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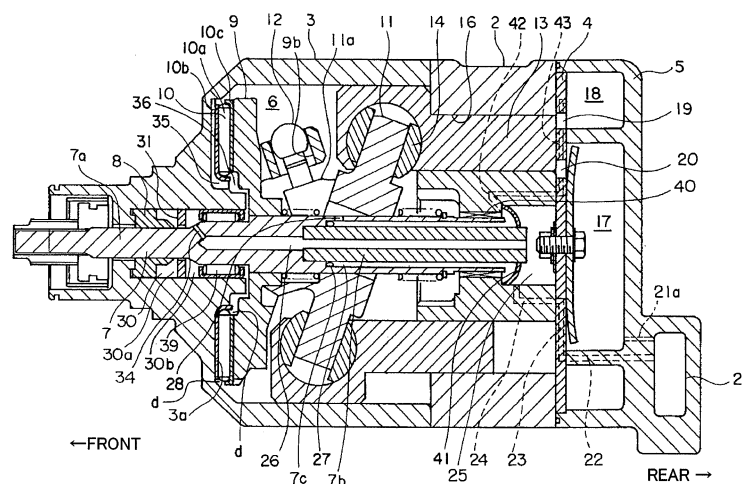
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(57) A compressor includes a housing, a rotary shaft, a bearing, a seal, a shaft seal chamber, a lug plate, a thrust bearing, a first passage for connecting the crank chamber to the shaft seal chamber, a second passage provided in the housing for connecting the crank chamber to the shaft seal chamber, a third passage provided in the rotary shaft for connecting the shaft seal chamber to a discharge pressure

region of the compressor, a partition provided in the shaft seal chamber for dividing the shaft seal chamber into a seal-side chamber and a bearing-side chamber and a clearance formed through the partition for drawing the refrigerant gas from the seal-side chamber of the shaft seal chamber to the bearing-side chamber of the shaft seal chamber, the clearance being formed radially inward of the inner circumferential surface of the shaft seal chamber.

FIG. 1**EP 1 906 015 A1**

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a compressor and, more particularly, to a lubrication mechanism for lubricating a seal for a rotary shaft of the compressor, a bearing for the rotary shaft and a thrust bearing.

[0002] Japanese Unexamined Patent Application Publication No. 2004-176543 discloses a compressor having a housing which has a crank chamber being formed therein and has a cylindrical shaft hole through which a rotary shaft extends and in which a shaft seal member is disposed for sealing the rotary shaft. In this compressor, a recess is formed around the shaft seal member and an oil passage is formed in the housing for connecting the recess to the crank chamber, so that lubricating oil which is drawn from the crank chamber into the oil passage is collected in the recess. In addition, the compressor has an injection circuit for supplying a part of refrigerant gas from the crank chamber to the shaft seal member through the oil passage and for cooling the shaft seal member.

[0003] Japanese Unexamined Patent Application Publication No. 2002-310067 discloses a compressor having a slide bearing supporting a rotary shaft in a housing of the compressor and a seal disposed on the rotary shaft at a position that is outer than the slide bearing in the housing, so that a space is formed between the seal and the slide bearing. In this compressor, an oil passage is formed in the housing which provides fluid communication between the space and a crank chamber of the compressor. In addition, a clearance is formed between flat surfaces of the slide bearing and of the rotary shaft for serving as an oil lubrication passage between the space and the crank chamber. By so constructing the compressor, the space between the seal and the bearing and the crank chamber are made in communication with each other through the two passages thereby to allow the lubricating oil to circulate between the space and the crank chamber, with the result that troubles associated with seizure between the seal and the rotary shaft are prevented.

[0004] However, the space formed in the periphery of the shaft seal member (hereinafter referred to as "shaft seal chamber"), such as the aforementioned recess or space, is provided around the rotary shaft at a location near the axial center of the rotary shaft. On the other hand, in operation of the compressor when rotating members such as the rotary shaft, a swash plate and a lug plate are being rotated, a larger amount of lubricating oil is present in radially outer region of the crank chamber under the influence of centrifugal force, and this tendency becomes more remarkable during high-speed operation of the compressor when lubrication of the seal is more important. Since the lubricating oil in the crank chamber exists in the form of mist in refrigerant gas, it is hard to draw a large amount of lubricating oil into the shaft seal

chamber which is formed in the periphery of the shaft seal member. In addition, the compressor has a bearing supporting a rotary shaft and a thrust bearing supporting a lug plate and clearances are formed in such bearings. When the refrigerant gas circulates between the crank chamber and the shaft seal chamber through the clearances provided in the bearings, the lubricating oil attached on the bearings tends to be washed away by the refrigerant gas sprayed against the bearings.

[0005] The present invention is directed to a compressor which is capable of effectively lubricating a bearing for the rotary shaft, a thrust bearing and a seal for preventing refrigerant gas from leaking out of a housing of the compressor along the rotary shaft of the compressor.

SUMMARY OF THE INVENTION

[0006] In accordance with an aspect of the present invention, a compressor includes a housing defining therein a crank chamber, a rotary shaft having opposite ends at least one end of which extends out of the housing, a bearing provided in the housing for rotatably supporting the rotary shaft, a seal provided on the rotary shaft at a position which is axially outer side of the bearing for preventing refrigerant gas from leaking out of the housing along the rotary shaft, a shaft seal chamber defined by the seal, the bearing, the housing and the rotary shaft, a lug plate fixed to the rotary shaft, a thrust bearing for axially supporting the lug plate such that the lug plate is rotatable relative to the housing, a first passage provided in the housing for connecting the crank chamber to the shaft seal chamber so that the refrigerant gas containing therein lubricating oil in the crank chamber is drawn into the shaft seal chamber, a second passage provided in the housing for connecting the crank chamber to the shaft seal chamber so that the refrigerant gas in the shaft seal chamber is drawn into the crank chamber, a third passage provided in the rotary shaft for connecting the shaft seal chamber to a discharge pressure region of the compressor so that the refrigerant gas in the discharge pressure region is drawn into the shaft seal chamber, a partition provided in the shaft seal chamber for dividing the shaft seal chamber into a seal-side chamber and a bearing-side chamber, and a clearance formed through the partition for drawing the refrigerant gas from the seal-side chamber of the shaft seal chamber to the bearing-side chamber of the shaft seal chamber, the clearance being formed radially inward of the inner circumferential surface of the shaft seal chamber. The first passage is in communication with the seal-side chamber of the shaft seal chamber. The second passage is in communication with the bearing-side chamber of the shaft seal chamber. The third passage is in communication with the bearing-side chamber of the shaft seal chamber. The refrigerant gas in the discharge pressure region of the compressor is flowed through the third passage into the bearing-side chamber of the shaft seal chamber such that the refrigerant gas is brought into contact with the partition. The

refrigerant gas in the bearing-side chamber of the shaft seal chamber is flowed through the second passage into the crank chamber.

[0007] 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

[0008] 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 compressor according to a first preferred embodiment of the present invention;

FIG. 2 is a partially enlarged sectional view showing a front part of the compressor and, more specifically, a discharged-refrigerant passage 34 and a fourth passage 35 and their related parts of the compressor of Fig. 1;

FIG. 3 is a schematic transverse sectional view showing a first passage 32, a second passage 33, the discharged-refrigerant passage 34 and the fourth passage 35 of the compressor of Fig. 1;

FIG. 4 is a partially enlarged sectional view similar to FIG. 2, but showing specifically the first passage 32 and its related parts of the compressor of FIG. 1;

FIG. 5 is also a partially enlarged sectional view similar to FIG. 2, but showing specifically the second passage 33 and its related parts of the compressor of FIG. 1;

FIG. 6 is also a partially enlarged sectional view similar to FIG. 2, but showing a second passage 55 and its related parts of the compressor of a second preferred embodiment;

FIG. 7 is a schematic transverse sectional view similar to FIG. 3, but showing a first passage 54, the second passage 55, the discharged-refrigerant passage 34 and a fourth passage 56 of the compressor of Fig. 6; and

FIG. 8 is a schematic transverse sectional view showing a first passage 64, a second passage 65, the discharged-refrigerant passage 34 and a fourth passage 66 of a compressor according to a third preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] The following will describe embodiments of a compressor according to the present invention with reference to the accompanying drawings. Referring to FIG. 1 which is a longitudinal sectional view showing a variable displacement compressor 1 according to a first embodiment of the present invention, the left side of the drawing corresponds to the front side of the variable displacement compressor 1 and the right side of the drawing corresponds to the rear side of the variable displacement compressor 1.

[0010] The variable displacement compressor 1 includes a cylinder block 2 and a front housing 3 which is joined to the front end of the cylinder block 2 thereby to define a crank chamber 6. A rear housing 5 is joined to the rear end of the cylinder block 2 through a valve plate assembly 4 disposed therebetween.

[0011] A drive shaft 7 that serves as a rotary shaft is provided in the crank chamber 6 at the center of the front housing 3 and the cylinder block 2. The drive shaft 7 is rotatably supported at the front end portion thereof by a radial roller bearing 39 which serves as a bearing for the rotary shaft and is fitted in the front housing 3. The rear end of the drive shaft 7 is rotatably supported by a radial roller bearing 39 which is fitted in the cylinder block 2. The drive shaft 7 having opposite ends is so arranged that its front end extends out of the front housing 3 to be connected to a drive source (not shown).

[0012] The drive shaft 7 includes a first shaft portion 7a which is of a hollowed cylindrical shape having an opening at one end thereof and a second shaft portion 7b which is also of a hollowed cylindrical shape but having openings at the opposite ends thereof and press-fitted in the first shaft portion 7a, as shown in FIG. 1. An O ring 7c is interposed between the inner circumferential surface of the first shaft portion 7a and the outer circumferential surface of the second shaft portion 7b at a position adjacent to the front end of the second shaft portion 7b, as shown in Fig. 1. An axial passage 26 is formed centrally through the first shaft portion 7a and the second shaft portion 7b and a passage 27 is formed between the inner circumferential surface of the first shaft portion 7a and the outer circumferential surface of the second shaft portion 7b, as shown in Fig. 1.

[0013] A lug plate 9 is fixed on the drive shaft 7 for rotation therewith behind the radial roller bearing 39 in the crank chamber 6. A thrust bearing 10 is interposed between the lug plate 9 and the inner sidewall 3a of the front housing 3 for axially supporting the lug plate 9 such that the lug plate 9 is rotatable relative to the front housing 3. The thrust bearing 10 includes a bearing main body 10a and a pair of bearing races 10b, 10c. The bearing main body 10a includes a plurality of needles provided at spaced intervals. Each of the bearing races 10b, 10c is made of a hollowed disk with an L-shape section and arranged in facing relation to each other such that clear-

ances d are formed between the two bearing races 10b, 10c at the radially and outer peripheries thereof holding the bearing main body 10a therebetween, as shown in Fig. 2. Therefore, the refrigerant gas and lubricating oil can flow in the thrust bearing 10 by passing through the clearances d of the bearing races 10b, 10c. A space 36 is defined by the front housing 3, the lug plate 9 and the thrust bearing 10 which is in communication with the crank chamber 6 through the thrust bearing 10.

[0014] A swash plate 11 is mounted on the drive shaft 7 on the rear side of the lug plate 9 in such a way that the swash plate 11 is inclinable with respect to the drive shaft 7 while sliding in axial direction of the drive shaft 7. The swash plate 11 has a connecting portion 11 a projecting therefrom and a pair of guide pins 12 is mounted at the distal end of the connecting portion 11 a. The pair of guide pins 12 engages with a pair of guide holes 9b in the lug plate 9 for causing the swash plate to rotate with the lug plate 9. A plurality of cylinder bores 16 is formed in the cylinder block 2 around the drive shaft and a pistons 13 is received in each cylinder bores 16 for reciprocal movement therein. The piston 13 is connected to the swash plate 11 through paired shoes 14, respectively, so that, as the swash plate 11 rotates, the piston 13 is reciprocated in the respective cylinder bores 16.

[0015] A lip seal 8 is provided on the drive shaft 7 on the front side of the radial roller bearing 39 in the front housing 3 at a position which is axially outer side of the radial roller bearing 39 and for sealing the drive shaft 7. The lip seal 8 prevents the refrigerant gas and lubricating oil from leaking out of the variable displacement compressor 1 by flowing along the drive shaft 7 whose front end extends out of the front housing 3. The lip seal 8, the radial roller bearing 39, the front housing 3 and the drive shaft 7 cooperate to define a shaft seal chamber 30.

[0016] A partition 31 is provided in the shaft seal chamber 30 to separate the lip seal 8 and the radial roller bearing 39. The partition 31 is of an annular disc shape and a clearance A is formed through the partition 31 and formed between the inner circumferential surface 31 a of the partition 31 and the outer circumferential surface 7d of the drive shaft 7 which faces the inner circumferential surface 31 a, as shown in Fig. 2. The clearance A has a dimension of about 0.2-0.3 mm as measured in radial direction of the drive shaft 7. The dimension is smaller than that of a first passage which will be described later. The clearance A is formed radially inward of the inner circumferential surface 30c of the shaft seal chamber 30. The shaft seal chamber 30 is divided by the partition 31 into the seal-side chamber 30a located on the side of the lip seal 8 and the rotary shaft bearing-side chamber 30b (referred to merely as "bearing-side chamber" hereinafter) located on the side of the radial roller bearing 39.

[0017] FIG. 3 schematically shows the shaft seal chamber 30 and its related parts and elements of the variable displacement compressor 1. It is noted that vertical disposition of the variable displacement compressor

in Fig. 3 corresponds to the gravity direction. Bold lines C, D, E are provided to separate the drawing into three parts corresponding to different transverse sectional views of the variable displacement compressor 1 to show first through fourth passages which will be described later. The first passage 32, the second passage 33 and the fourth passage 35 are provided extending radially in the front housing 3. The fourth passage 35 is provided as seen from the gravity direction extending along the gravity direction. The first passage 32 and the second passage 33 are provided obliquely relative to the gravity direction on both sides of the fourth passage 35 in a symmetric relation to each other with respect to the fourth passage 35. The discharged-refrigerant passage 34 extends radially.

[0018] As shown in FIG. 4, the first passage 32 includes a passage 32a formed as a groove in the front housing 3 and a passage 32b formed as a hole which passing through the front housing 3. The passage 32a extends radially between the inner sidewall 3a of the front housing 3 and the outer surface of the bearing race 10b and is in connection with outer periphery region of the crank chamber 6 and the passage 32b. The passage 32b is also in communication with the seal-side chamber 30a. Thus, the first passage 32 connects the seal-side chamber 30a to the outer periphery region of the crank chamber 6. The passage 32a is closed by the bearing race 10b, so that refrigerant gas in the first passage 32 is prevented from flowing into the bearing main body 10a and the space 36.

[0019] As shown in FIG. 5, the second passage 33 includes a passage 33a formed as a groove in the front housing 3 and a passage 33b formed as a hole which passes through the front housing 3. The passage 33a is formed radially between the inner sidewall 3a of the front housing 3 and the outer surface of the bearing race 10b and in connection with the outer periphery region of the crank chamber 6 and the passage 33b. The passage 33b is also in connection with the bearing-side chamber 30b. Thus, the second passage 33 connects the outer periphery region of the crank chamber 6 to the bearing-side chamber 30b. The passage 33a is closed by the bearing race 10b, so that refrigerant gas in the second passage 33 is prevented from flowing into the bearing main body 10a and the space 36.

[0020] As shown in FIG. 2, the discharged-refrigerant passage 34 is provided obliquely in facing to the partition in the drive shaft 7 for establishing fluid communication between the bearing-side chamber 30b and the passage 26 in the drive shaft 7. The passage 26 is in communication with a discharge pressure region of the variable displacement compressor 1, which will be described later, from which refrigerant gas is drawn into the bearing-side chamber 30b. Because the discharged-refrigerant passage 34 is provided obliquely in the drive shaft 7, as shown in Fig. 2, the refrigerant gas is directed against the partition 31 for contact therewith when the refrigerant gas is flowed from the discharge pressure region into the

bearing-side chamber 30b.

[0021] As shown in Fig. 6, in the crank chamber 6, the fourth passage 35 is formed radially between the inner sidewall 3a of the front housing 3 and the outer surface of the bearing race 10b. The fourth passage 35 is in connection at one end thereof with the outer periphery region of the crank chamber 6 and with the space 36 at the other end of the fourth passage 35 which extends along the central axis of the drive shaft 7 as seen in the transverse section of Fig. 6.

[0022] The first passage 32, the second passage 33, the discharged-refrigerant passage 34 and the fourth passage 35 constructed as described above are formed around the shaft seal chamber 30. Referring to FIG. 3, the first passage 32 connects the crank chamber 6 to the seal-side chamber 30a and the second passage 33 connects the crank chamber 6 to the bearing-side chamber 30b, thereby forming a circulating passage. The circulating passage permits fluid to pass from the crank chamber 6 through the first passage 32, the seal-side chamber 30a, the clearance A, the bearing-side chamber 30b and the second passage 33 in this order and back to the crank chamber 6. On the other hand, the discharged-refrigerant passage 34 connects the passage 26 in the drive shaft 7 to the bearing-side chamber 30b thereby to form a passage. The passage allows fluid to flow through the discharge pressure region, the discharged-refrigerant passage 34, the bearing-side chamber 30b and the second passage 33 in this order and then to the crank chamber 6. Referring to FIG. 2, the fourth passage 35 connects the outer periphery region of the crank chamber 6 to the space 36 thereby to form a circulating passage. The passage allows fluid to flow from the crank chamber 6 through the fourth passage 35, the space 36 and the thrust bearing 10 in this order and back to the crank chamber 6.

[0023] Referring back to FIG. 1, a discharge chamber 17 that provides a part of the discharge pressure region of the variable displacement compressor 1 is formed at the axial center of the rear housing 5 and connected to external refrigerant circuit through an outlet (not shown). A suction chamber 18 that provides a part of the suction pressure region of the compressor is formed annularly in the outer peripheral portion of the rear housing 5 and connected to the external refrigerant circuit through an inlet (not shown). The valve plate assembly 4 includes a suction port 19 and a suction valve (not shown) for each cylinder bore 16 for selective communication between the suction chamber 18 and each cylinder bore 16. The valve plate assembly 4 also includes a discharge port 20 and a discharge valve (not shown) for each cylinder bore 16 for selective communication between each cylinder bore 16 and the discharge chamber 17.

[0024] A control valve 21 is provided in the rear housing 5 for adjusting the flow rate of the refrigerant gas drawn into the crank chamber 6 thereby to control the internal pressure in the crank chamber 6 (crank chamber pressure P_c). The control valve 21 includes a valve portion

(not shown) having a throttling function and is in communication with the discharge chamber 17 through a passage 21 a, as shown in FIG. 1. The control valve 21 is also in communication with a passage 22 which is formed in the rear housing 5 and in turn in communication with a passage 23 which is formed in the valve plate assembly 4. The passage 23 is in communication with a passage 24 which is formed in the cylinder block 2 and further in communication with the passage 26 formed in the drive shaft 7 through a communication passage 25 formed in the center of the cylinder block 2. The passage 26 is in communication with the discharged-refrigerant passage 34.

[0025] A passage 28 is formed in the drive shaft 7 at a position between the swash plate 11 and the lug plate 9 for allowing part of the refrigerant gas in the crank chamber 6 to flow therethrough to the suction chamber 18. The passage 28 is in communication with a passage 42 which is formed in the cylinder block 2 through the passage 27. A lip seal 41 is disposed at the rear end of the drive shaft 7 in the communication passage 25 in such a way that the axial passage 26 and the passage 27 of the drive shaft 7 are shut off from each other. The passage 42 communicates with a passage 43 which is formed in the valve plate assembly 4 and opened to the suction chamber 18.

[0026] Now, operation of the variable displacement compressor 1 according to the first embodiment will be described with reference to FIG. 1. As the drive shaft 7 is rotated by a drive source (not shown), the swash plate 11 is rotated to cause each piston 13 to slide reciprocally in its corresponding cylinder bore 16. In accordance with the reciprocation of the piston 13, the refrigerant gas which circulates in the external refrigerant circuit is drawn into the suction chamber 18 and then into each cylinder bore 16 through the suction port 19 and is compressed in the cylinder bore 16 by the piston 13. The compressed refrigerant gas in the cylinder bore 16 is discharged into the discharge chamber 17 through the discharge port 20 and then circulates in the external refrigerant circuit.

[0027] While the compressed refrigerant gas circulates in the external refrigerant circuit, part of the compressed refrigerant gas is drawn into the crank chamber 6 through the control valve 21. Flow rate of the refrigerant gas drawn into the crank chamber 6 is changed by adjusting the opening of the control valve 21. The flow of refrigerant gas passing through the control valve 21 is throttled by the valve portion of the control valve 21 thereby to lower the temperature of the refrigerant gas. The refrigerant gas whose temperature has been thus lowered passes through the passages 22, 23, 24, 25, 26 and 34 in this order and is drawn into the bearing-side chamber 30b of the shaft seal chamber 30 while being brought into contact with the partition 31. In the bearing-side chamber 30b, the refrigerant hardly passes through the radial roller bearing 39, but it is drawn to the crank chamber 6 through the second passage 33 which has a relatively large cross sectional area (refer to FIG. 5).

[0028] The crank chamber pressure P_c is created by the refrigerant gas which is drawn into the crank chamber 6 in accordance with the opening degree of the control valve 21. The inclination of the swash plate 11 with respect to the drive shaft 7 is controlled by the pressure difference between the crank chamber pressure P_c and the internal pressure in each cylinder bore 16 thereby to adjust the displacement of the variable displacement compressor 1. That is, the inclination of the swash plate 11 is changed by controlling the crank chamber pressure P_c in the crank chamber 6. The refrigerant gas in the crank chamber 6 passes through the passages 28, 27, 42 and 43 in this order and then is drawn into the suction chamber 18.

[0029] Now referring specifically to FIGs. 2, 4 and 5, the behavior of the refrigerant gas around the shaft seal chamber 30 will be described. The refrigerant gas drawn into the crank chamber 6 contains therein lubricating oil in the form of mist. In particular, when the lug plate 9 and the swash plate 11 are driven to rotate by the drive shaft 7, oil attached to these members is splashed radially outward, so that a relatively large quantity of oil exists in the periphery region of the crank chamber 6.

[0030] The refrigerant gas in the crank chamber 6 is drawn into the suction chamber 18. On the other hand, part of the refrigerant gas is drawn into the seal-side chamber 30a through the first passage 32 (refer to FIG. 4). The refrigerant gas drawn into the seal-side chamber 30a is introduced into the bearing-side chamber 30b through the clearance A. The refrigerant gas in the bearing-side chamber 30b hardly passes through the radial roller bearing 39, but it is drawn into the seal-side chamber 30a through the second passage 33 (refer to FIG. 5). The refrigerant gas drawn into the seal-side chamber 30a flowed into the bearing-side chamber 30b through the clearance A. Because the refrigerant gas in the bearing-side chamber 30b hardly passes through the radial roller bearing 39, the refrigerant gas returns to the crank chamber 6 through the second passage 33 (refer to FIG. 5) which has a relatively large cross sectional area. The refrigerant gas containing therein the lubricating oil and drawn into the shaft seal chamber 30 is whirled in the shaft seal chamber 30 with the rotation of the drive shaft 7. The lubricating oil contained in the refrigerant gas tends to accumulate in the vicinity of the inner circumferential surface 30c of the shaft seal chamber 30.

[0031] The clearance A of the partition 31 is formed radially inward of the inner circumferential surface 30c of the shaft seal chamber 30, so that the refrigerant having a lower oil content exists in the vicinity of the clearance A. Therefore, the bearing-side chamber 30b receives refrigerant gas with less oil content and the lubricating oil present in the radially outer region tends to accumulate in the seal-side chamber 30a. This tendency is especially notable during high-speed operation of the variable displacement compressor 1.

[0032] The oil attached to the upper periphery region in the crank chamber 6 is drawn into the space 36 through

the fourth passage 35 (refer to FIG. 2) due to the gravity. Since the space 36 is in communication with the crank chamber 6 through the thrust bearing 10, oil in the space 36 is returned to the crank chamber 6 due to the centrifugal force of the rotating lug plate 9.

[0033] The refrigerant gas in the crank chamber 6 circulates flowing through the first passage 32, the seal-side chamber 30a, the clearance A of the partition 31, the bearing-side chamber 30b and the second passage 33 in this order, and back to the crank chamber 6, thus a circulation passage for the refrigerant gas being formed in the variable displacement compressor 1. Thus, oil in the refrigerant gas effectively lubricates the lip seal 8. The clearance A which is formed between the inner circumferential surface 31a of the partition 31 and the outer circumferential surface 7d of the drive shaft 7 facing the inner circumferential surface 31a of the partition 31 is located radially inward of inner circumferential surface 30c of the shaft seal chamber 30. Thus, the lubricating oil tends to stay in the seal-side chamber 30a and, therefore, the oil lubricates the lip seal 8 efficiently.

[0034] Because the cross sectional area of the clearance A is smaller than that of the first passage 32, the refrigerant gas drawn into the seal-side chamber 30a hardly passes into the bearing-side chamber 30b, so that the lip seal 8 is efficiently lubricated.

[0035] The refrigerant gas present in the discharge pressure region is drawn into the bearing-side chamber 30b through the discharged-refrigerant passage 34 in such a way that the refrigerant gas moves in contact with the partition 31, so that the partition 31 is cooled. Therefore, the seal-side chamber 30a is cooled and the lip seal 8 and the drive shaft 7 are also cooled. In addition, the part of the drive shaft 7 which slides relative to the lip seal 8 is prevented from being heated and, therefore, the lubrication can be accomplished more efficiently.

[0036] Because the second passage 33 directly connects the bearing-side chamber 30b to the crank chamber 6, the refrigerant gas hardly passes through the radial roller bearing 39 and the thrust bearing 10. Thus, the lubricating oil attached to these bearings is hardly washed away by the refrigerant gas sprayed to the bearings, so that the lubrication of the bearings can be also accomplished effectively.

[0037] Lubricating oil present in the upper region of the crank chamber 6 is supplied into the space 36 through the fourth passage 35 and then supplied to the thrust bearing 10 by the rotation of the lug plate. Thus, the thrust bearing 10 can be lubricated effectively.

[0038] A variable displacement compressor according to a second embodiment of the present invention is shown in Figs. 6 and 7 wherein the vertical disposition of the compressor in the drawings corresponds to the gravity direction. In FIG. 7, bold lines F and G are provided to show different cross sectional areas and all of the first through fourth passages are shown in the same drawing. The same reference numerals will be used in Figs. 6 and 7 to denote those parts or elements of the second em-

bodiment which correspond to the counterparts of the first preferred embodiment and the description thereof will be omitted.

[0039] The compressor of the second embodiment uses a front housing 53 which is different in structure from the front housing 3 of the first embodiment. As shown in Figs. 6 and 7, a second passage 55 is formed in the front housing 53 below the shaft seal chamber 30 as seen from the gravity direction and connects the bearing-side chamber 30b to the crank chamber 6. The second passage 55 is in communication with the bearing-side chamber 30b which is located above the second passage 55 as seen in the gravity direction and in communication with the outer periphery region of the crank chamber 6 which is located below the second passage 55 in the same direction. Thus, the second passage 55 is so formed that the refrigerant gas in the bearing-side chamber 30b is flows into the bottom of the crank chamber 6 (in the lower side of the drawing).

[0040] As shown FIG. 7, a fourth passage 56 is formed in the front housing 53 in substantially the same manner as the fourth passage 35 according to the first embodiment. A pair of first passage 54 is formed obliquely on the both sides of the fourth passage 56 in a symmetrical manner with respect to the fourth passage 56. The first passage 54 connects the crank chamber 6 to the seal-side chamber 30a, in substantially the manner as the first passage 32 of the first embodiment. The other structure of the compressor is substantially the same as that of the first

preferred embodiment.

[0041] Providing the second passage 55 below the shaft seal chamber 30, oil accumulated at the bottom of the crank chamber 6 is thrown up to the upper region of the crank chamber 6 by the refrigerant gas. Thus, oil is drawn into the first passage 54 and the fourth passage 56 more easily, so that lubrication of the compressor is accomplished with increased efficiency.

[0042] A variable displacement compressor according to a third embodiment is shown in FIG. 8. The drawing is separated by bold lines H, I and J into three different cross sectional areas for showing the first through fourth passages in the same drawing. In the third embodiment, a front housing 63 is used instead of the front housing 3 of the first embodiment. In the front housing 63, a fourth passage 66 is formed for connecting the crank chamber 6 to the space 36 and a recess 66a is formed at one end of the fourth passage 66 which is in communication with the space 36. The recess 66a extends in the circumferential direction of the drive shaft 7 and connects the fourth passage 66 to the space 36 therethrough. A first passage 64 and a second passage 65 are substantially in the same manner as the first passage 32 and the second passage 33 according to the first embodiment. The other structure is substantially the same as that of the first

preferred embodiment.

[0043] Because the recess 66a connects the fourth passage 66 to the space 36, lubricating oil can be supplied to wider areas of the space 36 and the thrust bearing 10. Thus, oil is supplied to the thrust bearing easily, thereby to lubricate the thrust bearing 10 efficiently. Although the first passage 64 and the second passage 65 of the third embodiment are formed substantially in same the manner as in the first embodiment, the first passage 64 and the second passage 65 may be formed substantially same as the first passage 54 and the second passage 55 of the second embodiment.

[0044] In the first through third embodiments according to the present invention, the third passage is formed obliquely with respect to the drive shaft, so that the partition 31 is cooled by refrigerant gas drawn into the bearing-side chamber 30b of the shaft seal chamber 30. However, the third passage need not necessarily be directed to the partition. In the first through third embodiments, the fourth passage is formed along the direction of gravity. If the fourth passage is formed obliquely with respect to the direction of gravitational force, oil is supplied from the crank chamber to the space due to the gravity. Therefore, the fourth passage is not limited to a disposition along the gravity direction. In the first through third embodiments, the passage 27 is formed in the drive shaft 7 and the refrigerant gas in the crank chamber 6 is flowed into the suction chamber 18 through the passage 27. An appropriate passage may be formed otherwise as far as refrigerant gas in the crank chamber 6 is allowed to flow therethrough into the suction chamber 18. In the first through third embodiments, a part of the first passage, a part of the second passage and the fourth passage are formed in the front housing in the form of a groove. The shape of their cross sections is not limited to U-shape or rectangular shape as far as the refrigerant gas is allowed to pass therethrough.

[0045] 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.

[0046] A compressor includes a housing, a rotary shaft, a bearing, a seal, a shaft seal chamber, a lug plate, a thrust bearing, a first passage for connecting the crank chamber to the shaft seal chamber, a second passage provided in the housing for connecting the crank chamber to the shaft seal chamber, a third passage provided in the rotary shaft for connecting the shaft seal chamber to a discharge pressure region of the compressor, a partition provided in the shaft seal chamber for dividing the shaft seal chamber into a seal-side chamber and a bearing-side chamber and a clearance formed through the partition for drawing the refrigerant gas from the seal-side chamber of the shaft seal chamber to the bearing-side chamber of the shaft seal chamber, the clearance being formed radially inward of the inner circumferential

surface of the shaft seal chamber.

Claims

1. A compressor (1) comprising:

a housing (3) defining therein a crank chamber (6);
 a rotary shaft (7) having opposite ends at least one end of which extends out of the housing (3);
 a bearing (39, 40) provided in the housing (3) for rotatably supporting the rotary shaft (7);
 a seal (8, 41) provided on the rotary shaft (7) at a position which is axially outer side of the bearing (39, 40) for preventing refrigerant gas from leaking out of the housing (3) along the rotary shaft (7);
 a shaft seal chamber (30) defined by the seal (8), the bearing (39), the housing (3) and the rotary shaft (7);
 a lug plate (9) fixed to the rotary shaft (7);
 a thrust bearing (10) for axially supporting the lug plate (9) such that the lug plate (9) is rotatable relative to the housing (3);
 a first passage (32, 54, 64) provided in the housing (3) for connecting the crank chamber (6) to the shaft seal chamber (30) so that the refrigerant gas containing therein lubricating oil in the crank chamber (6) is drawn into the shaft seal chamber (30);
 a second passage (33, 55, 65) provided in the housing (3) for connecting the crank chamber (6) to the shaft seal chamber (30) so that the refrigerant gas in the shaft seal chamber (30) is drawn into the crank chamber (6);
 a third passage (34) provided in the rotary shaft (7) for connecting the shaft seal chamber (6) to a discharge pressure region of the compressor (1) so that the refrigerant gas in the discharge pressure region is drawn into the shaft seal chamber (30);
 a partition (31) provided in the shaft seal chamber (30) for dividing the shaft seal chamber (30) into a seal-side chamber (30a) and a bearing-side chamber (30b); and
 a clearance (A) formed through the partition (31) for drawing the refrigerant gas from the seal-side chamber (30a) of the shaft seal chamber (30) to the bearing-side chamber (30b) of the shaft seal chamber (30), the clearance (A) being formed radially inward of the inner circumferential surface of the shaft seal chamber (30),

characterized in that

the first passage (32, 54, 64) is in communication with the seal-side chamber (30a) of the shaft seal chamber (30),

in that the second passage (33, 55, 65) is in communication with the bearing-side chamber (30b) of the shaft seal chamber (30),

in that the third passage (34) is in communication with the bearing-side chamber (30b) of the shaft seal chamber (30),

in that the refrigerant gas in the discharge pressure region of the compressor (1) is flowed through the third passage (34) into the bearing-side chamber (30b) of the shaft seal chamber (30) such that the refrigerant gas is brought into contact with the partition (31), and

in that the refrigerant gas in the bearing-side chamber (30b) of the shaft seal chamber (30) is flowed through the second passage (33, 65) into the crank chamber (6).

2. The compressor (1) according to claim 1, further comprising:

a space (36) defined by the housing (3), the lug plate (9) and the thrust bearing (10); and
 a fourth passage (35, 56, 66) provided above the shaft seal chamber (30) as seen from the gravity direction in the housing (3) for connecting the space (36) to the crank chamber (6).

3. The compressor (1) according to claim 1 or 2, wherein the second passage (55) is provided below the shaft seal chamber (30) as seen from the gravity direction.

4. The compressor (1) according to any one of claims 1 through 3, wherein a recess (66a) is formed in the circumferential direction of the rotary shaft (7) at one end of the fourth passage (66) which is in communication with the space (36).

5. The compressor (1) according to any one of claims 1 through 4, wherein the clearance (A) is formed between the inner circumferential surface of the partition (31) and the outer circumferential surface of the drive shaft (7) which faces the inner circumferential surface.

6. The compressor (1) according to any one of claims 1 through 5, wherein the clearance (A) has a cross section whose area is smaller than that of the first passage (32, 54, 64).

7. The compressor (1) according to any one of claims 1 through 6, wherein the third passage (34) is formed obliquely in facing relation to the partition (31).

8. The compressor (1) according to any one of claims 1 through 7, wherein the fourth passage (35, 56, 66) is formed extending along the gravity direction.

FIG. 1

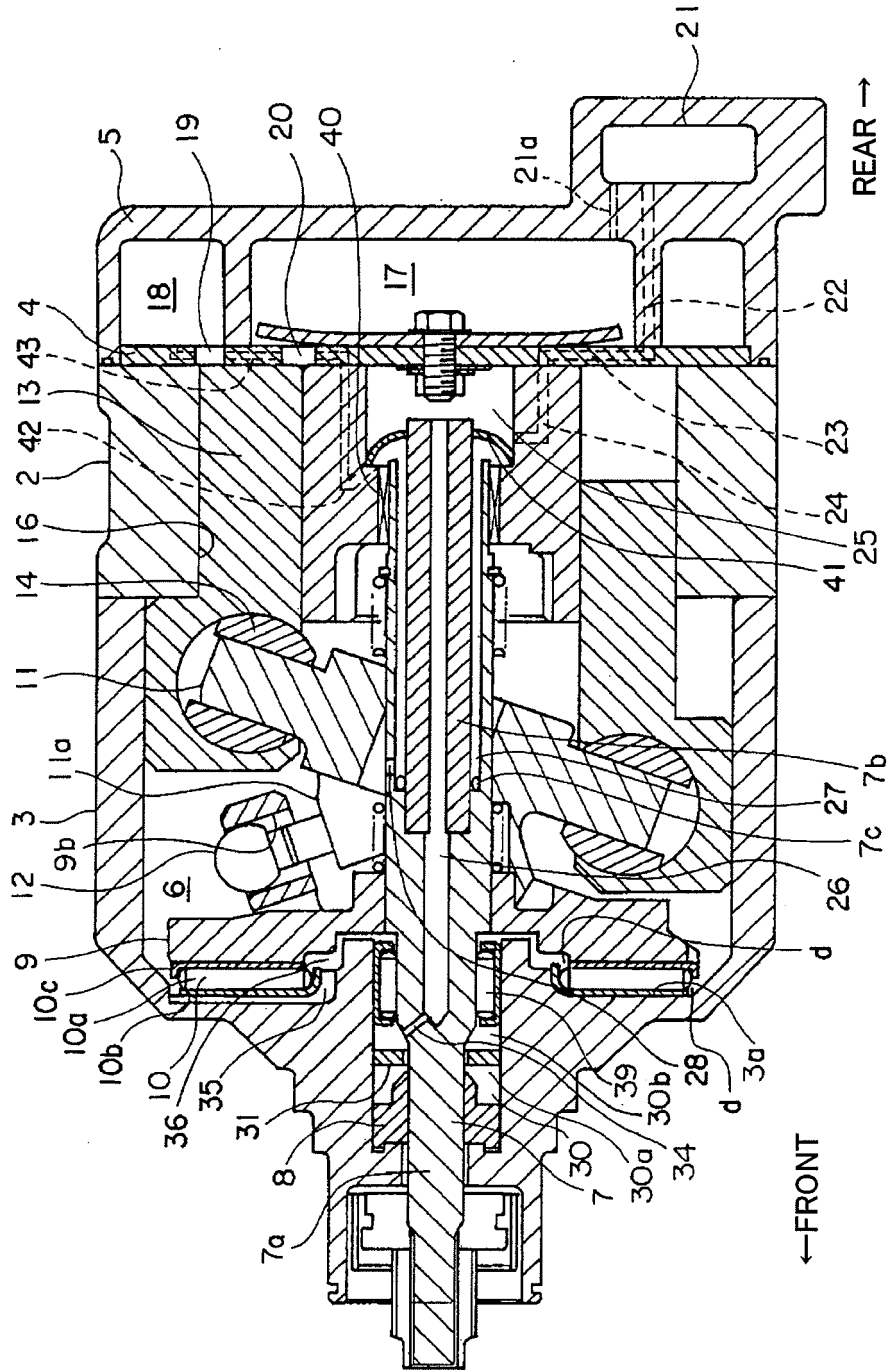


FIG. 2

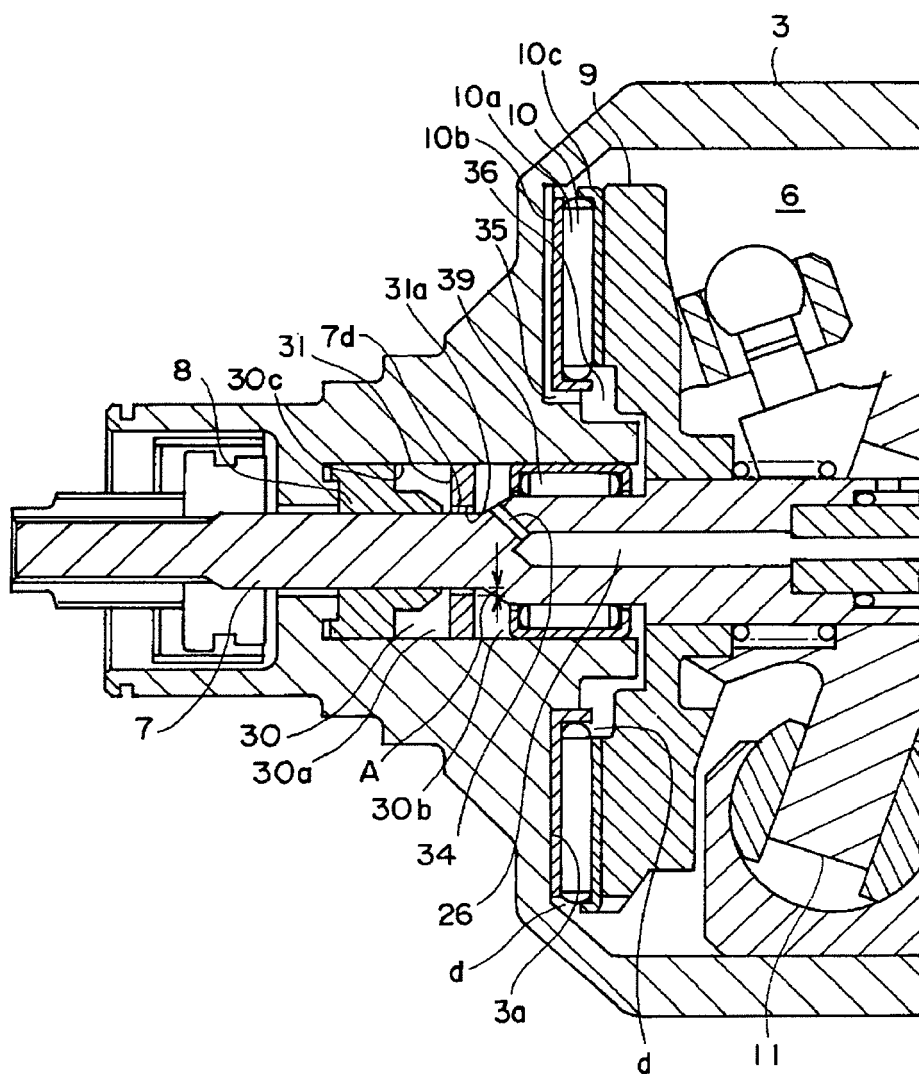


FIG. 3

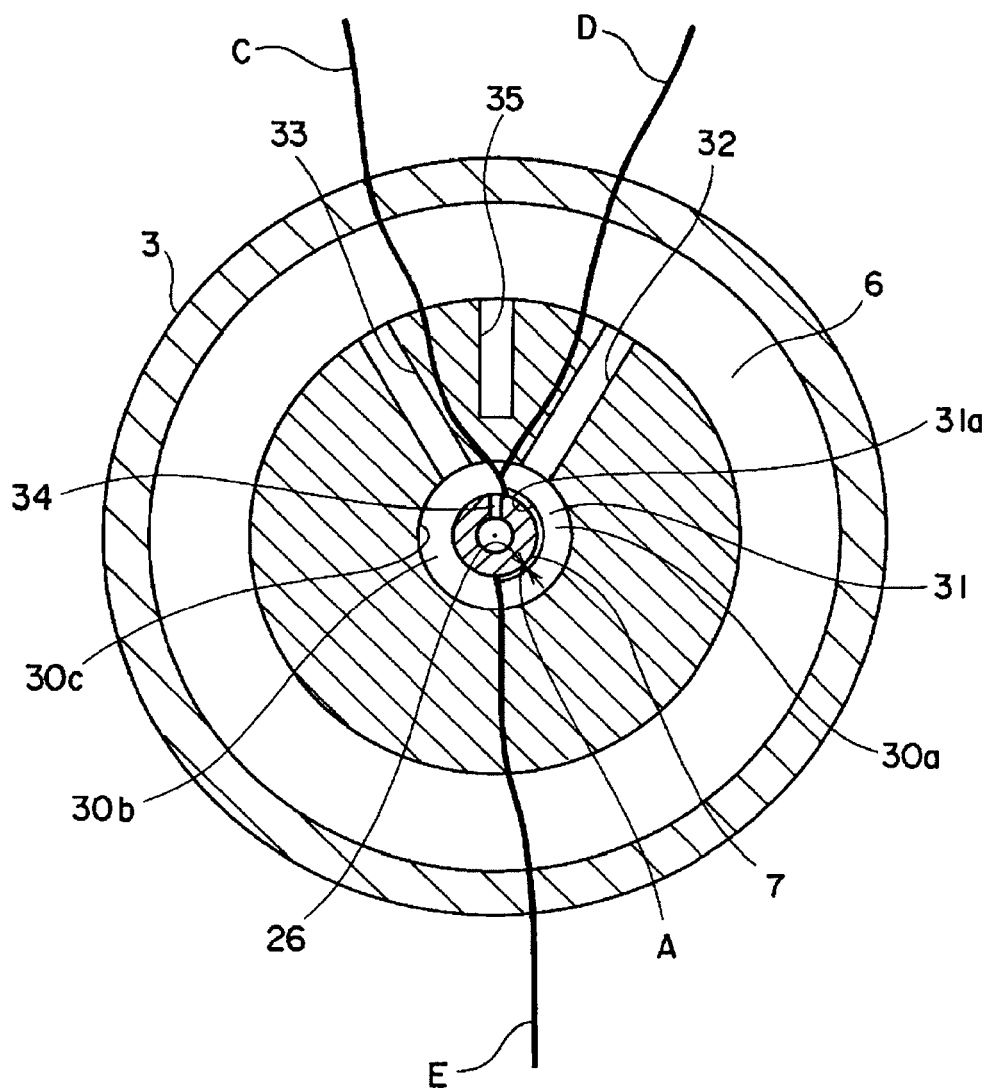


FIG. 4

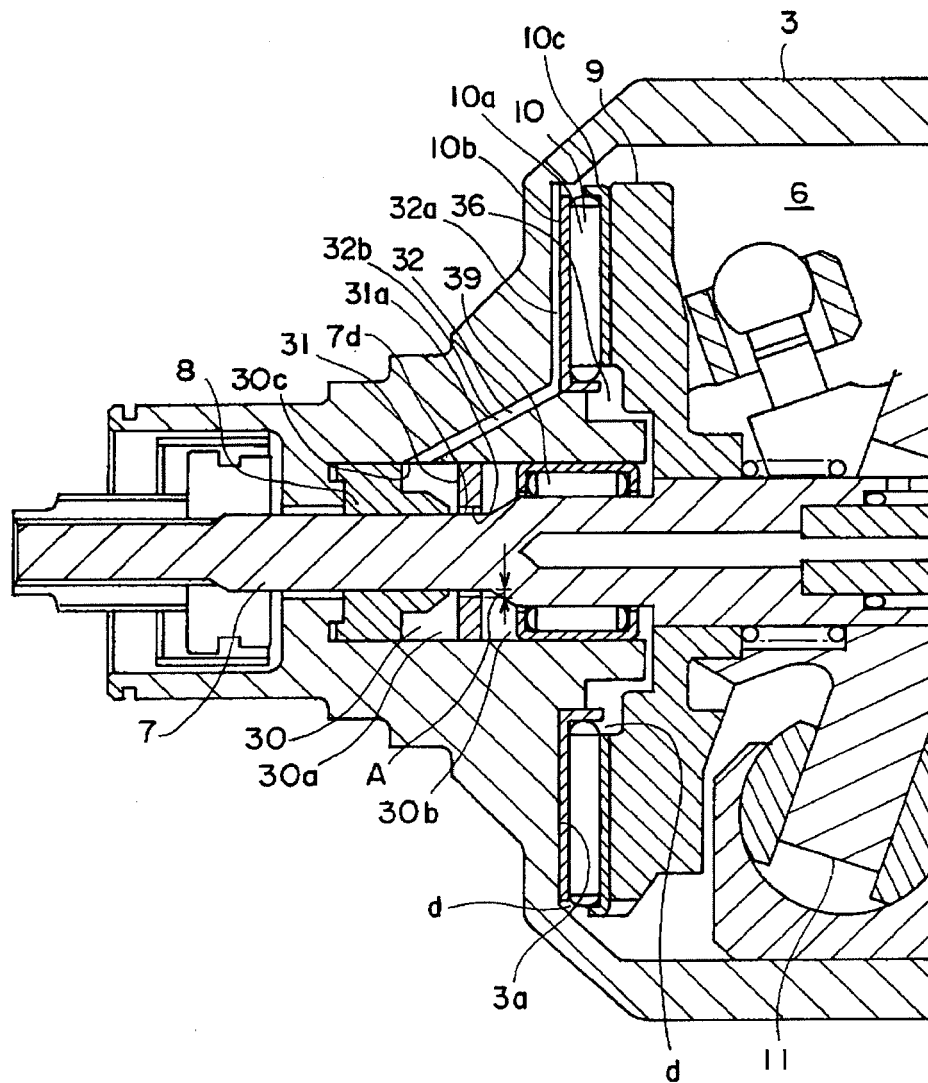


FIG. 5

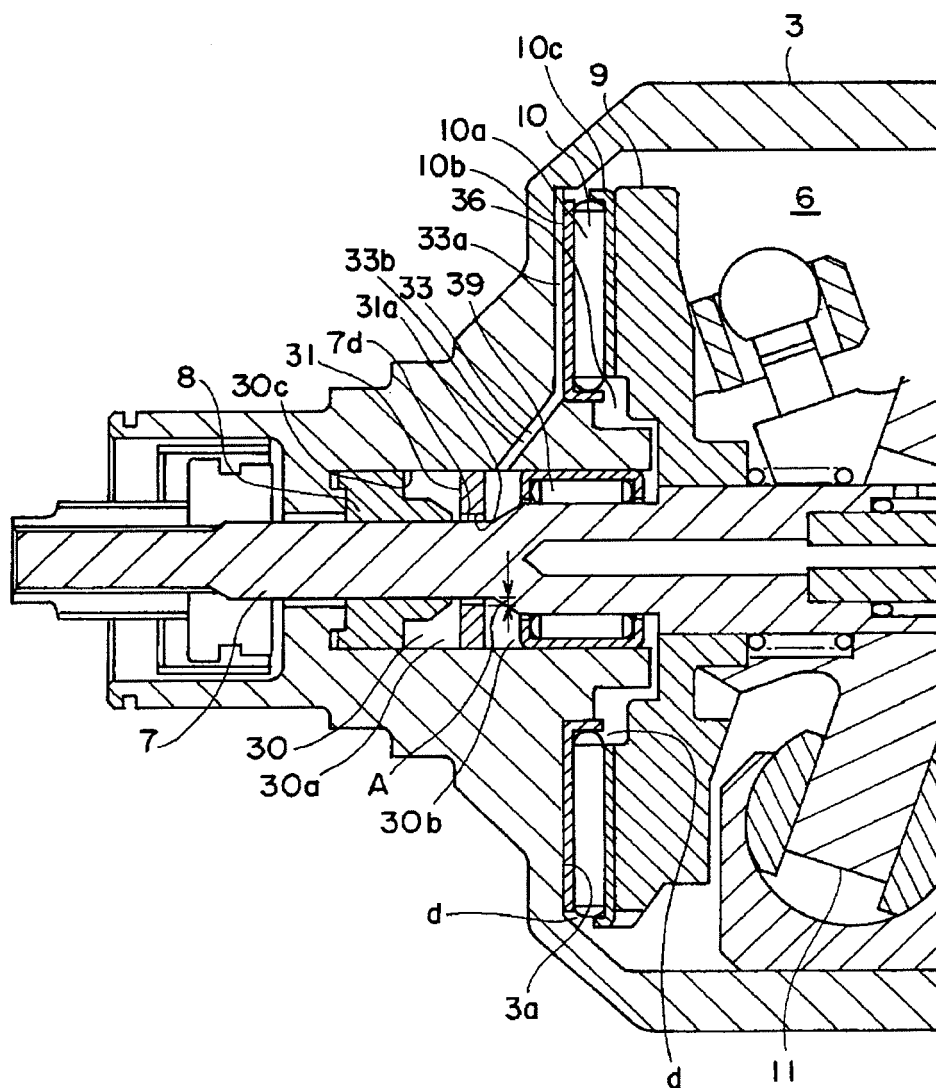


FIG. 6

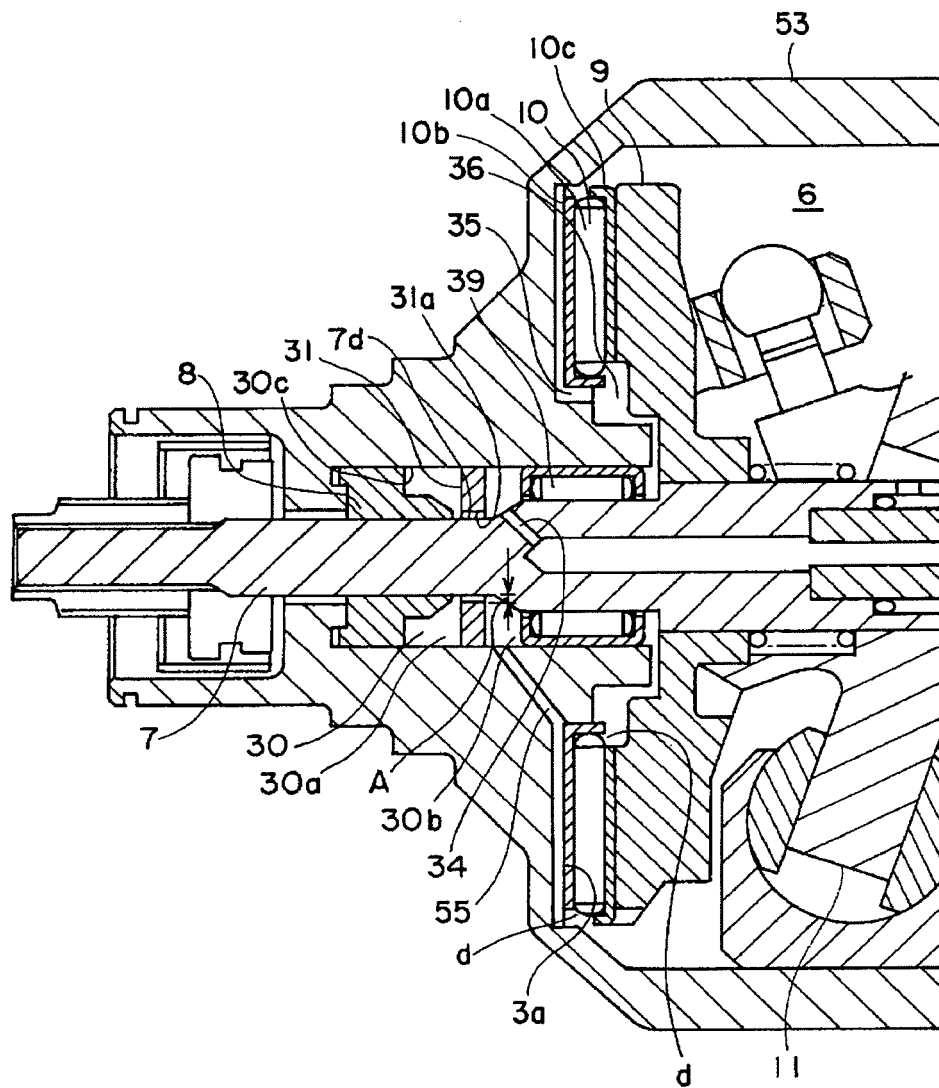


FIG. 7

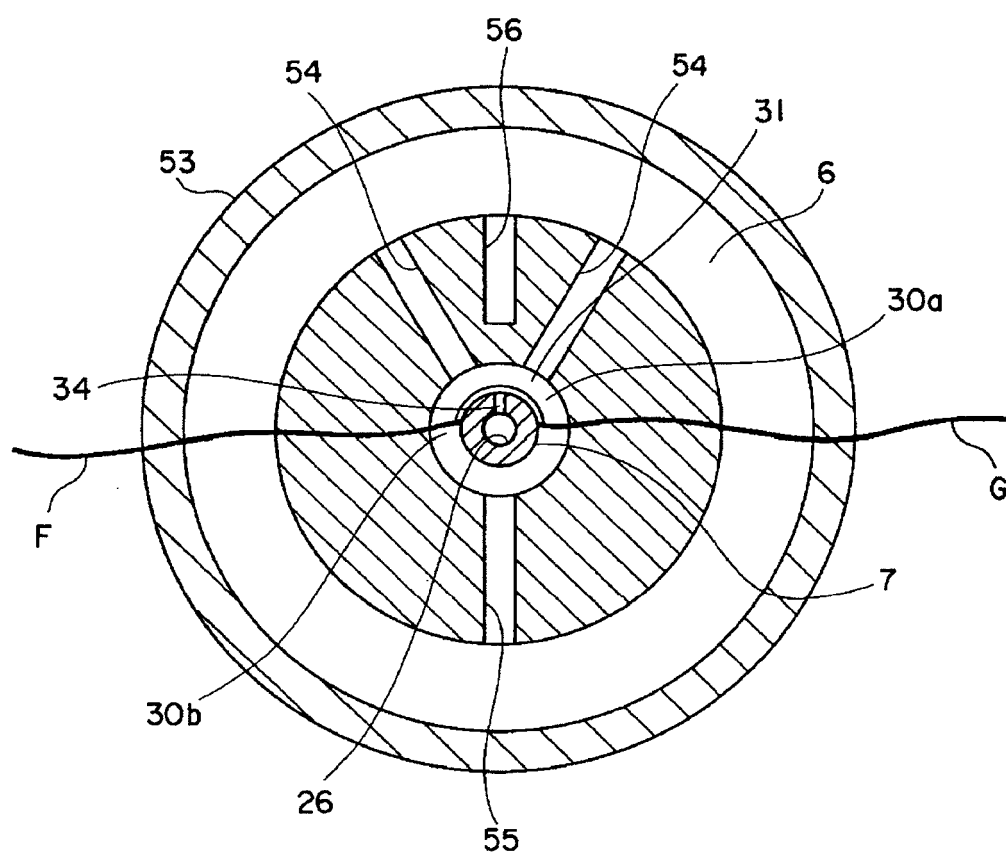
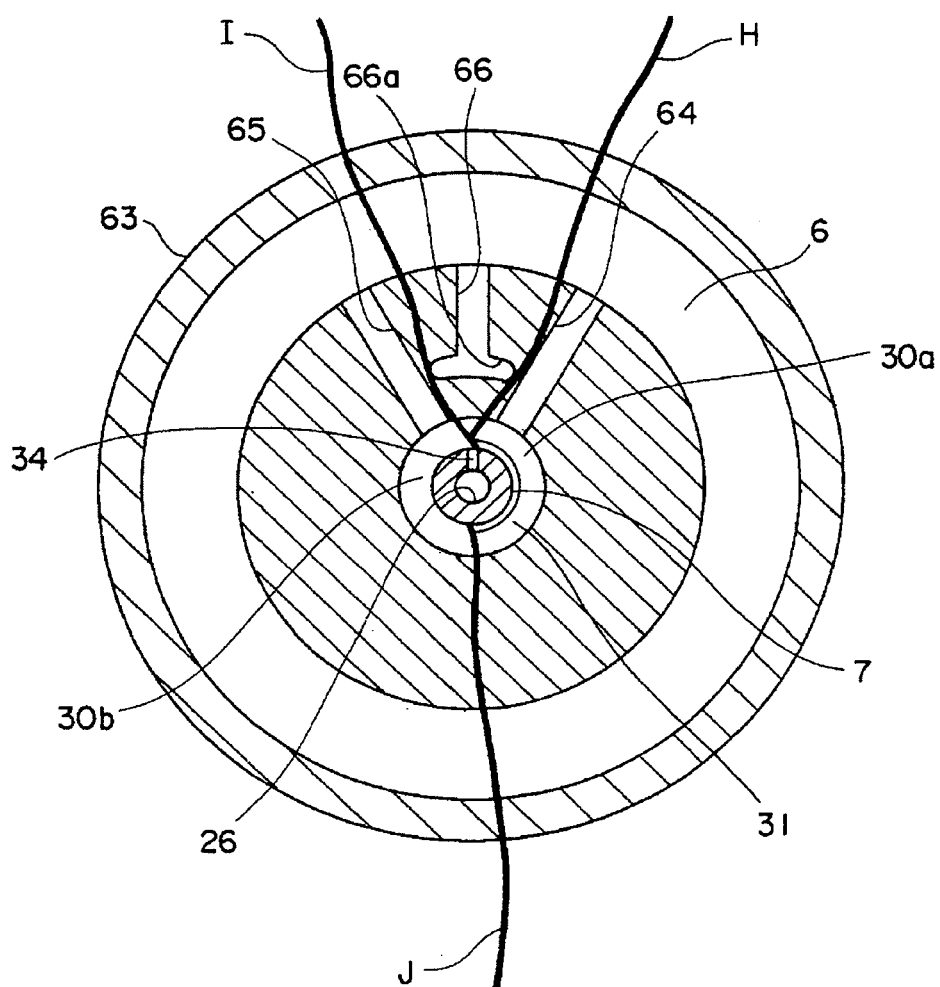


FIG. 8





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EUROPEAN SEARCH REPORT

Application Number
EP 07 11 6634

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			F04B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 November 2007	Examiner Pinna, Stefano
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