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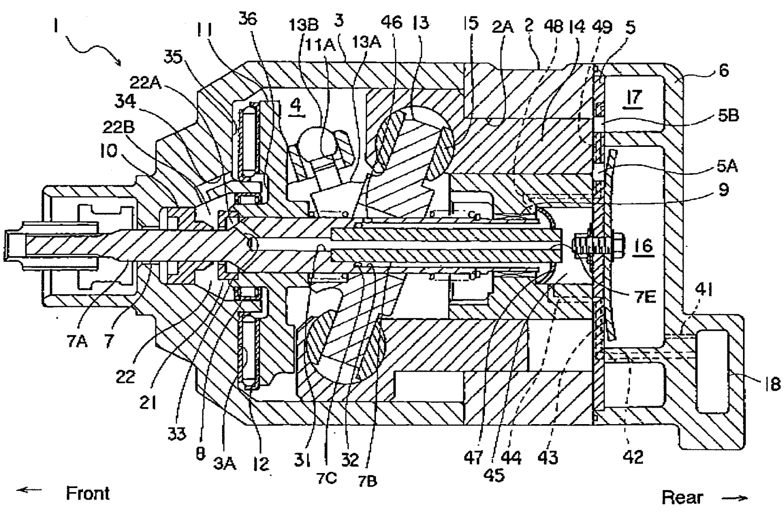
(54) **Variable displacement compressor**

(57) A variable displacement compressor includes a housing, a rotary shaft, a bearing, a seal member, a shaft seal chamber, a discharge refrigerant passage and a partition. The partition is provided in the shaft seal chamber for partitioning the shaft seal chamber into a first seal chamber to which the discharge refrigerant passage is opened and a second seal chamber part of the periphery of which is formed by the bearing and the seal member. The partition is provided with a first guide passage through which refrigerant containing lubricating oil flowed from the discharge refrigerant passage into the first seal chamber is substantially all supplied to the seal member of the second seal chamber.

FIG. 1



EP 2 107 245 A1

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a variable displacement compressor and more particularly to a structure for lubricating a seal member sealing a rotary shaft of the variable displacement compressor.

[0002] Japanese Patent Application Publication No. 4-179874 discloses a swash plate compressor including a crankcase, a rotary shaft, a radial bearing and a lip seal. The crankcase has therein a crank chamber. The rotary shaft is supported by the radial bearing and one end of the rotary shaft is exposed outside the crankcase. The lip seal serves to seal the rotary shaft. The crankcase, the rotary shaft, the radial bearing and the lip seal cooperate to form a space. The rotary shaft has therein a pressure control passage through which compressed refrigerant gas flows into the crank chamber. In addition, the rotary shaft has therein an oil feed hole for interconnecting the pressure control passage and the space. A part of the compressed refrigerant gas flows into the crank chamber through the pressure control passage, the oil feed hole, the space and the clearances in the radial bearing. Refrigerant gas contains lubricating oil in the form of a mist, which lubricates various sliding surfaces in the crank chamber.

[0003] Japanese Patent Application Publication No. 2006-307700 discloses a swash plate compressor wherein a partition is provided in a shaft seal chamber for separating a lip seal and a bearing and a clearance is formed between the partition and a rotary shaft. The compressor of this publication includes a first passage and a second passage. The first passage interconnects the crank chamber and the shaft seal chamber and allows refrigerant gas containing lubricating oil and flowing from the crank chamber to pass therethrough. The second passage is formed between the lug plate fixed on the rotary shaft and the housing so as to interconnect the bearing and the crank chamber. In this structure of the compressor, refrigerant gas circulates through the crank chamber, the first passage, a region of the shaft seal chamber between the lip seal and the partition, the clearance between the partition and the rotary shaft, a region of the shaft seal chamber between the partition and the bearing, the bearing and the second passage. Such circulation makes it easier for refrigerant gas containing lubricating oil to flow into the region of the shaft seal chamber between the lip seal and the partition, so that the lip seal is lubricated efficiently.

[0004] In the compressor according to the former publication, the sliding surfaces between the rotary shaft and the lip seal are lubricated by lubricating oil contained in the refrigerant gas flowed into the space through the oil feed hole. Because the oil feed hole extends only in the radial direction of the rotary shaft, however, the refrigerant gas flowing into the space through the oil feed hole moves radially outward of the space under the centrifugal force and then passes through the radial bearing. Therefore, the lubricating oil fails to be supplied in an adequate amount to the sliding surfaces between the rotary shaft and the lip seal and such poor lubrication may deteriorate the reliability of the lip seal.

[0005] In the compressor according to the latter publication, a part of refrigerant gas in the discharge chamber flows through a discharge refrigerant passage formed in the rotary shaft into the region of the shaft seal chamber between the partition and the bearing, and then flows into the crank chamber through the bearing and the second passage. However, the lubricating oil contained in the refrigerant gas flowed into the region of the shaft seal chamber between the partition and the bearing tends to reside in the region of the shaft seal chamber adjacent to the housing under the influence of the centrifugal force. In addition, the lubricating oil contained in the refrigerant gas flowed into the region of the shaft seal chamber between the partition and the bearing through the discharge refrigerant passage is difficult to flow into the region of the shaft seal chamber between the lip seal and the partition because the partition is provided in the shaft seal chamber for separating the lip seal and the bearing and also the clearance between the partition and the rotary shaft is vary small. Therefore, the lubricating oil fails to be supplied in an adequate amount to the sliding surfaces between the lip seal and the rotary shaft and such poor lubrication may deteriorate the reliability of the lip seal.

[0006] The present invention is directed to a variable displacement compressor wherein the durability of the seal member in sealing the rotary shaft is improved, thereby enhancing the reliability of the seal member.

SUMMARY OF THE INVENTION

[0007] In accordance with an aspect of the present invention, there is provided a variable displacement compressor that includes a housing, a rotary shaft, a bearing, a seal member, a shaft seal chamber, a discharge refrigerant passage and a partition. The housing has a crank chamber. The rotary shaft is disposed in the crank chamber with at least one end thereof exposed outside the housing. The bearing is disposed in the housing for rotatably supporting the rotary shaft. The seal member is disposed in the housing at a position between the exposed end of the rotary shaft and the bearing for preventing refrigerant mixed with lubricating oil from leaking out of the housing along the rotary shaft. The shaft seal chamber is formed by the housing, the rotary shaft, the bearing and the seal member. The discharge refrigerant passage is formed in the rotary shaft. The refrigerant flows into the shaft seal chamber through the discharge refrigerant passage. The partition is provided in the shaft seal chamber for partitioning the shaft seal chamber into a first seal chamber to which the discharge refrigerant passage is opened and a second seal chamber part of the periphery of which is formed by the bearing and the seal member. The partition is provided with a first guide passage through which the refrigerant flowed from the discharge refrigerant passage into the first seal chamber is substantially all supplied to the seal member of the second seal 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 an enlarged longitudinal sectional view showing a shaft seal chamber and its related parts of the variable displacement compressor of Fig. 1;

Fig. 3 is an enlarged fragmentary longitudinal sectional view showing a shaft seal chamber and its related parts of a variable displacement compressor according to a second embodiment of the present invention;

Fig. 4 is an enlarged fragmentary longitudinal sectional view showing a shaft seal chamber and its related parts of a variable displacement compressor according to a third embodiment of the present invention;

Fig. 5 is an enlarged fragmentary longitudinal sectional view showing a shaft seal chamber and its related parts of a variable displacement compressor according to a fourth embodiment of the present invention;

Fig. 6 is an enlarged fragmentary longitudinal sectional view showing a shaft seal chamber and its related parts of a variable displacement compressor according to a fifth embodiment of the present invention; and

Fig. 7 is an enlarged fragmentary longitudinal sectional view showing a shaft seal chamber and its related parts of a variable displacement compressor according to a sixth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] The following will describe the variable displacement compressors according to the embodiments of the present invention with reference to the accompanying drawings. Referring firstly to Fig. 1, the variable displacement compressor of the first embodiment is designated by reference numeral 1 and will be hereinafter referred to merely as a compressor 1, The compressor 1 forms a part of refrigeration system (not shown) in which refrigerant gas mixed with lubricating oil is sealed. Carbon dioxide is preferably used as the refrigerant gas. It is noted that the front and rear of the compressor 1 in the following description are indicated by arrows directed in opposite directions in Fig. 1. The compressor 1 includes a cylinder block 2 having a plurality of cylinder bores 2A. A front housing 3 is joined to the front end of the cylinder block 2 and has therein a crank chamber 4. A rear housing 6 is joined to the rear end of the cylinder block 2 through a valve plate assembly 5 and has a discharge chamber 16 and a suction chamber 17.

[0011] The discharge chamber 16 and the suction chamber 17 are communicable with the cylinder bores 2A via the valve plate assembly 5. More specifically, the valve plate assembly 5 has a set of a discharge port 5A, a discharge valve (not shown), a suction port 5B and a suction valve (not shown) for each cylinder bore 2A. The discharge port 5A interconnects the cylinder bore 2A and the discharge chamber 16 and the suction port 5B interconnects the cylinder bore 2A and the suction chamber 17, respectively. The discharge chamber 16 is connected to one end of the external refrigeration system through an outlet port (not shown) of the compressor 1 and the suction chamber 17 is connected to the other end of the external refrigeration system through an inlet port (not shown) of the compressor 1.

[0012] A drive shaft 7 is disposed in the crank chamber 4 at the center of the front housing 3 and the cylinder block 2. The drive shaft 7 has a large-diameter portion adjacent to the cylinder block 2, a tapered portion that tapers forward from the front end of the large-diameter portion and a small-diameter portion that extends forward from the front end of the tapered portion. A lug plate 11 is fixed on the drive shaft 7 at the front end of the large-diameter portion thereof for rotation therewith within the crank chamber 4. The lug plate 11 is rotatably supported by a thrust bearing 12 provided between the rear surface 3A of the front wall of the front housing 3 and the front surface of the lug plate 11. In addition, the lug plate 11 is rotatably supported by a radial roller bearing 8 inserted in the front housing 3 at such a position that the front portion of the drive shaft 7 is also rotatably supported by the radial roller bearing 8 through the lug plate 11, The rear portion of the drive shaft 7 is rotatably supported by a radial roller bearing 9 inserted in the cylinder block 2. Thus, the drive shaft 7 is rotatably supported by the radial roller bearings 8, 9 and serves as the rotary shaft of the present invention. The front end of the drive shaft 7 is exposed outside the front housing 3 and connected to a drive source (not shown). The rear end of the drive shaft 7 is located in a space 45 formed in the rear end of the cylinder block 2.

[0013] A swash plate 13 is mounted on the large-diameter portion of the drive shaft 7 behind the lug plate 11 so as to be tiltable relative to the axis of the drive shaft 7 and also slidable along the axial direction of the drive shaft 7. The swash plate 13 has on the side thereof adjacent to the lug plate 11 a connection 13A and a pair of guide pins 13B mounted on the connection 13A. The lug plate 11 has on the side thereof adjacent to the swash plate 13 a pair of guide holes 11 A, With the paired guide pins 13B inserted in the paired guide holes 11A, the swash plate 13 and the lug plate 11 are connected to each other so as to be rotatable together. A piston 14 is disposed in each cylinder bore 2A and connected to the swash plate 13 through a pair of shoes 15, The shoes 15 convert the oscillating motion of the swash plate 13 into the reciprocating motion of the piston 14.

[0014] A lip seal 10 is mounted on the drive shaft 7 at a position between the small-diameter portion of the drive shaft 7 and the front housing 3 in front of the lug plate 11 and the radial roller bearing 8 for sealing the drive shaft 7. The lip seal 10 has in the rear end thereof a tapered portion tapering rearward and having an outer circumferential surface 10B. The lip seal 10 serves as a seal member for sealing the drive shaft 7. The lip seal 10 serves to prevent refrigerant gas and lubricating oil in the crank chamber 4 from leaking out of the front housing 3 along the outer clrcumferentlal surface of the drive shaft 7. A shaft seal chamber 22 is defined in the front housing 3 by the front housing 3, the small-diameter portion and the tapered portion of the drive shaft 7, the radial roller bearing 8, the lip seal 10 and the lug plate 11.

[0015] The discharge chamber 16 communicates with the crank chamber 4 via a supply passage through which refrigerant gas in the discharge chamber 16 flows into the crank chamber 4. The supply passage will be described below. A control valve 18 is disposed in the rear housing 6 and has a throttle (not shown) that regulates the flow of refrigerant gas passing through the supply passage for controlling the pressure Pc in the crank chamber 4. The control valve 18 communicates with the discharge chamber 16 through a passage 41 that is formed in the rear housing 6 and also with a passage 42 that is formed in the rear housing 6. The passage 42 is in communication with the space 45 of the cylinder block 2 via a passage 43 that is formed in the valve plate assembly 5 and a passage 44 that is formed in the cylinder block 2. The passages 41, 42, 43, 44 and the space 45 provide a part of the supply passage.

[0016] The drive shaft 7 includes a first shaft portion 7A which is of a substantially hollowed cylindrical shape having one end thereof opened and a second shaft portion 7B which is also of a hollowed cylindrical shape having opposite two ends thereof opened and is press-fitted in the first shaft portion 7A, as shown in Fig. 1. An axial passage 31 is formed centrally in the first shaft portion 7A and the second shaft portion 7B and communicates with the space 45 of the cylinder block 2 through the opening 7E formed at the rear end of the drive shaft 7. An annular passage 32 is formed between the inner circumferential surface of the first shaft portion 7A and the outer circumferential surface of the second shaft portion 7B. A lip seal 47 is provided at the rear end of the drive shaft 7 in the space 45 for shutting off the fluid communication between the axial passage 31 and the annular passage 32. An O-ring 7C is held between the inner circumferential surface of the first shaft portion 7A and the outer circumferential surface of the second shaft portion 7B at the front end of the passage 32. A slanted passage 33 is formed in the drive shaft 7 at an angle relative to the axis of the drive shaft 7 and serves as the discharge refrigerant passage of the present invention. The slanted passage 33 extends from the front end of the axial passage 31 to an outer circumferential surface 7F of the tapered portion of the drive shaft 7and is opened at 33A of the slanted passage 33 to the shaft seal chamber 22. Thus, the slanted passage 33 interconnects the axial passage 31 and the shaft seal chamber 22. The axial passage 31 and the slanted passage 33 provide a part of the supply passage.

[0017] Referring to Fig. 2, the structure of the shaft seal chamber 22 and its related parts will be described in detail. An annular partition 21 having an L-shape section is disposed between the lip seal 10 and the lug plate 11 in the shaft seal chamber 22. The partition 21 is located so as to cover the opening 33A of the slanted passage 33 and fixed to the front end of the lug plate 11 for rotation therewith. Thus, the shaft seal chamber 22 is partitioned by the partition 21 into two chambers, namely, a first seal chamber 22A to which the slanted passage 33 is opened and a second seal chamber 22B part of the periphery of which is formed by the radial roller bearing 8 and the lip seal 10.

[0018] Clearance A is formed between the inner circumferential surface 21 A of the partition 21 and the outer circumferential surface 7D of the small-diameter portion of the drive shaft 7 facing the inner circumferential surface 21A, serving as the first guide passage of the present invention, Therefore, the refrigerant gas flowed into the first seal chamber 22A through the slanted passage 33 flows into the second seal chamber 22B through the clearance A. The refrigerant gas flowed into the second seal chamber 22B is substantially all directed to move to the lip seal 10 along the outer circumferential surface 7D of the small-diameter portion of the drive shaft 7 and then passes close to the lip seal 10.

[0019] The front housing 3 has in the front wall thereof a passage 34. The rear surface 3A of the front wall of the front housing 3 is formed with a groove that extends in the radial direction of the drive shaft 7. By being covered by the front surface of the thrust bearing 12, the groove is formed into a radial passage 35. One end of the above passage 34 is opened to the second seal chamber 22B of the shaft seal chamber 22 and the other is connected to the radial passage 35 at one end thereof adjacent to the drive shaft 7. The other end of the radial passage 35, which is far from drive shaft 7, is opened to a region in the crank chamber 4 adjacent to the inner periphery of the front housing 3.

[0020] A space 36 is defined behind the radial roller bearing 8 by the front housing 3, the radial roller bearing 8, the lug plate 11 and the thrust bearing 12. The radial roller bearing 8 includes an annular bearing race 8A having a section of a channel shape opened radially inward and a bearing body 8B disposed in the bearing race 8A and having a plurality of needles arranged circumferentially at a spaced interval. As shown in Fig. 2, clearance d1 is formed between the inner circumferential surface of the bearing race 8A and the outer circumferential surface of the lug plate 11. Therefore, refrigerant gas and lubricating oil in the second seal chamber 22B are allowed to flow into the space 36 through the clearance d1 between the bearing race 8A and the lug plate 11 and the interior of the radial roller bearing 8.

[0021] The thrust bearing 12 includes a pair of bearing races 12A and 12B each having an L-shape section, and a bearing body 12C. The paired bearing races 12A and 12B cooperate to form a hollow disc and the bearing body 12C has a plurality of needles arranged circumferentially at a spaced interval, The paired bearing races 12A and 12B hold the bearing body 12C with clearances d2 formed between the inner ends of the bearing races 12A, 12B and between the outer ends of the bearing races 12A, 12B, respectively. Therefore, refrigerant gas and lubricating oil in the space 36 are allowed to flow into the region in the crank chamber 4 adjacent to the inner periphery of the front housing 3 through the clearances d2 between the bearing races 12A, 12B and the interior of the thrust bearing 12. That is, the space 36 is in communication with the second seal chamber 22B of the shaft seal chamber 22 via the radial roller bearing 8 and also with the region in the crank chamber 4 adjacent to the inner periphery of the front housing 3 via the thrust bearing 12, The shaft seal chamber 22, the passages 34 and 35 provide a part of the supply passage. The shaft seal chamber 22, the clearance d1 between the bearing race 8A and the lug plate 11, the interior of the radial roller bearing 8, the space 36, the clearances d2 between the bearing races 12A, 12B and the interior of the thrust bearing 12 also provide a part of the supply passage.

[0022] The crank chamber 4 communicates with the suction chamber 17 via a bleed passage through which refrigerant gas in the crank chamber 4 is released into the suction chamber 17, The drive shaft 7 has therein a radial passage 46 at a position between the lug plate 11 and the swash plate 13, interconnecting the crank chamber 4 and the annular passage 32 of the drive shaft 7 and allowing the refrigerant gas in the crank chamber 4 to flow into the annular passage 32. The annular passage 32 is in communication with the suction chamber 17 via a passage 48 formed in the cylinder block 2 and a passage 49 formed in the valve plate assembly 5. The passages 46, 32, 48 and 49 provide the aforementioned bleed passage.

[0023] The operation of the compressor 1 of the first embodiment will be described with reference to Fig. 1. When the drive shaft 7 is driven to rotate by the drive source, the swash plate 13 is rotated with the lug plate 11 thereby to cause each piston 14 to reciprocate in the cylinder bore 2A through the pair of shoes 15. During the reciprocating motion of the piston 14, refrigerant gas in the external refrigeration system is drawn into the cylinder bore 2A through the suction chamber 17 and the suction port 5B for compression. The refrigerant gas in the cylinder bore 2A is compressed by the piston 14 and then discharged into the discharge chamber 16 through the discharge port 5A. Major part of the refrigerant gas in the discharge chamber 16 flows out of the compressor 1 into the external refrigeration system.

[0024] On the other hand, a part of the refrigerant gas in the discharge chamber 16 flows into the control valve 18 through the passage 41, When the refrigerant gas flowing into the control valve 18 passes through the throttle, the flow of the refrigerant gas is regulated and the temperature of the refrigerant gas is decreased, accordingly. The refrigerant gas with a decreased temperature in the control valve 18 then flows into the first seal chamber 22A through the passages 42, 43, 44, the space 45, the axial passage 31 and the slanted passage 33 in this order.

[0025] As shown in Fig. 2, the first seal chamber 22A and the second seal chamber 22B are in communication with each other via the clearance A formed between the inner circumferential surface 21 A of the partition 21 and the outer circumferential surface 7D of the small-diameter portion of the drive shaft 7 facing the inner circumferential surface 21A. Therefore, the refrigerant gas flowed into the first seal chamber 22A flows along the outer circumferential surface 7D of the drive shaft 7 into the second seal chamber 22B through the clearance A. The refrigerant gas flowed into the second seal chamber 22B through the first seal chamber 22A and the clearance A is substantially all supplied to the lip seal 10 that is located in front of the partition 21 and then passes close to the sliding surfaces between the drive shaft 7 and the lip seal 10.

[0026] Lubricating oil contained in the form of a mist in the refrigerant gas supplied to the lip seal 10 lubricates the sliding surfaces between the drive shaft 7 and the lip seal 10. In addition, the refrigerant gas, whose temperature is decreased when passing through the throttle of the control valve 18 (refer to Fig. 1), cools the sliding surfaces between the drive shaft 7 and the lip seal 10 when supplied to the lip seal 10.

[0027] A part of the refrigerant gas which has passed close to the lip seal 10 flows into the crank chamber 4 through the passages 34 and 35. The rest of the refrigerant gas flows into the crank chamber 4 through the radial roller bearing 8, the space 36 and the thrust bearing 12. The radial roller bearing 8 and the thrust bearing 12 are lubricated by the lubricating oil contained in the refrigerant gas flowing through such bearings 8 and 12.

[0028] Referring back to Fig.1, the pressure Pc is created in the crank chamber 4 by the refrigerant gas flowed into the crank chamber 4. The variable pressure difference between the pressure Pc in the crank chamber 4 and the pressure in the cylinder bore 2A causes the inclination angle of the swash plate 13 to vary, thus determining the displacement of the compressor 1. The refrigerant gas flowed into the crank chamber 4 then flows into the suction chamber 17 through the passages 46, 32, 48, 49.

[0029] In the above-described compressor 1 including the shaft seal chamber 22 and the slanted passage 33 that supplies refrigerant gas containing lubricating oil to the shaft seal chamber 22, refrigerant gas is supplied into the shaft seal chamber 22 through the slanted passage 33. By virtue of the provision of the partition 21 in the shaft seal chamber 22 for partitioning the shaft seal chamber 22 into the first seal chamber 22A and the second seal chamber 22B and also of the clearance A between the partition 21 and the drive shaft 7 for allowing the refrigerant gas flowed into the second seal chamber 22B through the first seal chamber 22A and the clearance A to be substantially all supplied to the lip seal 10, substantially all the refrigerant gas flowed into the second seal chamber 22B passes close to the sliding surfaces between the drive shaft 7 and the lip seal 10. Thus, an adequate amount of lubricating oil is supplied to the sliding surfaces between the drive shaft 7 and the lip seal 10. Therefore, the durability of the lip seal 10 in sealing the drive shaft 7 is improved, thereby enhancing the reliability of the lip seal 10.

[0030] Referring to Fig. 3, a part of the variable displacement compressor of the second embodiment is shown. The compressor of the second embodiment differs from that of the first embodiment in that the radial roller bearing 8 of the first embodiment is replaced by a plain bearing 51. In the following description of the second and other embodiments, like reference numerals or symbols denote the like elements or parts of the compressor 1 used in the description of the first embodiment and the detailed description of such elements or parts will be omitted. In the second embodiment, the lug plate 11 is rotatably supported by the plain bearing 51 inserted in the front housing 3.

[0031] The plain bearing 51 is provided by a cylindrical metal member with the opposite ends thereof opened. In the second embodiment, a part of the refrigerant gas which has passed close to the sliding surfaces between the drive shaft 7 and the lip seal 10 flows into the crank chamber 4 through the plain bearing 51, the space 36 and the thrust bearing 12. The rest of the refrigerant gas flows into the crank chamber 4 through the passages 34, 35, The rest of the structure of the compressor of the second embodiment is substantially the same as that of the compressor 1 of the first embodiment. Thus, the compressor of the second embodiment using the plain bearing 51 offers substantially the same effects as that of the first embodiment.

[0032] Referring to Fig. 4, a part of the variable displacement compressor of the third embodiment is shown, In the first embodiment, the lug plate 11 is rotatably supported by the radial roller bearing 8 inserted in the front housing 3. The third embodiment differs from the first embodiment in that the radial roller bearing 8 and the annular partition 21 are replaced by a radial roller bearing 108 and an annular partition 121, respectively.

[0033] The compressor of the third embodiment includes a front housing 103 having a crank chamber 104. A drive shaft 107 is disposed in the crank chamber 104 at the center of the front housing 103. The front portion of the drive shaft 107 is rotatably supported by the radial roller bearing 108 inserted in the front housing 103, The rear portion of the drive shaft 107 is also rotatably supported by the radial roller bearing 9 inserted in the cylinder block 2. Thus, the drive shaft 107 is rotatably supported by the radial roller bearings 108, 9 and serves as the rotary shaft of the present invention. The drive shaft 107 has a slanted passage 133 as that of the first embodiment. A shaft seal chamber 122 is formed in the front housing 103 by the front housing 103, the small-diameter portion, the tapered portion and the large-diameter portion of the drive shat 107, the radial roller bearing 108 and the lip seal 10, An annular partition 121 having an L-shape section is disposed between the lip seal 10 and the radial roller bearing 108 in the shaft seal chamber 122. The partition 121 is located so as to cover the opening 133A of the slanted passage 133 that is opened to the shaft seal chamber 122, and fixed to the outer circumferential surface of the large-diameter portion of the drive shaft 107 for rotation therewith. Thus, the shaft seal chamber 122 is partitioned into a first seal chamber 122A and a second seal chamber 122B by the partition 121.

[0034] Clearance B is formed between the inner circumferential surface 121 A of the partition 121 and the outer circumferential surface 107D of the small-diameter portion of the drive shaft 107 facing the inner circumferential surface 121 A and serves as the first guide passage of the present invention. Therefore, the refrigerant gas flowed into the first seal chamber 122A through the slanted passage 133 flows into the second seal chamber 122B through the clearance B. The refrigerant gas flowed into the second seal chamber 122B is substantially all supplied to the lip seal 10 along the outer circumferential surface 107D of the small-diameter portion of the drive shaft 107 and then passes close to the lip seal 10. The rest of the structure of the compressor of the third embodiment is substantially the same as that of the compressor 1 of the first embodiment. Thus, the compressor of the third embodiment wherein the drive shaft 107 is rotatably supported by the radial roller bearing 108 inserted in the front housing 103 and the partition 121 is fixed on the drive shaft 107 offers substantially the same effects as that of the first embodiment.

[0035] Referring to Fig. 5, a part of the variable displacement compressor of the fourth embodiment is shown. The compressor of the fourth embodiment differs from that of the first embodiment in that the annular partition 21 of the first embodiment is replaced by an annular partition 221.

[0036] As shown in Fig. 5, the annular partition 221 is fixed to the front end of the lug plate 11 for rotation therewith. Clearance A is formed between the inner circumferential surface 221A of the partition 221 and the outer circumferential surface 7D of the drive shaft 7 facing the inner circumferential surface 221A. The partition 221 has in the rear thereof a slanted inner circumferential surface 221 B that defines the first seal chamber 22A with the outer circumferential surface 7F of the tapered portion of the drive shaft 7. The slanted inner circumferential surface 221 B is formed so that the inside diameter of the partition 221 decreases from the rear end of the partition 221 to the rear end of the inner circumferential surface 221A. Thus, the first seal chamber 22A is defined between the inner circumferential surface 221 B of the partition 221 and the outer circumferential surface 7F of the tapered portion of the drive shaft 7 so that its sectional area decreases from a position adjacent to the opening 33A of the slanted passage 33 toward the clearance A. Therefore, the flow of refrigerant gas flowing into the first seal chamber 22A through the slanted passage 33 is restricted in passing through the passage formed between the inner circumferential surface 221 B and the outer circumferential surface 7F and the refrigerant gas is flowed into the second seal chamber 22B through the clearance A at an increased velocity. The rest of the structure of the compressor of the fourth embodiment is substantially the same as that of the compressor 1 of the first embodiment.

[0037] The refrigerant gas thus having increased its velocity is supplied to the lip seal 10 and passes close to the lip seal 10. Although the lip seal 10 is heated by the heat produced in the sliding surfaces between the lip seal 10 and the drive shaft 7, the amount of heat that is released from the lip seal 10 to refrigerant gas is increased because the velocity of the refrigerant gas that passes close to the lip seal 10 is increased. Therefore, heat generation of the lip seal 10 is decreased thereby to further enhance the reliability of the lip seal 10.

[0038] Referring to Fig. 6, a part of the variable displacement compressor of the fifth embodiment is shown. The compressor of the fifth embodiment differs from that of the first embodiment in that the partition 21 of the first embodiment is replaced by an annular partition 321.

[0039] As shown in Fig. 6, the annular partition 321 is fixed to the front end of the lug plate 11 for rotation therewith. The partition 321 serves to partition the shaft seal chamber 22 into the first seal chamber 22A and the second seal chamber 22B and the clearance A is formed between the partition 321 and the drive shaft 7 as in the first embodiment. The front end of the partition 321 is formed so as to cover the tapered portion of the lip seal 10. The partition 321 has a slanted inner circumferential surface 321C that is substantially parallel to the outer circumferential surface 10B of the tapered portion of the lip seal 10, Clearance C is formed between the outer circumferential surface 10B of the tapered portion of the lip seal 10 and the slanted inner circumferential surface 321C of the partition 321 and serves as the second guide passage of the present invention. Therefore, the refrigerant gas flowed into the first seal chamber 22A through the slanted passage 33 then flows into the second seal chamber 22B through the clearances A and C. Because the refrigerant gas flowed into the clearance C is prevented from diffusing radially outward by the slanted inner circumferential surface 321C of the partition 321, substantially all the refrigerant gas flowed into the clearance C passes close to the sliding surfaces between the drive shaft 7 and the lip seal 10. The rest of the structure of the compressor of the fourth embodiment is substantially the same as that of the compressor 1 of the first embodiment.

[0040] Thus, providing the partition 321 with the clearance C allowing the refrigerant gas flowed through the clearance A to flow along the outer circumferential surface 10B of the lip seal 10, the refrigerant gas supplied to the lip seal 10 through the clearance A is substantially all prevented from diffusing radially outward by the slanted inner circumferential surface 321C of the partition 321 and passes close to the sliding surfaces between the drive shaft 7 and the lip seal 10. Therefore, lubricating oil is supplied positively to the sliding surfaces between the drive shaft 7 and the lip seal 10.

[0041] Referring to Fig. 7, a part of the variable displacement compressor of the sixth embodiment is shown. The compressor of the sixth embodiment differs from that of the third embodiment in that the partition 121 of the third embodiment is replaced by the partition 321 of the fifth embodiment. In the following description of the sixth embodiment, like reference numerals or symbols denote the like elements or parts of the compressor used in the description of the first and third embodiments and the detailed description of such elements or parts will be omitted.

[0042] As shown in Fig. 7, an annular partition 421 is disposed between the lip seal 10 and the radial roller bearing 108 in the shaft seal chamber 122. The partition 421 is located so as to cover the opening 133A of the slanted passage 133 and fixed to the outer circumferential surface of the large-diameter portion of the drive shaft 107 for rotation therewith. The partition 421 serves to partition the shaft seal chamber 122 into the first seal chamber 122A and the second seal chamber 122B and the clearance D is formed between the partition 421 and the drive shaft 107 as in the third embodiment. The clearance D serves as the first guide passage of the present invention. The front end of the partition 421 is formed so as to cover the tapered portion of the lip seal 10 and has a slanted inner circumferential surface 421C that is substantially parallel to the outer circumferential surface 10B of the tapered portion of the lip seal 10 as in the fifth embodiment. Clearance C is formed between the outer circumferential surface 10B of the tapered portion of the lip seal 10 and the slanted inner circumferential surface 421C of the partition 421 and serves as the second guide passage of the present invention. The rest of the structure of the compressor of the sixth embodiment is substantially the same as that of the compressor 1 of the first embodiment,

[0043] Thus, the compressor of the sixth embodiment wherein the partition 421 is fixed on the drive shaft 107 offers substantially the same effects as that of the fifth embodiment.

[0044] Although in each of the first through sixth embodiments a single slanted passage is formed in the drive shaft, a plurality of such slanted passages may be formed in the drive shaft.

[0045] In the third through sixth embodiments, the radial roller bearing may be replaced by the plain bearing 51 in the second embodiment.

[0046] Although in each of the fifth and sixth embodiments the partition covers the outer circumferential surface 10B of the tapered portion of the lip seal 10, the region of the lip seal 10 to be covered by the partition is not limited to the tapered portion but it may include the outer circumferential surface of the lip seal 10 that is parallel to the axial direction of the drive shaft.

[0047] In each of the fifth and sixth embodiments, the inner circumferential surface of the partition that defines the first seal chamber may be formed as in the fourth embodiment. That is, the partition may be formed with the inside diameter thereof decreased from the rear end of the partition to the clearance A or D.

[0048] Although in each of the fifth and sixth embodiments the inner circumferential surface of the partition that forms the clearance C is substantially parallel to the outer circumferential surface 10B of the tapered portion of the lip seal 10, the positional relation between the inner circumferential surface of the partition and the outer circumferential surface 10B of the lip seal 10 is not limited to the parallel disposition. The inner circumferential surface of the partition may be inclined in any way as long as the surface prevents refrigerant gas from diffusing radially outward.

[0049] A variable displacement compressor includes a housing, a rotary shaft, a bearing, a seal member, a shaft seal chamber, a discharge refrigerant passage and a partition. The partition is provided in the shaft seal chamber for partitioning the shaft seal chamber into a first seal chamber to which the discharge refrigerant passage is opened and a second seal chamber part of the periphery of which is formed by the bearing and the seal member. The partition is provided with a first guide passage through which refrigerant containing lubricating oil flowed from the discharge refrigerant passage into the first seal chamber is substantially all supplied to the seal member of the second seal chamber.

Claims

1. A variable displacement compressor (1) comprising;
a housing (3, 103) having a crank chamber (4,104);
a rotary shaft (7, 107) disposed in the crank chamber (4, 104) with at least one end thereof exposed outside the housing (3, 103);
a bearing (8, 108) disposed in the housing (3, 103) for rotatably supporting the rotary shaft (7, 107);
a seal member (10) disposed in the housing (3, 103) at a position between the exposed end of the rotary shaft (7,107) and the bearing (8, 108) for preventing refrigerant mixed with lubricating oil from leaking out of the housing (3, 103) along the rotary shaft (7, 107);
a shaft seal chamber (22, 122) defined by the housing (3, 103), the rotary shaft (7, 107), the bearing (8, 108) and the seal member (10); and
a discharge refrigerant passage (33, 133) formed in the rotary shaft (7, 107), wherein the refrigerant flows into the shaft seal chamber (22, 122) through the discharge refrigerant passage (33,133);
characterized in that
a partition (21,121,221,321,421) is provided in the shaft seal chamber (22, 122) for partitioning the shaft seal chamber (22, 122) into a first seal chamber (22A, 122A) to which the discharge refrigerant passage (33, 133) is opened and a second seal chamber (22B, 122B) part of the periphery of which is formed by the bearing (8, 108) and the seal member (10), wherein the partition (21, 121, 221, 321, 421) is provided with a first guide passage (A, B, D) through which the refrigerant flowed from the discharge refrigerant passage (33, 133) into the first seal chamber (22A, 122A) is substantially all supplied to the seal member (10) of the second seal chamber (22B, 122B).

2. The variable displacement compressor (1) according to claim 1, **characterized in that** a lug plate (11) is fixed on the rotary shaft (7, 107) for rotation therewith, wherein the shaft seal chamber (22) is defined by the housing (3, 103), the rotary shaft (7), the lug plate (11), the bearing (8) and the seal member (10).

3. The variable displacement compressor (1) according to claim 2, **characterized in that** the partition (21, 221, 321) is provided on the lug plate (11).

4. The variable displacement compressor (1) according to claim 1, **characterized in that** the partition (21, 221, 321) is provided on the rotary shaft (7).

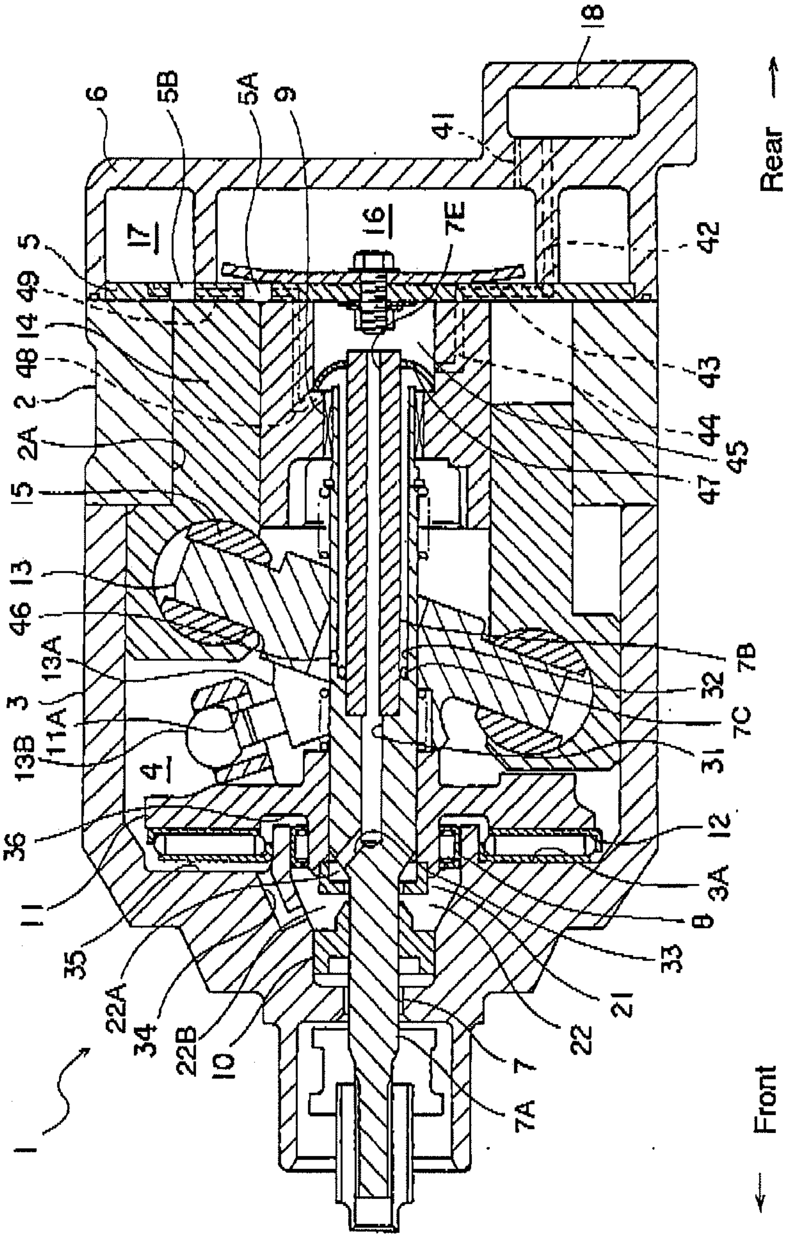
5. The variable displacement compressor (1) according to any one of claims 1 through 4, **characterized in that** the first guide passage (A, B, D) is formed between the end of the partition (21, 121, 221, 321, 421) and the outer surface (7D, 107D) of the rotary shaft (7, 107).

6. The variable displacement compressor (1) according to claim 5, **characterized in that** the first guide passage (A, B, D) is formed along the outer surface (7D, 107D) of the rotary shaft (7, 107) and toward the seal member (10).

7. The variable displacement compressor (1) according to any one of claims 1 through 6, **characterized in that** the first seal chamber (22A, 122A) is defined between the partition (21, 121, 221, 321, 421) and the rotary shaft (7, 107) so that an area of the first seal chamber (22A, 122A) decreases from a position adjacent to the discharge refrigerant passage (33, 133) toward the first guide passage (A, B, D).

8. The variable displacement compressor (1) according to any one of claims 1 through 7, **characterized in that** the partition (321, 421) is further provided with a second guide passage (C) through which the refrigerant flowed through the first guide passage (A, B, D) is allowed to flow along an outer circumferential surface (10B) of the seal member (10).

FIG. 1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Front
1
6
5B
5A
9
41
18
16
17
7E
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14
48
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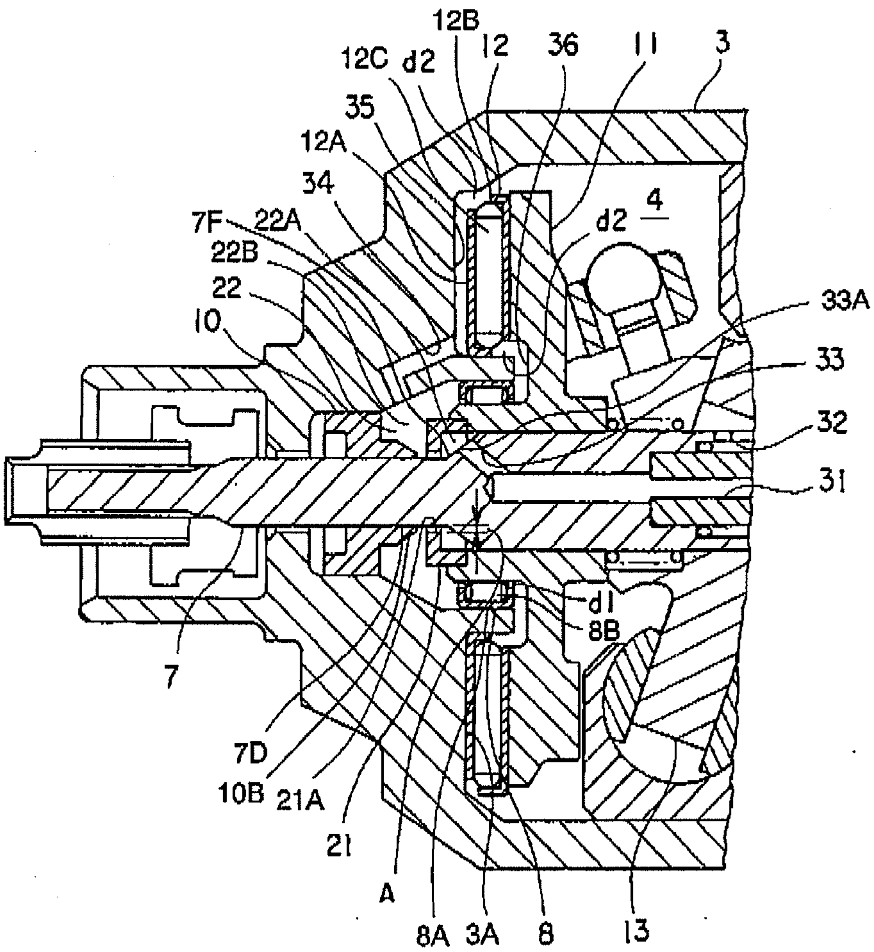
15
13
46
13A
3
11A
13B
4
36
11
35
22A
34
22B
10
7A
7
22
21
33
8
3A
12
31
7C
32
7B
47
45
44
43
42

FIG. 2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d2
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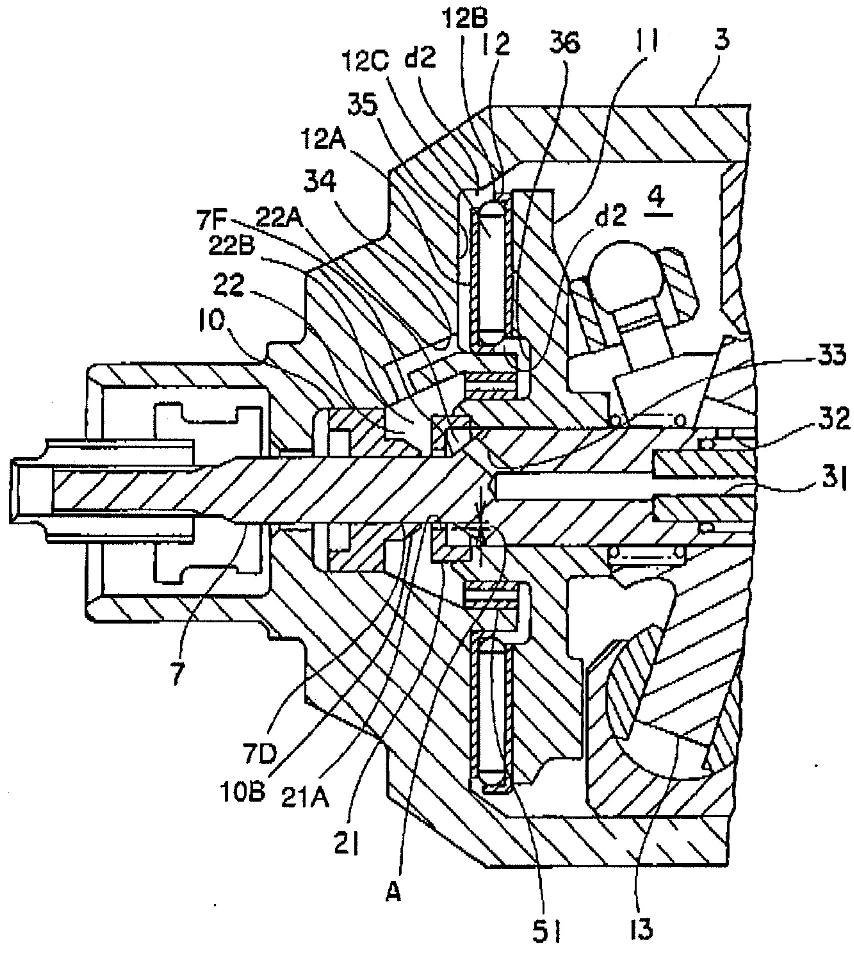
3A
8
13

FIG. 3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d2
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12A
34
4
d2
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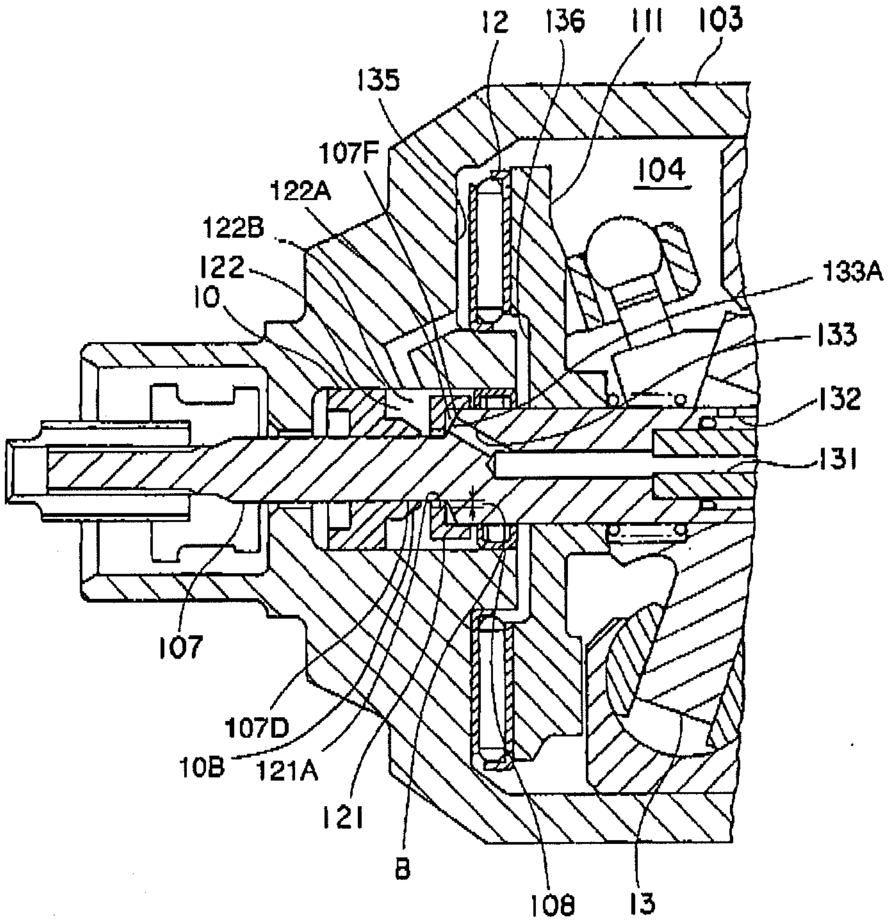
21
A
51
13

FIG. 4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107D
10B
121A
121
B
108
13

FIG. 5

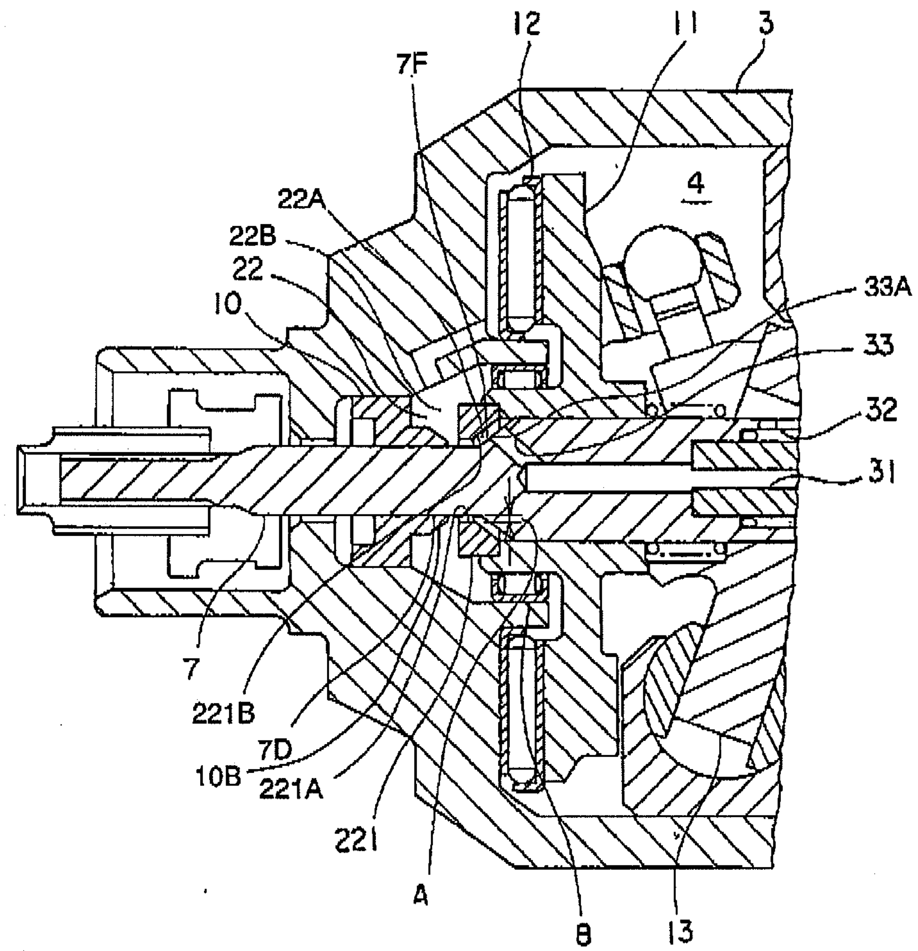


FIG. 6

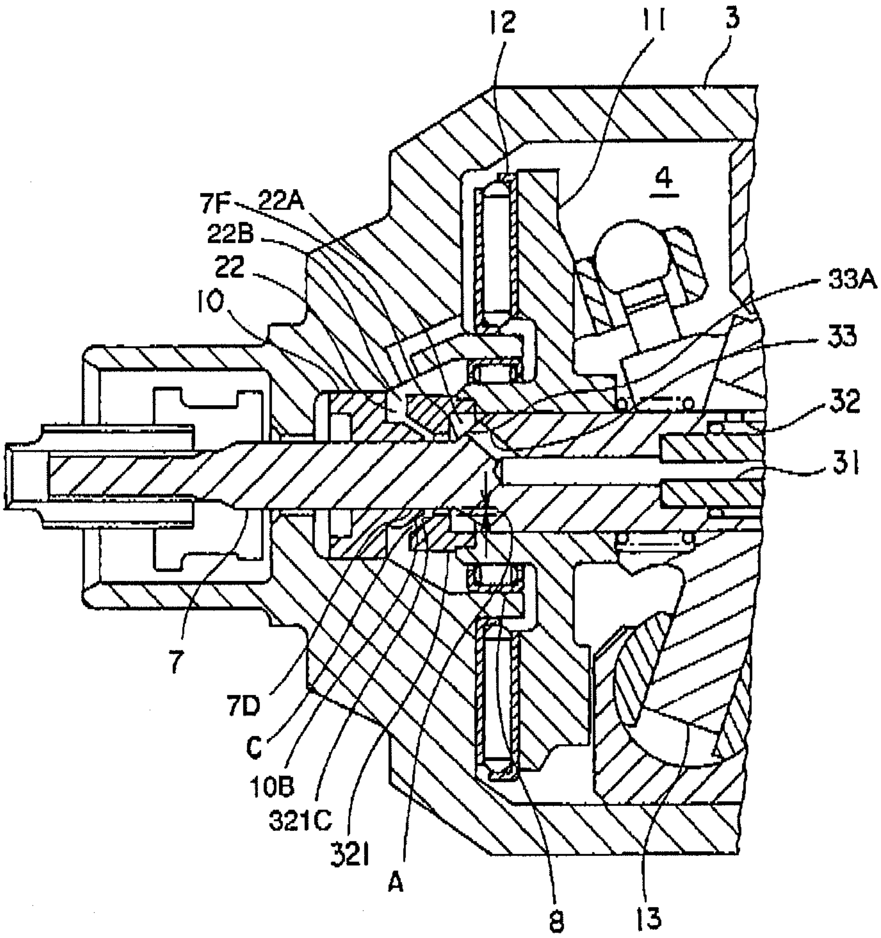
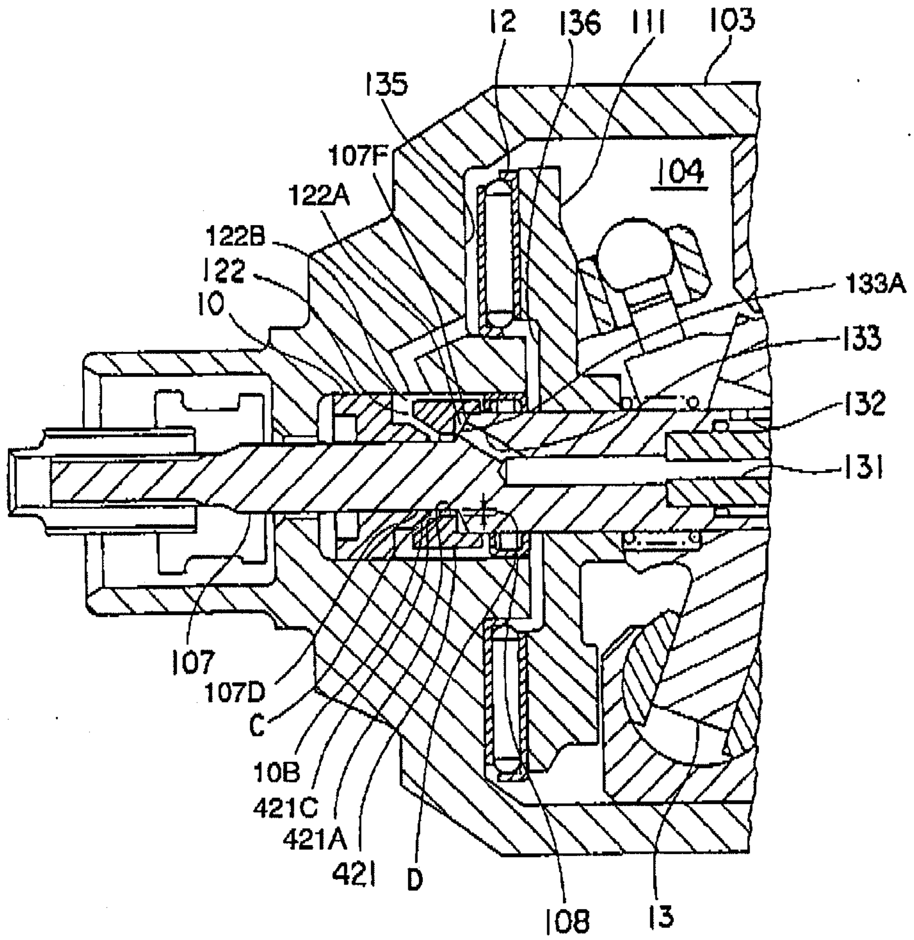


FIG. 7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132
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107D
C
10B
421C
421A
421
D
108
13

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 6176

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			F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 July 2009	Pinna, Stefano

4

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