



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.01.2007 Bulletin 2007/03

(51) Int Cl.:
F04B 27/18 (2006.01)

(21) Application number: **06117116.1**

(22) Date of filing: **13.07.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(72) Inventors:
• **Fukanuma, Tetsuhiko**
Kariya-shi
Aichi 448-8671 (JP)
• **Yokomachi, Naoya**
Kariya-shi
Aichi 448-8671 (JP)
• **Enami Shingo**
Kariya-shi
Aichi 448-8671 (JP)

(30) Priority: **15.07.2005 JP 2005207442**

(71) Applicant: **KABUSHIKI KAISHA TOYOTA JIDOSHOKKI**
Kariya-shi, Aichi 448-8671 (JP)

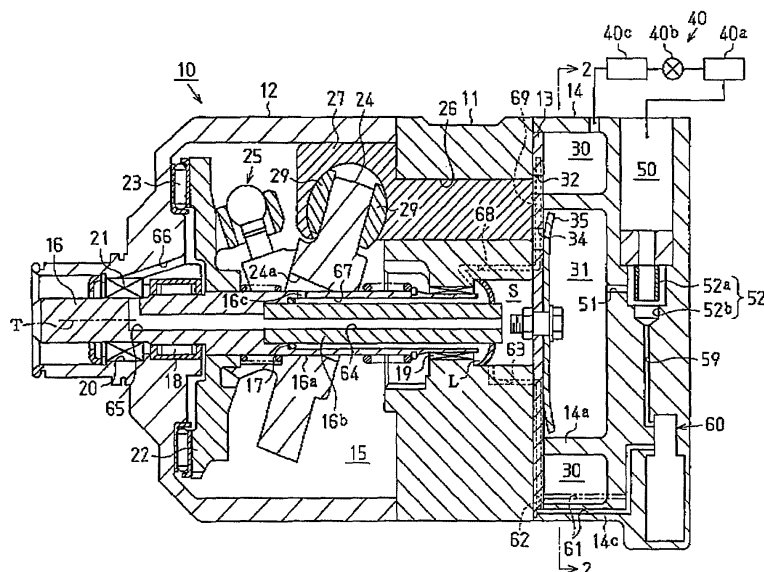
(74) Representative: **TBK-Patent**
Bavariaring 4-6
80336 München (DE)

(54) **Variable displacement compressor**

(57) A variable displacement compressor for forming a refrigerant circuit with an external refrigerant circuit includes a housing, a drive shaft, a swash plate, a shaft seal member, a supply passage, a control valve and a gas passage. The housing has a suction chamber, a crank chamber, a discharge chamber and a shaft seat chamber formed therein. The discharge chamber is in

communication with the crank chamber through the supply passage. The supply passage has the shaft seal chamber. The discharge chamber is in communication with the external refrigerant circuit through the gas passage. The supply passage is formed differently from the gas passage. A part of the supply passage is located adjacent to the suction chamber and nearer to the suction chamber than the discharge chamber.

FIG. 1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a variable displacement compressor whose displacement is variable by changing angle of inclination of a swash plate of the compressor.

[0002] In this type of variable displacement compressor (hereinafter referred to merely as a compressor), refrigerant gas in a discharge chamber is supplied into a crank chamber through a supply passage while the refrigerant gas in the crank chamber is drawn out to a suction chamber through a bleed passage for controlling pressure in the crank chamber, whereby the angle of inclination of the swash plate is adjusted. A control valve is provided in the supply passage. As an opening degree of the control valve is adjusted, flow rate of the refrigerant gas supplied into the crank chamber is adjusted, so that the angle of inclination of the swash plate is adjusted thereby to adjust stroke of a piston and hence the displacement of the compressor.

[0003] A shaft seal chamber is provided in an outer side of a drive shaft in a housing of the compressor. A shaft seal member is accommodated in the shaft seal chamber for preventing the refrigerant gas from leaking out of the compressor along the circumferential surface of the drive shaft. Since the shaft seal member is constantly in slide contact with the circumferential surface of the drive shaft, the shaft seal member generates heat during operation of the compressor. To prevent degradation caused by excessive generation of heat of the shaft seal member, the compressor has a structure for cooling the shaft seal member.

[0004] Japanese Unexamined Patent Application Publication (KOKAI) No. 4-179874 discloses one example of the structure. Specifically, the shaft seal chamber is provided in the supply passage, through which the refrigerant gas is supplied from the discharge chamber to the crank chamber. The refrigerant gas is decompressed by the control valve to lower its temperature, and then is supplied into the crank chamber through the shaft seal chamber. Therefore, the refrigerant gas is blown to the shaft seal member in the shaft seal chamber thereby to cool the shaft seal member. This prevents the degradation caused by excessive generation of heat of the shaft seal member.

[0005] In the above-referenced compressor, however, since the refrigerant gas discharged into the discharge chamber is high temperature, even if the refrigerant gas is decompressed by the control valve to lower its temperature, the refrigerant gas blown to the shaft seal member in the shaft seal chamber is still high temperature. Therefore, cooling effect of the shaft seal member caused by the refrigerant gas is not sufficiently performed.

[0006] The present invention is directed to a variable displacement compressor for sufficiently cooling the

shaft seal member.

SUMMARY OF THE INVENTION

[0007] The present invention provides a variable displacement compressor for forming a refrigerant circuit with an external refrigerant circuit. The variable displacement compressor includes a housing, a drive shaft, a swash plate, a shaft seal member, a supply passage, a control valve and a gas passage. The housing has a suction chamber, a crank chamber, a discharge chamber and a shaft seal chamber formed therein. The drive shaft is rotatably supported by the housing. The swash plate is connected to the drive shaft so that angle of inclination of the swash plate relative to the drive shaft is variable. The swash plate is accommodated in the crank chamber. The shaft seal member is accommodated in the shaft seal chamber. The discharge chamber is in communication with the crank chamber through the supply passage. The supply passage includes the shaft seal chamber. The control valve is disposed in the supply passage. Flow rate of refrigerant gas supplied from the discharge chamber to the crank chamber through the supply passage is adjusted by adjusting an opening degree of the control valve. The discharge chamber is in communication with the external refrigerant circuit through the gas passage. The supply passage is formed differently from the gas passage. A part of the supply passage is located adjacent to the suction chamber and nearer to the suction chamber than the discharge chamber.

[0008] 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

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

FIG. 2 is a cross sectional view taken in the direction of the arrows substantially along the line 2-2 of FIG. 1;

FIG. 3 is a longitudinal sectional view showing a variable displacement compressor according to a second embodiment of the present invention;

FIG. 4 is a longitudinal sectional view showing a var-

iable displacement compressor according to a third embodiment of the present invention;

FIG. 5 is a cross sectional view taken in the direction of the arrows substantially along the line 5-5 of FIG. 4;

FIG. 6 is a cross sectional view of a variable displacement compressor showing another example of a position at which a part of a supply passage is arranged;

FIG. 7 is a cross sectional view of a variable displacement compressor showing another example of a position at which a part of a supply passage is arranged;

FIG. 8 is a cross sectional view of a variable displacement compressor showing another example of a position at which a part of a supply passage is arranged; and

FIG. 9 is a cross sectional view of a variable displacement compressor showing another example of a position at which a part of a supply passage is arranged.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] The following will describe a variable displacement compressor (hereinafter referred to merely as a compressor) according to a first preferred embodiment of the present invention with reference to FIGs. 1 and 2.

[0011] FIG. 1 shows a longitudinal sectional view of a compressor 10 of the first embodiment. In FIG. 1, the left side and the right side of the drawing correspond to the front side and the right side of the compressor 10, respectively. As shown in FIG 1, the compressor 10 includes a cylinder block 11, a front housing 12 which is fixedly joined to the front end of the cylinder block 11, and a rear housing 14 which is fixedly joined to the rear end of the cylinder block 11 through a valve plate assembly 13. The cylinder block 11, the front housing 12 and the rear housing 14 form a housing of the compressor 10.

[0012] The cylinder block 11 and the front housing 12 define a crank chamber therebetween. A drive shaft 16 is rotatably supported by the cylinder block 11 and the front housing 12 so as to pass through the crank chamber 15. The drive shaft 16 includes a cylindrical hollow first shaft portion 16a having an opening at the rear end thereof (at the right end of FIG. 1) and a cylindrical hollow second shaft portion 16b having openings at the opposite ends thereof (at the right and left ends of FIG. 1) and press-fitted (or inserted) into the first shaft portion 16a to form double pipe structure. An O-ring 17 is held between the inner circumferential surface of the first shaft portion 16a and the outer circumferential surface of the second

shaft portion 16b at the front side of the second shaft portion 16b (at the left side of FIG. 1).

[0013] The drive shaft 16 is rotatably supported at the opposite sides thereof (at the right and left sides of FIG. 1) by radial bearings 18 and 19, respectively. In the front housing 12, a shaft seal chamber 20 is formed forward of the radial bearing 18. A lip seal 21 that serves as a shaft seal member is provided between the circumferential surface of the front side of the drive shaft 16 (or the first shaft portion 16a) and the shaft seal chamber 20. The lip seal 21 is constantly in slide contact with the drive shaft 16 thereby to prevent refrigerant gas from leaking from the crank chamber 15 to the outside of the compressor 10 along the circumferential surface of the drive shaft 16.

[0014] In the cylinder block 11, an accommodation space S is defined rearward of the radial bearing 19. The rear side of the drive shaft 16 is accommodated in the accommodation space S.

[0015] In the crank chamber 15, a lug plate 22 is secured to the drive shaft 16 for rotation therewith. A thrust bearing 23 is provided between the lug plate 22 and the inner wall surface of the front housing 12. In the crank chamber 15, a swash plate 24 is accommodated. An insertion hole 24a is bored in the middle of the swash plate 24, in which the drive shaft 16 is inserted. A hinge mechanism 25 is interposed between the lug plate 22 and the swash plate 24. The swash plate 24 is connected to the lug plate 22 through the hinge mechanism 25 and supported by the drive shaft 16 through the insertion hole 24a. This permits the swash plate 24 to rotate synchronously with the lug plate 22 and the drive shaft 16 and incline with respect to the drive shaft 16 while sliding in the direction of an axis T of the drive shaft 16.

[0016] The cylinder block 11 has a plurality of cylinder bores 26 (only one of them being shown in FIG. 1) around the drive shaft 16 at equiangular intervals, extending in the direction of the axis T. Each cylinder bore 26 receives therein a single-headed piston 27 for reciprocation. The front and rear openings of the cylinder bore 26 are closed by the piston 27 and the valve plate assembly 13, respectively. In the cylinder bore 26, a compression chamber (not shown) is defined. The volume of the compression chamber varies in accordance with the reciprocation of the piston 27. The piston 27 engages with the outer peripheral portion of the swash plate 24 through a pair of shoes 29.

[0017] In the rear housing 14, the suction chamber 30 and the discharge chamber 31 are defined so as to face the valve plate assembly 13. More specifically, the discharge chamber 31 is provided in the middle of the rear housing 14 and a partition wall 14a is formed radially outward of the discharge chamber 31. In the rear housing 14, the suction chamber 30 is provided radially outward of the discharge chamber 31 through the partition wall 14a in an annular shape so as to surround the discharge chamber 31. In addition, in the rear housing 14, a peripheral wall 14c is formed radially outward of the outer pe-

ripheral portion of the suction chamber 30 for forming a part of the rear housing 14. A suction port 32 and a suction valve (not shown) are provided in the valve plate assembly 13 so as to be located between the corresponding compression chamber and the suction chamber 30. In a similar manner, a discharge port 34, a discharge valve (not shown) and a retainer 35 are provided in the valve plate assembly 13 so as to be located between the corresponding compression chamber and the discharge chamber 31.

[0018] In the rear housing 14, an accommodation chamber 50 is defined and is in communication with the discharge chamber 31 through a discharge passage 51. The discharge chamber 31 is connected to an external refrigerant circuit 40 through the discharge passage 51 and the accommodation chamber 50, so that high-pressure refrigerant gas discharged to the discharge chamber 31 is led to the external refrigerant circuit 40 through the discharge passage 51 and the accommodation chamber 50. Thus, the discharge passage 51 and the accommodation chamber 50 form a gas passage for leading the refrigerant gas discharged to the discharge chamber 31 to the external refrigerant circuit 40.

[0019] The refrigerant gas which is led to the external refrigerant circuit 40 through the gas passage is cooled by a condenser 40a which forms the external refrigerant circuit 40. Subsequently, the refrigerant gas is expanded by an expansion valve 40b and then transferred to an evaporator 40c to be evaporated therein. The refrigerant gas returned from the evaporator 40c (which forms the external refrigerant circuit 40) is drawn into the suction chamber 30. The compressor 10 of the present embodiment forms a refrigerant circuit with the external refrigerant circuit 40.

[0020] In the accommodation chamber 50 of the gas passage, an oil separator 52 is disposed for separating lubricating oil contained in the refrigerant gas discharged to the discharge chamber 31 from the refrigerant gas. The oil separator 52 includes an oil separation portion 52a for separating the lubricating oil from the refrigerant gas by centrifugal separation and an oil reservoir 52b in which the oil separated by the oil separation portion 52a is temporarily reserved.

[0021] In the oil separator 52, the oil separation portion 52a has a cylindrical shape, the lower end of which is opened to the oil reservoir 52b. The discharge passage 51 is opened to the accommodation chamber 50 at a position facing the oil separation portion 52a. The refrigerant gas led from the discharge chamber 31 to the accommodation chamber 50 through the discharge passage 51 is circled around the oil separation portion 52a in the circumferential direction thereof. At this time, the lubricating oil is separated from the refrigerant gas by centrifugal separation and the separated lubricating oil is temporarily reserved in the oil reservoir 52b. A part of the refrigerant gas whose lubricating oil is separated passes through the inside of the oil separation portion 52a and then is supplied to the condenser 40a of the

external refrigerant circuit 40.

[0022] In the rear housing 14, an electromagnetic type displacement control valve 60 that serves as a control valve is disposed on the downstream side of the accommodation chamber 50. In addition, a communication passage 59 is formed in the rear housing 14. The oil reservoir 52b and the control valve 60 are in communication with each other through the communication passage 59. Furthermore, a first passage 61 is formed in the rear housing 14. The control valve 60 and a second passage 62 formed in the valve plate assembly 13 are in communication with each other through the first passage 61. As shown in FIG. 2, a part of the first passage 61 is formed so as to pass through the peripheral wall 14c of the rear housing 14 in the direction of the axis T. That is, the part of the first passage 61 is located radially outward of the partition wall 14a which separates the suction chamber 30 and the discharge chamber 31, and is located radially outward of the suction chamber 30 so as to be located adjacent to the suction chamber 30. In other words, the part of the first passage 61 is located adjacent to the suction chamber 30 so that the refrigerant gas in the part of the first passage 61 is cooled by the refrigerant gas in the suction chamber 30.

[0023] As shown in FIG. 1, the second passage 62 is in communication with a third passage 63 formed in the cylinder block 11, and the third passage 63 is in communication with the accommodation space S. In the drive shaft 16, a fourth passage 64 is formed in the second shaft portion 16b so as to pass through the second shaft portion 16b in the direction of the axis T. The fourth passage 64 is in communication with the accommodation space S. In addition, in the drive shaft 16, a fifth passage 65 is formed so as to extend on the front side of the first shaft portion 16a in the direction of the axis T and extend in the radial direction of the axis T. The fifth passage 65 is in communication with the fourth passage 64 and is in communication with the shaft seal chamber 20 in the front housing 12. The shaft seal chamber 20 is in communication with the crank chamber 15 through a sixth passage 66 formed in the front housing 12.

[0024] Therefore, the discharge passage 51, the accommodation chamber 50 (or the oil reservoir 52b), the communication passage 59, the control valve 60, the first passage 61, the second passage 62, the third passage 63, the accommodation space S, the fourth passage 64, the fifth passage 65, the shaft seal chamber 20 and the sixth passage 66 form a supply passage for supplying the refrigerant gas in the discharge chamber 31 to the crank chamber 15. The supply passage is formed differently from the gas passage. When the control valve 60 is operated, the opening degree of the supply passage is adjusted. A controller (not shown) is connected to the control valve 60 for performing control of current supply (duty cycle control). In the supply passage, the control valve 60 is provided on the upstream side of the first passage 61 located adjacent to the suction chamber 30. That is, in the supply passage, the first passage 61 which

forms the part of the supply passage is located downstream from the control valve 60.

[0025] In the drive shaft 16, a bleed port 16c is formed in the first shaft portion 16a at a position between the swash plate 24 and the lug plate 22. The bleed port 16c is in communication with a seventh passage 67 formed between the inner circumferential surface of the first shaft portion 16a and the outer circumferential surface of the second shaft portion 16b. The seventh passage 67 is in communication with the accommodation space S. The accommodation space S is in communication with an eighth passage 68 formed in the cylinder block 11, and the eighth passage 68 is in communication with a ninth passage 69 formed in the valve plate assembly 13. The ninth passage 69 is in communication with the suction chamber 30. The bleed port 16c, the seventh passage 67, the accommodation space S, the eighth passage 68 and the ninth passage 69 form a bleed passage for drawing the refrigerant gas from the crank chamber 15 to the suction chamber 30. In the accommodation space S, a lip seal L is interposed between the inner wall surface of the accommodation space S and the outer circumferential surface of the rear end of the second shaft portion 16b of the drive shaft 16 in such a way that a part of the supply passage and a part of the bleed passage which are defined in the accommodation space S are shut off from each other.

[0026] The operation of the compressor 10 of the present embodiment will now be described. As the drive shaft 16 is rotated by a drive source (not shown), the swash plate 24 is rotated and the pistons 27 are reciprocally moved in the respective cylinder bores 26, accordingly. At this time, the refrigerant gas circulating through the external refrigerant circuit 40 is drawn from the suction chamber 30 into the cylinder bores 26 through the corresponding suction valves and suction ports 32, thereby to be compressed in the compression chambers (not shown), respectively. The compressed refrigerant gas is discharged to the discharge chamber 31 through the corresponding discharge ports 34 and discharge valves. The refrigerant gas discharged to the discharge chamber 31 is led to the oil separator 52 in the accommodation chamber 50 through the discharge passage 51, and the oil separation portion 52a of the oil separator 52 separates the oil from the refrigerant gas.

[0027] A part of the refrigerant gas whose lubricating oil is separated passes through the inside of the oil separation portion 52a and then is supplied to the condenser 40a of the external refrigerant circuit 40. That is, the part of the refrigerant gas is led to the external refrigerant circuit 40 through the gas passage including the accommodation chamber 50 and the discharge passage 51. Meanwhile, the other part of the refrigerant gas whose lubricating oil is separated in the oil separator 52 passes through the oil reservoir 52b and then is led to the control valve 60 through the communication passage 59 with the lubricating oil in the oil reservoir 52b. That is, the refrigerant gas discharged to the discharge chamber 31 is di-

vided into the gas passage for the external refrigerant circuit 40 and the communication passage 59 for the control valve 60 through the discharge passage 51. Therefore, the refrigerant gas is separately led to the external refrigerant circuit 40 and the control valve 60.

[0028] Of the refrigerant gas led to the control valve 60, flow rate of the refrigerant gas supplied to the crank chamber 15 through the supply passage is adjusted by adjusting the opening degree of the control valve 60. When the refrigerant gas passes through the control valve 60, the refrigerant gas is throttled by a valve portion (not shown) of the control valve 60 thereby to be decompressed. When the refrigerant gas is decompressed, the temperature of the refrigerant gas is reduced.

[0029] In addition, the refrigerant gas whose temperature is reduced passes through the first passage 61. The part of the first passage 61 is disposed in the peripheral wall 14c so as to be located adjacent to the suction chamber 30. Meanwhile, the refrigerant gas which circulates through the external refrigerant circuit 40 thereby to be lowered in temperature is drawn into the suction chamber 30. The refrigerant gas in the suction chamber 30 is lower in temperature than the refrigerant gas passing through the supply passage (the first passage 61). Therefore, the refrigerant gas passing through the first passage 61 of the supply passage is cooled by the refrigerant gas in the suction chamber 30. That is, the refrigerant gas which is discharged to the discharge chamber 31 and then passes through the control valve 60 and a part of the supply passage is cooled by two cooling means, in other words, the control valve 60 and the suction chamber 30. Thus, the refrigerant gas which is discharged to the discharge chamber 31 and then passes through the control valve 60 and a part of the supply passage is lower in temperature than the refrigerant gas in the discharge chamber 31.

[0030] In the drive shaft 16, the seventh passage 67 is formed radially outward of the fourth passage 64 so as to surround the fourth passage 64 which forms a part of the supply passage. Therefore, the refrigerant gas which passes through the seventh passage 67 performs insulation effect for shutting off transfer of heat from the outside of the outer circumferential surface of the drive shaft 16 to the fourth passage 64, thereby to maintain the refrigerant gas in the fourth passage 64 (the supply passage) at low temperature.

[0031] The refrigerant gas which passes through the first passage 61 to be lowered in temperature is drawn into the shaft seal chamber 20 through the second passage 62, the third passage 63, the accommodation space S, the fourth passage 64 and the fifth passage 65, and then is blown to the lip seal 21 in the shaft seal chamber 20. The lip seal 21 which generates heat due to constant sliding contact with the drive shaft 16 is thus cooled by the refrigerant gas. Thereafter, the refrigerant gas drawn into the shaft seal chamber 20 is supplied from the sixth passage 66 to the crank chamber 15.

[0032] The refrigerant gas in the crank chamber 15 is

drawn to the bleed passage, and furthermore drawn to the suction chamber 30. The balance between the flow rate of the refrigerant gas supplied into the crank chamber 15 through the supply passage and the flow rate of the refrigerant gas drawn from the crank chamber 15 through the bleed passage is controlled to determine (or adjust) the pressure in the crank chamber 15. When the pressure in the crank chamber 15 is changed, the pressure difference between the crank chamber 15 and the cylinder bores 26 through the respective pistons 27 is changed thereby to change angle of inclination of the swash plate 24. Consequently, stroke of each piston 27 (displacement of the compressor 10) is adjusted.

[0033] The first embodiment has the following advantageous effects.

(1) The discharge chamber 31 and the crank chamber 15 are in communication with each other through the supply passage. A part of the supply passage (the first passage 61) is located radially outward of the partition wall 14a, and is located radially outward of the suction chamber 30 (in the peripheral wall 14c) so as to be located adjacent to the suction chamber 30. The part of the supply passage is nearer to the suction chamber than the discharge chamber. Therefore, the refrigerant gas which is discharged to the discharge chamber 31 and then passes through the control valve 60 is cooled by the low-temperature refrigerant gas in the suction chamber 30. The cooled refrigerant gas is supplied into the shaft seal chamber 20 through the supply passage, so that the cooled refrigerant gas is blown to the lip seal 21 in the shaft seal chamber 20. Thus, the refrigerant gas which is supplied into the shaft seal chamber 20 is reduced in temperature compared to the case where the refrigerant gas which is discharged to the discharge chamber 31 and then passes through the control valve 60 is directly supplied into the shaft seal chamber 20. Consequently, temperature of the refrigerant gas which is blown to the lip seal 21 in the shaft seal chamber 20 is reduced thereby to sufficiently cool the lip seal 21.

(2) The compressor 10 is so arranged that the discharge chamber 31 is defined in the middle of the rear housing 14 and the annular suction chamber 30 is defined radially outward of the discharge chamber 31 through the partition wall 14a. In the compressor 10, a part of the supply passage (the first passage 61) is located in such a position that the first passage 61 and the discharge chamber 31 sandwich the partition wall 14a and the suction chamber 30. Therefore, the refrigerant gas which passes through the first passage 61 is not affected by the high-temperature refrigerant gas in the discharge chamber 31 and is even cooled by the refrigerant gas in the suction chamber 30 directly. Thus, the refrigerant gas which passes through the first passage 61 is effi-

ciently cooled by the refrigerant gas in the suction chamber 30.

(3) In addition, in the compressor 10, a part of the supply passage (the first passage 61) is located in the peripheral wall 14c which is located radially outward of the suction chamber 30. Therefore, the refrigerant gas in the suction chamber 30 is not directly heated by the refrigerant gas which passes through the first passage 61, for example, as in the case where the first passage 61 is so arranged as to traverse the suction chamber 30. Thus, deterioration of the cooling efficiency in the external refrigerant circuit 40 caused by the refrigerant gas in the suction chamber 30 being heated is prevented,

(4) In the rear housing 14, the gas passage through which a part of the refrigerant gas is led to the external refrigerant circuit 40 and the communication passage 59 through which the other part of the refrigerant gas is led to the control valve 60 are so formed that the communication passage 59 is separated from the accommodation chamber 50 of the gas passage. That is, although the supply passage shares the discharge passage 51 with the gas passage, the supply passage is formed differently from the gas passage. Therefore, the refrigerant gas discharged to the discharge chamber 31 is separately led from the discharge passage 51 to the external refrigerant circuit 40 and the supply passage, and only the refrigerant gas supplied to the supply passage is cooled by the refrigerant gas in the suction chamber 30. That is, since in the compressor 10 of the present embodiment all the refrigerant gas discharged to the discharge chamber 31 is not led to the external refrigerant circuit 40 so as to be cooled by the refrigerant gas in the suction chamber 30 on the way to the external refrigerant circuit 40, temperature of the refrigerant gas in the suction chamber 30 is hard to rise. Consequently, as described in the above effect (3) deterioration of the cooling efficiency in the external refrigerant circuit 40 caused by the refrigerant gas in the suction chamber 30 being heated is prevented.

(5) In the rear housing 14, the gas passage through which a part of the refrigerant gas is led to the external refrigerant circuit 40 and the communication passage 59 (the supply passage) through which the other part of the refrigerant gas is led to the control valve 60 are differently formed. Therefore, for example, compared to the case that the gas passage through which the refrigerant gas discharged to the discharge chamber 31 is led to the external refrigerant circuit 40 also serves as the supply passage, increase of the diameter of a passage which is indispensable for ensuring the flow rate of the refrigerant gas into the external refrigerant circuit 40 and the flow rate of the

refrigerant gas into the crank chamber 15 is prevented.

(6) A part of the supply passage (the first passage 61) which is located adjacent to the suction chamber 30 is located on the downstream side of the control valve 60. Therefore, the refrigerant gas is decompressed by the control valve 60 and then is cooled by the refrigerant gas in the suction chamber 30. Thus, the refrigerant gas in the supply passage is effectively cooled.

(7) A part of the supply passage (the fourth passage 64 and the fifth passage 65) is formed in the drive shaft 16 and a part of the bleed passage (the seventh passage 67) is formed radially outward of the part of the supply passage (the fourth passage 64 and the fifth passage 65). Thus, the refrigerant gas in the crank chamber 15 passes through the bleed passage at the position between the outer circumferential surface of the drive shaft 16 and the part of the supply passage so as to perform heat insulation between radially outward area of the outer circumferential surface of the drive shaft 16 and the inside area of the supply passage and then is drawn out to the suction chamber 30. Therefore, the refrigerant gas in the supply passage is maintained at low temperature thereby to blow the low-temperature refrigerant gas to the lip seal 21, which furthermore enhances the cooling effect of the lip seal 21.

The following will describe a variable displacement compressor (hereinafter referred to merely as a compressor) according to a second preferred embodiment of the present invention with reference to FIG. 3. The second embodiment differs from the first embodiment in that the positions of the supply passage and the bleed passage of the first embodiment are changed. The overlapped description for repeating the same part is omitted.

As shown in FIG. 3, the drive shaft 16 of the second embodiment is not provided with the double pipe structure formed by the first shaft portion 16a and the second shaft portion 16b but is formed in a cylindrical shape. A first passage 71 is formed in the rear housing 14, which is in communication with the control valve 60. The first passage 71 is in communication with a second passage 72 formed in the cylinder block 11. A part of the first passage 71 is located radially outward of the partition wall 14a which separates the suction chamber 30 and the discharge chamber 31, and is located in the peripheral wall 14c which is located radially outward of the suction chamber 30 so as to be located adjacent to the suction chamber 30. That is, the part of the first passage 71 is arranged in such a position that the refrigerant gas which passes through the first passage 71 is cooled by the refrigerant gas in the suction chamber 30. The second passage 72 is in communication with a third

passage 73 formed in the front housing 12, and the third passage 73 is in communication with the shaft seal chamber 20.

The shaft seal chamber 20 is in communication with the crank chamber 15 through a fourth passage 74 formed in the front housing 12. Therefore, the discharge passage 51, the accommodation chamber 50 (the oil reservoir 52b), the communication passage 59, the control valve 60, the first passage 71, the second passage 72, the third passage 73, the shaft seal chamber 20 and the fourth passage 74 form the supply passage for supplying the refrigerant gas in the discharge chamber 31 to the crank chamber 15. A bleed passage 77 through which the crank chamber 15 and the suction chamber 30 are in communication with each other is formed through the cylinder block 11 and the valve plate assembly 13, thereby to allow the refrigerant gas in the crank chamber 15 to be drawn out to the suction chamber 30.

Therefore, the second embodiment has the following advantageous effects in addition to the effects (1) through (6) of the first embodiment.

(8) In the second embodiment, the supply passage is formed in the housing (the cylinder block 11, the front housing 12 and the rear housing 14) of the compressor 10. Therefore, the supply passage is cooled by air outside the housing of the compressor 10. Thus, the temperature of the refrigerant gas blown to the lip seal 21 is reduced thereby to sufficiently cool the lip seal 21 in the shaft seal chamber 20.

[0034] The following will describe a variable displacement compressor (hereinafter referred to merely as a compressor) according to a third preferred embodiment of the present invention with reference to FIGs. 4 and 5. The third embodiment differs from the first embodiment in that the positions of the discharge chamber and the suction chamber of the first embodiment are reversed and that the positions of the supply passage and the bleed passage of the first embodiment are changed. The overlapped description for repeating the same part is omitted.

[0035] As shown in FIG. 4, the suction chamber 30 is formed in the middle of the rear housing 14. Meanwhile, in the rear housing 14, the partition wall 14a is formed radially outward of the suction chamber 30. In addition, in the rear housing 14, the discharge chamber 31 is provided radially outward of the suction chamber 30 through the partition wall 14a in an annular shape so as to surround the suction chamber 30. Furthermore, in the rear housing 14, an outlet 31a is formed so as to be in communication with the discharge chamber 31. The discharge chamber 31 is connected to the external refrigerant circuit 40 through the outlet 31a. The high-pressure refrigerant gas discharged to the discharge chamber 31 is led to the external refrigerant circuit 40 through the outlet 31a.

Therefore, the outlet 31a forms the gas passage.

[0036] In the rear housing 14, the control valve 60 is disposed. In addition, in the rear housing 14, the discharge passage 80 is formed so as to communicate the discharge chamber 31 and the control valve 60. Furthermore, in the rear housing 14, a first passage 81 is formed so as to communicate the control valve 60 and a second passage 82 formed in the valve plate assembly 13.

[0037] As shown in FIG. 5, a part of the first passage 81 is formed in the rear housing 14 so as to pass through the partition wall 14a. The part of the first passage 81 is located in the inner wall surface of the partition wall 14a which separates the discharge chamber 31 and the suction chamber 30. The part of the first passage 81 is located adjacent to the suction chamber 30, that is, the part of the first passage 81 is nearer to the suction chamber than the discharge chamber 31. Therefore, the part of the first passage 81 is arranged in such a position that the refrigerant gas which passes through the first passage 81 is cooled by the refrigerant gas in the suction chamber 30.

[0038] As shown in FIG. 4, the second passage 82 is in communication with a third passage 83 formed in the cylinder block 11, and the third passage 83 is in communication with a fourth passage 84 formed in the front housing 12. The fourth passage 84 is in communication with the shaft seal chamber 20, which is in communication with the crank chamber 15 through a fifth passage 85 formed in the front housing 12. Therefore, the discharge passage 80, the control valve 60, the first passage 81, the second passage 82, the third passage 83, the fourth passage 84, the shaft seal chamber 20 and the fifth passage 85 form the supply passage for supplying the refrigerant gas in the discharge chamber 31 to the crank chamber 15. A bleed passage 87 through which the crank chamber 15 and the suction chamber 30 are in communication with each other is formed through the cylinder block 11 and the valve plate assembly 13, thereby to allow the refrigerant gas in the crank chamber 15 to be drawn to the suction chamber 30.

[0039] Therefore, the third embodiment has the effects similar to the effects (1) and (3) through (6) of the first embodiment. In addition, modifications of the above embodiments are as follows.

[0040] In a modification of the first embodiment, as shown by alternate long and two short dashes line of FIG. 1 and additionally as shown in FIG. 6, the first passage 61 which forms a part of the supply passage may be located so as to traverse the suction chamber 30 radially outward of the partition wall 14a and a part of the first passage 61 may be located inside the suction chamber 30. In a similar manner, in a modification of the second embodiment, as shown by alternate long and two short dashes line of FIG. 3 and additionally as shown in FIG. 6, the first passage 71 which forms a part of the supply passage may be located so as to traverse the suction chamber 30 radially outward of the partition wall 14a and a part of the first passage 71 may be located inside the

suction chamber 30. In these structures, the refrigerant gas in the suction chamber 30 is in contact with entire circumference of each of the first passages 61, 71. Therefore, the entire circumference of each of the first passages 61, 71 is cooled by the refrigerant gas in the suction chamber 30.

[0041] In a modification of the first embodiment, as shown in FIG. 7, a part of the first passage 61 which forms a part of the supply passage may be located in the inner wall surface of the peripheral wall 14c which is located radially outward of the partition wall 14a. In a modification of the first embodiment, as shown in FIG. 8, a part of the first passage 61 which forms a part of the supply passage may be located in the outer wall surface of the partition wall 14a. In these structures, contact areas between the outer peripheral surface of the first passage 61 and the refrigerant gas in the suction chamber 30 are increased compared to the case where the part of the first passage 61 is formed so as to pass through the peripheral wall 14c or the partition wall 14a without changing the shape of the peripheral wall 14c or the partition wall 14a. Therefore, the refrigerant gas which passes through the first passage 61 is efficiently cooled by the refrigerant gas in the suction chamber 30. In a similar manner, in a modification of the second embodiment, as shown in FIG. 7, a part of the first passage 71 which forms a part of the supply passage may be located in the inner wall surface of the peripheral wall 14c which is located radially outward of the partition wall 14a. In a modification of the second embodiment, as shown in FIG. 8, a part of the first passage 71 which forms a part of the supply passage may be located in the outer wall surface of the partition wall 14a. In these structures, contact areas between the outer peripheral surface of the first passage 71 and the refrigerant gas in the suction chamber 30 are increased compared to the case where a part of the first passage 71 is formed so as to pass through the peripheral wall 14c or the partition wall 14a without changing the shape of the peripheral wall 14c or the partition wall 14a. Therefore, the refrigerant gas which passes through the first passage 71 is efficiently cooled by the refrigerant gas in the suction chamber 30.

[0042] In a modification of the third embodiment, as shown in FIG. 9, the first passage 81 which forms a part of the supply passage may be located so as to traverse the suction chamber 30 radially inward of the partition wall 14a and a part of the first passage 81 may be located inside the suction chamber 30. In this structure, the refrigerant gas in the suction chamber 30 is in contact with entire peripheral wall of the first passage 81. Therefore, the entire peripheral wall of the first passage 81 is cooled by the refrigerant gas in the suction chamber 30.

[0043] In a modification of each embodiment, the control valve 60 may be disposed downstream from the suction chamber 30 in the supply passage.

[0044] In a modification of the first embodiment, while the drive shaft 16 has only the fourth passage 64 and the fifth passage 65 formed therein, the drive shaft 16 may

dispense with the bleed port 16c and the seventh passage 67. That is, the drive shaft 16 may be formed to have a part of the supply passage and not to have a part of the bleed passage. In this case, the bleed passage is formed in the cylinder block 11.

[0045] In a modification of each embodiment, the oil separator 52 is not necessarily needed. In this case, the refrigerant gas discharged to the discharge chamber 31 may be directly led to the external refrigerant circuit 40 and the control valve 60.

[0046] In a modification of the third embodiment, the first passage 81 which forms a part of the supply passage may be formed so as to traverse the suction chamber 30. In addition, the supply passage may be formed in the drive shaft 16 such that the crank chamber 15 and the discharge chamber 31 are in communication with each other.

[0047] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.

[0048] A variable displacement compressor for forming a refrigerant circuit with an external refrigerant circuit includes a housing, a drive shaft, a swash plate, a shaft seal member, a supply passage, a control valve and a gas passage. The housing has a suction chamber, a crank chamber, a discharge chamber and a shaft seal chamber formed therein. The discharge chamber is in communication with the crank chamber through the supply passage. The supply passage has the shaft seal chamber. The discharge chamber is in communication with the external refrigerant circuit through the gas passage. The supply passage is formed differently from the gas passage. A part of the supply passage is located adjacent to the suction chamber and nearer to the suction chamber than the discharge chamber.

Claims

1. A variable displacement compressor for forming a refrigerant circuit with an external refrigerant circuit, including a housing, a drive shaft, a swash plate, a shaft seal member, a supply passage and a control valve, the housing having a suction chamber, a crank chamber, a discharge chamber and a shaft seal chamber formed therein, the drive shaft being rotatably supported by the housing, the swash plate being connected to the drive shaft so that angle of inclination of the swash plate relative to the drive shaft is variable, the swash plate being accommodated in the crank chamber, the shaft seal member being accommodated in the shaft seal chamber, the discharge chamber being in communication with the crank chamber through the supply passage, the supply passage including the shaft seal chamber, the control valve being disposed in the supply passage,

flow rate of refrigerant gas supplied from the discharge chamber to the crank chamber through the supply passage being adjusted by adjusting an opening degree of the control valve, **characterized in that**

the discharge chamber is in communication with the external refrigerant circuit through a gas passage, **in that** the supply passage is formed differently from the gas passage, and **in that** a part of the supply passage is located adjacent to the suction chamber and nearer to the suction chamber than the discharge chamber.

2. The variable displacement compressor according to claim 1, wherein the suction chamber is formed radially outward of the discharge chamber, the part of the supply passage being located radially outward of a partition wall which separates the discharge chamber and the suction chamber.
3. The variable displacement compressor according to claim 2, wherein the part of the supply passage is located radially outward of the suction chamber.
4. The variable displacement compressor according to claim 2 or 3, wherein the part of the supply passage is located so as to traverse the suction chamber.
5. The variable displacement compressor according to claim 1, wherein the suction chamber is formed radially inward of the discharge chamber, the part of the supply passage being located radially inward of a partition wall which separates the discharge chamber and the suction chamber.
6. The variable displacement compressor according to claim 5, wherein the part of the supply passage is located so as to traverse the suction chamber.
7. The variable displacement compressor according to claim 1, wherein the suction chamber is formed radially outward of the discharge chamber, the part of the supply passage being located in an outer wall surface of a partition wall which separates the discharge chamber and the suction chamber.
8. The variable displacement compressor according to claim 1, wherein the suction chamber is formed radially inward of the discharge chamber, the part of the supply passage being located in an inner wall surface of a partition wall which separates the discharge chamber and the suction chamber.
9. The variable displacement compressor according to any one of claims 1 through 8, wherein the part of the supply passage is located downstream from the control valve in the supply passage.

10. The variable displacement compressor according to any one of claims 1 through 9, wherein another part of the supply passage is formed in the drive shaft.

11. The variable displacement compressor according to any one of claims 1 through 9, wherein a bleed passage through which the refrigerant gas in the crank chamber is drawn to the suction chamber is disposed in the housing, and wherein at least parts of the supply passage and the bleed passage are formed in the drive shaft, the part of the supply passage which is formed in the drive shaft being in communication with the shaft seal chamber, the part of the bleed passage which is formed in the drive shaft being formed between the part of the supply passage in the drive shaft and an outer circumferential surface of the drive shaft.

12. The variable displacement compressor according to claim 11, wherein the drive shaft includes a cylindrical hollow first shaft portion and a cylindrical hollow second shaft portion inserted in the first shaft portion, the part of the bleed passage formed in the drive shaft being defined by an inner circumferential surface of the first shaft portion and an outer circumferential surface of the second shaft portion, the part of the supply passage formed in the drive shaft being defined by an inner circumferential surface of the second shaft portion.

13. The variable displacement compressor according to claim 12, wherein an accommodation space is defined in the housing for accommodating a rear end of the drive shaft therein, parts of the supply passage and the bleed passage being defined in the accommodation space by a seal member disposed on the second shaft portion.

14. The variable displacement compressor according to claim 13, wherein the part of the supply passage is in communication with the accommodation space through a valve plate assembly.

15. The variable displacement compressor according to any one of claims 1 through 14, wherein the supply passage and the gas passage are partially shared and then are separated from each other.

16. The variable displacement compressor according to any one of claims 1 through 14, wherein the supply passage and the gas passage are separately formed.

55

FIG. 1

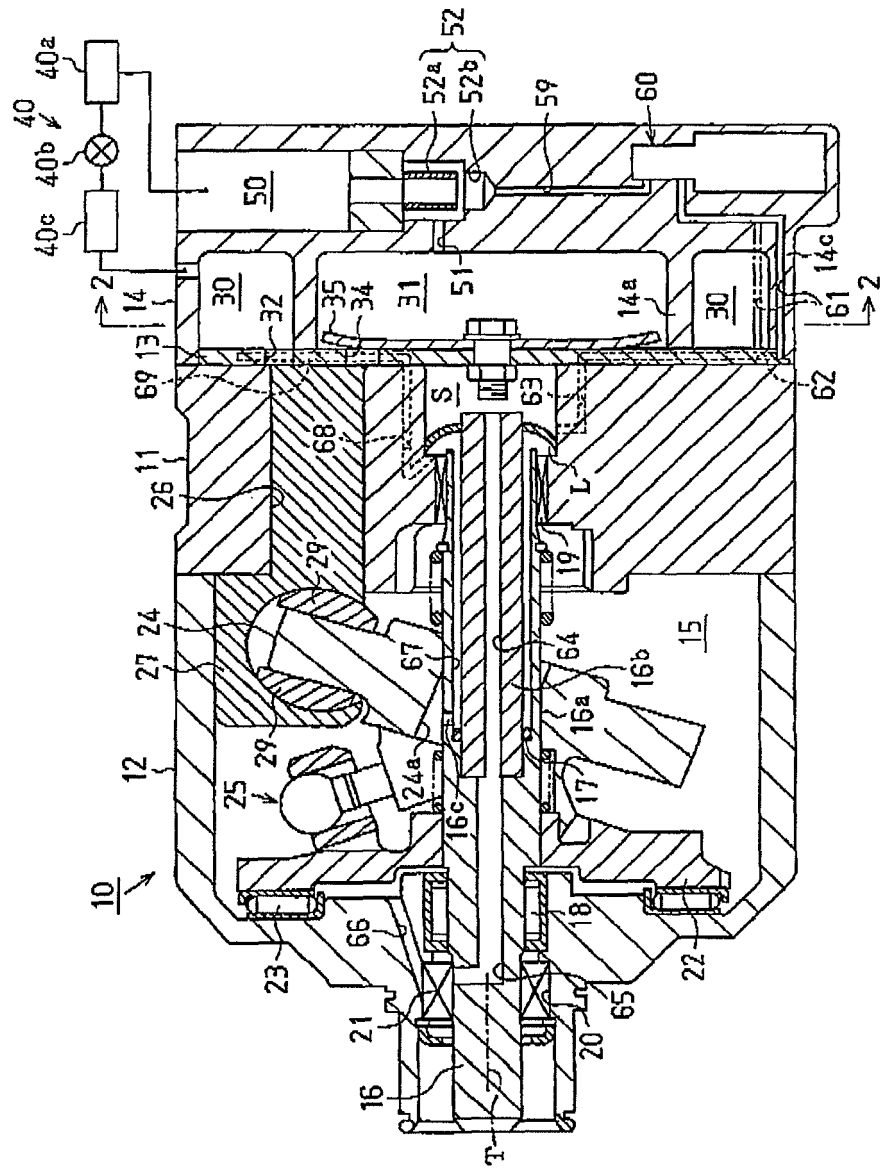


FIG. 2

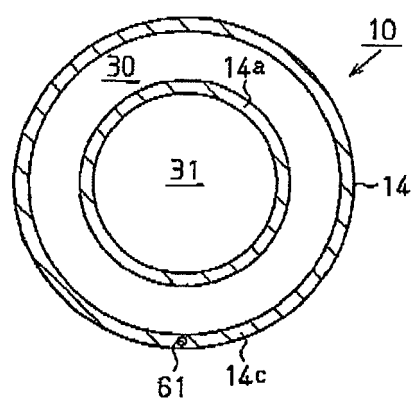


FIG. 3

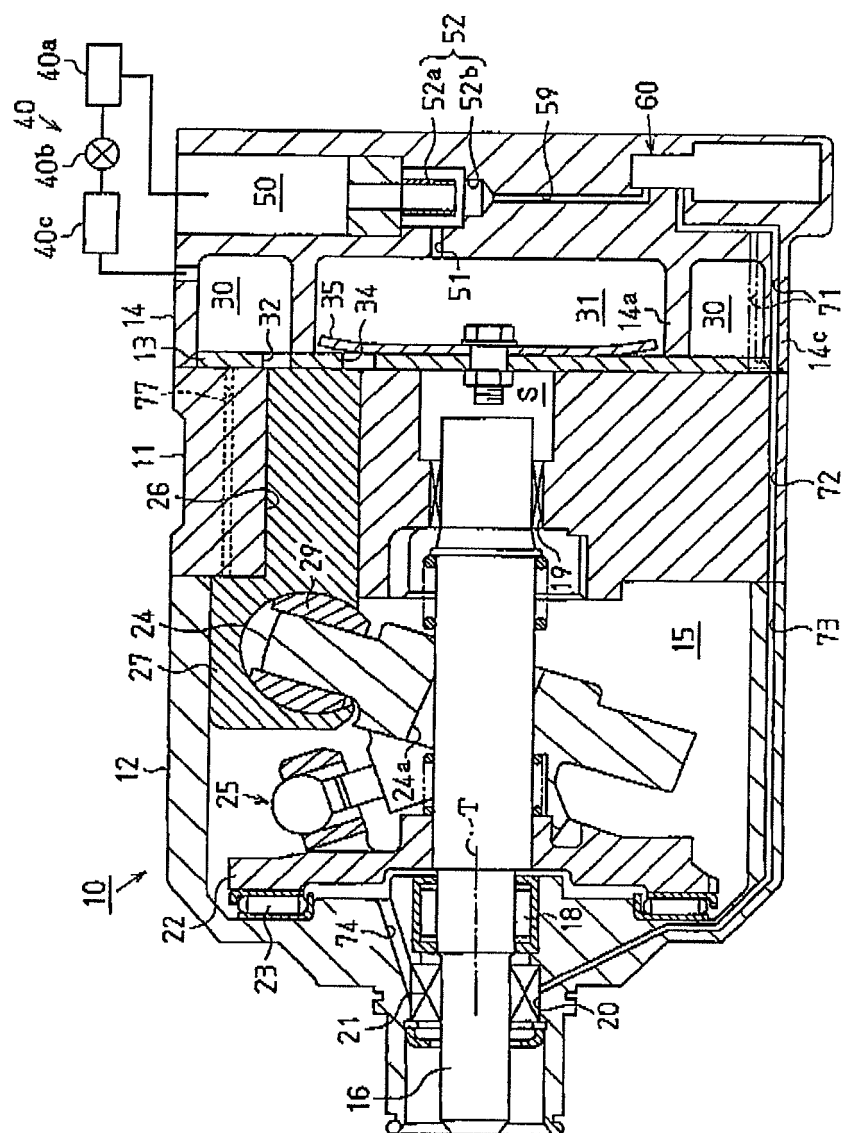


FIG. 4

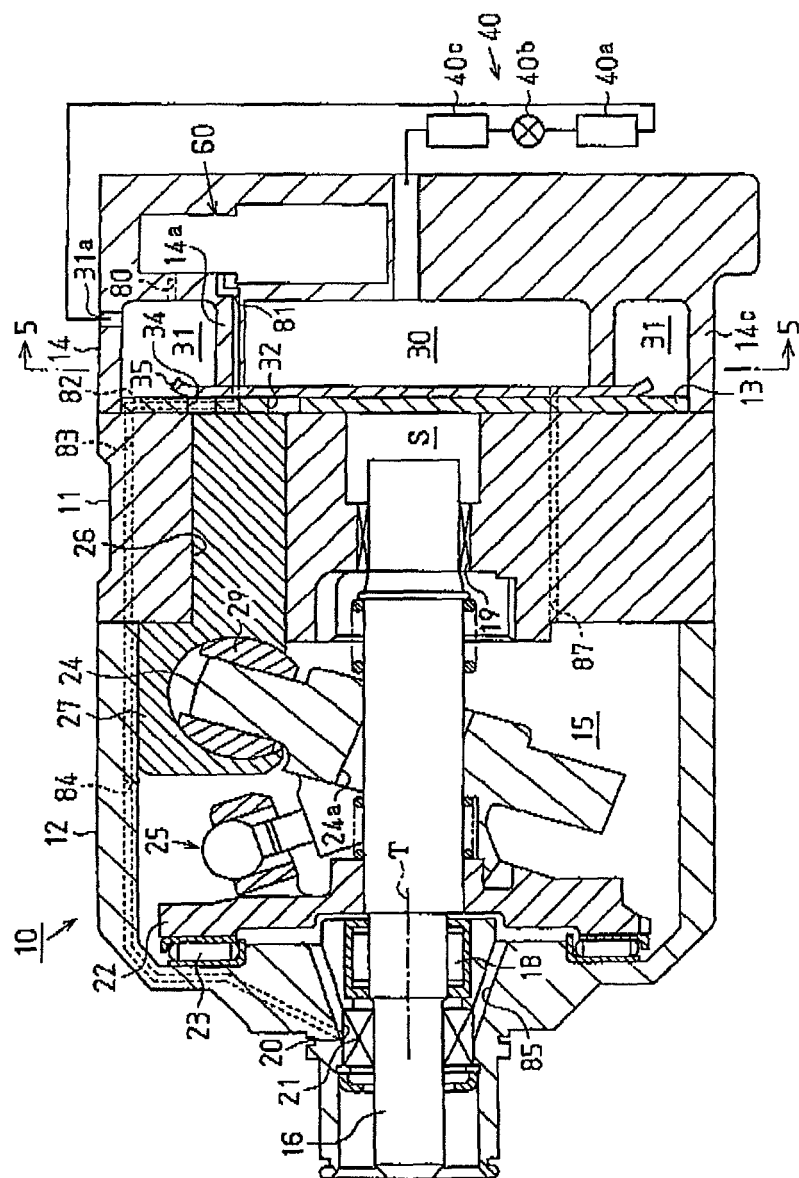


FIG. 5

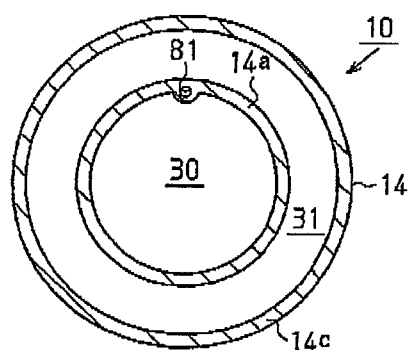


FIG. 6

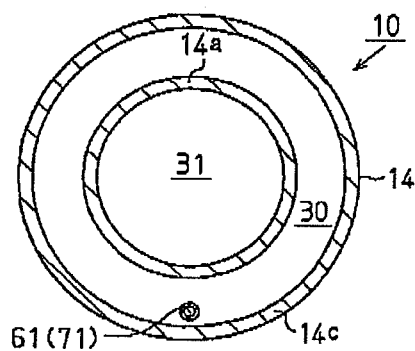


FIG. 7

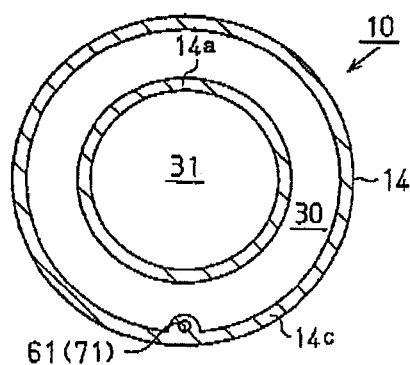


FIG. 8

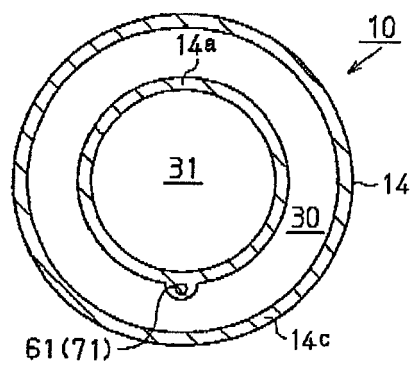
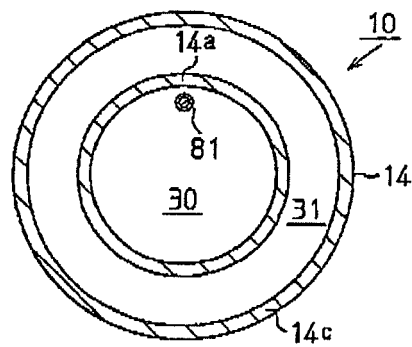


FIG. 9





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 11 7116

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2003/086791 A1 (BREINDEL JOHN A [US] ET AL) 8 May 2003 (2003-05-08) * abstract; figures 1,2 * * paragraph [0012] * -----	1	INV. F04B27/18
X	US 4 037 993 A (ROBERTS RICHARD W) 26 July 1977 (1977-07-26) * column 6, line 25 - column 6, line 40 * * abstract; figures * -----	1	
A	EP 1 347 173 A (CALSONIC KANSEI CORP [JP]) 24 September 2003 (2003-09-24) * abstract; figures * -----	1-16	
A	US 4 061 443 A (BLACK DENNIS A ET AL) 6 December 1977 (1977-12-06) * abstract; figures * -----	1-16	
A	US 4 174 191 A (ROBERTS RICHARD W [US]) 13 November 1979 (1979-11-13) * abstract; figure 1 * -----	1	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC) F04B
Place of search Munich		Date of completion of the search 24 October 2006	Examiner Pinna, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

1
EPO FORM 1503 03.82 (P04C01)

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

EP 06 11 7116

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-10-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003086791 A1	08-05-2003	NONE	

US 4037993 A	26-07-1977	AU 505611 B2	29-11-1979
		AU 2392977 A	12-10-1978
		BR 7702518 A	28-02-1978
		DE 2718117 A1	10-11-1977
		FR 2349048 A1	18-11-1977
		IT 1078415 B	08-05-1985
		JP 52131204 A	04-11-1977

EP 1347173 A	24-09-2003	JP 2003343440 A	03-12-2003
		US 2004005223 A1	08-01-2004

US 4061443 A	06-12-1977	AU 512033 B2	18-09-1980
		AU 3097077 A	31-05-1979
		DE 2752797 A1	08-06-1978
		FR 2372973 A1	30-06-1978
		GB 1558685 A	09-01-1980
		IT 1090831 B	26-06-1985
		JP 1220951 C	26-07-1984
		JP 53069911 A	21-06-1978
		JP 58053198 B	28-11-1983
		SE 7713630 A	03-06-1978

US 4174191 A	13-11-1979	NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 4179874 A [0004]