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

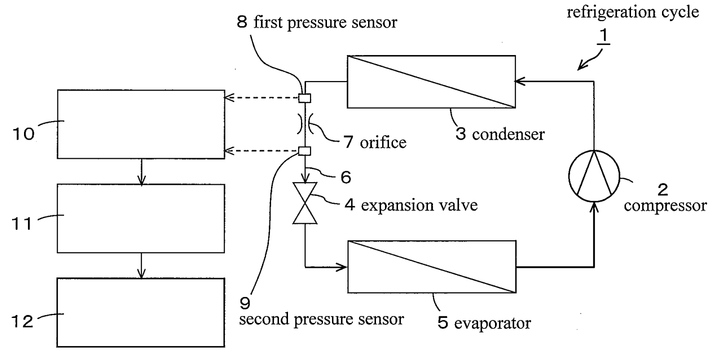
(72) Inventors:
- **ISHIZEKI Tetsuya**
  Isesaki-shi
  Gunma 372-8502 (JP)
- **INOUE Atsuo**
  Isesaki-shi
  Gunma 372-8502 (JP)
- **TSUBOI Masato**
  Isesaki-shi
  Gunma 372-8502 (JP)
- **SUZUKI Kenichi**
  Isesaki-shi
  Gunma 372-8502 (JP)

(74) Representative: **Prüfer & Partner GbR**
European Patent Attorneys
Sohnckestrasse 12
81479 München (DE)

(54) **REFRIGERATION CYCLE**

(57) Provided is a refrigeration cycle wherein, when an orifice is disposed within a refrigeration circuit, and a differential pressure between the upstream side and the downstream side of the orifice is detected using two pressure sensors, the difference between the characteristics of the pressure sensors can be adequately and easily absorbed in software, to accurately determine an actual differential pressure, so that the flow rate of refrigerant and the torque of a compressor can be accurately estimated. The refrigeration cycle wherein the orifice is provided within a refrigerant circuit, and the pressure sensors are respectively provided on the upstream side and the downstream side of the orifice, is **characterized in that**, with regard to output characteristics representing the relationship between the detected pressure and the sensor output of each pressure sensor, the difference between the output characteristics of one pressure sensor and the output characteristics of the other pressure sensor is determined based on the outputs of both pressure sensors at a condition where the flow of refrigerant is stopped.

FIG. 1



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Description

Technical Field of the Invention

[0001] The present invention relates to a refrigeration cycle, and specifically, to a refrigeration cycle which has an orifice and two pressure sensors disposed on the upstream and downstream sides thereof, which enables to estimate a flow rate of refrigerant, a compressor torque, etc. more accurately and which is suitable in use for an air conditioning system for vehicles, etc.

Background Art of the Invention

[0002] For example, in a refrigeration cycle having a compressor, a condenser, a pressure reduction/expansion mechanism and an evaporator in this order, for example, in a refrigeration cycle of an air conditioning system for vehicles, there is a case where pressure sensors are respectively provided at an upstream position and a downstream position in the flow direction of refrigerant in a refrigerant circuit, and a differential pressure between the pressures detected by both pressure sensors is determined. Further, in order to give a clear differential pressure efficiently within a short zone, usually, it is effective to provide an orifice (for example, Patent document 1). If this differential pressure can be accurately determined, it becomes possible to accurately estimate a flow rate of refrigerant having a high correlation with the differential pressure, and further, to accurately estimate a torque for driving a compressor using the flow rate of refrigerant. If the compressor torque can be estimated accurately and at real time, it also becomes possible to reflect it to a control of a vehicle engine as a drive source for the compressor, etc. (for example, engine fuel injection control), and it may contribute to save the fuel consumption of the vehicle.

[0003] As described above, although it becomes possible to estimate a flow rate of refrigerant at that time based on a predetermined relationship between a differential pressure and a flow rate of refrigerant by providing pressure sensors respectively on the upstream and downstream sides of the orifice in the refrigerant flow direction and determining the differential pressure between the pressures detected by both pressure sensors, in order to carry out this estimation at a high accuracy, it is necessary to determine the differential pressure at a high accuracy. Then, in order to determine the differential pressure accurately, it is necessary at least that the pressure detection properties of both pressure sensors are same, or that the pressure detection properties are recognized clearly. Each pressure sensor itself does not have so great problem as long as a single pressure sensor detects a pressure at a certain position, because it has an excellent repeatability with regard to the relationship between the detected pressure and the sensor output. However, in case where a plurality of pressure sensors are provided, there is a case where a slight difference occurs between the respective pressure sensors with regard to the output characteristics representing a relationship between a detected pressure and a sensor output ascribed to an error of manufacture of pressure sensors, etc. Since the above-described differential pressure between the upstream and downstream sides of the orifice may become a much smaller value as compared with the absolute value of the pressure detected by each pressure sensor, if there is a slight difference in output characteristics between the respective sensors, there is a high fear that the difference appears as a relatively large error relatively to the accuracy of the differential pressure to be determined. If a relatively large error occurs in the determined differential pressure, high-accuracy estimation of flow rate of refrigerant or torque of compressor cannot be expected.

Prior art documents

Patent documents

[0004]

Patent document 1: JP-A-6-281300

Summary of the Invention

Problems to be solved by the Invention

[0005] Accordingly, an object of the present invention is to provide a refrigeration cycle wherein, when an orifice is disposed within a refrigeration circuit and a differential pressure on the upstream and downstream sides thereof is detected using two pressure sensors, the difference between the characteristics of the respective pressure sensors can be adequately and easily absorbed in software, to accurately determine an actual differential pressure, so that the flow rate of refrigerant and the torque of a compressor can be accurately estimated.

Means for solving the Problems

[0006] To achieve the above-described object, a refrigeration cycle according to the present invention wherein an orifice is provided within a refrigerant circuit, and pressure sensors are respectively provided on an upstream side and a downstream side of the orifice, is **characterized in that**, with regard to output characteristics representing a relationship between a detected pressure and a sensor output of each of the pressure sensors, a difference in characteristics between output characteristics of one pressure sensor and output characteristics of the other pressure sensor is determined based on outputs of both pressure sensors at a condition where a flow of refrigerant is stopped.

[0007] In such a refrigeration cycle according to the present invention, since a difference in output characteristics between output characteristics of the respective pressure sensors disposed on upstream and downstream sides of the orifice is determined at a condition where a flow of refrigerant is stopped, which is considered to be a condition at that both pressure sensors substantially detect a same pressure, it becomes possible to accurately determine the difference in output characteristics between the respective pressure sensors ascribed to error in manufacture, etc. of the respective pressure sensors, it becomes possible to accurately recognize the difference in output characteristics in advance before an actual detection or control is carried out, and as needed, it becomes possible to carry out a calibration in software between the pressure sensors. Since such a calibration in software can be accurately carried out without adding a mechanical processing to a pressure sensor itself, it can be performed very easily. Then, if the calibration between the pressure sensors can be carried out accurately, an actual differential pressure can be determined accurately.

[0008] This calibration can be achieved, for example, by the following structure. Namely, it is a structure wherein a pressure calculation means, into which outputs of the above-described pressure sensors are inputted, is provided, and in the pressure calculation means, based on the above-described difference in characteristics determined, output characteristics of one pressure sensor is calibrated on the basis of output characteristics of the other pressure sensor. By this, the output characteristics of both pressure sensors can be made even in software, and even if the differential pressure is small, it can be accurately determined. Namely, in a condition where refrigerant flows, using the above-described calibrated output characteristics of the pressure sensor, a differential pressure between the upstream and downstream sides of the orifice may be calculated from outputs of both pressure sensors.

[0009] Further, if a relationship between a flow rate of refrigerant and a differential pressure between the upstream and downstream sides of the orifice is being determined by an examination and the like in advance, from the above-described calculated differential pressure, a flow rate of refrigerant at that time can be accurately calculated referring to the predetermined relationship between a flow rate of refrigerant and a differential pressure between the upstream and downstream sides of the orifice.

[0010] Further, if a relationship between a flow rate of refrigerant and a torque of the compressor in the refrigeration cycle is being determined by an examination and the like in advance, from the above-described calculated differential pressure, a torque of the compressor at that time can be accurately calculated referring to the predetermined relationship between a flow rate of refrigerant and a torque of the compressor in the refrigeration cycle.

[0011] Thus, if the compressor torque can be estimated accurately, by sending a signal of the above-described calculated torque of the compressor to a control unit for a drive source of the compressor, an optimum control of the drive source can be realized. In case where the drive source of the compressor is a prime mover for a vehicle (an engine), by estimating the compressor torque accurately and at real time, it can be reflected, for example, to a fuel injection control of the engine, thereby contributing to save the fuel consumption of the vehicle, etc.

[0012] With respect to the above-described calibration of the output characteristics of the pressure sensor, for example as described later, it can be carried out using a preset calculation equation having a correction term. Alternatively, the above-described calibration of the output characteristics of the pressure sensor can also be carried out using a map preset with a plurality of output characteristics.

[0013] The above-described difference in characteristics between output characteristics of the pressure sensors is preferably determined after a predetermined time passes since the refrigeration cycle is stopped. When a predetermined time passes since the refrigeration cycle is stopped, because the flow of refrigerant is in a stable condition, the difference in output characteristics can be determined more accurately.

[0014] Such a refrigeration cycle according to the present invention is suitable particularly for use in an air conditioning system for vehicles which requires an accurate information of compressor driving torque from the viewpoint of drive control of a prime mover for a vehicle, etc. Further, also from the viewpoint that the determination of the difference between output characteristics of the pressure sensors and the calibration between the pressure sensors can carried out in software and therefore can be inexpensively without requiring a space, it is suitable for use in an air conditioning system for vehicles which strongly requires space saving and cost down.

Effect according to the Invention

[0015] In the refrigeration cycle according to the present invention, when the orifice is disposed within the refrigeration circuit and the differential pressure between the upstream and downstream sides thereof is detected using two pressure sensors, the difference between output characteristics of the respective pressure sensors can be adequately and easily treated and absorbed in software, and an actual differential pressure can be determined properly and accurately. Therefore, based on the differential pressure determined accurately, the flow rate of refrigerant can be estimated accurately, and ultimately, it becomes possible to estimate the compressor torque accurately. Consequently, by applying the refrigeration cycle according to the present invention, while achieving a high-accuracy control, and space saving and cost down as the whole of the refrigeration cycle, an air conditioning system for vehicles having an optimum formation can be realized.

Brief explanation of the drawings

[0016]

[Fig. 1] Fig. 1 is a schematic diagram of a refrigeration cycle according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is an enlarged sectional view showing an example of a part of an orifice and pressure sensors in the refrigeration cycle depicted in Fig. 1.

[Fig. 3] Fig. 3 is a diagram in characteristics showing an example of correction of shift of output characteristics of one pressure sensor relative to output characteristics of the other pressure sensor in the refrigeration cycle depicted in Fig. 1.

[Fig. 4] Fig. 4 depicts diagrams in characteristics showing examples of P-h diagrams of the refrigeration cycle depicted in Fig. 1.

Embodiments for carrying out the Invention

[0017] Hereinafter, desirable embodiments of the present invention will be explained referring to figures. Fig. 1 shows a schematic structure of a refrigeration cycle according to an embodiment of the present invention. In the figure, symbol 1 indicates the whole of a refrigeration cycle, and refrigeration cycle 1 has a compressor 2 for compressing refrigerant, a condenser 3 for condensing the compressed refrigerant, an expansion valve 4 as a pressure reduction-expansion mechanism for pressure reducing and expanding the refrigerant sent from the condenser 3, and an evaporator 5 for evaporating the refrigerant sent from the expansion valve 4. In this embodiment, an orifice 7 for throttling the flow of refrigerant is provided on a refrigerant path 6 between condenser 3 and expansion valve 4 in the refrigerant circuit of refrigeration cycle 1, and at the upstream and downstream positions of the orifice 7 in the direction of the refrigerant flow, a first pressure sensor 8 and a second pressure sensor 9 each detecting the pressure of refrigerant are provided, respectively. Orifice 7 and first and second pressure sensors 8, 9 provided in this refrigerant path 6 are disposed, for example, as shown in Fig. 2. These may be formed as an integrated unit.

[0018] The outputs of the detected pressures from the above-described first pressure sensor 8 and second pressure sensor 9 are sent to pressure calculation means 10. Although each pressure sensor 8 or 9 has output characteristics representing a relationship between a detected pressure (P) and a sensor output (V) such as one shown in Fig. 3 for example, output V1 of first pressure sensor 8 and output V2 of second pressure sensor 9 relative to a detected pressure (P) may be slightly shifted from each other originating from errors in manufacture of the respective pressure sensors 8, 9, etc. As aforementioned, there is a case where such a slight shift becomes a relatively large amount of shit in case where a differential pressure between the pressures detected by both sensors. In pressure calculation means 10, with regard to output characteristics representing a relationship between a detected pressure and a sensor output of each of pressure sensors 8, 9, a difference in characteristics between output characteristics of both sensors is determined from outputs of both pressure sensors at a condition where the flow of refrigerant is stopped, preferably, from outputs of both pressure sensors after a predetermined time (a time necessary for stabilizing the flow of the refrigerant at its condition being stopped) passes since refrigeration cycle 1 is stopped. Then, a correction calculation is performed so that, based on the determined difference in characteristics, output characteristics of one pressure sensor is calibrated on the basis of output characteristics of the other pressure sensor. In the example shown in Fig. 3, the calibration is performed in software so as to adjust the characteristics of output V2 of second pressure sensor 9 to the characteristics of output V1 of first pressure sensor 8, for example, with regard to a reference pressure Pa. Since this calibration is performed under a condition where the outputs of both pressure sensors 8, 9 at the condition of the flow of refrigerant being stopped, that is, the pressures to be detected by both pressure sensors 8, 9 are basically in a same pressure (uniform pressure) based on the outputs of both pressure sensors 8, 9, the calibration is preformed accurately. By this, the output characteristics of both pressure sensors 8, 9 can be made even in software (for example, base points such as zero points can be made even in software), and via pressure detection using the output characteristics made even, even in case where the differential pressure is small in an actual pressure detection at a condition where the refrigerant flows, the differential pressure can be accurately and properly determined.

[0019] Such a calibration of the output characteristics of pressure sensor 9 can be carried out, for example, by using the following preset calculation equation having a correction term (H) which corresponds to the above-described difference between output characteristics.

$$Pa = A \times V1 + B = A \times V2 + B + H$$

Where, B is a constant.

[0020] Alternatively, although it is not depicted, the above-described calibration of the output characteristics of pressure sensor 9 can also be carried out by using a map preset with a plurality of output characteristics.

[0021] If the differential pressure between the upstream and downstream positions of orifice 7 is thus calculated accurately, by a condition where a relationship between a flow rate of refrigerant and a differential pressure between the upstream and downstream sides of the orifice is being determined by an examination and the like in advance and the relationship is stored in memory, from the differential pressure calculated as described above, by a refrigerant flow rate estimation means 11, a flow rate of refrigerant at that time can be accurately calculated referring to this predetermined relationship between a flow rate of refrigerant and a differential pressure between the upstream and downstream sides of the orifice.

[0022] Furthermore, by a condition where a relationship between a flow rate of refrigerant and a torque of compressor 2 in refrigeration cycle 1 is being determined by an examination and the like in advance and the relationship is stored in memory, from the flow rate of refrigerant calculated as described above, by a compressor torque estimation means 12, a torque of the compressor 2 at that time can be accurately calculated referring to this predetermined relationship between a flow rate of refrigerant and a torque of the compressor 2 in the refrigeration cycle 1.

[0023] Then, if the compressor torque can be thus estimated accurately, as aforementioned, by sending a signal of the estimated compressor torque to a control unit for a drive source of the compressor (for example, an engine for a vehicle), an optimum control of the drive source can be realized. In particular, in case where the drive source of the compressor is a prime mover for a vehicle (an engine), by estimating the compressor torque accurately and at real time, it can be reflected, for example, to a fuel injection control of the engine, thereby contributing to save the fuel consumption of the vehicle, etc.

[0024] Where, with respect to the position provided with the above-described orifice and the property for giving a pressure loss to the provided orifice, it is possible to optimize them from the viewpoint of the operation property of refrigeration cycle 1. The operation property of refrigeration cycle 1 can be represented by a P-h diagram, for example, as shown in Figs. 4 (A) and (B). Namely, by orifice 7 provided on refrigerant path 6, a differential pressure between the upstream and downstream sides of the orifice can be forcibly given, and it becomes possible to detect a differential pressure necessary, for example, for estimating the flow rate of refrigerant by first and second pressure sensors 8, 9. Then, it becomes possible to estimate the flow rate of refrigerant having a high correlation with this differential pressure by refrigerant flow rate estimation means 11, and ultimately, to estimate the compressor torque by compressor torque estimation means 12. At that time, the stable and accurate detection of the differential pressure between the upstream and downstream sides of the orifice may contribute to an accurate estimation of refrigerant flow rate and an accurate estimation of compressor torque. In order to detect the differential pressure between the upstream and downstream sides of the orifice accurately at a stable condition, it is preferred to detect it at a condition where there is no phase change of refrigerant or an extremely small phase change. For example, as shown in Fig. 4(A), it is preferred to be set so that a differential pressure ΔP due to the orifice occurs in the same liquid phase. However, for example, as shown in Fig. 4(B), even if a differential pressure ΔP occurs over the phase changing region, although the accuracy may be reduced slightly, it is possible to estimate the refrigerant flow rate and the compressor torque at a sufficiently high accuracy.

<u>Industrial Applications of the Invention</u>

[0025] The refrigeration cycle according to the present invention can be applied to any refrigeration cycle requiring to determine the differential pressure between upstream and downstream sides of an orifice using the orifice and pressure sensors disposed at upstream and downstream sides thereof, and from the point in that the calibration of the pressure sensor can be carried out in software inexpensively, in particular, it is suitable for use in an air conditioning system for vehicles which strongly requires cost down.

<u>Explanation of symbols</u>

[0026]

1: refrigeration cycle
2: compressor
3: condenser
4: expansion vale as pressure reduction-expansion mechanism
5: evaporator
6: refrigerant path
7: orifice
8: first pressure sensor
9: second pressure sensor
10: pressure calculation means
11: refrigerant flow rate estimation means
12: compressor torque estimation means

Claims

1. A refrigeration cycle wherein an orifice is provided within a refrigerant circuit, and pressure sensors are respectively provided on an upstream side and a downstream side of said orifice, **characterized in that**, with regard to output characteristics representing a relationship between a detected pressure and a sensor output of each of said pressure sensors, a difference in characteristics between output characteristics of one pressure sensor and output characteristics of the other pressure sensor is determined based on outputs of both pressure sensors at a condition where a flow of refrigerant is stopped.

2. The refrigeration cycle according to claim 1, wherein a pressure calculation means, into which outputs of said pressure sensors are inputted, is provided, and in said pressure calculation means, based on said difference in characteristics determined, output characteristics of one pressure sensor is calibrated on the basis of output characteristics of the other pressure sensor.

3. The refrigeration cycle according to claim 2, wherein, in a condition where refrigerant flows, using said output characteristics of said pressure sensor calibrated, a differential pressure between said upstream and downstream sides of said orifice is calculated from outputs of both pressure sensors.

4. The refrigeration cycle according to claim 3, wherein, from said differential pressure calculated, a flow rate of refrigerant at that time is calculated referring to a predetermined relationship between a flow rate of refrigerant and a differential pressure between said upstream and downstream sides of said orifice.

5. The refrigeration cycle according to claim 4, wherein, from said flow rate of refrigerant calculated, a torque of a compressor at that time is calculated referring to a predetermined relationship between a flow rate of refrigerant and a torque of said compressor in said refrigeration cycle.

6. The refrigeration cycle according to claim 5, wherein a signal of said torque of said compressor calculated is sent to a control unit for a drive source of said compressor.

7. The refrigeration cycle according to any of claims 2 to 6, wherein calibration of said output characteristics of said pressure sensor is carried out using a preset calculation equation having a correction term.

8. The refrigeration cycle according to any of claims 2 to 6, wherein calibration of said output characteristics of said pressure sensor is carried out using a map preset with a plurality of output characteristics.

9. The refrigeration cycle according to any of claims 1 to 8, wherein said difference in characteristics between output characteristics of said pressure sensors is determined after a predetermined time passes since said refrigeration cycle is stopped.

10. The refrigeration cycle according to any of claims 1 to 9, wherein said refrigeration cycle is used for an air conditioning system for vehicles.

FIG. 1

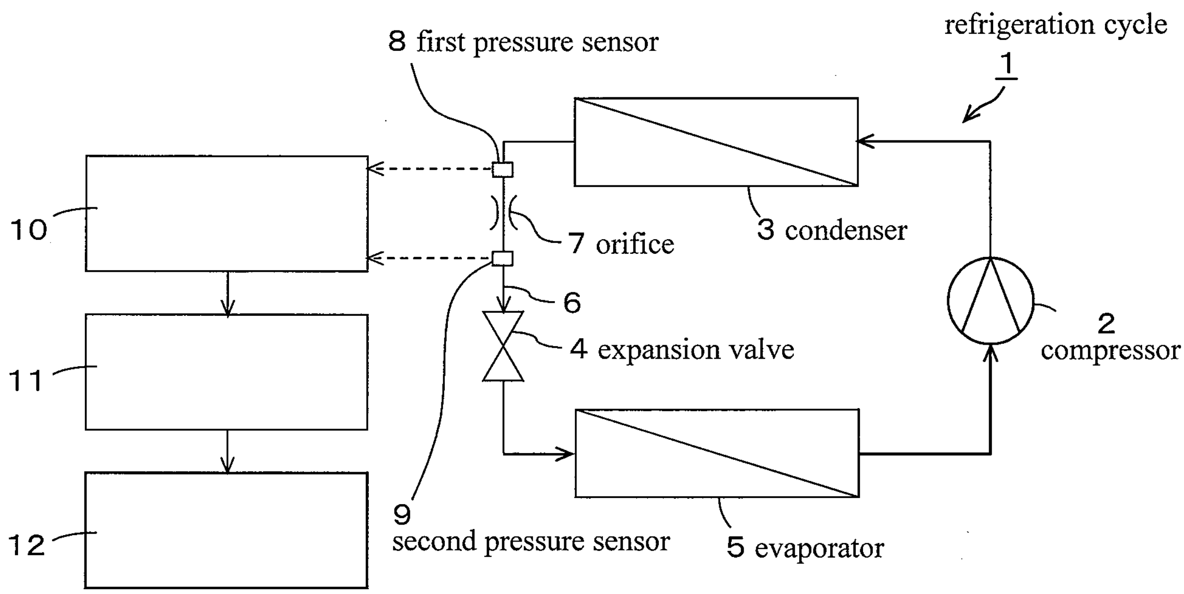

8 first pressure sensor
refrigeration cycle
1
10
7 orifice
3 condenser
6
4 expansion valve
2
compressor
11
9
second pressure sensor
12
5 evaporator

FIG. 2

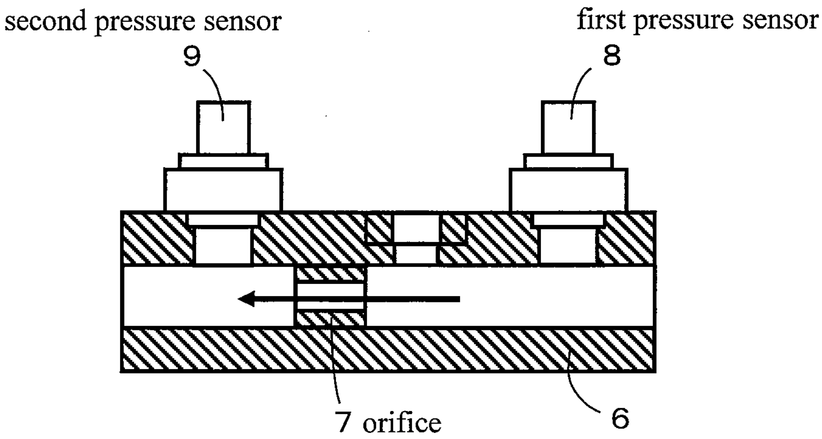

second pressure sensor
9
first pressure sensor
8
7 orifice
6

FIG. 3

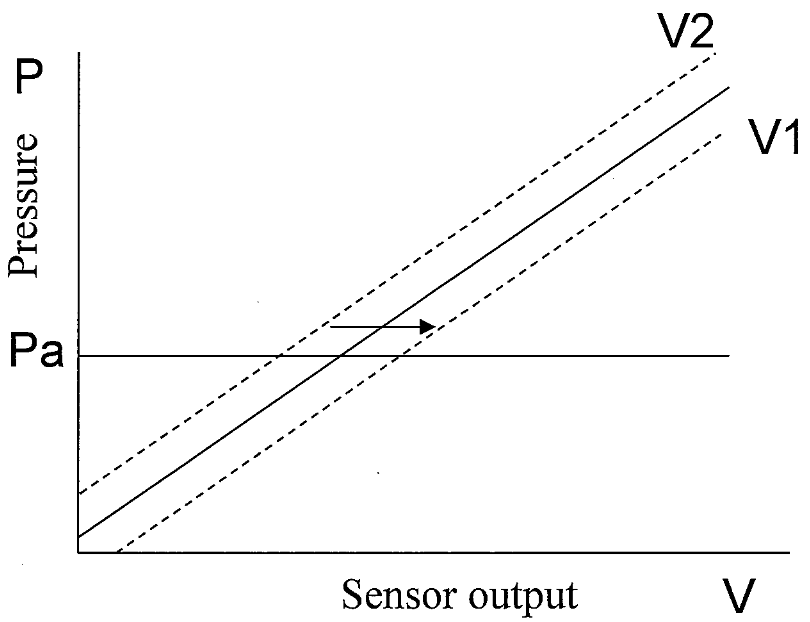
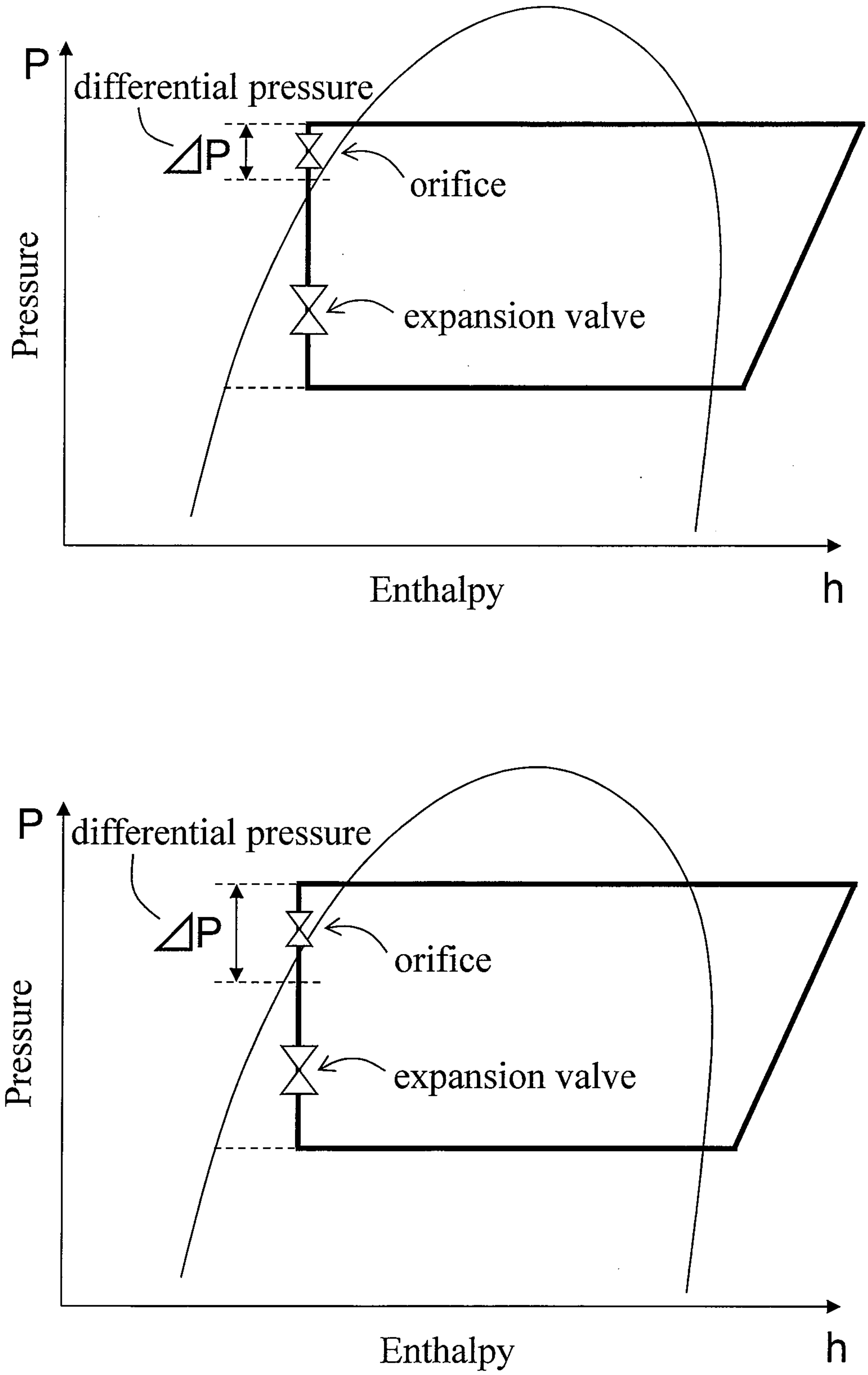


FIG. 4

(A)

(B)


P
differential pressure
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expansion valve
Pressure
Enthalpy
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orifice
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Pressure
Enthalpy
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/062187

A. CLASSIFICATION OF SUBJECT MATTER
F25B49/02(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)
F25B49/02

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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 2009-63179 A (Sanden Corp.), 26 March 2009 (26.03.2009), claims; paragraphs [0001] to [0117]; fig. 1 to 18 & WO 2009/031425 A1	1-10
Y	JP 6-27598 B2 (Mitsubishi Heavy Industries, Ltd.), 13 April 1994 (13.04.1994), claims; column 3, line 13 to column 4, line 17; fig. 1 to 3 & US 4848096 A & GB 2194059 A & AU 7521787 A	1-10

☒ 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
28 September, 2010 (28.09.10)	12 October, 2010 (12.10.10)

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/062187

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 2001-173521 A (Mitsubishi Motors Corp.), 26 June 2001 (26.06.2001), claims; paragraphs [0001] to [0034]; fig. 1 to 4 (Family: none)	2-10
A	JP 6-281300 A (Toshiba Corp.), 07 October 1994 (07.10.1994), entire text; all drawings (Family: none)	1-10

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6281300 A **[0004]**