



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.07.2009 Bulletin 2009/29

(51) Int Cl.:
F04C 18/356 ^(2006.01) **F04C 23/00** ^(2006.01)
F04C 29/12 ^(2006.01)

(21) Application number: **09150282.3**

(22) Date of filing: **09.01.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA RS

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(30) Priority: **11.01.2008 JP 2008004337**

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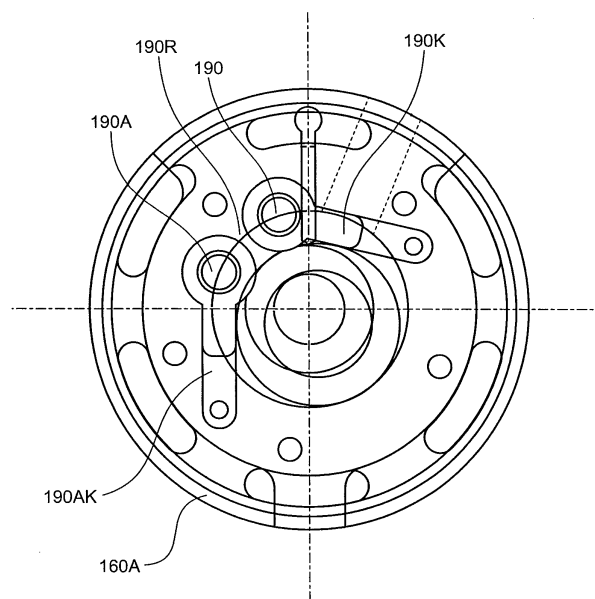
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(54) **Rotary compressor**

(57) A rotary compressor (1) includes a compressing section (12) including a cylindrical cylinder (121), two end plates (160A, 160B) closing both ends of the cylinder (121), respectively, and a piston (125) held by an eccentric section (152) of a rotary shaft (15) driven to rotate by a motor (11). A working chamber is formed between the piston (125) and the cylinder inner wall. The rotary compressor (1) also includes a vane protruding from within a vane groove of the cylinder (121) into the working

chamber; an airtight compressor housing (10) accommodating therein a compressing section; a suction hole (135) provided in the cylinder (121) and communicating a suction chamber with a low-pressure side of a refrigerating cycle; and a discharge hole (190) provided in one of the end plates (160A) and communicating the compression chamber with a high-pressure side of the refrigerating cycle. An auxiliary discharge hole different from the discharge hole (190) is provided in the one end plate (160A).

FIG.3



Description

TECHNICAL FIELD

[0001] The present invention relates to a rotary compressor used in a refrigerating cycle of an air-conditioner.

BACKGROUND ART

[0002] There is conventionally known a rotary compressor configured so that a rotary compressor element and an electric element that drives the compressor element are pressed into and held in a cylindrical airtight container with an internal pressure of the container kept high. Furthermore, the rotary compressor is configured so that a discharge port (discharge hole) and a discharge valve opened or closed according to a magnitude of a discharge pressure are provided in each of an upper bearing (end plate) closing an upper opening of a cylindrical compression chamber of a cylinder and forming one bearing of a rotary shaft of the electric element and a lower bearing (end plate) closing a lower opening of the compression chamber and forming another bearing of the rotary shaft. The rotary compressor of this type is disclosed in, for example, Japanese Utility Model Application Laid-Open No. S56-175594.

[0003] There is also known a two-stage rotary compressor configured so that two stages of rotary compressing sections are stacked and so that a compression target fluid is compressed by the low-stage compressing section and the high-stage compressing section by two stages. Furthermore, the two-stage rotary compressor is configured so that an inside diameter of a compression chamber of the low-stage compressing section is set larger than that of a compression chamber of the high-stage compressing section. Moreover, a second discharge valve chamber (discharge hole) of the low-stage compressing section different from a first discharge valve chamber provided in a main bearing (end plate) is arranged at a position of a partition plate dividing a compressing section into the low-stage compressing section and the high-stage compressing section, which portion corresponds to an outer portion of the compression chamber of the low-stage compressing section. The compressor of this type is disclosed in, for example, Japanese Patent Application Laid-Open No. S63-272988.

[0004] Furthermore, there is known a compressor configured to include, in an airtight container, an electric element and a compressor element driven by the electric element and including a compression chamber that compresses a cooling medium containing lubricating oil. The compression chamber includes an introduction port for introducing the cooling medium containing the lubricating oil into the compression chamber, a first discharge port from which the compressed cooling medium is discharged, and a second discharge port from which the lubricating oil is discharged. A first discharge valve opened when a pressure of the compressed cooling me-

dium reaches a first pressure in the compression chamber is provided in the first discharge port. A second discharge valve opened at a second pressure higher than the first pressure is provided in the second discharge port. The compressor of this type is disclosed in, for example, Japanese Patent Application Laid-Open No. 2006-275035.

[0005] An inverter-type rotary compressor has the following problems. Particularly during high-speed rotation, over-compression loss caused by a flow resistance of the cooling medium in the discharge port increases and the loss causes deterioration in efficiency of the rotary compressor. If a diameter of the discharge hole is increased to reduce the flow resistance, it is necessary to increase a thickness of the valve to ensure strength of the discharge port. If the valve is thicker, opening of the valve delays, resulting in the over-compression loss.

[0006] Moreover, according to the technique disclosed in Japanese Utility Model Application Laid-Open No. S56-175594, the discharge ports (discharge holes) are provided in both of the upper and lower bearings, respectively. Due to this, the structure of the compressing section is complicated, resulting in an increase in manufacturing cost of the rotary compressor. According to the technique disclosed in the Japanese Patent Application Laid-Open No. S63-272988, the discharge valve chambers (discharge holes) are provided in both the main bearing and the partition plate, respectively. Similarly to the technique disclosed in Japanese Utility Model Application Laid-Open No. S6-175594, the structure of each of the compressing sections is complicated, resulting in an increase in manufacturing cost of the rotary compressor.

[0007] According to the conventional technique disclosed in Japanese Patent Application Laid-Open No. 2006-275035, if the compressor is actuated to perform only cooling operation in a refrigerating and cooling cycle, a cooling medium gas inlet path on a front-stage (low-stage) compressing section of the two-stage compressor is completely cut off and the cooling medium gas is sucked in only from a rear-stage (high-stage) compressing section. At this time, a pressure of the front-stage (low-stage) compressing section is close to vacuum, the lubricating oil is impregnated into the front-stage compressing section from narrow gaps formed by components constituting a compression chamber of the front-side compressing section, and the compression chamber turns into a liquid compression state, thereby disadvantageously and greatly deteriorating efficiency of the compressor. The second discharge port is intended to discharge the lubricating oil from the compression chamber so as to prevent the deterioration in efficiency. Accordingly, during high-speed rotation of the compressor, the second discharge port is disadvantageously incapable of reducing the over-compression loss caused by the flow resistance of the cooling medium in the discharge port.

DISCLOSURE OF INVENTION

[0008] It is an object of the present invention to at least partially solve the problems in the conventional technology.

[0009] According to an aspect of the present invention, a rotary compressor includes a compressing section. The compressing section includes a cylindrical cylinder; two end plates closing both ends of the cylinder, respectively; a piston held by an eccentric section of a rotary shaft driven to rotate by a motor, and revolving in the cylinder along a cylinder inner wall of the cylinder, a working chamber being formed between the piston and the cylinder inner wall; and a vane protruding from within a vane groove of the cylinder into the working chamber, abutting on the piston, and dividing the working chamber into a suction chamber and a compression chamber. The rotary compressor also includes an airtight compressor housing accommodating therein the compressing section; a suction hole provided in the cylinder and communicating the suction chamber with a low-pressure side of a refrigerating cycle; and a discharge hole provided in one of the end plates and communicating the compression chamber with a high-pressure side of the refrigerating cycle. In the one end plate, an auxiliary discharge hole different from the discharge hole is provided.

[0010] According to another aspect of the present invention, a rotary compressor includes a low-stage compressing section and a high-stage compressing section stacked on the low-stage compressing section via an intermediate partition plate. The low-stage compressing section includes a cylindrical low-stage cylinder; a low-stage end plate closing one end of the low-stage cylinder; a low-stage piston held by a low-stage eccentric section of a rotary shaft driven to rotate by a motor and revolving in the low-stage cylinder along a low-stage cylinder inner wall of the low-stage cylinder, a low-stage working chamber being formed between the low-stage piston and the low-stage cylinder inner wall; and a low-stage vane protruding from within a low-stage vane groove of the low-stage cylinder into the low-stage working chamber, abutting on the low-stage piston, and dividing the low-stage working chamber into a low-stage suction chamber and a low-stage compression chamber. The high-stage compressing section includes a cylindrical high-stage cylinder; a high-stage end plate closing one end of the high-stage cylinder; a high-stage piston held by a high-stage eccentric section of the rotary shaft driven to rotate by the motor and revolving in the high-stage cylinder along a high-stage cylinder inner wall of the high-stage cylinders, a high-stage working chamber being formed between the high-stage piston and the high-stage cylinder inner wall; and a high-stage vane protruding from within a high-stage vane groove of the high-stage cylinder into the high-stage working chamber, abutting on the high-stage piston, and dividing the high-stage working chamber into a high-stage suction chamber and a high-stage compression chamber. The rotary compressor also in-

cludes an airtight compressor housing accommodating therein the low-stage compressing section and the high-stage compressing section; a low-stage suction hole provided in the low-stage cylinder and communicating the low-stage suction chamber with a low-pressure side of a refrigerating cycle; a low-stage discharge hole provided in the low-stage end plate and communicating the low-stage compression chamber with a high-stage suction hole provided in the high-stage cylinder; and a high-stage discharge hole provided in the high-stage end plate and communicating the high-stage compression chamber with a high-pressure side of the refrigerating cycle. In the low-stage end plate, a low-stage auxiliary discharge hole different from the low-stage discharge hole is provided.

[0011] The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

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

FIG. 2 is a top view of a compressing section of the rotary compressor shown in FIG. 1;

FIG. 3 is a perspective view of an upper surface of the compressing section closed by one of end plates; FIG. 4 is a chart showing the relationship between a revolution angle of a piston and a discharge pressure;

FIG. 5 is a chart showing the relationship between the revolution angle of the piston and a change of a volume of a compression chamber;

FIG. 6 is a chart showing the relationship between the revolution angle of the piston and a change rate of the volume of the compression chamber;

FIG. 7 is a longitudinal sectional view of a rotary compressor according to a second embodiment of the present invention;

FIG. 8 is a bottom view of a low-stage compressing section of the rotary compressor shown in FIG. 7;

FIG. 9 is a cross-sectional view of a high-stage compressing section of the rotary compressor shown in FIG. 7;

FIG. 10 is a perspective view of a lower surface of the low-stage compressing section closed by a low-stage end plate;

FIG. 11 is a chart showing the relationship between a revolution angle of a piston and a discharge pressure of the low-stage compressing section;

FIG. 12 is a bottom view of a low-stage compressing section of a rotary compressor according to a modification of the second embodiment;

FIG. 13 is a perspective view of a lower surface of the low-stage compressing section closed by a low-stage end plate according to the modification of the second embodiment;

FIG. 14 is a longitudinal sectional view of a rotary compressor according to a third embodiment of the present invention;

FIG. 15 is a cross-sectional view of first and second compressing sections of the rotary compressor shown in FIG. 14;

FIG. 16 is a top view of a compressing section of a rotary compressor according to a fourth embodiment of the present invention; and

FIG. 17 is a top view of the compressing section of the rotary compressor according to the first embodiment for reference.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

[0013] Exemplary embodiments of a rotary compressor according to the present invention will be described below with reference to the accompanying drawings. It is to be noted that the present invention is not limited to the embodiments.

First Embodiment

[0014] FIG. 1 is a longitudinal sectional view of a rotary compressor according to a first embodiment of the present invention. FIG. 2 is a top view of a compressing section of the rotary compressor shown in FIG. 1. FIG. 3 is a perspective view of an upper surface of the compressing section closed by one of end plates. FIG. 4 is a chart showing the relationship between a revolution angle of a piston and a pressure of a compression chamber. FIG. 5 is a chart showing the relationship between the revolution angle of the piston and a volume of the compression chamber. FIG. 6 is a chart showing the relationship between the revolution angle of the piston and a change rate of the volume of the compression chamber.

[0015] As shown in FIG. 1, a rotary compressor 1 according to the first embodiment includes, in an airtight cylindrical compressor housing 10, a compressing section 12, and a motor 11 driving the compressing section 12.

[0016] A stator 111 of the motor 11 is fixedly shrunk to an inner circumferential surface of the compressor housing 10. A rotor 112 of the motor 11 is arranged in a central portion of the stator 111 and fixedly shrunk to a rotary shaft 15 mechanically connecting the motor 11 to the compressing section 12.

[0017] As shown in FIGS. 1 and 2, the compressing section 12 includes a short cylindrical cylinder 121. A cylindrical cylinder inner wall 123 is formed on the cylinder 121 to be concentric with the motor 11. A cylindrical piston 125 having an outside diameter smaller than a diameter of the cylinder inner wall 123 is arranged in the

cylinder inner wall 123, and a working chamber 130 (compression space) sucking in, compressing, and discharging a cooling medium is formed between the cylinder inner wall 123 and the piston 125.

[0018] A vane groove 128 is formed in the cylinder 121 in a range of an entire length of the cylinder 121 from the cylinder inner wall 123 in a radial direction of the cylinder 121. A flat vane 127 is fitted into the vane groove 128. A spring, not shown, is arranged in an inner part of the vane groove 128. In a normal state, the vane 127 protrudes from within the vane groove 128 into the working chamber 130 by a repulsive force of the spring, a tip end of the vane 127 abuts on an outer circumferential surface of the piston 125, and the vane 127 divides the working chamber 130 (compression space) into a suction chamber 131 and a compression chamber 133.

[0019] A backpressure introduction path 129 communicating the inner part of the vane groove 128 with an interior of the compressor housing 10 and applying a backpressure to the vane 127 is formed on the cylinder 121. A suction hole 135 communicating with the suction chamber 131 is provided in the cylinder 121 to suck the cooling medium into the suction chamber 131.

[0020] As shown in FIG. 1, one end plate 160A is disposed on an upper end of the cylinder 121 and closes an upper portion of the working chamber 130 of the cylinder 121. The other end plate 160B is disposed on a lower end of the cylinder 121 and closes a lower portion of the working chamber 130.

[0021] A sub bearing 161B is formed on the other end plate 160B and a sub bearing support 151 of the rotary shaft 15 is rotatably supported by the sub bearing 161B. A main bearing 161A is formed on one end plate 160A and a main bearing support 153 of the rotary shaft 15 is rotatably supported by the main bearing 161A.

[0022] The rotary shaft 15 includes an eccentric section 152 and the eccentric section 152 rotatably holds the piston 125 of the compressing section 12. When the rotary shaft 15 rotates, the piston 125 revolves clockwise in the cylinder 121 along the cylinder inner wall 123 in FIGS. 2 and 3 and the vane 127 follows to reciprocate. Volumes of the suction chamber 131 and the compression chamber 133 continuously change by movements of the piston 125 and the vane 127, and the compressing section 121 continuously sucks in, compresses, and discharges the cooling medium.

[0023] As shown in FIG. 1, a muffler cover 170 is disposed above one end plate 160A and a muffler chamber 180 is formed between the muffler cover 170 and the end plate 160A. A discharge portion of the compressing section 12 communicates with the interior of the compressor housing 10 via the muffler chamber 180. Accordingly, a discharge hole 190 communicating the compression chamber 133 of the cylinder 121 with the muffler chamber 180 is provided in one end plate 160A near the vane 127 and a discharge valve 200 preventing backflow of the compressed cooling medium is provided in the discharge hole 190.

[0024] Furthermore, a discharge valve holding member 201 as well as the discharge valve 200 is fixed to the end plate 160A by a rivet so as to restrict a deflection opening amount of the discharge valve 200. The muffler chamber 180 reduces pressure pulsation of the discharged cooling medium.

[0025] The other end plate 160B, the cylinder 121, one end plate 160A, and the muffler cover 170 are integrally fastened by a bolt that is not shown. Among the integrally fastened constituent elements of the compressing section 12, an outer peripheral portion of one end plate 160A is fixedly bonded to the compressor housing 10 by spot welding to thereby fix the compressing section 12 to the compressor housing 10.

[0026] As shown in FIG. 1, a through hole 101 is provided in an outer circumferential wall of the cylindrical compressor housing 10. An accumulator 25 formed of an independent and cylindrical airtight container is arranged outside of the compressor housing 10 and held by an accumulator holder 251 and an accumulator band 253.

[0027] A system connecting pipe 255 connecting the accumulator 25 to a low-pressure side of a refrigerating cycle is provided in a central portion of a top surface of the accumulator 25. A low-pressure connecting pipe 31 having one end extending toward an upper portion of an interior of the accumulator 25 and the other end connected to the other end of a suction pipe 104 is connected to a bottom through hole 257 provided at a bottom of the accumulator 25.

[0028] The low-pressure connecting pipe 31 introducing a low-pressure cooling medium of the refrigerating cycle to the compressing section 12 via the accumulator 25 is connected to the suction hole 135 (see FIG. 2) via the through hole 101 and the suction pipe 104. Accordingly, the suction hole 135 communicates with the low-pressure side of the refrigerating cycle.

[0029] A discharge pipe 107 connected to a high-pressure side of the refrigerating cycle and discharging a high pressure cooling medium toward the high-pressure side of the refrigerating cycle is connected to a top of the compressor housing 10. Accordingly, the discharge hole 190 communicates with the high-pressure side of the refrigerating cycle.

[0030] The compressor housing 10 is filled with lubricating oil almost up to a height of the cylinder 121. The lubricating oil circulates in the compressing section 12 by a vane pump, not shown, attached to a lower portion of the rotary shaft 15 and seals a portion defining the working chamber 130 (compression space) for the compressed cooling medium by lubrication of sliding components and narrow gaps.

[0031] As shown in FIG. 3, the rotary compressor 1 according to the first embodiment is characteristically configured so that an auxiliary discharge hole 190A communicating the compression chamber 133 with the high-pressure side of the refrigerating cycle is provided in one end plate 160A in which the discharge hole 190 is provided.

The discharge valve 200 and the discharge valve holding member 201 are disposed in the auxiliary discharge hole 190A similarly to the discharge hole 190.

[0032] As shown in FIGS. 2 and 3, a discharge groove 124 communicating with the discharge hole 190 is provided in a region of the cylinder inner wall 123 corresponding to a position of the discharge hole 190 provided in one end plate 160A. A discharge groove 124A communicating with the auxiliary discharge hole 190A is provided in a region of the cylinder inner wall 123 corresponding to a position of the auxiliary discharge hole 190A. The discharge grooves 124 and 124A reduce the flow resistance of the cooling medium discharged from the compression chamber 133 into the discharge hole 190 and the auxiliary discharge hole 190A.

[0033] The auxiliary discharge hole 190A is provided at a position away from the vane groove 128 by 230° to 300° in a direction of revolution of the piston 125 along the cylinder inner wall 123. The reason is as follows. As shown in FIG. 3, concave portions 190K and 190AK are provided in the end plate 160A separately to accommodate the discharge valves 200 and the discharge valve holding members 201 (see FIG. 1) preventing backflow of the cooling medium in the discharge hole 190 and the auxiliary discharge hole 190A, respectively. If the concave portions 190K and 190AK interfere with each other, a rib 190R wears away and strength of the end plate 160A weakens. To prevent this, the auxiliary discharge hole 190A is provided at the position within 300° from the vane groove 128 in the direction of revolution of the piston 125 along the cylinder inner wall 123.

[0034] On the other hand, as shown in FIG. 4, when the piston 125 revolves clockwise by about 210° from the position of the vane groove 128, a pressure of the compression chamber 133 reaches a discharge pressure according to rated cooling conditions and the discharge valves 200 that have closed the discharge hole 190 and the auxiliary discharge hole 190A, respectively are opened. Furthermore, as shown in FIG. 6, the rotary compressor 1 has a high change rate of a volume of the compression chamber 133, that is, a high discharge flow speed when the piston 125 revolves by 135° to 225° from the position of the vane groove 128.

[0035] Accordingly, right after the discharge valve 200 opens by 210°, a flow speed of the discharged cooling medium is the highest and pressure loss is the greatest. If the auxiliary discharge hole 190A is communicable without being cut off by end surfaces of the compression chamber 133 and the piston 125 right after the discharge valve 200 opens by 210°, the auxiliary discharge hole 190A operates effectively. Due to this, the auxiliary discharge hole 190A is provided at the position away from the vane groove 128 at least by 230° in the direction of the revolution of the piston 125 along the cylinder inner wall 123. However, in the present invention, the position of the auxiliary discharge hole 190A is not limited to the above-stated position. As long as the auxiliary discharge hole 190A is used under conditions that the strength of

the end plate 160A is sufficiently high, the rib 190R may not be provided and the auxiliary discharge hole 190A may be provided at a position away from the vane groove 128 by 300° or more.

[0036] Operation of the rotary compressor 1 described so far will next be described. If the rotary compressor 1 is actuated, the cooling medium flowing from the low-pressure side of the refrigerating cycle into the accumulator 25 through the system connecting pipe 255 is separated into a liquid cooling medium and a gas cooling medium. Specifically, the liquid cooling medium is accumulated in a lower portion of the accumulator 25 and the gas cooling medium is accumulated in an upper portion thereof.

[0037] When the piston 125 revolves in the cylinder 121 and a volume of the suction chamber 131 increases, the gas cooling medium in the accumulator 25 is sucked into the suction chamber 131 of the compressing section 12 through the low-pressure connecting pipe 31, the suction pipe 104, and the suction hole 135. When the piston 125 revolves once, the suction chamber 131 is cut off from the suction hole 135 and changed over to the compression chamber 133, and the cooling medium is compressed in the compression chamber 133.

[0038] If the pressure of the compressed cooling medium in the compression chamber 133 becomes equal to a pressure of the muffler chamber 180 located downstream of the discharge valves 200 provided in the discharge hole 190 and the auxiliary discharge hole 190A, respectively, that is, discharge pressure, then the discharge valves 200 open, and the cooling medium is discharged into the muffler chamber 180 through the discharge hole 190 and the auxiliary discharge hole 190A at low flow resistance and the pressure pulsation causing noise is reduced in the muffler chamber 180. The cooling medium is discharged, as a high-pressure cooling medium, into the compressor housing 10. Thereafter, the high-pressure cooling medium is fed to an upper portion of the motor 11 through a core notch, not shown, of the stator 111 of the motor 11 and a gap between a core and a coil, and discharged toward the high-pressure side of the refrigerating cycle through the discharge pipe 107.

[0039] In the rotary compressor 1 according to the first embodiment, the cooling medium is discharged into the muffler chamber 180 through the discharge hole 190 and the auxiliary discharge hole 190A at the low flow resistance. Therefore, the over-compression loss can be reduced. Further, there is no need to work the concave portion 190K accommodating therein the discharge hole 190, the valve seat around the discharge hole 190, and the discharge valve 200 to be provided on each of the end plates 160A and 160B. Therefore, working cost can be reduced.

Second Embodiment

[0040] FIG. 7 is a longitudinal sectional view of a rotary compressor according to a second embodiment of the

present invention. FIG. 8 is a bottom view of a low-stage compressing section of the rotary compressor shown in FIG. 7. FIG. 9 is a cross-sectional view of a high-stage compressing section of the rotary compressor shown in FIG. 7. FIG. 10 is a perspective view of a lower surface of the low-stage compressing section closed by a low-stage end plate. FIG. 11 is a chart showing the relationship between a revolution angle of a piston and a discharge pressure of the low-stage compressing section. FIG. 12 is a bottom view of a low-stage compressing section of a rotary compressor according to a modification of the second embodiment. FIG. 13 is a perspective view of a lower surface of the low-stage compressing section closed by a low-stage end plate according to the modification of the second embodiment.

[0041] As shown in FIG. 7, a rotary compressor 2 according to the second embodiment includes, in an airtight cylindrical compressor housing 10, a compressing section 12 and a motor 11 driving the compressing section 12.

[0042] A stator 111 of the motor 11 is fixedly shrunk to an inner circumferential surface of the compressor housing 10. A rotor 112 of the motor 11 is arranged in a central portion of the stator 111 and fixedly shrunk to a rotary shaft 15 mechanically connecting the motor 11 to the compressing section 12.

[0043] The compressing section 12 includes a low-stage compressing section 12L and a high-stage compressing section 12H connected in series to the low-stage compressing section 12L and disposed to be stacked on an upper side of the low-stage compressing section 12L. As shown in FIGS. 7 and 8, the low-stage compressing section 12L includes a short cylindrical cylinder 121L. As shown in FIGS. 7 and 9, the high-stage compressing section 12H includes a short cylindrical cylinder 121H.

[0044] Cylindrical low-stage and high-stage cylinder inner walls 123L and 123H are formed on the low-stage cylinder 121L and the high-stage cylinder 121H to be concentric with the motor 11, respectively. Cylindrical low-stage and high-stage pistons 125L and 125H having outside diameters smaller than diameters of the low-stage and high-stage cylinder inner walls 123L and 123H are arranged in the low-stage and high-stage cylinder inner walls 123L and 123H, respectively. Further, low-stage and high-stage working chambers 130L and 130H (compression spaces) absorbing, compressing, and discharging a cooling medium are formed between the low-stage and high-stage cylinder inner walls 123L and 123H and the low-stage and high-stage pistons 125L and 124H, respectively.

[0045] Low-stage and high-stage vane grooves 128L and 128H are formed in the low-stage and high-stage cylinders 121L and 121H in a range of entire lengths of the low-stage and high-stage cylinders 121L and 121H from the low-stage and high-stage cylinder inner walls 123L and 123H in a radial direction of the low-stage and high-stage cylinders 121L and 121H, respectively. Low-

stage and high-stage flat vanes 127L and 127H are fitted into the low-stage and high-stage vane grooves 128L and 128H, respectively.

[0046] To make a volume of the high-stage working chamber 130H of the high-stage compressing section 12H smaller than that of the low-stage working chamber 130L of the low-stage compressing section 12L, the high-stage cylinder 121H, the high-stage piston 125H, and the high-stage vane 127H are set lower in axial height than the low-stage cylinder 121L, the low-stage piston 125L, and the low-stage vane 127L, respectively.

[0047] Low-stage and high-stage springs, not shown, are arranged in inner parts of the low-stage and high-stage vane grooves 128L and 128H, respectively. In a normal state, the low-stage and high-stage vanes 127L and 127H protrude from within the low-stage and high-stage vane grooves 128L and 128H into the low-stage and high-stage working chambers 130L and 130H by repulsive forces of the low-stage and high-stage springs, respectively. Tip end of the low-stage and high-stage vanes 127L and 127H abut on outer circumferential surfaces of the low-stage and high-stage pistons 125L and 125H, and the low-stage and high-stage vanes 127L and 127H divide the low-stage and high-stage working chambers 130L and 130H (compression spaces) into low-stage and high-stage suction chambers 131L and 131H and low-stage and high-stage compression chambers 133L and 133H, respectively.

[0048] Low-stage and high-stage backpressure introduction paths 129L and 129H communicating the inner parts of the low-stage and high-stage vane grooves 128L and 128H with an interior of the compressor housing 10 and applying a backpressure to the low-stage and high-stage vanes 127L and 127H are formed on the low-stage and high-stage cylinders 121L and 121H, respectively.

[0049] Low-stage and high-stage suction holes 135L and 135H communicating with the low-stage and high-stage suction chambers 131L and 131H are provided in the low-stage and high-stage cylinders 121L and 121H to absorb the cooling medium into the low-stage and high-stage suction chambers 131L and 131H, respectively.

[0050] As shown in FIG. 7, an intermediate partition plate 140 is provided between the low-stage cylinder 121L and the high-stage cylinder 121H to divide a working chamber into the low-stage working chamber 130L of the low-stage cylinder 121L and the high-stage working chamber 130H of the high-stage cylinder 121H. A low-stage end plate 160L is disposed on a lower end of the low-stage cylinder 121L and closes the low-stage working chamber 130L of the low-stage cylinder 121L. A high-stage end plate 160H is disposed on an upper end of the high-stage cylinder 121H and closes the high-stage working chamber 130H of the high-stage cylinder 121H.

[0051] A sub bearing 161L is formed on the low-stage end plate 160L and a sub bearing support 151 of the rotary shaft 15 is rotatably supported by the sub bearing 161L. A main bearing 161H is formed on the high-stage end plate 160H and a main bearing support 153 of the

rotary shaft 15 is rotatably supported by the main bearing 161H.

[0052] The rotary shaft 15 includes low-stage and high-stage eccentric sections 152L and 152H eccentric to be shifted in phase by 180° from each other. The low-stage eccentric section 152L rotatably holds the low-stage piston 125L of the low-stage compressing section 12L. The high-stage eccentric section 152H rotatably holds the high-stage piston 125H of the high-stage compressing section 12H.

[0053] When the rotary shaft 15 rotates, the low-stage and high-stage pistons 125L and 125H revolve clockwise in the low-stage and high-stage cylinders 121L and 121H along the low-stage and high-stage cylinder inner walls 123L and 123H in FIG. 8 (revolve counterclockwise in FIG. 9), and the low-stage and high-stage vanes 127L and 127H follow to reciprocate. Volumes of the low-stage and high-stage suction chambers 131L and 131H and the low-stage and high-stage compression chambers 133L and 133H continuously change by movements of the low-stage and high-stage pistons 125L and 125H and the low-stage and high-stage vanes 127L and 127H, respectively, and the compressing section 12 continuously absorbs, compresses, and discharges the cooling medium.

[0054] As shown in FIG. 7, a low-stage muffler cover 170L is disposed below the low-stage end plate 160L and a low-stage muffler chamber 180L is formed between the low-stage muffler cover 170L and the low-stage end plate 160L. A discharge portion of the low-stage compressing section 12L opens to the low-stage muffler chamber 180L. Accordingly, a low-stage discharge hole 190L communicating the low-stage compression chamber 133L of the low-stage cylinder 121L with the low-stage muffler chamber 180L is provided in the low-stage end plate 160L near the low-stage vane 127L and a low-stage discharge valve 200L preventing backflow of the compressed cooling medium is provided in the low-stage discharge hole 190L.

[0055] As shown in FIG. 10, the low-stage muffler chamber 180L is one annularly communicable chamber and a part of an intermediate communicating path communicating a discharge side of the low-stage compressing section 12L with a suction side of the high-stage compressing section 12H. The low-stage muffler chamber 180L reduces pressure pulsation of the discharged cooling medium.

[0056] Furthermore, a low-stage discharge valve holding member 201L as well as the low-stage discharge valve 200L is fixed to the low-stage end plate 160L by a rivet so as to restrict a deflection opening amount of the low-stage discharge valve 200L. A low-stage muffler discharge hole 210L discharging the cooling medium in the low-stage muffler chamber 180L to outside is provided in an outer peripheral wall of the low-stage end plate 160L. The low-stage muffler discharge hole 210L is provided radially at a position in a circumferential direction of the compressor housing 10 and different in phase from

the low-stage and high-stage suction holes 135L and 135H of the compressing section 12.

[0057] As shown in FIG. 7, a high-stage muffler cover 170H is disposed above the high-stage end plate 160H and a high-stage muffler chamber 180H is formed between the high-stage muffler cover 170H and the high-stage end plate 160H. A high-stage discharge hole 190H communicating the high-stage compression chamber 133H of the high-stage cylinder 121H with the high-stage muffler chamber 180H is provided in the high-stage end plate 160H near the high-stage vane 127H and a high-stage discharge valve 200H preventing backflow of the compressed cooling medium is provided in the high-stage discharge hole 190H. Furthermore, a high-stage discharge valve holding member 201H as well as the high-stage discharge valve 200H is fixed to the high-stage end plate 160H by a rivet so as to restrict a deflection opening amount of the high-stage discharge valve 200H. The high-stage muffler chamber 180H reduces pressure pulsation of the discharged cooling medium.

[0058] The low-stage cylinder 121L, the low-stage end plate 160L, the low-stage muffler cover 170L, the high-stage cylinder 121H, the high-stage end plate 160H, the high-stage muffler cover 170H, and the intermediate partition plate 140 are integrally fastened by a bolt that is not shown. Among the integrally fastened constituent elements of the compressing section 12, an outer peripheral portion of the high-stage end plate 160H is fixedly bonded to the compressor housing 10 by spot welding to thereby fix the compressing section 12 to the compressor housing 10.

[0059] As shown in FIG. 7, first, second, and third through holes 101, 102, and 103 are provided in an outer circumferential wall of the cylindrical compressor housing 10 to be axially away from one another in ascending order from a lower portion. An accumulator 25 formed of an independent and cylindrical airtight container is arranged outside of the compressor housing 10 and held by an accumulator holder 251 and an accumulator band 253.

[0060] A system connecting pipe 255 connecting the accumulator 25 to a low-pressure side of a refrigerating cycle is provided in a central portion of a top surface of the accumulator 25. A low-pressure connecting pipe 31 having one end extending toward an upper portion of an interior of the accumulator 25 and the other end connected to the other end of a suction pipe 104 is connected to a bottom through hole 257 provided at a bottom of the accumulator 25.

[0061] The low-pressure connecting pipe 31 introducing a low-pressure cooling medium of the refrigerating cycle to the compressing section 12 via the accumulator 25 is connected to the low-stage suction hole 135L of the low-stage cylinder 121L via the second through hole 102 and the low-stage suction pipe 104. Accordingly, the low-stage suction hole 135L communicates with the low-pressure side of the refrigerating cycle.

[0062] One end of the low-stage discharge pipe 105 is connected to the low-stage muffler discharge hole

210L of the low-stage muffler chamber 180L through the first through hole 101. One end of the high-stage discharge suction pipe 106 is connected to the high-stage suction hole 135H of the high-stage cylinder 121H through the third through hole 103. Further, the other end of the low-stage discharge pipe 105 is connected to the other end of the high-stage suction pipe 106 by an intermediate connecting pipe 23. A low-pressure connecting pipe 31 and the intermediate connecting pipe 23 are formed so as not to interfere with each other.

[0063] A discharge portion of the high-stage compressing section 12H communicates with the interior of the compressor housing 10 via the high-stage muffler chamber 180H. Namely, the high-stage discharge hole 190H communicating the high-stage compression chamber 133H of the high-stage cylinder 121H with the high-stage muffler chamber 180H is provided in the high-stage end plate 160H, and the high-stage discharge valve 200H preventing backflow of the compressed cooling medium is disposed in the high-stage discharge hole 190H.

[0064] A discharge pipe 107 connected to a high-pressure side of the refrigerating cycle and discharging the high-pressure cooling medium toward the high-pressure side of the refrigerating cycle is connected to a top of the compressor housing 10. Accordingly, the high-stage discharge hole 190H communicates with the high-pressure side of the refrigerating cycle.

[0065] The compressor housing 10 is filled with lubricating oil almost up to a height of the high-stage cylinder 121H. The lubricating oil circulates in the compressing section 12 by a vane pump, not shown, attached to a lower portion of the rotary shaft 15 and seals a portion defining the low-stage and high-stage working chambers 130L and 130H (compression spaces) for the compressed cooling medium by lubrication of sliding components and narrow gaps.

[0066] As shown in FIG. 10, the rotary compressor 2 according to the second embodiment is characteristically configured so that a low-stage auxiliary discharge hole 190LL communicating the low-stage compression chamber 133L with the high-stage compressing section 12H is provided in the low-stage end plate 160L in which the low-stage discharge hole 190L is provided. A low-stage discharge valve 200L is disposed in the low-stage auxiliary discharge hole 190LL similarly to the low-stage discharge hole 190L.

[0067] As shown in FIGS. 8 and 10, a discharge groove 124L communicating with the low-stage discharge hole 190L is provided in a region of the low-stage cylinder inner wall 123L corresponding to a position of the low-stage discharge hole 190L provided in the low-stage end plate 160L. A discharge groove 124LA communicating with the low-stage auxiliary discharge hole 190LL is provided in a region of the low-stage cylinder inner wall 123L corresponding to a position of the low-stage auxiliary discharge hole 190LL. The discharge grooves 124L and 124LA reduce the flow resistance of the cooling medium discharged from the low-stage compression chamber

133L into the low-stage discharge hole 190L and the low-stage auxiliary discharge hole 190LL.

[0068] The low-stage auxiliary discharge hole 190LL is provided at a position away from the low-stage vane groove 128L by 190° to 300° in a direction of revolution of the low-stage piston 125L along the low-stage cylinder inner wall 123L. The reason for providing the low-stage auxiliary discharge hole 190LL at the position within 300° is the same as that described in the first embodiment.

[0069] On the other hand, as shown in FIG. 11, when the low-stage piston 125L revolves clockwise by about 170° from the position of the low-stage vane groove 128L, a pressure of the low-stage compression chamber 133L reaches a low-stage discharge pressure (an intermediate pressure) and the low-stage discharge valves 200L that have closed the low-stage discharge hole 190L and the low-stage auxiliary discharge hole 190LL, respectively are opened. In other words, since a pressure ratio is lower than that according to the first embodiment, the low-stage piston 125L opens quickly by about 40° as compared with the first embodiment.

[0070] Furthermore, similarly to the first embodiment, as shown in FIG. 11, the rotary compressor 2 has a high change rate of a volume of the low-stage compression chamber 133L, that is, a high discharge flow speed when the low-stage piston 125L revolves by 135° to 225° from the position of the low-stage vane groove 128L. Accordingly, right after the low-stage discharge valve 200L opens by 170°, a flow speed of the discharged cooling medium is the highest and pressure loss is the greatest. If the low-stage auxiliary discharge hole 190LL is communicable without being cut off by end surfaces of the low-stage compression chamber 133L and the low-stage piston 125L right after the low-stage discharge valve 200L opens by 170°, the low-stage auxiliary discharge hole 190LL operates effectively. Due to this, the low-stage auxiliary discharge hole 190LL is provided at the position away from the low-stage vane groove 128L at least by 190° in the direction of the revolution of the low-stage piston 125L along the low-stage cylinder inner wall 123L.

[0071] Operation of the rotary compressor 2 described so far will next be described. If the rotary compressor 2 is actuated, the cooling medium flowing from the low-pressure side of the refrigerating cycle into the accumulator 25 through the system connecting pipe 255 is separated into a liquid cooling medium and a gas cooling medium. Specifically, the liquid cooling medium is accumulated in a lower portion of the accumulator 25 and the gas cooling medium is accumulated in an upper portion thereof.

[0072] When the low-stage piston 125L revolves in the low-stage cylinder 121L and a volume of the low-stage suction chamber 131L increases, the gas cooling medium in the accumulator 25 is absorbed into the low-stage suction chamber 131L of the low-stage compressing section 12L through the low-pressure connecting pipe 31, the low-stage suction pipe 104L, and the low-stage suction hole 135. When the low-stage piston 125L revolves

once, the low-stage suction chamber 131L is cut off from the low-stage suction hole 135L and changed over to the low-stage compression chamber 133L, and the cooling medium is compressed in the low-stage compression chamber 133L.

[0073] If the pressure of the compressed cooling medium in the low-stage compression chamber 133L becomes equal to the pressure of the low-stage muffler chamber 180L located downstream of the low-stage discharge valves 200L provided in the low-stage discharge hole 190L and the low-stage auxiliary discharge hole 190LL, respectively, that is, the intermediate pressure (low-stage discharge pressure), then the low-stage discharge valves 200L open, and the cooling medium is discharged into the low-stage muffler chamber 180L through the low-stage discharge hole 190L and the low-stage auxiliary discharge hole 190LL at low flow resistance and the pressure pulsation causing noise is reduced in the low-stage muffler chamber 180L. Thereafter, the cooling medium is fed to the high-stage suction chamber 131H of the high-stage compressing section 12H through the low-stage discharge pipe 105, the intermediate connecting pipe 23, and the high-stage suction hole 135H.

[0074] The cooling medium fed to the high-stage suction chamber 131H of the high-stage compressing section 12H is compressed and discharged by similar operation to that of the low-stage compressing section 12L and the pressure pulsation is reduced in the high-stage muffler chamber 180H. Thereafter, the cooling medium is discharged, as a high-pressure cooling medium, into the compressor housing 10. Thereafter, the high-pressure cooling medium is fed to an upper portion of the motor 11 through a core notch, not shown, of the stator 111 of the motor 11 and a gap between a core and a coil, and discharged toward the high-pressure side of the refrigerating cycle through the discharge pipe 107.

[0075] In the rotary compressor 2 according to the second embodiment, the cooling medium is discharged into the low-stage muffler chamber 180L through the low-stage discharge hole 190L and the low-stage auxiliary discharge hole 190LL at the low flow resistance. Therefore, the over-compression loss can be reduced. Further, manufacturing cost can be reduced as compared with of the case in which the low-stage auxiliary discharge hole is provided in the intermediate partition plate 140.

[0076] Moreover, in the two-stage rotary compressor 2, the pressure ratio is shared between the two compression chambers and the low-stage pressure ratio is generally, therefore, as low as 1.5 to 2.0. Accordingly, since the cooling medium is discharged from the compression chambers in a state in which a volume of the cooling medium is large, it is effective to provide the auxiliary discharge hole particularly for reduction of the over-compression loss

(flow resistance).

[0077] FIG. 12 is a bottom view of a low-stage com-

pressing section according to a modification of the second embodiment. FIG. 13 is a perspective view of a lower surface of the low-stage compressing section closed by a low-stage end plate according to the modification of the second embodiment. In the modification of the second embodiment shown in FIGS. 12 and 13, concave portions 190K and 190AK provided in the low-stage end plate 160L are caused to interfere with each other, a rib 190R is removed, a fixed portion 190S common to integrated L-shaped lower-stage discharge valve and lower-stage discharge valve holding member is provided, thereby providing an L-shaped concave portion. The L-shaped concave portion accommodates therein the integrated L-shaped lower-stage discharge valve and lower-stage discharge valve holding member for preventing backflow in the low-stage discharge hole 190L and the low-stage auxiliary discharge hole 190LL.

[0078] According to the modification of the second embodiment, it is possible to ensure that the low-stage end plate 160L has sufficient strength by providing different concave portions near the low-stage discharge hole 190L and the low-stage auxiliary discharge hole 190LL, respectively. It is also possible to integrate the low-stage discharge valve with the low-stage discharge valve holding member by making only the fixed portion 190S common to the low-stage discharge valve and the low-stage discharge valve holding member. Cost can be thereby reduced.

[0079] Third Embodiment

[0080] FIG. 14 is a longitudinal sectional view of a rotary compressor according to a third embodiment of the present invention. FIG. 15 is a cross-sectional view of a second compressing section of the rotary compressor shown in FIG. 14.

[0081] As shown in FIG. 14, a rotary compressor 3 according to the third embodiment includes, in an airtight cylindrical compressor housing 10, a compressing section 12 and a motor 11 driving the compressing section 12.

[0082] A stator 111 of the motor 11 is fixedly shrunk to an inner circumferential surface of the compressor housing 10. A rotor 112 of the motor 11 is arranged in a central portion of the stator 111 and fixedly shrunk to a rotary shaft 15 mechanically connecting the motor 11 to the compressing section 12.

[0083] The compressing section 12 includes a first compressing section 12S and a second compressing section 12T connected in parallel to the first compressing section 12S and disposed to be stacked on an upper side of the first compressing section 12S. The first and second compressing sections 12S and 12T include short cylindrical cylinders 121S and 121T, respectively.

[0084] As shown in FIG. 15, circular first and second cylinder inner walls 123S and 123T are formed on the first cylinder 121S and the second cylinder 121T to be concentric with the motor 11, respectively. Cylindrical first and second pistons 125S and 125T having outside diameters smaller than diameters of the first and second

cylinder inner walls 123S and 123T are arranged in the first and second cylinder inner walls 123S and 123T, respectively. Further, first and second working chambers 130S and 130T (compression spaces) absorbing, compressing, and discharging a cooling medium are formed between the first and second cylinder inner walls 123S and 123T and the first and second pistons 125S and 124T, respectively.

[0085] First and second vane grooves 128S and 128T are formed in the first and second cylinders 121S and 121T in a range of entire lengths of the first and second cylinders 121S and 121T from the first and second cylinder inner walls 123S and 123T in a radial direction of the first and second cylinders 121S and 121T, respectively. First and second flat vanes 127S and 127T are fitted into the first and second vane grooves 128S and 128T, respectively.

[0086] To make a volume of the second working chamber 130T of the second compressing section 12T smaller than that of the first working chamber 130S of the first compressing section 12S, the second cylinder 121T, the second piston 125T, and the second vane 127T are set lower in axial height than the first cylinder 121S, the first piston 125S, and the first vane 127S, respectively.

[0087] First and second springs, not shown, are arranged in inner parts of the first and second vane grooves 128S and 128T, respectively. In a normal state, the first and second vanes 127S and 127T protrude from within the first and second vane grooves 128S and 128T into the first and second working chambers 130S and 130T by repulsive forces of the first and second springs, respectively. Tip end of the first and second vanes 127S and 127T abut on outer circumferential surfaces of the first and second pistons 125S and 125T, and the first and second vanes 127S and 127T divide the first and second working chambers 130S and 130T (compression spaces) into first and second suction chambers 131S and 131T and first and second compression chambers 133S and 133T, respectively.

[0088] First and second backpressure introduction paths 129S and 129T communicating the inner parts of the first and second vane grooves 128S and 128T with an interior of the compressor housing 10 and applying a backpressure to the first and second vanes 127S and 127T are formed on the first and second cylinders 121S and 121T, respectively.

[0089] First and second suction holes 135S and 135T communicating with the first and second suction chambers 131S and 131T are provided in the first and second cylinders 121S and 121T to absorb the cooling medium into the first and second suction chambers 131S and 131T, respectively.

[0090] As shown in FIG. 14, an intermediate partition plate 140 is provided between the first cylinder 121S and the second cylinder 121T to divide a working chamber into the first working chamber 130S of the first cylinder 121S and the second working chamber 130T of the second cylinder 121T. A first end plate 160S is disposed on

a lower end of the first cylinder 121S and closes the first working chamber 130S of the first cylinder 121S. A second end plate 160T is disposed on an upper end of the second cylinder 121T and closes the second working chamber 130T of the second cylinder 121T.

[0091] A sub bearing 161S is formed on the first end plate 160S and a sub bearing support 151 of the rotary shaft 15 is rotatably supported by the sub bearing 161S. A main bearing 161T is formed on the second end plate 160T and a main bearing support 153 of the rotary shaft 15 is rotatably supported by the main bearing 161T.

[0092] The rotary shaft 15 includes first and second eccentric sections 152S and 152T eccentric to be shifted in phase by 180° from each other. The first eccentric section 152S rotatably holds the first piston 125S of the first compressing section 12S. The second eccentric section 152T rotatably holds the second piston 125T of the second compressing section 12T.

[0093] When the rotary shaft 15 rotates, the first and second pistons 125S and 125T revolve clockwise in the first and second cylinders 121S and 121T along the first and second cylinder inner walls 123S and 123T, and the first and second vanes 127S and 127T follow to reciprocate. Volumes of the first and second suction chambers 131S and 131T and the first and second compression chambers 133S and 133T continuously change by movements of the first and second pistons 125S and 125T and the first and second vanes 127S and 127T, respectively, and the compressing section 12 continuously absorbs, compresses, and discharges the cooling medium.

[0094] As shown in FIG. 14, a first muffler cover 170S is disposed below the first end plate 160S and a first muffler chamber 180S is formed between the first muffler cover 170S and the first end plate 160S. A discharge portion of the first compressing section 12S opens to the first muffler chamber 180S. Namely, a first discharge hole 190S communicating the first compression chamber 133S of the first cylinder 121S with the first muffler chamber 180S is provided in the first end plate 160S near the first vane 127S and a first discharge valve 200S preventing backflow of the compressed cooling medium is provided in the first discharge hole 190S.

[0095] The first muffler chamber 180S is one annularly communicable chamber and a part of an intermediate communicating path communicating a discharge side of the first compressing section 12S with the interior of the compressor housing 10. The first muffler chamber 180S reduces pressure pulsation of the discharged cooling medium.

[0096] Furthermore, a first discharge valve holding member 201S as well as the first discharge valve 200S is fixed on the first discharge valve 200S by a rivet so as to restrict a deflection opening amount of the first discharge valve 200S.

[0097] As shown in FIG. 14, a second muffler cover 170T is disposed above the second end plate 160T and a second muffler chamber 180T is formed between the second muffler cover 170T and the second end plate

160T. A second discharge hole 190T communicating the second compression chamber 133T of the second cylinder 121T with the second muffler chamber 180T is provided in the second end plate 160T near the second vane 127T and a second discharge valve 200T preventing backflow of the compressed cooling medium is provided in the second discharge hole 190T.

[0098] Furthermore, a second discharge valve holding member 201T as well as the second discharge valve 200T is fixed by a rivet so as to restrict a deflection opening amount of the second discharge valve 200T. The second muffler chamber 180T reduces pressure pulsation of the discharged cooling medium.

[0099] The first cylinder 121S, the first end plate 160S, the first muffler cover 170S, the second cylinder 121T, the second end plate 160T, the second muffler cover 170T, and the intermediate partition plate 140 are integrally fastened by a bolt that is not shown. Among the integrally fastened constituent elements of the compressing section 12, an outer peripheral portion of the second end plate 160T is fixedly bonded to the compressor housing 10 by spot welding to thereby fix the compressing section 12 to the compressor housing 10.

[0100] As shown in FIG. 14, first and second through holes 101 and 102 are provided in an outer circumferential wall of the cylindrical compressor housing 10 to be axially away from each other in ascending order from a lower portion. An accumulator 25T formed of an independent and cylindrical airtight container is arranged outside of the compressor housing 10 and held by an accumulator holder 251 and an accumulator band 253.

[0101] A system connecting pipe 255 connecting the accumulator 25T to a low-pressure side of a refrigerating cycle is provided in a central portion of a top surface of the accumulator 25T. First and second connecting pipes 31S and 31T each having one end extending toward an upper portion of an interior of the accumulator 25T and the other end connected to the other end of first and second suction pipes 104 and 105 are connected to bottom through holes 257 provided at a bottom of the accumulator 25T, respectively.

[0102] The first and second connecting pipes 31S and 31T introducing a low-pressure cooling medium of the refrigerating cycle to the first and second compressing sections 12S and 12T via the accumulator 25T are connected to first and second suction holes 135S and 135T of the first and second cylinders 121S and 121T via the first and second through holes 101 and 102 and the first and second suction pipes 104, respectively. Namely, the first and second suction holes 135S and 135T communicate with the low-pressure side of the refrigerating cycle in parallel.

[0103] Discharge portions of the first and second compressing sections 12S and 12T communicate with the interior of the compressor housing 10 via the first and second muffler chambers 180S and 180H, respectively. Accordingly, the first and second discharge holes 190S and 190T communicating the first and second compress-

sion chambers 133S and 133T of the first and second cylinders 121S and 121T with the first and second muffler chambers 180S and 180H are provided in the first and second end plates 160S and 160T, and the first and second discharge valves 200S and 200T preventing back-flow of the compressed cooling medium are disposed in the first and second discharge holes 190S and 190T, respectively.

[0104] A discharge pipe 107 connected to a high-pressure side of the refrigerating cycle and discharging the high-pressure cooling medium toward the high-pressure side of the refrigerating cycle is connected to a top of the compressor housing 10. Accordingly, the first and second discharge holes 190S and 190T communicate with the high-pressure side of the refrigerating cycle.

[0105] The compressor housing 10 is filled with lubricating oil almost up to a height of the second cylinder 121T. The lubricating oil circulates in the compressing section 12 by a vane pump, not shown, attached to a lower portion of the rotary shaft 15 and seals a portion defining the first and second working chambers 130S and 130T (compression spaces) for the compressed cooling medium by lubrication of sliding components and narrow gaps.

[0106] First and second auxiliary discharge holes 190SS and 190TT are provided at positions from the first and second vane grooves 128S and 128T by 230° to 300° in a direction of revolution of the first and second pistons 125S and 125T along the first and second cylinder inner walls 123S and 123T, respectively. The arrangement is similar to that of the auxiliary discharge hole 190A according to the first embodiment since the two cylinders 121S and 121T are arranged in parallel and equal in responsible pressure ratio.

[0107] In the rotary compressor 3 according to the third embodiment, the first and second auxiliary discharge holes 190SS and 190TT are provided in the first and second end plates 160S and 160T of the first and second compressing sections 12S and 12T, respectively. Alternatively, an auxiliary hole may be provided only in one of the end plates.

[0108] Operation of the rotary compressor 3 described so far will next be described. If the rotary compressor 3 is actuated, the cooling medium flowing from the low-pressure side of the refrigerating cycle into the accumulator 25T through the system connecting pipe 255 is separated into a liquid cooling medium and a gas cooling medium. Specifically, the liquid cooling medium is accumulated in a lower portion of the accumulator 25T and the gas cooling medium is accumulated in an upper portion thereof.

[0109] When the first and second pistons 125S and 125T revolve in the first and second cylinders 121S and 121T and a volume of each of the first and second suction chambers 131S and 131T increases, the gas cooling medium in the accumulator 25T is absorbed into the first and second suction chambers 131S and 131T of the first and second compressing sections 12S and 12T through

the first and second connecting pipes 31S and 31T, the first and second suction pipes 104, and the first and second suction holes 135S and 135T. When the first and second pistons 125S and 125T revolve once, the first and second suction chambers 131S and 131T are cut off from the first and second suction holes 135S and 135T and changed over to the first and second compression chambers 133S and 133T, and the cooling medium is compressed in the first and second compression chambers 133S and 133T.

[0110] If the pressure of the compressed cooling medium in each of the first and second compression chambers 133S and 133T becomes equal to the pressure of each of the first and second muffler chambers 180S and 180T located downstream of the first and second discharge valves 200S and 200T provided in the first and second discharge hole 190S and 190T and the first and second auxiliary discharge holes 190SS and 190TT, respectively, then the first and second discharge valves 200S and 200T open, and the cooling medium is discharged into the first and second muffler chambers 180S and 180T through the first and second discharge holes 190S and 190T and the first and second auxiliary discharge holes 190SS and 190TT at low flow resistance and the pressure pulsation causing noise is reduced in the first muffler chamber 180S. The cooling medium is discharged, as a high-pressure cooling medium, into the compressor housing 10. Thereafter, the high-pressure cooling medium is fed to an upper portion of the motor 11 through a core notch, not shown, of the stator 111 of the motor 11 and gaps between a core and a coil and discharged toward the high-pressure side of the refrigerating cycle through the discharge pipe 107.

[0111] In the rotary compressor 3 according to the third embodiment, the cooling medium is discharged into the compressor housing 10 through the first and second discharge holes 190S and 190T and the first and second auxiliary discharge holes 190SS and 190TT at the low flow resistance. Therefore, the over-compression loss can be reduced.

Fourth Embodiment

[0112] FIG. 16 is a top view of a compressing section of a rotary compressor according to a fourth embodiment of the present invention. FIG. 17 is a top view of the compressing section of the rotary compressor according to the first embodiment for reference. As shown in FIG. 16, in the rotary compressor according to the fourth embodiment, a discharge groove 124 communicating with a discharge hole 190 is provided in a region of a cylinder inner wall 123 corresponding to a position of the discharge hole 190 provided in one end plate 160A but no discharge groove is provided in a region of the cylinder inner wall 123 corresponding to a position of an auxiliary discharge hole 190A.

[0113] If a discharge groove 124A is provided in the region of the cylinder inner wall 123 corresponding to the

position of the auxiliary discharge hole 190A similarly to the rotary compressor 1 according to the first embodiment shown in FIG. 1, the cooling medium compressed in the compression chamber 133 leaks into the suction chamber 131 through narrow gaps between corners of the discharge groove 124A and the piston 125 when the eccentric section 152 of the piston 125 passes through the position of the discharge groove 124A.

[0114] As shown in the rotary compressor according to the fourth embodiment, if a center of the auxiliary discharge hole 190A is located inward of the cylinder inner wall 123 and no discharge groove is provided in the region of the cylinder inner wall 123 corresponding to the position of the auxiliary discharge hole 190A, the cooling medium leaking from the compression chamber 133 into the suction chamber 131 can be reduced. Accordingly, efficiency can be improved, as compared with the case in which the discharge groove 124 is provided.

[0115] In the rotary compressor according to an embodiment of the present invention, the auxiliary discharge hole different from the discharge hole is provided in one end plate in which the discharge hole is provided to increase a total area of the discharge hole. Therefore, there is no need to work a concave portion for the discharge hole, the valve seat around the discharge hole, and the discharge valve to be provided on each of both end plates. It is thereby possible to reduce working cost.

[0116] Although the invention has been described with respect to a specific embodiment for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

Claims

1. A rotary compressor (1) comprising:

a compressing section (12) including
a cylindrical cylinder (121),
two end plates (160A, 160B) closing both ends
of the cylinder (121), respectively,
a piston (125) held by an eccentric section (152)
of a rotary shaft (15) driven to rotate by a motor
(11), and revolving in the cylinder (121) along a
cylinder inner wall (123) of the cylinder (121), a
working chamber (130) being formed between
the piston (125) and the cylinder inner wall (123),
and
a vane (127) protruding from within a vane
groove (128) of the cylinder (121) into the work-
ing chamber (130), abutting on the piston (125),
and dividing the working chamber (130) into a
suction chamber (131) and a compression
chamber (133);
an airtight compressor housing (10) accommo-

dating therein the compressing section (133);
a suction hole (135) provided in the cylinder
(121) and communicating the suction chamber
(131) with a low-pressure side of a refrigerating
cycle; and

a discharge hole (190) provided in one of the
end plates (160A) and communicating the com-
pression chamber (133) with a high-pressure
side of the refrigerating cycle,

wherein an auxiliary discharge hole (190A) different
from the discharge hole (190) is provided in the one
end plate (160A).

2. The rotary compressor (1) according to claim 1,
wherein
discharge valves (200) are provided in the discharge
hole (190) and the auxiliary discharge hole (190A),
respectively, and
concave portions (190K, 190AK) accommodating
therein the discharge valves (200) are separately
provided in each of the end plates (160A, 160B),
respectively.

3. The rotary compressor (1) according to claim 1,
wherein
integrated L-shaped discharge valves are provided
in the discharge hole (190) and the auxiliary dis-
charge hole (190A), respectively, and
a concave portion accommodating therein the inte-
grated L-shaped discharge valves and having a fixed
portion common to the L-shaped discharge valves
is provided in each of the end plates (160A, 160B).

4. The rotary compressor (1) according to any one of
claims 1 to 3,
wherein a discharge groove communicating with the
discharge hole (190) is provided in a region of the
cylinder inner wall (123) corresponding to a position
of the discharge hole (190) provided in the one end
plate (160A), and no discharge groove is provided
in a region of the cylinder inner wall (123) corre-
sponding to a position of the auxiliary discharge hole
(190A) provided in the one
end plate (160A).

5. A rotary compressor (2) comprising:

a low-stage compressing section (12L) including
a cylindrical low-stage cylinder (121L),
a low-stage end plate (160L) closing one end of
the low-stage cylinder (121L),
a low-stage piston (125L) held by a low-stage
eccentric section (152L) of a rotary shaft (15)
driven to rotate by a motor (11) and revolving in
the low-stage cylinder (121L) along a low-stage
cylinder inner wall (123L) of the low-stage cyl-
inder (121L), a low-stage working chamber

(130L) being formed between the low-stage piston (125L) and the low-stage cylinder inner wall (123L), and

a low-stage vane (127L) protruding from within a low-stage vane groove (128L) of the low-stage cylinder (121L) into the low-stage working chamber (130L), abutting on the low-stage piston (125L), and dividing the low-stage working chamber (130L) into a low-stage suction chamber (131L) and a low-stage compression chamber (133L);

a high-stage compressing section (12H) stacked on the low-stage compressing section (12L) via an intermediate partition plate (140), the high-stage compressing section (12H) including

a cylindrical high-stage cylinder (121H),
a high-stage end plate (160H) closing one end of the high-stage cylinder (121H),
a high-stage piston (125H) held by a high-stage eccentric section (152H) of the rotary shaft (15) driven to rotate by the motor (11), and revolving in the high-stage cylinder (121H) along a high-stage cylinder inner wall (123H) of the high-stage cylinder (121H), a high-stage working chamber (130H) being formed between the high-stage piston (125H) and the high-stage cylinder inner wall (123H), and

a high-stage vane (127H) protruding from within a high-stage vane groove (128H) of the high-stage cylinder (121H) into the high-stage working chamber (130H), abutting on the high-stage piston (125H), and dividing the high-stage working chamber (130H) into a high-stage suction chamber (131H) and a high-stage compression chamber (133H);

an airtight compressor housing (10) accommodating therein the low-stage compressing section (12L) and the high-stage compressing section (12H);

a low-stage suction hole (135L) provided in the low-stage cylinder (121L) and communicating the low-stage suction chamber (131L) with a low-pressure side of a refrigerating cycle;

a low-stage discharge hole (190L) provided in the low-stage end plate (160L) and communicating the low-stage compression chamber (133L) with a high-stage suction hole (135H) provided in the high-stage cylinder (121H); and
a high-stage discharge hole (190H) provided in the high-stage end plate (160H) and communicating the high-stage compression chamber (133H) with a high-pressure side of the refrigerating cycle,

wherein a low-stage auxiliary discharge hole (190LL) different from the low-stage discharge hole (190L) is provided in the low-stage end plate (160L).

6. The rotary compressor (2) according to claim 5, wherein
discharge valves (200) are provided in the low-stage discharge hole (190L) and the low-stage auxiliary discharge hole (190LL), respectively, and concave portions (190K, 190AK) accommodating therein the discharge valves (200) are separately provided in the low-stage end plate (160L), respectively.

7. The rotary compressor (2) according to claim 5, wherein
integrated L-shaped discharge valves are provided in the low-stage discharge hole (190L) and the low-stage auxiliary discharge hole (190LL), respectively, and
a concave portion accommodating therein the integrated L-shaped discharge valves and having a fixed portion common to the L-shaped discharge valves is provided in the low-stage end plate (160L).

8. The rotary compressor (2) according to any one of claims 5 to 7,
wherein a discharge groove communicating with the low-stage discharge hole (190L) is provided in a region of the low-stage cylinder inner wall (123L) corresponding to a position of the low-stage discharge hole (190L) provided in the one end plate, and no discharge groove is provided in a region of the low-stage cylinder inner wall (123L) corresponding to a position of the low-stage auxiliary discharge hole (190LL) provided in the low-stage end plate (160L).

FIG.1

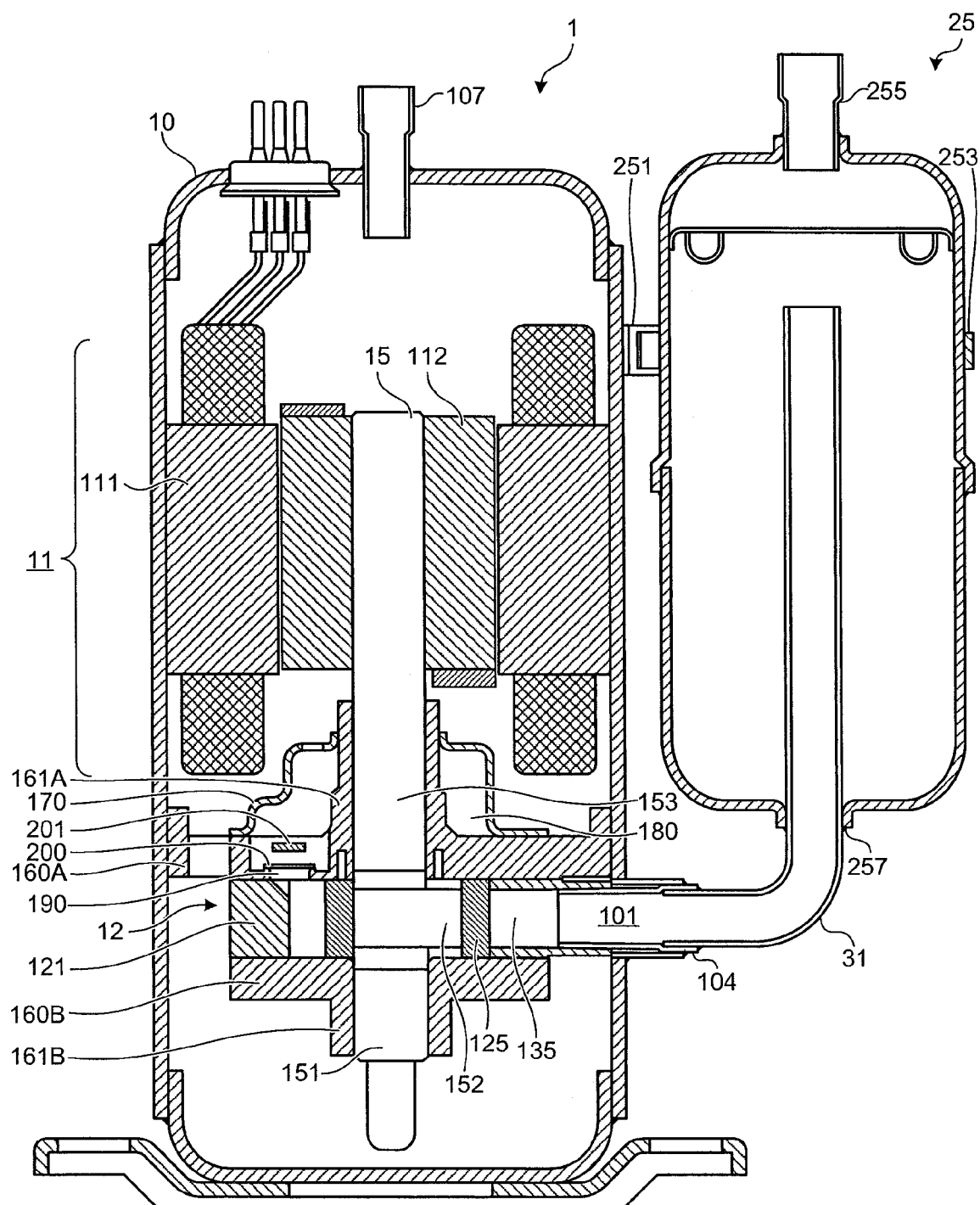


FIG.2

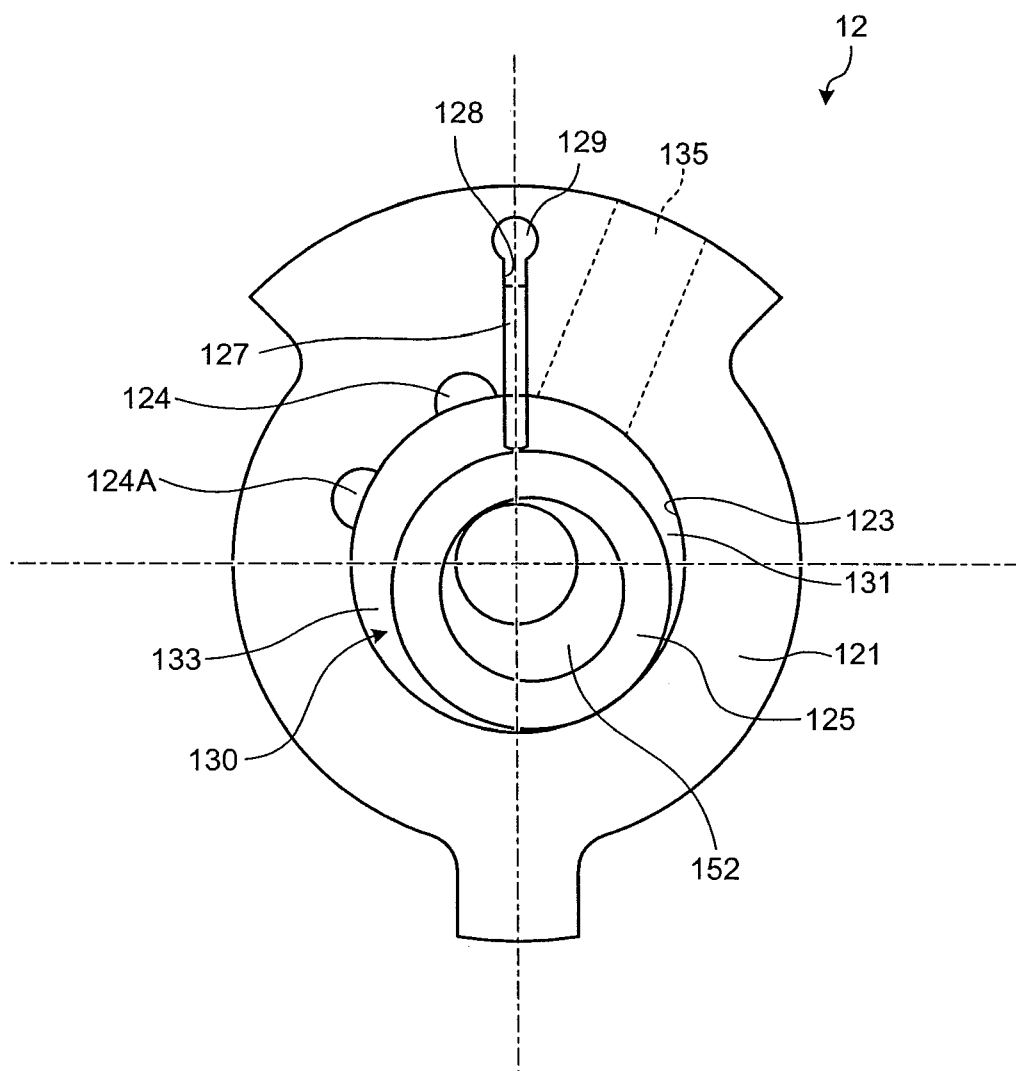


FIG.3

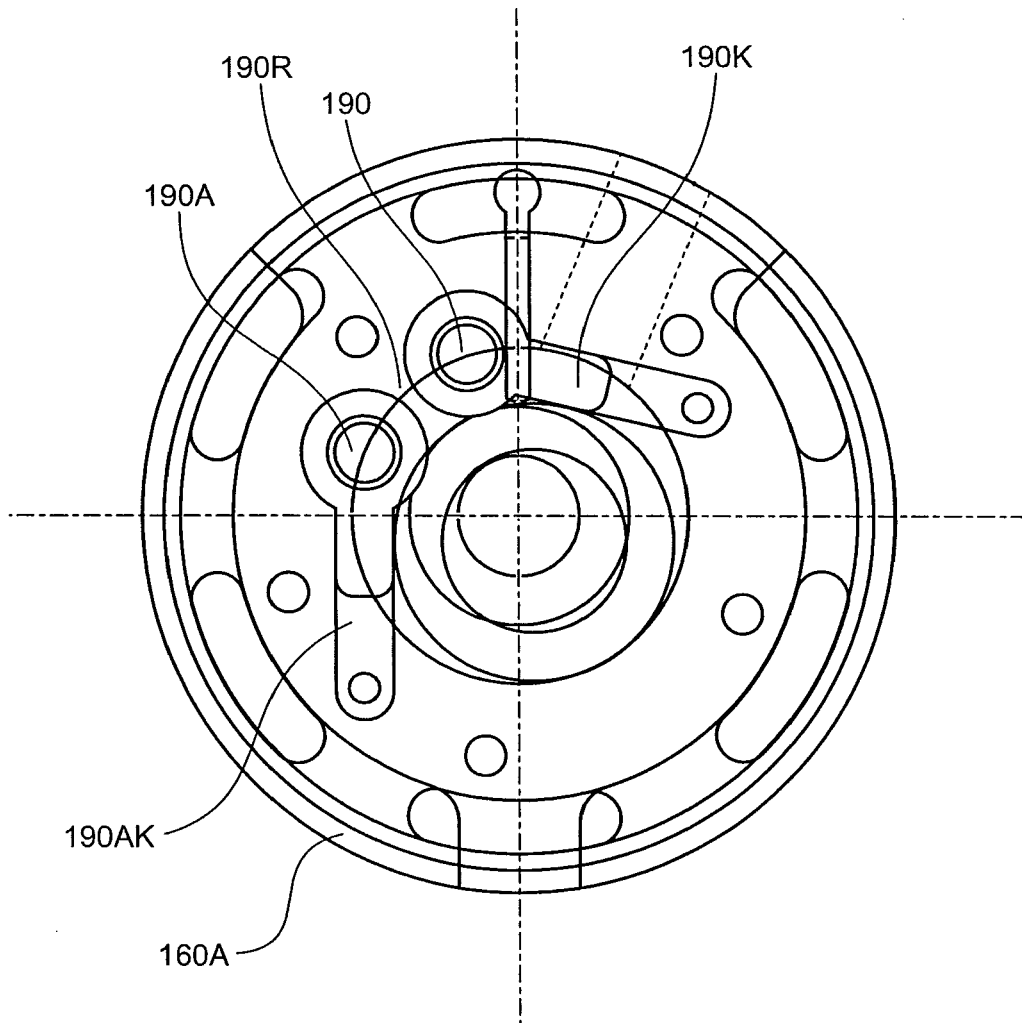
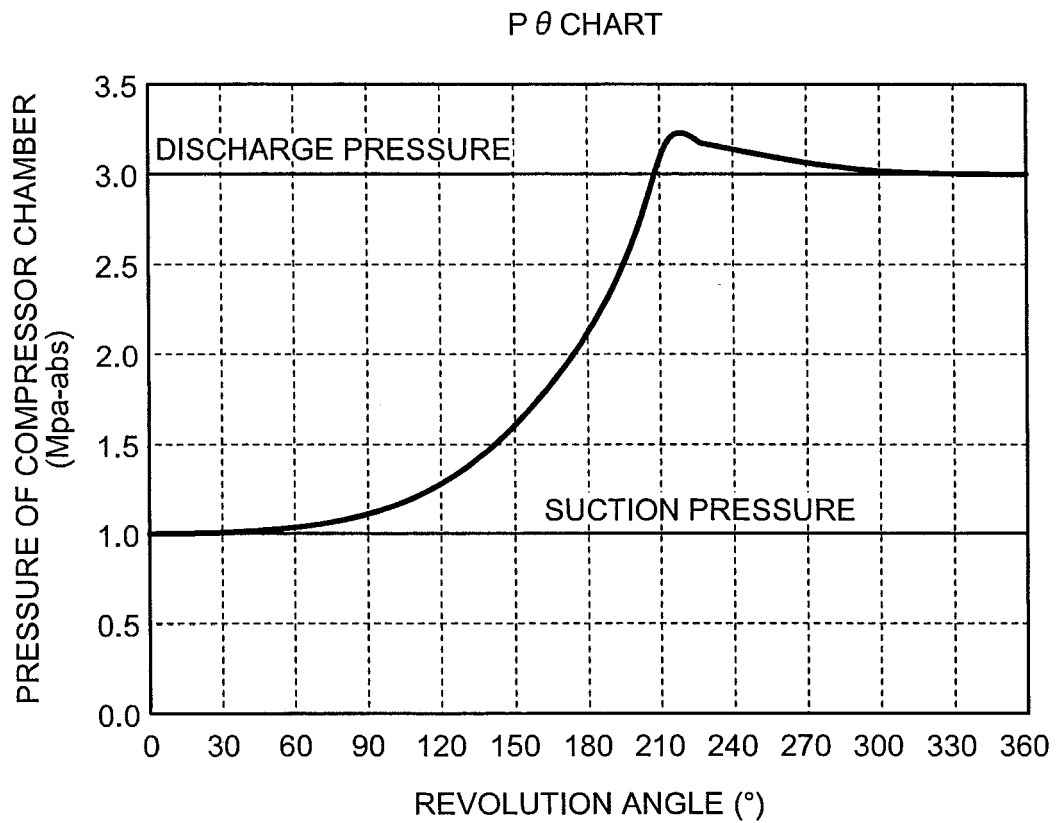


FIG.4



PRESSURE OF COMPRESSOR CHAMBER RELATIVE TO REVOLUTION
ANGLE OF PISTON WHEN ROTARY COMPRESSOR IS OPERATED USING
COOLING MEDIUM R410A UNDER RATED COOLING CONDITIONS

FIG.5

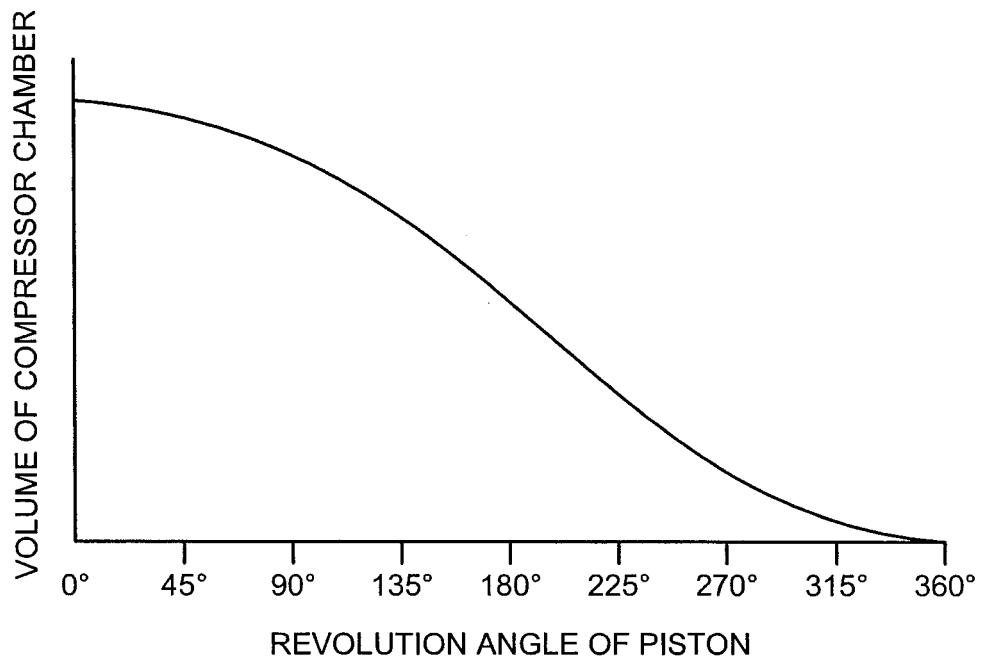


FIG.6

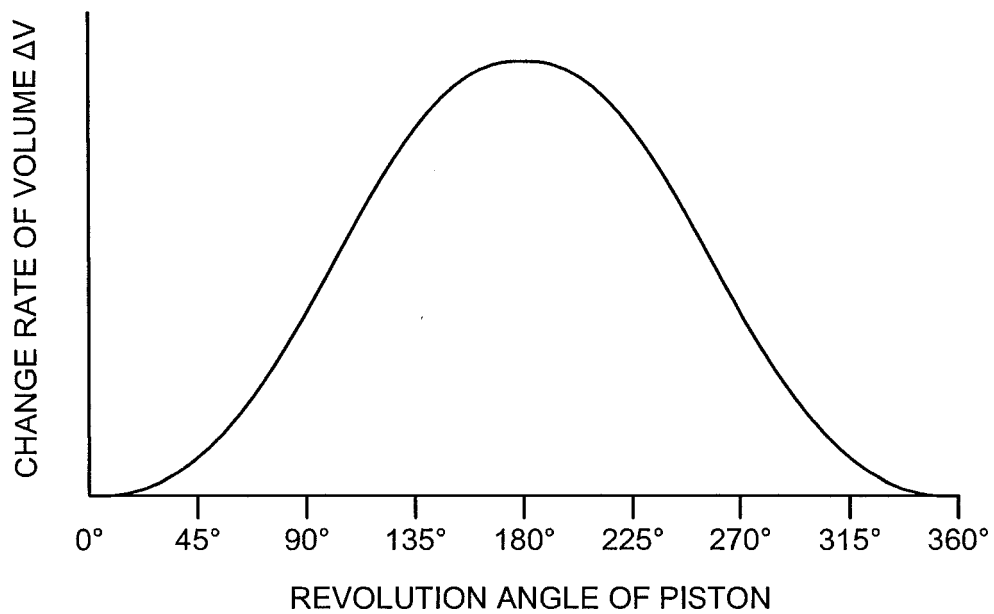


FIG.7

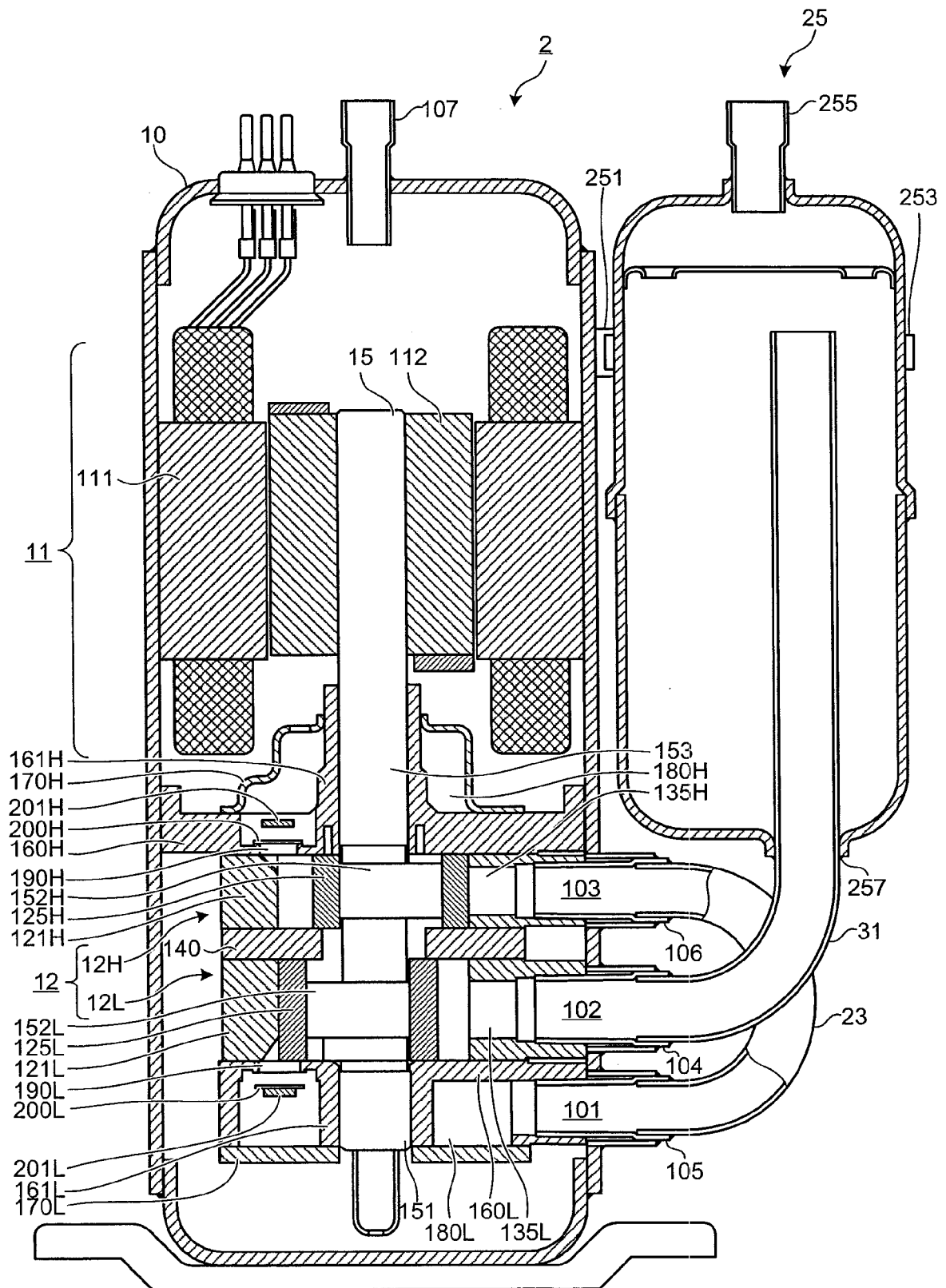


FIG.8

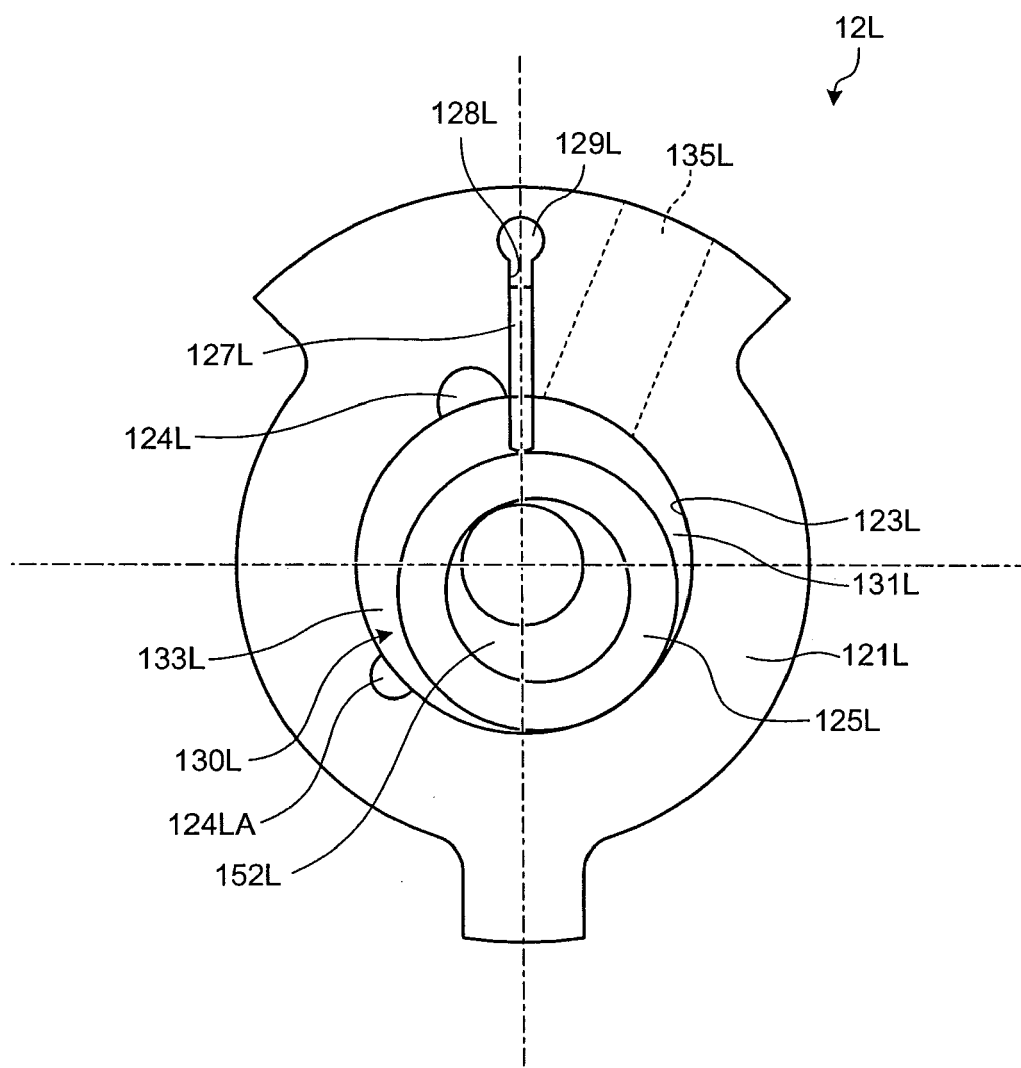


FIG.9

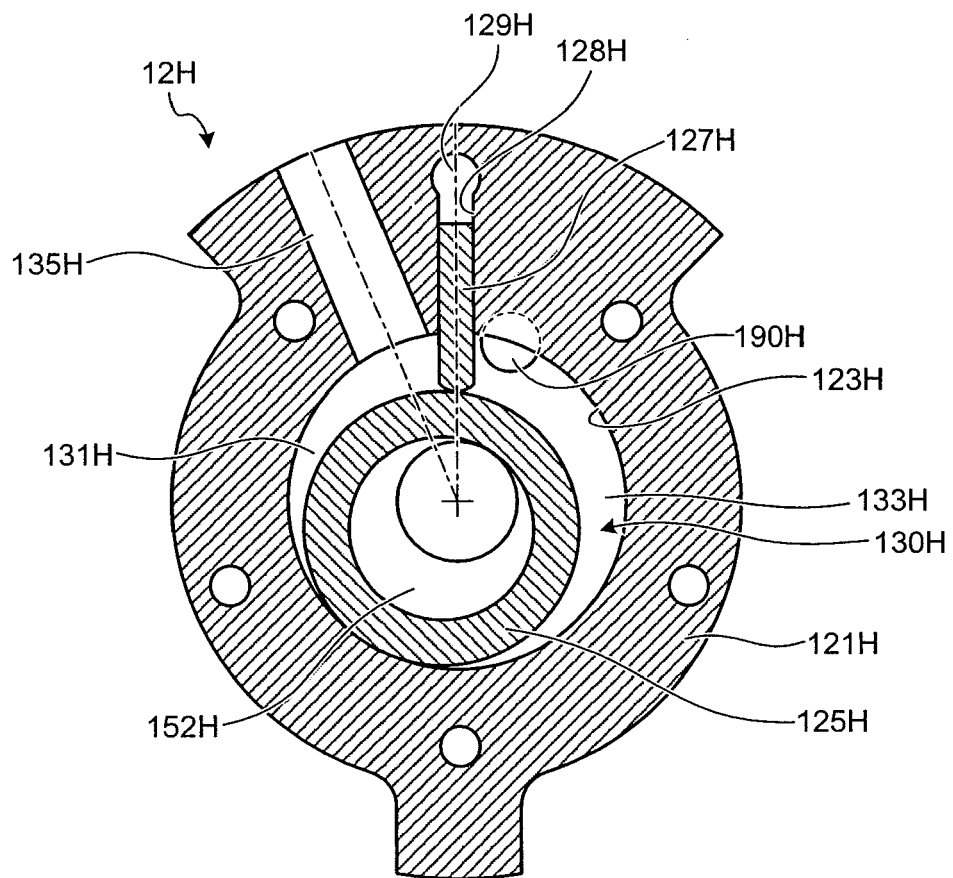


FIG.10

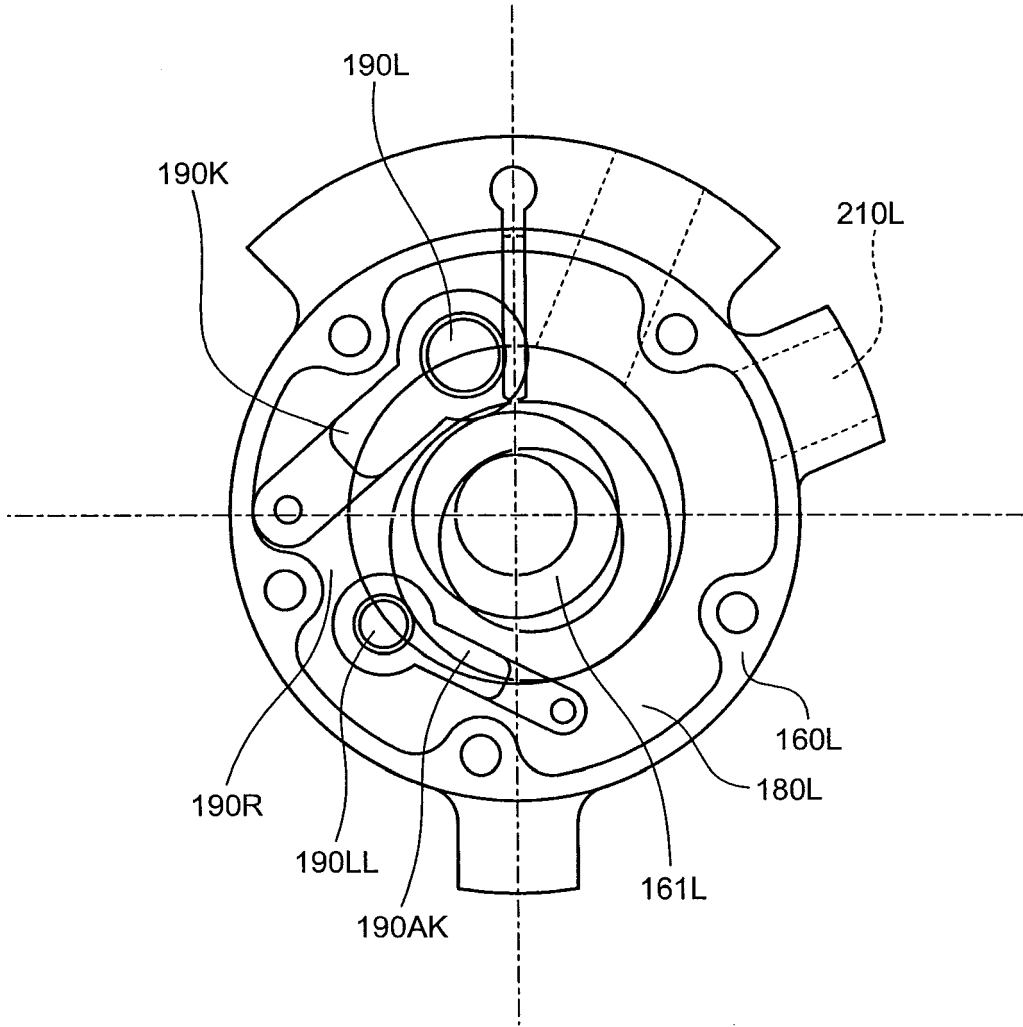
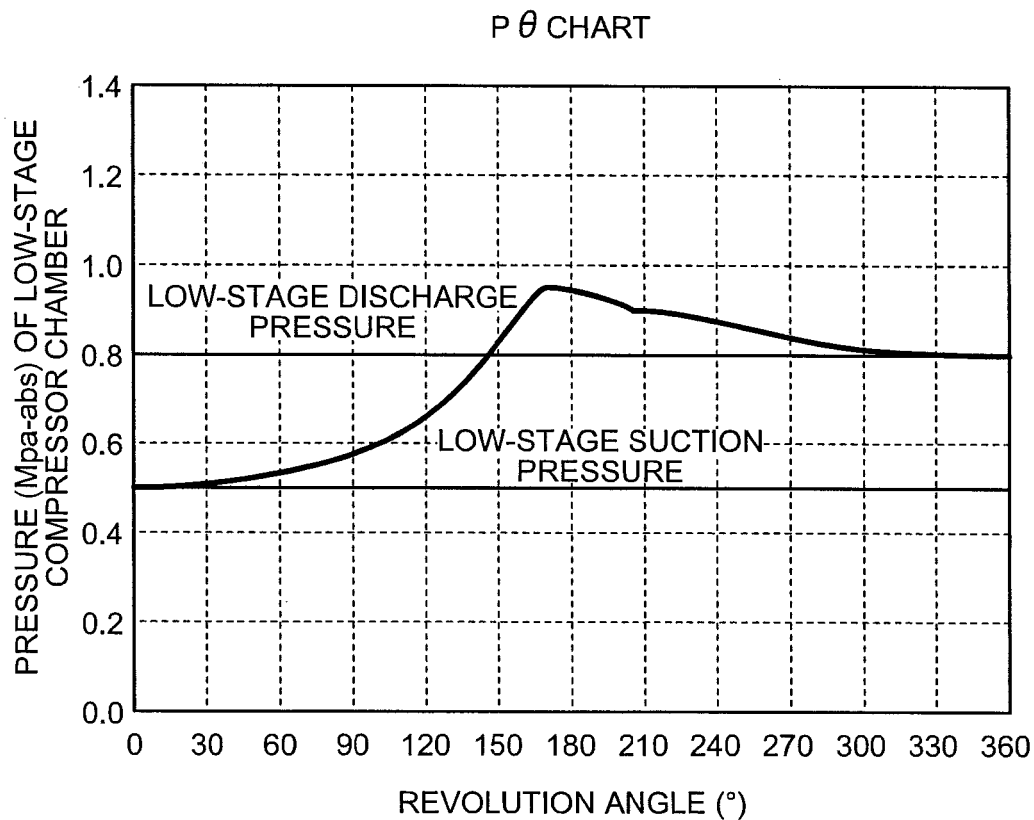


FIG.11



PRESSURE OF LOW-STAGE COMPRESSOR CHAMBER RELATIVE TO
 REVOLUTION ANGLE OF LOW-STAGE PISTON WHEN ROTARY COMPRESSOR IS
 OPERATED IN HEATING MODE USING COOLING MEDIUM R410A UNDER
 CONDITION OF AN OUTSIDE TEMPERATURE OF -7°C

FIG.12

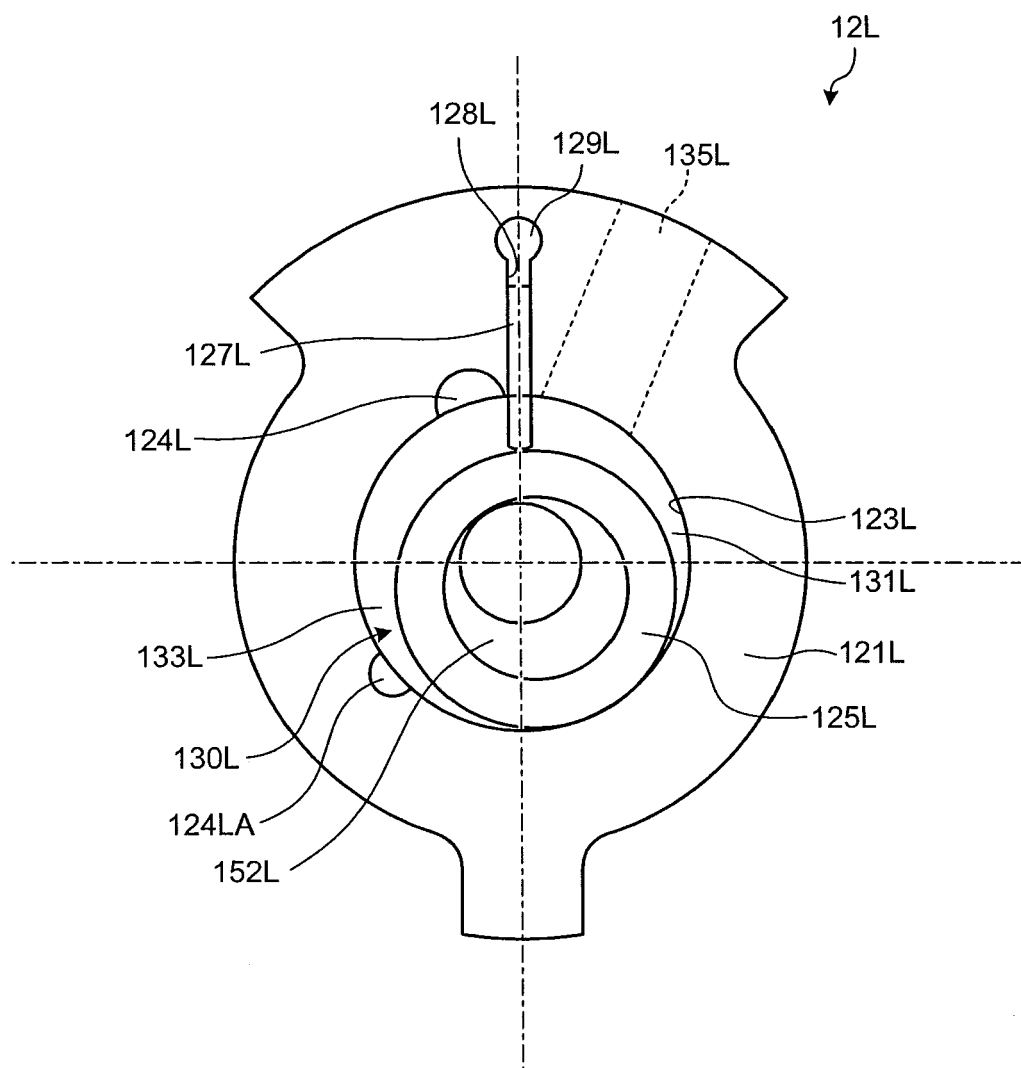


FIG.13

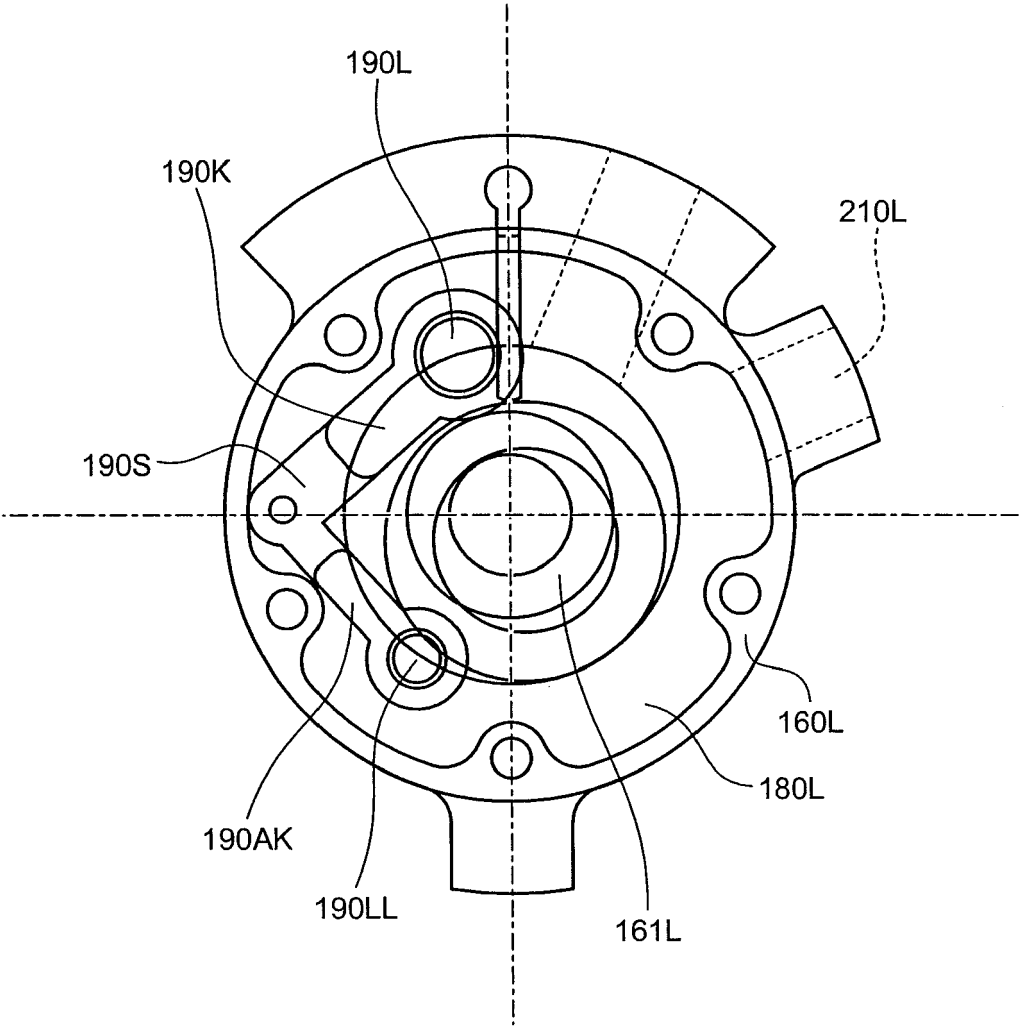


FIG.14

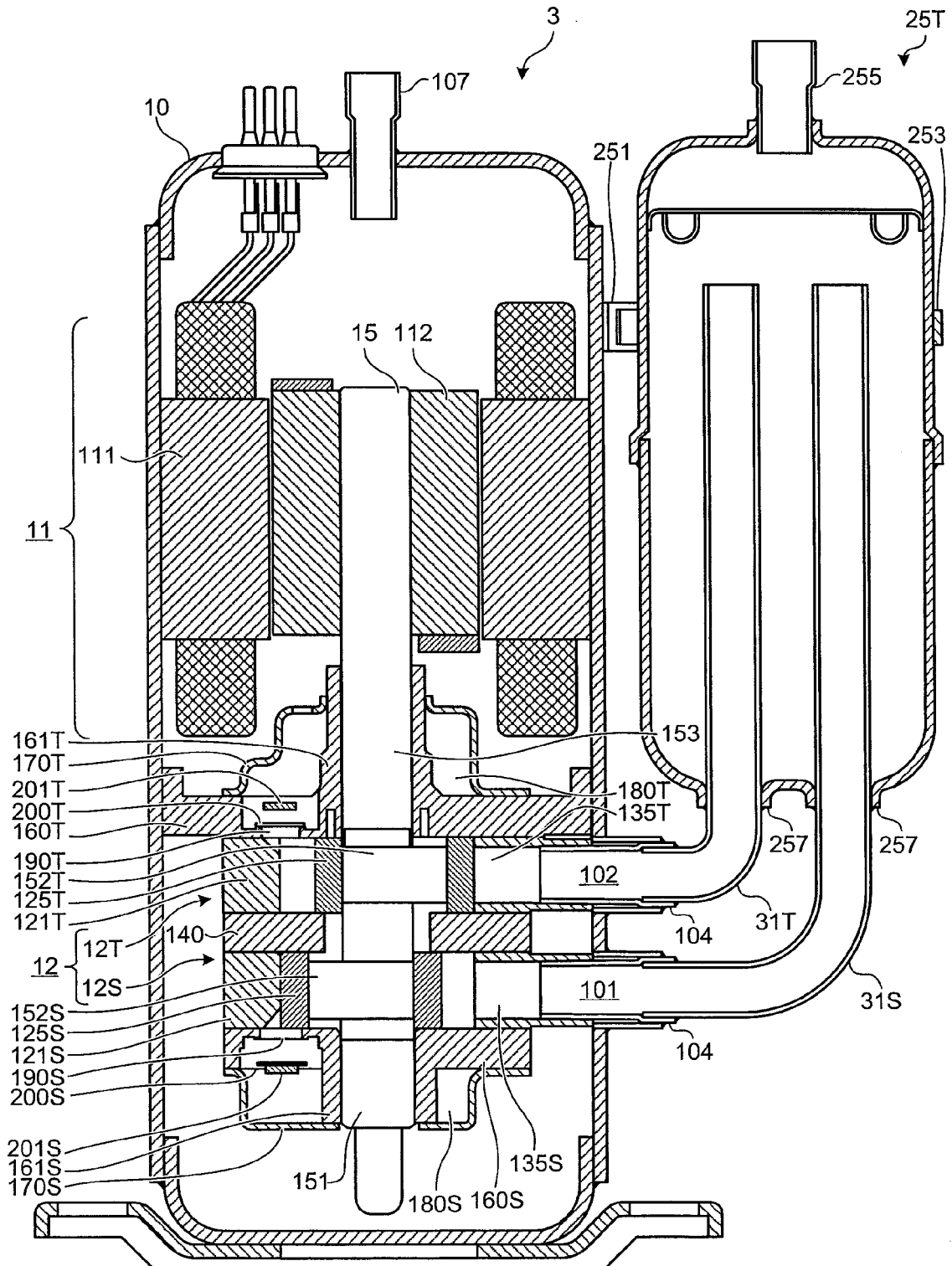


FIG.15

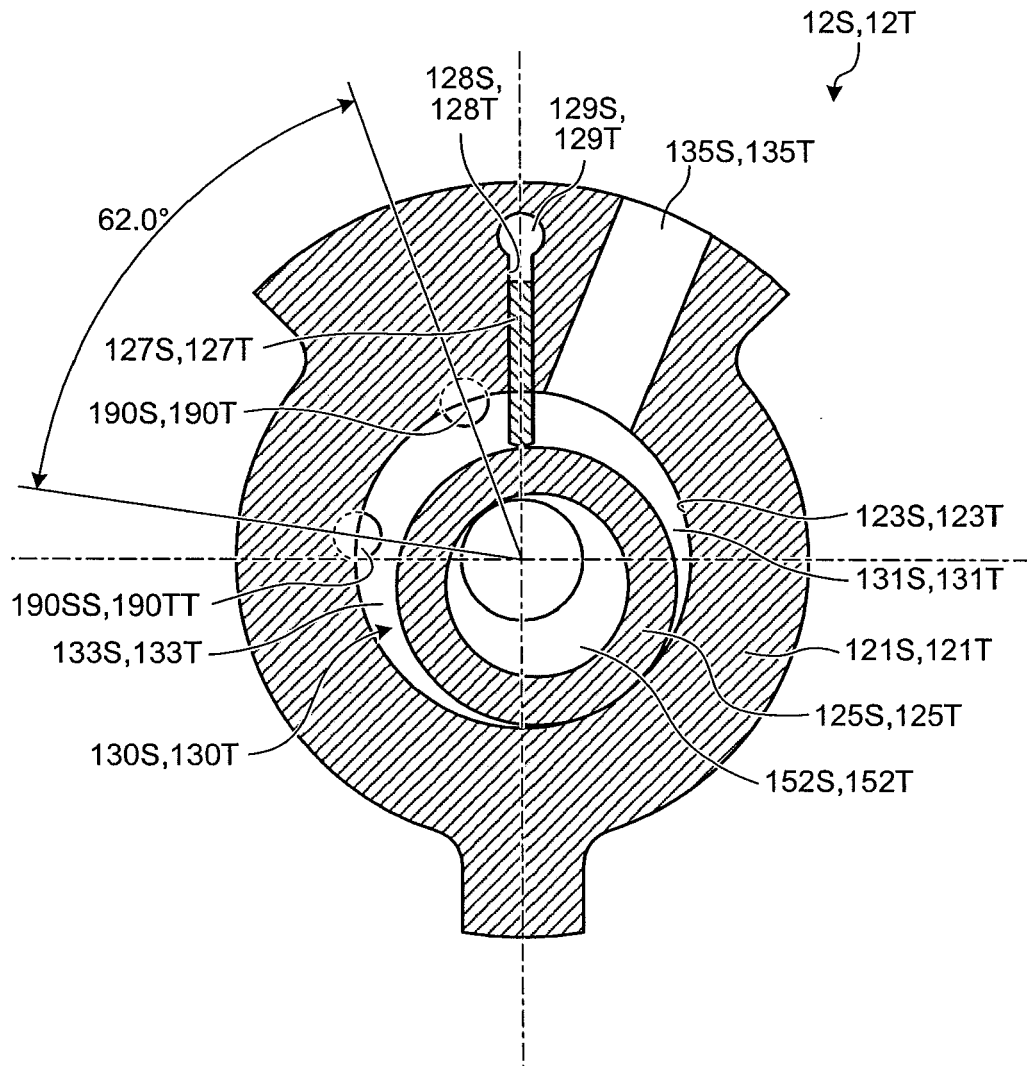


FIG.16

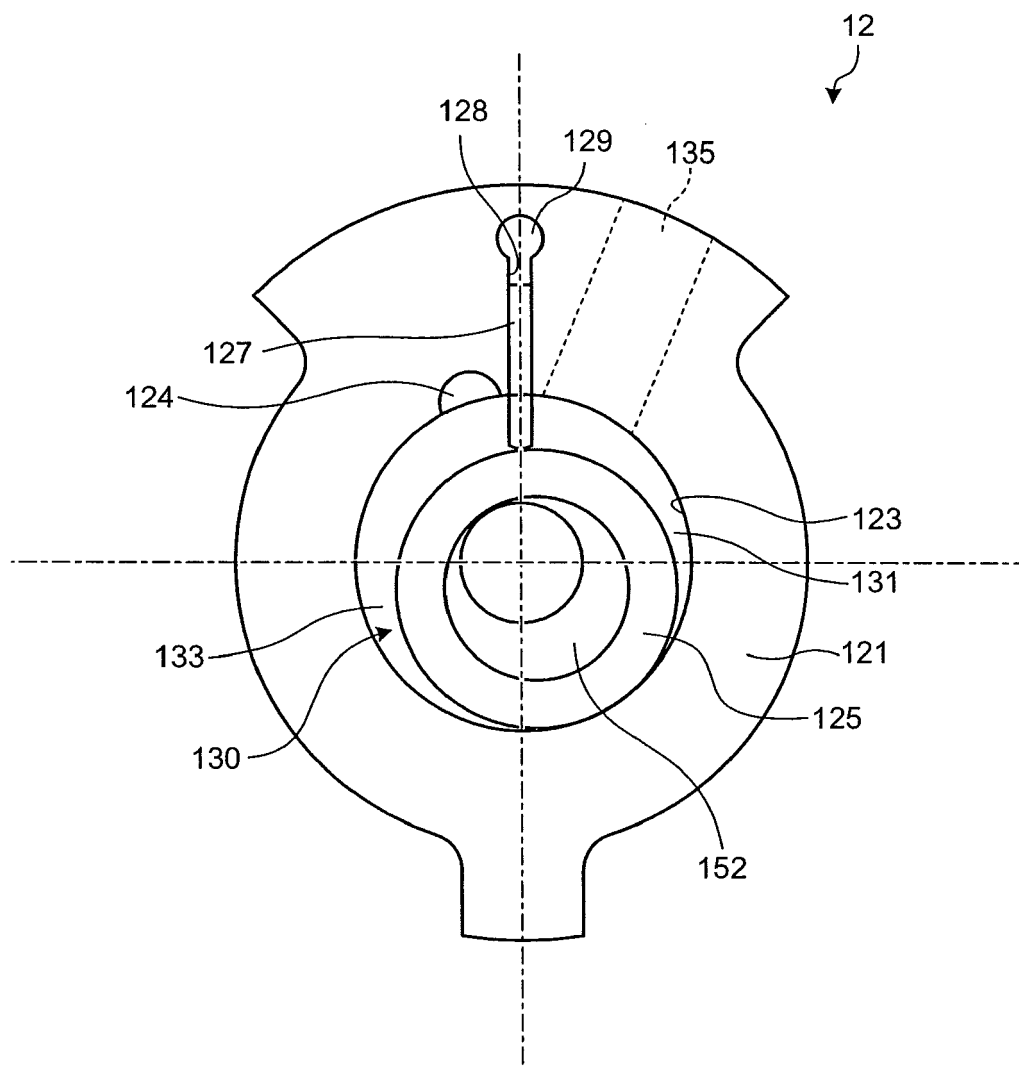
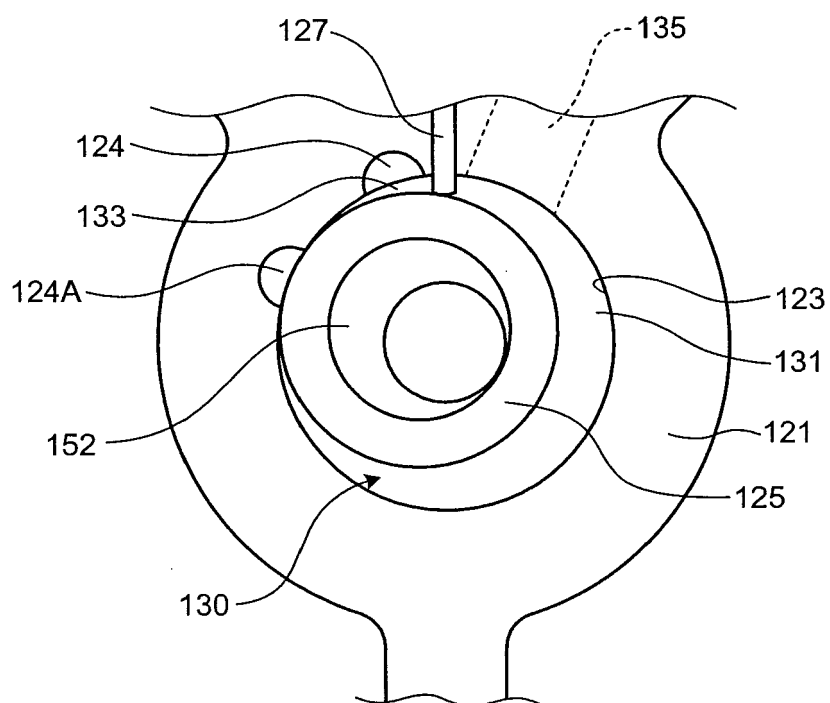


FIG.17



REFERENCES CITED IN THE DESCRIPTION

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