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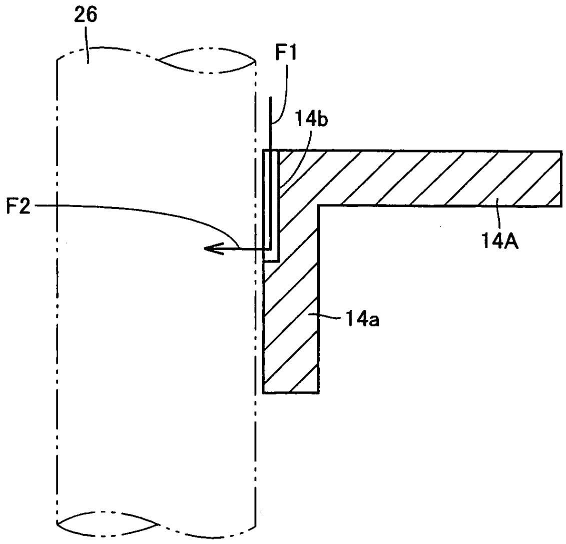
(54) ENCLOSED COMPRESSOR

(57) In a sealed type compressor, an oil supply groove (14b) is not a communicating groove open at the upper and lower ends, and extends only to a region partway of a bearing portion (14a) at a lower end side of a crankshaft (26). As a result, the lubricant supplied to a lower bearing (14A) is entirely applied to the lower bearing (14A) without a portion being discharged to an oil reservoir. By employing such a configuration to reduce futile drawing of the lubricant at an oil pump, there can be provided a sealed type compressor that allows the oil supply capability of the oil pump to be improved to suppress occurrence of pump loss.

FIG.2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a sealed type compressor, more particularly, an improvement in the structure of a sealed type compressor.

BACKGROUND ART

<Overall Arrangement of Rotary Compressor>

[0002] An overall arrangement of a rotary compressor will be described with reference to Fig. 6. Fig. 6 is a vertical sectional view representing an overall arrangement of a rotary compressor. At the lower end side of a casing 1 is arranged a compression element 7 corresponding to induction pipes 5a and 5b for compressing the input working fluid. In addition, a drive element 8 for driving compression element 7 is arranged thereabove, occupying substantially the entire region of the internal space. At the internal space defined by a lower lid 4 at the lower end region of casing 1, an oil reservoir 9 storing a lubricant O is formed. A storage space 10 for storing compressed working fluid is formed at another space.

<Compression Element 7>

[0003] Compression element 7 is configured having a cylinder chamber at an upper stage and at a lower stage, i.e. two cylinder chambers. Compression element 7 includes an upper cylinder 12a with a cylinder chamber 11a having a circular transverse cross section, a lower cylinder 12b with a cylinder chamber 11b having a circular transverse cross section, and a middle plate 18 therebetween. On both upper and lower surfaces of upper cylinder 12a and lower cylinder 12b are provided an upper bearing 13 having a boss-shaped bearing portion 13a at its center and a lower bearing 14 also having a boss-shaped bearing portion 14a at its center, fastened by a plurality of bolts 15 to set cylinder chambers 11a and 11b at a sealed state.

[0004] Upper cylinder 12a and lower cylinder 12b are supported at a horizontal state in casing 1. An outlet 13c is provided at upper bearing 13. A front muffler 16 is secured to upper bearing 13 around bearing portion 13a so as to form an annular gap with respect to bearing portion 13a of upper bearing 13. Furthermore, an outlet 14c is provided at lower bearing 14. In addition, a rear muffler 17 that partitions oil reservoir 9 from the discharge space is secured to lower bearing 14 around bearing portion 14a of lower bearing 14.

[0005] An upper piston 19a and a lower piston 19b are arranged at cylinder chambers 11a and 11b of upper cylinder 12a and lower cylinder 12b, respectively. Upper and lower pistons 19a and 19b are arranged at the outer circumference of eccentric portions 20a and 20b of a crankshaft 26.

<Drive Element 8>

[0006] Drive element 8 includes an electric motor constituted of a stator 24 and a rotor 25. Stator 24 is fixedly-supported to an inner wall of a middle cylindrical body 2 in a casing 1. A rotor 25 is disposed concentrically with and at the inner side of stator 24 with a predetermined circumferential gap therebetween. The upper half portion of crankshaft 26 is mounted at the inner side of rotor 25 to rotate integrally about the shaft center. The lower half portion of crankshaft 26 is fit-supported rotatably by both bearing portions 13a and 14a of upper bearing 13 and lower bearing 14.

[0007] An oil channel 26a extending along the shaft center direction is formed at crankshaft 26. A centrifugal oil pump 27 is attached at the lower end of crankshaft 26. Oil pump 27 is constantly immersed in lubricant O of oil reservoir 9 to draw up lubricant O into oil channel 26a according to the rotation of crankshaft 26. The lubricant is supplied through a plurality of lubricant supply holes 26b provided at crankshaft 26 to each slidable site of compression element 7 and drive element 8.

[0008] The supply of lubricant towards bearing portion 14a of lower bearing 14 will be described hereinafter with reference to Figs. 7 and 8. Fig. 7 is a perspective view of lower bearing 14, viewed from the bearing portion 14a side. Fig. 8 is a vertical sectional view of lower bearing 14. As shown in Fig. 7, a communicating groove 14c is provided at the inner circumferential face of bearing portion 14a of lower bearing 14, spanning from the upper end to the lower end in parallel with crankshaft 26 along the shaft center direction. The lubricant output from lubricant supply opening 26b provided at crankshaft 26 runs along the outer surface of crankshaft 26 (F1) via communicating groove 14c to be supplied to the region between bearing portion 14a and the sliding face of crankshaft 26 (F2).

[0009] Since communicating groove 14c has both the upper and lower ends open as shown in Fig. 8, not all the lubricant (F1) output from lubricant supply hole 26b is supplied to the region between bearing portion 14a and the sliding face of crankshaft 26. A portion of the lubricant (F3) is discharged to oil reservoir 9 without being used as the lubricant.

[0010] It is to be noted that oil pump 27 draws up an amount of lubricant, a portion that will discharged to oil reservoir 9 without being used for lubrication, in addition to the amount required for lubrication towards respective sliding sites, causing futile pump loss. Patent Document 1 set forth below can be cited as a document disclosing a rotary compressor such as that shown in Fig. 4. In addition, Non-Patent Document 1 can be cited as a document disclosing the art of a rotary compressor oil supply system.

[0011] Patent Document 1: Japanese Patent Laying-Open No. 2004-324652

[0012] Non-Patent Document 1: Takahide Ito et al. "Study On Oil Supply System for Rotary Compressors", Mitsubishi Juko Giho, Mitsubishi Heavy Industries Ltd. September 1992, Vol. 29, No. 5, pp. 458-462

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0013] The problem to be solved by the invention arises from the fact that the oil supply groove provided at the lower bearing employed in a sealed type compressor is a communicating groove with both the upper and lower ends open. Futile pump loss occurs since the oil pump must draw up the lubricant that is merely to be output to the oil reservoir without being supplied to the lower bearing even though there is sufficient lubricant to be discharged to the oil reservoir. Thus, the present invention is directed to solving the above-described problem, and provides a sealed type compressor allowing improvement in the oil supply capability of the oil pump to suppress occurrence of pump loss by reducing futile induction of lubricant at the oil pump.

MEANS FOR SOLVING THE PROBLEMS

[0014] A sealed type compressor according to the present invention has a compression element and a drive element accommodated in a sealed vessel, and includes a crankshaft, a piston disposed at an outer circumference of an eccentric portion of the crankshaft, a cylinder defining a cylinder chamber where the piston is disposed, and an upper bearing and a lower bearing having a bearing portion to support the crankshaft axially, and sandwiching the cylinder and the piston from respective axial sides of the crankshaft.

[0015] The sealed type compressor includes an oil pump provided at a lower end of the crankshaft to draw up a lubricant stored in an oil reservoir at the lower end portion of the sealed vessel into an oil channel provided extending along a shaft center direction of the crankshaft to provide lubrication to each sliding site of the compression element and drive element, and an oil supply groove provided at a sliding face of the bearing portion of the lower bearing, extending along an axial direction of the crankshaft to supply the lubricant to the outer surface of the crankshaft.

[0016] The oil supply groove has one end side open at an end face of the cylinder side, and the other end side closed at a lower end side of the crankshaft.

EFFECTS OF THE INVENTION

[0017] According to the sealed type compressor of the present invention, the oil supply groove provided at the lower bearing is not a communicating groove open at the upper and lower ends, and is closed at the lower end side of the crankshaft. As a result, the lubricant supplied to the lower bearing is entirely applied to the lower bearing without a portion being discharged to the oil reservoir.

[0018] Thus, by reducing futile induction of lubricant at the oil pump, the oil supply capability of the oil pump can be improved to suppress occurrence of pump loss.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a perspective view of only a lower bearing employed in a rotary compressor according to an embodiment of the present invention, viewed from the bearing portion side.

Fig. 2 is a vertical sectional view of a lower bearing employed in a rotary compressor according to an embodiment of the present invention.

Fig. 3 represents the oil supply rate to each sliding site when the lower bearing of background art is employed, and the oil supply rate to each sliding site when the lower bearing of the present embodiment is employed.

Fig. 4 is a sectional view representing the dimensional relationship of a lower bearing employed in a rotary compressor according to an embodiment of the present invention.

Fig. 5 represents the relationship of X/L and the bearing temperature increase (°C) of a lower bearing employed in a rotary compressor according to an embodiment of the present invention.

Fig. 6 is a vertical sectional view representing an overall arrangement of a rotary compressor according to background art.

Fig. 7 is a perspective view of only a lower bearing employed in a rotary compressor according to background art, viewed from the bearing portion side.

Fig. 8 is a vertical sectional view of a lower bearing employed in a rotary compressor according to background art.

DESCRIPTION OF THE REFERENCE SIGNS

[0020] 1 casing; 4 lower lid; 5a, 5b induction pipe; 7 compressor element; 8 drive element; 9 oil reservoir; 10 storage space; 11a, 11b cylinder chamber; 12a upper cylinder; 12b lower cylinder; 13 upper bearing; 13a bearing portion; 13c, 14c outlet; 14A lower bearing; 14a bearing portion; 14b oil supply groove; 14c communicating groove; 15 bolt; 16 front muffler; 17 rear muffler; 18 middle plate; 19a upper piston; 19b lower piston; 24 stator; 25 rotor; 26a oil channel; 26b lubricant supply hole; 27 oil pump; O lubricant.

BEST MODES FOR CARRYING OUT THE INVENTION

[0021] Each of the embodiments of a sealed type compressor according to the present invention will be described hereinafter with reference to the drawings. As an example of a sealed type compressor of the present embodiment, an application of the present invention to the rotary compressor set forth above in the background art will be described.

[0022] The rotary compressor of the present embodiment has the same basic arrangement as the rotary compressor with a cylinder chamber at an upper stage and at a lower stage, i.e. two cylinder chambers, described with reference to Fig. 6. A compression element 7 and a drive element 8 are accommodated in a casing 1 that is a sealed vessel. The rotary compressor includes a crankshaft 26, an upper piston 19a and a lower piston 19b arranged at the outer circumference of eccentric portions 20a and 20b of crankshaft 26, an upper cylinder 12a and a lower cylinder 12b defining cylinder chambers 11a and 11b where upper piston 19a and lower piston 19b are disposed, and bearing portions 13a and 14a to axial-support crankshaft 26.

[0023] There are further provided an upper bearing 13 and a lower bearing 14 sandwiching upper cylinder 12a, upper piston 19a, lower cylinder 12b and lower piston 19b from respective axial sides of crankshaft 26.

[0024] In addition, at the lower end of crankshaft 26 is provided an oil pump 27 to draw up a lubricant O stored in an oil reservoir 9 at the lower end portion of casing 1 into an oil channel 26a provided so as to extend along the shaft center direction of crankshaft 26 to provide lubrication to each sliding site of compression element 7 and drive element 8, according to the rotation of crankshaft 26.

[0025] In the following description, elements identical to or corresponding to those of the rotary compressor described with reference to Fig. 6 have the same reference characters allotted, and description thereof will not be repeated. Only the characteristic features of the present invention will be described in detail hereinafter.

[0026] Referring to Figs. 1 and 2, the characteristic portion of the rotary compressor of the present embodiment will be described. Fig. 1 is a perspective view of only lower bearing 14A employed in the rotary compressor of the present embodiment, viewed from the bearing portion 14a side. Fig. 2 is a vertical sectional view of lower bearing 14A.

[0027] As shown in Fig. 1, an oil supply groove 14b is provided at the inner circumferential face of bearing portion 14a of lower bearing 14A. Oil supply groove 14b has one end side open at the end face of the cylinder 12b side (refer to Fig. 6).

[0028] The other end side of oil supply groove 14b extends to a region partway of bearing portion 14a at the lower end side of crankshaft 26.

[0029] The lubricant (F1) discharged from lubricant supply opening 26b provided at crankshaft 26 (refer to Fig. 6) runs along the outer surface of crankshaft 26 via oil supply groove 14b to be supplied to the region between bearing portion 14a and the sliding face of crankshaft 26 (F2).

[0030] As shown in Fig. 2, oil supply groove 14b is not a communicating groove open at the lower end, and extends to a region only as far as partway of bearing portion 14a at the lower end side of crankshaft 26. Since oil supply groove 14b takes a closed state at the lower end side of crankshaft 26, the lubricant supplied to lower bearing 14A is entirely applied to lower bearing 14A without a portion being discharged to oil reservoir 9 (refer to Fig. 6). Fig. 1 represents a configuration in which oil supply groove 14b extends to a region only as far as partway of bearing portion 14a at the lower end side of crankshaft 26. In the case where the groove is provided extending from the upper end to the lower end of crankshaft 26, likewise of communicating groove 14c shown in Fig. 7, a structure of closing the lower end side of the oil supply groove can be adapted by providing another member such as a plate member at the lower end of the groove.

[0031] Fig. 3 represents the oil supply rate (cc/min) of the lubricant to each sliding site corresponding to the case where lower bearing 14 of the background art shown in Fig. 8 is employed, and the oil supply rate (cc/min) to each sliding site corresponding to the case where lower bearing 14A of the present embodiment is employed. The oil supply rate (cc/min) of the lubricant supplied to the upper bearing (A1), upper piston 19a (A2), and lower piston 19b (A3) does not vary between the background art and the present embodiment.

[0032] However the oil supply rate (cc/min) of lubricant to the lower bearing (A4) is greatly reduced in the present embodiment, as compared to that of the background art. This is because the lubricant supplied to lower bearing 14A of the present embodiment is entirely applied to lower bearing 14 without being partially discharged to oil reservoir 9 (refer to Fig. 6), as described before, avoiding unnecessary drawing up of lubricant by oil pump 27.

[0033] The effect on the bearing performance when oil supply groove 14b is closed at the lower end side of bearing portion 14a will be studied from the standpoint of

<bearing friction loss> and <cooling performance of bearing>.

<Bearing Friction Loss>

[0034] The most critical factor in the issue of the oil supply rate involved in the reliability of a bearing is the cooling performance. It is possible to appraise the cooling performance by estimating how much the oil temperature rises by the generated bearing friction loss. The bearing friction loss W can be expressed by equation 1 set forth below, where L is the overall bearing length, r the bearing radius, μ the oil viscosity, u the sliding rate, C the clearance, and δ the oil film clearance. Assuming that overall bearing length L, bearing radius r, oil viscosity μ and sliding rate u are constants in equation 1, bearing friction loss W will rapidly increase when the oil film clearance δ approaches zero.

$$W = [2\pi L r \mu u^2] \div [C(1-\lambda^2)^{1/2}] \qquad \ldots (1)$$

(where $\lambda = 1 - (\delta/C)$)

<Cooling Performance of Bearing>

[0035] In the case where it is assumed that the oil supply rate to the bearing varies linearly when the length of the oil supply groove is shortened, and that the oil film clearance in such a case also varies linearly in proportion to the oil supply rate, a shorter length of the oil supply groove causes reduction in the oil supply rate, which in turn reduces the oil film clearance to increase the bearing friction loss. It is to be noted that the bearing friction loss tends to increase suddenly when the oil film clearance becomes small, as indicated by equation 1 set forth above. Therefore, when the oil film clearance becomes small, the temperature of the bearing rises significantly since cooling is effected with a smaller amount of lubricant corresponding to the greater bearing friction loss.

[0036] The relationship between the ratio (X/L) of the length of the oil supply groove (X) to the entire length of the bearing (L) and the bearing temperature increase will be described with reference to Figs. 4 and 5. Fig. 4 is a sectional view representing the dimensional relationship of lower bearing 14A. Fig. 5 represents the relationship between X/L and the bearing temperature increase (°C). As shown in Fig. 5, the bearing temperature is maintained below approximately 20 degrees when the X/L is from 0.4 to 1. The bearing temperature is also below approximately 40 degrees when the X/L is from 0.2 to 0.4. However, when the X/L becomes lower than 0.2, the oil film clearance becomes small to cause increase of the bearing friction loss. As a result, the cooling performance is greatly degraded. It is therefore desirable that the X/L is in the range from 0.2 to 0.8, preferably from 0.6 to 0.8.

[0037] Although the embodiment has been described based on the case where the present invention is applied to a rotary compressor having a cylinder at an upper stage and at a lower stage, i.e. two cylinders, the present invention is also applicable to a rotary compressor having a cylinder at one stage. Moreover, the structure based on the present invention is widely applicable, not only to rotary compressors, but to other sealed type compressors having a similar compression element structure.

[0038] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the appended claims, and all changes that fall within the limits and bounds of the claims, or equivalence thereof are intended to be embraced by the claims.

Claims

1. A sealed type compressor having a compression element (7) and a drive element (8) accommodated in a sealed vessel (1), the sealed type compressor including a crankshaft (26), a piston (19a, 19b) disposed at an outer circumference of an eccentric portion (20a, 20b) of said crankshaft (26), a cylinder (12a, 12b) defining a cylinder chamber

(11a, 11b) where said piston (19a, 19b) is disposed, and an upper bearing (13) and a lower bearing (14) having a bearing portion (13a, 13b) to support said crankshaft axially, and sandwiching said cylinder (12a, 12b) and said piston (19a, 19b) from respective axial sides of said crankshaft (26), said sealed type compressor comprising:

an oil pump (27) provided at a lower end of said crankshaft (26) to draw up a lubricant (O) stored in an oil reservoir (9) at a lower end portion of said sealed vessel (1) into an oil channel (26a) provided extending in a shaft center direction of said crankshaft (26) to provide lubrication at each sliding site of the compression element (7) and drive element (8), according to rotation of said crankshaft (26), and
an oil supply groove (14b) provided at a sliding face of said bearing portion (14a) of said lower bearing (14), extending along an axial direction of said crankshaft (26) to supply the lubricant to an outer surface of said crankshaft (26),
said oil supply groove (14b) having one end side open at an end plane of said cylinder (12b) side and an other end side of said oil supply groove (14b) closed at a lower end side of said crankshaft (26).

2. The sealed type compressor according to claim 1, wherein the other end side of said oil supply groove (14b) extends to a region partway of said bearing portion (14a).

3. The sealed type compressor according to claim 1, wherein a value of X/L is set in a range from 0.2 to 1.0, where X is a length of said oil supply groove (14b) and L is an overall bearing length L of said bearing portion (14a).

FIG.1

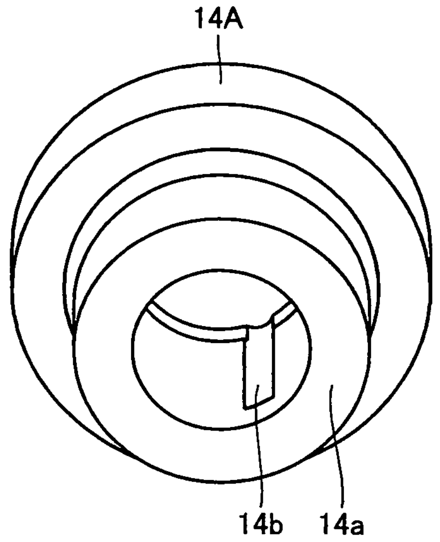


FIG.2

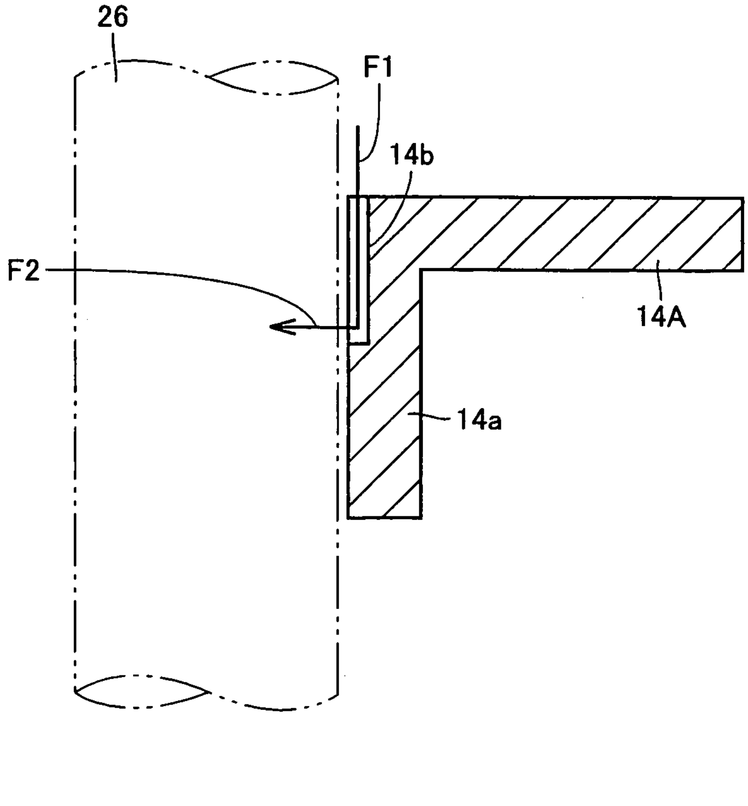


FIG.3

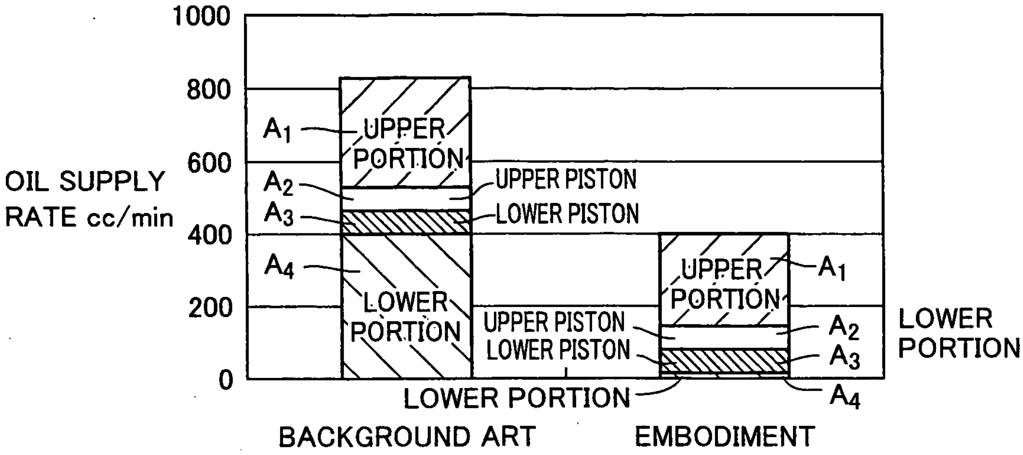


FIG.4

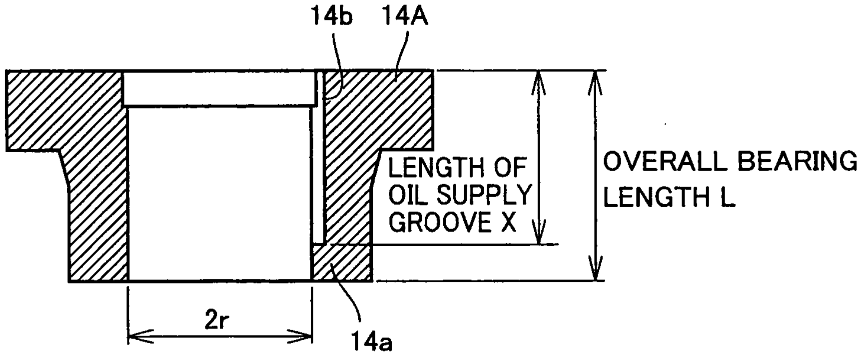


FIG.5

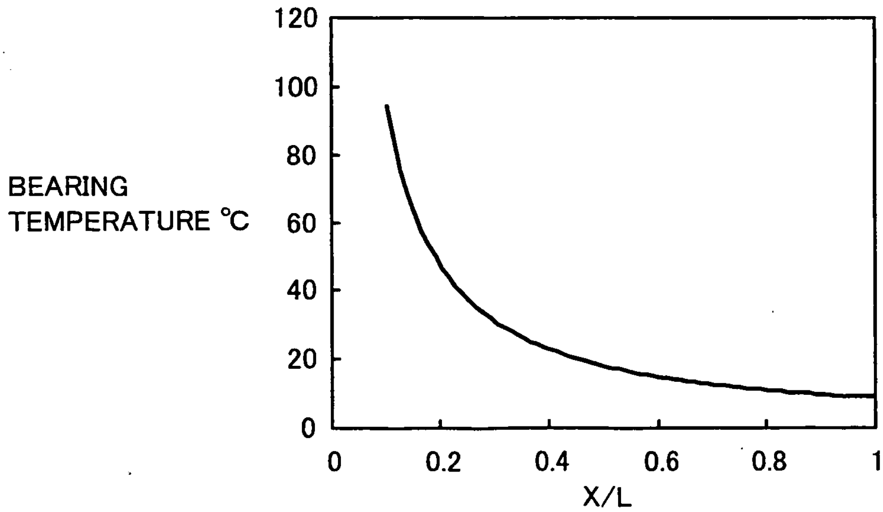


FIG.6

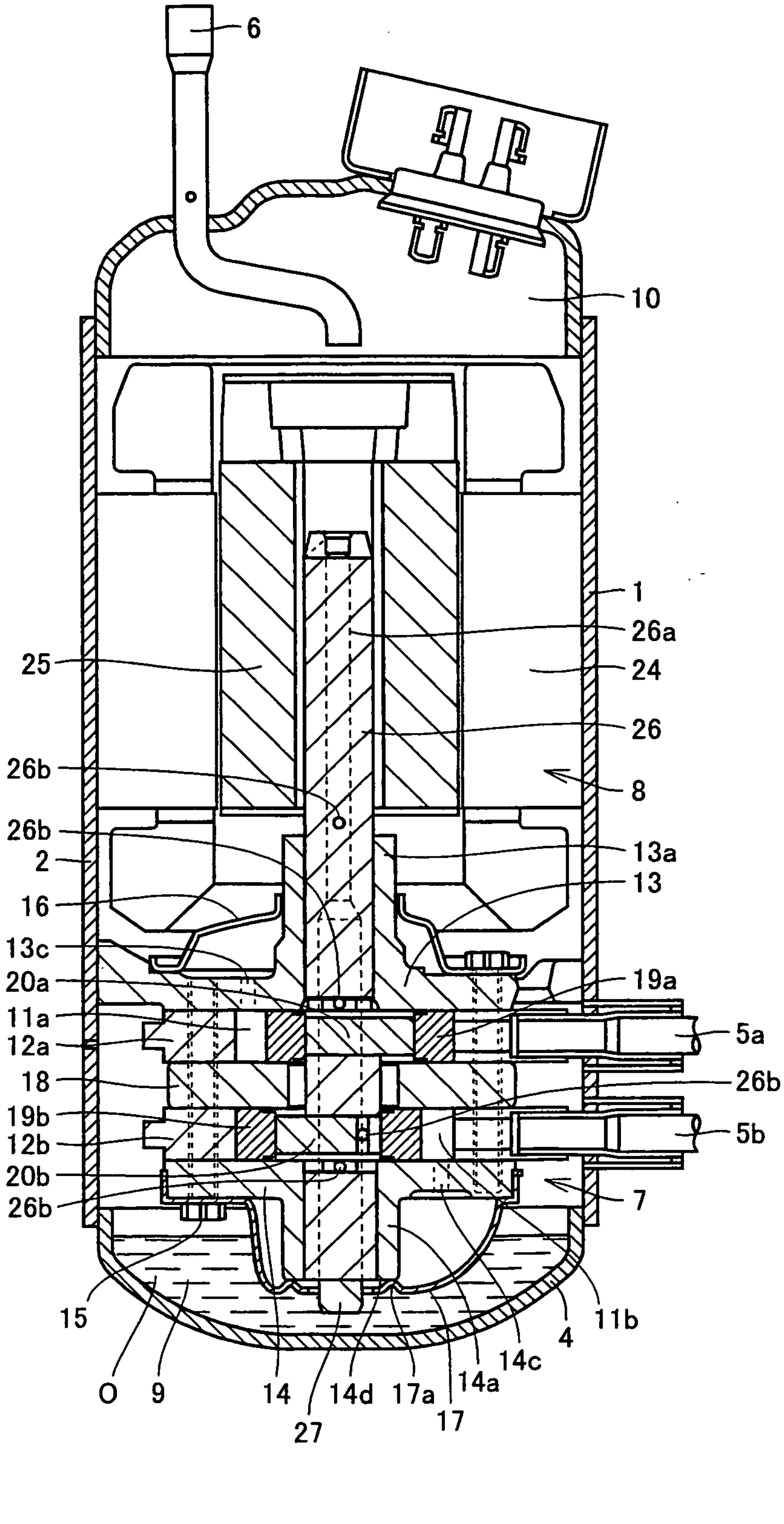

6
10
1
26a
25
24
26
26b
8
26b
13a
2
13
16
13c
19a
20a
11a
5a
12a
18
26b
19b
5b
12b
20b
7
26b
15
11b
4
14c
14a
O
9
14
14d
17a
17
27

FIG.7

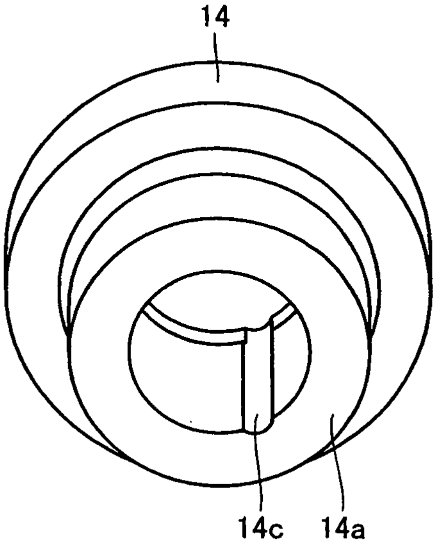
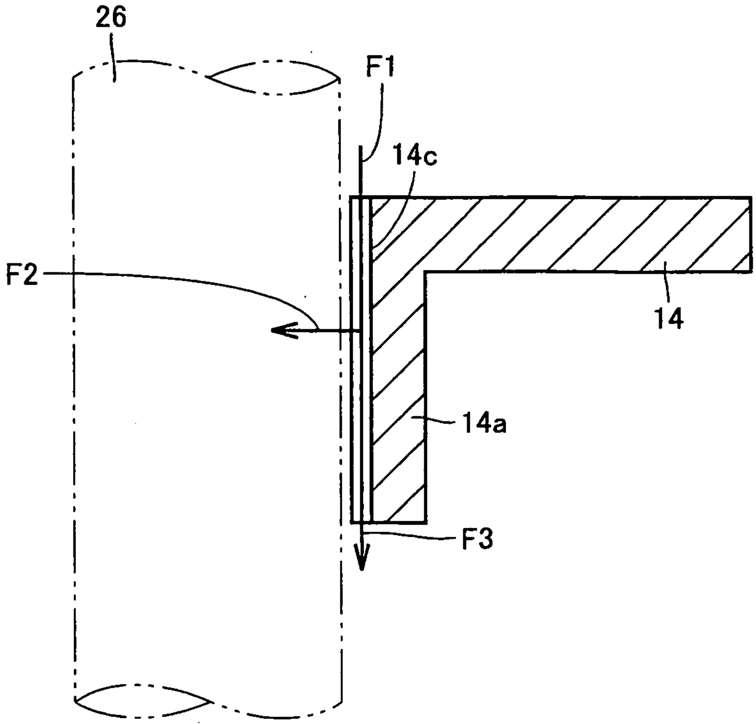


FIG.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/069493

A. CLASSIFICATION OF SUBJECT MATTER
F04C29/02(2006.01)i, *F04C29/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04C29/02, F04C29/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 54669/1991(Laid-open No. 7986/1993) (Mitsubishi Heavy Industries, Ltd.), 02 February, 1993 (02.02.93), Full text; Figs. 3, 5, 6 (Family: none)	1-3
Y	JP 2004-332687 A (Matsushita Electric Industrial Co., Ltd.), 25 November, 2004 (25.11.04), Full text; all drawings & CN 1538071 A	1-3

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
20 January, 2009 (20.01.09)	03 February, 2009 (03.02.09)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/069493

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 213/1996(Laid-open No. 1194/1996) (Sanyo Electric Co., Ltd.), 30 July, 1996 (30.07.96), Full text; all drawings (Family: none)	1-3

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004324652 A **[0011]**

Non-patent literature cited in the description

- **Takahide Ito ; Mitsubishi Juko Giho et al.** Study On Oil Supply System for Rotary Compressors. Mitsubishi Heavy Industries Ltd, September 1992, vol. 29, 458-462 **[0012]**