the aperture control valve being configured to increase the opening area as a pressure difference between the first space portion and the second space portion is increased and to decrease the opening area as the pressure difference is decreased.

[0007] In the reciprocating compressor according to the embodiment of the present invention, the suction chamber is partitioned by the partition member into the first space portion and the second space portion. The suction passage is connected to the first space portion, and the suction hole is connected to the second space portion. The communication portion penetrates the first space portion and the second space portion. The aperture control valve decreases the opening area of the communication portion as the pressure difference between the first space portion and the second space portion is decreased. In this way, transmission of pressure pulsation to the external refrigerant circuit side can be restricted. Thus, the reciprocating compressor according to the embodiment of the present invention can adjust the opening area of the communication portion penetrating the first space portion and the second space portion. Therefore, a reciprocating compressor can be provided such that an aperture control valve can be disposed without restrictions due to the position and/or orientation of the suction passage.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

FIG. 1 is a cross sectional view of a reciprocating compressor according to a first embodiment of the present invention;

FIG. 2 is a view of a cylinder head in the embodiment as viewed from the valve plate side;

FIG. 3 is a top view of a valve plate in the embodiment;

FIG. 4 is a partially enlarged view of FIG. 1;

FIG. 5 is a top view of a head gasket and a partition member in the embodiment;

FIG. 6 is a partial cross sectional view taken along A-A of FIG. 4;

FIG. 7 is an enlarged cross sectional view of a suction throttle valve in the embodiment, seated on a valve seat of a valve body;

FIG. 8 is an enlarged cross sectional view of the suction throttle valve in the embodiment, omitting illustration of the valve body and a compression coil spring;

FIG. 9 is a side view of the suction throttle valve as viewed from arrow direction B in FIG. 7;

FIG. 10 is a partial cross sectional view of the reciprocating compressor according to a second embodiment of the present invention;

FIG. 11 is a cross sectional view of a support member illustrated in FIG. 10; and

FIG. 12 is a partial cross sectional view of the reciprocating compressor according to a third embodiment of the present invention.

DETAILED DESCRIPTION

[0009] In the following detailed description, for purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

[0010] In the following, embodiments of the present invention will be described with reference to the attached drawings. FIG. 1 is a cross sectional view of a swash plate type variable displacement compressor 100 as an example of a reciprocating compressor to which the present invention is applied. The variable displacement compressor 100 is connected to an external refrigerant circuit (not shown). The variable displacement compressor 100 compresses and discharges a refrigerant, suctioned from the external refrigerant circuit, by reciprocating a plurality of pistons 136. According to the present embodiment, the variable displacement compressor 100 is envisioned to be used in a vehicle air conditioner system.

[0011] As illustrated in FIG. 1, the variable displacement compressor 100 includes a cylinder block 101, a front housing 102, and a cylinder head 104. In the cylinder block 101, cylinder bores 101a in which the pistons 136 are disposed are formed. The front housing 102 is provided at one end of the cylinder block 101. The cylinder head 104 is provided at the other end of the cylinder block 101 via a valve plate 103 and the like.

[0012] The cylinder block 101 and the front housing 102 form a crank chamber 140 to the back of the pistons 136. A drive shaft 110 is provided traversing the crank chamber 140. The drive shaft 110 is rotatably supported by the cylinder block 101 and the front housing 102. In the cylinder block 101, the cylinder bores 101a are arranged around the drive shaft 110.

[0013] Around an intermediate portion of the drive shaft 110 in an axial direction thereof, a swash plate 111 is disposed. At the center of the swash plate 111, a through-hole 111b is formed. The drive shaft 110 is inserted in the through-hole 111b. A rotor 112 is fixed to the drive shaft 110. The swash plate 111 is coupled via a link mechanism 120 to the rotor 112 that integrally rotates with the drive shaft 110. The link mechanism 120 enables the swash plate 111 to rotate with the drive shaft 110 and the rotor 112, and also enables the inclination angle of the swash plate 111 to be varied with respect to the axis of the drive shaft 110.

[0014] The link mechanism 120 includes a first arm 112a protruding from the rotor 112, a second arm 111a protruding from the swash plate 111, and a link arm 121. One end of the link arm 121 is rotatably coupled via a first coupling pin 122 to the first arm 112a. The other end of the link arm 121 is rotatably coupled via a second coupling pin 123 to the second arm 111a.

[0015] The through-hole 111b of the swash plate 111 is formed in a shape allowing the swash plate 111 to be inclined in a range from a maximum inclination angle to a minimum inclination angle. According to the present embodiment, in the through-hole 111b, a minimum inclination angle-restricting portion is formed. The minimum inclination angle-restricting portion abuts the drive shaft 110, thereby restricting the inclination angle displacement (tilting) of the swash plate 111 in a direction of decreasing inclination angle. For example, the inclination angle of the swash plate 111 is zero when the swash plate 111 is perpendicular to the drive shaft 110. In this case, the minimum inclination angle-restricting portion is formed such that the inclination angle displacement (tilting) of the swash plate 111 is permitted until the inclination angle of the swash plate 111 becomes effectively zero. The inclination angle displacement (tilting) of the swash plate 111 in a direction of increasing inclination angle is restricted by the swash plate 111 abutting the rotor 112. Thus, the inclination angle of the swash plate 111 is at the maximum inclination angle when the swash plate 111 abuts the rotor 112.

[0016] On the drive shaft 110, an inclination angle reducing spring 114 and an inclination angle increasing

spring 115 are attached across the swash plate 111. The inclination angle reducing spring 114 biases the swash plate 111 in the direction of decreasing inclination angle. The inclination angle increasing spring 115 biases the swash plate 111 in the direction of increasing inclination angle. Specifically, the inclination angle reducing spring 114 is mounted between the swash plate 111 and the rotor 112. The inclination angle increasing spring 115 is mounted between the swash plate 111 and a spring support member 116 provided on the drive shaft 110.

[0017] The biasing forces of the inclination angle increasing spring 115 and the inclination angle reducing spring 114 are set such that, when the inclination angle of the swash plate 111 is the minimum inclination angle, the biasing force of the inclination angle increasing spring 115 is greater than the biasing force of the inclination angle reducing spring 114. Thus, when the drive shaft 110 is not rotating; namely, when the variable displacement compressor 100 is stopped, the inclination angle of the swash plate 111 is an inclination angle ($>$ minimum inclination angle) such that the biasing force of the inclination angle reducing spring 114 and the biasing force of the inclination angle increasing spring 115 balance each other out.

[0018] One end of the drive shaft 110 penetrates a boss portion 102a of the front housing 102 and extends externally of the front housing 102, and is coupled to a power transmission apparatus (not shown). Between the drive shaft 110 and the boss portion 102a, a shaft seal device 130 is inserted. Thus, the inside of the crank chamber 140 is shielded from the external space.

[0019] The coupled assembly of the drive shaft 110 and the rotor 112 is supported by radial bearings 131, 132 in the radial direction and by a thrust bearing 133 and a thrust plate 134 in the thrust direction. The end of the drive shaft 110 on the thrust plate 134 side and the thrust plate 134 are adjusted to have a predetermined gap by an adjust screw 135. The drive shaft 110 is rotated in synchronism with the power transmission apparatus as power from the external drive source, (not shown), is transmitted to the power transmission apparatus.

[0020] In the cylinder bores 101a, the pistons 136 are disposed. In a space inside of an end portion of the pistons 136 that is protruding into the crank chamber 140, an outer peripheral portion of the swash plate 111 is housed. The swash plate 111 is configured to cooperate with the pistons 136 via a pair of shoes 137. The shoes 137 convert the rotating motion of the swash plate 111 into a reciprocating motion of the pistons 136. Thus, the pistons 136 are reciprocated within the cylinder bores 101a.

[0021] In the cylinder head 104, a suction chamber 141 and a discharge chamber 142 are separately formed. The suction chamber 141 is disposed at one end side of the drive shaft 110 (specifically, on the extension of an axis O). The discharge chamber 142 in annular shape is concentrically disposed outside the suction chamber 141, as illustrated in FIG. 1 and FIG. 2. Specifically, the

suction chamber 141 is in communication with the cylinder bores 101a via suction holes 103a and suction valves (not shown) formed in a suction valve forming plate. The suction holes 103a (see FIG. 1 and FIG. 3) are formed in a valve plate 103 abutting a suction chamber side surface of the cylinder head 104 (that is, disposed between the cylinder head 104 and the cylinder block 101), each corresponding to the respective cylinder bores 101 a. Thus, when the pistons are reciprocated by rotation of the drive shaft 110, the refrigerant suctioned from the suction chamber 141 via the suction holes 103a and the like into the cylinder bores 101a is compressed therein. The compressed refrigerant is discharged into a discharge side refrigerant circuit via the discharge chamber 142 as well as a muffler 143 and a discharge port 106a which will be described below.

[0022] According to the present embodiment, the suction holes 103a are arranged as illustrated in FIG. 3. That is, when the valve plate 103 is assembled between the cylinder head 104 and the cylinder block 101, the respective suction holes 103a are spaced from the axis O of the drive shaft 110 in a circumferential direction with approximately equal distance therefrom, and are spaced apart from each other at approximately equal intervals around the drive shaft 110. A communication hole 150a which will be described below is formed with its center of opening aligned with the axis O of the drive shaft 110. In other words, the suction holes 103a are spaced apart in a circumferential direction of the communication hole 150a, with approximately equal distance from the center of opening of the communication hole 150a.

[0023] The discharge chamber 142 is in communication with the cylinder bores 101 a via a discharge valve (not shown) formed in the discharge valve forming plate, and via discharge holes 103b formed in the valve plate 103. The suction chamber 141 and the discharge chamber 142 are partitioned by a partition wall 104b. The partition wall 104b is formed in an approximately circular ring shape about the axis O of the drive shaft 110. The suction chamber 141 as a whole has an approximately circular shape.

[0024] The front housing 102, a center gasket (not shown), the cylinder block 101, a cylinder gasket 138, the suction valve forming plate (not shown), the valve plate 103, the discharge valve forming plate (not shown), a head gasket 139, and the cylinder head 104 are fastened by a plurality of through bolts 105, forming a housing. FIG. 4 is a partial cross sectional view of the cylinder gasket 138, the valve plate 103, and the head gasket 139. FIG. 5 is a top plan view of the head gasket 139.

[0025] In the cylinder head 104, a suction passage 104a having a connection port 104a' is formed. The connection port 104a' is connected to a suction side refrigerant circuit of the aforementioned vehicle air conditioner system. Thus, refrigerant flows into the suction chamber 141 (a first space portion 141 a which will be described below) from the suction passage 104a. The suction passage 104a extends from the outer periphery of the cylinder

der head 104 into the suction chamber 141 in a straight line, traversing a part of the discharge chamber 142.

[0026] The suction chamber 141 is partitioned by the partition member 150 into the first space portion 141a connected to the suction passage 104a, and the second space portion 141b connected to the suction holes 103a. In the partition member 150, the communication hole 150a providing communication between the first space portion 141a and the second space portion 141b is formed. The partition member 150 and the communication hole 150a will be described in detail below.

[0027] In the second space portion 141b, a suction throttle valve 250 is disposed. The suction throttle valve 250 adjusts its opening degree in accordance with a change in flow rate of the refrigerant flowing into the second space portion 141b from the first space portion 141a via the communication hole 150a. The suction throttle valve 250 will also be described in detail below.

[0028] As illustrated in FIG. 1, the muffler 143 is provided on the outside of the cylinder block 101. The muffler 143 includes a tubular wall 101b extending upward from an outer surface of the cylinder block 101, and a lid member 106 with a bottomed tubular shape which is coupled to the tubular wall 101b via a seal member (not shown). In the lid member 106, the discharge port 106a is formed. The discharge port 106a is connected to the discharge side refrigerant circuit of the vehicle air conditioner system. A muffler space 143a in the muffler 143 and the discharge chamber 142 are in communication via a communication passage 144. The communication passage 144 is formed through the cylinder block 101, the valve plate 103, and the cylinder head 104. The muffler space 143a and the communication passage 144 form a discharge passage providing communication between the discharge chamber 142 and the discharge port 106a. The muffler 143 forms the muffler space 143a in the discharge passage.

[0029] A check valve 200 for opening or closing the inlet to the muffler 143 is disposed in the muffler 143. The check valve 200 is disposed where the communication passage 144 and the muffler space 143a are connected. The check valve 200 operates responsive to a pressure difference between the communication passage 144 (upstream side) and the muffler space 143a (downstream side). For example, the check valve 200 is opened when the difference (pressure difference) between a pressure P_u in the communication passage 144 (upstream side pressure) and a pressure P_d in the muffler space 143a (downstream side pressure) is greater than a predetermined value SL ($P_u - P_d > SL > 0$). The check valve 200 is closed, for example, when the pressure difference is equal to or less than the predetermined value SL .

[0030] The cylinder head 104 is further fitted with a control valve 300. The control valve 300 adjusts the opening degree of a pressure supply passage 145 providing communication between the discharge chamber 142 and the crank chamber 140. In this way, the control valve 300

controls the amount of discharge gas introduced into the crank chamber 140. The refrigerant in the crank chamber 140 flows into the suction chamber 141 (second space portion 141b) via a pressure release passage 146 (which will be described below).

[0031] Hence, the control valve 300 adjusts the amount of discharged refrigerant introduced into the crank chamber 140 to vary the pressure of the crank chamber 140, thereby varying the inclination angle of the swash plate 111, or the stroke of the pistons 136. Therefore, the control valve 300 can variably control the discharge displacement of the variable displacement compressor 100.

[0032] The control valve 300 includes a solenoid. The amount of power flowing in the solenoid is adjusted based on an external signal. The control valve 300 variably controls the discharge displacement to give a predetermined pressure of the suction chamber 141 (the first space portion 141a or the second space portion 141b), which is introduced into a pressure sensing chamber of the control valve 300 via the pressure introduction passage 147. The control valve 300 may also forcibly open the pressure supply passage 145 by cutting the supply of power to the solenoid. The control valve 300 therefore controls the discharge displacement of the variable displacement compressor 100 to be at a minimum.

[0033] In the following, referring to FIGS. 2 to 6, the partition member 150, the communication hole 150a, and the pressure release passage 146 among others will be described in detail.

[0034] The partition member 150 is formed, as will be described below, by a protrusion of the head gasket 139. In addition, as described above, the partition member 150 partitions the suction chamber 141 into the first space portion 141a connected to the suction passage 104a and the second space portion 141b connected to the suction holes 103a. Thus, the suction chamber 141 is partitioned into the second space portion 141b directly connected to the suction holes 103a, and the first space portion 141a providing a space on the upstream side of the second space portion.

[0035] As illustrated in FIG. 4 and FIG. 5, the second space portion 141b extends radially from the center toward the respective suction holes 103a. The second space portion 141b is provided with guide passages 141b1. The guide passages 141b1 guide the suction refrigerant flowing out of the suction throttle valve 250. As illustrated in FIG. 6, the guide passages 141b1 include a bottom wall 150b and side walls 150c. As illustrated in FIG. 4, the bottom wall 150b is formed as an inclined wall portion with decreasing passage cross sectional area toward the suction holes 103a.

[0036] In the partition member 150, the communication hole 150a is formed. The communication hole 150a is formed, for example, to communicate between the first space portion 141a and the second space portion 141b at the radial center of the suction chamber 141. Specifically, the communication hole 150a is formed such that the center of opening of the communication hole 150a is

aligned with the axis O of the drive shaft 110.

[0037] As described herein, the second space portion 141b is directly connected to the suction holes 103a while being partitioned from the suction passage 104a by the partition member 150. Thus, the second space portion 141b is substantially a suction chamber. The first space portion 141a directly connected to the suction passage 104a may be regarded as a part of the suction passage. The communication hole 150a substantially provides a suction passage outlet. The first space portion 141a is an extension space that functions as a muffler. In this configuration, the substantial suction passage outlet (communication hole 150a) can be disposed at the radial center of the suction chamber 141 without being influenced by the position and/or orientation of the suction passage 104a formed in the cylinder head 104.

[0038] On a suction chamber forming wall of the cylinder head 104 facing the valve plate 103, a plurality of protrusion portions 104d is provided. The protrusion portions 104d press portions of the head gasket 139 corresponding to the peripheral edge portions of the partition member onto the valve plate side. Specifically, the protrusion portions 104d extend from the bottom wall 104c (the suction chamber forming wall) of the cylinder head 104 in such a way as to press regions between the guide passages 141b1. The protrusion portions 104d press the valve plate 103 via the head gasket 139 and the discharge valve forming plate. The protrusion portions 104d in annular shape are disposed concentrically to the center of the cylinder head 104 at approximately equal intervals (see FIG. 2 and FIG. 4).

[0039] The head gasket 139 is disposed between the valve plate 103 and the cylinder head 104. For example, the partition member 150 is formed by causing a part of the head gasket 139 facing the suction chamber 141 to protrude into the suction chamber 141. Thus, the partition member 150 is formed by utilizing the head gasket 139. Therefore, there is no need to add a new component as the partition member 150. There is also no need to separately add a structure for fixing the partition member 150 within the suction chamber 141. As a result, cost increase due to the provision of the partition member 150 can be limited. The head gasket 139 is a rubber coated thin plate of metal. The partition member 150 is pressed integrally with the head gasket 139 and then provided with rubber coating. That is, the partition member 150 and the head gasket 139 are integrally formed. In radially outside regions of the head gasket 139 corresponding to the discharge chamber 142, retainers 139a (see FIG. 5) are formed. The retainers 139a restrict the opening degree of the discharge valve.

[0040] Both sides of the side walls 150c where the guide passages 141b1 of the partition member 150 are formed, provided are flat portions 139b (see FIG. 6) of the head gasket 139. The flat portions 139b are pressed by the protrusion portions 104d. In this way, the partition member 150 can be securely retained on the valve plate 103 side, whereby vibration of the partition member 150

can be suppressed.

[0041] In the bottom wall 150b of one of the guide passages 141b1 that is disposed below the axis O of the drive shaft 110 in gravity direction, a small hole 150d (see FIG. 5) is formed. The small hole 150d provides communication between the first space portion 141a and the guide passages 141b1 (namely, the second space portion 141b). The small hole 150d is provided to return oil that accumulates below the first space portion 141a in gravity direction back into the second space portion 141b.

[0042] The pressure release passage 146 provides communication between the crank chamber 140 and the second space portion 141b, which are on the back of the pistons 136, to release the pressure from the inside of the crank chamber. For example, the pressure release passage 146 may include a communication passage 101c (see FIG. 1) formed in the cylinder block 101 in parallel with the drive shaft 110, a space 101d (see FIG. 1 and FIG. 4) formed at the end of the drive shaft 110, a communication hole (not shown) formed in each of the cylinder gasket 138 and the suction valve forming plate, an orifice 103c (see FIG. 1 and FIG. 4) formed in the valve plate 103, and a communication hole formed in the discharge valve forming plate. The refrigerant in the crank chamber 140 flows into the suction chamber 141 (second space portion 141b) via the pressure release passage 146.

[0043] Referring now to FIG. 1, FIG. 4, and FIGS. 7 to 9, the structure of the suction throttle valve 250 and a method of retaining it will be described in detail. In FIG. 8, a valve body 251 and a compression coil spring 252 which will be described below are not shown.

[0044] The suction throttle valve 250 is an aperture control valve configured to adjust the opening area of a communication portion, penetrating the partition member 150 and providing communication between the first space portion 141a and the second space portion 141b, in accordance with a pressure difference between the first space portion 141a and the second space portion 141b. The suction throttle valve 250 increases the opening area as the pressure difference is increased, and decreases the opening area as the pressure difference is decreased. According to the present embodiment, the communication portion penetrating the partition member 150 and providing communication between the first space portion and the second space portion refers to a housing 253 including a peripheral wall 253e1, a flange portion 253e2, and a peripheral wall 253e3 which will be described below. The suction throttle valve 250 corresponds to "aperture control valve" according to the present invention.

[0045] The structure of the suction throttle valve 250 will be described. Specifically, the suction throttle valve 250 includes a valve body 251, a compression coil spring 252, the housing 253, and a cap 254. The valve body 251, the housing 253, and the cap 254 may be made by resin molding.

[0046] The valve body 251 includes a cylindrical pe-

ripheral wall, and an end wall closing one end of the peripheral wall.

[0047] The compression coil spring 252 biases the valve body 251. One end of the compression coil spring 252 abuts the end wall of the valve body 251, and the other end abuts the cap 254. In this way, the compression coil spring 252 biases the valve body 251 toward a valve seat 253c as will be described below.

[0048] The housing 253 includes the peripheral wall 253e1, the flange portion 253e2 formed on an outer periphery of the peripheral wall 253e1, and the peripheral wall 253e3 extending from one end portion of the peripheral wall 253e1. As previously stated, the housing 253 corresponds to "communication portion" according to the present invention.

[0049] The peripheral wall 253e1 forms a cylindrical valve chamber 253a (see FIG. 7 and FIG. 8) housing the valve body 251 and the compression coil spring 252. The suction throttle valve 250 includes an inlet opening 253b and a plurality of outlet openings 253d. The inlet opening 253b is opened toward the first space portion 141a. The outlet openings 253d are opened in a radial direction of the second space portion 141b.

[0050] Specifically, the inlet opening 253b is formed by opening the end of the housing 253 on the peripheral wall 253e3 side in the direction of the axis O of the drive shaft 110. The housing 253 as the communication portion is positioned at the radial center of the suction chamber 141. Specifically, as illustrated in FIG. 4, the end of the housing 253 on the peripheral wall 253e3 side is inserted in, and connected to, the communication hole 150a of the partition member 150. In this way, communication is provided between the inlet opening 253b and the first space portion 141a. The inlet opening 253b provides communication between the valve chamber 253a and the first space portion 141a. The inlet opening 253b is formed with an inner diameter (inner diameter of the peripheral wall 253e3) smaller than an inner diameter of the cylindrical valve chamber 253a (inner diameter of the peripheral wall 253e1), as illustrated in FIG. 7. Thus, as illustrated in FIG. 7 and FIG. 8, one end portion of the peripheral wall 253e3 provides a valve seat 253c with which the end wall of the valve body 251 comes into or out of contact. The end wall of the valve body 251, by coming into or out of contact with the valve seat 253c, operates to open or close the inlet opening 253b.

[0051] Specifically, the plurality of outlet openings 253d is formed by opening the outer periphery of the peripheral wall 253e1 of the housing 253. The outlet openings 253d communicate between the valve chamber 253a and the second space portion 141b. The outlet openings 253d are spaced apart at substantially equal intervals along the outer periphery of the peripheral wall 253e1. The number of the outlet openings 253d is, for example, four. Thus, the first space portion 141a is placed in communication with the second space portion 141b via the communication portion (housing 253).

[0052] As illustrated in FIG. 8 and FIG. 9, the outlet

openings 253d provide triangular opening portions, for example, with one of the vertexes of each triangle pointing toward the inlet opening 253b. The vertex provides a minimum opening portion 253d1 that is not completely closed by the peripheral wall of the valve body 251 even when the end wall of the valve body 251 abuts the valve seat 253c (see FIG. 7). The minimum opening portion 253d1 prevents the first space portion 141a and the second space portion 141b from being shut off from each other, thus providing communication therebetween at all times. The opening area of the minimum opening portion 253d1 is set to a minimum area such that self-excited vibrations of the valve body 251 itself in a region of a very small flow rate of refrigerant can be suppressed. The opening area of the communication portion according to the present embodiment refers to the area of the outlet openings 253d that is not closed by the peripheral wall of the valve body 251. Thus, in the present embodiment, the suction throttle valve 250 adjusts the substantial area of the outlet openings 253d of the housing 253 operating as the communication portion. Further, the suction throttle valve 250 includes the minimum opening portion 253d1. Thus, the suction throttle valve 250 is configured to prevent the opening portion of the communication portion from being completely closed.

[0053] The cap 254 closes an open end portion of the housing 253. The cap 254 is securely fitted in the open portion of the housing 253 at the other end of the peripheral wall 253e1. Thus, the cap 254 closes the open portion of the peripheral wall 253e1 at the other end side thereof. At the center of the cap 254, a communication hole 254a is formed. In the valve plate 103, a communication hole 103d (see FIG. 3 and FIG. 4) is formed. The communication hole 103d provides communication between a space 152a in a support member 152, which will be described below, and the second space portion 141b. In this way, a space 255 (see FIG. 7) partitioned by the valve body 251, the peripheral wall 253e1 of the housing 253, and the cap 254 is placed in communication with the second space portion 141b via the communication hole 254a, the space 152a, and the communication hole 103d of the valve plate 103. As a result, the pressure of the second space portion 141b acts in the space 255.

[0054] On the cap 254, a plurality of protrusions 254b (see FIGS. 7 to 9) is formed. Thus, even when the other end portion of the suction throttle valve 250 abuts the support member 152, a gap is formed by the protrusions 254b between the other end portion of the suction throttle valve 250 and the support member 152. Therefore, the opening of the communication hole 254a can be prevented or restricted from being shut off by the support member 152. In this way, the pressure of the second space portion 141b can be caused to securely act in the space 255 within the suction throttle valve 250.

[0055] Next, the structure for holding the suction throttle valve 250 will be described. At the radial center of a discharge valve forming plate (not shown), the valve plate 103 (see FIG. 3), and a suction valve forming plate (not

shown), through-holes (the through-hole 103e for the valve plate 103) are formed. The centers of the respective through-holes are aligned with the communication hole 150a of the partition member 150. According to the present embodiment, the through-hole 103e of the valve plate 103 is formed with a diameter slightly larger than the outer diameter of the peripheral wall 253e1. The other through-holes are formed with diameters greater than the through-hole 103e of the valve plate 103. Thus, the suction throttle valve 250 is allowed to be inserted in the through-hole 103e formed in the valve plate 103. In this way, the through-hole 103e provides a guide for restricting the movement of the suction throttle valve 250 in the radial direction. Therefore, the through-hole 103e facilitates the positioning of the suction throttle valve 250 in the radial direction. The through-hole for guiding the suction throttle valve 250 is not limited to the through-hole 103e of the valve plate 103, and may be the through-hole of the discharge valve forming plate or the through-hole of the suction valve forming plate.

[0056] When the peripheral wall 253e1 of the suction throttle valve 250 is inserted in the through-hole (such as 103e), the other end portion (the side of the cap 254) of the suction throttle valve 250 protrudes into the space 101d, as illustrated in FIG. 4. The space 101d provides a recess at the radial center of the cylinder block 101 at one end surface thereof.

[0057] The other end portion (the end on the cap 254 side) of the suction throttle valve 250 is supported by the support member 152 disposed in the space 101d. For example, the support member 152 is formed by causing a part of the cylinder gasket 138 facing the space 101d to protrude into the space 101d in a generally truncated conical shape. In this way, the need to add a new component as the support member 152 can be eliminated. Further, the need for a structure for supporting the support member 152 can be eliminated. Thus, cost increase due to the provision of the support member 152 can be limited. The cylinder gasket 138 is a rubber coated thin plate of metal. The support member 152 is pressed integrally with the cylinder gasket 138 and then rubber coated. The support member 152 provides a partition wall between a region in which the pressure of the crank chamber 140 acts and a region in which the pressure of the suction chamber 141 acts. The support member 152 can be stably held in place because its peripheral edges are sandwiched between the cylinder block 101 and the valve plate 103.

[0058] The one end portion (the end on the peripheral wall 253e3 side) of the suction throttle valve 250 is configured to be pressed toward the support member 152 via the peripheral edge portion of the communication hole 150a of the partition member 150. Thus, the suction throttle valve 250 is disposed in a region on the extension of the axis O of the drive shaft 110. When the compressor housing is formed by fastening the front housing 102, the cylinder block 101, and the cylinder head 104 together by the plurality of through bolts 105, the partition member

150 presses the one end portion of the suction throttle valve 250. At the same time, the suction throttle valve 250 is sandwiched between the partition member 150 and the support member 152. In this way, the suction throttle valve can be easily held in place.

[0059] Specifically, between the one end portion (such as one end surface of the flange portion 253e2) of the suction throttle valve 250 and the partition member 150 at the peripheral edge portion of the communication hole 150a, an elastic member 151 is disposed. Thus, the one end surface of the suction throttle valve 250 is elastically supported by the partition member 150. The elastic member 151 may include a circular ring-shaped rubber seat or an O ring. In this way, the suction throttle valve 250 can be easily pressed and held in place. The location of the elastic member 151 is not limited between the one end portion of the suction throttle valve 250 and the partition member 150, and may be between the other end portion (the end on the cap 254 side) of the suction throttle valve 250 and the support member 152 (not shown).

[0060] Operation of the suction throttle valve 250 in the variable displacement compressor 100 configured as described above will be described with reference to FIGS. 4 to 7.

[0061] When the variable displacement compressor 100 is activated and the pistons 136 are reciprocated, refrigerant is circulated in the refrigerant circuit of the air conditioner system. In accordance with the flow rate of the refrigerant, a pressure difference is produced between the first space portion 141a and the second space portion 141b. The valve body 251 receives the pressure of the first space portion 141a from the inlet opening 253b side, and also receives the pressure of the second space portion 141b from the space 255 side. Thus, the suction throttle valve 250 operates the valve body 251 responsive to the pressure difference between the first space portion 141a and the second space portion 141b. In this way, the suction throttle valve 250 adjusts the substantial opening area of the outlet openings 253d of the housing 253 as the communication portion.

[0062] Specifically, the suction throttle valve 250 increases the substantial opening area of the outlet openings 253d when the flow rate of the refrigerant circulating in the refrigerant circuit is increased such that the pressure difference is increased above the predetermined value. As the flow rate of the refrigerant decreases and the pressure difference is reduced, the suction throttle valve 250 decreases the substantial opening area of the outlet openings 253d. Thus, the suction throttle valve 250 adjusts the substantial opening area of the outlet openings 253d in accordance with a change in refrigerant flow rate. When the refrigerant flow rate becomes very small, and the pressure difference is reduced to equal to or less than the predetermined value, the suction throttle valve 250 decreases the substantial opening area of the outlet openings 253d to the minimum value. As a result, the suction pressure pulsation on the second space portion 141b side, which may be produced particularly when the

refrigerant flow rate becomes small, can be restricted from being transmitted to the first space portion 141a side in the suction stroke of the pistons 136. In this way, transmission of pressure pulsation to the external refrigerant circuit side can be restricted. Therefore, vibration of the heat exchanger and the like can be decreased.

[0063] Thus, in the variable displacement compressor 100 according to the present embodiment, the suction chamber 141 is partitioned by the partition member 150 into the first space portion 141a and the second space portion 141b. The suction passage 104a is connected to the first space portion 141a, and the suction holes 103a are connected to the second space portion 141b. As the pressure difference between the first space portion 141a and the second space portion 141b decreases, the opening area of the communication portion (housing 253) penetrating the first space portion 141a and the second space portion 141b is decreased by the suction throttle valve 250 (aperture control valve). In this way, transmission of pressure pulsation to the external refrigerant circuit side can be restricted. Because the variable displacement compressor 100 is configured to adjust the opening area of the communication portion (housing 253) penetrating the first space portion 141a and the second space portion 141b, the suction throttle valve 250 can be disposed without being restricted by the position and/or orientation of the suction passage 104a. Therefore, a reciprocating compressor such that the suction throttle valve 250 can be disposed without restrictions by the position and/or orientation of the suction passage can be provided.

[0064] Further, according to the present embodiment, the communication portion (housing 253) is positioned at the radial center of the suction chamber 141. The suction holes 103a are formed in the valve plate 103. The suction throttle valve 250 (aperture control valve) includes the inlet opening 253b opened toward the first space portion 141a, and the plurality of outlet openings 253d opened in the radial direction of the second space portion 141b. Specifically, the suction holes 103a are spaced apart along the circumferential direction of the communication hole 150a, with approximately equal distance from the center of opening of the communication hole 150a. Thus, the length of the flow passages from the communication hole 150a, i.e., the substantial outlet of the suction passage 104a, to the respective outlet openings 253d and suction holes 103a can be made approximately equal. As a result, the suction pressure pulsation on the second space portion 141b side can be minimized. This is combined with the effect of tightening the suction throttle valve 250 in a synergistic effect, whereby transmission of pressure pulsation from the first space portion 141a to the external refrigerant circuit side can be effectively restricted.

[0065] According to the embodiment, the support member 152 is integrally formed with the cylinder gasket 138. The support member may be formed separately from the cylinder gasket 138, as according to a second

embodiment described below.

[0066] FIG. 10 and FIG. 11 are partially enlarged views of the variable displacement compressor 100 according to the second embodiment of the present invention. In the second embodiment, elements similar to those of the first embodiment will be designated with similar reference signs and their description will be omitted, while focusing on different portions. Description of operation of the suction throttle valve 250 will also be omitted as the operation is similar to that in the first embodiment.

[0067] Referring to FIG. 11, in the present embodiment, a support member 152' is formed separately from the cylinder gasket 138. The support member 152' is formed in a generally truncated conical shape, for example. The support member 152' includes a bottom wall 152'a, a peripheral wall 152'b, and a flange 152'c. The support member 152' is formed, for example, by pressing a thin plate of metal. The support member 152' may be formed of resin material.

[0068] As illustrated in FIG. 10, the support member 152' is inserted in a through-hole formed at the radial center of a suction valve forming plate 153 disposed between the cylinder gasket 138 and the valve plate 103. Both the bottom wall 152'a and the peripheral wall 152'b protrude into the space 101d. The flange 152'c abuts the suction valve forming plate 153. At an abutting portion of the valve plate 103 that abuts the flange 152'c, a recess is formed in consideration of the plate thickness of the flange 152'c. In this way, the flange 152'c is positioned between the suction valve forming plate 153 and the valve plate 103 and held therebetween.

[0069] The suction valve forming plate 153 is formed of a plate material having elasticity. Preferably, the depth of the abutting portion of the valve plate 103 is set such that the suction valve forming plate 153 can slightly press the flange 152'c when the flange 152'c is positioned and held between the suction valve forming plate 153 and the valve plate 103. Further preferably, the surface of the support member 152' is rubber coated, as is the cylinder gasket 138 and the like. The support member 152' can be therefore stably held between the suction valve forming plate 153 and the valve plate 103, leading to further prevent or restrict the leakage of refrigerant from the space 101d (where the pressure of the crank chamber acts) to the second space portion 141b (where the pressure of the suction chamber acts).

[0070] In the valve plate 103 and a discharge valve forming plate 154, communication holes are formed so that the pressure of the second space portion 141b acts in the space 255 in the suction throttle valve 250. The communication holes communicate between the space 152a' in the support member 152' and the second space portion 141b. For details on the communication hole 103d of the valve plate 103, the reader is referred to FIG. 4.

[0071] As illustrated in FIG. 10, the suction throttle valve 250 is inserted in the through-holes formed at the radial center of the valve plate 103 and the discharge valve forming plate 154. Thus, the protrusions 254b abut

the bottom wall 152'a of the support member 152'. When the front housing 102, the cylinder block 101, and the cylinder head 104 are fastened by the plurality of through bolts 105, the partition member 150 presses one end portion of the suction throttle valve 250 via the elastic member 151. At the same time, the suction throttle valve 250 is sandwiched between the partition member 150 and the support member 152'.

[0072] The flange 152'c may be positioned between the discharge valve forming plate 154 (see FIG. 10), disposed and held between the head gasket 139 and the valve plate 103, and the valve plate 103, instead of between the suction valve forming plate 153 and the valve plate 103. Alternatively, the flange 152'c may be positioned and held between the suction valve forming plate 153 and the discharge valve forming plate 154.

[0073] According to the first and the second embodiments, the partition member 150 is integrally formed with the head gasket 139, but not limited thereto. Alternatively, for example, the partition member 150 may be formed separately from the head gasket 139, as will be described below with reference to a third embodiment.

[0074] FIG. 12 is a partially enlarged view of the variable displacement compressor 100 according to the third embodiment of the present invention. In the third embodiment, elements similar to those of the first embodiment will be designated with similar signs with their description omitted, and only different portions will be described. Operation of the suction throttle valve 250 is also similar to that according to the first embodiment and its description will be omitted.

[0075] According to the present embodiment, a partition member 150' is formed separately from the head gasket 139. The partition member 150' is made of a plate material or the like. As illustrated in FIG. 12, the partition member 150' fits in a stepped portion 141c formed in the middle of the suction chamber forming wall of the suction chamber 141. The partition member 150' partitions the suction chamber 141 into a first space portion 141a and a second space portion 141b.

[0076] Further, according to the present embodiment, the one end portion (peripheral wall 253e3 side) of the suction throttle valve 250 abuts the partition member 150'. The other end portion (cap 254 side) of the suction throttle valve 250 is completely housed within the second space portion 141b and abuts the head gasket 139. Thus, the suction throttle valve 250 is configured such that, when the front housing 102, the cylinder block 101, and the cylinder head 104 are fastened by the plurality of through bolts 105, the partition member 150' presses the one end portion of the suction throttle valve 250 via the elastic member 151. At the same time, the suction throttle valve 250 is sandwiched between the partition member 150' and the support member 152" (head gasket 139). In this way, the suction throttle valve can be easily held in place.

[0077] According to the present embodiment, as illustrated in FIG. 12, the head gasket 139 also provides the

support member 152", but not limited thereto. Alternatively, for example, any of the discharge valve forming plate 154, the valve plate 103, the suction valve forming plate 153, and the cylinder gasket 138 may also provide the support member 152". For example, when the discharge valve forming plate 154 is used as the support member 152", a through-hole is provided at the position of the head gasket 139 corresponding to the other end portion of the suction throttle valve 250.

[0078] According to the present embodiment, the other end portion (cap 254 side) of the suction throttle valve 250 is completely housed within the second space portion 141b, but not limited thereto. Alternatively, for example, the other end portion (cap 254 side) of the suction throttle valve 250 may protrude into the space 101d of the cylinder block 101, as according to the first and second embodiments. In this case, the support member 152' of the first embodiment, or the support member 152' of the second embodiment may be applied as the support member.

[0079] According to the various embodiments, the communication hole 150a formed in the partition member 150 is formed at the radial center of the suction chamber 141, but not limited thereto. Alternatively, for example, the communication hole 150a may be formed in accordance with the location of the suction throttle valve 250.

[0080] According to the various embodiments, the suction throttle valve 250 is held in place by being sandwiched between the partition member 150 and the support member (152, 152', 152"), but not limited thereto. Alternatively, for example, the suction throttle valve 250 may be fixed to the partition member 150.

[0081] According to the various embodiments, the suction throttle valve 250 includes the minimum opening portion 253d1 that is not completely closed by the peripheral wall of the valve body 251. Further, when the valve body 251 is seated on the valve seat 253c, the flow passage in the suction throttle valve 250 is not completely blocked. However, these are not limitations, and the suction throttle valve 250 may be configured such that the flow passage in the suction throttle valve 250 is completely blocked when the valve body 251 is seated on the valve seat 253c.

[0082] According to the various embodiments, a swash plate type variable displacement compressor has been described as an example of the reciprocating compressor according to the present invention. However, the reciprocating compressor according to the present invention is not limited to the swash plate type, and may be a wobble plate type variable displacement compressor. Further, the reciprocating compressor according to the present invention is not limited to variable displacement compressors, and is applicable to all reciprocating compressors. For example, the reciprocating compressor according to the present invention may be applied in reciprocating compressors such as a fixed displacement compressor and an electric compressor driven by a motor.

[0083] While the contents of the present invention have

been described with reference to preferred embodiments thereof, it should be obvious that numerous various modifications may be readily made by those skilled in the art based on the basic technical concepts and teachings of the present invention.

[0084] The reciprocating compressor according to the present invention may be the following first to seventh reciprocating compressors. The first reciprocating compressor comprises a suction chamber disposed on one end side of a drive shaft and into which refrigerant flows from a suction passage; a plurality of cylinder bores arranged around the drive shaft; a suction hole corresponding to each of the cylinder bores; and a discharge chamber in annular shape concentrically disposed outside the suction chamber, wherein pistons in the cylinder bores are reciprocated by rotation of the drive shaft so as to compress the refrigerant suctioned into the cylinder bores from the suction chamber via the suction hole, and wherein the compressed refrigerant is discharged via the discharge chamber, the reciprocating compressor including a partition member partitioning the suction chamber into a first space portion connected to the suction passage and a second space portion connected to the suction hole, and an aperture control valve adjusting the area of an opening of a communication portion penetrating the partition member and providing communication between the first space portion and the second space portion, the aperture control valve being configured to increase the opening area as a pressure difference between the first space portion and the second space portion increases and to decrease the opening area as the pressure difference decreases.

[0085] The second reciprocating compressor is the first reciprocating compressor wherein the communication portion is positioned at a radial center of the suction chamber, and wherein the suction holes are formed in a valve plate abutting a suction chamber side surface of a cylinder head that forms the suction chamber, the aperture control valve including an inlet opening opened toward the first space portion, and a plurality of outlet openings opened in a radial direction of the second space portion.

[0086] The third reciprocating compressor is the second reciprocating compressor wherein the valve plate includes a through-hole in which the aperture control valve is inserted, restricting radial movement of the aperture control valve.

[0087] The fourth reciprocating compressor is the second or the third reciprocating compressor and is characterized in that the partition member is formed by a part of a head gasket disposed between the valve plate and the cylinder head, the part facing and protruding into the suction chamber.

[0088] The fifth reciprocating compressor is the fourth reciprocating compressor characterized in that the cylinder head includes a suction chamber forming wall facing the valve plate and having a protrusion portion pressing a peripheral edge portion of the partition member part of

the head gasket toward the valve plate.

[0089] The sixth reciprocating compressor is one of the first to fifth reciprocating compressors wherein the aperture control valve is supported on one end portion thereof by a support member, with another end portion of the aperture control valve being pressed by the partition member toward the support member.

[0090] The seventh reciprocating compressor is the sixth reciprocating compressor characterized by an elastic member disposed between the one end portion of the aperture control valve and the support member, or between the other end portion of the aperture control valve and the partition member.

[0091] The foregoing detailed description has been presented for the purposes of illustration and description. Many modifications and variations are possible in light of the above teaching. It is not intended to be exhaustive or to limit the subject matter described herein to the precise form disclosed. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims appended hereto.

Claims

1. A reciprocating compressor (100) including:

a suction chamber (141) disposed on one end side of a drive shaft (110) and into which a refrigerant flows from a suction passage (104a); a plurality of cylinder bores (101a) arranged around the drive shaft;
a suction hole (103a) corresponding to each of the cylinder bores; and
a discharge chamber (142) in annular shape concentrically disposed outside the suction chamber,
wherein pistons (136) in the cylinder bores are reciprocated by rotation of the drive shaft to compress the refrigerant suctioned into the cylinder bores from the suction chamber via the suction hole and discharge the compressed refrigerant via the discharge chamber,
the reciprocating compressor **characterized by** comprising:

a partition member (150, 150') partitioning the suction chamber into a first space portion (141a) connected to the suction passage and a second space portion (141b) connected to the suction hole, and
an aperture control valve (250) that adjusts the area of an opening of a communication

portion (253) penetrating the partition member and providing communication between the first space portion and the second space portion, the aperture control valve being configured to increase the opening area as a pressure difference between the first space portion and the second space portion is increased and to decrease the opening area as the pressure difference is decreased.

the other end portion of the aperture control valve and the partition member.

2. The reciprocating compressor according to claim 1, wherein
the communication portion is positioned at a radial center of the suction chamber,
the suction holes are formed in a valve plate (103) abutting a suction chamber side surface of the cylinder head that forms the suction chamber, and the aperture control valve includes an inlet opening (253b) opened toward the first space portion, and a plurality of outlet openings (253d) opened in a radial direction of the second space portion.
3. The reciprocating compressor according to claim 2, wherein
the valve plate includes a through-hole in which the aperture control valve is inserted, the through-hole being configured to restrict radial movement of the aperture control valve.
4. The reciprocating compressor according to claim 2 or 3, further comprising a head gasket (139) disposed between the valve plate and the cylinder head, wherein
the head gasket includes a part that forms the partition member, the part facing and protruding into the suction chamber.
5. The reciprocating compressor according to claim 4, further comprising a protrusion portion (104d) formed on a suction chamber forming wall of the cylinder head, the wall facing the valve plate, wherein the protrusion portion is configured to press a peripheral edge portion of the partition member part of the head gasket toward the valve plate.
6. The reciprocating compressor according to any one of claims 1 to 5, further comprising a support member (152, 152') supporting one end portion of the aperture control valve, wherein
the partition member is configured to press another end portion of the aperture control valve toward the support member.
7. The reciprocating compressor according to claim 6, further comprising an elastic member (151) disposed between the one end portion of the aperture control valve and the support member or disposed between

FIG. 1

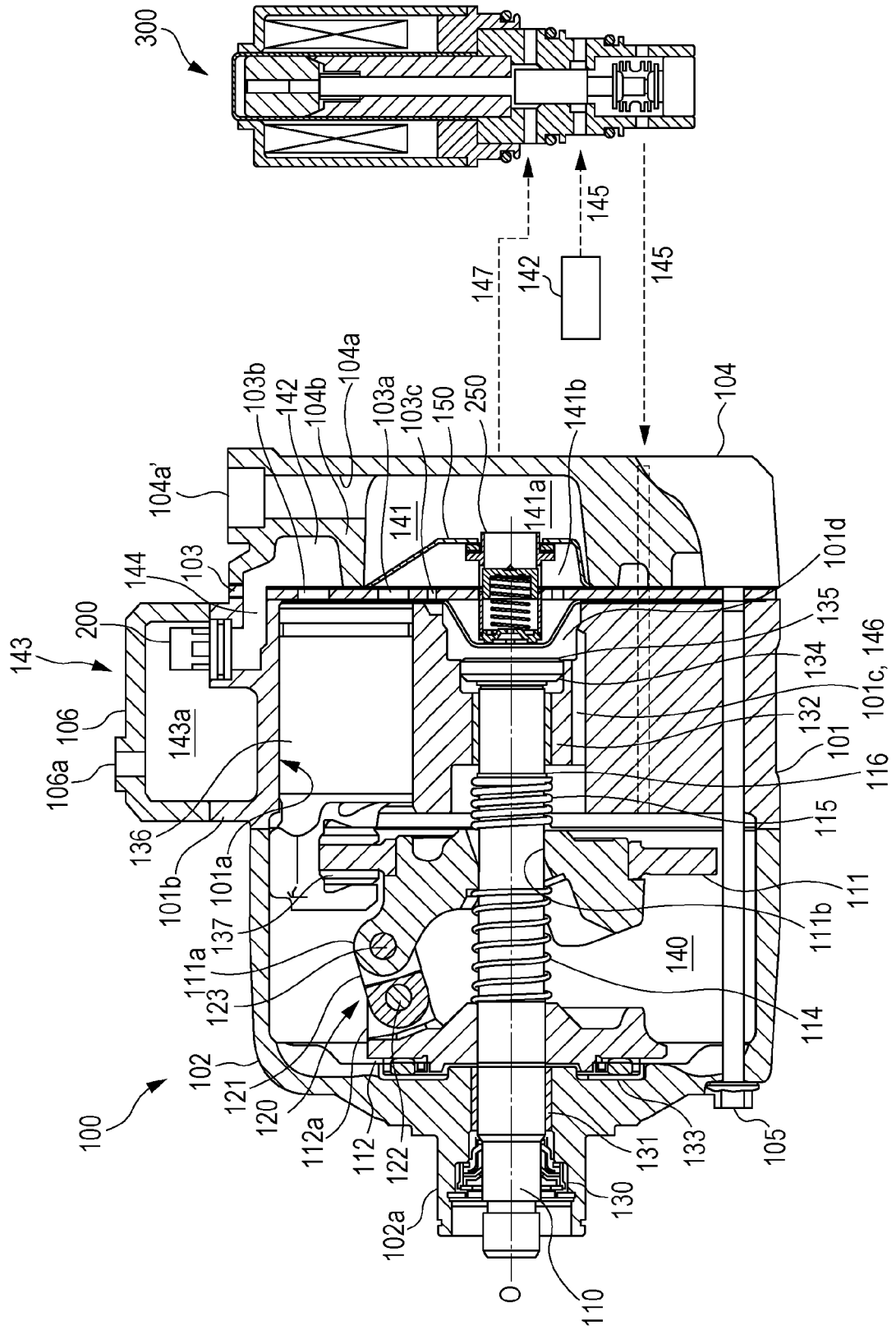


FIG. 2

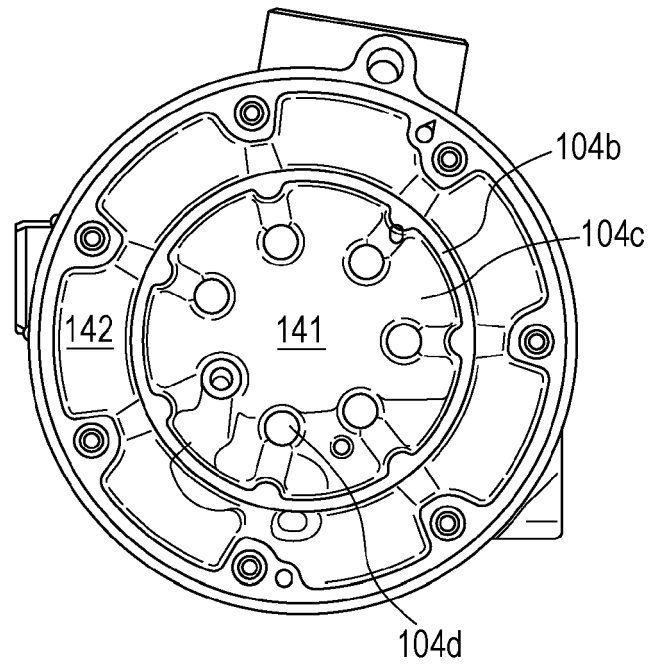


FIG. 3

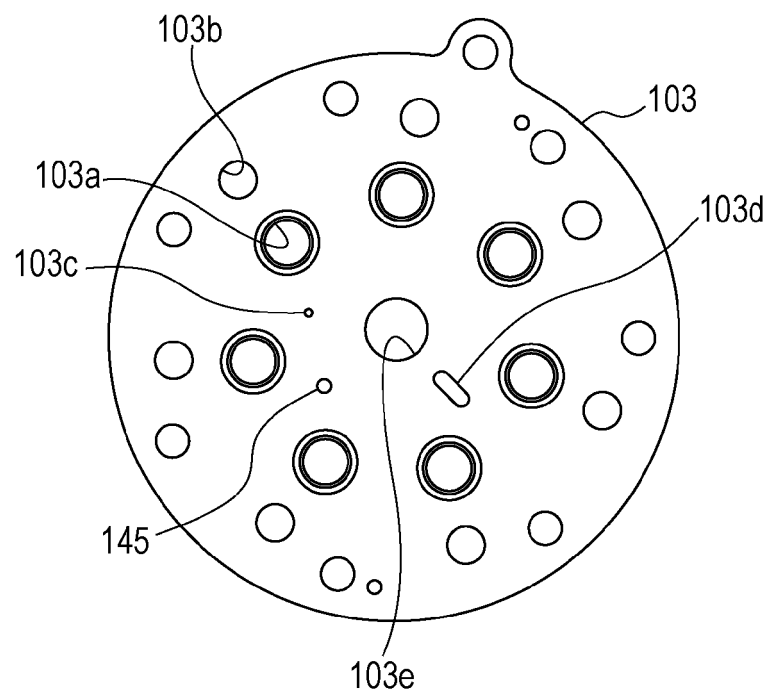


FIG. 4

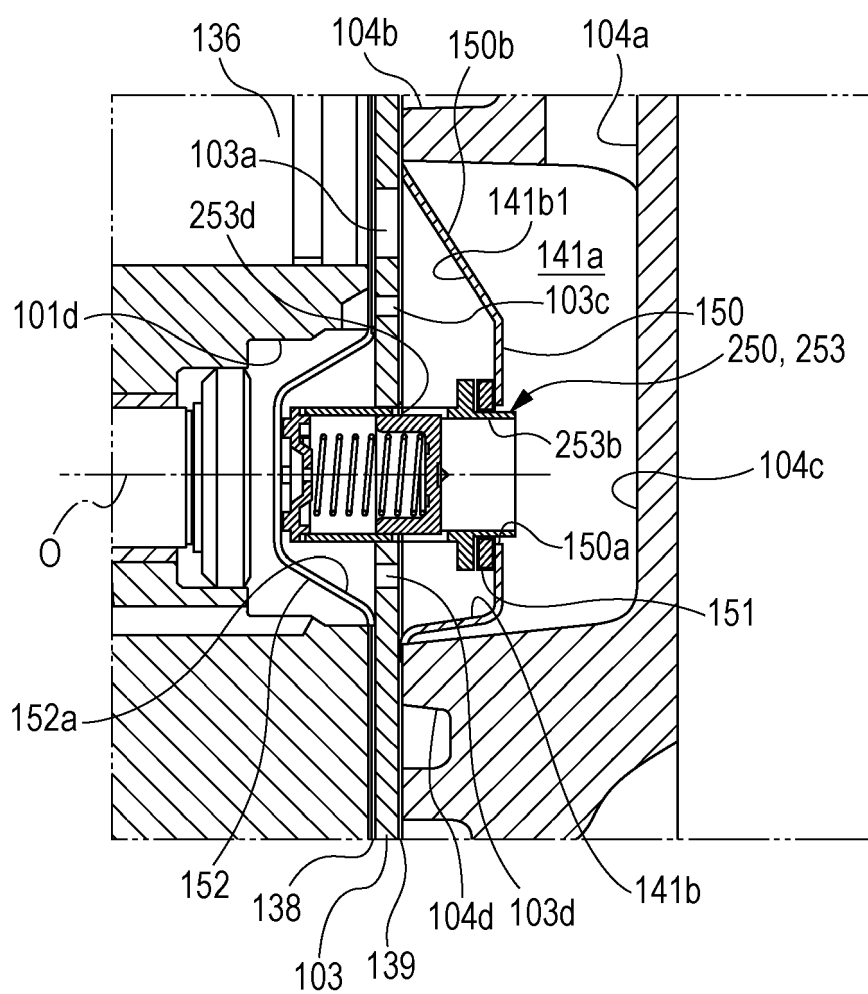


FIG. 5

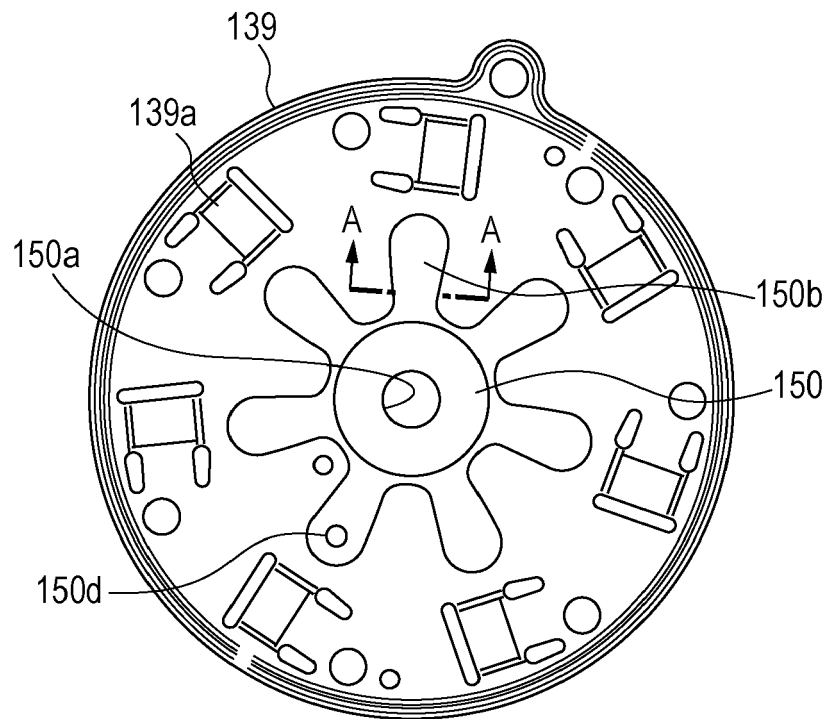


FIG. 6

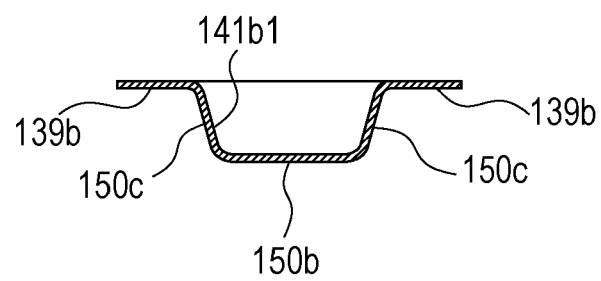


FIG. 7

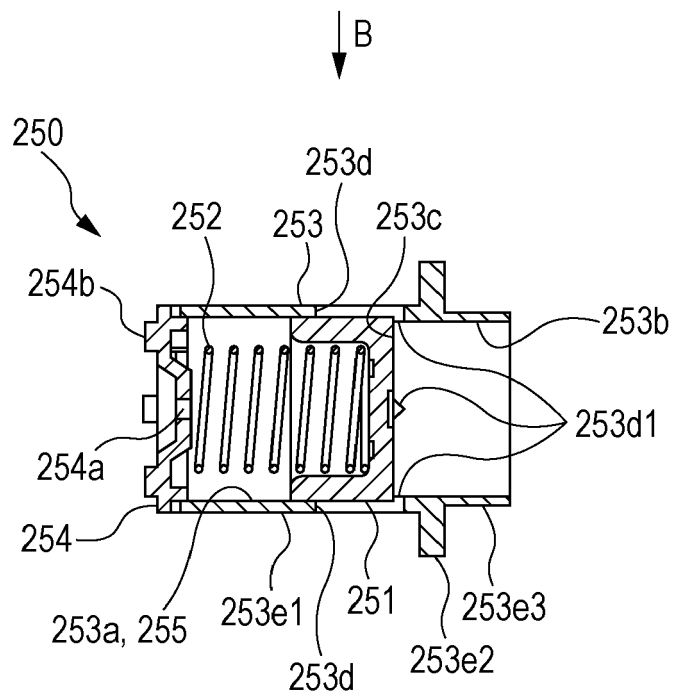


FIG. 8

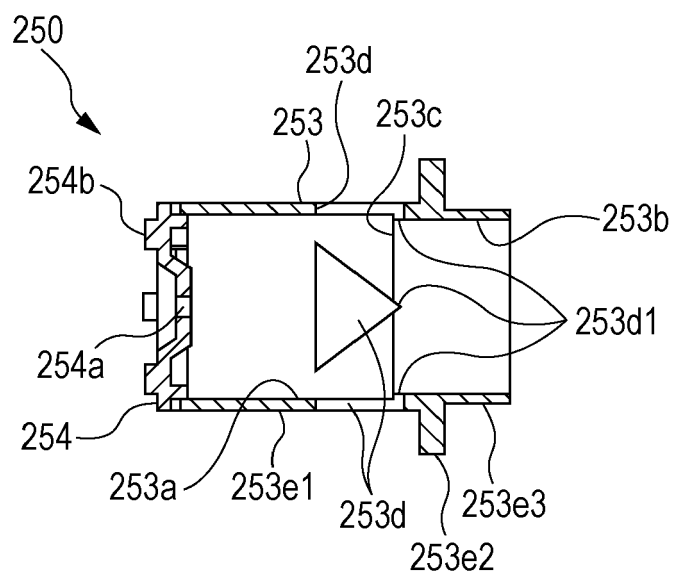


FIG. 9

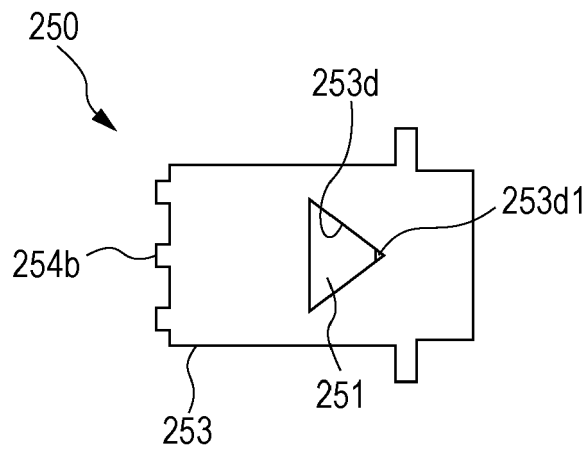


FIG. 10

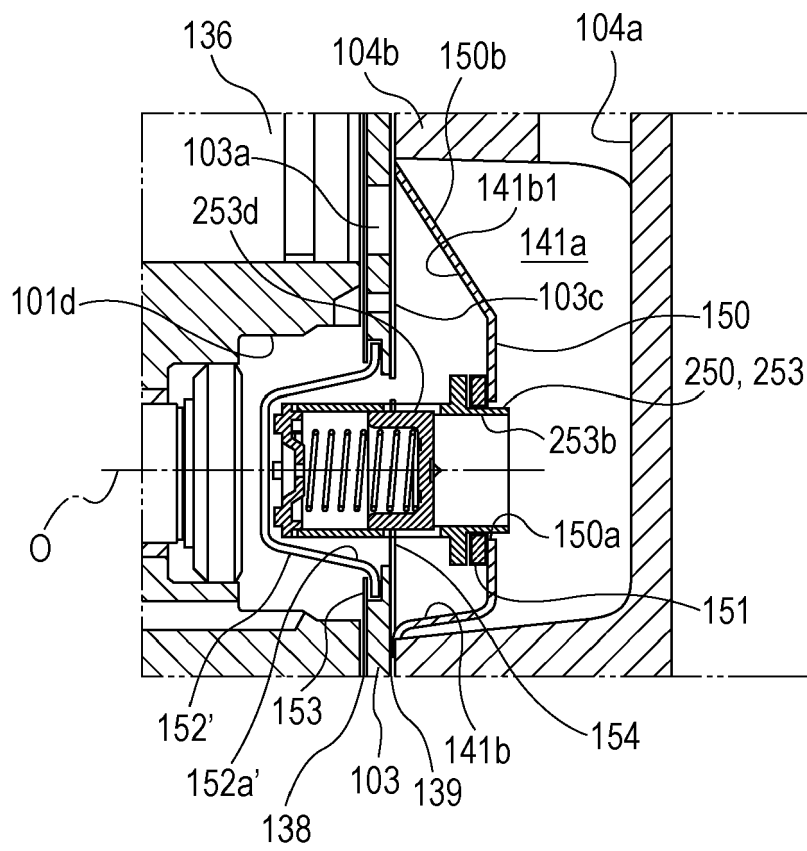


FIG. 11

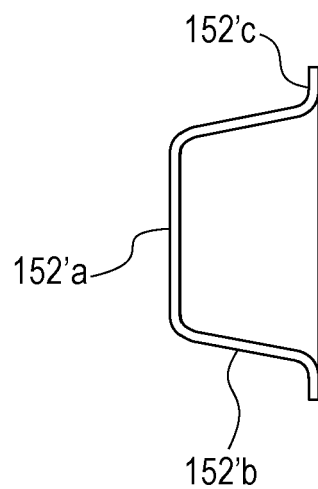
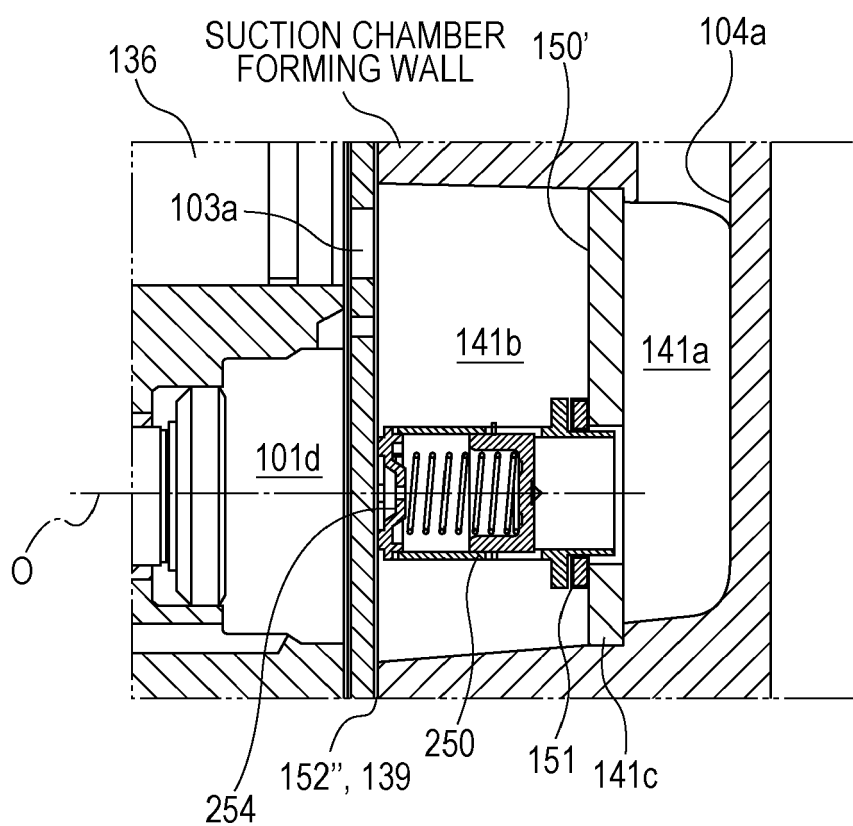


FIG. 12





EUROPEAN SEARCH REPORT

 Application Number
EP 14 17 0949

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 441 957 A1 (SANDEN CORP [JP]) 18 April 2012 (2012-04-18) * paragraph [0021]; claim 1; figure 1 * -----	1-7	INV. F04B27/08 F04B27/10
A	US 3 119 550 A (WEST WALTER J ET AL) 28 January 1964 (1964-01-28) * column 1, line 53 - column 2, line 16 * -----	1	
A	US 4 392 788 A (NAKAMURA TERUO [JP] ET AL) 12 July 1983 (1983-07-12) * column 1, line 53 - column 2, line 37 * -----	1	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F04B
Place of search		Date of completion of the search	Examiner
Munich		10 November 2014	Fistas, Nikolaos
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 17 0949

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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10-11-2014

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