



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

(43) Date of publication:
13.04.2011 Bulletin 2011/15

(51) Int Cl.:
F25B 1/00 (2006.01)

(21) Application number: **09742690.2**

(86) International application number:
PCT/JP2009/058292

(22) Date of filing: **27.04.2009**

(87) International publication number:
WO 2009/136566 (12.11.2009 Gazette 2009/46)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA RS

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(30) Priority: **08.05.2008 JP 2008122301**

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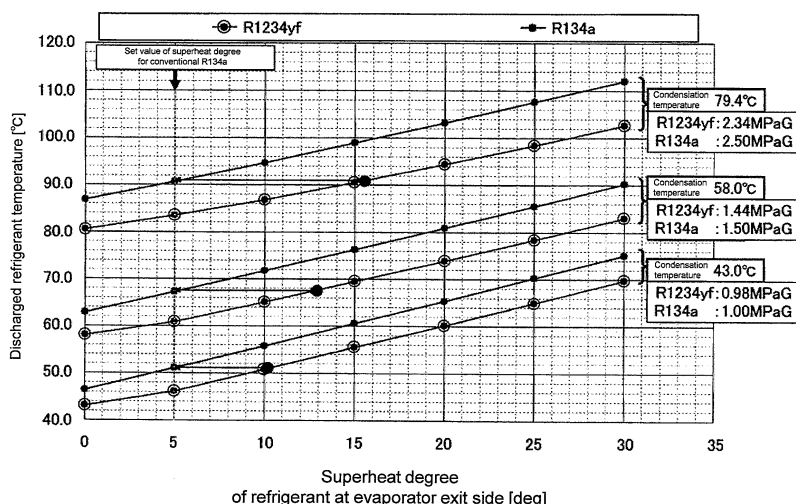
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(54) **FREEZING CYCLE**

(57) In a refrigeration cycle comprising a compressor, a condenser, a pressure reduction and expansion means, and an evaporator, R1234yf is used as the refrigerant, the refrigerant at the exit side of the evaporator is controlled in a superheated condition, and the refrigeration cycle is operated in a range of 5 to 16 degrees of superheat, and preferably in a range of 10 to 16 de-

grees of superheat. When the refrigerant used is changed to the new refrigerant R1234yf, while high advantage for improving the coefficient of performance can be achieved, the rise in temperature of the discharged refrigerant is appropriately suppressed so that deterioration of refrigerating machine oil in the refrigerant can be prevented, and a high-efficiency operation can be realized as the entirety of the refrigeration cycle.

FIG. 4



Description

Technical Field of the Invention

[0001] The present invention relates to a refrigeration cycle, and specifically relates to a refrigeration cycle which can be efficiently operated when a specific new-type refrigerant is used.

Background Art of the Invention

[0002] A refrigeration cycle used in an automotive air conditioning system, etc., has basic configuration which is shown in Fig. 1, for example. In Fig. 1, refrigeration cycle 1 has compressor 2 for compressing refrigerant, condenser 3 for condensing compressed refrigerant, expansion valve 4 as a pressure reduction and expansion means for reducing in pressure and expanding condensed refrigerant, and evaporator 5 for evaporating pressure-reduced and expanded refrigerant, where the refrigerant is circulated in refrigeration cycle 1 as changing its state. It is known to be effective for improving the refrigeration performance that such refrigeration cycle 1 is operated while the refrigerant at the outlet side of evaporator 5 is kept in a condition superheated with respect to its saturation curve.

[0003] For example, where sample 11 of operating condition of refrigeration cycle 1 is shown in the Mollier diagram (enthalpy/pressure curve) of Fig. 2, it is known that the refrigeration performance and the Coefficient Of Performance (COP) of refrigeration cycle 1 can be sometimes improved by giving degree of superheat 14 with respect to saturation curve 13 to refrigerant at the outlet side of evaporator before compression process 12 using compressor 2. In the Mollier diagram of Fig. 2, symbol 15 implies an isentrope and symbol 16 implies an isotherm line.

[0004] Characteristics as shown in Fig. 2 may be basically expressed as general characteristics of a refrigeration cycle which is operated as keeping the refrigerant in a superheat condition at the outlet side of the evaporator, regardless of the type of refrigerant. However, the concrete characteristics having a concrete numeric value may depend greatly on the type of refrigerant.

[0005] R134a is a refrigerant which is typical at present, however, research and development to find a new-type refrigerant are being performed in order to improve Global Warming Potential (GWP), as disclosed in non-patent document 1. R1234yf has been announced recently as a new refrigerant aiming at such an improvement, and it is becoming possible that it is examined and studied for applying to refrigeration cycle used for an automotive air conditioning system, etc.

Prior art documents

Non-patent documents

[0006] Non-patent document 1: Refrigeration, Vol. 83, No. 965, March issue, 2008

Summary of the Invention

Problems to be solved by the Invention

[0007] At present when R134a is used as refrigerant, the refrigerant condition is generally controlled around 5 superheat degrees at the outlet side of the evaporator, and the operation, regardless of high load and low load, is performed in a condition around 5 degrees superheat. Such a condition of 5 degrees superheat has been configured for the following reasons. (1) The condition of 5 superheat degrees is regarded as being close to the requisite minimum to achieve a target refrigeration gasification state at the outlet side of the evaporator. (2) If the condition is set as substantially higher than 5 degrees superheat, the temperature of refrigerant discharged from the evaporator might exceed a certain level as causing deterioration of refrigerant oil contained in the refrigerant.

[0008] However, because specific enthalpy difference of R1234yf in an operating zone is less than that of R134a, refrigerant flow rate for an operation using R1234yf has to be increased to achieve a refrigeration performance same as that for an operation using R134a as a conventional refrigerant. In order to achieve the same refrigeration performance in refrigeration cycle 1 with basic configuration as shown in Fig. 1, the refrigerant flow rate has to be increased by increasing the rotational speed of compressor 2, however, it may cause an increase of the power consumption of compressor 2, and consequently refrigeration coefficient of performance may be reduced, so that the operating condition becomes undesirable on efficiency.

[0009] According to the above-described new knowledge, an object of the present invention is to provide a refrigeration cycle which can be operated with a high efficiency even if the refrigerant has been replaced with R1234yf as new-type refrigerant.

Means for solving the Problems

[0010] To achieve the above-described object, a refrigeration cycle according to the present invention is a refrigeration cycle comprising a compressor for compressing refrigerant, a condenser for condensing compressed refrigerant, a pressure reduction and expansion means for reducing in pressure and expanding condensed refrigerant, and an evaporator for evaporating pressure-reduced and expanded refrigerant, **characterized in that** R1234yf is used as refrigerant for the refrigeration cycle, and the refrigeration cycle is operated so that the refrigerant at an exit side of the evaporator is controlled in a superheated condition, and the superheated condition is controlled in a range of 5 to 16 degrees of superheat.

[0011] In other words, it is **characterized in that** conventional operating condition around 5 superheat degrees in a case using R134a as refrigerant so as to keep

the refrigerant superheated at the exit side of the evaporator has been changed to an operating condition between 5 and 16 superheat degrees, when the refrigerant has been replaced with R1234yf as a new-type refrigerant so as to keep the refrigerant superheated at the exit side of the evaporator. As shown in Fig. 3, the use of R1234yf as refrigerant can improve the coefficient of performance (COP) more greatly than the use of R134a as refrigerant, even when the refrigerant superheat degree increases as well at the exit side of the evaporator. Further, when the R134a is used the condition has actually to be maintained around 5 superheat degrees in case that temperature of discharged refrigerant might increase to deteriorate the refrigerant oil in the refrigerant, and on the other hand, when R1234yf is used the operating condition can be controlled in a range of 5 - 16 superheat degrees as keeping the same level of the discharged refrigerant temperature as operated around 5 superheat degrees. Therefore, coefficient of performance (COP) can be improved by increasing superheat degree, as properly preventing from excessive rise of the discharged refrigerant temperature, so that operation with high-efficiency and deterioration prevention of the refrigerant oil can be desirably achieved.

[0012] The refrigeration cycle according to the present invention may be operated at 5 -16 superheat degrees of refrigerant at the exit side of the evaporator, and more preferably, is operated at in a range of 10 - 16 superheat degrees thereof as keeping the superheat degree as high as possible, in order to achieve the deterioration prevention of the refrigerant oil by suppressing the discharged refrigerant temperature rise. Namely, if attention is focused on the discharged refrigerant temperature shown in Fig. 4, the above-described operating condition of 10 superheat degrees is comparable with the operating condition around 5 superheat degrees under low load in R134a case, and the above-described operating condition of 16 superheat degrees is comparable with the operating condition around 5 superheat degrees under high load in R134a case. Therefore, the operating condition of 10 - 16 superheat degrees keeps the discharged refrigerant temperature at the same level to any load condition in R134a case, so that the lower limit for operating condition of superheat degree can be kept as high as possible. The operating condition range of superheat degree with lower limit of 10 degrees does not overlap the conventional condition range around 5 superheat degrees in R134a case at all.

[0013] In addition, the refrigeration cycle according to the present invention, whose basic configuration is shown in Fig. 1, preferably has means for elevating the degree of superheat of the refrigerant at the exit side of the evaporator, as compared with a case where R134a is used as refrigerant. In other words, the means for elevating the superheat degree may be provided in order to meet the operating condition of superheat degree higher than around 5 superheat degrees for the R134a case. For such a means for elevating the degree of superheat,

conventionally known means and mechanisms can be applied. For example, a liquid/gas heat exchanger, such as an internal heat exchanger which exchange heat between high-pressure side of the condenser outlet and low-pressure side of the evaporator outlet, can be provided. As well, the evaporation tube inside the evaporator may be extended, a so-called sensible heat exchanger may be provided, or the set value of the pressure-reduction/expansion means such as expansion valve may be altered.

[0014] Such a refrigeration cycle according to the present invention is basically applicable to any refrigeration cycle which aims to use the new-type refrigerant R1234yf, and is specifically suitable to a refrigeration cycle used in an automotive air conditioning system which is required to achieve efficient operation and to be highly durable for a long term by preventing the refrigerant oil from deterioration.

Effect according to the Invention

[0015] The refrigeration cycle according to the present invention makes it possible that when the refrigerant is replaced to the new-type refrigerant R1234yf, the improvement of coefficient of performance (COP) can be greatly achieved and the discharged refrigerant temperature can be properly kept from rising as preventing from the deterioration of the refrigerant oil in refrigerant, so that refrigeration cycle can be operated efficiently as a whole.

Brief explanation of the drawings

[0016]

[Fig. 1] Fig. 1 is a schematic framework showing a basic equipment layout of a refrigeration cycle as an object of the present invention.

[Fig. 2] Fig. 2 is a Mollier diagram showing a sample of the operating condition of the refrigeration cycle accompanying superheat degree of refrigerant at the exit side of the evaporator.

[Fig. 3] Fig. 3 is a relationship diagram between superheat degree of refrigerant at the exit side of the evaporator and the increase rate of coefficient of performance (COP).

[Fig. 4] Fig. 4 is a relationship diagram between superheat degree of refrigerant at the exit side of the evaporator and temperature of discharged refrigerant.

Embodiments for carrying out the Invention

[0017] Hereinafter, the present invention will be explained as referring to figures as well as embodiments of the present invention.

The basic configuration of equipments provided in a refrigeration cycle of the present invention can be the one

as shown in Fig. 1. As described above, in Fig. 1 refrigeration cycle 1 has compressor 2 for compressing refrigerant, condenser 3 for condensing compressed refrigerant, expansion valve 4 as a pressure-reduction/expansion means for reducing in pressure and expanding condensed refrigerant, and evaporator 5 for evaporating refrigerant which is pressure-reduced and expanded, which is operated as keeping refrigerant superheated at the exit side of evaporator 5 in refrigeration cycle 1 so as to improve refrigeration performance. The Mollier diagram in Fig. 2 shows a basic cycle where the refrigerant changes in state as the superheat degree is given.

[0018] Fig. 3 shows a relationship between superheat degree of refrigerant at the exit side of the evaporator and the increase rate of coefficient of performance (COP), where a case using refrigerant R134a is compared to a case using refrigerant R1234yf, in a certain condition (refrigerant condensation temperature = 52.6 degrees Celsius; refrigerant evaporation temperature = 10 degrees Celsius; subcool degree in front of expansion valve = 6.1 deg) of a certain refrigeration cycle. Fig. 3 shows that the COP increase rate rises in both R134a case and R1234yf case when increasing the superheat degree of refrigerant at the exit side of the evaporator, and that the increase rate of the R1234yf case is relatively higher. Therefore in the R1234yf case, the more superior coefficient of performance (COP) can be obtained by keeping high superheat degree of refrigerant at the exit side of the evaporator.

[0019] Fig. 4 shows a relationship between superheat degree of refrigerant at the exit side of the evaporator and temperature of discharged refrigerant, for a high-pressure (high-load) condition (Condensation temperature = 79.4 degrees Celsius), a medium-pressure (medium-load) condition (Condensation temperature = 58.0 degrees Celsius), and a low-pressure (low-load) condition (Condensation temperature = 43.0 degrees Celsius). The conventional set value of superheat degree in the R134a case has been around 5 deg regardless of loads, as described above. As shown in Fig. 4, a desirable range in the R1234yf case can be defined by the superheat degree of refrigerant at the exit side of the evaporator in the intersection where the line of discharged refrigerant temperature value in the R134a case of each condition intersects the characteristic line of the R1234yf, in order to keep the discharged refrigerant temperature at the same level between the R1234yf case and the R134a case, as suppressing the discharged refrigerant temperature increase. In other words, superheat of 5 deg in a low-pressure (low-load) condition in the R134a case is comparable with superheat of 10 deg in a low-pressure (low-load) condition in the R1234yf case, and superheat of 5 deg in a high-pressure (high-load) condition in the R134a case is comparable with superheat of 16 deg in a high-pressure (high-load) condition in the R1234yf case. Therefore, Fig. 4 shows that 5 deg as a conventional set value of superheat degree to suppress the discharged refrigerant temperature in the R134a case is

comparable with 10 deg - 16 deg as a setting range of superheat degree in the R1234yf case, where the deterioration of refrigerant oil derived from the discharged refrigerant temperature increase can be suppressed in operation to the same level as conventional. If the lower limit value of this range is set to 5 deg which is the same as conventional, the increase of discharged refrigerant temperature can be suppressed more securely, so that the deterioration of refrigerant oil can be prevented more surely.

[0020] The characteristics comparison between R134a and R1234yf in Fig. 3 and Fig. 4 and the proper setting of superheat degree of refrigerant at the exit side of the evaporator in operation shows that the present invention makes it possible that, in a case using R1234yf, coefficient of performance (COP) is improved by high superheat degree and simultaneously the discharged refrigerant temperature is properly prevented from excessive increase, so that both high-efficiency operation and deterioration prevention of refrigerant oil can be achieved.

Industrial Applications of the Invention

[0021] The refrigeration cycle according to the present invention is applicable to any refrigeration cycle, and specifically, is suitable as a refrigeration cycle used in an automotive air conditioning system.

Explanation of symbols

[0022]

- 1: refrigeration cycle
- 2: compressor
- 3: condenser
- 4: expansion valve as pressure-reduction/expansion means
- 5: evaporator
- 11: sample of operating condition of refrigeration cycle
- 12: compression process
- 13: saturation curve
- 14: superheat degree
- 15: isentrope
- 16: isothermperature line

Claims

1. A refrigeration cycle comprising a compressor for compressing refrigerant, a condenser for condensing compressed refrigerant, a pressure reduction and expansion means for reducing in pressure and expanding condensed refrigerant, and an evaporator for evaporating pressure-reduced and expanded refrigerant, **characterized in that** R1234yf is used as refrigerant for said refrigeration cycle, and said

refrigeration cycle is operated so that said refrigerant at an exit side of said evaporator is controlled in a superheated condition, and said superheated condition is controlled in a range of 5 to 16 degrees of superheat.

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2. The refrigeration cycle according to claim 1, wherein said refrigeration cycle is operated at said superheated condition in a range of 10 to 16 degrees of superheat of said refrigerant at said exit side of said evaporator. 10
3. The refrigeration cycle according to claim 1, wherein said refrigeration cycle comprises means for elevating said degree of superheat of said refrigerant at said exit side of said evaporator, as compared with a case where R134a is used as refrigerant for said refrigeration cycle. 15
4. The refrigeration cycle according to claim 1, wherein said refrigeration cycle is used in an air conditioning system for vehicles. 20

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FIG. 1

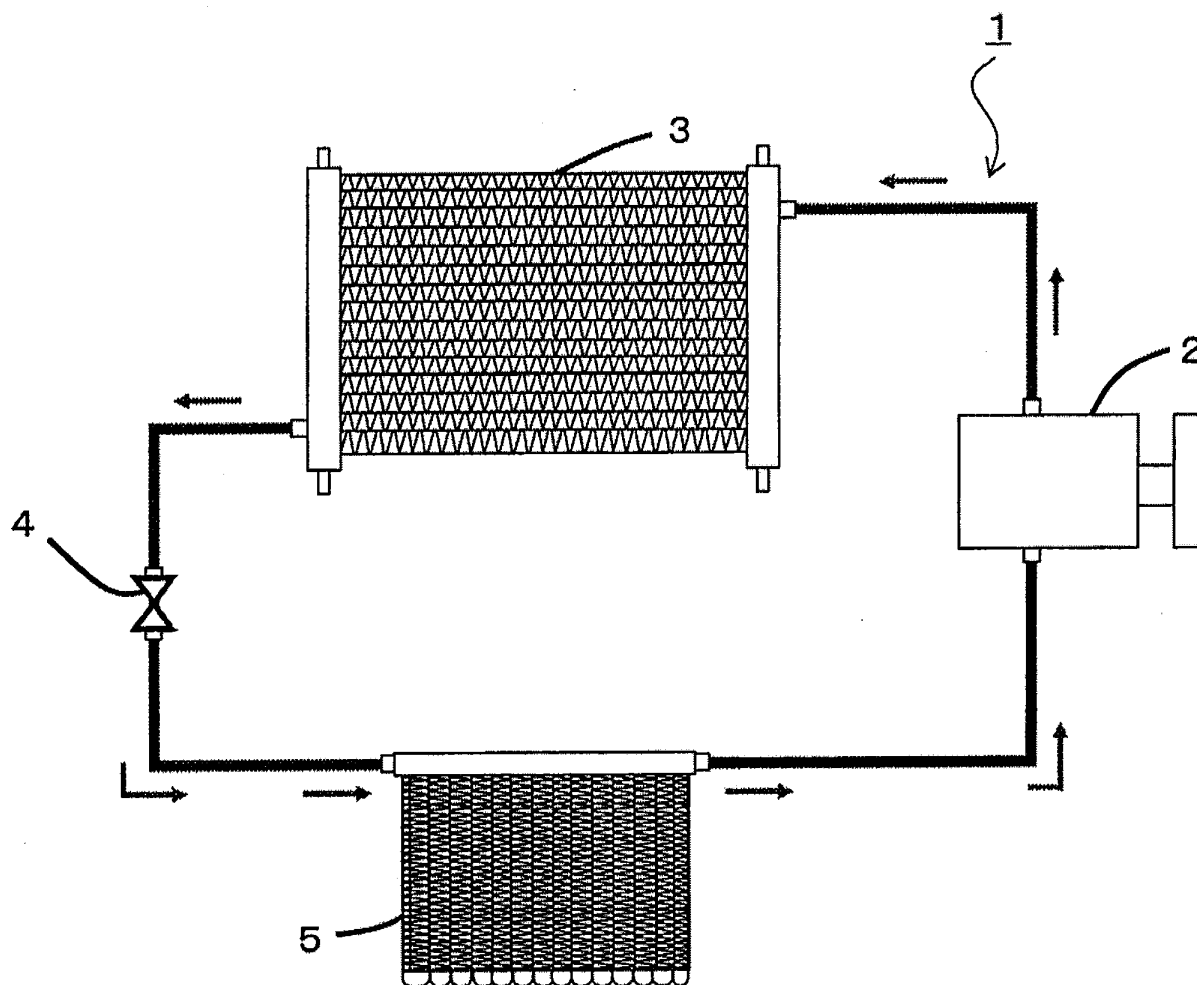


FIG. 2

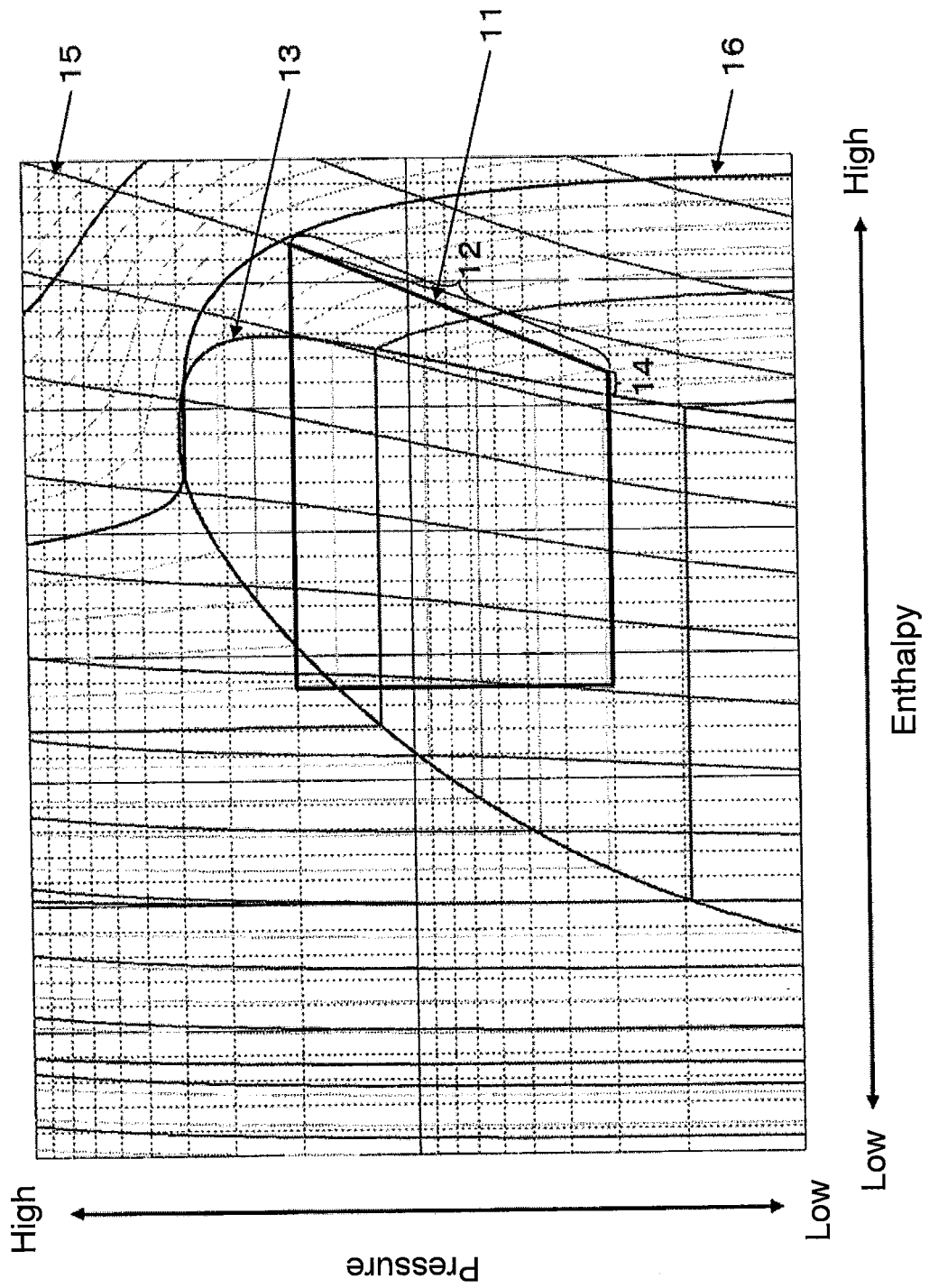


FIG. 3

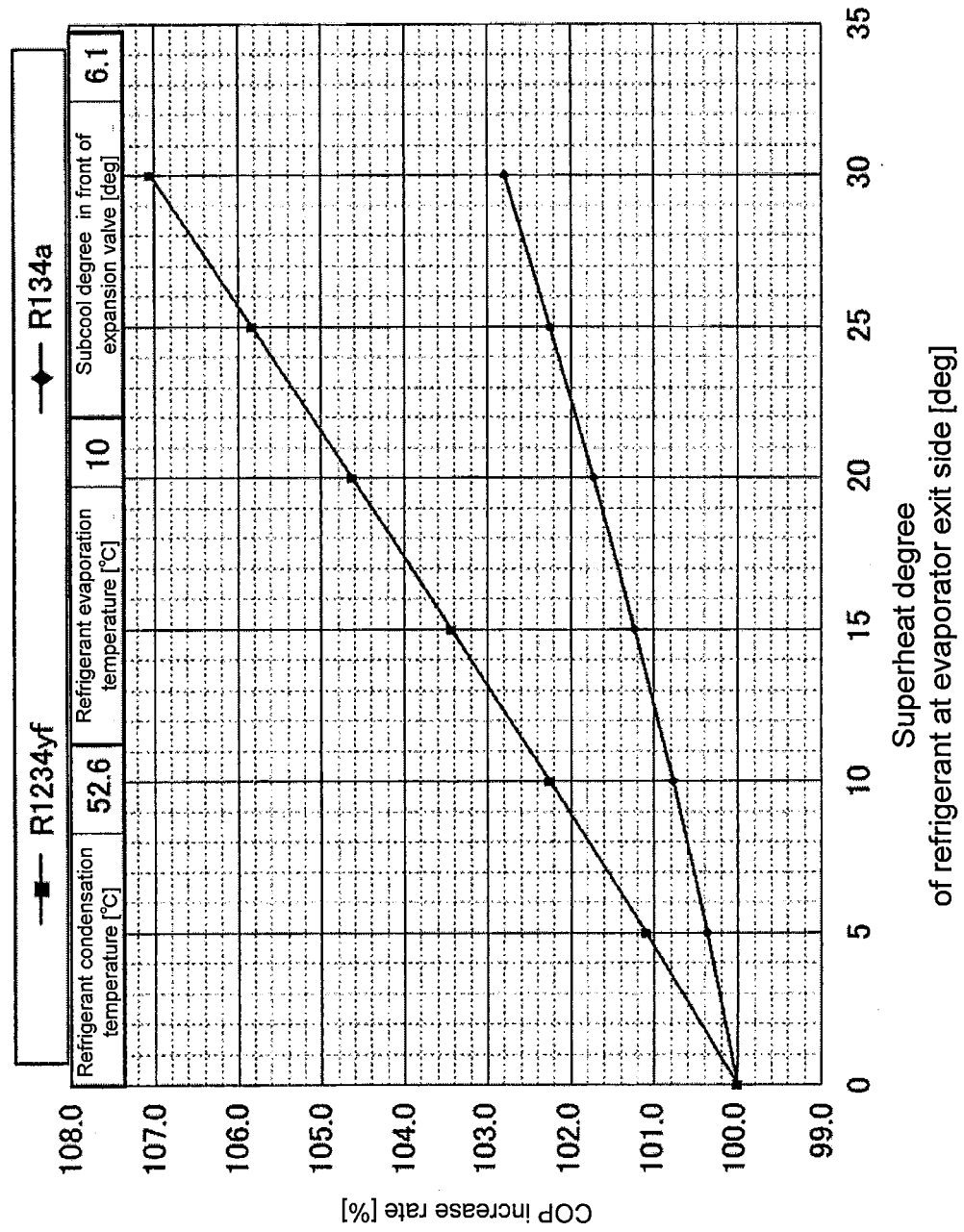
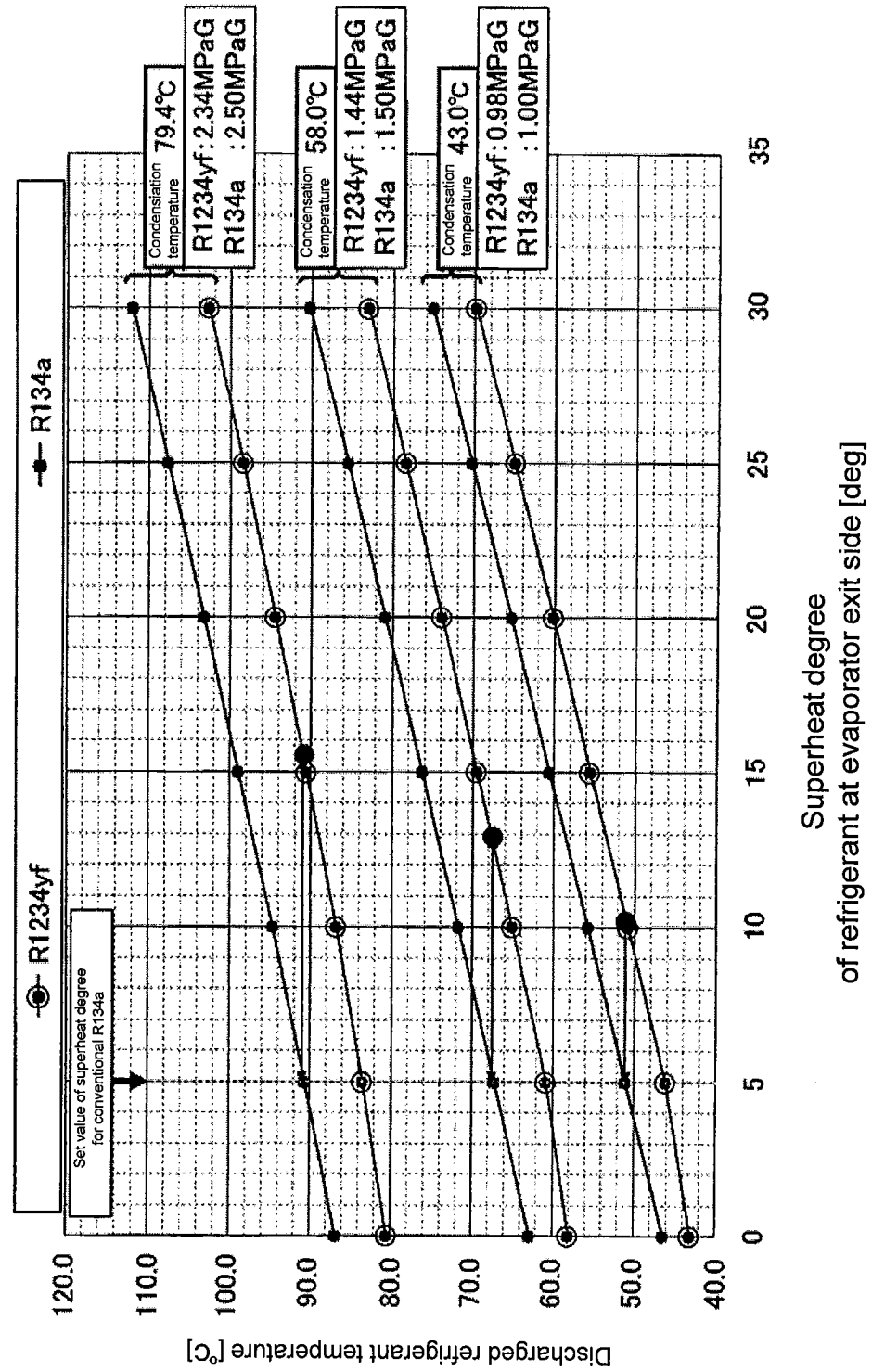


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/058292

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00 (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)

F25B1/00

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	JP 2007-315663 A (Sanden Corp.), 06 December, 2007 (06.12.07), Full text; Fig. 1 (Family: none)	1-4
Y	JP 10-19390 A (Daikin Industries, Ltd.), 23 January, 1998 (23.01.98), Par. No. [0037] (Family: none)	1-4
P, X	JP 2008-281326 A (Calsonic Kansei Corp.), 20 November, 2008 (20.11.08), Full text; Fig. 10 & WO 2008/126848 A1	1-4

☐ 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
15 May, 2009 (15.05.09)Date of mailing of the international search report
26 May, 2009 (26.05.09)Name and mailing address of the ISA/
Japanese Patent Office

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REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- *Refrigeration*, March 2008, vol. 83 (965 [0006])