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(54) **Refrigerant compressor having an oil separator**

(57) A refrigerant compressor (10) includes a compression mechanism, a discharge passage (49), and an oil separator (50). The compression mechanism compresses a refrigerant gas containing a lubricant oil. The refrigerant gas that has been compressed by the compression mechanism flows through the discharge passage. The oil separator (50) is arranged in the discharge passage and separates the lubricant oil from the refrigerant gas flowing in the discharge passage. The oil separator has a rotator (52) that causes the refrigerant gas to flow around the axis (M) of the rotator and a circumferential wall (51A) that encompasses the rotator and extends along the axis of the rotator. The rotator and the circumferential wall define a separation zone in between. The lubricant oil is separated from the refrigerant gas by the flow of the refrigerant gas around the rotator in the separation zone. The circumferential wall has an oil outlet that allows the separated lubricant oil to flow to the exterior of the oil separator. The oil separator has an inlet port (54A) that allows the refrigerant gas to flow into the separation zone and an outlet port (52C) that allows the refrigerant gas to flow out of the separation zone. The rotator is arranged between the inlet port and the outlet port. The inlet port and the outlet port are arranged so that an inlet direction of the refrigerant gas flowing through the inlet port is substantially parallel with an outlet

direction of the refrigerant gas flowing through the outlet port.

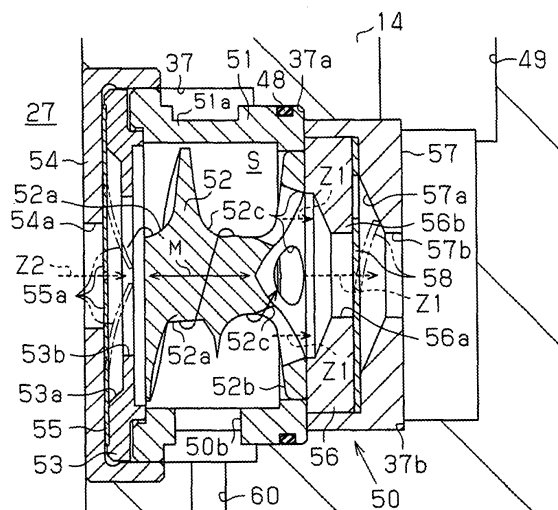


Fig.2

Description

[0001] The present invention relates to a refrigerant compressor having an oil separator that separates lubricant oil from refrigerant gas by causing the refrigerant gas to flow around a rotating member in a separation zone.

[0002] A refrigerant compressor is incorporated in a refrigerating circuit of an air conditioner and compresses refrigerant gas. Lubricant oil is mixed with the refrigerant gas. The mixture is supplied to a compression mechanism of the compressor in order to ensure smooth operation of the compression mechanism. However, the lubricant oil may flow from the refrigerant compressor into an external refrigerant circuit, together with the refrigerant gas. In this case, the lubricant oil adheres to inner wall surfaces of circuit components such as a gas cooler and an evaporator, thus decreasing heat exchange efficiency. To prevent the lubricant oil from flowing into the external refrigerant circuit, an oil separator is provided in a discharge passage of the refrigerant gas in the compressor, as described in, for example, Japanese Laid-Open Patent Publication No. 2002-5021 and Japanese Laid-Open Patent Publication No. 2001-165049.

[0003] Specifically, as shown in Fig. 6, an oil separator of Japanese Laid-Open Patent Publication No. 2002-5021 has a cylindrical inner tube 90, a cylindrical outer tube 91 arranged around the inner tube 90, and an oil separation chamber 92 defined by the inner and outer tubes 90, 91. A separation zone 93 is defined between the outer circumferential surface of the inner tube 90 and the inner circumferential surface of the outer tube 91. A lower end 90b of the inner tube 90 defines a gas outlet and communicates with an external refrigerant circuit (not shown). A discharge chamber 94 and the oil separation chamber 92 communicate with each other through an inlet pipe 95. An oil outlet 97 is defined in an upper portion of the outer tube 91. An oil retainer chamber 96 is defined around the oil separation chamber 92 and communicates with the oil separation chamber 92 through the oil outlet 97.

[0004] In a refrigerant compressor having the oil separator, the refrigerant gas that has been discharged into the discharge chamber 94 flows into the separation zone 93 of the oil separation chamber 92 through the inlet pipe 95. As indicated by the arrows of Fig. 6, the refrigerant gas moves upward in the separation zone 93 while flowing spirally around the inner tube 90. Such spiral flow of the gas produces centrifugal force that acts to separate the lubricant oil from the refrigerant gas. The separated lubricant oil adheres to the inner circumferential surface of the outer tube 91. Then, the lubricant oil adhered to the inner circumferential surface of the outer tube 91 moves upward together with the refrigerant gas and flows out to the oil retainer chamber 96 through the oil outlet 97 of the outer tube 91. The refrigerant gas, from which the lubricant oil has been separated, moves downward in the inner tube 90 and is supplied to an external refrigerant

circuit through the gas outlet defined by the lower end 90b of the inner tube 90.

[0005] As shown in Fig. 7, an oil separator of Japanese Laid-Open Patent Publication No. 2001-165049 is provided in a chamber 108 formed in a housing. The oil separator has a main body 101 having a cylindrical shape with a bottom and a flanged gas inlet pipe 102. The main body 101 has a separation chamber 100. The gas inlet pipe 102 is mounted in the main body 101 in such a manner that the gas inlet pipe 102 extends downward from the upper opening end of the separation chamber 100 coaxially with the main body 101. A through hole 101a is defined in a side wall of the main body 101 and communicates with a discharge passage 104 that causes communication between the separation chamber 100 and the discharge chamber 103. The discharge passage 104 extends through a fixing member 106 that fixes a discharge valve to the housing. A through hole 105 is defined in the bottom wall of the main body 101.

[0006] In a refrigerant compressor having the oil separator, the refrigerant gas is discharged into the discharge chamber 103 and then flows from the discharge passage 104 to the separation chamber 100 through the through hole 101a. As indicated by the arrows of Fig. 7, the refrigerant gas flows around the gas inlet pipe 102 in the separation chamber 100. As has been described, such swirl flow generates centrifugal force that acts to separate the lubricant oil from the refrigerant gas. The separated lubricant oil adheres to the inner circumferential surface of the side wall of the main body 101. The lubricant oil then passes through the through hole 105 of the bottom wall of the separation chamber 100 and sits on the bottom of the chamber 108. The refrigerant gas, from which the lubricant oil has been separated, flows through the gas inlet pipe 102 and is supplied to an external refrigerant circuit through another discharge passage.

[0007] In the oil separator of Japanese Laid-Open Patent Publication No. 2002-5021, the refrigerant gas that has been introduced into the oil separation chamber 92 through the inlet pipe 95 collides the inner tube 90. This shifts the flow of the refrigerant gas in a direction perpendicular to the inlet direction of the refrigerant gas flowing into the oil separation chamber 92. The refrigerant gas thus flows along the inner tube 90 and rotates spirally in the separation zone 93. Therefore, the flow rate of the refrigerant gas in the separation zone 93 is decreased compared to the flow rate of the refrigerant gas before the gas is introduced into the separation zone 93. In order to separate as much amount of lubricant oil as possible from the refrigerant gas that flows at the decreased flow rate, the moving distance of the refrigerant gas must be maximized. As a result, the axial dimensions of the inner tube 90 and the outer tube 91 are prolonged, thus enlarging the oil separator.

[0008] In the oil separator of Japanese Laid-Open Patent Publication No. 2001-165049, the refrigerant gas that has been introduced into the separation chamber 100

through the discharge passage 104 collides the gas inlet pipe 102. This shifts the flow of the refrigerant gas in a direction perpendicular to the inlet direction of the refrigerant gas flowing into the separation chamber 100. The refrigerant gas thus flows along the flanged gas inlet pipe 102 and flows spirally around the gas inlet pipe 102. Therefore, the flow rate or flow velocity of the refrigerant gas in the separation chamber 100 is decreased compared to the flow rate of the refrigerant gas before the gas is introduced into the separation chamber 100. In order to separate as much amount of lubricant oil as possible from the refrigerant gas that flows at the decreased flow rate, the flow velocity of the refrigerant gas around the gas inlet pipe 102 must be increased. It is thus necessary to increase the flow rate of the refrigerant gas before the refrigerant gas collides the gas inlet pipe 102. For this purpose, the discharge passage 104 to introduce the refrigerant gas into the separation chamber 100 requires to be prolonged. As a result, the oil separator becomes large-sized.

[0009] Accordingly, it is an objective of the present invention to provide a piston type compressor that reduces the size of an oil separator while ensuring sufficient separation performance of lubricant oil.

[0010] According to an aspect of the invention, a refrigerant compressor including a compression mechanism, a discharge passage, and an oil separator is provided. The compression mechanism compresses a refrigerant gas containing a lubricant oil. The refrigerant gas that has been compressed by the compression mechanism flows through the discharge passage. The oil separator is arranged in the discharge passage and separates the lubricant oil from the refrigerant gas flowing in the discharge passage. The oil separator has a rotator that causes the refrigerant gas to flow or swirl around the axis of the rotator and a circumferential wall that encompasses the rotator and extends along the axis of the rotator. The rotator and the circumferential wall define a separation zone in between. The lubricant oil is separated from the refrigerant gas through spiral flow of the refrigerant gas in the separation zone. The circumferential wall has an oil outlet that allows the separated lubricant oil to flow to the exterior of the oil separator. The oil separator has an inlet port that allows the refrigerant gas to flow into the separation zone and an outlet port that allows the refrigerant gas to flow out of the separation zone. The rotator is arranged between the inlet port and the outlet port. The inlet port and the outlet port are arranged so that an inlet direction of the refrigerant gas flowing through the inlet port substantially parallel with an outlet direction of the refrigerant gas flowing through the outlet port.

[0011] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0012] The invention, together with objects and advantages thereof, may best be understood by reference to

the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a longitudinal cross-sectional view showing a refrigerant compressor;

Fig. 2 is an enlarged cross-sectional view showing an oil separator according to a first embodiment of the present invention;

Fig. 3 is an enlarged cross-sectional view showing an oil separator according to a second embodiment of the present invention;

Fig. 4A is a perspective view showing a spiral passage defined in the oil separator of the second embodiment;

Fig. 4B is a cross-sectional view taken along line 4B-4B of Fig. 4A;

Fig. 5 is an enlarged cross-sectional view showing an oil separator according to a third embodiment of the present invention;

Fig. 6 is a cross-sectional view showing an oil separator of a prior art; and

Fig. 7 is a cross-sectional view showing an oil separator of another prior art.

[0013] A first embodiment of the present invention will now be described with reference to the attached drawings. In the following, a vertical direction of a refrigerant compressor 10 refers to the direction indicated by arrow Y1 of Fig. 1, and a forward-rearward direction of the compressor 10 refers to the direction indicated by arrow Y2 of the drawing.

[0014] Fig. 1 is a longitudinal cross-sectional view showing the refrigerant compressor 10. The refrigerant compressor 10 is employed in a refrigerating circuit of a vehicle air conditioner. As shown in Fig. 1, the housing of the refrigerant compressor 10 is formed by a cylinder block 11, a front housing member 12, and a rear housing member 14. The front housing member 12 is secured to the front end of the cylinder block 11. The rear housing member 14 is secured to the rear end of the cylinder block 11 through a valve plate assembly 13.

[0015] In the housing, a crank chamber 15 is provided between the cylinder block 11 and the front housing member 12. A drive shaft 16 is rotatably supported by the cylinder block 11 and the front housing member 12 in a manner extending through the crank chamber 15. An engine E, which is a drive source of the vehicle, is operably connected to the drive shaft 16 through a clutchless type power transmission mechanism PT. Thus, when the engine E operates, the power of the engine E is supplied to the drive shaft 16, thus constantly rotating the drive shaft 16.

[0016] A lug plate 17 is fixed to the drive shaft 16 in the crank chamber 15 in such a manner that the lug plate 17 rotates integrally with the drive shaft 16. A swash plate 18, or a disk-like cam plate, is accommodated in the crank chamber 15. The drive shaft 16 is passed through the

center of the swash plate 18. The swash plate 18 is thus supported by the drive shaft 16 in such a manner that the swash plate 18 is allowed to rotate integrally with and incline with respect to the drive shaft 16. A hinge mechanism 19 is arranged between the lug plate 17 and the swash plate 18. That is, the swash plate 18 is connected to the lug plate 17 through the hinge mechanism 19 and supported by the drive shaft 16. This structure allows the swash plate 18 to rotate synchronously with the lug plate 17 and the drive shaft 16, and to incline with respect to the drive shaft 16 while sliding on the drive shaft 16 in the axial direction of the drive shaft 16 (the direction defined by the axis L).

[0017] A plurality of cylinder bores 22 are defined about the axis L of the drive shaft 16 and spaced at equal angular intervals in the cylinder block 11. Each of the cylinder bores 22 extends through the cylinder block 11 in the forward-rearward direction. A single-headed piston 23 is reciprocally accommodated in each cylinder bore 22. One opening of each cylinder bore 22 is closed by the front surface of the valve plate assembly 13 and the other opening of the cylinder bore 22 is blocked by the rear end surface of the corresponding piston 23. A compression chamber 24 is defined in each cylinder bore 22 and the volume of the compression chamber 24 varies in correspondence with reciprocation of the piston 23.

[0018] Each of the pistons 23 is engaged with an outer circumferential portion of the swash plate 18 through a pair of shoes 25. When the swash plate 18 rotates through rotation of the drive shaft 16, the pistons 23 linearly reciprocate. In the first embodiment, the crank chamber 15, the drive shaft 16, the swash plate 18, and the pistons 23 form a compression mechanism.

[0019] In the housing, a suction chamber 26 and a discharge chamber 27 are defined between the valve plate assembly 13 and the rear housing member 14. The valve plate assembly 13 has suction ports 28 and suction valves 29 that are arranged between the compression chambers 24 and the suction chamber 26. The valve plate assembly 13 also has discharge ports 30 and discharge valves 31 that are provided between the compression chambers 24 and the discharge chamber 27.

[0020] The refrigerating circuit uses carbon dioxide as refrigerant gas and includes the compressor 10 and an external refrigerant circuit 41 connected to the compressor 10. The refrigerant gas flows from the external refrigerant circuit 41 into the suction chamber 26 through, specifically, the outlet of an evaporator 41a. As the pistons 23 move from the top dead center to the bottom dead center, the refrigerant gas is drawn into the compression chambers 24 through the corresponding suction ports 28 and suction valves 29. Then, as the pistons 23 move from the bottom dead center to the top dead center, the refrigerant gas is compressed to a predetermined pressure and discharged into the discharge chamber 27 through the discharge ports 30 and the discharge valves 31.

[0021] A connection passage 49 is defined in the rear housing member 14 and connects the discharge cham-

ber 27 to the external refrigerant circuit 41, or, more specifically, the inlet of a gas cooler 41b. The refrigerant gas is sent from the discharge chamber 27 to the external refrigerant circuit 41 through the connection passage 49.

5 The refrigerant gas is then cooled by the gas cooler 41b in the external refrigerant circuit 41 and depressurized by an expansion valve 41c. Subsequently, the refrigerant gas is sent to the evaporator 41a and thus evaporated. In the first embodiment, the discharge chamber 27 and the connection passage 49 define a discharge passage of the refrigerant gas in the refrigerant compressor 10.

[0022] As shown in Fig. 2, an accommodation bore 37 is defined in the rear housing member 14 and extends in the forward-rearward direction. The accommodation bore 37 is a part of the connection passage 49 and forms a portion of the discharge passage. An annular first seat 37a is provided on the circumferential surface of the accommodation bore 37 and substantially at the middle portion in axial direction of the accommodation bore 37. An annular second seat 37b is arranged rearward of the first seat 37a. The diameter of the second seat 37b is smaller than the diameter of the first seat 37a. The accommodation bore 37 accommodates an oil separator 50 that separates the lubricant oil from the refrigerant gas. The oil separator 50 communicates with the discharge chamber 27 and is connected to the inlet of the gas cooler 41b of the external refrigerant circuit 41 through the connection passage 49. Thus, after having been discharged from the discharge chamber 27, the refrigerant gas is supplied to the external refrigerant circuit 41 via the oil separator 50.

[0023] Referring to Fig. 1, a gas bleed passage 32, a gas supply passage 33, and a control valve 34 are provided in the housing of the refrigerant compressor 10. The gas bleed passage 32 connects the crank chamber 15 to the suction chamber 26. The gas supply passage 33 connects the connection passage 49 (the oil separator 50), which is a discharge pressure zone, to the crank chamber 15. The crank chamber 15 is a low pressure zone in which the pressure is lower than the pressure in the connection passage 49. The control valve 34 is arranged in the gas supply passage 33.

[0024] By adjusting the opening degree of the control valve 34, balance between the amount of the high-pressure discharge gas flowing into the crank chamber 15 through the gas supply passage 33 and the amount of the gas flowing out of the crank chamber 15 through the gas bleed passage 32 is regulated. This determines the pressure in the crank chamber 15. The difference between the pressure in the crank chamber 15 and the pressure in each compression chamber 24 is changed in correspondence with change of the pressure in the crank chamber 15. The inclination angle of the swash plate 18 is thus changed, and the stroke of the pistons 23, or the displacement of the refrigerant compressor 10, is changed. In other words, the refrigerant compressor 10 of the first embodiment is a variable displacement type compressor.

[0025] For example, if the opening degree of the control valve 34 decreases, the pressure in the crank chamber 15 drops. This increases the inclination angle of the swash plate 18 and thus the stroke of the pistons 23, raising the displacement of the refrigerant compressor 10. Contrastingly, if the opening degree of the control valve 34 increases, the pressure in the crank chamber 15 rises. This decreases the inclination angle of the swash plate 18 and thus the stroke of the pistons 23, reducing the displacement of the refrigerant compressor 10.

[0026] The oil separator 50 will be explained in the following.

[0027] As shown in Fig. 2, the oil separator 50, which separates the lubricant oil from the refrigerant gas, is provided in the discharge passage at a position downstream from the discharge chamber 27 and upstream from the external refrigerant circuit 41. The oil separator 50 has a cylindrical casing 51 that is press-fitted into the accommodation bore 37. In this state, the rear end of the casing 51 is held in contact with the first seat 37a so that rearward movement of the casing 51 is restricted.

[0028] A seal 48, which is formed by a rubber O ring, is fitted to the outer circumferential surface of a circumferential wall 51a of the casing 51. The seal 48 suppresses leakage of the refrigerant gas from between the accommodation bore 37 and the casing 51. An oil outlet 50b is defined in a lower portion of the circumferential wall 51a of the casing 51. The oil outlet 50b allows the lubricant oil that has been separated from the refrigerant gas to flow out of the casing 51 (the oil separator 50). The oil outlet 50b is connected to the control valve 34 through a passage 60 (see Fig. 1).

[0029] A rotator 52 is accommodated in the casing 51. The circumferential wall 51a of the casing 51 encompasses the rotator 52 and extends in the axial direction or along the axis M. An annular separation zone S is defined between the inner circumferential surface of the circumferential wall 51a and the outer circumferential surface of the rotator 52. The rotator 52 extends along the flow direction of the refrigerant gas in the discharge passage (the accommodation bore 37). The rotator 52 is arranged in the casing 51 in such a manner that the axial direction M of the rotator 52 coincides with the axial direction of the casing 51. The one end, or front end, of the rotator 52 is located at the side corresponding to the discharge chamber 27. The opposing end, or the rear end, of the rotator 52 is arranged at the side corresponding to the external refrigerant circuit 41.

[0030] A spiral groove 52a is defined in the circumferential surface of the rotator 52. The spiral groove 52a extends from the front end to the rear end of the rotator 52 and about the axis of the rotator 52. The spiral groove 52a forms a flow guide that guides the refrigerant gas to flow or swirl spirally around the rotator 52 and along the axial direction M of the rotator 52. The radial depth of the spiral groove 52a becomes gradually smaller from the front end toward the rear end of the rotator 52. The radial

depth of the spiral groove 52a becomes zero with respect to the axis of the rotator 52 at the rear end of the spiral groove 52a.

[0031] A flange 52b is formed at the rear end of the rotator 52. A plurality of (in the first embodiment, four) outlet ports 52c (only three of the outlet ports 52c are shown in Fig. 2) are defined in the flange 52b and spaced at regular intervals. After flowing into the separation zone S, the refrigerant gas is sent to the exterior of the separation zone S through the outlet ports 52c. In Fig. 2, arrows Z1 represent the outlet direction of the refrigerant gas flowing through the outlet ports 52c. In the drawing, the outlet direction Z1 of the refrigerant gas is substantially parallel with the axial direction M of the rotator 52.

[0032] A cylindrical lid member 54 is fitted in the front end of the casing 51 with a stopper 53 and a variable restrictor 55 in between. The lid member 54 has an inlet port 54a through which the refrigerant gas is introduced into the casing 51. The stopper 53 has a cylindrical shape and has a communication bore 53b defined at the center of the stopper 53. The inlet port 54a communicates with the interior of the casing 51 through the communication bore 53b. The inlet port 54a is arranged on the axis of the rotator 52. The four outlet ports 52c are located outwardly from the inlet port 54a in a radial direction of the rotator 52. After having been discharged into the discharge chamber 27, the refrigerant gas flows into the separation zone S in the casing 51 through the inlet port 54a and the communication bore 53b. The inlet direction of the refrigerant gas flowing through the inlet port 54a to the separation zone S is indicated by arrow Z2 of Fig. 2 and substantially coincides with the axial direction M of the rotator 52.

[0033] An outer circumferential portion of the variable restrictor 55 is clamped between an outer circumferential portion of the stopper 53 and an outer circumferential portion of the lid member 54. The variable restrictor 55 has a plurality of (in the first embodiment, two) restrictor valves 55a that are formed like flaps. A recess 53a is defined at the center of the front surface of the stopper 53 and allows elastic deformation of the restrictor valves 55a. As indicated by the double-dotted chain lines of Fig. 2, when the variable restrictor 55 receives a flow of the refrigerant gas, both restrictor valves 55a elastically deform and thus permits the flow of the refrigerant gas to proceed. The degree of elastic deformation of the restrictor valves 55a increases as the flow of the refrigerant gas increases. This increases the communication area of the refrigerant gas. Contrastingly, as the flow of the refrigerant gas decreases, the degree of elastic deformation of the restrictor valves 55a decreases. This reduces the communication area of the refrigerant gas. Therefore, if the flow of the refrigerant gas increases, the pressure difference between upstream and downstream of the variable restrictor 55 is likely to be small. Contrastingly, if the flow of the refrigerant gas decreases, such pressure difference between upstream and downstream of the variable restrictor 55 is likely to be large.

[0034] A cylindrical valve seat forming member 56 is accommodated in the accommodation bore 37 at a position rearward of the casing 51 (at a position closer to the external refrigerant circuit 41). A cylindrical clamping member 57 is fitted to the outer circumferential surface of the valve seat forming member 56. A check valve 58 is clamped between the valve seat forming member 56 and the clamping member 57. The valve seat forming member 56 has a valve hole 56a defined at the center of the valve seat forming member 56 and a valve seat 56b arranged around the valve hole 56a. The check valve 58 is capable of contacting the valve seat 56b. A recess 57a is defined in the front surface of the clamping member 57 opposed to the valve seat forming member 56 and permits elastic deformation of the check valve 58. As indicated by the double-dotted chain lines of Fig. 2, the check valve 58 elastically deforms when receiving a flow of the refrigerant gas. This permits the refrigerant gas to flow to the exterior of the separation zone S and blocks the flow of the refrigerant gas into the separation zone S. A gas outlet 57b, through which the refrigerant gas flows out of the oil separator 50, is defined at the center of the clamping member 57. The gas outlet 57b communicates with the interior of the casing 51, the valve hole 56a, and the connection passage 49.

[0035] The oil separator 50 is configured by accommodating the casing 51, the rotator 52, the stopper 53, the lid member 54, the variable restrictor 55, the valve seat forming member 56, the clamping member 57, and the check valve 58 in the accommodation bore 37 in an assembled state. Specifically, the clamping member 57, the check valve 58, the valve seat forming member 56, the casing 51, the rotator 52, the stopper 53, the variable restrictor 55, and the lid member 54 are received in the accommodation bore 37, in an assembled state in this order, toward the external refrigerant circuit 41.

[0036] The oil separator 50 separates the lubricant oil from the refrigerant gas through centrifugal separation. The inlet port 54a of the oil separator 50 is provided at a position corresponding to the front axial end of the rotator 52. Each of the outlet ports 52c of the oil separator 50 is arranged at a position corresponding to the rear axial end of the rotator 52. The rotator 52 is arranged in such a manner that the axial direction M of the rotator 52 extends substantially in the same direction as the inlet direction Z2 of the refrigerant gas flowing through the inlet port 54a into the separation zone S and the outlet direction Z1 of the refrigerant gas flowing through the outlet ports 52c to the exterior of separation zone S. Specifically, the outlet direction Z1 of the refrigerant gas is substantially parallel with the inlet direction Z2 of the refrigerant gas and the axial direction M of the rotator 52.

[0037] The passage 60, which is connected to the oil outlet 50b of the oil separator 50, forms a part of the gas supply passage 33. The oil separator 50 and the crank chamber 15 communicate with each other through the passage 60, or the gas supply passage 33. After having been separated by the oil separator 50, the lubricant oil

is returned to the crank chamber 15 through the passage 60, or the gas supply passage 33, together with the refrigerant gas that is supplied to the crank chamber 15 for controlling the displacement. The opening degree of the control valve 34 is varied in correspondence with the difference between the pressure in the upstream portion from the variable restrictor 55 (the pressure in the discharge chamber 27) and the pressure in the downstream portion from the variable restrictor 55 (the pressure in the casing 51). Such difference between the pressures reflects the amount of the refrigerant flowing in the refrigerating circuit.

[0038] After the refrigerant gas flows from the discharge chamber 27 through the inlet port 54a, the flow of the refrigerant gas is reduced by the variable restrictor 55. The refrigerant gas is then sent to the separation zone S in the casing 51. The rotator 52 extends along the inlet direction Z2 of the refrigerant gas in the casing 51. That is, the axial direction M of the rotator 52 is substantially parallel with the inlet direction Z2 of the refrigerant gas. This allows the refrigerant gas to proceed along the rotator 52 in the separation zone S without changing the flow direction to a direction perpendicular to the inlet direction Z2. In this state, the spiral groove 52a, which is defined in the circumferential surface of the rotator 52, forcibly guides the refrigerant gas to flow in a spiral manner. Since the spiral groove 52a extends along the entire length of the rotator 52 in the axial direction M, the refrigerant gas flows spirally along the entire length of the rotator 52 in the axial direction M.

[0039] Through such rotation of the refrigerant gas, the lubricant oil is centrifugally separated from the refrigerant gas. The separated lubricant oil adheres to the inner circumferential surface of the circumferential wall 51a of the casing 51. The lubricant oil is then caused to flow downward by the weight of the lubricant oil. Eventually, the lubricant oil flows out of the casing 51 (the oil separator 50) through the oil outlet 50b together with the refrigerant gas and is supplied to the control valve 34 and the crank chamber 15 through the passage 60.

[0040] On the other hand, the refrigerant gas from which the lubricant oil has been separated flows toward the outlet ports 52c. The inlet port 54a and the outlet ports 52c are arranged in such a manner that the outlet direction Z1 of the refrigerant gas flowing through the outlet ports 52c is substantially parallel with the inlet direction Z2 of the refrigerant gas flowing through the inlet port 54a. This arrangement allows the refrigerant gas to flow to the outlet ports 52c without shifting the flow direction of the refrigerant gas to a direction different from the inlet direction of the refrigerant gas through the inlet port 54a. In this state, the refrigerant gas is sent to the exterior of the separation zone S through the outlet ports 52c. The refrigerant gas is then supplied to the external refrigerant circuit 41 through the connection passage 49.

[0041] The first embodiment has the following advantages.

[0042] The oil separator 50 includes the inlet port 54a

and the outlet ports 52c. The inlet port 54a is arranged at the position corresponding to one end, or the front end, of the rotator 52 in the axial direction M. Each of the outlet ports 52c is provided at the position corresponding to the opposing end, or the rear end, of the rotator 52 in the axial direction M. The inlet port 54a and the outlet ports 52c are arranged in such a manner that the inlet direction Z2 and the outlet direction Z1 of the refrigerant gas are substantially parallel. Therefore, after flowing into the separation zone S through the inlet port 54a, the refrigerant gas flows to the outlet ports 52c while flowing around the rotator 52. In this state, without changing the flow direction of the refrigerant gas, the refrigerant gas flows out from the separation zone S through the outlet ports 52c. This prevents the flow of the refrigerant gas from being shifted in the direction perpendicular to the inlet direction of the refrigerant gas and suppresses decrease of the flow rate or the flow velocity of the refrigerant gas, unlike the prior art. It is thus unnecessary to increase the length of the rotator 52 or ensure a long inlet distance of the refrigerant gas to compensate for decrease of the separation performance of the lubricant oil caused by the decreased flow rate of the refrigerant gas. As a result, the oil separator 50 becomes compact.

[0043] The four outlet ports 52c are arranged around the axis of the inlet port 54a. The inlet direction Z2 and the outlet direction Z1 of the refrigerant gas may not coincide but are substantially parallel with each other. After being sent to the separation zone S through the inlet port 54a, the refrigerant gas flows to the outlet ports 52c while flowing around the rotator 52 and exits the outlet ports 52c. The refrigerant gas reaches the outlet ports 52c without changing its flow direction in the separation zone S. This prevents the flow rate or the flow velocity of the refrigerant gas from decreasing in the separation zone S, ensuring efficient separation of the lubricant oil. In other words, as long as the outlet direction Z1 and the inlet direction Z2 of the refrigerant gas are substantially parallel with each other, the lubricant oil is efficiently separated from the refrigerant gas. This makes it possible to change the locations of the outlet ports 52c as needed. The selection range of the positions of the outlet ports 52c is thus widened. Further, the location of the oil separator 50 in the refrigerant compressor 10 may be selected flexibly in correspondence with the configuration of the refrigerant compressor 10.

[0044] The oil outlet 50b of the oil separator 50 is defined in the circumferential wall 51a of the casing 51 to which the lubricant oil adheres after having been centrifugally separated from the refrigerant gas. The lubricant oil adhered to the circumferential wall 51a is caused to flow downward to the oil outlet 50b by its own weight. The lubricant oil then flows from the oil outlet 50b to the exterior of the oil separator 50. This shortens the distance covered by movement of the separated lubricant oil flowing to the oil outlet 50b. Therefore, unlike a case in which the oil outlet 50b is located, for example, in the flange 52b in which the outlet ports 52c are defined, it is unnecessary

for the lubricant oil adhered to the circumferential wall 51a to flow to the flange 52b together with the flow of the refrigerant gas. As a result, the lubricant oil rapidly flows out of the oil separator 50 and is quickly supplied to the compression mechanism or the like for lubrication.

[0045] After having been centrifugally separated by the oil separator 50, the lubricant oil flows to the exterior of the oil separator 50 through the oil outlet 50b without being retained in the oil separator 50. This suppresses escape of the lubricant oil to the external refrigerant circuit 41 together with the refrigerant gas.

[0046] It is unnecessary to provide a structure for retaining the lubricant oil in the oil separator 50. The oil separator 50 thus becomes further compact.

[0047] The spiral groove 52a is defined in the circumferential surface of the rotator 52. The refrigerant gas is thus forcibly guided to flow spirally in the flow direction of the refrigerant gas in the separation zone S. This suppresses the decrease of the flow rate or the flow velocity of the refrigerant gas and improves the separation performance of the lubricant oil from the refrigerant gas by the oil separator 50.

[0048] The oil separator 50 is formed by the casing 51, the rotator 52, the stopper 53, the lid member 54, the variable restrictor 55, the valve seat forming member 56, the clamping member 57, and the check valve 58 that are assembled together. These components are arranged along the inlet direction Z2 of the refrigerant gas flowing to the oil separator 50. This reduces the size of the oil separator 50 as a whole, unlike, for example, the background art in which the inner tube extends in a direction perpendicular to the flow direction of refrigerant gas. Further, the oil separator 50 is provided simply by arranging the components in the accommodation bore 37 in a predetermined order. This facilitates installation of the oil separator 50 in the refrigerant compressor 10.

[0049] In the oil separator 50, the rotator 52 and the outlet ports 52c are arranged along the inlet direction Z2 of the refrigerant gas. Also, the variable restrictor 55 and the check valve 58 are arranged along the inlet direction Z2 of the refrigerant gas. Therefore, the oil separator 50 becomes compact, compared to, for example, the background art in which the refrigerant gas flows in a direction perpendicular to the inlet direction Z2 of the refrigerant gas and the variable restrictor 55 and the check valve 58 cannot be assembled as an integral body in the oil separator 50.

[0050] A second embodiment of the present invention will hereafter be described with reference to the attached drawings. Same or like reference numerals are given to components of the second embodiment that are the same as or like corresponding components of the first embodiment and description thereof will be omitted or simplified.

[0051] As shown in Figs. 3, 4A, and 4B, the casing 51 of the oil separator 50 includes a bottom 65, which is formed integrally with the casing 51 at the rear side of the casing 51. A columnar projection 66 projects from

the bottom 65 toward the front side of the casing 51. The projection 66 forms a rotator around which the refrigerant gas flows. The separation zone S is defined between the projection 66 and the circumferential wall 51a. Referring to Figs. 4A and 4B, a recess 66a is defined in the front end of the projection 66. A guide portion 66b is formed in a front portion of the projection 66 and communicates with the recess 66a. The guide portion 66b is inclined diagonally from forward to rearward with respect to the projection 66. A spiral passage 67 is defined between the projection 66 and the circumferential wall 51a in the casing 51. The spiral passage 67 communicates with the recess 66a and the guide portion 66b and extends spirally in a circumferential direction of the projection 66. The spiral passage 67 forms a flow guide that forcibly guides the refrigerant gas to flow spirally around the projection 66. An outlet port 68 is defined in the bottom 65 for sending the refrigerant gas to the exterior of the separation zone S.

[0052] The projection 66 is arranged in such a manner that the axial direction M of the projection 66 extends substantially in the same direction as the inlet direction Z2 of the refrigerant gas flowing from the inlet port 54a into the separation zone S and the outlet direction Z1 of the refrigerant gas flowing from the outlet port 68 to the exterior of the separation zone S. The projection (rotator) 66 is arranged between the inlet port 54a and the outlet port 68. Further, the outlet direction Z1 and the inlet direction Z2 of the refrigerant gas substantially coincide with each other and with the axial direction M of the projection 66.

[0053] The refrigerant gas is introduced into the separation zone S through the inlet port 54a. The refrigerant gas then enters the recess 66a and is guided by the guide portion 66b to flow rearward in the separation zone S. The refrigerant gas is thus sent to the spiral passage 67. As flowing along the spiral passage 67, the refrigerant gas is forcibly guided to flow around the projection 66. In this state, the lubricant oil is centrifugally separated from the refrigerant gas.

[0054] Accordingly, the second embodiment has the following advantage in addition to the advantages of the first embodiment.

[0055] The spiral passage 67 is defined in the casing 51. The spiral passage 67 further reliably guides the refrigerant gas to spirally flow. This enhances separation performance of the lubricant oil from the refrigerant gas.

[0056] A third embodiment of the present invention will hereafter be described with reference to the attached drawings. Same or like reference numerals are given to components of the third embodiment that are the same as or like corresponding components of the first embodiment and description thereof will be omitted or simplified.

[0057] As shown in Fig. 5, a separate bottom member 70 is assembled with the casing 51 of the oil separator 50 at the rear side of the casing 51. The bottom member 70 includes a disk-like bottom plate 71 and a cylindrical tube 72 projecting from the bottom plate 71. When the

bottom member 70 is assembled with the casing 51, the tube 72 projects forward with respect to the casing 51. The tube 72 forms a rotator around which the refrigerant gas flows. A gas passage 72a is defined in the tube 72. A pair of through holes 72b extend through a surface of the tube 72 to face each other. The through holes 72b communicate with the gas passage 72a. An outlet port 72c of the refrigerant gas is provided at the rear end of the tube 72, which is the rear end of the gas passage 72a. The inlet port 54a and the outlet port 72c are arranged coaxially. The separation zone S is defined between the tube 72 and the circumferential wall 51a.

[0058] The casing 51 further includes a lid 73, which is arranged at the front side of the casing 51. A guide bore 74 extends through the lid 73. As indicated by the broken lines of Fig. 5, the guide bore 74 extends diagonally with respect to the axial direction M of the tube 72 and radially outward of the center of the lid 73. The guide bore 74 has an opening that communicates with the separation zone S, which is defined outside of the tube 72. The guide bore 74 forms a flow guide that guides the refrigerant gas to flow spirally around the tube 72.

[0059] The tube 72 is arranged in such a manner that the axial direction M of the tube 72 extends substantially in the same direction as the inlet direction Z2 of the refrigerant gas flowing from the inlet port 54a into the separation zone S and the outlet direction Z1 of the refrigerant gas flowing from the outlet port 72c to the exterior of the separation zone S. Further, the outlet direction Z1 and the inlet direction Z2 of the refrigerant gas substantially coincide with each other and with the axial direction M of the tube 72.

[0060] After having been introduced into the separation zone S through the inlet port 54a, the refrigerant gas is guided by the guide bore 74 to flow rearward in the separation zone S. Then, as flowing along the tube 72, the refrigerant gas is forcibly guided to flow around the tube 72. In this state, the lubricant oil is centrifugally separated from the refrigerant gas swirling in the separation zone S. Afterwards, the refrigerant gas, from which the lubricant oil has been separated, passes through the through hole 72b, the gas passage 72a, and the outlet port 72c, which are located on the rotation path of the refrigerant gas. The refrigerant gas is thus sent to the exterior of the separation zone S.

[0061] Accordingly, the third embodiment has the following advantage in addition to the advantages of the first embodiment.

[0062] In the third embodiment, the inclined guide bore 74 ensures spiral flow of the refrigerant gas. That is, the refrigerant gas is urged to flow spirally by a simple structure.

[0063] The illustrated embodiments may be modified in the following forms.

[0064] The refrigerant compressor 10 may be a wobble type variable displacement compressor having a wobble plate serving as a cam plate, instead of the swash plate type variable displacement compressor. The refrigerant

compressor 10 is not restricted to a variable displacement type but may be a fixed displacement type. Further, the refrigerant compressor may be a scroll type or a vane type, instead of the piston type. Although the refrigerant compressor 10 of the illustrated embodiments is the single-headed piston type, the refrigerant compressor 10 may be a double-headed piston type.

[0065] The refrigerant gas may be chlorofluorocarbon (for example, R134a), instead of carbon dioxide.

[0066] In the first embodiment, the variable restrictor 55 and the check valve 58 may be omitted from the oil separator 50.

[0067] The variable restrictor 55 may be replaced by a fixed restrictor.

[0068] After having been separated by the oil separator 50, the lubricant oil may be returned to the suction chamber 26, instead of the crank chamber 15. Alternatively, the separated lubricant oil may be retained in an oil retainer portion. In this case, the upstream end of the gas supply passage 33 is connected to the discharge passage at a position (for example, in the accommodation bore 37) outside the oil separator 50 and downstream from the variable restrictor 55.

[0069] The present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A refrigerant compressor (10) comprising:

a compression mechanism that compresses a refrigerant gas containing a lubricant oil;
a discharge passage through which the refrigerant gas that has been compressed by the compression mechanism flows, the compressed refrigerant gas being discharged to the exterior of the compressor (10) through the discharge passage; and
an oil separator (50) that is arranged in the discharge passage and separates the lubricant oil from the refrigerant gas flowing in the discharge passage,

wherein the oil separator (50) has a rotator (52, 66, 72) that causes the refrigerant gas to flow around the axis of the rotator (52, 66, 72) and a circumferential wall (51a) that encompasses the rotator (52, 66, 72) and extends along the axis of the rotator (52, 66, 72), the rotator (52, 66, 72) and the circumferential wall (51a) defining a separation zone (S) in between, the lubricant oil being separated from the refrigerant gas by the flow of the refrigerant gas around the rotator (52, 66, 72) in the separation zone (S), the circumferential wall (51a) having an oil outlet

(50b) that allows the separated lubricant oil to flow to the exterior of the oil separator (50), and

the refrigerant compressor (10) being **characterized in that** the oil separator (50) has an inlet port (54a) that allows the refrigerant gas to flow into the separation zone (S) and an outlet port (52c, 68, 72c) that allows the refrigerant gas to flow out of the separation zone (S), the rotator (52, 66, 72) being arranged between the inlet port (54a) and the outlet port (52c, 68, 72c), the inlet port (54a) and the outlet port (52c, 68, 72c) being arranged so that an inlet direction (Z2) of the refrigerant gas flowing through the inlet port (54a) is substantially parallel with an outlet direction (Z1) of the refrigerant gas flowing through the outlet port (52c, 68, 72c).

2. The compressor (10) according to claim 1, **characterized in that** the inlet port (54a) and the outlet port (68, 72c) are substantially coaxially arranged.

3. The compressor (10) according to claim 2, **characterized in that** the inlet port (54a), the outlet port (52c, 68, 72c), and the rotator (52, 66, 72) are arranged so that the inlet direction (Z2) of the refrigerant gas and the outlet direction (Z1) of the refrigerant gas substantially coincide with the axial direction (M) of the rotator (52, 66, 72).

4. The compressor (10) according to any one of claims 1 to 3, **characterized by** a flow guide (52a, 67, 74) that guides the refrigerant gas to flow spirally around the rotator (52, 66, 72) and along the axial direction (M) of the rotator (52, 66, 72).

5. The compressor (10) according to claim 4, **characterized in that** the flow guide (52a, 67, 74) has a spiral groove (52a) that is defined in a surface of the rotator (52) and spirally extends from an axial end of the rotator (52) to an opposing axial end of the rotator (52).

6. The compressor (10) according to claim 4, **characterized in that** the flow guide (52a, 67, 74) includes a spiral passage (67) that is arranged in the separation zone (S) and spirally extends from an axial end of the rotator (66) to an opposing axial end of the rotator (66).

7. The compressor (10) according to claim 4, **characterized in that** the flow guide (52a, 67, 74) has a guide bore (74) that extends from the inlet port (54a) to the separation zone (S) diagonally with respect to the axis of the rotator (72).

8. The compressor (10) according to claim any one of claims 1 to 7, **characterized in that** the oil separator

(50) further includes:

a restrictor (55) that is arranged at a downstream side of the inlet port (54a); and
a check valve (58) that is arranged at a downstream side of the rotator (52, 66, 72). 5

9. The compressor (10) according to any one of claims 1 to 7, **characterized in that** the axis of the rotator (52, 66, 72) extends along the inlet direction (Z2) and the outlet direction (Z1) of the refrigerant gas. 10

10. The compressor (10) according to claim 1, **characterized in that** the inlet port (54a) and the outlet port (52c, 68, 72c) are arranged substantially coaxially with the rotator (52, 66, 72). 15

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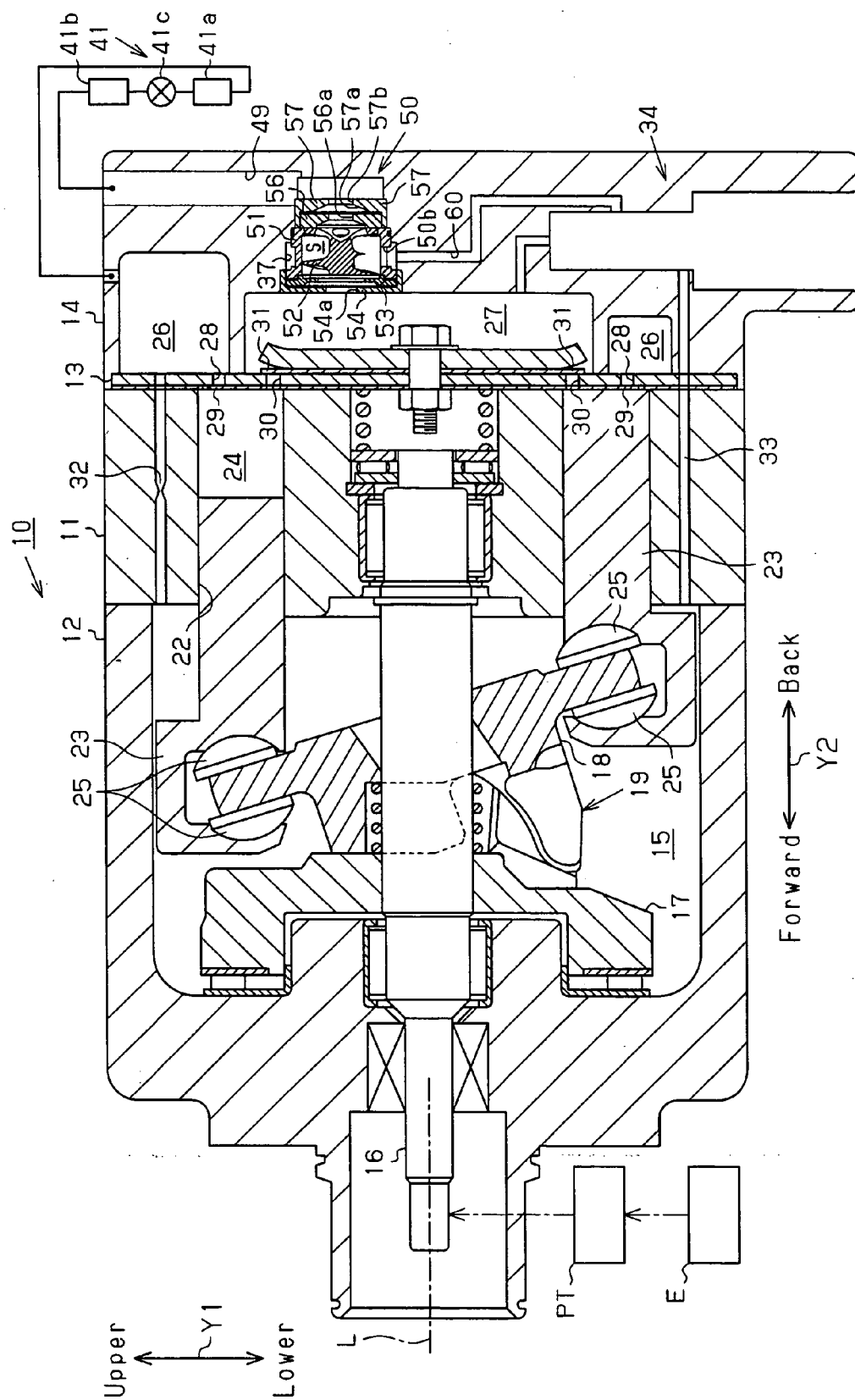


Fig. 1

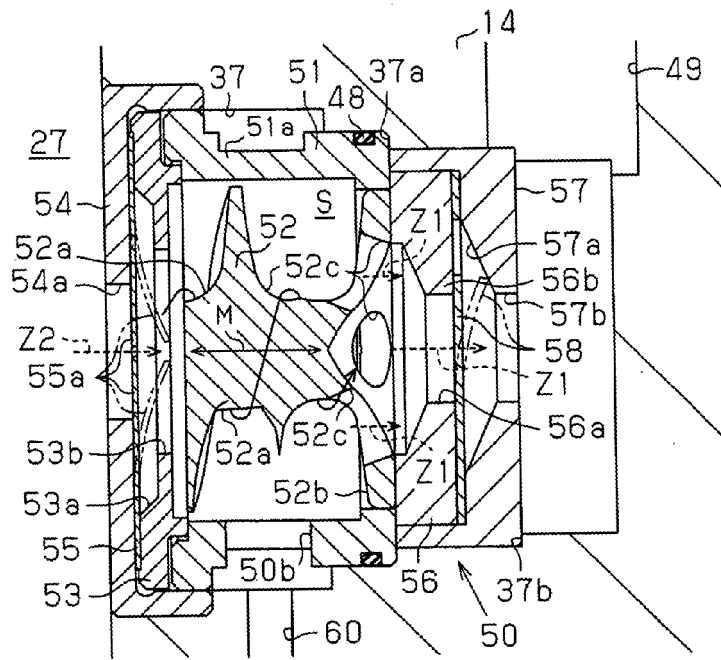


Fig. 2

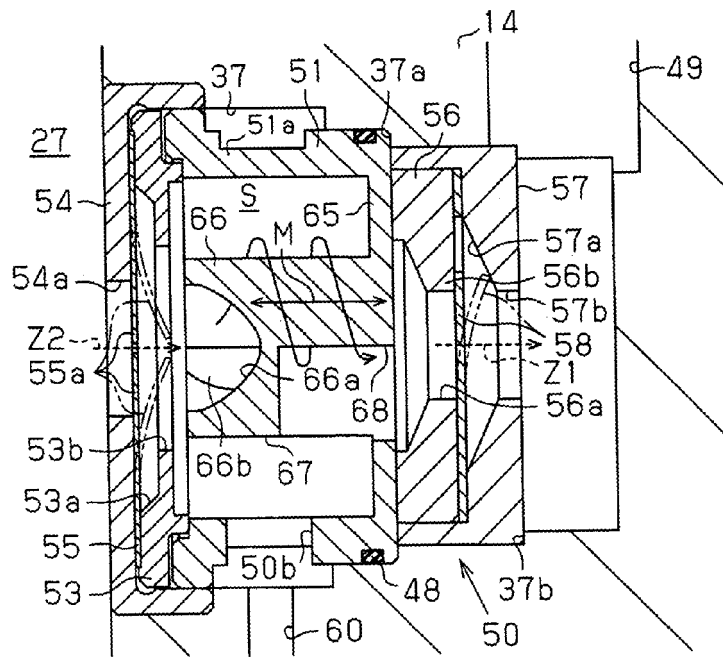


Fig. 3

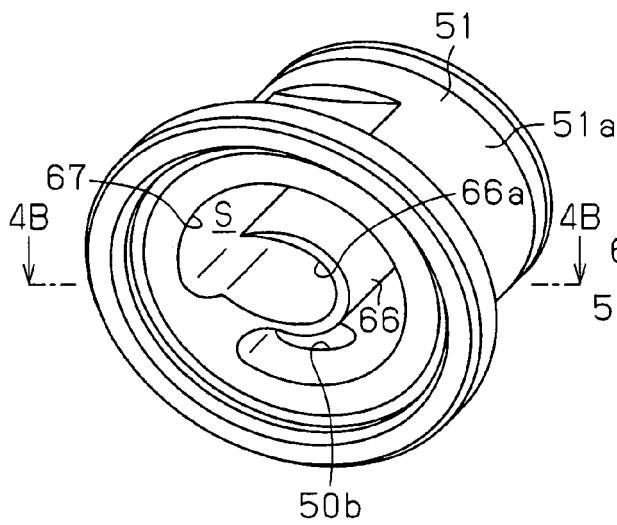


Fig. 4A

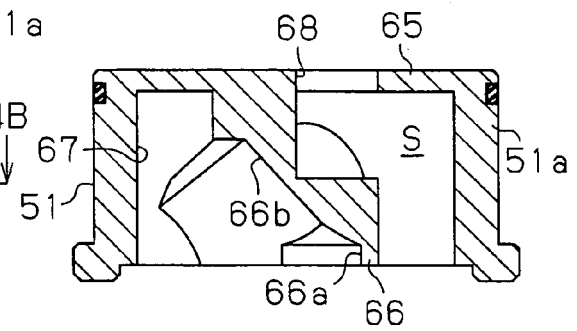


Fig. 4B

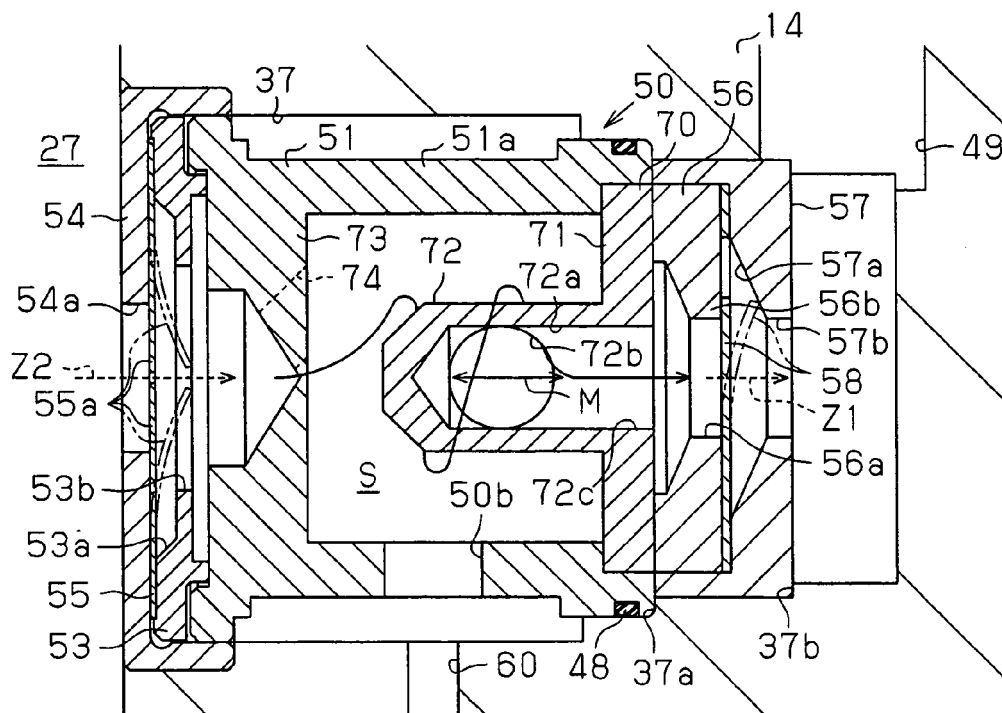


Fig. 5

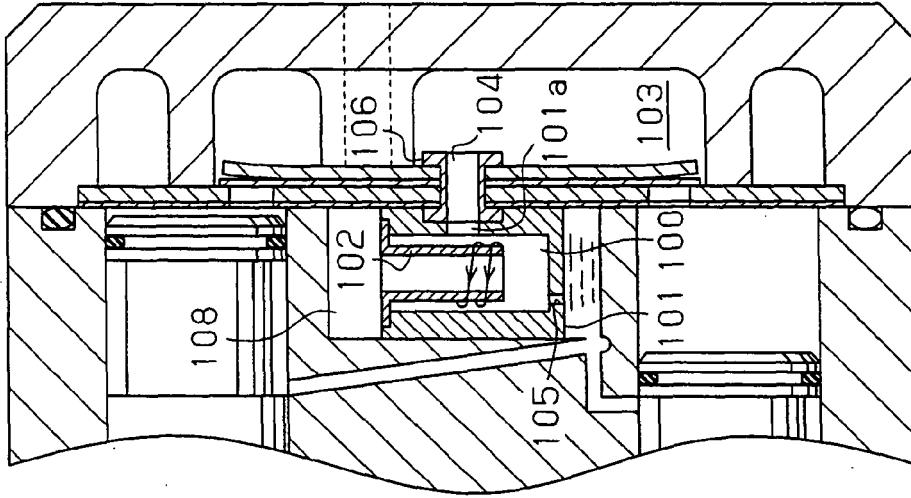


Fig. 7

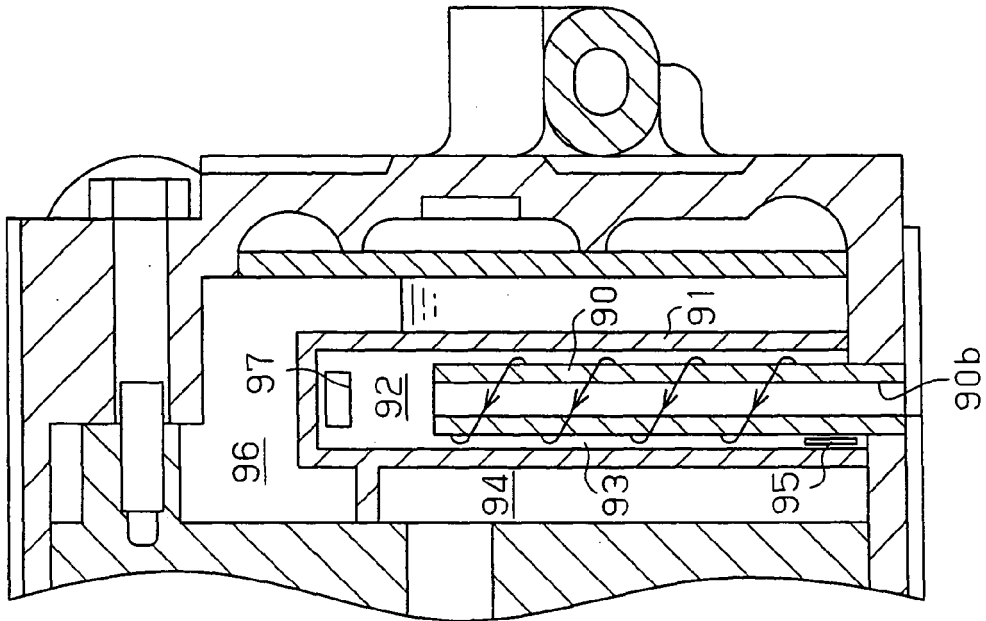


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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