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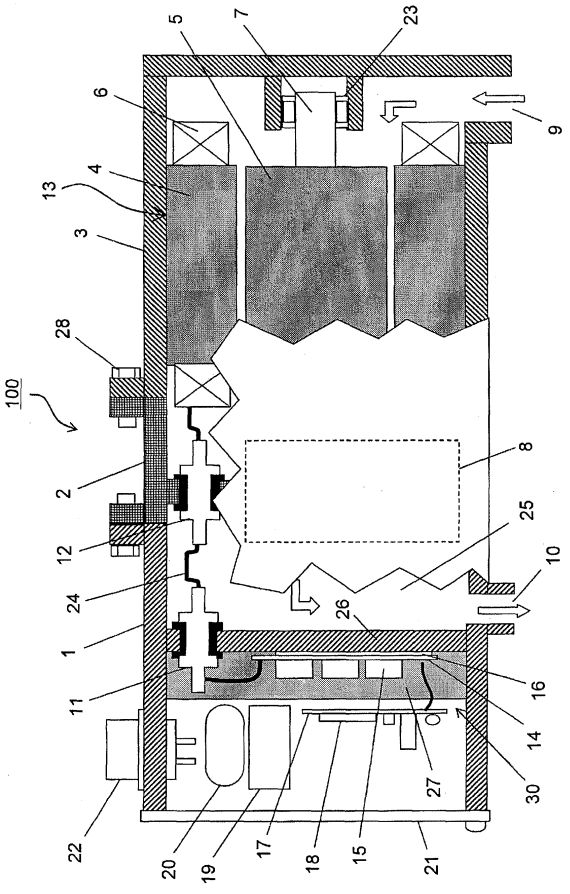
# (54) ELECTRIC COMPRESSOR HAVING DRIVE CIRCUIT INTEGRATED THEREINTO

(57) Disclosed is a drive circuit-integrated electric compressor, which is adapted to cool a power semiconductor element in a motor drive circuit with good efficiency without increasing the temperature of sucked refrigerant gas and while suppressing increase in pressure loss in a path for cooling. Specifically disclosed is a drive circuit-integrated electric compressor into which a motor drive circuit having a power semiconductor element is incorporated integrally, **characterized in that** the electric compressor is configured so that the power semiconductor element in the drive circuit is cooled by refrigerant gas to be discharged.

**FIG. 1**

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## Description

### Technical Field of the Invention

**[0001]** This invention relates to a drive circuit-integrated electric compressor which has a built-in motor and into which a motor drive circuit for driving the motor is incorporated integrally, and specifically, relates to a drive circuit-integrated electric compressor which is adapted to cool a power semiconductor element mounted on the motor drive circuit efficiently.

### Background Art of the Invention

**[0002]** In Patent Document 1, disclosed is a scroll-type electric compressor which has a built-in motor for driving a compression mechanism part and into which a motor drive circuit for driving the motor is incorporated integrally. In this motor drive circuit, particularly into its inverter, a power semiconductor element is assembled, and because the power semiconductor element generates heat, it is generally preferred to cool the element in order to secure the normal operation. Semiconductors currently used, including power semiconductor elements, usually consist of silicon (Si). Because the upper limit of the operating temperature of such a conventional power semiconductor element is about 150°C, it is preferred to cool the element so as not to exceed the upper limit. In Patent Document 1, utilizing refrigerant being sucked into a compressor, this cooling is carried out.

### Prior art documents

Patent documents

**[0003]**

Patent document 1: JP-A-2000-291557

### Summary of the Invention

### Problems to be solved by the Invention

**[0004]** However, in the method for cooling the power semiconductor element in a motor drive circuit utilizing the sucked refrigerant gas as described above, there is a fear that following problems may occur. Namely, because sucked refrigerant gas may be overheated by heat of the power semiconductor element, there is a fear that compression efficiency of the compressor may be reduced. Further, because a temperature of a compressed gas also elevates when the sucked gas is overheated, there is a possibility that a problem of thermal resistance on each part in the compressor may occur, thereby causing a fear that the life of the compressor may be shortened. Furthermore, because the sucked gas passes through a heat exchange route formed for cooling the power semiconductor element, there is a fear that the pressure loss in a refrigerant path in the compressor may increase and the compression efficiency may also be reduced.

**[0005]** Paying attention to the problems with the method for cooling the power semiconductor element in the motor drive circuit using sucked refrigerant gas as described above, the object of the present invention is to provide a drive circuit-integrated electric compressor which can efficiently cool the power semiconductor element in the motor drive circuit, basically without elevating the temperature of sucked refrigerant gas and while suppressing the increase of pressure loss in the path for cooling.

### Means for solving the Problems

**[0006]** To achieve the above-described object, a drive circuit-integrated electric compressor according to the present invention is an electric compressor into which a motor drive circuit having a power semiconductor element is incorporated integrally, characterized in that the electric compressor is configured so that the power semiconductor element of the drive circuit is cooled by refrigerant gas to be discharged. Namely, it is not configured so as to be cooled by sucked refrigerant gas as in the conventional technology, but it is configured so as to cool the power semiconductor element utilizing refrigerant gas to be discharged after having passed through a compression mechanism part of the compressor.

**[0007]** Namely, because the refrigerant gas to be discharged is used for cooling the power semiconductor element, the problems caused in case of using sucked refrigerant gas, that is, a decrease in compression efficiency caused by a temperature elevation of the sucked refrigerant gas, a decrease in life of the compressor caused by a temperature elevation of a compressed gas, an increase in pressure loss caused by passing of the sucked refrigerant gas through a heat exchange route for cooling and a decrease in compression efficiency accompanied with the pressure loss, do not occur basically. In other words, because sucked refrigerant gas is not used for cooling, the gas temperature does not elevate as in the conventional structure until the sucked refrigerant gas is compressed and discharged, and therefore, it is possible to secure a high compression efficiency and to contribute to improve the coefficient of performance (COP) of the compressor. Further, in a refrigerant path in the compressor, since the elevation of the gas temperature is suppressed until sucked refrigerant gas is compressed and discharged, the durability of the compressor is improved and the life thereof is lengthened. Moreover, because sucked refrigerant gas does not need to pass through the heat exchange route for cooling as in the conventional structure, the pressure loss in the refrigerant path in the compressor is reduced. Furthermore, in case of a configuration that a neodymium magnet is used for a rotor as a compressor built-in motor, the magnet may be demagnetized because of the elevation of the temperature.

In the conventional case where the power semiconductor element is cooled by sucked refrigerant gas, there has been a fear that the magnet may be demagnetized because the gas passes through the motor after the temperature of sucked refrigerant gas has been elevated by heat exchange, whereas in the present invention, such a problem can be solved because cooling is performed by refrigerant gas to be discharged which has passed through the motor.

**[0008]** In the present invention, however, because refrigerant gas to be discharged which has a higher temperature than that of sucked refrigerant gas is used for cooling the power semiconductor element, the power semiconductor element may be cooled to a higher temperature relative to that of the conventional structure. Therefore, it is necessary to use a semiconductor element having a higher thermal resistance, that is, a higher operating temperature limit, as the power semiconductor element.

**[0009]** In order to satisfy this necessity, in the present invention, a wide band gap semiconductor element can be used as the above-described power semiconductor element. Namely, as aforementioned, all the semiconductors currently used, including power semiconductors, consist of silicon (Si). Recently, a wide band gap (WBG) power semiconductor is being developed as a semiconductor material to be replaced from silicon. Because the upper limit of the operating temperature of the WBG semiconductor is 200 °C or higher whereas that of the conventional Si power semiconductor is about 150 °C, it becomes possible to cool it sufficiently down to a desired temperature even by the refrigerant gas to be discharged with a temperature which is generally in a range of 100-150 °C. Then, by cooling the power semiconductor by refrigerant gas to be discharged, the problems in the conventional case using sucked refrigerant gas will be solved at one sweep. Where, although a semiconductor using silicon carbide (SiC), gallium nitride (GaN) or diamond, etc., is known as the wide band gap power semiconductor, any type of wide band gap power semiconductor element can be used as long as it has such a high upper limit of the operating temperature as described above.

**[0010]** Further, since such a wide band gap power semiconductor element is small in on-state resistance and small in switching loss, the heat generated by the element itself is also small, and therefore the amount of heat required for cooling the element is small as compared with that for the Si power semiconductor element. From this point of view, it is possible to cool the wide band gap power semiconductor element sufficiently and efficiently by cooling due to the refrigerant gas to be discharged.

**[0011]** Furthermore, because the wide band gap semiconductor element has a high heatproof temperature, it is not necessary to create an extra low temperature as a cooling source, and therefore, the total efficiency determined as the whole of the refrigeration circuit system is also improved.

**[0012]** In the drive circuit-integrated electric compressor according to the present invention, it may be configured so that the power semiconductor element of motor drive circuit is cooled by refrigerant gas to be discharged, and various types of configurations can be employed as concrete cooling structures. For example, a structure may be employed wherein the above-described power semiconductor element is mounted on a high heat-conduction circuit board and a back surface of the circuit board is configured to be cooled by the refrigerant gas to be discharged through a wall of the compressor (a wall inside the compressor). By using a circuit board comprising a high heat-conduction material, for example, a material made of a high heat-conduction ceramic, etc., the power semiconductor element is cooled through the circuit board with a high efficiency.

**[0013]** Further, in the drive circuit-integrated electric compressor according to the present invention, a structure may be employed wherein the above-described power semiconductor element is coated with a low heat-conduction resin. Furthermore, a structure may be employed wherein a low heat-conduction heat shielding member is provided at a position between the above-described power semiconductor element and other electronic parts. Because heat radiation to other electronic parts can be prevented by being shielded by such a low heat-conduction resin or a low heat-conduction member, the temperature elevation of the other electronic parts can be suppressed, and the reliability as the whole of the motor drive circuit, and further, as the whole of the compressor, is improved.

**[0014]** The kind of refrigerant used in the drive circuit-integrated electric compressor according to the present invention is not particularly limited. Not only conventional refrigerants used generally, but also $CO_2$ and HFC1234yf can be used as the refrigerant. In the case of $CO_2$ refrigerant, although the refrigerant is used under a higher-temperature and higher-pressure condition, it is sufficiently applicable for cooling the above-described wide band gap semiconductor element. Further, HFC1234yf, which is a new refrigerant announced recently, is also sufficiently applicable for cooling the power semiconductor element.

**[0015]** In addition, in the drive circuit-integrated electric compressor according to the present invention, as the refrigerant gas to be discharged for cooling the above-described power semiconductor element in the drive circuit, for example, it is possible to use any of refrigerant gas to be discharged which has passed through a built-in motor and a compression part (a compression mechanism part) in this order, refrigerant gas to be discharged which has passed through a compression part and a built-in motor in this order and refrigerant gas to be discharged which passes through a built-in motor part after having passed through a compression part (for example, as shown in the embodiment described later, refrigerant gas to be discharged which passes through a discharged gas

path formed at a position between a stator of a built-in motor and a drive circuit housing after having passed a compression part).

**[0016]** Further, the drive circuit-integrated electric compressor according to the present invention is suitable, for example, for a scroll-type compressor in particular. That is, in the case of a scroll-type compressor, because a motor drive circuit can be easily disposed at a position near a path for refrigerant gas to be discharged, it is possible to cool the power semiconductor element of the motor drive circuit efficiently.

**[0017]** Furthermore, the drive circuit-integrated electric compressor according to the present invention is particularly suitable as a compressor mounted on a vehicle. A structure for efficiently cooling the power semiconductor can be realized by a simple configuration substantially without a gain of weight. In particular, this electric compressor is suitable particularly for a compressor installed in a refrigeration circuit of an air conditioning systems for vehicles.

Effect according to the Invention

**[0018]** In the drive circuit-integrated electric compressor according to the present invention, because refrigerant gas to be discharged is utilized for cooling the power semiconductor element, an elevation of the gas temperature before the compression and discharge of sucked refrigerant gas as in the conventional method may not be caused, a high compression efficiency can be achieved and the coefficient of performance (COP) of the compressor can be improved. Particularly, in the case using a wide band gap power semiconductor element as a power semiconductor element, the power semiconductor element can be efficiently cooled by utilizing refrigerant gas to be discharged.

**[0019]** Further, because the gas temperature is not elevated until sucked refrigerant gas is compressed and discharged, it is possible to improve the durability and life of the compressor. Furthermore, because sucked refrigerant gas does not have to pass through a heat exchange route for cooling as in a conventional structure, it is also possible to reduce the pressure loss.

Brief explanation of the drawings

**[0020]**

[Fig. 1] Fig. 1 is a schematic vertical sectional view of a drive circuit-integrated electric compressor according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a circuit diagram of a motor drive circuit and a control circuit in the compressor depicted in Fig. 1.

[Fig. 3] Fig. 3 is a schematic vertical sectional view of a drive circuit-integrated electric compressor according to a second embodiment of the present invention.

[Fig. 4] Fig. 4 is a schematic vertical sectional view of a drive circuit-integrated electric compressor according to a third embodiment of the present invention.

Embodiments for carrying out the Invention

**[0021]** Hereinafter, desirable embodiments of the present invention will be explained referring to figures. Fig. 1 shows a drive circuit-integrated electric compressor 100 according to a first embodiment of the present invention. In Fig. 1, symbol 1 indicates a drive circuit housing, symbol 2 indicates a compressor housing and symbol 3 indicates a suction housing. In this embodiment, a motor 13 constituted by a stator 4, a rotor 5 and a motor coil 6 is incorporated into suction housing 3. By this motor 13, a drive shaft 7 supported by a bearing 23 at a condition free to rotate is rotationally driven and a compression part 8 (a compression mechanism part) is operated. Compression part 8 is configured, for example, as a scroll type.

**[0022]** In compressor 100, a refrigerant path depicted by arrows is formed. The refrigerant gas is sucked at a suction port 9 formed in suction housing 3, passes through a motor part, is compressed at compression part 8, and then is discharged from a discharge port 10 formed in drive circuit housing 1 to an external circuit. Symbol 11 I indicates a sealed terminal A and symbol 12 indicates a sealed terminal B, and they supply power from a motor drive circuit 30 to motor 13, together with a lead wire 24.

**[0023]** Motor drive circuit 30 has a power semiconductor element 15, which is installed on a power circuit board 14. In this embodiment, a wide band gap power semiconductor element is used as this power semiconductor element 15. Power circuit board 14 is fixed to a wall 26 in drive circuit housing 1, which is located at a position where refrigerant gas to be discharged passes, via insulation material 16, and by utilizing refrigerant gas to be discharged which passes through a discharge chamber 25, power semiconductor element 15 mounted on power circuit board 14 is cooled. In order to improve cooling efficiency, power circuit board 14, further, insulation material 16, are made of a high heat-conduction ceramic, etc.

**[0024]** Symbol 17 indicates a board of control circuit for controlling motor drive circuit 30, and a micro controller 18 constituting the control circuit is installed on this control circuit board 17. Electric power is supplied from an external power source through a connector 22, and therefrom, the power is supplied to motor drive circuit 30 through a noise filter 20 and a smoothing capacitor 19. These circuit parts are covered with a lid 21, and shielded from the outside. Furthermore, in this embodiment, a low heat-conduction insulation resin 27 is provided on power circuit board 14, and power semiconductor element 15 is covered with this resin 27 so that heat radiation from power semiconductor element 15 to other electronic

parts is prevented. Where, symbol 28 in Fig. 1 shows a bolt connecting the respective housings to each other.

**[0025]** Motor drive circuit 30 and its control circuit are configured, for example, as shown in Fig. 2. In Fig. 2, motor drive circuit 30 is provided in electric compressor 100 as described above, and by supplying an output from motor drive circuit 30 to each of motor coils 6 of a built-in motor 13 through sealed terminal 11, motor 13 is rotationally driven and the compression by compression part 8 is carried out. Electric power from an external power source 42 (for example, a battery) is supplied to this motor drive circuit 30, then is supplied to an inverter 41 through noise filter 20 containing a coil and a capacitor and through smoothing capacitor 19, and is supplied to motor 13 after the direct current from power source 42 is converted into a pseudo three-phase alternate current by inverter 41. Signals controlling the compressor are supplied to motor control circuit 45 from, for example, an air conditioning unit for vehicles 44 through a connector for control signal 43. The above-described inverter 41 is provided with three sets of power semiconductor elements 15, 6 elements in total, each consisting of a Schottky barrier diode SiC-SBD 47 and a SiC-MOSFET 46 as wide band gap semiconductor. Similar motor drive circuit and control circuit can be used in the drive circuit-integrated electric compressors according to second and third embodiments described later.

**[0026]** In the embodiment thus constructed, power semiconductor element 15 is cooled efficiently as follows. As aforementioned, because the upper limit of the operating temperature of a wide band gap power semiconductor is 200°C or more whereas the upper limit of the operating temperature of a conventional Si power semiconductor is approximately 150°C, without using sucked refrigerant gas, the wide band gap power semiconductor can be cooled sufficiently even by a temperature of refrigerant gas to be discharged which is generally in a temperature range of 100-150°C. Therefore, an elevation of the temperature of the sucked refrigerant gas in the conventional cooling method can be prevented and the compression efficiency can be improved. Further, by suppressing the elevation of the temperature of the sucked refrigerant gas, the life of respective portions in the compressor can be improved. Furthermore, because it is not necessary to specially form a gas path for cooling a power semiconductor element by a sucked refrigerant gas, the reduction of the pressure loss can also be achieved.

**[0027]** In addition, as aforementioned, because a wide band gap power semiconductor is small in on-state resistance and small in switching loss, a heat generated by the element itself is also small, and therefore, the amount of heat for cooling may be smaller than that for an Si power semiconductor. Therefore, even refrigerant gas to be discharged can cool the element sufficiently.

**[0028]** In addition, as shown in this embodiment, by covering power semiconductor element 15 with low heat-conduction resin 27, for example, the heat radiation to electronic parts, smoothing capacitor 19 and noise filter 20 which are mounted on control circuit board 17 can be eliminated so that the elevation of temperature can be prevented, and proper operation of these electronic parts can be ensured. In addition, although it is not depicted in figures, it is also effective to partition between power semiconductor element 15 and control circuit board 17 by a heat shielding plate.

**[0029]** Further, in the structure of this embodiment, because it is not necessary to consider a path of the sucked refrigerant gas and the position of suction port 9 is not restricted, the design freedom increases and the installation to a vehicle is facilitated.

**[0030]** Furthermore, as aforementioned, because the wide band gap semiconductor element has a high heat-proof temperature and it is not necessary to create an extra low temperature as a cooling source, the total efficiency of the refrigeration circuit system is improved. Furthermore, in case where motor 13 has a rotor using a neodymium magnet, the magnet would be demagnetized to some extent by the temperature elevation. In the conventional case where the power semiconductor element is cooled by the sucked refrigerant gas, because the sucked refrigerant gas passes through a motor after the gas temperature has elevated due to the heat exchange, there has been a fear that the magnet may be demagnetized to some extent, but in the case of this embodiment, this problem is to be solved.

**[0031]** Fig. 3 depicts a drive circuit-integrated electric compressor 200 according to a second embodiment of the present invention. In this embodiment, the refrigerant gas sucked from suction port 9 is introduced directly into compression part 8 through suction gas chamber 31, passes through motor 13, cools power semiconductor element 15 and then is discharged from discharge port 10. Because a magnet of motor 13 is exposed to refrigerant gas to be discharged, it is preferred to use not a neodymium magnet having a demagnetization characteristic at high temperature, but a ferrite magnet, etc. having a demagnetization characteristic at low temperature. Further, it is also preferred to use a motor which has no fear of demagnetization (an induction motor, a switched reluctance motor, etc.). The other configurations of this embodiment are in accordance with those of the aforementioned first embodiment.

**[0032]** In such a configuration, the sucked refrigerant gas is not heated because the gas enters directly into compression part 8 before passing through motor 13. Therefore, it is possible to further improve the compression efficiency. Further, because the sucked refrigerant gas enters directly into compression part 8 without passing through motor 13, the pressure loss therebetween does not substantially occur.

**[0033]** Fig. 4 depicts a drive circuit-integrated electric compressor according to a third embodiment of the present invention. In this embodiment, a drive circuit is mounted in the radial direction of motor 13. The sucked refrigerant gas coming out of compression part 8 passes through discharge gas path 33 formed between stator 4

of motor 13 and drive circuit housing 32, and cools power semiconductor element 15 of the motor drive circuit. A drive circuit is incorporated into drive circuit housing 32, and motor 13 is incorporated into drive circuit housing 32. Compression part 8 is incorporated into suction housing 3. The sucked refrigerant gas enters into suction gas chamber 31 and then is sent to compression part 8. The other configurations of this embodiment are in accordance with those of the aforementioned first embodiment.

**[0034]** In such a configuration, while an excellent cooling effect of power semiconductor element 15 is obtained, the length of electric compressor 300 in the axial direction is shortened and the automotive installation facility is improved.

**[0035]** Fig. 1, Fig. 3 and Fig. 4 show configurations that power semiconductor element is mounted on a high heat-conduction circuit board. However, though it is not depicted in figures, it goes without saying that the same effect can be achieved when a discrete-type wide band gap power semiconductor element is mounted directly on a wall of a compressor.

Industrial Applications of the Invention

**[0036]** The structure of the drive circuit-integrated electric compressor according to the present invention can be applied to any type electric compressor assembled with a power semiconductor element, and specifically, is suitable for a compressor mounted on a vehicle, and in particular, is suitable for a compressor for air conditioning system for vehicles.

Explanation of symbols

**[0037]**

| | |
|---|---|
| 1: | drive circuit housing |
| 2: | compression part housing |
| 3: | suction housing |
| 4: | stator |
| 5: | rotor |
| 6: | motor coil |
| 7: | drive shaft |
| 8: | compression part |
| 9: | suction port |
| 10: | discharge port |
| 11, 12: | sealed terminal |
| 13: | motor |
| 14: | power circuit board |
| 15: | power semiconductor element |
| 16: | insulation material |
| 17: | control circuit board |
| 18: | microcontroller |
| 19: | smoothing capacitor |
| 20: | noise filter |
| 21: | lid |
| 22: | connector |
| 23: | bearing |
| 24: | lead wire |
| 25: | discharge chamber |
| 26: | wall |
| 27: | resin |
| 28: | bolt |
| 30: | motor drive circuit |
| 31: | suction gas chamber |
| 32: | drive circuit housing |
| 33: | discharge gas path |
| 41: | inverter |
| 42: | external power source |
| 43: | connector for control signals |
| 44: | air conditioning control unit |
| 45: | motor control circuit |
| 46: | SiC-MOSFET |
| 47: | SiC-SBD |
| 100, 200, 300: | drive circuit-integrated electric compressor |

**Claims**

1. A drive circuit-integrated electric compressor into which a motor drive circuit having a power semiconductor element is incorporated integrally, **characterized in that** said electric compressor is configured so that said power semiconductor element in said drive circuit is cooled by refrigerant gas to be discharged.

2. The drive circuit-integrated electric compressor according to claim 1, wherein said power semiconductor element is a wide band gap semiconductor element.

3. The drive circuit-integrated electric compressor according to claim 1 or 2, wherein said power semiconductor element is mounted on a high heat-conduction circuit board and a back surface of said circuit board is configured to be cooled by refrigerant gas to be discharged through a wall of said compressor.

4. The drive circuit-integrated electric compressor according to any of claims 1-3, wherein said power semiconductor element is coated with a low heat-conduction resin.

5. The drive circuit-integrated electric compressor according to any of claims 1-4, wherein a low heat-conduction heat-shielding member is placed at a position between said power semiconductor element and other electronic parts.

6. The drive circuit-integrated electric compressor according to any of claims 1-5, wherein $CO_2$ is used as refrigerant.

7. The drive circuit-integrated electric compressor ac-

cording to any of claims 1-5, wherein HFC1234yf is used as refrigerant.

**8.** The drive circuit-integrated electric compressor according to any of claims 1-7, wherein said refrigerant gas to be discharged for cooling said power semiconductor element in said drive circuit is refrigerant gas to be discharged which has passed through a built-in motor and a compression part in this order.

**9.** The drive circuit-integrated electric compressor according to any of claims 1-7, wherein said refrigerant gas to be discharged for cooling said power semiconductor element in said drive circuit is refrigerant gas to be discharged which has passed through a compression part and a built-in motor in this order.

**10.** The drive circuit-integrated electric compressor according to any of claims 1-7, wherein said refrigerant gas to be discharged for cooling said power semiconductor element in said drive circuit is refrigerant gas to be discharged which passes through a built-in motor part after having passed through a compression part.

**11.** The drive circuit-integrated electric compressor according to any of claims 1-10, wherein said electric compressor is a scroll-type compressor.

**12.** The drive circuit-integrated electric compressor according to any of claims 1-11, wherein said electric compressor is a compressor mounted on a vehicle.

**13.** The drive circuit-integrated electric compressor according to any of claims 1-12, wherein said electric compressor is a compressor installed in a refrigeration circuit of an air conditioning system for vehicles.

**FIG. 1**

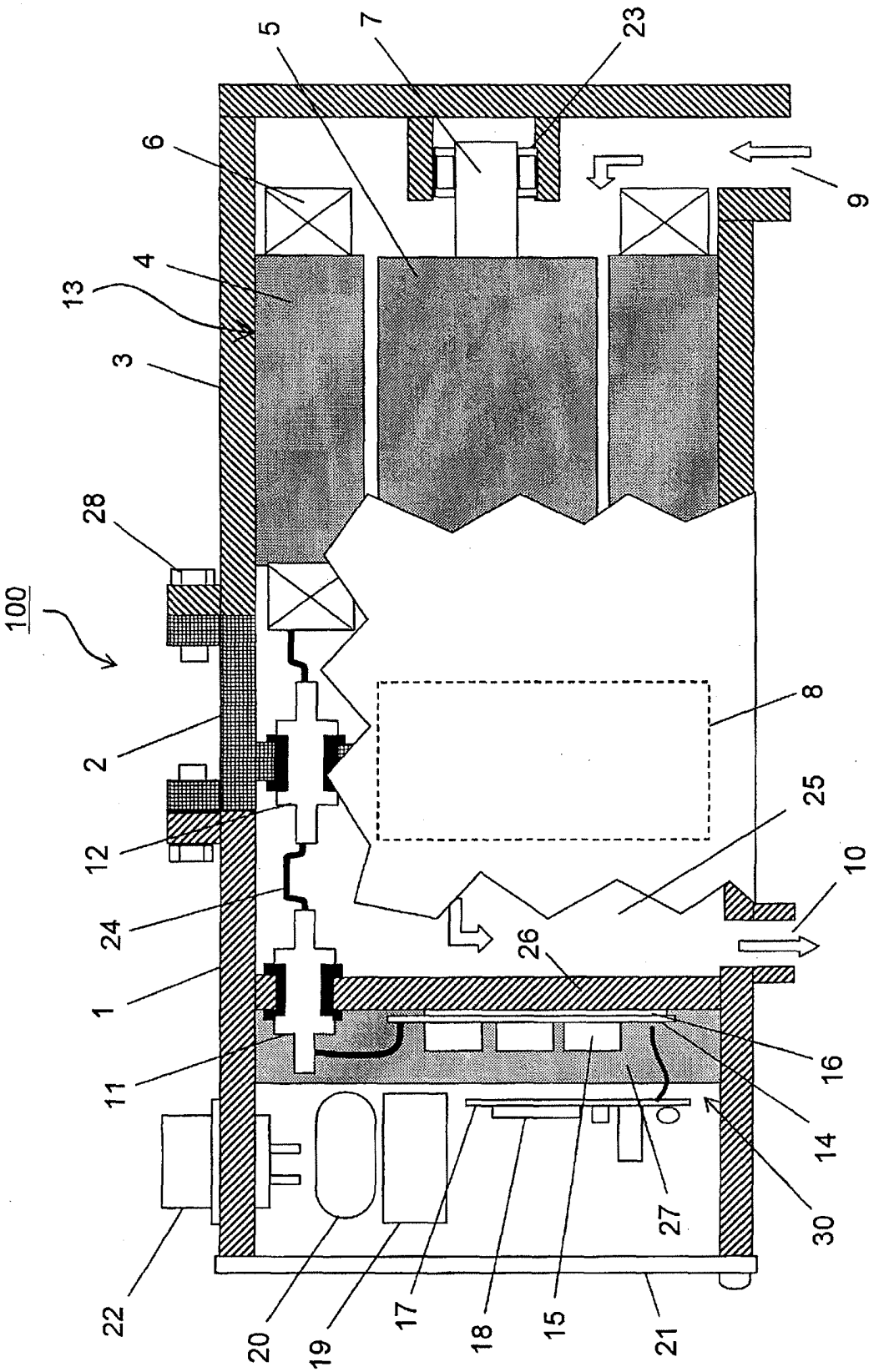
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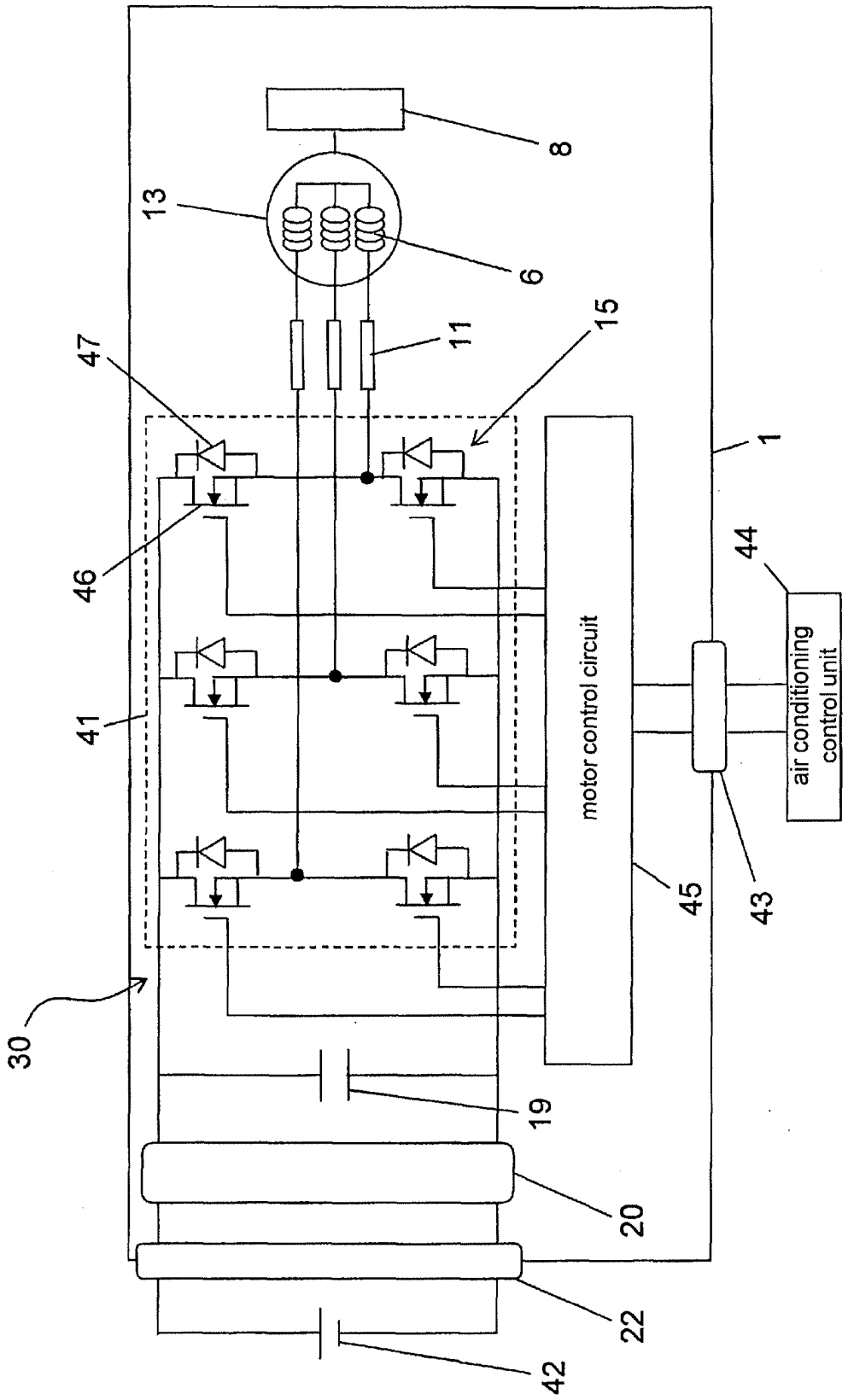
**FIG. 2**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15
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motor control circuit
air conditioning control unit
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**FIG. 3**

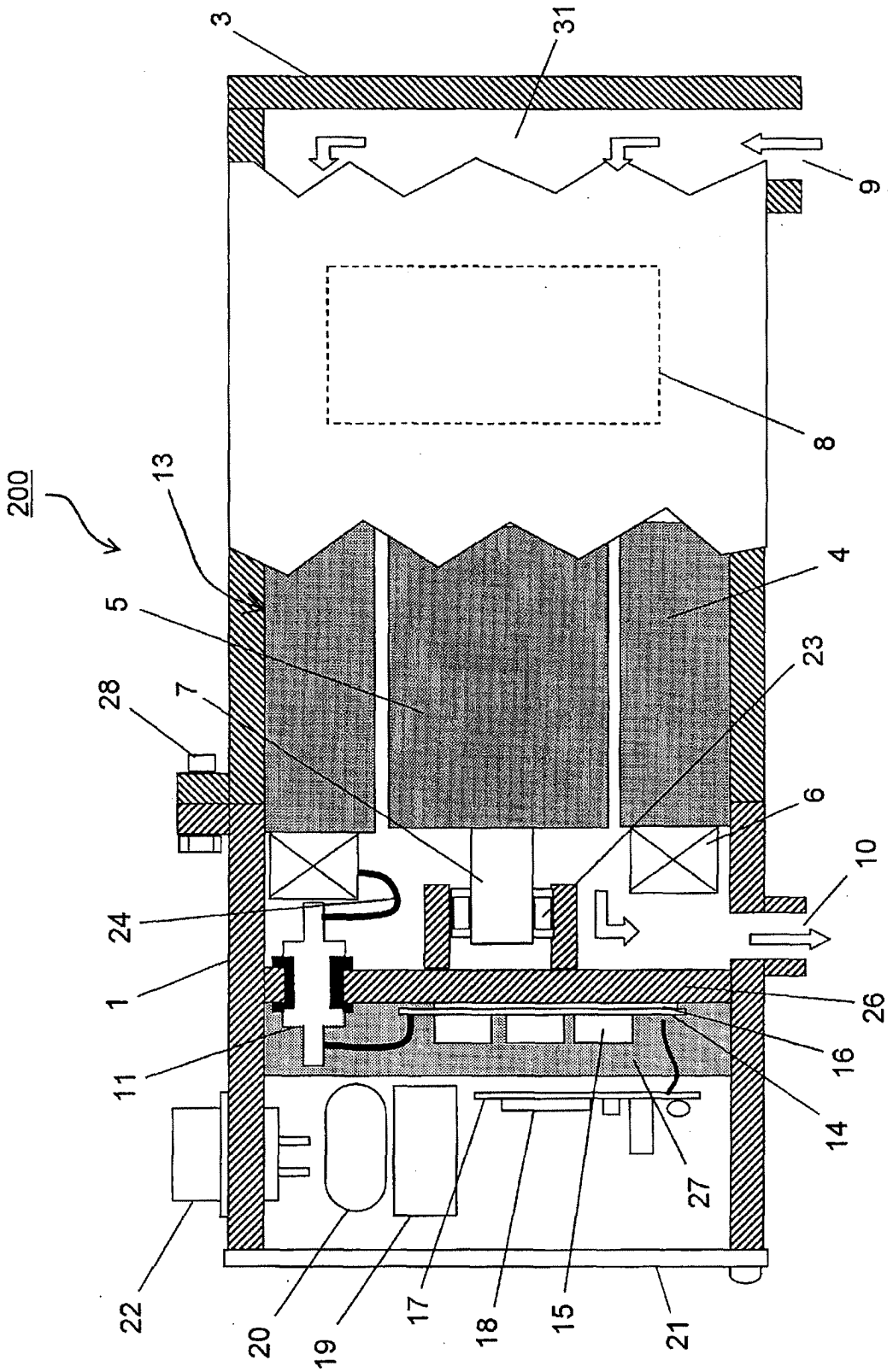
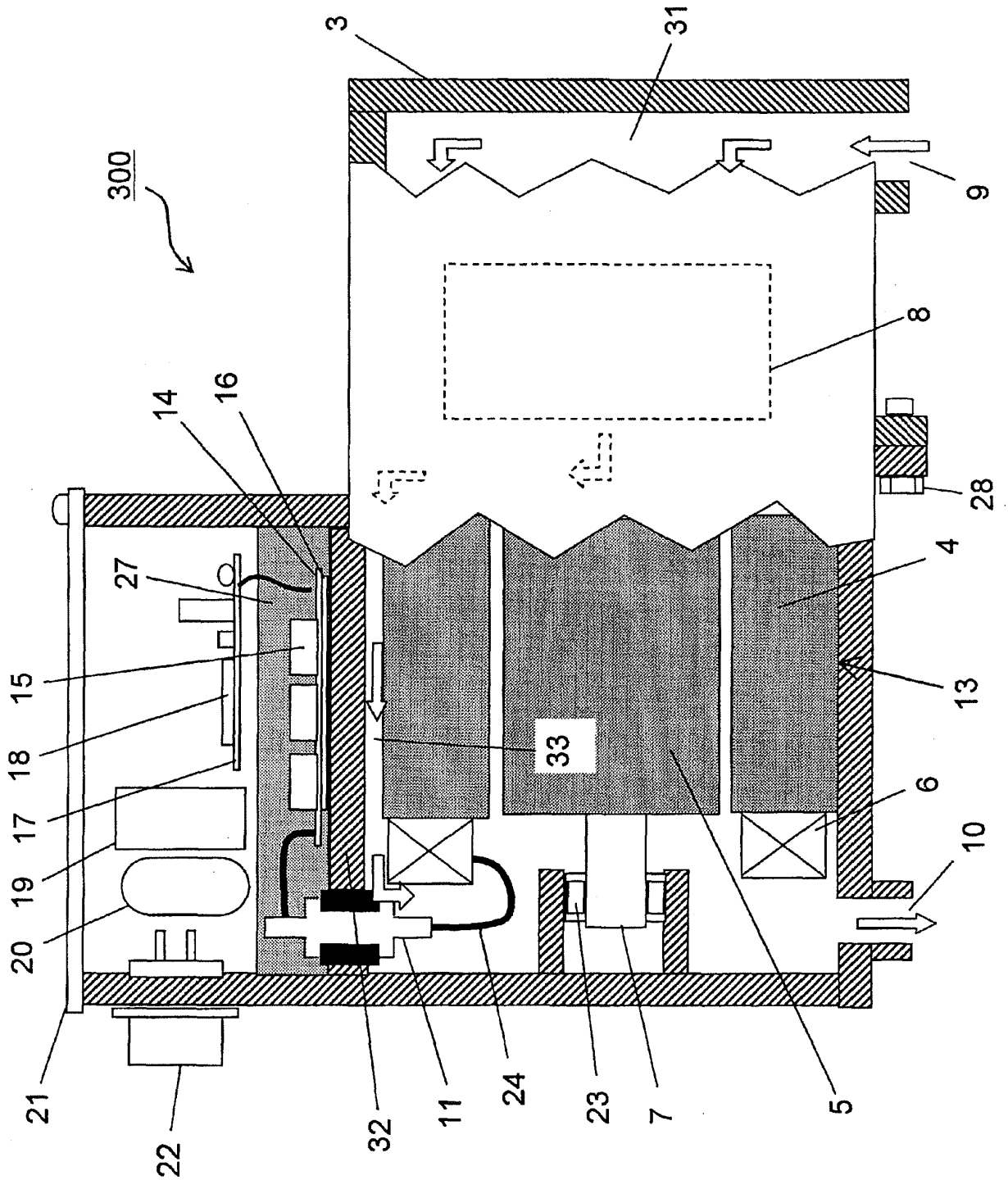


**FIG. 4**



**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2009/007027

A. CLASSIFICATION OF SUBJECT MATTER
*F04B39/06*(2006.01)i, *F04B39/00*(2006.01)i, *F04C18/02*(2006.01)i, *F04C29/04*(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, F04B39/00, F04C18/02, F04C29/04

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. |
|---|---|---|
| X<br>Y | JP 2008-57425 A (Daikin Industries, Ltd.),<br>13 March 2008 (13.03.2008),<br>paragraph [0016]; fig. 2 to 3<br>(Family: none) | 1-2,9-10<br>3-8,11-13 |
| X<br>A | JP 2008-267211 A (Daikin Industries, Ltd.),<br>06 November 2008 (06.11.2008),<br>paragraph [0048]; fig. 2, 4, 8<br>(Family: none) | 1,9-10<br>2-8,11-13 |
| Y | JP 2004-316615 A (Karusonikku Konpuressa Seizo Kabushiki Kaisha),<br>11 November 2004 (11.11.2004),<br>paragraph [0012]; fig. 1, 2<br>(Family: none) | 3-8,11-13 |

☒ 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 |
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| 04 February, 2010 (04.02.10) | 16 February, 2010 (16.02.10) |
| Name and mailing address of the ISA/<br>Japanese Patent Office<br><br>Facsimile No. | Authorized officer<br><br>Telephone No. |

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

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2009/007027

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## REFERENCES CITED IN THE DESCRIPTION

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