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

(11) EP 2 039 936 A1

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

(43) Date of publication:
25.03.2009 Bulletin 2009/13

(21) Application number: **07768242.5**

(22) Date of filing: **05.07.2007**

(51) Int Cl.:
F04C 18/02 *(2006.01)*

(86) International application number:
PCT/JP2007/063493

(87) International publication number:
WO 2008/007612 (17.01.2008 Gazette 2008/03)

(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
Designated Extension States:
AL BA HR MK RS

(30) Priority: **10.07.2006 JP 2006189137**

(71) Applicant: **Sanden Corporation**
Isesaki-shi,
Gunma 372-8502 (JP)

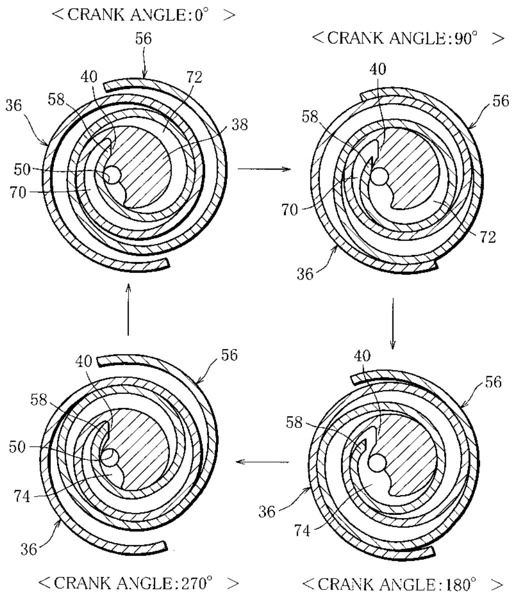
(72) Inventor: **NEGISHI, Masami**
Isesaki-shi, Gunma 372-8502 (JP)

(74) Representative: **Skuhra, Udo**
Reinhard, Skuhra, Weise & Partner GbR
Patent- und Rechtsanwälte
Friedrichstraße 31
80801 München (DE)

(54) SCROLL COMPRESSOR

(57) A scroll compressor has a scroll unit (30) that includes a fixed scroll (32) having a single discharge hole (50), and an orbital scroll (52) which makes an orbital movement with respect to the fixed scroll (32), those scrolls (32, 52) cooperate with each other to form two transient compression chambers (70, 72) into which a working fluid is sucked, and then form the transient compression chambers (70, 72) into a final compression chamber (74) at a center portion of the scroll unit (30), and the transient compression chambers have a volume ratio of 0.5 or greater, which expresses the ratio of a volume of the transient compression chambers (70, 72) immediately before formation of the final compression chamber (74) to a suction volume of the transient compression chambers (70, 72) at a time of sucking the working fluid.

FIG. 4



EP 2 039 936 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a scroll compressor, and, more particularly, to a scroll compressor suitable for compression of a working fluid with a high working pressure.

BACKGROUND ART

[0002] This kind of scroll compressor has a scroll unit which carries out a series of processes from suction of a working fluid to discharge thereof through compression thereof. In detail, the scroll unit includes a fixed scroll and an orbital scroll, which respectively have spiral laps to be engaged with each other, and end plates supporting the spiral laps. The orbital scroll makes a revolution movement about the axial of the fixed scroll without rotating, i.e., makes an orbital movement. This increases the space defined between the fixed and orbital scrolls or the volume of the compression chamber, thereby allowing the series of processes to be carried out.

[0003] When the operational speed of the compressor is varied, the suction pressure and the discharge pressure of the working fluid both change, and this pressure change may cause excessive compression of the working fluid. There is known a scroll unit which prevents such excessive compression of a working fluid (refer to Patent Document 1, for example). In this scroll unit, a plurality of communication passages as well as a discharge hole to discharge the compressed working fluid to a discharge chamber are formed in the end plate of the fixed scroll. Specifically, the discharge hole is positioned nearly at the center portion of the end plate to allow the compression chamber and the discharge chamber to communicate with each other at the end stage of compression of the working fluid, while a plurality of the communication passages are positioned near the discharge hole to allow the compression chamber and the discharge chamber to communicate with each other via a valve during compression of the working fluid.

Patent documents 1: Japanese Patent No. 3635826

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0004] By the way, recently, development of the refrigeration cycle which has taken into consideration global environment has progressed. The refrigeration cycle uses a working fluid which has a small global warming potential. As an example of this kind of working fluid, there is natural CO_2 (carbonic acid) gas. During the operation of a refrigeration cycle, the operation pressure of the CO_2 gas varies according to the outside air condition or the like. Therefore, the CO_2 gas may be excessively compressed, and such excessive compression lowers the performance of the refrigeration cycle.

[0005] It is supposed that the use of the technique of the Patent Document 1 overcomes the excessive compression of the CO_2 gas. However, the communication passages and valve of the Patent Document 1 not only complicates the configuration of the scroll unit but also increases the manufacturing cost thereof. Because the compression ratio of the CO_2 gas changes considerably, it is necessary to use the discharge valve that can cope with the change, and this requirement also becomes a big factor to increase the manufacturing cost of the scroll unit.

[0006] It is an object of the present invention to provide a scroll compressor that can surely prevent excessive compression of a working fluid by employing a simple configuration which does not increase the manufacturing cost.

Means for Solving the Problems

[0007] To achieve the object, a scroll compressor having a scroll unit which carries out a series of processes from suction of a working fluid to discharge thereof through compression thereof, the scroll unit including a fixed scroll having a single discharge hole, and an orbital scroll that makes an orbital movement with respect to the fixed scroll and forms two transient compression chambers into which the working fluid is sucked, in cooperation with the fixed scroll, and then forms the transient compression chambers into a final compression chamber at a center portion of the scroll unit, wherein the transient compression chambers have a volume ratio of 0.5 or greater, which expresses a ratio of a volume of the transient compression chambers immediately before formation of the final compression chamber to a suction volume of the transient compression chambers at a time of sucking the working fluid.

[0008] According to the scroll compressor, the volume ratio of the two transient compression chambers formed in the scroll unit is kept at 0.5 or greater until the final compression chamber is formed. Even in the case where the scroll unit compresses a working fluid with a high working pressure, therefore, the compression ratio of the working fluid is suppressed smaller, thus preventing excessive compression of the working fluid.

[0009] Since the scroll unit merely has a single discharge hole, it is unnecessary to adopt the technique of the Patent Document 1 or processing a plurality of communication passages with respect to the fixed scroll, and a valve which opens or closes each of the communication passages. As a result, the configuration of the scroll unit becomes simpler and the manufacturing cost becomes lower.

[0010] The fixed scroll according to the present invention can include a fixed end plate having the discharge hole formed therein, a fixed spiral lap projecting from the fixed end plate toward the orbital scroll, and a volume ratio determining portion formed as an inner peripheral end of the fixed spiral lap and positioned near the discharge hole.

[0011] Specifically, the volume ratio determining portion fills in space near the discharge hole, and has an outer shape partially surrounding an opening edge of the discharge hole. The volume ratio determining portion preferably has an inner wall adjoining the discharge hole, and an outer wall which connects the inner wall to the outer wall of the fixed spiral lap, and has an arc shape projecting outward as viewed in a radial direction of the fixed spiral lap.

[0012] According to the fixed scroll, the volume ratio determining portion can easily be obtained by merely modifying the profile of an existing fixed spiral lap. This can make the manufacturing cost of the scroll compressor while keeping the performance thereof.

[0013] Further, it is preferable that the volume ratio determining portion have a cavity in which case the weight reduction of the scroll compressor can be achieved.

[0014] The orbital scroll includes an orbital end plate facing the fixed end plate, and an orbital spiral lap projecting from the orbital end plate toward the fixed scroll and being engaged with the fixed spiral lap, wherein during the orbital movement of the orbital scroll, the orbital spiral lap has an inner peripheral end which periodically contacts the volume ratio determining portion. Such an orbital spiral lap can also be easily obtained by merely modifying the profile of an existing orbital spiral lap.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 illustrates a longitudinal cross-sectional view of a scroll compressor according to one embodiment of the present invention.

Fig. 2 illustrates a front view of a fixed scroll in Fig. 1.

Fig. 3 is a graph showing the relationship between the pressure in a compression chamber and the volume ratio when the scroll unit in Fig. 1 is used to compress a CO_2 refrigerant.

Fig. 4 is a diagram illustrating a compression process by the scroll unit in Fig. 1.

Fig. 5 illustrates a cross-sectional view of a fixed scroll according to another embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

[0016] A compressor 1 in Fig. 1 is inserted into a circulation path for circulating a working fluid in an air conditioner or a heat pump type water heater, etc., and uses, for example, a CO_2 refrigerant (hereinafter called "refrigerant") as the working fluid. The compressor 1 carries out suction of the refrigerant from a circulation path, compression of the sucked refrigerant, and discharge of the compressed refrigerant to the circulation path, thereby letting the refrigerant circulate in the circulation path.

[0017] More specifically, the compressor 1 has a housing 2. The housing 2 includes a cylindrical body portion 4 extending in the up and down direction, and an upper lid 6 and a lower lid 8 which respectively closes the upper end and lower end of the body portion 4 airtightly, defining an airtight chamber inside. The lower portion of the housing 2 is formed as an oil chamber 9 for storing a lubricant.

[0018] An electric motor 10 is accommodated in the body portion 4, and has a hollow drive shaft 12 at the center thereof. When power is supplied to the motor 10, the drive shaft 12 is rotated in one direction. The upper end portion of the drive shaft 12 is rotatably supported by an upper frame 14 via a bearing 16, and the upper frame 14 is fixed to the body portion 4.

[0019] The lower end portion of the drive shaft 12 is rotatably supported by a lower frame 18 via a bearing 20, and the lower frame 18 is also fixed to the body portion 4. An oil pump 22 is attached to the lower end of the drive shaft 12, and is driven by the rotation of the drive shaft 12. When the oil pump 22 is driven, the oil pump 22 sucks a lubricating oil in the oil chamber 9, and discharges the sucked lubricating oil into the drive shaft 12 or an oil passage 24 defined in the drive shaft 12. The oil passage 24 extends in the axial direction of the drive shaft 12, so that the lubricating oil discharged into the oil passage 24 is fed through the oil passage 24 toward the upper end of the drive shaft 12, and is then supplied to each sliding portion of the motor 10 and a scroll unit to be described later from the upper end of the drive shaft 12.

[0020] The scroll unit 30 is arranged in the body portion 4, and positioned above the motor 10. The scroll unit 30 carries out a series of processes from suction of the refrigerant and discharge thereof through compression thereof.

[0021] More specifically, the scroll unit 30 includes an orbital scroll 52 and a fixed scroll 32. The orbital scroll 52 has an end plate 54 and a spiral lap 56 formed integral with the end plate 54 and projecting toward an end plate 34 of the fixed scroll 32 from the end plate 54. The fixed scroll 32 has the end plate 34 and a spiral lap 36 formed integral with the end plate 34 and projecting toward the end plate 54 of the orbital scroll 52. The spiral laps 34, 56 have spiral shapes to engage with each other, and the spiral shapes are defined substantially by the involution.

[0022] When the orbital scroll 52 makes a revolution movement or an orbital movement with respect to the fixed scroll 32 without rotating, the spiral laps 36, 56 cooperate to form a plurality of compression chambers. More specifically, a compression chamber is formed at the outer peripheries of the spiral laps 36, 56 by the revolution movement of the orbital scroll 52, and the volumes of the formed compression chamber decreases as it moves toward the centers of the spiral laps 36, 56.

[0023] To permit the orbital scroll 52 to make the aforementioned orbital movement, a boss 66 is formed at the bottom side of the end plate 54. The boss 66 is rotatably supported by an eccentric shaft 26 via a bearing 28, the eccentric shaft 26 projecting integrally from the upper end of the drive shaft 12. The rotation of the orbital scroll 52 is inhibited by a plurality of pins 68 which protrude toward the upper frame 14 from the end plate 54 and are positioned in holes of the upper frame 14. The orbital radius of the pins 68 is determined by the holes.

[0024] The fixed scroll 32 is fixed to the upper frame 14, and a discharge chamber 80 is defined in the housing 2 between the end plate 34 of fixed scroll 32 and the upper lid 6. As shown in Fig. 2, the end plate 34 has a single discharge hole 50 which is positioned slightly eccentric from the center of the end plate 34, and penetrates the end plate 34.

[0025] As shown in Fig. 1, a discharge valve 82 is attached to the end plate 34, and opens and closes a discharge hole 82. A suction pipe 84 is connected to the body portion 4 to guide the refrigerant into the body portion 4.

[0026] Given that the suction volume of the CO_2 refrigerant in the scroll unit 30 is expressed by Vc and the volume of the compression chamber in relation to the suction volume Vc at the time of discharging the compressed refrigerant from the scroll unit 30 is expressed by V, the ratio of the volume V to the suction volume Vc or the volume ratio V/Vc is set to 0.5 or greater.

[0027] This setting of the volume ratio V/Vc is optimal when a compressor for a heat pump type water heater, which is recently commercialized, is used to compress a CO_2 refrigerant. Specifically, in the case of the scroll unit 30 of this embodiment, as shown in Fig. 3, when the compressed refrigerant is discharged from the scroll unit 30, the volume ratio V/Vc=0.5 or smaller is achieved.

[0028] The volume ratio V/Vc=0.5 or greater corresponds to the compression ratio of the refrigerant of about 2.0 or smaller.

[0029] To achieve the volume ratio, the scroll unit 30 of the embodiment has an improved scroll profile. More specifically, the inner peripheral ends of the orbital side and fixed side spiral laps of a normal scroll unit cyclically approach at the center portion of the end plate of the fixed scroll, and the cycle is set to about 2π (π=180°) in terms of the orbital angle of the orbital scroll or the crank angle of the eccentric shaft 26 described above.

[0030] However, while the scroll unit 30 of the embodiment has a volume ratio setting portion at the inner peripheral end of the spiral lap 36 to discharge the compressed refrigerant from the scroll unit 30 at the crank angle which determines the volume ratio V/Vc to 0.5 or greater, the position of the inner peripheral end of the spiral lap 56, i.e., the involute starting position of the spiral lap 56 is determined.

[0031] Specifically, as shown in Fig. 2, the volume ratio setting portion of the spiral lap 36 is formed as a space filling potion 38 which increases the volume of the inner peripheral end of the spiral lap 36, and the space filling portion 38 fills the space at approximately the center portion of the end plate 34. The space filling portion 38, like the spiral lap 36, projects toward the orbital scroll 52 from the end plate 34.

[0032] In more detail, the outer shape of the space filling portion 38 is made by an inner wall 40 facing the discharge hole 50 side and an outer wall 42 with an arc shape projecting outward in the radial direction of the spiral lap 36. The inner wall 40 extends toward the discharge hole 50 from the inner peripheral surface of the spiral lap 36, then surrounds about a half of the opening edge of the discharge hole 50 (right-hand side of the opening edge of the discharge hole 50 in Fig. 2), and then extends toward the outer wall 42 from the discharge hole 50 to be connected to the terminal end of the outer wall 42.

[0033] The inner peripheral end of the spiral lap 56 is formed as a retreat end 58 retreating in the spiral direction of the spiral lap 56 to avoid interference with the space filling portion 38. During the orbital movement of the orbital scroll 52, as apparent from Fig. 4, the retreat end 58 turns to come close and away from the inner wall 40 of the space filling portion 38 positioned above the discharge hole 50 shown in Fig. 4. At the end stage of the refrigerant compression process, therefore, the spiral lap 56 and the space filling portion 38 of the spiral lap 36 cooperate to form a final compression chamber 74 which achieves the compression ratio of the refrigerant corresponding to the volume ratio V/Vc.

[0034] According to the compressor 1, when the drive shaft 12 is driven, the orbital scroll 52 makes an orbital movement with respect to the fixed scroll 32 without rotating. Such an orbital movement of the orbital scroll 52 allows the refrigerant in the body portion 4 to be sucked into the scroll unit 30 from the outer surface of the scroll unit 30, after which the scroll unit 30 initiates the compression process of the sucked refrigerant.

[0035] As shown in Fig. 4, when the orbital scroll 52 is at the position of, for example 0° in terms of the rotational angle of the orbital scroll 52 or the crank angle, the retreat end 58 of the spiral lap 56 contacts the inner wall 40 of the space filling portion 38, forming two compression chambers 70, 72 sandwiching the spiral lap 56. More specifically, the compression chamber 70 is positioned outside the spiral lap 56, while the compression chamber 72 is positioned inside the spiral lap 56. Those compression chambers 70, 72 are completely separated by the retreat end 58 of the spiral lap 56. With regard to the volumes of the compression chambers 70, 72, their volume ratios V/Vc both exceed 0.5.

[0036] The compression chambers 70, 72 appears respectively at two refrigerant intake positions spaced apart from each other in the diametric direction of the scroll unit 30, and are moved to positions at the crank angle of 0°.

[0037] When the crank angle of the orbital scroll 52 reaches the position of 90°, the retreat end 58 of the spiral lap 56 comes nearest to the discharge hole 50. Further, when the crank angle of the orbital scroll 52 reaches the position of 180°, the retreat end 58 moves away from the inner wall 40 of the space filling portion 38, and the compression chambers 70, 72 communicate with each other to form one compression chamber 74. As a result, the refrigerants in the compression chambers 70, 72 are collected into the compression chamber 74.

[0038] Thereafter, as the retreat end 58 of the spiral lap 56 approaches the inner wall 40 of the space filling portion 38 again, the volume of the compression chamber 74 is reduced. In the process where the crank angle of the orbital scroll 52 moves to the position of 270° from the position of 180°, the volume of the compression chamber 74 is reduced to a range of 0.5 times the suction volume Vc or less (see Fig. 3). When the pressure of the compressed refrigerant in the compression chamber 74 overcomes the cut-off pressure of the discharge valve 82, the discharge valve 82 is opened. At this time, the compressed refrigerant in the compression chamber 74 is discharged into the discharge chamber 80 via the discharge valve 82. As a result, the discharge pressure of the refrigerant equivalent to the compression ratio of about 2.0 or greater is generated.

[0039] The compressed refrigerant discharged into the discharge chamber 80 circulates in the housing 2, and is then fed out through a discharge pipe 86. The discharge pipe 86 is attached to the upper lid 6 to be connected to the discharge chamber 80. That is, in case of the embodiment, the discharge chamber 80 is not defined in the housing 2, and communicates with the inside of the body portion 4 accommodating the motor 10.

[0040] As apparent from the foregoing description, according to the scroll unit 30 of the embodiment, the volume ratios of the volumes of the compression chambers 70, 72 immediately before the single compression chamber 74 is finally formed from the two compression chambers 70, 72 are set to 0.5 or greater. Therefore, even when the scroll unit 30 is operated in either the summer season where the compression efficiency of the refrigerant becomes lower or the winter season where the compression efficiency of the refrigerant is high due to a change in the density of the refrigerant, the discharge pressure of the refrigerant from the discharge hole of the scroll unit does not rise excessively, preventing excessive compression of the refrigerant.

[0041] Since the scroll unit 30 needs only the single discharge hole 50, it is unnecessary to apply the technique of the Patent Document 1 to the scroll unit 30. This eliminates the need for either the processing of a plurality of communicating passages to the fixed scroll or valves which open and close the communicating passages. As a result, the structure of the scroll unit 30 becomes simpler, the operational reliability thereof can be kept high, and further, the manufacturing cost of the scroll unit 30 becomes lower.

[0042] Further, the elimination of the need for communicating holes can make the discharge hole 50 larger. The increased diameter of the discharge hole 50 reduces the pressure loss in the discharge hole 50, which significantly contributes to reduction of the power needed by the scroll unit 30.

[0043] The condition of determining the volume ratio V/Vc to 0.5 or greater is achieved merely by forming the space filling portion 38 at the inner peripheral end of the spiral lap 36 of the fixed scroll 32 and forming the retreat end 58 at the inner peripheral end of the spiral lap 56 of the orbital scroll 52. Therefore, excessive compression of the refrigerant is prevented merely by modifying the profiles of the existing spiral laps 36, 56. As a result, reduction in the manufacturing cost of the scroll unit 30 can be achieved surely while maintaining the performance of the unit 30.

[0044] The present invention is not limited to the foregoing embodiment, and can be modified in various forms without departing from the scope of the invention.

[0045] For example, the space filling portion 38 is not limited to be solid, but may have a cavity 43 at the center as shown in Fig. 5. In this case, the weight of the fixed scroll 32 can be reduced.

[0046] Further, the starting angles of the spiral laps 36, 56 can be delayed by about 10° to about 45° in terms of the crank angle. In this case, forming the inner peripheral ends of the spiral laps 36, 56 as retreat ends can achieve the aforementioned condition of the volume ratio V/Vc. In addition, the present invention is applicable to an asymmetrical type of scroll unit which forms compression chambers 70, 72 with different shapes as well as a symmetrical type of scroll unit which forms compression chambers 70, 72 with similar shapes.

Claims

1. A scroll compressor comprising a scroll unit which carries out a series of processes from suction of a working fluid to discharge thereof through compression thereof, said scroll unit including:

    a fixed scroll having a single discharge hole; and an orbital scroll for making an orbital movement with respect to said fixed scroll and forming two transient compression chambers into which the working fluid is sucked, in cooperation with said fixed scroll, and then forming the transient compression chambers into a final compression chamber at a center portion of said scroll unit,

   wherein the transient compression chambers have a volume ratio of 0.5 or greater, which expresses a ratio of a volume of the transient compression chambers immediately before formation of the final compression chamber to a suction volume of the transient compression chambers at a time of sucking the working fluid.

2. The scroll compressor according to claim 1, wherein said fixed scroll includes:

    a fixed end plate having the discharge hole formed therein;

a fixed spiral lap projecting from the fixed end plate toward said orbital scroll; and
a volume ratio determining portion formed as an inner peripheral end of the fixed spiral lap and positioned near the discharge hole.

3. The scroll compressor according to claim 2, wherein the volume ratio determining portion fills in space near the discharge hole.

4. The scroll compressor according to claim 2, wherein the volume ratio determining portion has an outer shape partially surrounding an opening edge of the discharge hole.

5. The scroll compressor according to claim 2, wherein the volume ratio determining portion has:

an inner wall adjoining the discharge hole; and
an outer wall which connects the inner wall to the outer wall of the fixed spiral lap, and has an arc shape projecting outward as viewed in a radial direction of the fixed spiral lap.

6. The scroll compressor according to claim 2, wherein the volume ratio determining portion has a cavity therein.

7. The scroll compressor according to claim 2, wherein said orbital scroll includes:

an orbital end plate facing the fixed end plate; and
an orbital spiral lap projecting from the orbital end plate toward said fixed scroll, and being engaged with the fixed spiral lap,

wherein during the orbital movement of said orbital scroll, the orbital spiral lap has an inner peripheral end which periodically contacts the volume ratio determining portion.

FIG. 1

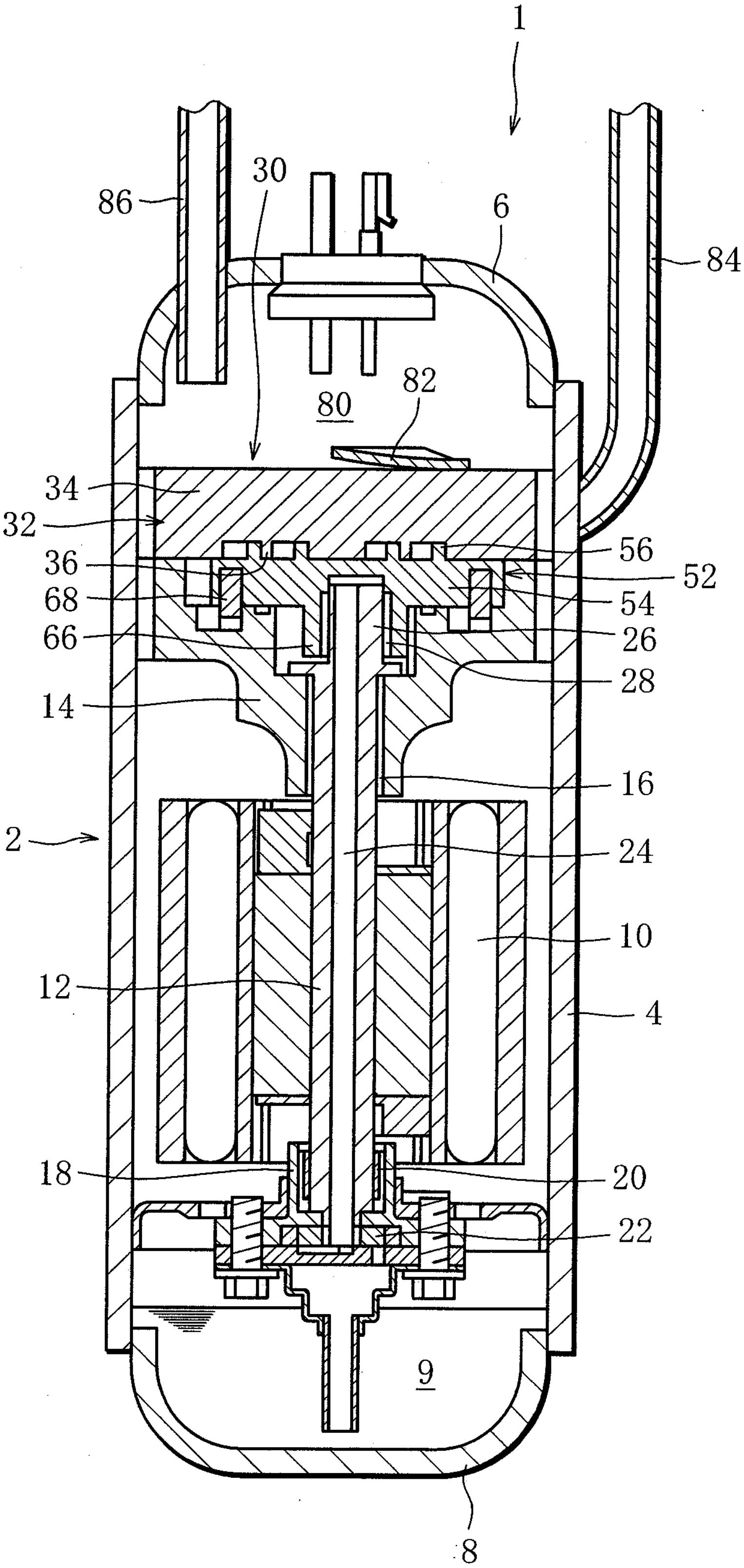

1
30
86
6
84
80
82
34
32
56
36
52
68
54
66
26
28
14
16
2
24
10
12
4
18
20
22
9
8

FIG. 2

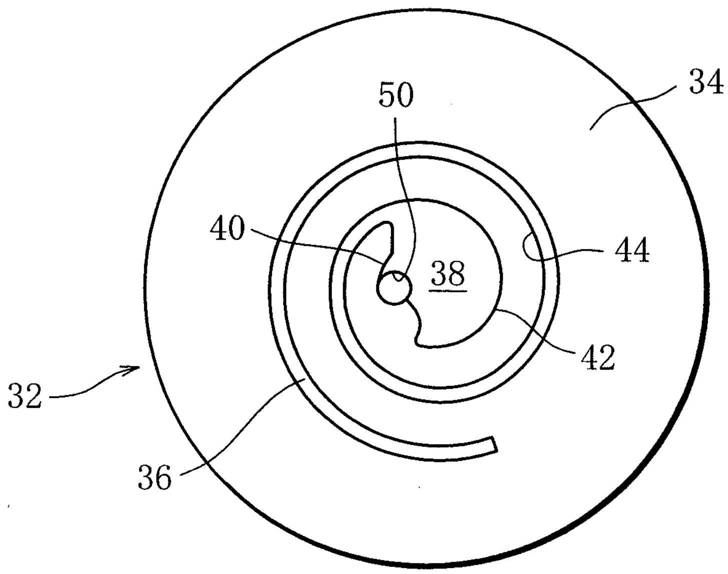

50
34
40
44
38
42
32
36

FIG. 3

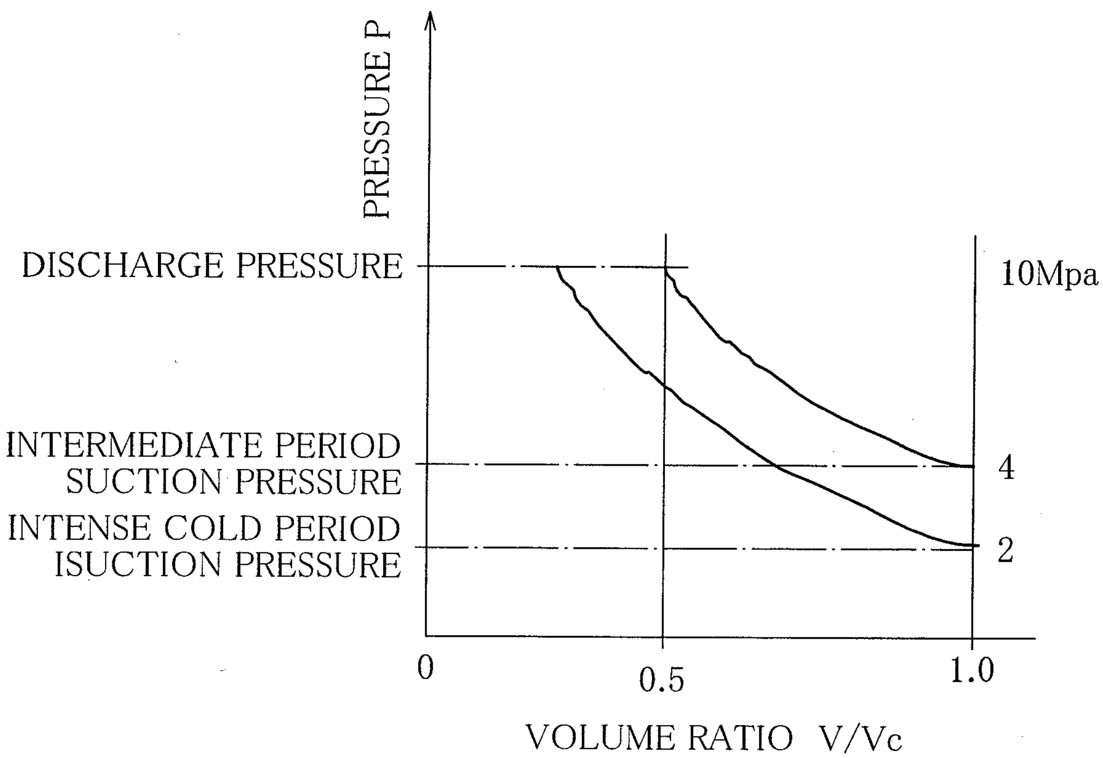

PRESSURE P
DISCHARGE PRESSURE
10Mpa
INTERMEDIATE PERIOD
SUCTION PRESSURE
4
INTENSE COLD PERIOD
ISUCTION PRESSURE
2
0
0.5
1.0
VOLUME RATIO V/Vc

FIG. 4

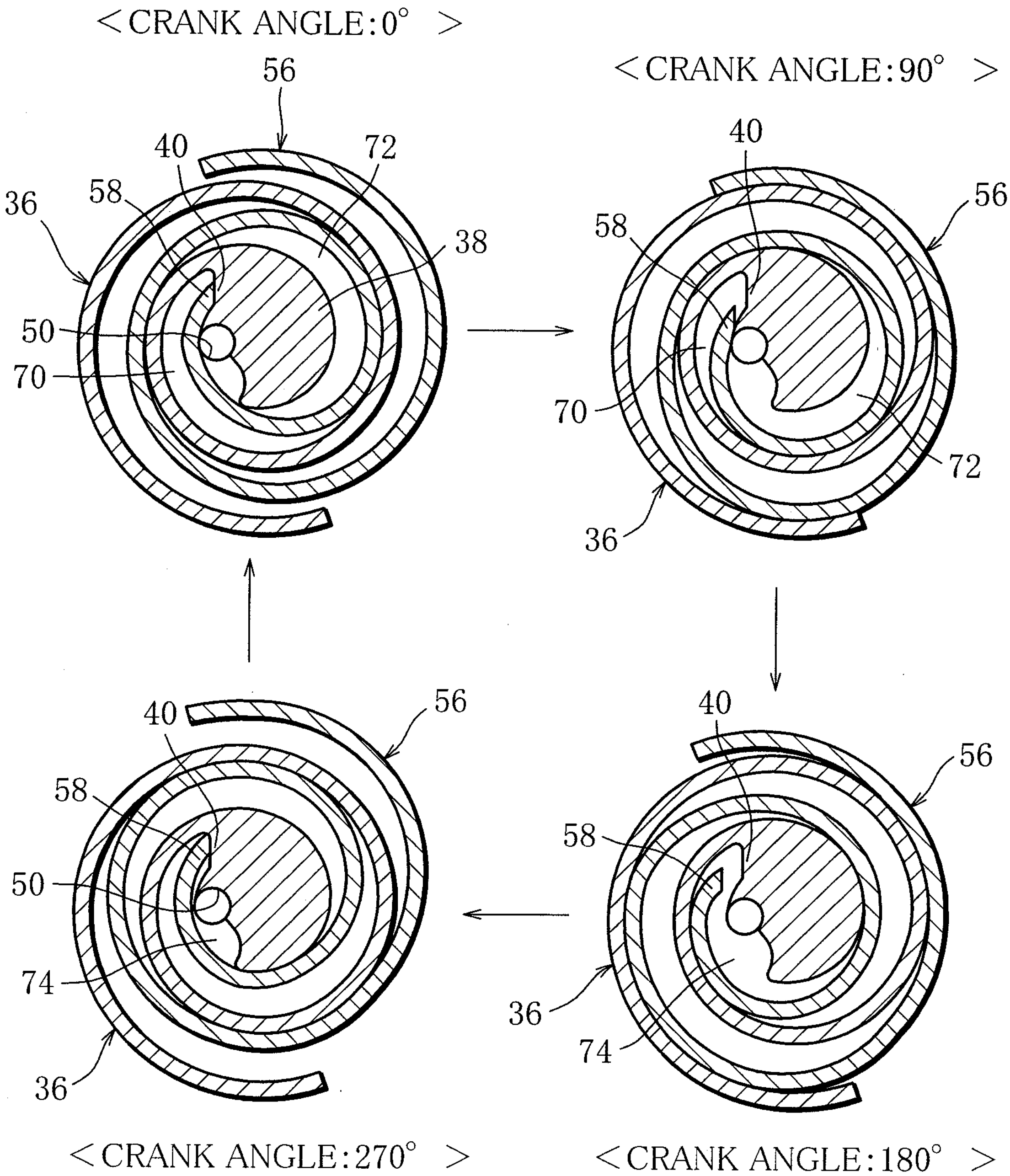
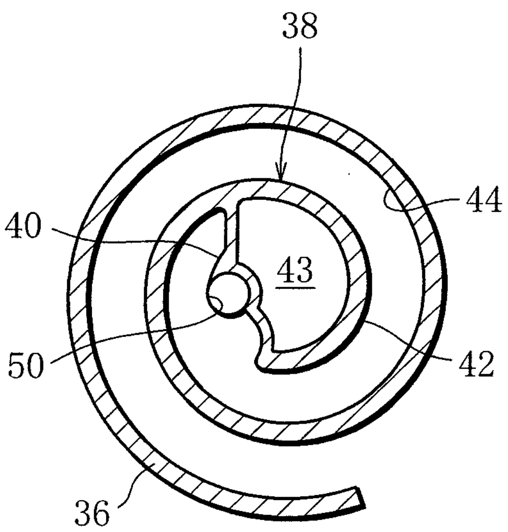

<CRANK ANGLE:0° >
56
40
72
36
58
38
50
70
<CRANK ANGLE:90° >
40
56
58
70
72
36
40
56
58
36
74
<CRANK ANGLE:180° >
40
56
58
50
74
36
<CRANK ANGLE:270° >

FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/063493

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/02(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)
F04C18/02

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.
Y	JP 2000-130369 A (Denso Corp.), 12 May, 2000 (12.05.00), Fig. 11 (Family: none)	1-7
Y	JP 2001-107881 A (Daikin Industries, Ltd.), 17 April, 2001 (17.04.01), Par. Nos. [0021],[0056], [0057] (Family: none)	1-7
Y	JP 2006-9640 A (Matsushita Electric Industrial Co., Ltd.), 12 January, 2006 (12.01.06), Par. No. [0025] (Family: none)	1-7

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 July, 2007 (24.07.07)	07 August, 2007 (07.08.07)

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

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/063493

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2002-221169 A (Nippon Soken, Inc.), 09 August, 2002 (09.08.02), Fig. 6 (Family: none)	6
Y	JP 3-275901 A (Iwata Air Compressor Mfg. Co., Ltd.), 06 December, 1991 (06.12.91), Fig. 2 & US 5145344 A & US 5258046 A & EP 0446635 A2 & EP 0807759 A2 & DE 69132650 T	7

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 3635826 B **[0003]**