(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 319 840 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.06.2003 Bulletin 2003/25

(51) Int Cl.[7]: **F04C 18/02**, F04C 29/08, F04C 29/02

(21) Application number: **03006366.3**

(22) Date of filing: **16.09.1998**

(84) Designated Contracting States:
DE ES FR GB IT

(30) Priority: **17.09.1997 JP 25212597**

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
98117556.5 / 0 903 499

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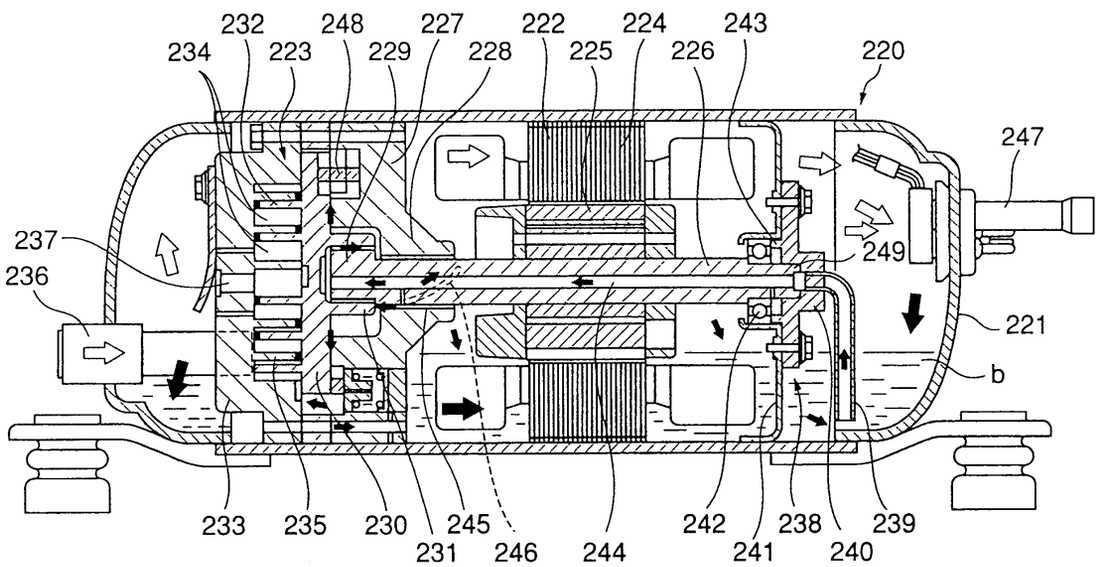
Remarks:
This application was filed on 20 - 03 - 2003 as a divisional application to the application mentioned under INID code 62.

(54) Scroll compressor

(57) A highly reliable scroll compressor with an unproved bearing lubrication comprises a refrigerant gas intake side, a rear surface of a swivel scroll and a main support frame, which are placed in communication the pressure among them being set low. The refrigerant gas is compressed under a gas-sealed condition while holding the swivel scroll away from a stationary scroll, and a lubricant is introduced from a lubricating portion and fed to sliding parts including a bearing via an oil feed passage provided in an rotating shaft, the lubricant being circulated for repeated use.

Fig. 2



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a scroll compressor mounted on an air conditioner, a refrigerating machine, etc. and, more particularly, to a scroll compressor adapted to discharge compressed gas, which has been compressed in a plurality of compression chambers formed by the engagement between a stationary scroll and a swivel scroll, out of a hermetic housing.

2. Description of Related Art

[0002] The compressor shown in Fig. 1 poses an problem in that it needs to be equipped with the oil releasing unit to avoid excessive lubricant supply since the use of the pump 108 for supplying the lubricant causes the amount of the lubricant supplied to vary according to the number of revolutions of the rotating shaft 106. This results in problems such as more complication of the entire system, more power consumed, and higher cost.

[0003] As a solution to the problem, there has been proposed the horizontal type scroll compressor under Japanese Examined Patent Publication No. 3-175186. As previously mentioned, this type does not employ the pump for supplying a lubricant, and it discharges compressed gas into a hermetic housing; it has a through hole in the swivel scroll to communicate an appropriate compression chamber among the scroll compression elements, the rear surface of the swivel scroll, and the support frame so as to set the pressure among them to an appropriate medium pressure, e.g. 8 to 9 kg/cm^2 that is lower than the pressure, e.g. 15 to 25 kg/cm^2, in the hermetic housing. By utilizing the pressure differential, the lubricant is sucked up and passed through the oil feed passage provided in the rotating shaft to be supplied to respective sliding parts including the support frame. The swivel scroll is pressed against a stationary scroll by the foregoing pressure to bring them into contact so as to provide gas seal thereby to compress the refrigerant gas.

[0004] This scroll compressor, however, has been presenting the following problem although the lubrication by the lubricant is satisfactory. The stationary scroll and the swivel scroll are brought in direct contact with each other by the pressure to provide the gas seal to compress the refrigerant gas; hence, more power is consumed, and the both stationary scroll and the swivel scroll need to be composed of iron casting or a combination of iron casting and aluminum or the like, making it impossible to use aluminum or an aluminum alloy for both stationary and swivel scrolls.

[0005] To solve the problem, according to yet another aspect of the invention, there is provided a horizontal scroll compressor that provides high refrigerating performance and ensures stable operation for a long time, that is able to ensure stable supply of a lubricant even when the number of revolutions of the rotating shaft varies, and that permits the use of aluminum or an aluminum alloy as the component material for both stationary and swivel scrolls thereof. This type of scroll compressor employs the system in which compressed gas is discharged into a hermetic housing rather than employing a pump for supplying a lubricant. The scroll compressor utilizes the pressure differential to suck up the lubricant and supplies it to sliding parts including the support frame via an oil feed passage provided in the rotating shaft. The scroll compressor does not, however, press the swivel scroll against the stationary scroll to bring them in contact; conversely, it sets the swivel scroll away from the stationary scroll to compress the refrigerant gas under the gas-sealed condition.

SUMMARY OF THE INVENTION

[0006] The inventors have enthusiastically studied to solve the problem and found a solution thereto, which has led to the accomplishment of the present invention. According to the solution, the refrigerant gas intake side, the rear surface of the swivel scroll, and the support frame are placed in communication and the pressure among them is set low. The refrigerant gas is compressed under a gas-sealed condition while holding the swivel scroll away from the stationary scroll, and the lubricant is introduced from the lubricating portion and fed to sliding parts including a bearing via the oil feed passage provided in the rotating shaft, the lubricant being circulated for repeated use. Accordingly, it is an object of the present invention to provide a highly reliable scroll compressor with an improved bearing lubrication.

[0007] A scroll compressor according to Claim 1 of the invention is equipped with an electric element which is provided with its rotating shaft laterally oriented and a scroll compression element driven by the electric element, both electric element and scroll compression element being placed in a hermetic housing, a support frame that is installed in the hermetic housing to support the scroll compression element and that is provided with a bearing portion for rotatably supporting the rotating shaft at the center thereof, a lubricant held in the hermetic housing, and a differential pressure lubricating portion provided on an end of the rotating shaft, wherein the scroll compression element includes a stationary scroll having a discharge port of compressed gas at the center thereof and a spiral lap on the rear surface thereof, and a swivel scroll having a spiral lap that revolves with respect to the stationary scroll by being driven by the electric element, the stationary scroll and the swivel scroll being meshed with each other to form a plurality of compression chambers, a refrigerant gas, which has been taken in from outside the hermetic housing, is com-

pressed in the compression chambers and discharged into the hermetic housing through the discharge port before it is discharged out of the hermetic housing; and wherein the sliding surface of the bearing is gas-sealed by the lubricant, and a refrigerant gas intake side, the rear surface of the swivel scroll, and the support frame are placed in communication to set the pressure thereamong lower than the pressure in the hermetic housing so as to feed the lubricant from the lubricating portion via the oil feed passage provided in the rotating shaft to respective sliding portions including the bearing thereby to circulate the lubricant for reuse, wherein a pin which is provided on the distal end of the rotary shaft and the center of which is eccentric to the axial center of the rotating shaft is inserted in a boss hole drilled at the center of the rear surface of the swivel scroll, and the boss hole and the sliding portion of the pin are gas-sealed with the lubricant sucked in from the lubricating portion.

[0008] According to another aspect of the invention described in Claim 2 of the invention, in the scroll compressor described in Claim 1, a small hole is provided that extends from the oil feed passage to the sliding surface of the bearing, and a spiral groove is provided in the surface of the rotating shaft on the side of the electric element from the small hole so that the lubricant, which has passed through the small hole, flows through the groove to lubricate the sliding surface and to gas-seal the sliding surface on the side of the scroll compression element from the small hole.

[0009] According to a further aspect of the invention described in Claim 3 of the invention, in the scroll compressor described in Claim 1, a small hole that extends from the oil feed passage to the sliding surface of the bearing is provided in the vicinity of the end of the bearing on the side of the electric element, and a spiral groove that extends in the opposite direction from the rotational direction of the rotating shaft is provided in the surface of the rotating shaft on the side of the scroll compression element from the small hole in such a manner that the end point of the spiral groove is positioned within the bearing so that the lubricant, which has passed through the small hole, flows through the groove to lubricate the sliding surface and to gas-seal the sliding surface on the side of the scroll compression element from the end point.

[0010] According to a further aspect of the invention described in Claim 4 of the invention, in the scroll compressor described in Claims 1 or 2, the lubricating portion is equipped with an auxiliary support frame having an auxiliary bearing that is installed in the hermetic housing to rotatably support the rotating shaft and that has an oil introducing pipe attached thereto; wherein a bearing is installed between the auxiliary support frame and the rotating shaft, and the receiving portion of the bearing is provided on the auxiliary bearing.

[0011] According to a further aspect of the invention described in Claim 5 of the invention, in the scroll compressor described in Claims 1 to 4, the gap between the rotating shaft and the sliding portion of the auxiliary bearing is adjusted to prevent gas from entering the lubricant.

[0012] According to a further aspect of the invention described in Claim 6 of the invention, in the scroll compressor described in Claims 1 to 5, the stationary scroll and the swivel scroll are made of aluminum or an aluminum alloy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Fig. 1 is a sectional view showing the entire composition of a conventional scroll compressor.

Fig. 2 is a sectional view showing the entire composition of an embodiment of the scroll compressor in accordance with an aspect of the present invention.

Fig. 3 is an enlarged schematic representation of a bearing and a rotating shaft of another scroll compressor in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Referring now to Fig. 2 and Fig. 3, the invention related to Claim 1 through Claim 6 of the present application will be described.

[0015] An embodiment of the invention will be described in detail in conjunction with the drawing given in Fig. 2. Figure 2 is a sectional view showing the entire composition of a horizontal type scroll compressor in accordance with the invention. Figure 3 is an enlarged schematic representation of the bearing and the rotating shaft of the horizontal type scroll compressor of another embodiment in accordance with the present invention.

[0016] The compressor shown in Fig. 2 is a scroll compressor 220 equipped with a cylindrical hermetic housing 221 having its both ends closed. Housed in the hermetic housing 221 are an electric element 222 and a scroll compression element 223 driven by the electric element 222.

[0017] The electric element 222 has a stator 224 fixed in the hermetic housing 221 and a rotor 225 positioned at the center of the stator 224. A rotating shaft 226 oriented in the direction of the axial center of the hermetic housing 221 is connected to the center of the rotor 225 in a penetrating fashion, and one end thereof penetrates the center of a support frame 227 supporting the scroll compression element 223 so that it is rotatably supported. In this case, the support frame 227 is connected and secured to the inner wall surface of the hermetic housing 221. The middle portion near one end of the rotating shaft 226 is rotatably supported by a bearing 228 of the support frame 227, and the rotor 225 is supported on the inner wall surface of the hermetic housing 221 via the rotating shaft 226 and the support frame 227.

[0018] The central part of one end of the rotating shaft 226 penetrating the support frame 227 is formed as a pin or crank 229 provided eccentrically in relation to the axial center of the rotating shaft 226. A swivel scroll 230 is joined to the pin 229. The swivel scroll 230 is provided with a boss hole 231 in which the pin 229 is inserted for connection to the center of one side surface of a discoid panel board, and a spiral lap 232 formed on the other side surface of the panel board.

[0019] A stationary scroll 233 is joined to the support frame 227. The stationary scroll 233 has a spiral lap 235 positioned in a zigzag fashion with respect to the lap 232 of the swivel scroll 230 so as to form a plurality of compression chambers 234.

[0020] Connected to the side wall surface of the stationary scroll 233 is an intake pipe 236 for refrigerant gas that penetrates the hermetic housing 221. Provided at the center of the stationary scroll 233 is a discharge port 237 for discharging a compressed refrigerant gas into the hermetic housing 221.

[0021] The intake side of the scroll compression element 223 of the refrigerant gas introduced through the intake pipe 236, the rear surface of the swivel scroll 230, i.e. the surface of the side where the boss hole 231 of the panel board is located, and the support frame 227 are in communication at the peripheral portion of the panel board of the swivel scroll 230. Hence, the pressure among those places is substantially as low as that at the foregoing refrigerant gas intake side and it is lower than the pressure in the hermetic housing 221.

[0022] A differential lubricating portion 238 is provided on the other end of the rotating shaft 226. The lubricating portion 238 is installed in the hermetic housing 221 to rotatably support the rotating shaft 226 and it is equipped with an auxiliary support frame 241 having an auxiliary bearing 240 with an oil introducing pipe 239 attached thereto. A bearing 242 is installed between the auxiliary support frame 241 and the rotating shaft 226, a receiving portion 243 of the bearing 242 being provided on the auxiliary bearing 240.

[0023] The rotating shaft 226 has an oil feed passage 244 extending from one end to the other end thereof. A small hole 245 communicating the oil feed passage 244 with the sliding surface of the bearing 228 is provided in the middle of the portion where the rotating shaft 226 is rotatably supported by the bearing 228. A spiral groove 246 in communication with the small hole 245 is provided in the surface of the rotating shaft 226, beginning from the outlet of the small hole 245 and extending toward the electric element 222 until it reaches a point slightly beyond the portion where the rotating shaft 226 is rotatably supported by the bearing 228. The lubricant that has left one end of the rotating shaft 226 gas-seals the boss hole 231 and the sliding surface of the pin 229, and the lubricant that has passed through the small hole 245 flows through the groove 246 to lubricate the sliding surfaces and also to gas-seal the sliding surface on the side of the scroll compression element 223 from the small hole 245.

[0024] The hermetic housing 221 is filled with the lubricant "b" up to a predetermined level. The lubricant "b" is sucked up from the lubricating portion 238 by the pressure differential mentioned above and it passes through the oil feed passage 244 provided in the rotating shaft 226 to be fed to respective sliding portions including the bearing 228. The lubricant is circulated for repeated use.

[0025] When the operation of the horizontal type scroll compressor 220 having the constitution described above is begun, the refrigerant gas is taken in through the intake pipe 236 to the outer peripheral portion of the scroll compression element 223, and compressed as it gradually moves toward the center of the scroll compressor. The refrigerant gas is discharged into the hermetic housing 221 through the discharge port 237 provided at the center of the stationary scroll 233 and the accompanying lubricant is separated in this space, thus suppressing pulsation.

[0026] The discharged gas flows through passages (not shown) provided in the stationary scroll 233 and the support frame 227 as indicated by the white arrows and reaches the electric element 222 side. And the lubricant in the refrigerant gas is further separated primarily by the centrifugal force generated by the rotation of the rotor 225 and by the baffle plate effect due to the stator 224, the auxiliary support frame 241, etc., then the refrigerant gas from which the lubricant has been separated is discharged out of the hermetic housing 221 through a discharge pipe 247. The separated lubricant flows as indicated by the black arrows and accumulates at the bottom of the hermetic housing 221 and it is circulated for repeated use.

[0027] The refrigerant gas intake side, the rear surface of the swivel scroll 230, and the support frame 227 are placed in communication; hence, the pressure among those places is substantially as low as that at the refrigerant gas intake side and it is lower than the pressure in the hermetic housing 221. This pressure differential causes the lubricant "b" to be sucked up through the oil introducing pipe 239 of the lubricating portion 238 and supplied under high pressure via the oil feed passage 244 provided in the rotating shaft 226, as indicated by the black arrows. A part of the supplied high-pressure lubricant passes through the small hole 245 as indicated by the black arrows and flows through the groove 246 toward the electric element 222 to lubricate sliding surfaces before it reaches the bottom of the hermetic housing 221. The clearance between the rotating shaft 226 and the bearing 228 is extremely small. The clearance is set, for example, to approximately 10 to 30 m; hence, the sliding portions of the rotating shaft 226 and the bearing 228 on the side of the scroll compression element 223 from the small hole 245 is well gas-sealed.

[0028] The high-pressure lubricant leaving one end of the rotating shaft 226 gas-seals the boss hole 231 and the sliding surface of the pin 229. After that, these lubricants flow between the swivel scroll 230 and the support

frame 227 as indicated by the black arrows to lubricate the groove of an Oldham ring 248, then flows along the outer periphery of the panel board of the swivel scroll 230 to be supplied to the refrigerant gas intake side in the scroll compression element 223 to lubricate sliding surfaces. The lubricant is then discharged together with the compressed gas through the discharge port 237 into the hermetic housing 221, and separated from the compressed gas before reaching the bottom of the hermetic housing 221.

[0029] The Oldham ring 248 is installed between the support frame 227 and the swivel scroll 230; it is revolved on a circular orbit by being driven by the electric element 222 so that the swivel scroll 230 does not rotate with respect to the stationary scroll 233.

[0030] As mentioned above, the pressure between the rear surface of the swivel scroll 230 and the support frame 227 is substantially as low as that at the refrigerant gas intake side, so that the swivel scroll 230 is not pressed against the stationary scroll 233. Conversely, the swivel scroll 230 is set away from the stationary scroll 233; therefore, it is necessary to compress the refrigerant gas under the gas-sealed condition generated by providing a spring-operated gas sealing device on the lap distal ends of the swivel scroll 230 and the stationary scroll 233, respectively, to provide a lubricant therebetween. This ensures an advantage of higher compression efficiency obtained by improved gas sealing in the scroll compression element 223 and it also allows the use of aluminum or an aluminum alloy for the stationary scroll 233 and the swivel scroll 230.

[0031] The bearing 242 is installed between the auxiliary support frame 241 of the lubricating portion 238 and the rotating shaft 226, and the receiving portion 243 of the bearing 242 is provided on the auxiliary bearing 240. This provides an advantage in that the rotating shaft 226 rotates stably and smoothly, leading to higher compression efficiency with resultant reduced vibration or noise.

[0032] It is possible to prevent the refrigerant gas from entering the lubricant by properly adjusting a gap 249 between the sliding portion of the rotating shaft 226 and that of the sliding portion of the auxiliary bearing 240. If the gap 249 is too large, then the gas may enter the lubricant; conversely, if the gap 249 is too small, then the resistance to the rotating shaft 226 may become too high. It is required, therefore, to properly adjust the gap 249.

[0033] The rotating shaft 226 of a horizontal type scroll compressor 220A of another embodiment in accordance with the present invention shown in Fig. 3 is provided with a small hole 245A that is located on the side of the electric element 222 of the portion where the rotating shaft 226 is rotatably supported by the bearing 228 and that extends from the oil feed passage 244 to the sliding surface of the bearing 228. A spiral groove 246A in communication with the small hole 245A is formed in the surface of the rotating shaft 226; it begins at the outlet of the small hole 245A and extends toward the scroll compression element 223 to the middle of the portion where the rotating shaft 226 is rotatably supported by the bearing 228. The spiral direction of the spiral groove 246A is opposite from the rotational direction of the rotating shaft 226. Except for this part of constitution, this type of scroll compressor shares the same constitution as that of the horizontal scroll compressor 220 shown in Fig. 2.

[0034] The pressure differential causes the lubricant "b" to be supplied under high pressure via the oil feed passage 244. As indicated by the black arrows, a part of the supplied high-pressure lubricant passes through the small hole 245A, flows through the groove 246A toward the scroll compression element 223 to lubricate the sliding surfaces and also to gas-seal the sliding surface of the portion of the rotating shaft 226 on the side of the scroll compression element 223 from the small hole 245A, and the sliding surface of the bearing 228. As in the case of the scroll compressor 220, after that, these lubricants flow between the swivel scroll 230 and the support frame 227 as indicated by the black arrows to lubricate the groove of the Oldham ring 248, then it is supplied into the scroll compression element 223 to lubricate sliding surfaces. The lubricant is then discharged together with the compressed gas through the discharge port 237 into the hermetic housing 221, and separated from the compressed gas before reaching the bottom of the hermetic housing 221. This provides an advantage in that the gas sealing in the scroll compression element 223 is further improved, leading to higher compression efficiency.

[0035] Hitherto, many compressors for refrigerators, vending machines, and showcases have been using dichloro-difluoromethane (R12). The R12 has been specified as a CFC control item because of its high possibility of damage to the ozone layer since if it is released into the air and reaches the ozone layer in the sky, it damages the ozone layer. The damage to the ozone layer is attributable to the chlorine radical (CI) contained in a refrigerant.

[0036] Specific examples of the refrigerant employed in the present invention are HFC-based refrigerants such as 1, 1, 1, 2-tetrafluoroethane (R134a) simple substance, a mixed refrigerant (R407C) of R134a, difluoromethane (R-32), and pentafluoroethane (R-125), and the mixed refrigerant (R410A) of R-32 and R-125, or HCFC-based refrigerants such as a simple substance or a mixed refrigerant of hydrochloro-difluoromethane (R22).

[0037] Specific examples of the lubricant employed in the present invention are ester-based oils or ether-based oils compatible with the refrigerants mentioned above, or alkylbenzene-based oils incompatible with the refrigerants, or mixtures of these.

[0038] The scroll compressor in accordance with the invention does not employ a pump for supplying a lubricant; it discharges the compressed gas into the hermetic

housing. By making use of the pressure differential, the lubricant is supplied, via the oil feed passage provided in the rotating shaft, to the sliding parts such as the support frame so as to lubricate them, thus circulating the lubricant for reuse. The swivel scroll is not pressed against the stationary scroll to bring them in contact. On the contrary, the swivel scroll is set away from the stationary scroll, and the refrigerant gas is compressed under the gas-sealed condition. Hence, aluminum or an aluminum alloy can be used as the constituent materials for both stationary and swivel scrolls. Moreover, even when the number of revolutions of the rotating shaft varies, the scroll compressor enables stable supply of a lubricant. Thus, the scroll compressor provides high refrigerating performance, consumes less power, and ensures stable operation for a long time.

Claims

1. A scroll compressor (220) comprising: an electric element (222) that is provided with a rotating shaft (226) thereof laterally oriented and a scroll compression element (223) driven by said electric element (222), both the electric element (222) and the scroll compression element (223) being housed in a hermetic housing (221); a support frame (227) that is installed in said hermetic housing (221) to support said scroll compression element (223) and that is provided with a bearing portion for rotatably supporting said rotating shaft (226) at the center thereof; a lubricant (b) held in said hermetic housing (221); and a differential pressure lubricating portion (238) provided on an end of said rotating shaft (226); wherein said scroll compression element (223) includes a stationary scroll (233) having a discharge port (237) of compressed gas at the center thereof and a spiral lap (235) on the rear surface thereof, and a swivel scroll (230) having a spiral lap (232) that revolves with respect to said stationary scroll (233) by being driven by said electric element (222), said stationary scroll (233) and said swivel scroll (230) being meshed with each other to form a plurality of compression chambers (234), a refrigerant gas, which has been taken in from outside said hermetic housing (221), being compressed in said compression chambers (234) and discharged into said hermetic housing (221) through said discharge port (237) before it is discharged out of said hermetic housing (221); and wherein the sliding surface of said bearing (228) is gas-sealed by a lubricant (b), and a refrigerant gas intake side, the rear surface of said swivel scroll (230), and said support frame (227) are placed in communication to set the pressure thereamong lower than the pressure in the hermetic housing (221) so as to feed the lubricant (b) from said lubricating portion (238) via the oil feed passage (244) provided in said rotating shaft (226) to respective sliding portions including said bearing (228) thereby to circulate the lubricant (b) for reuse, wherein a pin (229) which is provided on a distal end of said rotary shaft and the center of which is eccentric to the axial center of said rotating shaft (226) is inserted in a boss hole drilled at the center of the rear surface of said swivel scroll (230), and said boss hole and a sliding portion of said pin (229) are gas-sealed with the lubricant (b) sucked up from said lubricating portion (238).

2. A scroll compressor (220A) according to claim 1, wherein a small hole (245A) is provided that extends from said oil feed passage (244) to the sliding surface of said bearing (228), and a spiral groove (246A) is provided in the surface of said rotating shaft (226) on the side of said electric element (222) from said small hole (245A) so that the lubricant (b), which has passed through said small hole (245A), flows through said groove (246A) to lubricate the sliding surface and to gas-seal the sliding surface on the side of said scroll compression element (223) from said small hole (245A).

3. A scroll compressor (220A) according to claim 1, wherein a small hole (245A) that extends from said oil feed passage (244) to the sliding surface of said bearing (228) is provided in the vicinity of the end of said bearing (228) on the side of said electric element (222), and a spiral groove (246A) that extends in the opposite direction from the rotational direction of said rotating shaft (226) is provided in the surface of said rotating shaft (226) on the side of said scroll compression element (223) from said small hole (245A) in such a manner that the end point of said spiral groove (246A) is positioned within said bearing (228) so that the lubricant (b), which has passed through said small hole (245A), flows through said groove (246A) to lubricate the sliding surface and to gas-seal the sliding surface on the side of said scroll compression element (223) from said end point.

4. A scroll compressor (220A) according to claims 1 to 3, wherein said lubricating portion (238) comprises an auxiliary support frame (241) equipped with an auxiliary bearing (240) that is installed in said hermetic housing (221) to rotatably support said rotating shaft (226) and that has an oil introducing pipe (239) attached thereto; wherein a bearing is installed between said auxiliary support frame (241) and said rotating shaft, and a receiving portion of said bearing is provided on said auxiliary bearing (240).

5. A scroll compressor (220) according to claims 1 to 4, wherein the gap between said rotating shaft (226) and the sliding portion of said auxiliary bearing

(240) is adjusted to prevent gas from entering the lubricant.

6. A scroll compressor (220) according to claims 1 to 5, wherein said stationary scroll (233) and said swivel scroll (230) are made of aluminum or an aluminum alloy.

Fig. 1

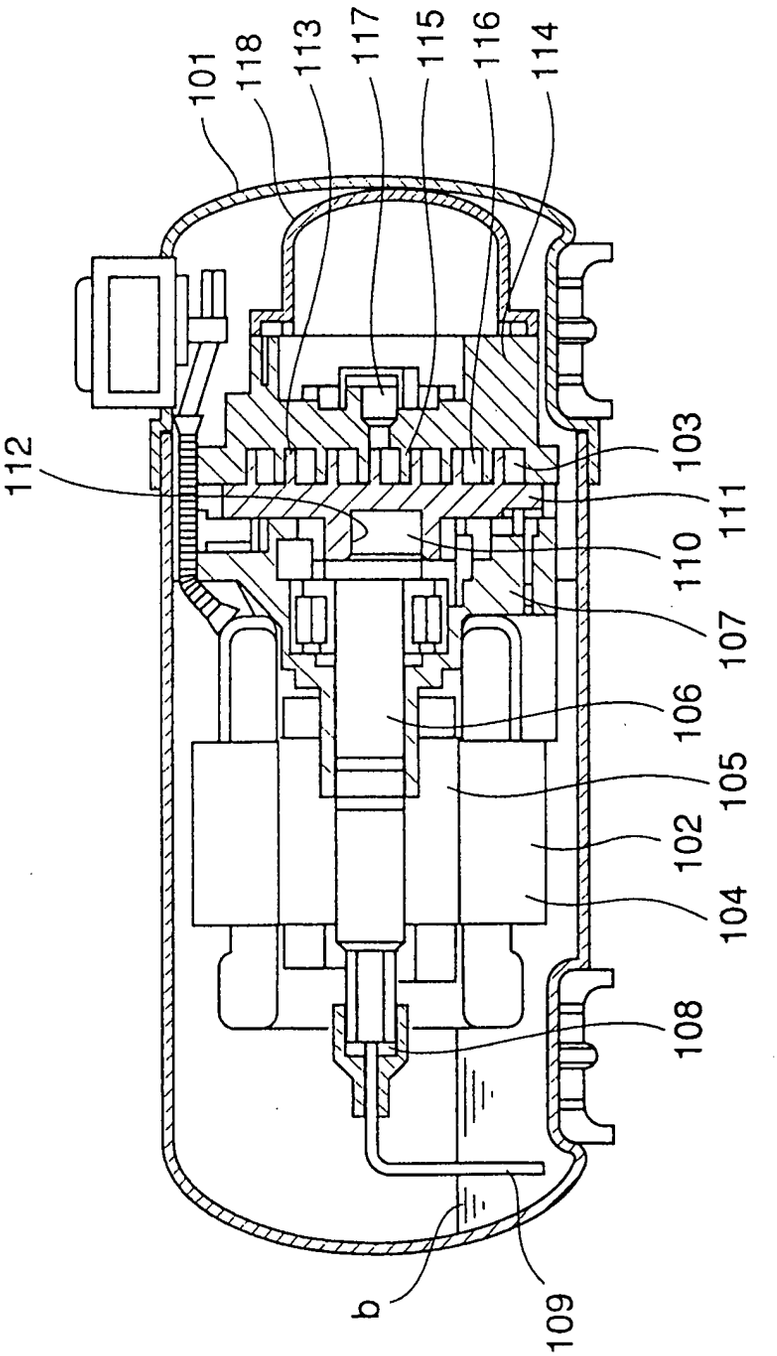
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Fig. 2

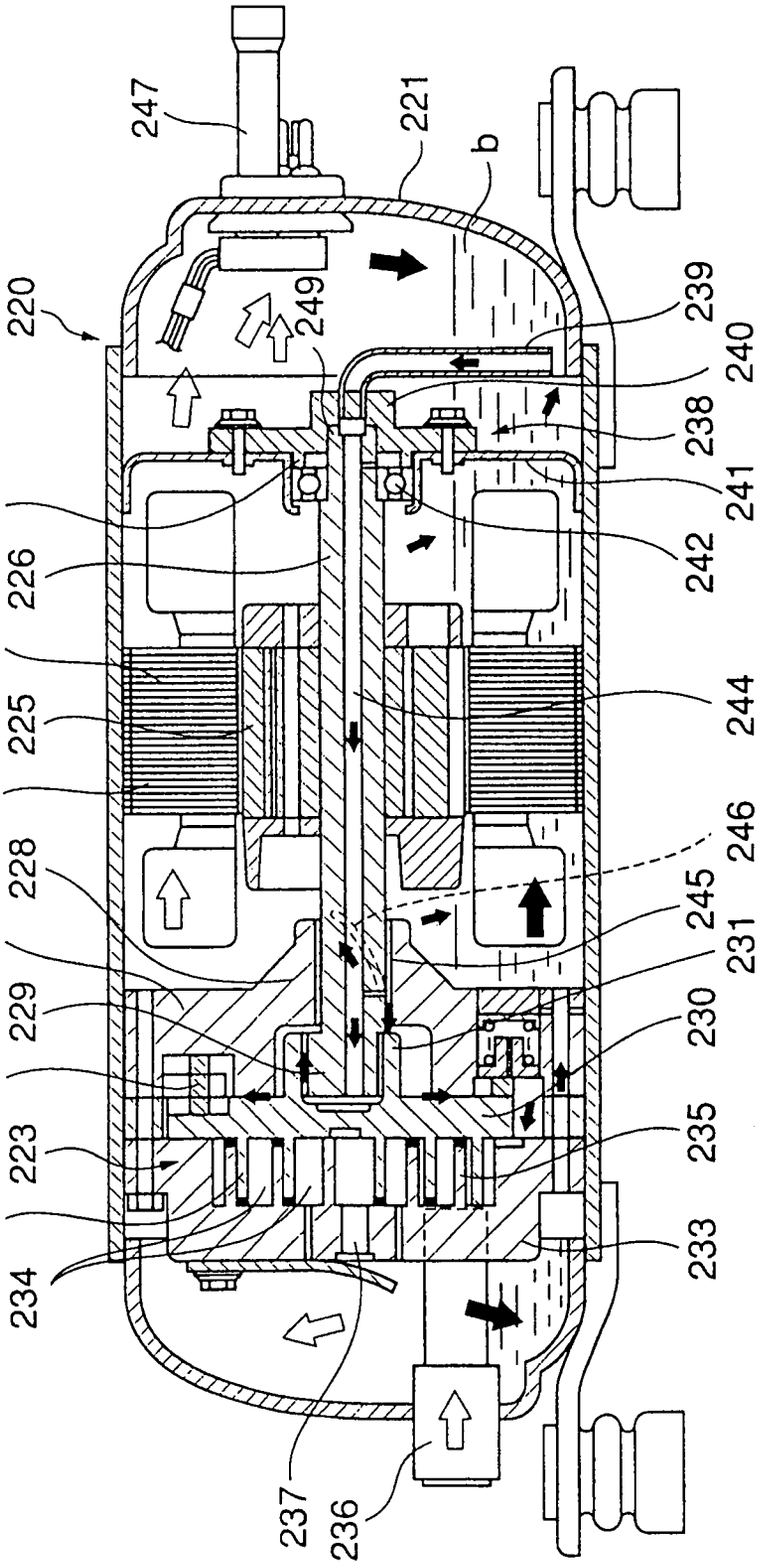
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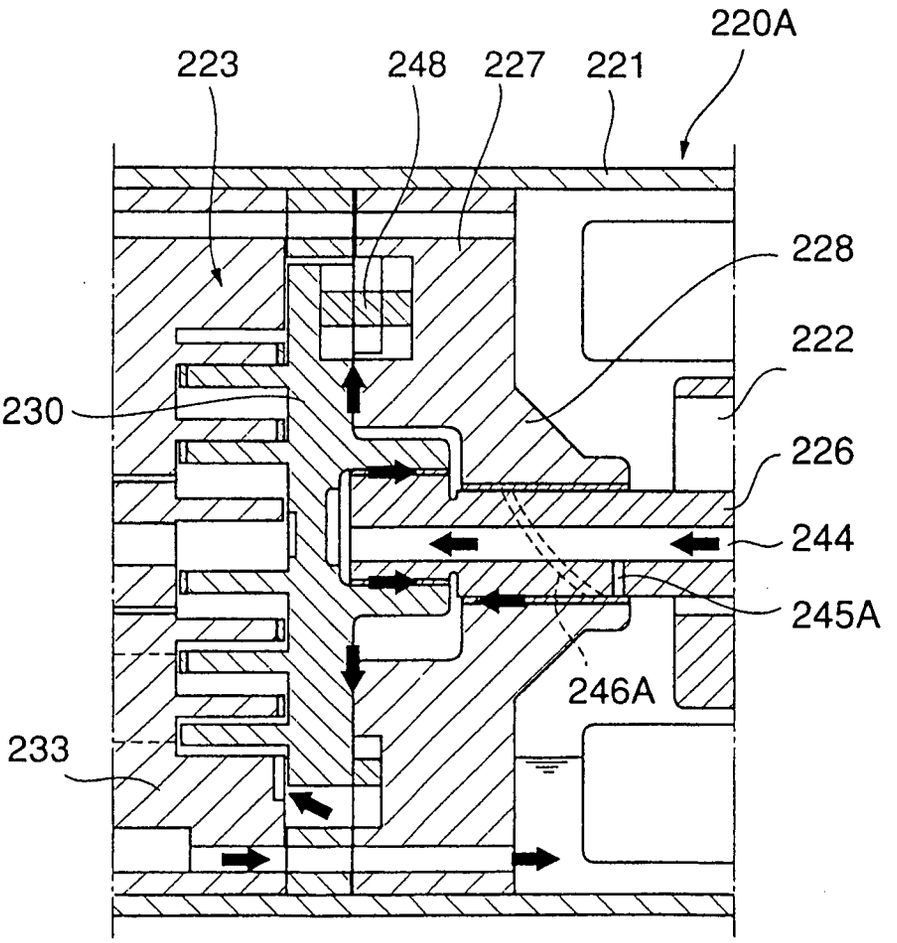
Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 03 00 6366

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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Y	PATENT ABSTRACTS OF JAPAN vol. 015, no. 013 (M-1069), 11 January 1991 (1991-01-11) & JP 02 264181 A (HITACHI LTD), 26 October 1990 (1990-10-26) * abstract *	2,3	
Y	US 5 110 268 A (SAKURAI ET AL.) 5 May 1992 (1992-05-05) * claim 1; figure 1 *	4,5	
X	US 5 013 225 A (RICHARDSON, JR.) 7 May 1991 (1991-05-07) * column 5, line 14 - column 6, line 19; figure 1 *	1	
A	US 5 660 539 A (MATSUNAGA ET AL.) 26 August 1997 (1997-08-26) * column 7, line 55 - column 8, line 6; figure 1 * * column 8, line 51 - column 9, line 32; figures 1,2 *	1-5	TECHNICAL FIELDS SEARCHED (Int.Cl.7) F04C F01C
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 427 (M-1174), 30 October 1991 (1991-10-30) & JP 03 179189 A (HITACHI LTD), 5 August 1991 (1991-08-05) * abstract *	1-3	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	4 April 2003	Dimitroulas, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 545 (M-1337), 16 November 1992 (1992-11-16) & JP 04 203377 A (HITACHI LTD), 23 July 1992 (1992-07-23) * abstract *	1-3	
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