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

(11) EP 2 088 322 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
12.08.2009 Bulletin 2009/33

(21) Application number: **07849947.2**

(22) Date of filing: **30.11.2007**

(51) Int Cl.:
F04B 39/06 (2006.01) ***F04B 27/08*** (2006.01)
F04B 39/10 (2006.01) ***F16K 3/26*** (2006.01)

(86) International application number:
PCT/JP2007/073169

(87) International publication number:
WO 2008/066156 (05.06.2008 Gazette 2008/23)

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

(30) Priority: **01.12.2006 JP 2006325544**

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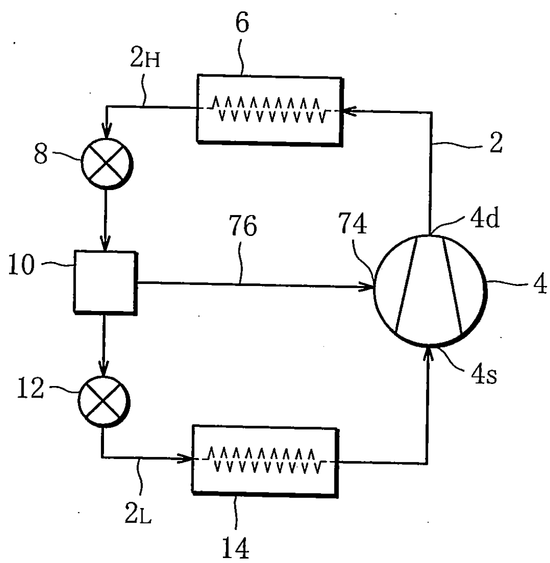
(54) RECIPROCATING COMPRESSOR OF REFRIGERATING MACHINE

(57) The present invention provides a reciprocating compressor for a refrigerator capable of restraining an increase in temperature of a refrigerant discharged and increasing refrigerant compression efficiency.

The compressor according to the present invention includes a housing (16) having cylinder bores (30), pistons (32) fitted in the respective cylinder bores (30) and each capable of reciprocating motion in the bore (30), an intermediate pressure chamber (68) arranged in the housing (16) and supplied with the refrigerant at a low temperature from a gas-liquid separator (10) of the refrigerator, and a rotary valve (78) arranged between the chambers (33,68). The rotary valve (78) is rotated in association with a main shaft (34) of the compressor and opened to inject the low-temperature refrigerant into each compression chamber (33) from the intermediate pressure chamber (68) while the compression chamber (33) is in a process of compressing the refrigerant.

FIG. 1



EP 2 088 322 A1

Description

Technical Field

[0001] This invention relates to a reciprocating compressor for a refrigerator, and particularly a compressor suited for a refrigerator included in an automotive air conditioning system.

Background Art

[0002] The reciprocating compressor of this type includes a cylinder block having a plurality of cylinder bores, pistons fitted in the respective cylinder bores to be capable of reciprocating within them, each piston defining a compression chamber within its own cylinder bore, and a main shaft rotatable to cause the pistons to reciprocate within their own cylinder bores. The rotation of the main shaft causes the respective pistons to reciprocate within their own cylinder bores successively. By reciprocating in this manner, each piston repeats a process of sucking a refrigerant into its compression chamber, compressing the refrigerant in the compression chamber and discharging the compressed refrigerant from the compression chamber (Patent Document 1).

Patent Document 1: Japanese Patent Application KOKAI Publication 2001-027177

Disclosure of the Invention

Problem to be solved by the Invention

[0003] Generally, an alternative for chlorofluorocarbon, called R134a, is used as a refrigerant in the automotive air conditioning system, specifically in the refrigerator thereof. Such alternatives for chlorofluorocarbon have, however, a very high GWP (Global Warming Potential). Specifically, the aforementioned alternative for chlorofluorocarbon has a GWP of about 1300.

[0004] Thus, the refrigerator of Patent Document 1 uses carbon dioxide (CO_2) having a low GWP as a refrigerant, in place of the aforementioned alternative for chlorofluorocarbon. In recent years, use of new alternative refrigerants having a low GWP has been proposed. Such new alternative refrigerants include a double bond (R1234yf etc., for example).

[0005] The temperature of the CO_2 refrigerant compressed by the compressor, namely the discharge temperature thereof, is higher than that of R134a compressed by the compressor. Specifically, the discharge temperature of the CO_2 refrigerant is above 150°C, so that the compressor undergoes a large thermal load. On the other hand, the discharge temperature of the aforementioned new alternative refrigerants compressed by the compressor is held down at the same level as that of R134a. The new alternative refrigerants including a double bond is however liable to decomposition at their discharge temperature, since the double bond is easily broken in high-temperature use conditions.

[0006] The primary object of the present invention is to provide a reciprocating compressor for a refrigerator capable of restraining an increase in discharge temperature of the refrigerant and increasing refrigerant compression efficiency.

Means for solving the Problem

[0007] In order to achieve the above object, a reciprocating compressor for a refrigerator according to the present invention comprises a housing having cylinder bores; pistons fitted in the respective cylinder bores to define compression chambers in the respective cylinder bores, the pistons each being capable of reciprocating motion in their own cylinder bore and each repeating, by their reciprocating motion, a process of sucking a refrigerant into their own compression chamber, compressing the sucked refrigerant in the compression chamber and discharging the compressed refrigerant from the compression chamber so that the discharged refrigerant is supplied to a refrigerant circulation path of the refrigerator; and an introduction device arranged in the housing to allow an intermediate refrigerant to be introduced from the refrigerant circulation path into each compression chamber only for a predetermined period of time while the compression chamber is in a process of compressing the refrigerant, where the pressure of the intermediate refrigerant is above the pressure of the refrigerant being compressed in the compression chamber.

[0008] It is desirable that the intermediate refrigerant allowed to be introduced into each compression chamber by the introduction device has a temperature lower than the temperature of the refrigerant being compressed within the compression chamber.

[0009] Specifically, it may be arranged such that the introduction device includes an intermediate pressure chamber defined in the housing and supplied with the intermediate refrigerant from the refrigerant circulation path; connection passages connecting the intermediate pressure chamber and the respective compression chambers; and a valve associated with the connection passages to open and close the connection passages, where the valve opens each connection passage while the corresponding compression chamber is in the process of compressing the refrigerant and closes the connection passage before the refrigerant being compressed reaches to the pressure of the intermediate refrigerant in the intermediate pressure chamber.

[0010] In the above-described reciprocating compressor, the valve is opened while each compression chamber is in the process of compressing the refrigerant. At the time that the valve is opened, the pressure of the intermediate refrigerant in the intermediate pressure chamber is higher than the pressure of the refrigerant being compressed in the compression chamber. Thus, when the valve is opened, the intermediate refrigerant is injected into the compression chamber. At this time, the temperature of the intermediate refrigerant is lower than the temperature of the refrigerant being compressed within the compression chamber. Consequently, by mixing with the intermediate refrigerant, the refrigerant being compressed within the compression chamber is cooled.

[0011] This restrains an increase in temperature of the refrigerant discharged from the compressor, therefore, allows carbon dioxide and the aforementioned refrigerants containing a compound with a double bond to be used as a refrigerant, which contributes much to prevention of global warming. Further, injecting the intermediate refrigerant into the compression chamber while the compression chamber is in the process of compressing the refrigerant leads to an increase in refrigerant compression efficiency, which results in a great improvement in energy efficiency of the refrigerator.

[0012] The aforementioned valve may be a rotary valve mechanically connected to a main shaft of the compressor to rotate integrally with the main shaft, or a rotary valve caused to rotate by a motor independent from the main shaft, or a solenoid-operated valve.

[0013] The compressor may further comprise a variable displacement mechanism capable of varying the amount of the compressed refrigerant discharged, where the variable displacement mechanism includes a swashplate.

Brief Description of the Drawings

[0014]

FIG. 1 is a diagram showing a schematic configuration of a refrigerator,'

FIG. 2 is a cross-sectional view showing details of a compressor indicated in FIG. 1,

FIG. 3 is a diagram showing a variant of a rotary valve, and

FIG. 4 is a diagram showing a solenoid-operated on-off valve.

Best Mode of Carrying out the Invention

[0015] A refrigerator shown in FIG. 1 is incorporated in an automotive air conditioning system and has a refrigerant circulation path 2. A compressor 4, a condenser 6, a first expansion valve 8, a gas-liquid separator 10, a second expansion valve 12 and an evaporator 14 in this order are inserted in the circulation path 2. The compressor 4 compresses a refrigerant and discharges the compressed refrigerant, and the refrigerant discharged is supplied to the condenser 6 and then circulates along the circulation path 2.

[0016] The circulation path 2 includes a high-pressure section 2_H extending from a discharge port 4d of the compressor 4 to the first expansion valve 8 via the condenser 6, and a low-pressure section 2_L extending from the first expansion valve 8 to an intake port 4s of the compressor 4 via the gas-liquid separator 10, the second expansion valve 12 and the evaporator 14.

[0017] FIG. 2 shows details of the compressor 4.

[0018] The compressor 4 is a variable-displacement reciprocating compressor and includes a housing 16. When viewed from the left side in FIG. 2, the housing 16 has an end plate 18, a center casing 20 and a cylinder head 22, and these end plate 18, center casing 20 and cylinder head 22 are integrally joined together.

[0019] The center casing 20 defines a crank chamber 24 therein. The crank chamber 24 is located between the end plate 18 and a cylinder block 26 which forms an end wall of the center casing 20.

[0020] Within the center casing 20, a compression unit 28 is arranged. The compression unit 28 will be described below in detail.

[0021] The cylinder block 26 has a plurality of cylinder bores 30 formed therein. The cylinder bores 30 are arranged circularly around the axis of the cylinder block 26 at equal intervals and each passes through the cylinder block 26. Pistons 32 are slidably fitted into the respective cylinder bores 30. The pistons 32 each define a compression chamber 33 within their own cylinder bore 30. FIG. 2 shows only one cylinder bore 30 and one piston 32.

[0022] A main shaft 34 is arranged in the crank chamber 24. The main shaft 34 is coaxial with the cylinder block 26 and has inner and outer ends. The inner end of the main shaft 34 is located in the cylinder block 26 and rotatably supported to the cylinder block 26 through a bearing 36. The outer end of the main shaft 34 is located outside the housing 16. Thus, the main shaft 34 penetrates the end plate 18 and is supported to the end plate 18 by means of a bearing 38 and a seal unit 40. The outer end of the main shaft 34 is connected to an automotive engine through a power transmission path (not shown). Thus, drive power transmitted from the engine to the main shaft 34 causes the main shaft 34 to rotate in one direction.

[0023] A rotor 42 is mounted on the main shaft 34. The rotor 42 is arranged within the crank chamber 24. The rotor 42 rotates integrally with the main shaft 34 and is rotatably supported on the end plate 18 through a thrust bearing 44.

[0024] Also a swashplate 46 is arranged within the crank and surrounds the main shaft 34. The swashplate 46 and the rotor 42 are connected together by means of a link 48. The link 48 allows the swashplate 46 to tilt with respect to the main shaft 34 so that the angle of inclination of the swashplate 46 can vary. Further, a wobble plate 54 is supported to the swashplate 46 through a radial bearing 50 and a thrust bearing 52. The wobble plate 54 is prevented from rotating on its axis by a rotation prevention mechanism (not shown).

[0025] The wobble plate 54 is connected to the pistons 32 through piston rods 56, respectively. Each piton rod 56 has a ball joint 57a, 57b at either end. The ball joint 57a connects the wobble plate 54 and the piston rod 56 together, while the ball joint 57b connects the piston rod

56 and the piston 32 together. Thus, when the main shaft 34 is rotated, the rotation of the main shaft 34 is converted into reciprocating motion of the pistons 32 by means of the rotor 42, the swashplate 46, the wobble plate 54 and the piston rods 56.

[0026] As clear from FIG. 2, a valve plate 58 is interposed between the cylinder block 26 and the cylinder head 22 with gaskets (not shown). The valve plate 58 have suction holes 60 and discharge holes 62, where one suction hole and one discharge hole are provided for each cylinder bore 30, thus, each compression chamber 33.

[0027] The valve plate 48 and the cylinder head 22 define a suction chamber 64, a discharge chamber 66 and an intermediate pressure chamber 68, and these chambers 64, 66, and 68 are independent from one another. More specifically, the intermediate pressure chamber 68 is located in the center of the cylinder head 22, the discharge chamber 66 annularly surrounds the intermediate pressure chamber 68, and the suction chamber 64 annularly surrounds the discharge chamber 66. Thus, the intermediate pressure chamber 68, the discharge chamber 66 and the suction chamber 64 form a triple structure.

[0028] The suction chamber 64 communicates with the suction holes 60 of the respective compression chambers 33, and is connected to the low-pressure section 2_L of the circulation path 2 by the aforementioned suction port 4s. The discharge chamber 66 communicates with the discharge holes 62 of the respective compression chambers 33, and is connected to the high-pressure section 2_H of the circulation path 2 by the aforementioned discharge port 4d. As clear from FIG. 2, the suction port 4s and the discharge port 4d are formed in the cylinder head 22.

[0029] The suction holes 60 have suction valves 70, respectively. The suction valves 70 can open and close the suction holes 60, respectively. The discharge holes 62 have discharge valves 72, respectively. The discharge valves 72 can open and close the discharge holes 62, respectively. The suction valves 70 and the discharge valves 72 are all reed valves. The suction valves 70 are arranged on one end face of the valve plate 58 located on the compression chamber side, and the discharge valves 72 are arranged on the other end face of the valve plate 58. In FIG. 2, reference character 73 denotes a valve retainer restricting the opening action of the discharge valve 72.

[0030] The cylinder head 22 also has an introduction port 74. The introduction port 74 communicates with the aforementioned intermediate pressure chamber 68, and is connected to an introduction path 76. As clear from FIG. 1, the introduction path 76 is connected to the aforementioned gas-liquid separator 10. The introduction path 76 conveys an intermediate refrigerant in gas phase from the gas-liquid separator 10 into the intermediate pressure chamber 68 through the introduction port 74.

[0031] A rotary valve 78 is arranged between the intermediate pressure chamber 68 and the main shaft 34. The rotary valve 78 is cylindrical in shape and rotatably fitted into cylinder block 26. Specifically, the cylinder block 26 has a cylinder hole 79 formed to receive the rotary valve 78, and the rotary valve 78 is air-tightly fitted within the cylinder hole 79.

[0032] The rotary valve 78 is coaxial with the main shaft 34 and integrally connected to the main shaft 34. Specifically, the main shaft 34 has a pin 80 projecting from its inner end into the rotary valve 78, and the pin 80 is connected to the rotary valve 78 by a key 82. Thus, the rotary valve 78 rotates integrally with the main shaft 34. While the rotary valve 78 is rotating, the outer cylindrical face of the rotary valve 78 is in an air-tight sliding contact with the inner cylindrical face of the cylinder hole 79. Further, the rotary valve 78 air-tightly penetrates through the valve plate 58 into the intermediate pressure chamber 68, and is rotatably fitted to the cylinder head 22 by means of an annular thrust bearing 84.

[0033] A valve passage 86 is formed in the rotary valve 78. The valve passage 86 has a valve opening 86a in the outer cylindrical face of the rotary valve 78 and a communication opening 86b communicating with the intermediate pressure chamber 86. As clear from FIG. 2, the valve opening 86a is located near the aforementioned one end face of the valve plate 58.

[0034] Further, a plurality of connection holes 88 are formed in the cylinder block 26. The connection holes 88 are associated with the compression chambers 33, respectively. More specifically, the connection holes 88 are radial holes 88 extending from the inner cylindrical face of the cylinder hole 79 to the respective compression chambers 33, and each having an outer end open to their associated compression chamber 33, near one end face of the valve plate 58, and an inner end open at the inner cylindrical face of the cylinder hole 79. The outer ends of the connection holes 88 are always connected to their associated compression chambers 33, irrespective of the reciprocating motion of the pistons 32. The inner ends of the connection holes 88 are arranged circularly around the rotary valve 78 at equal intervals, and while the rotary valve 78 is rotating, become connected to the valve opening 86a of the valve passage 86 periodically. Thus, the inner ends of the connection holes 88 are located on the circular track which the valve opening 86a describes while the rotary valve 78 is rotating.

[0035] Thus, when the rotary valve 78 is rotated integrally with the main shaft 34, the valve opening 86a of the valve passage 88 becomes connected to the connection holes 88 of the compression chambers 33, successively. This means that while the rotary valve 78 is rotating, the intermediate pressure chamber 68 becomes connected to the compression chambers 33 successively, by means of the rotary valve 78. Thus, the rotary valve 78 serves as a distribution valve for distributing the intermediate refrigerant in the intermediate pressure chamber 68 to the compression chambers 33 by opening and closing the connection holes 88, successively. The timing of distributing the intermediate refrigerant from the intermediate pressure chamber 68 to each compression chamber 33 and the duration of distribution will become clear from the description given later.

[0036] As mentioned above, while the main shaft 34 is rotated, the pistons 32 perform reciprocating motion within their own cylinder bores 30, successively. Consequently, the refrigerant is sucked into each compression chamber 33 from the suction chamber 64 via the suction valve 70 and the suction hole 60. The sucked refrigerant is then compressed within the compression chamber 33, and the compressed refrigerant is discharged from the compression chamber 33 into the discharge chamber 66 via the discharge hole 62 and the discharge valve 72. Since the discharge chamber 66 is connected to the high-pressure section 2_H of the circulation path 2, the discharged refrigerant is supplied from the compressor 2 to the condenser 6. Since, on the other hand, the suction chamber 64 is connected to the low-pressure section 2_L of the circulation path 2, the refrigerant from the evaporator 14 is drawn into each suction chamber 64 or each compression chamber 33.

[0037] The rotary valve 78 rotates integrally with the main shaft 34, and the valve opening 86a of the valve passage 86 of the rotary valve 78 is connected to the connection hole 88 of the compression chamber 33 which is in a process of compressing the refrigerant at the distribution timing, only for the distribution duration. In other words, the rotary valve 78 is opened at the distribution timing, and closed when the distribution duration expires. The distribution timing and distribution duration are set such that the distribution to each compression chamber 33 is carried out while the compression chamber is in the process of compressing the refrigerant and terminates before the pressure of the compressed refrigerant reaches to the pressure of the intermediate refrigerant in the intermediate pressure chamber 68.

[0038] Thus, while the refrigerant is being compressed, the intermediate refrigerant in the intermediate pressure chamber 68 is injected into the compression chamber 33 through the rotary valve 78 and the connection 88 when the rotary valve 78 is opened. As mentioned above, the intermediate pressure chamber 68 is supplied with the gaseous intermediate refrigerant from the aforementioned gas-liquid separator 10 via the introduction path 76. Thus, the intermediate refrigerant held in the intermediated pressure chamber 68 and injected into the compression chamber 33 has a temperature sufficiently lower than the discharge temperature of the refrigerant discharged from the compressor 4 and a pressure lower than the discharge pressure of the refrigerant discharged from the compressor 4. Since the low-temperature intermediate refrigerant injected into the compression chamber 33 mixes with the high-temperature refrigerant being compressed, the refrigerant being compressed within the compression chamber 33 is cooled, which restrains an increase in temperature of the refrigerant discharged from the compressor 4.

[0039] Since the increase in temperature of the refrigerant discharged is restricted in this manner, even when carbon dioxide is used as the refrigerant, the thermal load on the compressor 4 is reduced to a great extent, and even when a new alternative refrigerant including a double bond hydrocarbons, such as R1234yf, is used as the refrigerant, the double bond is not broken. Thus, the compressor 4 according to the present invention allows use of refrigerants suited to prevent global warming, such as carbon dioxide and the aforementioned new alternative refrigerants.

[0040] Further, the above-described injection of the low-temperature refrigerant into each compression chamber 33 increases the refrigerant compression efficiency in each compression chamber 33, which results in a significant improvement in energy efficiency of the refrigerator. This means easy realization of a multi-effect cycle demanded for this type of refrigerator.

[0041] The aforementioned crank chamber 24 is connected to the suction chamber 64 and the discharge chamber 66 through connection passages 96, 98 indicated in dashed line in FIG. 2, respectively. These connection passages 96, 98 penetrate the valve plate 58 and the cylinder block 26. The connection passage 96 includes an orifice 100, and the connection passage 98 includes a solenoid-operated control valve 102. The solenoid-operated control valve 102 controls the amount of the high-pressure refrigerant allowed to enter the crank chamber 24 from the discharge chamber 66, thereby regulating the pressure in the crank chamber 24.

[0042] The angle of inclination of the aforementioned swashplate 46 is determined by the compression reaction forces exerted on the front face of the swashplate 56 by the respective pistons 32 and the back pressure, i.e., the pressure in the crank chamber 24 exerted on the back face of the swashplate 46, and therefore varied by regulating the pressure in the crank chamber 24. Since the angle of inclination of the swashplate 46 determines the stroke of the pistons 32, the amount of the refrigerant discharged from the compressor 4 is varied according to the angle of inclination of the swashplate 46.

[0043] Since the aforementioned connection holes 86 of the compression chambers 33 are each located near the top dead center of their associated piston 32, varying the stroke of the pistons does not affect the timing and duration of distribution by the rotary valve 78 to each compression chamber 33. Consequently, the relationship between the pressure of the refrigerant discharged from the compressor 4 and the pressure of the intermediate refrigerant in the intermediate pressure chamber 68 is kept almost constant, regardless of the varying stroke of the pistons 32, which allows the low-temperature intermediate refrigerant to be stably injected into each compression chamber 33 while the compression chamber is in the process of compressing the refrigerant.

[0044] The present invention is not limited to the above-described embodiment but can be modified in various ways.

[0045] For example, FIG. 3 shows a rotary valve 78 caused to rotate independently from the main shaft 34. In this case, the rotary valve 78 is connected to an output shaft 92 of an electric motor 90. The electric motor 90 is mounted on the outer face of the cylinder head 22. Normally, the electric motor 90 causes the rotary valve 78 to rotate in synchronization with the main shaft 34, but can vary the timing and duration of distribution by the rotary valve 78 as necessary.

[0046] FIG. 4 shows a solenoid-operated on-off valve 94 substituting for the rotary valve 78. The solenoid-operated on-off valve 94 is provided for each compression chamber 33 and performs the similar function as the above-described rotary valve 78.

[0047] The reciprocating compressor according to the present invention may be configured as a fixed displacement compressor, and may be driven by an electric motor in place of the engine. Further, the reciprocating motion mechanism is not limited to the illustrated swashplate type but may be a single sided piston or both sided piston swashplate type, or another axial piston type.

Claims

1. A reciprocating compressor for a refrigerator, comprising:

   a housing having cylinder bores
   pistons fitted in the respective cylinder bores to define compression chambers in the respective cylinder bores, said pistons each being capable of reciprocating motion in their own cylinder bore and each repeating, by their reciprocating motion, a process of sucking a refrigerant into their own compression chamber, compressing the sucked refrigerant in the compression chamber and discharging the compressed refrigerant from the compression chamber so that the discharged refrigerant is supplied to a refrigerant circulation path of the refrigerator, and
   an introduction device arranged in said housing to allow an intermediate refrigerant to be introduced from the refrigerant circulation path into each compression chamber only for a predetermined period of time while the compression chamber is in the process of compressing the refrigerant, where the pressure of the intermediate refrigerant is above the pressure of the refrigerant being compressed in the compression chamber.

2. The reciprocating compressor for the refrigerator according to claim 1, wherein the intermediate refrigerant allowed to be introduced into each compression chamber by said introduction device has a temperature lower than the temperature of the refrigerant being compressed in the compression chamber.

3. The reciprocating compressor for the refrigerator according to claim 1, wherein

   said introduction device includes
   an intermediate pressure chamber defined in said housing and supplied with the intermediate refrigerant from the refrigerant circulation path,
   connection passages connecting the intermediate pressure chamber and the respective compression chambers, and
   a valve associated with the connection passages to open and close the connection passages, where the valve opens each connection passage while the corresponding compression chamber is in the process of compressing the refrigerant and closes the connection passage before the refrigerant being compressed reaches to the pressure of the intermediate refrigerant in the intermediate pressure chamber.

4. The reciprocating compressor for the refrigerator according to claim 3, wherein the valve is a rotary valve mechanically connected to a main shaft of the compressor to rotate integrally with the main shaft.

5. The reciprocating compressor for the refrigerator according to claim 3, wherein the valve is a rotary valve caused to rotate by a motor independent from a main shaft of the compressor.

6. The reciprocating compressor for the refrigerator according to claim 3, wherein the valve is a solenoid-operated valve.

7. The reciprocating compressor for the refrigerator according to claim 1, further comprising a variable displacement mechanism capable of varying the amount of the compressed refrigerant discharged, where said variable displacement mechanism includes a swashplate.

8. The reciprocating compressor for the refrigerator according to claim 1, wherein the refrigerant is carbon dioxide.

9. The reciprocating compressor for the refrigerator according to claim 1, wherein the refrigerant includes a compound having hydrocarbons containing one or more double bond between carbon atoms.

FIG. 1

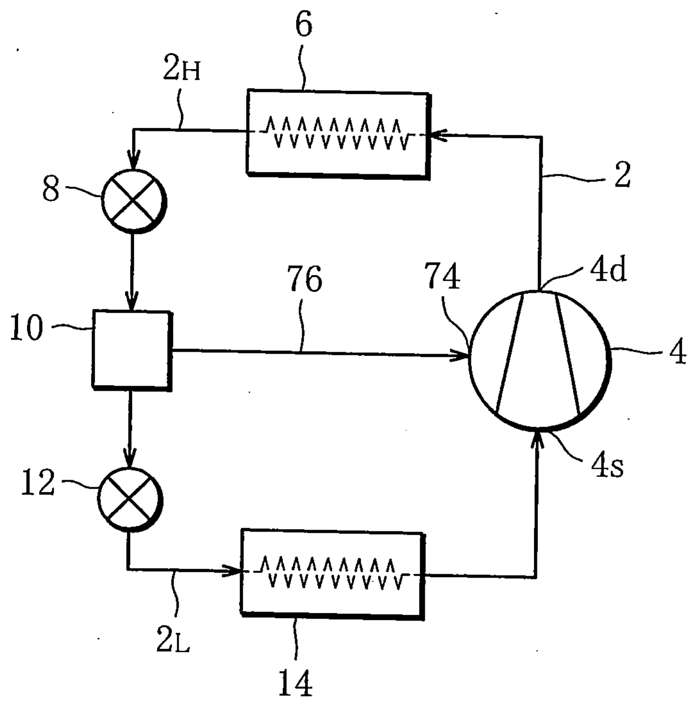


FIG. 2

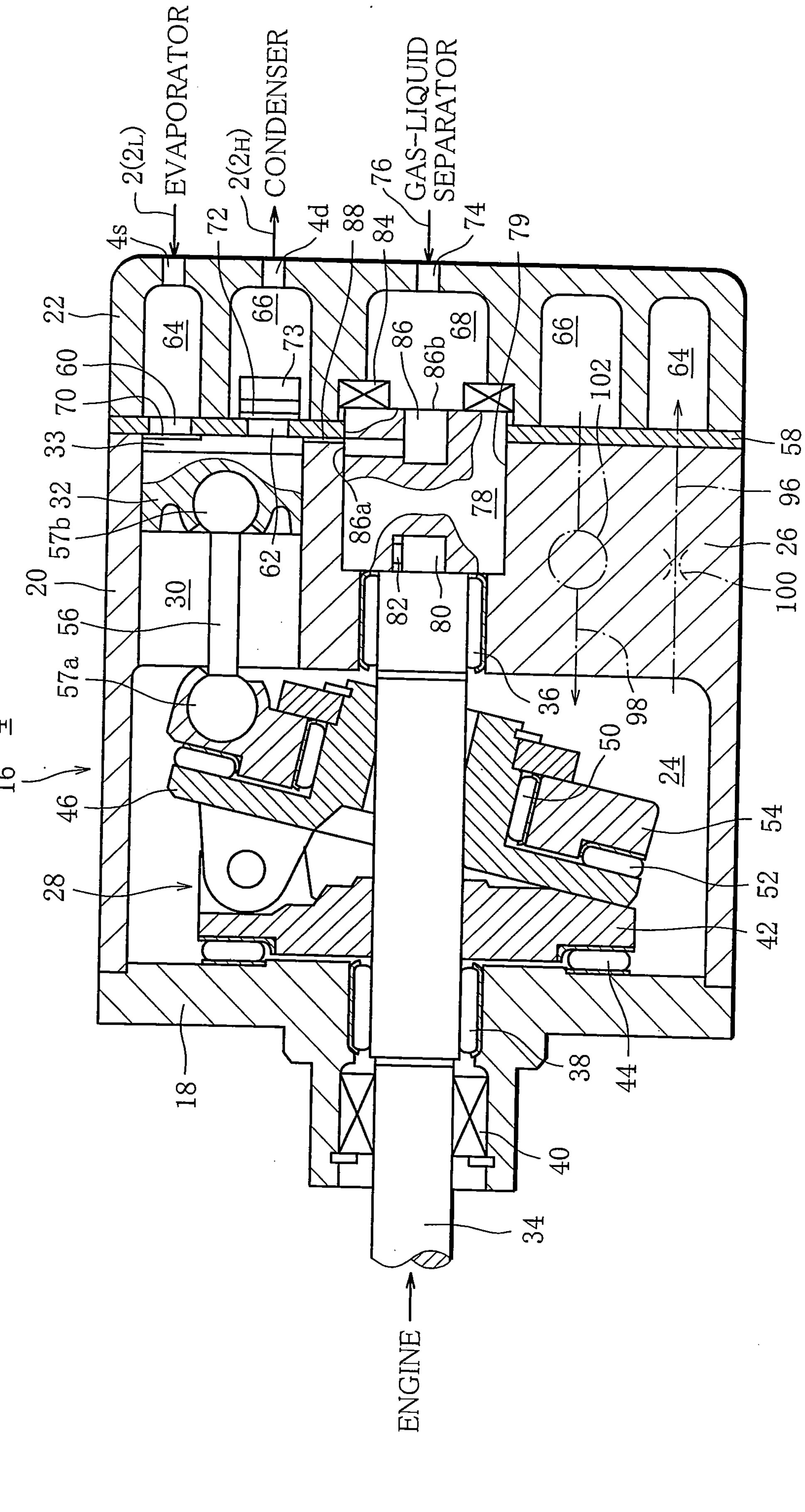


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FIG. 3

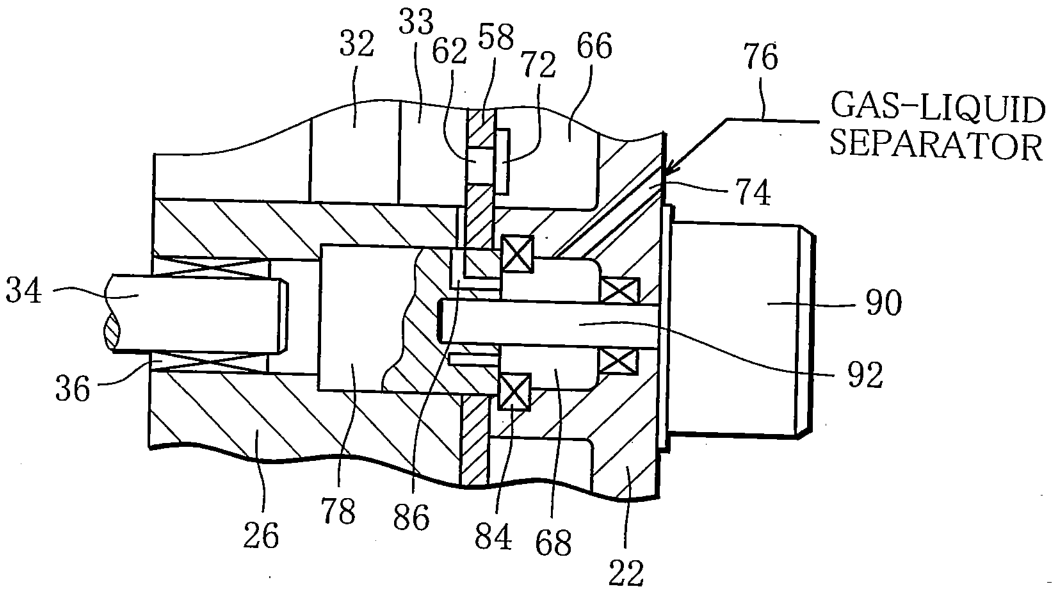
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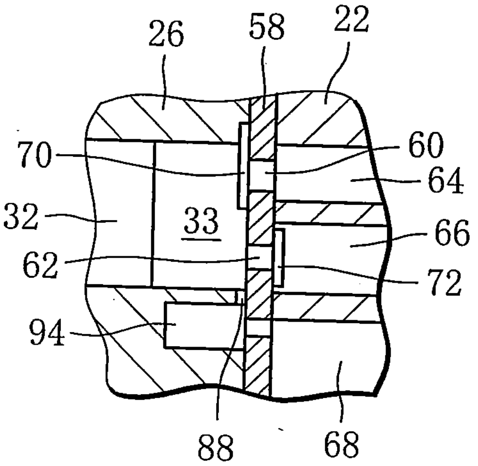
FIG. 4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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/073169

A. CLASSIFICATION OF SUBJECT MATTER
F04B39/06(2006.01)i, *F04B27/08*(2006.01)i, *F04B39/10*(2006.01)i, *F16K3/26* (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)
F04B39/06, F04B27/08, F04B39/10, F16K3/26

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	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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.
X Y A	JP 2000-145641 A (Sanden Corp.), 26 May, 2000 (26.05.00), Par. Nos. [0010] to [0030]; Figs. 1 to 7 (Family: none)	1-2,8 7,9 3-6
X Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 25939/1983(Laid-open No. 131984/1984) (Mitsubishi Heavy Industries, Ltd.), 04 September, 1984 (04.09.84), Description, page 3, line 17 to page 5, line 14; Figs. 2 to 4 (Family: none)	1-2 3-4,8-9 5-7

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

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Date of the actual completion of the international search	Date of mailing of the international search report
18 December, 2007 (18.12.07)	08 January, 2008 (08.01.08)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2007/073169

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 57-49083 A (Hitachi, Ltd.), 20 March, 1982 (20.03.82), Page 1, right column, line 13 to page 3, upper right column, line 9; Figs. 1 to 5 (Family: none)	1-3 4,8-9 5-7
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Form PCT/ISA/210 (continuation of second sheet) (April 2007)

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